Appendix A

Notice of Preparation

Appendix A-1
NOP

Notice of Preparation and Public Scoping Meeting

Date: December 9, 2022

To: Office of Planning and Research, Responsible and Trustee Agencies, Clerk of the County of San Diego, and Other Interested Stakeholders

Subject: Notice of Preparation of Supplement to the Environmental Impact Report for the 2021 Regional Plan and Public Scoping Meeting Notice

The San Diego Association of Governments (SANDAG), as lead agency under the California Environmental Quality Act (CEQA), will prepare a Supplement to the Final Program Environmental Impact Report (SEIR) for an amendment to the 2021 Regional Plan. In accordance with CEQA Guidelines Section 15082, SANDAG has issued this Notice of Preparation to provide responsible agencies, trustee agencies, and other interested stakeholders with information describing the proposed project and its potential environmental effects.

Project Location

The Project location includes the 18 cities and unincorporated areas of San Diego County.

Project Description

Senate Bill 375 (SB 375) provides for a planning process to coordinate land use planning and regional transportation plans (RTP) to help California meet the greenhouse gas (GHG) emissions reductions established in Assembly Bill 32. SB 375 requires RTPs prepared by metropolitan planning organizations (MPOs), including SANDAG, to incorporate into an RTP a Sustainable Communities Strategy (SCS) that demonstrates how the region would achieve GHG emissions reduction targets for passenger vehicles set by the California Air Resources Board (CARB).

In March 2018, CARB updated regional GHG emissions reduction targets. The current SANDAG targets are per capita carbon dioxide emissions reductions from passenger vehicles of 15 percent by 2020 and 19 percent by 2035, relative to 2005 levels. In accordance with state and federal law, SANDAG developed the 2021 Regional Plan, which included both the region's RTP and SCS, and achieved the 2020 and 2035 GHG emissions reduction targets set by CARB. On December 10, 2021, the SANDAG Board of Directors adopted the 2021 Regional Plan and certified the Final Program EIR for the 2021 Regional Plan.

Following adoption of the 2021 Regional Plan, the SANDAG Board directed staff to prepare a focused amendment to the 2021 Regional Plan without the regional road usage charge (Project), and an environmental analysis for the Board's consideration. A road usage charge is a direct user fee where drivers pay to use the roadway network, whether the vehicle is powered by gas or electricity or hydrogen, based on distance traveled or other factors.

EIR Scope

A lead agency may choose to prepare a supplement to an EIR when "[a]ny of the conditions described in Section 15162 would require the preparation of a subsequent EIR" and when "only minor additions or changes would be necessary to make the previous EIR adequately apply to the project in the changed situation." (CEQA Guidelines § 15163, subd. (a)(1)–(2).) A supplement to an EIR "need contain only the information necessary to make the previous EIR adequate for the project as revised. (CEQA Guidelines § 15163, subd. (b).) As the lead agency, SANDAG will describe and analyze the impacts of the proposed Project on the physical environment. The SEIR will identify potential impacts to the following environmental resources:

- Aesthetics and Visual Resources
- Agricultural and Forestry Resources
- Air Quality
- Biological Resources
- Cultural Resources
- Energy
- Geology, Soils, and Paleontological Resources
- Greenhouse Gas Emissions
- Hazards and Hazardous Materials
- Hydrology and Water Quality
- Land Use
- Mineral Resources
- Noise and Vibration
- Population and Housing
- Public Services and Utilities
- Transportation
- Tribal Cultural Resources
- Water Supply
- Wildfire

In addition, the SEIR will address cumulative impacts, growth inducing impacts, alternatives, and other issues required by CEQA.

Submitting Comments

Responsible and trustee agencies, and other interested stakeholders are invited to provide written comments on the scope and content of the SEIR. Consistent with CEQA, your response should be sent at the earliest possible date, but no later than thirty days after publication of this Notice. Please submit your comments by 5:00 p.m. PST on January 9, 2023, by mail or email to:

Kirsten Uchitel, Associate Regional Planner
SANDAG
401 B Street, Suite 800
San Diego, CA 92101
Kirsten.Uchitel@sandag.org

Scoping Meeting

SANDAG will hold a public scoping meeting where interested stakeholders will receive a brief presentation on the Project and will have the opportunity to provide comments on the scope and content of the environmental analysis that will be included in the SEIR for the Project.

Date and Time:	December 21, 2022, at 4:00 p.m. PST
Place:	Virtual meeting accessible at https://us02web.zoom.us/j/84519676872 Call in at +1 669 900 6833 Meeting ID: 845 1967 6872

Appendix A-2

NOP Comments

From: Kirsten Uchitel
To: Lauren Lee
Subject: 2021 Amendment Comment
Date: Friday, January 27, 2023 11:21:29 AM

From: Brit Chadwick <britchadwick@gmail.com>
Sent: Friday, December 16, 2022 6:20 PM
To: Kirsten Uchitel <kirsten.uchitel@sandag.org>
Subject: Public comments

To whom it may concern,

The Vehicle Miles Traveled tax (VMT) makes rural and semi rural communities suffer far more than metro and suburban communities and is in no way equitable.

We are already paying excessive fuel taxes.

Sandag has never supported road improvements for Ramona and we tend to drive more miles so we'll pay a bigger portion of the VMT tax with less to show for it.

We still remember Sandag is the agency that decided instead of improving Hwy 67 for vehicles, they'd add more bike lanes.

As a Ramona resident who lives off of highway 67, I oppose the Vehicle Miles Traveled Tax.

Sincerely,
Britni Chadwick
16246 Boortz LN
Ramona CA 92065
--
Britni Chadwick, Coordinator
TLC Supported Living Services
(858)705-1748
Inline image

From:	Kirsten Uchitel
To:	Lauren Lee
Subject:	2021 Amendment Comment
Date:	Friday, January 27, 2023 11:24:18 AM

From: Dan Silver <dsilverla@me.com>
Sent: Thursday, December 22, 2022 3:05 PM
To: Kirsten Uchitel <Kirsten.Uchitel@sandag.org>
Cc: Keith Greer <keith.greer@sandag.org>; Michael Beck <beckehl@icloud.com>
Subject: Notice of Preparation of Supplement to the Environmental Impact Report for the 2021 Regional Plan

You don't often get email from dsilverla@me.com. Learn why this is important

CAUTION: This email originated from outside of SANDAG. Do not click links or open attachments unless you are expecting the content.

Dec. 22, 2022

Kirsten Uchitel, Associate Regional Planner SANDAG
401 B Street, Suite 800
San Diego, CA 92101

RE: Notice of Preparation of Supplement to the Environmental Impact Report for the 2021 Regional Plan

Dear Ms Uchitel:

Endangered Habitats League (EHL) appreciates the opportunity to comment on the scope of the Supplemental EIR (SEIR). For your reference, EHL is a regional conservation group dedicated so ecosystem protection, sustainable land use, and collaborative conflict resolution.

EHL is deeply concerned over the negative effects of removing the road charge. A road service charge of some type is inevitable due to loss of the gas tax with electrification, and San Diego could have been a national leader.

The SEIR should account for the direct loss of funds from all classes of vehicles (electric, gas, etc.). It should also account for the incentives and disincentives inherent in a carefully crafted road charge. Losing the road charge means that driver behavior will not be modified, and there will be corresponding increase in VMTs and GHGs, *irrespective* of whether the project list itself is unaltered. Mitigation measures should be offered to compensate for the loss of behavioral change. However, the increased GHG impacts may not be mitigable.

Finally, the SEIR should include a "no action" alternative in which the road charge is maintained, and an alternative for a partial or refined road charge geared to targeted disincentives for long commutes or multiple daily trips.

Thank you for considering our views

Regards and Holiday wishes,
Dan

Dan Silver, Executive Director
Endangered Habitats League
8424 Santa Monica Blvd., Suite A 592
Los Angeles, CA 90069-4267

213-804-2750
dsilverla@me.com
https://ehleague.org

From:	Kirsten Uchitel
To:	Lauren Lee
Subject:	2021 Amendment Comment
Date:	Friday, January 27, 2023 11:22:18 AM

From: Gary King <gking@startmail.com>
Sent: Sunday, December 18, 2022 1:03 PM
To: Kirsten Uchitel <kirsten.uchitel@sandag.org>
Subject: STOP TAXING US!

Dear SANDAG,

You have been deaf to the financial plight of citizens in this RECESSION. Your misappropriations of our taxes for lavish dinners & booze are embarrassing & criminal embezzlement. You demand tax increases incessantly while you waste our tax dollars on mass transit with few riders, but plenty of risks of criminal attack & Covid transmission. Then you steal our roadways & street parking near local stores from vehicular traffic for a scant group of loud bicycle activists who don't pay road taxes, but zip around without helmets & ignore traffic laws.

You ignored your obligation to expand & maintain roads & freeways in North County that was required by tax measures passed on propositions years ago. So, instead you built billion dollar projects in 2 cities, San Diego & Chula Vista, you reduce general traffic lanes, you set up toll roads to make us pay twice for the lanes we need, and you spend all your damn time figuring out how to raid our bank accounts for your next dinner party, political activities & government worker unions (who parasitize taxpayers for lavish pensions & who funnel money back to support your regime).

You sicken me. But your corruption also make it impossible for many retired in California to survive financially here. Your insane "Milleage Tax" schemes, repeated increases in sales taxes, and the $1.40 per gallon gas taxes punish the working class & retired communities. You aren't true "Public Servants," but see yourselves as the Ruling Elitists that think you "know better" what to spend OUR money for.

I spit on you. SANDAG must be dissolved & every one of you fired without severance or pensions. Parasites & Crooks are what you are. Go to Hell!
Gary King

From: Kirsten Uchitel
To: Lauren Lee
Subject: Amendment Comment
Date: Friday, January 27, 2023 11:31:41 AM

From: David De Vries <DDeVries@poway.org>
Sent: Monday, January 9, 2023 1:43 PM
To: Kirsten Uchitel <kirsten.uchitel@sandag.org>
Cc: Bob Manis <BManis@poway.org>; SDFORWARD <sdforward@sandag.org>; asilva@poway.org; JohnWilly Aglupos <JAglupos@poway.org>; Hector Salgado <HSalgado@poway.org>; Charlotte Brenner <CBrenner@poway.org>; Linh Diep <LDiep@poway.org>; Hoger Saleh <HSaleh@poway.org>
Subject: Supplemental Environmental Impact Report for an amendment to the 2021 Regional Plan Comments - City of Poway

Thank you for allowing us to submit comments on the Supplemental Environmental Impact Report for an amendment to the 2021 Regional Plan.

Regarding Scripps Poway Parkway, the City of Poway would like to see vehicle, bike, pedestrian and transit infrastructure improvements and connections to be added from the Highway 67 through Scripps Poway Parkway to the I-15 Freeway. Please note that the majority of the City of Poway and areas east of the City of Poway are in the Very High Fire Severity Zone. Evacuation routes for the region should consider alternative routes and not only highway routes. Figure 4.9-2 of the EIR shows that there are no evacuation routes through the City of Poway. Providing vehicle, bike, pedestrian and transit infrastructure improvements along Scripps Poway Parkway and establishing it as an Evacuation Route will provide better access for emergency vehicles and sufficient routes for persons evacuating through the City of Poway. I have spoken to several property and business owners within the South Poway Business Park (SPBP) including Geico and parking is a constant issue. There is currently no public transit route into the SPBP. Having public transit, bike, pedestrian and highway/road improvements/connections providing more efficient access to the SPBP is essential for future employment growth and public safety in the area. Many workers in the Poway area live in Ramona and East County and this is a vital connection for the City and the Region. SANDAG has also identified the SPBP as a Tier 3 employment center in their draft Employment Center analysis. Construction is also underway to add thousands of more employees in the SPBP. To be clear, we are recommending that Scripps Poway Parkway be shown as a critical connection, a multimodal corridor, and an evacuation route in the San Diego region (https://www.sandag.org/uploads/publicationid/publicationid_4720_28341.pdf).

Regarding the Hwy 67, please note that the City of Poway's General Plan Transportation Element and the San Vicente CMCP includes a multi-use path onSR-67 (reference p. 3 http://docs.poway.org/weblink/0/doc/50446/Electronic.aspx). This multi-use path would include a separated two-way bike path and a fenced DG equestrian trail. The multi-use path provides a critical and safe pathway for hikers, bikers, runners, walkers, children, and equestrians. A multi-use path also creates a necessary loop between the City's Iron Mountain trailhead and other destinations (e.g., Mt. Woodson, Lake Poway) which is also a goal within the Transportation Element. We recommend the Regional Plan be consistent with the San Vicente CMCP and with the City's plans. Also, for public safety, please recall that there are considerable traffic collisions along the Hwy 67 and we recommend that traffic safety improvements be considered along the Hwy 67 corridor.

State Route 67 is also designated as a scenic roadway by the Poway General Plan. As a part of the General Plan requirements, a 50-foot wide landscape open space easement is required from adjacent property owners from the ultimate right-of-way line along State Route 67 when development is proposed. This easement shall be landscaped and modified as needed to enhance the scenic quality of the area as discussed in the General Plan Transportation Element Policy B – Scenic Roadways. Providing scenic roadway elements to the design will also help the corridor be more compatible with surrounding open space. To contribute to the General Plan goals, we would suggest that the right-of-way incorporate design elements consistent with a scenic roadway (e.g., naturalized decorative solid walls, native landscaped medians and shoulders, additional landscape areas and trees where feasible, earthen berms). Also, the EIR for the 2021 Regional Plan Table 4.1-1 and Figure 4.1-1 shows Highway 67 as not an Officially Designated or an Eligible State Scenic Highway, however, the Caltrans Scenic Highway System Lists (https://dot.ca.gov/programs/design/lap-landscape-architecture-and-community-livability/lap-liv-i-scenic-highways) notes Highway 67 as an Eligible State Scenic Highway and the EIR needs to be revised to show Highway 67 as an Eligible State Scenic Highway.

As a part of the San Diego Forward Plan and the 5 Big Moves Plan, SANDAG established the SR-67 corridor as a Comprehensive Multimodal Corridor Plan (CMCP) calling for a multimodal road along the SR-67 (https://www.sdforward.com/docs/default-source/default-document-library/agenda-june-5-2020.pdf?sfvrsn=891afe65_4) . As stated on p. 6-2 of the 2050 RTP, "Our region has consistently supported a multimodal approach to transportation that looks at the overall system and improvements that benefit all modes, rather than prioritizing one over the other. This approach gives all of the transportation system users choices traveling within and through the region." Further, "A well designed and thoughtfully integrated multimodal transportation system will give people choices, allowing them to select the transportation mode that is best suited for a particular trip. In an area as large and diverse as the San Diego region, this approach is necessary to make the best use of our limited transportation resources." As discussed, a multi-modal transportation system provides users transportation options and choices and thereby reduces traffic congestion and ghg emissions. Regional multi-use paths have been a great asset to communities across the country. Here in San Diego, the SR-56 Bike Path is separated from the highway and is often used by runners, walkers, and equestrians. In contrast, it is uncommon to see bikers, walkers, and equestrians in a bike route adjacent to a highway (for instance, SR-76). A multi-use path is also kid friendly because of the separation from the highway and kids are often seen on the SR-56 Bike Path and not commonly seen within bike routes adjacent to a Highway. The multi-use path also accommodates a more rural aesthetic and is safer for users. Multi-use paths have become a critical component to the transportation system and are treasured by the communities they are a part of. The addition of the multi-use path along Hwy 67 is more consistent with the goals and policies of the 2050 RTP. We recommend the San Vicente corridor plan provides a separated mixed-use path throughout the full length of the corridor.

Regarding unique geological features or landforms, page 4.7-30 of the EIR for the 2021 Regional Plan notes that the City of Poway General Plan "does not contain policies or regulations specific to unique geological features or landforms." This is incorrect, the General Plan and Habitat Conservation Plan notes unique geological features and landforms and related policies that include the preservation of rock outcroppings, open space, hillsides, ridgelines, and cultural, historical, and paleontological resources. Please update this in the EIR to be accurate.

Regarding Poway's General Plan, page 4.11-16 of the EIR for the 2021 Regional Plan notes that the City of Poway Comprehensive Plan was adopted November 1991 and that the Housing Element update is in the process of being updated. Please update the EIR as follows: "Poway General Plan November 1991 (Transportation Element updated March 2010; Housing Element updated August 2021; Public Safety Element being updated as of October 2021)."

Thank you for considering our comments. Please feel free to reach out to me with any questions.

Thank you,

David De Vries, AICP
City Planner
Development Services
City of Poway | 13325 Civic Center Drive | Poway, CA 92064
Phone (858) 668-4604 | Fax (858) 668-1211
ddevries@poway.org

From: David De Vries <DDeVries@poway.org>
Sent: Thursday, August 5, 2021 10:34 AM
To: San Diego Association of Governments - San Diego Association of Governments (sdforward@sandag.org) <sdforward@sandag.org>
Cc: Bob Manis <BManis@poway.org>
Subject: 2021 Regional Plan Comments - City of Poway

Thank you for allowing us to submit comments on the Draft 2021 Regional Plan.

Regarding Scripps Poway Parkway, the City of Poway would like to see vehicle, bike, pedestrian and transit infrastructure improvements and connections to be added from the Highway 67 through Scripps Poway Parkway to the I-15 Freeway. I have spoken to several property and business owners within the South Poway Business Park (SPBP) including Geico and parking is a constant issue. There is currently no public transit route into the SPBP. Having public transit, bike, pedestrian and highway/road improvements/connections providing better more efficient access to the SPBP is essential for future employment growth in the area. Many workers in the Poway area live in Ramona and East County and this is a vital connection for the City and the Region. SANDAG has also identified Scripps Poway as a Tier 3 employment center in their draft Employment Center analysis. Construction is also underway to add thousands of more employees in the SPBP. To be clear, we are recommending that Scripps Poway Parkway become a critical connection and a multimodal corridor (https://www.sandag.org/uploads/publicationid/publicationid_4720_28341.pdf).

Regarding the Hwy 67, please note that the City of Poway's General Plan Transportation Element includes a multi-use path on the west side of SR-67 (reference p. 3 http://docs.poway.org/weblink/0/doc/50446/Electronic.aspx). This multi-use path would include a separated two-way bike path and a fenced DG equestrian trail. The multi-use path provides a critical and safe pathway for hikers, bikers, runners, walkers, children, and equestrians. A multi-use path also creates a necessary loop between the City's Iron Mountain trailhead and other destinations (e.g., Mt. Woodson, Lake Poway) which is also a goal within the Transportation Element. We recommend the San Vicente corridor plan is consistent with the City's plans.

State Route 67 is also designated as a scenic roadway by the Poway General Plan. As a part of the General Plan requirements, a 50-foot wide landscape open space easement is required from adjacent property owners from the ultimate right-of-way line along State Route 67 when development is proposed. This easement shall be landscaped and modified as needed to enhance the scenic quality of the area as discussed in the General Plan Transportation Element Policy B – Scenic Roadways. Providing scenic roadway elements to the design will also help the corridor be more compatible with surrounding open space. To contribute to the General Plan goals, we would suggest that the right-of-way incorporate design elements consistent with a scenic roadway (e.g., naturalized decorative solid walls, native landscaped medians and shoulders, additional landscape areas and trees where feasible, earthen berms).

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Lastly, during the workshop portion for the Draft 2021 Regional Plan, workshops were provide by area (North, East, Central, etc.). Based on the mapped areas shown, Poway residents and community stakeholders were not represented as a part of any region and that outreach with appropriate comment period should be provided prior to moving forward with Draft. I'd be happy to assist you with what an appropriate outreach should be.

Thank you for considering our comments. Please feel free to reach out to me with any questions.

Thank you,

David De Vries, AICP
City Planner
Development Services
City of Poway | 13325 Civic Center Drive | Poway, CA 92064
Phone (858) 668-4604|Fax (858) 668-1211
ddevries@poway.org

From:	Kirsten Uchitel
To:	Lauren Lee
Subject:	2021 Amendment Comments
Date:	Friday, January 27, 2023 11:31:13 AM
Attachments:	20230108_SANDAG_2023_Draft_SEIR_Scoping_Comments_57-Pages.pdf

From: Katheryn Rhodes <laplayaheritage@gmail.com>
Sent: Sunday, January 8, 2023 9:16 AM
To: Kirsten Uchitel <kirsten.uchitel@sandag.org>; Keith Greer <Keith.Greer@sandag.org>; Katheryn Rhodes <laplayaheritage@gmail.com>
Subject: Public Scoping Commends 2023 SEIR

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Please see attached.

Regards,

Katheryn Rhodes
619-402-8688

January 8, 2023

SANDAG
401 B Street, Suite 800
San Diego, California 92101. Via email.
Attention: Kirsten Uchitel, Associate Regional Planner kirsten.uchitel@sandag.org
Keith Greer, Environmental Planning Manager Keith.Greer@sandag.org

Subject: Public Scoping Comments on SANDAG's new 2023 Draft Supplement to the Environmental Impact Report (2023 Draft SEIR) for the 2021 Regional Plan; 12/09/2022 CEQA Notice of Preparation (NOP); and 12/21/2022 Public Scoping Meeting. State Clearinghouse No. 202212021.

References: 12/21/2022 Video https://www.youtube.com/watch?v=g8j-9AM0pTE&t=54s
12/09/2022 CEQA 2023 Draft SEIR Notice of Preparation (NOP).
https://sandag.org/-/media/SANDAG/Documents/PDF/regional-plan/2021-regional-plan/environmental-impact-report/nop-2021-regional-plan-amendment-2022-09-12.pdf 12/21/2022 2023 Draft SEIR Presentation
https://sandag.org/-/media/SANDAG/Documents/PDF/regional-plan/2021-regional-plan/environmental-impact-report/supplemental-environmental-impact-scoping-meeting-2022-12-21.pdf

Dear SANDAG:

Thank you for the opportunity to present public scoping comments to SANDAG's new upcoming 2023 Draft Supplement to the Environmental Impact Report (SEIR) for SANDAG's 2021 Regional Plan which was approved 13 months ago on 12/10/2021. This new 2023 Draft SEIR is unneeded, but is being updated to take out SANDAG's extra local Road Usage Charge (RUC), aka Mileage Tax, as a funding source for transit projects at the direction of the SANDAG Board of Directors (BOD).

The unneeded 2023 Draft SEIR will analyze the associated predicted increases in GreenHouse Gas (GHG) emissions and Vehicle Miles Traveled (VMT) resulting from getting rid of the extra local RUC Mileage Tax revenues, "*along with a cumulative impacts analysis and an analysis of alternatives that further reduce environmental impacts.*"

In addition, the 2023 Draft SEIR should update Appendix V Funding and Revenue assumptions for a public 0.5-cent Sales Tax increase in 2022 that never happened.
"*The 2021 Regional Plan assumes a one-half cent measure following the 2022 election*"
https://sdforward.com/docs/default-source/final-2021-regional-plan/appendix-v---funding-and-revenues.pdf?sfvrsn=e3c3fd65_2

My request is the SANDAG Board take back their 10/28/2022 Vote on Agenda Item 8 for $1.5 million increase in the FY-2023 Program Budget for an Amendment to the 2021 Regional Plan to get rid of the extra local RUC Milage Tax and the associated requirements for a new 2023

Draft SEIR within one year, by a new Board Agenda Item and vote do to nothing, and wait for the 2025 EIR instead. https://twitter.com/LaPlayaHeritage/status/1586352068985384960

This will allow SANDAG to be in conformance with existing California Air Resources Board (CARB) requirement of -19 percent reduction of 2005 GHG levels by 2035. Until the new required comprehensive 2025 EIR is published, which will most likely require meeting new expected higher CARB GHG reduction goals.

Instead of an unneeded 2023 Draft SEIR, the SANDAG Board should allow SANDAG staff to concentrate on the upcoming state required comprehensive updated Environmental Impact Report (EIR) for SANDAG's upcoming 2025 Regional Plan. Where a scoping meeting is planned next week, on 01/12/2023. Short-term by not taking out the RUC Milage Tax and not updating the 2023 Draft SEIR, SANDAG staff can concentrate on the Regional Housing Needs Assessment (RHNA) and Housing Element updates for small cities. Instead of two EIRs, there will be three EIRs in a four year period: the adopted EIR for the 2021 Regional Plan, the unneeded Draft SEIR in 2023, and a new required comprehensive EIR in 2025.

Instead of a new 2023 Draft SEIR to the adopted 2021 EIR; a new comprehensive 2025 EIR is needed due to substantial changes for several government projects in downtown and the Midway neighborhood that require major revisions, and due to new information becoming available in accordance with Public Resources Code (PRC) Section 21166.

Instead of a limited amount of Resource Areas, comprehensive Updated Analysis are required for the 2023 Draft SEIR and 2025 EIR studies for the following: Greenhouse Gas (GHG) Emissions, Geology, Soils, Mineral Resources, Transportation, Water Supply, Hydrology and Water Quality, Public Services and Utilities, Geologic Hazards, Population and Housing, Land Use, and Hazardous Materials.

Resource Area: Greenhouse Gas (GHG) Emissions.

The California Legislative Analyst's Office (LAO) released their California Air Resources Board (CARB) 2022 Scoping Plan Update on Assessing California's Climate Policies on 01/04/2023. The LAO recommended major future changes to CARB to achieve new GHG reduction targets. https://lao.ca.gov/Publications/Report/4656?utm_source=t.co&utm_medium=referral&utm_campaign=4656

"*California Legislative Analyst's Office says we won't meet our 2030 emissions goals. Part of the problem - state plans call for a 25% reduction in driving by 2030 whereas state policy will achieve only a 4% reduction by 2045*."
https://twitter.com/AaronGuhreen/status/1610705155586150400

By the time the 2023 Draft SEIR and/or the 2025 EIR are approved, there may be significant changes to the -19 percent reduction in GHG levels by 2035 that may change so dramatically that SANDAG would not meet the new California goals without massive changes to upcoming plans. Therefore, a new 2023 Draft SEIR may not meet the new GHG levels, and therefore may be useless.

SANDAG should also analyze GHG reductions from the new Otay Mesa East Port of Entry (POE) Border Crossing, Airport Connectivity and Central Mobility Hub (CMH) project, Del Mar Train Track relocation, Midway Rising, downtown City Hall redevelopment, etc.

Resource Areas: Geology, Soils, Mineral Resources, Transportation, Water Supply, Hydrology, Water Quality, and Public Services and Utilities.

So far SANDAG has yet to analyze the potential massive reduction in Greenhouse Gas (GHG) emission that can be achieved through Attachment-1 the alternative La Playa Plan (LPP) for a Full Tidelands Reclamation project on liquefiable soils, consisting of former filled in Salt Marsh Tide Lands with high water tables, subject to tidal influences, and flooding from below.
www.tinyurl.com/20190130a www.tinyurl.com/20210527a

The alternative La Playa Plan (LPP) would create new subterranean public space including transit corridors, Urban Storm Water capture in underground cisterns to improvement water quality, parking, and basements. Including the Midway neighborhood, Sports Arena, San Diego International Airport (SDIA), the Port of San Diego's Headquarters and the North Embarcadero areas, Naval Base Point Loma, Old Town Campus (NBPL OTC) SPAWAR Redevelopment, and SANDAG's Airport Connectivity and Central Mobility Hub (CMH) projects. A thorough analysis of all Resource Areas for the La Playa Plan (LPP) for a full Tidelands Reclamation project would confirm it mitigates for Sea Level Rise through adaptation, will future-proof low income San Diego neighborhoods against Climate Change and tidal flooding during King Tides, plus dramatically reduce GHG emissions.

Plus, the liquefiable hydraulic fill placed on former Salt Water Marsh Lands, can be reclassified as Mineral Resources to be used for construction, and beach sand replenishment projects.

In addition, SANDAG should analyze an alternative site for a new City Hall, directly north of the County Administration Center on Pacific Highway, between Grape and Hathorne Street.

Resource Area: Geologic Hazards.

By now SANDAG's should have conducted preliminary fault investigations for the CEQA analysis for the Airport Connectivity and Central Mobility Hub (CMH) projects along Pacific Highway, North Harbor Drive, and C Street along the trolley tracks in downtown San Diego. These preliminary fault investigations should have confirmed or denied active faulting presumed northwest of the Rental Car Center (RCC), on North Harbor Drive, at Pacific Highway and Laurel Street, at Pacific Highway and Broadway, and at Pacific Highway and Harbor Drive, amongst other areas. All fault investigations require third-party review, and submission to the State Geology. How many fault investigations have been conducted by SANDAG? Where are the third-party reviews? Did SANDAG submit their fault investigations and third-party reviews to the State Geologist as required?

Substantial changes including new 09/23/2021 State of California Alquist-Priolo (AP) Maps for the active Rose Canyon Fault Zone (RCFZ) in the La Jolla and Point Loma Quadrangles. The final AP maps took out the Navy Broadway Complex (NBC) Manchester Pacific Gateway, 1QHQ https://iqhqreit.com/project/radd/; the SANDAG and San Diego Metropolitan Transit Service (SDMTS) new Downtown Headquarters and Bus Stopover project, and the western terminus of Route-52/La Jolla Parkway/Interstate I-5 from Draft map areas where no active faulting was found based on inadequate and incomplete fault investigations, without third-party reviews.

Instead, the final AP maps for "*Earthquake Zones of Required Investigation"* included the NBC/MPG/IQHQ, Seaport Village, North Embarcadero, Old Town, Bay Park, San Diego International Airport (SDIA), the downtown SANDAG and SDMTS Headquarters and Bus Stopover project, and Interstate I-5/Route-52/La Jolla Parkway in areas where active faulting is presumed until more required scientific information is given to the State Geologist. Third-party reviews to confirm or deny active faulting at these still presumed active sites are still missing.

Attachment-2 is the 10/28/2022 SANDAG Item-13 Audit Committee regarding my ongoing Seismic Hazard concerns and solutions of reconvening the Caltrans's 2006 Coronado Fault Technical Advisory Panel (TAP) for seismic guidance. In addition, in areas of former Salt Marsh Tide Lands, any feature for active faulting would be buried by either unconsolidated fill soils or are located underwater. SANDAG should state that active faulting should be presumed in these underwater areas as well, and that fault investigation should be mandated. In addition, SANDAG should require Seismic Reflection lines, not just limited trenching be used.

https://www.conservation.ca.gov/cgs/Documents/Publications/EZRIM/POINT_LOMA_EZRIM_a11y.pdf
https://www.conservation.ca.gov/cgs/Documents/Publications/EZRIM/LA_JOLLA_EZRIM_a11y.pdf

SANDAG's planned new Headquarters and SDMTS Bus Stopover is located directly north of the new State Courthouse at 1100 Union Street. Windows are breaking at the Courthouse, which also has sewage smells, and plumbing problems. These are all signs of foundation movement. In addition, the City of San Diego is allowing construction at Union and C Street, where active faulting was previously found during fault investigations for new State and Federal Courthouses. https://www.cbs8.com/article/news/local/windows-spontaneously-shattering-at-the-san-diego-courthouse/509-2f34b49c-6fe2-4c33-84df-ce08995d18be

Resource Areas: Land Use, Population and Housing, and Hazardous Materials.

There has been substantial changes in new significant environmental effects with new public projects including Midway Rising by the City of San Diego in the Midway neighborhood, Naval Base Point Loma, Old Town Campus (NBPL OTC) SPAWAR Redevelopment, downtown City Hall redevelopment, the planned Seaport Village project, the new Otay Mesa East Port of Entry (POE) Border Crossing, SANDAG's Airport Connectivity and Central Mobility Hub (CMH) projects, and Attachment-3 the new 01/12/2021 Federal Aviation Administration (FAA) laws allowing normally restricted airport revenue diversion for rail and transit access to San Diego International Airport (SDIA). Please analyze the new FAA laws to confirm that the Airport Connectivity and CMH projects can be fully funded using Airport revenues only.

Also there has been no CEQA analysis of Resource Areas for Land Use or Population and Housing for the massive increase in Federal United States Navy and military personnel presence in San Diego since 2020. There is a need for military workforce affordable housing at the Old Town Campus (NBPL OTC) SPAWAR Redevelopment project, which is also a toxic waste Superfund site. Currently there are no requirements for Affordable Housing, therefore, presumably only luxury housing will be built. The Navy and military should clean up the toxic Superfund site. Plus take care of new personnel and homeless Veterans with public funding at this Federal site, and at the City of San Diego's Midway Rising project at the Sports Arena, and downtown City Hall Redevelopment project. Plus discuss the Navy's Spawar Superfund site and if there are any plans to clean up the toxic mess on liquefiable soils.

There has also been a massive increase in homeless deaths in San Diego due to the lack of Affordable Housing and Emergency Shelters in San Diego. Please analyze the dire homeless situation in San Diego. According to the SDUT, approximately 10,000 SROs were destroyed in downtown San Diego from 2010-2016. However, the annual Regional Housing Needs Assessment (RHNA) reports compiled by SANDAG from numbers given to them by the City of San Diego, and San Diego Housing Commission (SDHC) stated there were hardly any destroyed affordable housing units, with some years zero. SANDAG needs to be investigations on how many Affordable Housing units were destroyed in former Redevelopment Agency (RDA) Project Areas, without replacement units, or moving expenses for the newly homeless seniors.

The EIRs for the NBPL OTA, Midway Rising, and downtown City Hall Redevelopment should be tiered with the 2023 Draft SEIR and 2025 EIR in accordance with Public Resources Code (PRC) Sections 21093:

"tiering of environmental impact reports will promote construction of needed housing and other development projects by (1) streamlining regulatory procedures, (2) avoiding repetitive discussions of the same issues in successive environmental impact reports, and (3) ensuring that environmental impact reports prepared for later projects which are consistent with a previously approved policy, plan, program, or ordinance concentrate upon environmental effects which may be mitigated or avoided in connection with the decision on each later project."
https://leginfo.legislature.ca.gov/faces/codes_displayText.xhtml?lawCode=PRC&division=13.&title=&part=&chapter=2.6.&article=

For example, Midway Rising stated they will confirm with the City of San Diego Standards for sea level rise adaptation. City Standards include porous pavements, but nothing else. There is no discussion of required foundations for high rise structures on liquefiable soils. SANDAG should create new design and construction standards that everyone should follow. Which hopefully will follow the La Playa Plan (LPP) for a full Tidelands Reclamation taking out liquefiable soils and creating subsurface space, so foundations will not be built on shifting sands.

ALTERNATIVE FUNDING: Normally Restricted FAA Airport Revenue for Transit.

SANDAG's Board voted to not put the Road Usage Charge (RUC) Mileage Tax or a 2022 Sales Tax Increase on the Ballot. Therefore, Appendix V Funding and Revenue should be amended for the 2023 SEIR and 2025 EIR.

These reductions in funding assumption have been mitigated from the new $300+ million from the State and Federal government for the Del Mar Train Track Bluff Stabilization and Relocation project, the new expected revenues from the Otay Mesa East Port of Entry (POE) project, and the $350 million from the San Diego County Regional Airport Authority (SDCRAA) for the SANDAG's Airport Connectivity project. So far in 3 years, there has been $0 from the SDCRAA to SANDAG. Please investigate if, and when, the $350 million will be requested from the FAA Airport District Officer (ADO) in Los Angeles, what is the timeline for payments?

Below is the new 01/12/2021 FAA Memorandum that lets normally restricted FAA Revenue be used off site for Rail Access and Transit projects, and full funding for a Central Mobility Hub (CMH). Allowing FAA Revenue Diversion for transit in general. FAA Revenue can be used as an alternative funding source to the Road Usage Charge (RUC) to reduce GHG.

https://www.faa.gov/airports/pfc/pfc_updates/media/pfc_75_21_rail_access_policy.pdf
https://downloads.regulations.gov/FAA-2016-6596-0024/attachment_1.pdf
https://downloads.regulations.gov/FAA-2016-6596-0040/attachment_1.pdf

Linked below is the Record of Decision (ROD) for LaGuardia Airport (LGA) Improvement Project in Queens, New York that uses normally restricted airport revenue for off airport transit to connect the airport with existing rail and transit stations.
https://www.faa.gov/airports/environmental/environmental_documents/lga/media/EIS-ROD-LGA-NY-Access-Improvement-2021-07-21.pdf

Also linked below is the final FAA Grandfather Airport order where both the private airlines and Federal FAA staff were trying to take away the States Port Authority of New York and New Jersey (PANYNJ) Grandfathered status, and lost in 2022 after several years of legal fighting. Federal FAA staff and the private Airlines came together against the States Tidelands Trusts to try to sabotage the public's Grandfathered Revenue Diversion status. New York and New Jersey local governments, and the public fought for their public Tidelands Trust rights, and Billions in normally restricted FAA Cash for transit and rail links to the airport.
https://downloads.regulations.gov/FAA-2015-0026-0075/attachment_1.pdf

Similar, but opposite, to how the San Diego County Regional Airport Authority (SDCRAA), the local FAA Los Angeles (LA) Airport District Officer (ADO), and SANDAG staff think San Diego International Airport (SDIA) somehow lost their Grandfather status for State Public Tidelands based on misinterpretation of State law years later, and without public notices or public hearings by the Airport, SANDAG, County, or the State.

In conclusion, please ask the SANDAG Board to revote on getting rid of the extra local RUC Mileage Tax and a new 2023 Draft SEIR, and ask to wait for the required updated 2025 EIR instead.

In addition, Updated Analysis are required for several Resource Areas including:
Land Use, Mineral Resources, Population and Housing, Public Services and Utilities, Transportation, Geology, Soils, Greenhouse Gas (GHG) Emissions, Water Supply, Geologic Hazards and Hazardous Materials, Hydrology and Water Quality.

Regards

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Attachment-1	04/19/2022 Alternative La Playa Plan (LPP) for a Full Tidelands Reclamation project to be analyzed in the 2023 Draft EIR and 2025 EIR
Attachment-2	10/28/2022 SANDAG BOD Item-13 Seismic Hazard Concerns
Attachment-3	04/25/2022 Sabotage of SANDAG's Airport Connectivity On-Airport Rail Access Project and Central Mobility Hub CMH) Funding by the San Diego County Regional Airport Authority (SDCRAA) and San Diego International Airport (SDIA).

April 19, 2022

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Subject: The La Playa Plan (LPP) for a Central Mobility Hub (CMH) and Subway Transit Corridors (STC) to the Airport and Convention Center. A continuation of the 1908 and 1926 Nolan Plans for Public Government Buildings on our Waterfront. Including a New City Hall, and new SANDAG and Port Headquarters along Pacific Highway.

Dear SANDAG:

Prior to publishing your CEQA Notice of Preparation (NOP) for Mayor Todd Gloria and SANDAG's Updated Vision for a two-phased project for transit to the Airport, and a downtown Central Mobility Hub (CMH) as part of a new City Hall compound for the City of San Diego; please analyze the La Playa Plan (LPP) for a Full Tidelands Reclamation as its own Alternative Project in the CEQA Notice of Preparation (NOP) and the Supplemental Environmental Impact Report (SEIR).

Currently, SANDAG's Phase 1 plans include new above and below ground Transit Corridors to San Diego International Airport (SDIA); a new transit station from the Rental Car Center (RCC); improvements at the existing Middletown Station at West Palm Avenue with a new transit station; a separate Transit Corridor to the Santa Fe Train Depot with a new transit station; a new transit station at the County Administration Center (CAC); and a new Unified Port of San Diego Headquarters. Besides a new Intermodal Transit Center (ITC) [now CMH], with 14% transit to the airport; a new low-cost Youth Hostel hotel, and direct access ramps from Interstate I-5 to the Rental Car Center (RCC) are also required. Per previous California Coastal Commission (CCC) approvals.

SANDAG's Phase 2 plans include a new Central Mobility Hub (CMH) and City Hall in the middle of downtown San Diego at the location of the existing dilapidated City Hall and surrounding public property. On 10 blocks, including City of San Diego property bounded by A, C, and Front Streets, and Third Avenue. With subsurface tunnels for subway connections 80 feet below grade, as part of a new downtown City Hall compound, which includes the dangerous 101 Ash Street litigation.
https://voiceofsandiego.org/2022/04/13/gloria-sandag-settle-on-airport-transit-connection-and-a-regional-transit-hub-downtown/
https://www.sandiegouniontribune.com/news/transportation/story/2022-04-13/regional-planners-change-course-on-long-sought-plan-for-delivering-transit-to-airport
https://sandiego.hylandcloud.com/211agendaonlinecouncil/Documents/ViewDocument/March_14th_DREAM_Presentation?meetingId=4903&documentType=Agenda&itemId=207758&publishId=557342&isSection=false

At the December 3, 2021 SANDAG Board of Directors meeting as Item 4, staff identified the existing Port Headquarters (HQ) on Pacific Highway as the **Superior Alternative** for the Central Mobility Hub (CMH) and transit to the airport. https://sandag.org/uploads/meetingid/meetingid_5685_31105.pdf

"SANDAG analysis to date on the Port HQ site, however, demonstrates that it offers a proximate, potentially ***superior alternative*** *to the ITC site for a transit connection to the Airport due to the larger size of the available land and the closer location to Airport terminals. SANDAG is actively exploring the Port HQ site in close collaboration with the Port and is taking into account potential Port needs, such as a low-cost accommodation hotel, as well as the Airport needs to connect to the Rental Car Center."*

<u>The La Playa Plan (LPP) should be analyzed as its own Alternative in the SEIR.</u>

The LPP Airport Connectivity Project consists of a Central Mobility Hub (CMH) and direct transit connections to the Airport. The La Playa Plan (LPP) Alternative CEQA project agrees with SANDAG staff that Port Headquarters on State Public Tidelands adjacent the airport, is a **"Superior Alternative"** for a new Central Mobility Hub (CMH). The LPP for a Full Tidelands Reclamation consists of the following elements, some of which are shown on Figures 1-3:

- New Central Mobility Hub (CMH) on Pacific Highway, South of Port HQ, directly East of the Train Tracks. With views of San Diego International Airport (SDIA) and downtown.
- New SANDAG and Port Headquarters at Southeast corner of Pacific Highway & Sassafras Street.
- Adaptive Reuse of the existing Port HQ for the required low-cost Youth Hostel hotel.
- New Subway Transit Corridors (STC) several new Subway Stations. With underground corridors for Class 1 Bike Lanes, and Pedestrian walkways.
  <u>Subway Transit Corridor STC-1</u> From the Central Mobility Hub (CMH) and Rental Car Center (RCC). south along Pacific Highway to Laurel Street, then West along Harbor Drive and Airport property, to both Airport Terminals and Harbor Island.
  <u>Subway Transit Corridor STC-2</u> Along Pacific Highway connecting at Laurel Street at a new transfer station, south to Harbor Drive, and the 12^{th} and Imperial SDMTS Trolley Station.
- Automated People Movers (APM) to start with. With analysis of alternative Personal Rapid Transit (PRT) podcar vehicles and systems in the SEIR.
- New Subsurface Subway Station at the Airport Rental Car Center (RCC).
- Direct connecting ramps from Interstate I-5 to the Rental Car Center (RCC) on Pacific Highway.
- New San Diego City Hall directly north of the County of San Diego Administration Center (CAC) bounded by Pacific Highway, Grape Street, Harbor Drive, and Hawthorn Street.
- Trenched underground tunnels under Grape and Hawthorn Streets and the Train Tracks. With direct subsurface connections from Interstate I-5 on- and off-ramps, west to Pacific Highway and Harbor Drive. Moves fast through traffic underground, allowing passenger drop off at the new STC Station at the Future City Hall.
- Confirm that San Diego International Airport (SDIA) is 1 of 12 Grandfathered Airport on public State Port Tidelands which allows normally restricted FAA Airport revenue to be diverted for off airport transportation projects.
- Required San Diego International Airport (SDIA) to annex land on the east side of the Airport to the train tracks. From Washington Street to Laurel Street, to create new Airport property. So that ALL hoarded Billions in FAA Restricted Airport Revenue can fund the full Central Mobility Hub (CMH) and Subway Transit Corridors (STC) to the Airport projects. A joint Central Mobility Hub (CMH) and City Hall site in downtown San Diego could never be annexed by the airport. Which is another reason to not choose the downtown CMH site.

The La Playa Plan (LPP) provides effective subsurface and surface transportation access to the airport. The La Playa Plan (LPP) can "*provide the connectivity, density and overall convenience we need to truly transform the regional transit system through this investment… The Central Mobility Hub is a fundamental concept in San Diego Forward: The 2021 Regional Plan, which is SANDAG's blueprint for enhanced mobility.*" The public Waterfront *"is the perfect location for a transformational project that will enhance transit mobility for the entire region."*

The LPP envisions new joint Headquarters for SANDAG (326 employees), and the Port of San Diego (526 employees). For a Total of 852 employees on the Waterfront. With an unknown number requiring office space. A new multi-story building is planned at the Port Headquarter's existing parking lot. Directly north of the existing Port HQ, south of Sassafras Street. With Adaptive Reuse of the existing Port Headquarters into the CCC required low-cost Youth Hostel hotel.

The new Central Mobility Hub (CMH) would be located directly south of the Port Headquarters with views of the Airport and downtown. The CMH would include room for future a High-Speed Rail depot, and access to MTS Trolley, COASTER and Amtrak Pacific Surfliner commuter rails, and a Greyhound Bus Station. The CMH would be attached to two subsurface Subway Transit Corridors (STC) using Automated People Movers (APM) to the Airport, Harbor Island, Convention Center, and the SDMTS 12th and Imperial Transit Station. With new multi-stories of underground space for transportation, parking, and airport cell phone lots. With CEQA analysis for a new alternative Waterfront location for a new City Hall for San Diego, bounded by Pacific Highway, Grape Street, Harbor Drive, and Hawthorn Streets, in accordance with the Nolan Plans.

The two Subway Transit Corridors (STC) will intersect at Pacific Highway and Laurel Street. The main Subway Transit Corridor (STC-1) will connect the new Central Mobility Hub (CMH) to the Rental Car Center (RCC) on Pacific Highway; the planned SDIA Airport Transit Station between the two Airport Terminals; and links and new transit stations on Harbor Island.

The LPP also includes a separate second Subway Transit Corridor (STC-2) from Laurel Street and Pacific Highway, south to the SDMTS 12th and Imperial Transit Station. With new subsurface subway stations at the new City Hall for the City of San Diego located on Pacific Highway, Grape Street, Harbor Drive, and Hawthorn Street; the San Diego County Administration Center (CAC); near the Santa Fe Train Depot at Broadway and Pacific Highway; IQHQ the former Navy Broadway Complex (NBC); Seaport Village; and the San Diego Convention Center. With opportunity to extend the Subway Transit Corridors (STC) north to the Midway, Sports Arena, Pacific Beach, Ocean Beach, and Liberty Station neighborhoods; and south to the International Border on State public trust tidelands.

At the March 14, 2022 City Council meeting, several City Council Members were excited for a potential new **Waterfront** location between Hawthorn and Grape for a new City Hall, only if it constructed close to public transit. In the CEQA documents, SANDAG will already analyze a new City Hall and transit station. Instead of downtown, please analyze the **Superior Waterfront** location.

When analyzing a downtown location for a new City Hall, please also investigate putting the C Street trolley below grade, from the Santa Fe Depo to Park Avenue (12th Avenue). Moving transit below grade will allow C Street to become a downtown pedestrian plaza in accordance with plans.

<u>The La Playa Plan (LPP) for a Full Tidelands Reclamation through Bathtub Foundations.</u>

The La Playa Plan (LPP) is San Diego's Green New Deal (GND) for natural resource efficiency. See Pages 16-25 https://www.sandag.org/uploads/meetingid/meetingid_5126_25250.pdf

A Full Tidelands Reclamation project would bring in new Federal and State revenue streams to the San Diego Region. SANDAG, Cities, and the County of San Diego have not applied for the major Federal and State Reclamation grant funding available for storm water capture and reuse. Which can be realized using structural cistern foundations at sea level. Only limited Climate Change funding for Sea Level Rise (SLR) adaption has been secured. With no future SLR projects planned by either the City of San Diego, Airport, or the Port for uplift of streets and pavements, already happening at the Port, old Midway Post Office, and Sports Arena sites due to high King Tides. https://voiceofsandiego.org/2016/01/07/those-giant-tides-are-worse-than-ever-and-may-be-hint-of-whats-to-come/ https://www.youtube.com/watch?v=MNztqtmhTJI

A Full Tidelands Reclamation project would creating new subsurface space from 15 to 50 feet deep for transportation project including Subway Transit Corridors (STC), and Urban Storm Water capture and reuse with the use of cisterns. All improvements would be located on Public Trust Tidelands, east of San Diego International Airport (SDIA) across Pacific Highway to the Train and Trolley Tracks, from Washington Street to Laurel Street to Harbor Drive.

The Central Mobility Hub (CMH) and subsurface Subway Transit Corridors (STC) to the Airport project should include a Full Tidelands Reclamation of liquefiable soils under all structures. With all foundations embedded into formational material. The Subway Transit Corridors (STC) should be constructed using a series of bathtub foundations to create waterproof bulkheads to future proof against Sea Level Rise (SLR) and create subsurface space for transportation, parking, and Urban Storm Water capture and reuse. Construction of the bathtub foundation embedded into competent soils, with a shallow water table, will get rid of the seismic hazard of liquefaction. The former Navy Broadway Complex (NBC) has constructed a large bathtub foundation, several stories deep that increased their parking dramatically. The adjacent Seaport Village also plans to use the bathtub foundation design to mitigate against Sea Level Rise (SLR).

The Qatar Integrated Railway Project video is a great example of the Cut and Cover, Bottom-Up trench construction method, using slurry walls. This construction method is a relatively inexpensive way to create subsurface space, with minimal surface traffic disruptions. https://www.youtube.com/watch?v=ORAPYUUriHs&t=56s Trenching is cheaper than tunneling, and is opened to the open air. Trenching get rids of the seismic hazard of liquefaction to create a new waterproof United States Bulkhead, and subterranean space for transportation. Tunneling does not.

San Diego Bay's existing United States Bulkhead elevation was established in 1850 by the US Army Corps of Engineers (USACE). Climate Change and associated Sea Level Rise (SLR) requires that a new **higher** United States Bulkhead elevation be established for San Diego Bay as part of this project. Existing porous Bulkheads on San Diego Bay includes some wooden piles. The Undocumented Fill from dredging operations since 1850 create partial reclamation conditions, and unstable ground. With liquefiable soils subject to tidal influences.

The State Mines and Geology Board (SMGB) should reanalyze Port tidelands, and reclassify the liquefiable areas from Mineral Resource Zone MRZ-1, to MRZ-2 instead. The dredged spoils from the trenched excavations should be sorted for use as constructed material, and available for beach sand replenishment projects. Currently, the San Diego Region imports sand and gravel from Canada. Historically, San Diego County pays the highest cost for raw materials such as

sand and gravel in California. A local supply of sand and gravel is needed for several proposed public construction projects including the Central Mobility Hub (CMH), the Subway Transit Corridors (STC), Midway Sports Arena Redevelopment, the Navy's SPAWAR Redevelopment, a new City Hall, new SANDAG and Port Headquarters, and the North Embarcadero Visionary Plan (NEVP). *"Over the last decade, prices have varied from more than 20 per ton in areas with depleting or depleted aggregate supplies and high demands such as San Diego"*
– California Geological Survey (CGS) 2018.
https://www.conservation.ca.gov/cgs/Documents/Publications/Map-Sheets/MS_052_California_Aggregates_Report_201807.pdf
https://www.conservation.ca.gov/cgs/Documents/Publications/Map-Sheets/MS_052_California_Aggregates_Map_201807.pdf
https://www.sandag.org/uploads/publicationid/publicationid_1558_12638.pdf
https://www.latimes.com/business/la-fi-canadian-gravel-20171104-htmlstory.html

The 2006 CALTRANS Coronado Fault Tunnel Technical Advisory Panel (TAP) should be reconvened and renamed the Rose Canyon Fault Zone (RCFZ) Technical Advisory Panel (TAP).
https://scholarsmine.mst.edu/cgi/viewcontent.cgi?article=2901&context=icrageesd
The new RCFZ TAP should analyze and give guidance to SANDAG regarding seismic hazards including active faults throughout the projects, sheet pile wall construction, and foundation design. The LPP would create a Full Tidelands Reclamation and subsurface space throughout areas of liquefaction, with a low water table, and relatively shallow depths to competent formational materials. The US Army Corps of Engineers (USACE) should also give guidance to SANDAG for the dredging operations required for a Full Tidelands Reclamation adjacent San Diego Bay.

Title 14, Code of Federal Regulations, includes the DOT Federal Aviation Administration (FAA) "*Part 77 - Objects Affecting Navigable Airspace*." The associated FAA Part 77 determination are discretionary, and done by the FAA Airport District Officer (ADO) in Los Angeles (LA) on a case-by-case basis, after a nearby development project is submitted. With the exception of the FAA's blanket 500-foot maximum height limit for high-rise structures in downtown San Diego.
https://www.ecfr.gov/current/title-14/chapter-I/subchapter-E/part-77

It would be great if SANDAG created their own GIS map for FAA Part 77 maximum elevation contours adjacent the SDIA airport runway. With maximum allowable heights to 600 feet, with height contours in 20-foot increments. Then have the map approved by the FAA ADO in LA.

Proposed new LPP improvements are located adjacent the airport runway. Without a FAA Part 77 Determinations calculations to create a maximum elevation contour map, it is unknown if the new SANDAG and Port Headquarters can be 10 to 20 stories in height. Or if the Central Mobility Hub (CMH) or new City Hall on Pacific Highway can be 3 to 8 stories tall.

Funding the La Playa Plan (LPP) by confirming Grandfathered Airport Revenue Diversion status, and Annexing Port Tidelands to create new Airport Land.

The Central Mobility Hub (CMH) and Subway Transit Corridors (STC) from Mexico to Pacific Beach can be fully funded solely through FAA Airport Revenue diversion allowed for through Grandfathered Airports Revenue diversion status. Please request a legal opinion from the California State Lands Commission (SLC) if SDIA lost its Grandfathered status when the Port and Airport split in 2002. Or if the Airport and FAA ADO LA Staff made up the excuse in order to **Hoard Cash.**

Senate Bill SB-1896, written by former State Senator Steve Peace was approved on September 26, 2002, split up the Port and Airport. Mr. Peace stated that changes to Grandfathered Airport Revenue diversion status was specifically not part of his SB-1898 Bill. And SDIA is still a Grandfathered Airport, with the Port as the Airport Sponsor.
https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=200120020SB1896

The San Diego County Regional Airport Authority (SDCRAA) Act is documented in Public Utility Code (PUC) Sections 170000-170084. PUC 170060 "*a) The port shall retain trusteeship of lands underlying the airport consistent with the State Lands Commission's requirement and shall execute a 66-year lease with the authority for control of the airport property. The authority shall pay one dollar ($1) per year during the term of the lease… (b)(1) The port may continue or enter into contracts, memorandums of understanding, or other agreements necessary to fulfill its responsibilities as trustee of the lands underlying the airport or adjacent lands under its control."*
https://leginfo.legislature.ca.gov/faces/codes_displayText.xhtml?lawCode=PUC&division=17.&title=&part=&chapter=3.&article=

The September 30, 2009 FAA Airport Compliance Manual (ACM) and the Federal Register identified San Diego International Airport (SDIA) and the San Diego Unified Port District as its Public Trust Tideland Sponsor as, as 1 of 12 Grandfathered Airport in the United States. On November 22, 2021, the FAA updated their Airport Compliance Manual (ACM). Page 214 of their ACM report still identifies SDIA as 1 of 12 Grandfathered Airport that allow revenue diversion. https://www.faa.gov/documentLibrary/media/Order/Order-5190-6B-Change1.pdf

*"**Grandfathered Airport List***

1. *State of Maryland—Baltimore/Washington International and Martin State.*
2. *Massachusetts Port Authority—Boston-Logan and Hanscom Field.*
3. *Port Authority of New York and New Jersey—JFK, Newark, LaGuardia, and Teterboro.*
4. *City of Saint Louis, Missouri—Lambert-St. Louis.*
5. *State of Hawaii—all publicly owned/public use airports.*
6. *City and County of Denver—Denver International.*
7. *City of Chicago—Chicago O'Hare and Midway.*
8. *City and County of San Francisco—San Francisco International.*
9. ***Port of San Diego—San Diego International.***
10. *Niagara Frontier Transportation Port Authority, NY—Greater Buffalo and Niagara Falls.*
11. *City and Borough of Juneau, AK—Juneau International.*
12. *Texarkana Airport Authority, AR—Texarkana Regional"*

The MOU to fund the CMH and STC mentioned several Federal and FAA Regulations. But did not include the most important one -- the 2009 Airport Compliance Manual (ACM), and 2021 Update. Both of which confirm continuous Grandfathered Airport Revenue diversion status for SDIA.

Another way to fully fund the Central Mobility Hub (CMH) and Subway Transit Corridors (STC) to the Airport Terminals is to require the SDCRAA and San Diego International Airport (SDIA) annex and lease additional public Port Tidelands on the east side of the airport for $1. Including Pacific Highway, from the airport east to the train tracks. From Washington Street on the North to Laurel Street to the South, then west along North Harbor Drive. Then the annexed public Trust property can be considered official Airport property. Then **Any and All** normally restricted FAA Airport Revenue can be diverted to fully fund the projects on newly acquired, on site Airport property. The Central Mobility Hub (CMH) at the Port Headquarters could be fully funded through the LPP. Compared to the planned joint Central Mobility Hub (CMH) and City Hall site in downtown San Diego, which could never be annexed by the airport, and has limited funds.

In order to **Hoard Cash**, around 2012 the SDCRAA and SDIA staff, and the FAA ADO in LA started the unfounded rumors that SDIA lost its Grandfathered Airport status when the Port and Airport split in 2002. Therefore, Airport Revenue cannot pay for off airport mitigation projects. These legal and financial lies have been repeated and parroted by SANDAG staff, without independent analysis or verification. As of FY-2022, for the Central Mobility Hub (CMH), Project Number 1149000, RTIP Number SAN258, SANDAG has spent a total of $38 million ($38,339,000). While the Airport has contributed $0 (nothing).

San Diego International Airport (SDIA) and the San Diego County Regional Airport Authority (SDCRAA) are **Hoarding Cash** reserved for off-site Airport mitigation. Virtually stealing from the public. Claiming they are only allowed to pay their "*fair share contributions"* for the traffic mess made by their constant expansions and on-airport improvements. Both are in violations of several CEQA documents for off-site mitigation, traffic, and transit improvements. Previous agreements with the California Coastal Commission (CCC), CALTRANS, SANDAG, Port, and City of San Diego have been ignored. Instead of only a rich and beautiful world class Airport (SDIA), the San Diego County Region can have a beautiful world class Transportation System.

Both SDIA and SDCRAA are violating the 2008 Airport Master Plan by failing to meet the goal of 14% transit to the airport. Transit to the Airport was 1% in 2008, and 14 years later is still 1% in 2022. SDIA and SDCRAA have refused to admit that normally restricted FAA Airport Revenue can be used to fully mitigate for their massive Airport improvements including the new Terminal 1 (T1), Terminal 2 (T2) Parking Structure, and the Rental Car Center (RCC). Citing their "*fair share contributions*" as an excuse to not mitigation projects they agreed to fully pay for during the CEQA approval process.

Their other scare tactic is the potential for the FAA ADO in LA to not approve expenditures for mitigation of off-airport projects, because his approval is Discretionary. So far, the Airport has never asked for FAA ADO LA budgetary approvals for SANDAG's CEQA analysis and environmental review for the Central Mobility Hub (CMH) and transit to the airport projects. The Airport also slow walks FAA approvals, by refusing to ask the FAA Airport District Officer (ADO) in Los Angeles to approve the $515 million from the Airport to SANDAG for this project. The 2020 $515 million promise from the airport, requires that SANDAG secures Non-Airport Revenue totaling $350 million from State, Federal, and Other Sources including Public Private Partnerships (PPP). In previous budgets, the SDCRAA always had ongoing contracts with engineers and construction consultants. With balances of at least has $20+ million available in unused consulting contracts to fund technical reviews. SANDAG should ask the SDCRAA and SDIA staff how much is immediately available in existing outstanding consulting contracts.

The 2020 Memorandum of Understanding (MOU), and Proposed SDCRAA and SANDAG Joint Authority PUC Changes for Airport Transit and Circulation Projects.

On February 14, 2020, as Item 7 SANDAG's Board of Directors approved the MOU "*Memorandum of Understanding regarding Major Regional Projects"* between SANDAG, San Diego Unified Port District (SDUPD), City of San Diego, and the San Diego County Regional Airport Authority (SDCRAA).

The Memorandum of Understanding (MOU) goals state: *"improvements to Airport access are expected to provide environmental benefits, including reduced greenhouse gas emissions, criteria and hazardous pollutant emissions,* [reduced] *vehicles miles traveled, noise, and traffic congestion on the surrounding roadways and highways*."
https://sandag.org/uploads/meetingid/meetingid_5527_27177.pdf

MOU. Section 1 "*E. The Airport Authority shall have sole discretion to determine which projects require FAA-approval for the use of airport revenue… the Airport Authority will use best efforts to secure FAA concurrence that such AOLA Funding is an eligible use of airport revenue consistent with the FAA Revenue Use Policy and applicable federal laws.*
MOU Section 1 "*F. In accordance with the Final ADP EIR, the Airport Authority will use best efforts to fund the following mitigation measures, subject to FAA approval, which the Airport Authority shall use best efforts to obtain."*

PUC Section "*170048 (a) The authority has **exclusive responsibility** to study, plan, and implement any improvements, expansion, or enhancements at San Diego International Airport."*
PUC Section "*170052 The authority shall be responsible for developing all aspects of airport facilities that it operates, including, but not limited to, all of the following:*
(a) The location of terminals, hangars, aids to air navigation, Runway Protection Zones (RPZ), Airport Influence Areas (AIA), parking lots and structures, and all other facilities and services necessary to serve passengers and other customers of the airport.
(b) Street and highway access and egress with the objective of minimizing, to the extent practicable, traffic congestion on access routes in the vicinity of the airport.
(c) Providing for public mass transportation access in cooperation and coordination with the responsible public transportation agency in whose jurisdiction the airport is located.
(d) Analyzing and developing intercity bus and passenger rail access to terminals in cooperation with an established agency or organization experienced in developing and operating that service

The MOU and current law give the SDCRAA *"sole discretion"* for planning and constructing transit and circulation to the Airport. The MOU does not allow SANDAG to seek independent FAA ADO LA approval for delayed funding for Airport Connectivity transit projects.

The MOU and PUC laws should be changed to required SANDAG and SDCRAA have Joint Discretion and decision-making authority for airport connectivity, and transit to the airport. And allow SANDAG to contact the FAA ADO in LA directly for faster and clearer funding approvals.

The MOU for $515 million for "*Pre-Approved Funding*" was over signed 2+ years ago. To date, the Airport has given $0 (nothing) to SANDAG for CEQA Environmental Review and Technical Studies for the Airport Connectivity Project. Future Airport Budgets do not even mention the joint project of a Central Mobility Hub (CMH) and Transit to the Airport. Therefore, for future Airport Budgets, Airport staff are asking for $0 (nothing) for this project. This allows staff to continue to purposely hoard cash, belonging to the region, not just the rich airport.

Without new Revenue from the Airport for FY-2023 this Airport Connectivity project cannot move forward. SANDAG is only budgeting $4 million for the Central Mobility Hub (CMH) project and transit to the airport. The Airport should budget and give SANDAG at least an additional $20+ million for FY-2023 Budgets to continue the Environmental Review process under CEQA.

<u>Future Alternatives to Automated People Movers (APM) to be discussed in the CEQA SEIR.</u>

The Nolan Plans envisioned direct connections and links from the Waterfront on San Diego Bay, to Balboa Park. The La Playa Plan (LPP) includes Gondolas starting from the future Central Mobility Hub (CMH) directly south of the Port's Headquarters, crossing Interstate I-5. Figures 1-3 show the general Gondola alignment, east along Redwood Street, to Balboa Park and the Hillcrest neighborhood. A Gondola is this area would provide spectacular views of San Diego Bay, and allow San Diegans to park in subsurface parking structures, then take an Automated People Mover (APM) to the Central Mobility Hub (CMH), and board the adjacent Gondola Depot to Balboa Park.

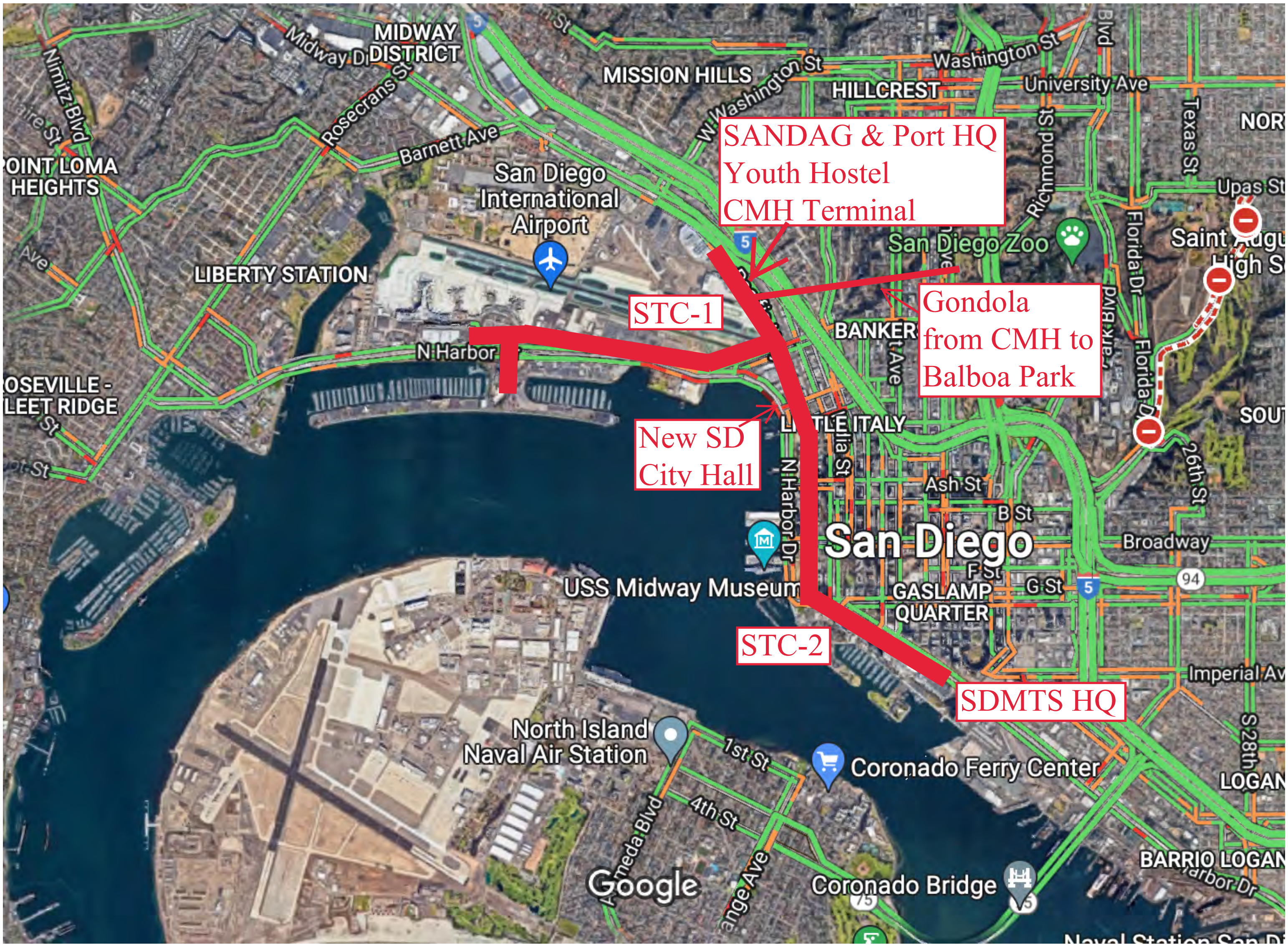
Beside just Automated People Movers (APM), SANDAG should also analyze the latest Maglev technology and Personal Rapid Transit (PRT) podcar vehicles and systems for transit to the airport in the CEQA SEIR. Elon Musk and Tesla should also be contacted for their recommendations for alternative future vehicles for the new Subway Transportation Corridors (STC) on public lands. Which could include space for his Hyperloop Technology. https://www.tesla.com/blog/hyperloop
https://tcdocs.ingeniumcanada.org/sites/default/files/2020-08/Hyperloop%20prelim%20study.pdf

SANDAG's Phase 1 Maglev Study report dated March 17, 2006 should be updated. A new Maglev study should be conducted for new 25-mile Subway Transit Corridors (STC) from the International Border with Mexico, north to Pacific Beach on State Public Trust Tidelands.
https://www.sandag.org/programs/transportation/comprehensive_transportation_projects/Maglev/2006_maglev_reduced.pdf
Currently, at 19 mph, the one-way journey takes 1 Hour 20 Minutes by Trolley from San Ysidro to the Balboa Avenue Trolley Stations. Versus a 40 mph on an Automated People Mover (APM) with a travel time of 37 Minutes. Or a future 100 mph Personal Rapid Transit (PRT) Maglev vehicle, with a travel time of 15 Minutes. Or a 350 mph Maglev Bullet Train with a travel time of 4 Minutes.

Thank you for this opportunity to present the La Playa Plan (LPP) for a Full Tidelands Reclamation as an Alternative project for analysis in SANDAG's CEQA NOP and SEIR. If you have any questions, please contact me.

Regards,
Katheryn Rhodes, Civil Engineer RCE 62730
laplayaheritage@gmail.com 619-402-8688

Google Maps



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Live traffic Fast Slow

Two New Subway Transit Corridors (STC), Subway Stations, and Automated People Movers (APM):
* Subway Transit Corridor STC-1 From the Central Mobility Hub (CMH) and Rental Car Center (RCC) along Pacific Highway to Laurel Street, then West to both Airport Terminals and Harbor Island, and
* Subway Transit Corridor STC-2 Along Pacific Highway connecting at Laurel Street, south to Harbor Drive, and the 12th and Imperial SDMTS Trolley Station.

New City Hall at Pacific Highway, Harbor Drive, Grape and Hawthorne St

FIGURE 1

The La Playa Plan (LPP) for a Full Tidelands Reclamation on the SDIA Airport Layout Plan (ALP).
* New Port and SANDAG Headquarters at Southeast corner of Pacific Highway and Sassafras Street.
* Adaptive Reuse of the existing Port HQ for the low-cost Youth Hostel.
* New Central Mobility Hub (CMH) on Pacific Highway, South of Port HQ, directly East of Train Tracks.
* New Subway Transit Corridors (STC) Along Pacific Highway to Laurel Street, then West to both Airport Terminals and Harbor Island.
* New Subway Station at the Rental Car Center (RCC) with direct access ramps to Interstate I-5.

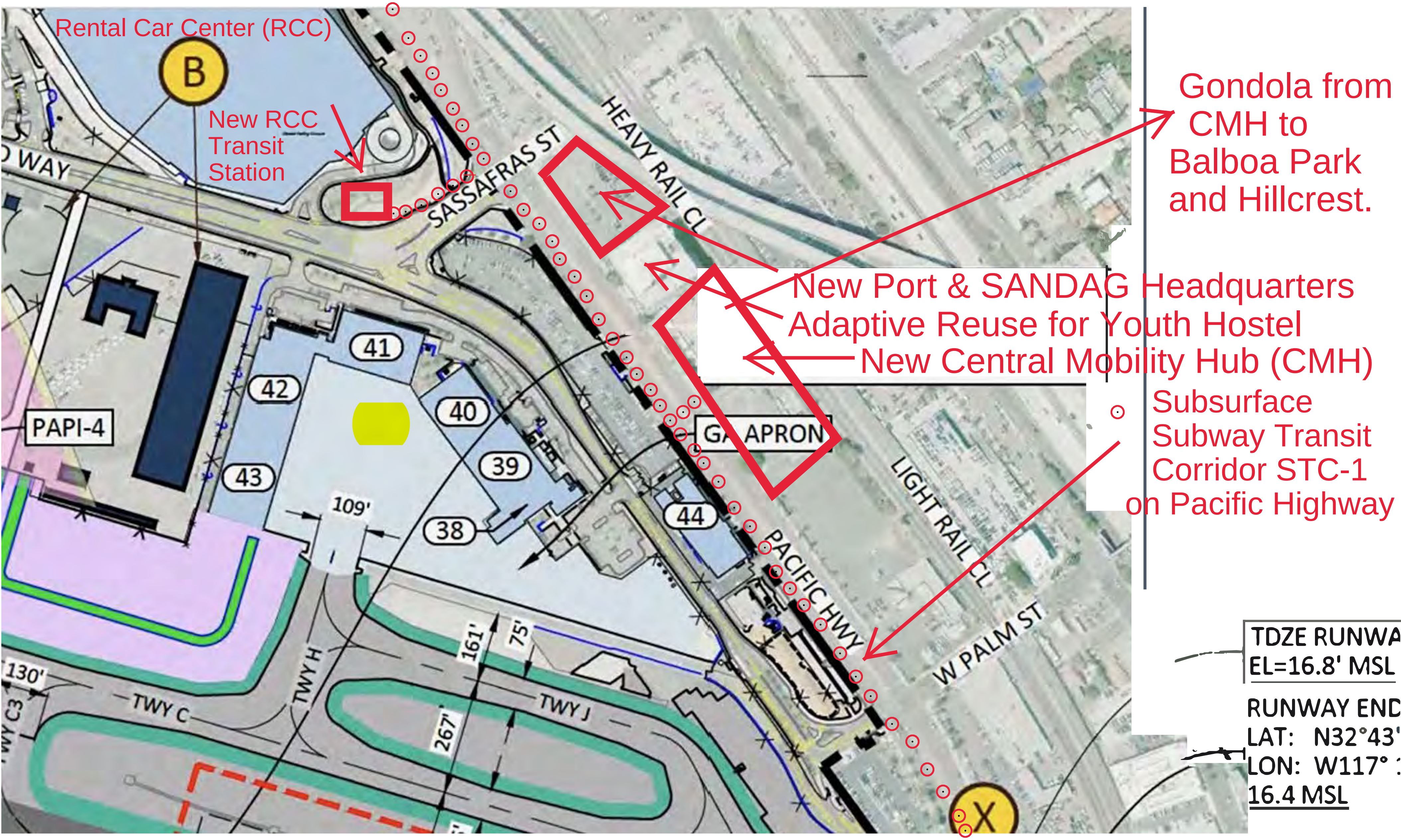


FIGURE 2

https://www.san.org/DesktopModules/Bring2mind/DMX/API/Entries/Download?Command=Core_Download&EntryId=14619&language=en-US&PortalId=0&TabId=225

Basis of Survey:

1. **Basis of Bearings:** Bearings are referenced to grid north as defined by the California Coordinate System 1983 (CCS83), Zone 6, and are based on the calculated line from Point No. 374 (Station SDUPD-59) to Point No. 371 (SDUPD-60), as shown on Record of Survey 17055. I.E. N75°34' 34"W.
2. **Basis of Coordinates:** Coordinates are referenced to the North American Datum Of 1983 at Epoch 2010.00 and are expressed in terms of the California Coordinate System 1983 (CCS83), Zone 6. Distances are ground and in terms of the U.S. Survey Foot. Control Point 350: Grid Distance = Ground Distance X Combined Scale Factor (1.00001478) Control Point 350: Northing: 1845852.6289 Easting: 6275498.5303.
3. **Benchmark:** The basis of elevations for this survey is the North American Vertical Datum of 1988 (NAVD88). Benchmark designation is Point No. 374 (Station SDUPD-59) per Record of Survey 17055 located in the northeast corner of concrete fuel vault south of vehicle service road at the foot of Stillwater Road. Elevation 15.62 (NAVD88).
4. **Date of Survey:** August 24, 2016.

SURVEY CONTROL POINTS

POINT NUMBER	NORTHING	EASTING	MSL (feet)
310	1846392.02	6268078.80	10.05
311	1846255.37	6266672.22	11.306
312	1847486.59	6266857.60	9.749
313	1846550.61	6271053.27	14.213
314	1847370.42	6271221.63	14.842
350	1845852.63	6275498.53	9.143
351	1844713.46	6265847.34	13.867
352	1848406.16	6266855.59	12.131
353	1853250.53	6265911.18	54.933
354	1851608.21	6273091.83	18.336
355	1850682.87	6274512.91	26.888
356	1852949.84	6278340.05	267.874

SURVEY CONTROL POINTS

POINT NUMBER	NORTHING	EASTING	MSL (feet)
357	1850026.85	6276716.48	141.809
358	1848534.16	6277816.77	160.555
359	1849079.76	6276570.42	41.408
360	1847653.39	6277131.92	21.776
361	1847186.00	6277977.84	50.612
362	1845881.50	6277805.00	17.967
363	1844085.70	6278781.13	27.675
364	1846147.22	6276678.36	11.816
365	1846132.21	6274404.10	10.873
366	1847267.32	[illegible]	[illegible]
367	1846354.12	6272187.89	13.717
368	1847811.28	[illegible]	13.634
369	1848343.17	6273941.76	13.503
370	1848596.32	6271573.87	12.788
371	1848656.02	6267997.17	12.689
372	1848433.53	6268608.32	13.309
373	1848332.58	6269640.06	13.399
374	1847587.63	6272151.12	15.62
375	1846736.39	6274990.10	12.466
376	1849274.58	6275018.02	17.773
377	1850741.36	6272493.58	12.269
378	1849913.80	6273723.14	17.267
379	1849790.03	6272113.28	13.619
380	1849722.01	6269941.89	14.149
381	1850082.85	6268850.45	12.242
382	1850088.51	6267638.68	9.632
383	1848978.45	6267341.58	11.13

LEGEND

	EXISTING	FUTURE
Subway Transit Corridors (STC)		
Subway Stations		
AIRPORT BOUNDARY		
BUILDING RESTRICTION LINE		
NAVAID CRITICAL AREA		
RUNWAY THRESHOLD LIGHTS		
GLIDESLOPE ANTENNA		
RVR		
ROTATING BEACON		
ASOS		
PAPI-4		
WINDSOCK		
SURVEY MONUMENT		
TRAVERSE WAY POINT WITH ADJUSTED MSL ELEV.		
AIRPORT REFERENCE POINT (ARP)		
RUNWAY SAFETY AREA (RSA)	RSA	
RUNWAY OBJECT FREE AREA (ROFA)	ROFA	
RUNWAY OBSTACLE FREE ZONE (OFZ)	OFZ	
RUNWAY PROTECTION ZONE (RPZ)	RPZ	
TAXIWAY OBJECT FREE AREA (TOFA)		TOFA
TAXIWAY SAFETY AREA (TSA)		TSA
PRECISION OBSTACLE FREE ZONE (POFZ)	P O F Z	
FENCE		
BLAST FENCE		
ROADWAY		
FUTURE SERVICE ROADWAY		
BUILDING NUMBER		
FEATURE NUMBER		
BUILDINGS TO BE DEMOLISHED		
BUILDING		
OFF AIRPORT BUILDING		
RUNWAY		
TAXIWAY		
SHOULDER		
APRON		
FAULT ZONE		
FAULT ZONE BUFFER		
CALIFORNIA LEAST TERN NESTING AREA		

EXISTING BUILDING AND FACILITIES TABLE

BUILDING NUMBER	TOP ELEV MSL	DESCRIPTION
1	48'	TERMINAL ONE (T1)
2	55'	TERMINAL TWO (T2) EAST
3	90'	T2 WEST
6	47'	USO AND PARKING OPERATIONS BUILDING
7	26'	TRITURATOR
8	44'	HVAC PLANT
9	32'	SWITCHGEAR BUILDING
10	35'	WASH BAY
11	50'	AIR CARGO BUILDING
12	41'	SOUTHWEST AIRLINES PROVISRAY AIR CARGO BUILDING
13	41'	AIR CARGO BUILDING
14	N/A	FUEL DISPENSING FACILITY
15	47'	AIRLINE SUPPORT
16	45'	AIRLINE SUPPORT
18	65'	SDCRAA ADMINISTRATION OFFICE
19	38'	SDCRAA MAINTENANCE SHOPS
20	28'	SDCRAA FACILITIES MANAGEMENT OFFICE
21	40'	SDCRAA SHIPPING AND RECEIVING
22	N/A	ELECTRIC VAULT & EMERGENCY GENERATOR
23	22'	FAA COMMUNICATIONS
25	TBD	SWA CARGO
26	34'	RUNWAY 9 LOCALIZER SHELTER, LOCALIZER ANTENNA, & DME ANTENNA
27	19'	RUNWAY 27 LOCALIZER ANTENNA
28	N/A	ELECTRICAL UTILITY AREA
29	22'	RUNWAY 27 LOCALIZER TRANSMITTER BUILDING (INSIDE ROFA)

EXISTING BUILDING AND FACILITIES TABLE

BUILDING NUMBER	TOP ELEV MSL	DESCRIPTION
30	20'	RUNWAY 27 DME AND LOCALIZER ANTENNAS (INSIDE ROFA)
31	14'	FUEL DISPENSING FACILITY ADMINISTRATION BUILDING
32	46'	FUEL STORAGE TANKS
33	35'	ARFF STATION
34	48'	FEDEX SORT FACILITY
35	152'	AIRPORT TRAFFIC CONTROL TOWER
36	44'	CENTRAL RECEIVING AND DISTRIBUTION CENTER
37	92'	RENTAL CAR FACILITY
38	55'	SIGNATURE FLIGHT SUPPORT TERMINAL
39	55'	SIGNATURE FLIGHT SUPPORT HANGAR 1
40	61'	SIGNATURE FLIGHT SUPPORT HANGAR 2
41	55'	SIGNATURE FLIGHT SUPPORT HANGAR 3
42	55'	SIGNATURE FLIGHT SUPPORT HANGAR 4
43	55'	SIGNATURE FLIGHT SUPPORT HANGAR 5
44	TBD	SAN DIEGO WIND TUNNEL
45	25'	RCC BUS / TAXI HOLD LOT BUILDING
46	TBD	SOLAR CAR PORT
47	TBD	RAMP CONTROL TOWER
48	TBD	T2 WEST FIS
49	TBD	T2 PARKING PLAZA
50	TBD	SWA PROVISIONING
51	TBD	GLIDESLOPE EQUIPMENT SHELTER
52	TBD	GUARD SHACK
53	TBD	ELECTRICAL BUILDING
54	TBD	ENVIRONMENTAL HAZMAT STORAGE TRAILER

FUTURE FEATURES

FEATURE ID	DESCRIPTION
	AIRPORT SUPPORT FACILITIES
A	AIR CARGO DEVELOPMENT
B	FACILITIES MANAGEMENT DEPT. CAMPUS
C	AIRLINE SUPPORT FACILITY
D	WEST FUEL RACK
E	AIRFIELD LIGHTING VAULT
F	AUTOMATED SURFACE OBSERVATION SYSTEM (ASOS)
G	RUNWAY VISUAL RANGE (RVR)
H	RUNWAY STATUS LIGHTS (RWSL) SHELTER & MALS PAD
I	VEHICLE SERVICE ROAD (VSR)
J	AIRCRAFT FUEL STORAGE TANKS
	PHASE 1A
K	T1 REPLACEMENT TERMINAL - 19 GATES
L	T1 PARKING PLAZA
M	TAXIWAY B RELOCATION & TAXIWAY A CONSTRUCTION
N	ON-AIRPORT ACCESS ROADS
O	AIRCRAFT FUEL STORAGE - OPERATIONS FACILITY
P	RON APRON
Q	SOLID WASTE FACILITY
R	TRITURATOR/WASH BAY
S	AIRPORT ADMINISTRATION BUILDING
	PHASE 1B
T	T1 REPLACEMENT TERMINAL - ADDITIONAL 11 GATES
U	RESERVED FOR FUTURE TRANSIT USE
	OTHER PROJECTS
V	INTERMODAL TRANSPORTATION CENTER
W	NORTH SIDE PASSENGER PROCESSING FACILITY
X	BLAST FENCE
Y	ENGINEERED MATERIALS ARRESTING SYSTEMS (EMAS)

FUTURE TAXIWAY/TAXILANE DATA TABLE

NAME	DIMENSIONS: TWY WIDTH ACTUAL-STANDARD	SHOULDER WIDTH ACTUAL-STANDARD	TWY SAFETY AREA	OBJECT FREE AREA	TWY EDGE SAFETY MARGIN	TWY DESIGN GROUP	SEPARATION FROM TWY CL TO FIXED/MOVABLE OBJECT	LIGHTING
A	50'-50'	20'-20'	118'	186'	10'	4	93'	MITL
A1	125'-50'	20'-20'	118'	186'	10'	4	93'	MITL
A2	125'-50'	20'-20'	118'	186'	10'	4	93'	MITL
A3	271'-50'	20'-20'	214'	320'	15'	6	160'	MITL
A4	137'-50'	20'-20'	118'	186'	10'	4	93'	MITL
A5	137'-50'	20'-20'	118'	186'	10'	4	93'	MITL
A6	108'-50'	20'-20'	118'	186'	10'	4	93'	MITL
A7	124'-50'	20'-20'	118'	186'	10'	4	93'	MITL
A8	160'-75'	20'-20'	214'	320'	15'	6	160'	MITL
A9	182'-75'	20'-20'	214'	320'	15'	6	160'	MITL
A10	182'-75'	20'-20'	214'	320'	15'	6	160'	MITL
A11	136'-75'	20'-20'	214'	320'	15'	6	160'	MITL
A12	136'-75'	20'-20'	214'	320'	15'	6	160'	MITL
A13	136'-75'	20'-20'	214'	320'	15'	6	160'	MITL
B2	75'-75'	20'-20'	214'	320'	15'	6	160'	MITL
B3	94'-75'	20'-20'	214'	320'	15'	6	160'	MITL
A3 (TLN)	306'-320'	0'-0'	214'	320'	15'	6	160'	MITL
A10 (TLN)	50'-50'	0'-0'	118'	186'	10'	4	93'	MITL
E (TLN)	50'-50'	0'-0'	118'	162'	10'	3	81'	MITL
G (TLN)	276'-75'	0'-0'	214'	276'	15'	5	160'	MITL
K (TLN)	162'-50'	0'-0'	118'	162'	10'	3	81'	MITL
L (TLN)	162'-50'	0'-0'	118'	162'	10'	3	81'	MITL
M (TLN)	271'-50'	20'-20'	214'	320'	15'	6	160'	MITL

PACS/SACS LOCATIONS

DESIGNATION	TYPE	LATITUDE	LONGITUDE	ELEVATION
AP 1973SAN STA B3	PACS	32°-44'-11.75616" N	117°-12'-17.53779" W	9.5'
SAN C 1994	SACS	32°-44'-03.69278" N	117°-11'-24.68196" W	14.6'
SAN AP 1966 STA A3	SACS	32°-43'-47.77451" N	117°-10'-38.57462" W	11.8'

0' 400' 800'

GRAPHIC SCALE: 1" = 400'

ALP Prepared By

JACOBSEN | DANIELS
Planning, Implementation, Operations & Management

Drawn: CLS
Approved: SRG
Date: 06-16-2021
Project No.: 09-071-12-01

No.	Date	Revisions

Notes

1. Survey Control Points 351, 353, 354, 356, 357, 358 and 363 are located beyond the plan view area.
2. Taxiway and taxilane data is provided on Data Sheet 2; not shown on plan for clarity.
3. NAVA D lights located in Navy Lagoon were not identified because they are beyond the extents of the survey boundary.
4. TSS not shown on plan for clarity. Refer to Approach/Departure Plan & Profile drawing.
5. The TERPS Departure Surface is not shown for clarity. Please refer to the Inner Approach Plan & Profile drawings for their location.
6. See Sheet 4 for existing apron dimensions.
7. See Terminal Area Plan for future terminal apron dimensions.
8. Refer to Inner Approach drawing for traverse way locations.
9. Perimeter fence height TBD.

Sources

1. Additional existing airport information obtained from 2016 SAN ALP dated 08-11-16.
2. Survey control points obtained from topo survey drawing produced by Aerotech Mapping, Inc. for Lindbergh Field Drainage project; aerial photogrammetry flown on August 22, 2016.

MAGNETIC DECLINATION
11 56° EAST ±0.33°
AUGUST 1, 2017

SAN DIEGO INTERNATIONAL AIRPORT
LET'S GO.

FUTURE AIRPORT LAYOUT PLAN DRAWING

Airport Layout Plan Drawing Set #724

Figure 3

May 27, 2021

CentralMobilityHub@sandag.org
Kirsten Uchitel
SANDAG
401 B Street, Suite 800
San Diego, CA 92101

Subject: SANDAG's Central Mobility Hub (CMH)
Public Comments on Scoping for the CEQA Draft EIR
https://sandag.mysocialpinpoint.com/centralmobilityhub

Dear SANDAG:

Thank you for the opportunity to comment on SANDAG's Central Mobility Hub (CMH) and alternatives under consideration. I previously presented comments at SANDAG's Public Scoping Meeting on May 11, 2021 https://www.youtube.com/watch?v=XTs1zvoqB5Y Video Start Time: 37 to 42 Minutes; and 1 Hour 7 to 9 Minutes.

Attached please find the La Playa Plan (LPP) concept for a full Tidelands Reclamation project sent to SANDAG's Airport Connectivity Subcommittee on September 25, 2019. The La Playa Plan (LPP) would create subsurface transportation corridors including subways using structural bathtub foundations, within the boundary of SANDAG's Comprehensive Multimodal Corridor Plan for the Central Mobility Hub and Connections Corridor, west of the train tracks on partially reclaimed tidelands consisting of uncompacted, loose, hydraulic fills with a low water table.

The LPP gets rid of the seismic hazard of liquefaction, recycles trenching spoils to construct new concrete underground space for a network of subway lines for Automated People Movers (APM), and protects against sea level rise due to climate change. The concrete trenches can also capture urban stormwater runoff.

Plus trenching into bedrock provides stable foundations, instead of above-grade aerial columns that would create unnecessary visual blight in congested traffic areas. Aerial columns and guideways may interfere with SDIA airplane landing operations at the northwest corner of Pacific Highway and Laurel Street.

Instead of analyzing Concepts 1 to 4, please consider a new Concept 5 which closely resembles portions of the Proposed Project, with a few major changes. The new Concept 5 would not create a new Central Mobility Hub (CMH) at the Naval Base Point Loma Old Town Campus (OTC), the present site of the former SPAWAR, now the Naval Warfare Systems Command (NAVWAR), and the saving would allow for an expansion of the underground transit connection corridors south to the San Diego Convention Center, and west along Sports Arena Boulevard.

Instead of a new CMH, the current Old Town Transit Center (OTTC) would be expanded within its existing footprint and west onto Pacific Highway to create space for a substantially smaller future High-Speed Rail terminal that could be renamed the Old Town Transit Central Mobility

Hub (OTTCMH). In the large parking lot west of the train tracks and Pacific Highway, a full tidelands reclamation using structural bathtub foundations would create subsurface space for the northern terminal of network of subway lines for Automated People Movers (APM).

The April 21, 2021 Notice of Preparation for the Draft EIR states "*due to right-of way and other constraints, the existing transit hubs at OTTC and Santa Fe Depot could not be expanded.*" What right-of-way and other constraints are there at the OTTC site, the adjacent large parking lot, and on Pacific Highway that would preclude redevelopment for a small terminal for the future High-Speed Rail that was previously planned at this location? Or the addition of an underground subway system? All properties are owned by public agencies, and utilities can always be rerouted.

Lines of subsurface structural bathtub foundations, similar to watertight bulkheads on ships, would create the new concrete underground transportation corridors to connect the Old Town Transit Center (OTTC) with the San Diego International Airport (SDIA). Via the NAVWAR redevelopment project, the Airport Rental Car Center (RCC), and Harbor Island East Basin as shown in the Proposed Project.

However the new Option 5 would continue the underground transportation corridor south under Pacific Highway and Harbor Drive to connect to downtown San Diego, the Santa Fe Depot, and the 12^{th} and Imperial Transit Center near the San Diego Convention Center. Subsequent subway lines would also connect to the Sports Arena redevelopment project. Locations for the new subway corridors and underground transit stations would require reconfiguration and full tidelands reclamation of major public roads including Pacific Highway, Harbor Drive, Laurel Street, and Sports Arena Boulevard; and rerouting of existing utilities.

If the concrete trenches are two-story in depth, then car through-traffic could also be rerouted underground to create new green spaces for the Coastal Rail Trail to make the area along Pacific Highway pleasant and safer for pedestrians and bicycles.

Regards,

Katheryn Rhodes
laplayaheritage@gmail.com
619-402-8688

September 25, 2019

SANDAG
401 B Street, Suite 800
San Diego, California 92101
clerk@sandag.com

Subject: September 25, 2019. Airport Connectivity Subcommittee.
Item 3. Recommended Concepts for Improved Regional Airport Connectivity.
The La Playa Plan (LPP) Concept. A Full Tidelands Reclamation Project.
Central Mobility Hub with Subterranean Automated People Mover (APM) Route adjacent Train Tracks and Pacific Highway, Instead of Concept 2 Surface/Elevated APM Route
https://www.sandag.org/uploads/meetingid/meetingid_5268_26543.pdf

Dear SANDAG:

Thank you for the opportunity to provide comments on this thorough preliminary feasibility analysis of four concepts.

1. Seismic

Specifically, thank you for confirming that active faulting of the Rose Canyon Fault Zone needs to be confirmed or denied at the Preliminary Design Phase for both the Old Town and Airport properties, in order to save money.

> **Section 5.4.d. Geotechnical, Seismic Conditions, Hazardous Materials, and Soils.**
>
> Page 61. *"Comprehensive Geotechnical Fault Hazard, Environmental, and Hazardous Materials studies should be performed during the Preliminary Design Phase."*
>
> Page 62. *"Crossing an active fault will increase the cost of all structures. Late identification of a fault during construction may cause unknown cost and construction delays. Extensive Geotechnical Investigation, and Fault Studies will be required."*

Prior all government agencies including SANDAG, City of San Diego, County of San Diego, Port of San Diego, and the San Diego County Regional Airport Authority (SDCRAA) stated that fault investigations are only needed prior to Building Permits being issued, or after Construction has already started, or not at all. Also, all government agencies stated that the Airport and the Old Town Midway Corridor were Categorically Exempt, and outside the boundaries in official Alquist-Priolo (AP) Maps, therefore fault investigation were not required at all. But fault investigations could be done on a volunteer basis by the SDCRAA, Port, and the City.

To resolve these issues, please update the old 2003 Point Loma Quadrangle (16 years-old) and 1991 La Jolla Quadrangle (28 years-old) AP-Maps with guidance from our State Geologist to include the Airport, Midway Corridor, Old Town, Sports Arena, Mission Bay, La Jolla, and Point Loma for the Point Loma Fault as areas for further investigation for potential inclusion into new and updated AP-

Maps and Zones. Also, please require all existing fault investigations with third-party approvals to be turned into the State Geologist to update the old AP-Maps.
Then require the Port and Airport Authority to confirm or deny active faulting as part of the Port's upcoming Port Master Plan (PMP), and the SDCRAA's Airport Development Plan (ADP) through funding of their own. Currently in their CEQA documents, neither government agency has planned to confirm or deny active faulting during their "Preliminary Design Phase" because they are considering themselves exempt, and have legal loopholes to not knowing.

Please ask for State Legislation to move all regional planning and CEQA-level project of the Airport and Port to SANDAG.

2. FAA Grandfathered Airport Revenue.

Also thank you for confirming that normally-restricted Federal Aviation Administration (FAA) Airport Revenue funds could be used to pay for projects off-airport grounds with the approval of the Los Angelica FAA Airport District Officer (ADO). This is great news that local government acknowledges the availability of use of previously hoarded Airport Revenue for off-site mitigation, transportation projects to the airport, and a Central Mobility Hub outside the airport's footprint.

This acknowledgement that hoarded and normally-restricted Federal Aviation Administration (FAA) Airport Revenue funds could have always been used to pay for the San Diego International Airport (SDIA) mitigation projects for the Rental Car Center (RCC) including connector ramps to Interstate 5, and local road improvements is great movement forward.

Currently, the official SANDAG guiding legal analysis on the use of Airport Revenue is the March 9, 2018, SANDAG Executive Committee Item 7 San Diego Regional Airport Authority: Federal Funding and Responsibilities. Page 4 of the report stated: *"As discussed below, the Airport Authority under Federal Law is prohibited from spending Airport Revenue for Off-Airport Transportation Facilities. Virtually all Revenue of the Airport Authority is so restricted."*

www.tinyurl.com/20180309a

https://sandag.org/index.asp?fuseaction=meetings.sc&mid=EC030918&cName=Executive%20Committee&mType=Regular%20Session&mDate=3/9/2018
Audio: 45 Minutes to 1 Hour and 11 Minutes.

Please see Audio Time 53-56 minutes for the Loophole under FAA requirements for allow Airport Revenue funding for off-site transportation projects including transit to the airport and an Intermodal Terminal Center (ITC).

Thank you for the great discussion on the availability of normally-restricted airport revenue through a new $500 million agreement with the Airlines, which comes from Airport Revenue which makes up 46% of Total Revenues. However, at SDIA the citizens of the State of California are also allowed access to other 54% Non-Airport Revenue sources due to being 1 of 12 Grandfathered Airports located on State Tidelands. Other non-aviation Non-Airport revenue sources include leases, fees, sale taxes, and other revenue sharing agreements with third-parties.

Thank you very much for a great report . Plus and forcing the Airport to admit that formally hoarded $500 million in Airport Revenue can be used for mitigation and off-airport transportation projects. Prior the Airport and SANDAG both stated it would be illegal to use Airport Revenues off site.

Airport Comprehensive Annual Financial Report (CAFR) Revenues for FY-2018 and FY-2017

SDIA CAFR Revenues	FY-2018	FY-2017
Airport Revenue	$123,157,000 46%	$116,381,000 47%
Non-Airport Revenue	+ $142,674,000 54%	+ $132,466,000 53%
TOTAL REVENUE	= $265,831,000	= $248,847,000

As part of this Airport Connectivity project please ask the State Lands Commission (SLC) for a Legal Opinion if San Diegan International Airport (SDIA) gave up their Grandfathered Airport Revenue Diversion status with the creation of the SDCRAA away from the Port of San Diego.

If Grandfathered Airport status is acknowledged, then there will be Billions in additional Airport Revenue dollars that in theory could pay for these Regional Transportation project under the control of our elected officials through SANDAG. If the full La Playa Playa planned is analyze for a subterranean transportation corridor from Mission Bay to the Border, additional value can be created and funded with help of Federal and State Reclamation and Water bonds.

3. The La Playa Plan.

The La Playa Plan is a continuation of the 1908 and 1926 Nolan Plans, which established Lindbergh Field – San Diego International Airport (SDIA), Pacific Highway, Harbor Drive, regional transportation infrastructure, and public government buildings on our publicly-owned Waterfront mostly founded on uncompacted, loose, hydraulic fills. The La Playa Plan will "future proof" the public and private lands through a full State Public Trust Tidelands Reclamation project by taking out all the hydraulic fills, so foundations for new free subterranean lands can be founded on competent soils, not subject to flooding, or sea level rise. Both the Navy Broadway Complex (NBC) and Seaport Village will be design using Bathtub foundations specifically to combat climate change.

The depths to competent formational material under the liquefiable bay fill range from zero adjacent west of the train tracks to approximately 40 feet near Terminals 1 and 2.

Instead of hauling out dredge soils, we ask SANDAG to request a formal evaluation to potentially reclassification of Mineral Resources Zone (MRZ) for Urbanized Areas for the Airport, Port, Pacific Highway, Midway Corridor, Mission Bay from MRZ-1 to MRZ-2 . Then recycle and use spoils for use as construction material and Beach Replenishment projects.

The La Playa Plan is part of the new Green New Deal (GND) for resource efficiency, which focuses on maximizing the use of our natural State Public Trust Tidelands for the financial benefit of all. The GND public works projects would create new jobs, combat climate change, build new and free subterranean space, take out all hydraulic fills, recycle raw materials, while adapting partially reclaimed land to full reclamation for sea level rise, using the regional planning powers of SANDAG. Please see the attached document for a full public trust tidelands reclamation project.

The LPPC Subterranean APM Route would provide proof of concept for the La Playa Plan. Which could then be used all along San Diego Bay to create up to a zero to 40-foot subterranean corridor for transportation projects and storm water capture. This would help low income communities along San Diego Bay, and help with social equity issues by creating wealth.

4. The La Playa Plan Concept. An Alternative Subterranean Design Based Upon Concept 2. and Concept 4

We would like to present an additional concept for CEQA Review called the La Playa Plan Concept (LPPC) for a Full Tidelands Reclamation Project funded in part by Grandfathered Airport Revenues.

The La Playa Plan Concept is similar to Concept 2. However, instead of At-Grade, Surface, and/or Elevated Automated People Mover (APM) Route, the APM Route would be subterranean, and located adjacent west of the existing Train Corridor and/or Pacific Highway, without encroaching into private property and existing underground utilities.

In addition, there would only be one stop at the Rental Car Center (RCC) instead of the two stops in Concept 2. Since the tunnel can be exposed to the air at every level and not a tunnel, normal fire mitigations measures are feasible.

Also, a new United States Bulkhead Elevation will be established, to combat climate change and sea level rise problems on liquefiable soils. All first-story building elevation will be built to at least the new US Bulkhead height. And a shallow tunnel system design would be used, where all liquefiable soils would be excavated, down to formational grade.

Page 28 states: *"Another suggestion was to create a shallow tunnel system of roadways, to and from the airport for improved connectivity. This concept was not carried forward due to cost, impacts to the community, and design and construction challenges. It would be expensive and challenging to construct in the soils made up of bay fill and around the airport from the surface level to roughly 40 feet deep (see Figure 4-2)."*

The 40-foot depth to formational materials may be a maximum, not minimum depth to formational materials. It is reasonable to assumed the depth to formational material at the Airport Transit-Ready Areas located between Terminals 1 and 2 along North Harbor Drive is 40 feet. However, adjacent and west of the train tracks, the elevation to competent formation materials may only zero to ten feet. Therefore, an actual analysis of depth to formational materials should be analyzed in the upcoming CEQA review for a subterranean route along Concept 2 APM Route, and adjacent and west of the train tracks.

The maximum 40-foot depth to formational materials is a plus, not a minus. Up to three level of transportation corridors could fit into a 40-foot high tunnel opened to the air. Including a subterranean APM Route, and In-bound and Out-Bound Airport Traffic. Please reanalyze our La Playa Plan for a shallow tunnel system to create a Full Tidelands Reclamation project on liquefiable soils. That would create subterranean space 15 to 40 feet deep to future-proof and combat climate change and sea level rise through the use of connection of Structural Bathtub Foundations to create new transportation routes.

Regards,

Katheryn Rhodes 619-402-8688 rhodes@laplayaheritage.com

FIGURE 5 - CISTERN. This article is about the underground water reservoirs that prevent evaporation unlike surface water reservoirs.
http://en.wikipedia.org/wiki/Cistern

A **cistern** (Middle English *cisterne*, from Latin *cisterna*, from *cista*, box, from Greek *kistê*, basket) [1] is a receptacle for holding liquids, usually water. Often **cisterns** are built to catch and store rainwater. They range in capacity from a few liters to thousands of cubic meters (effectively covered reservoirs).

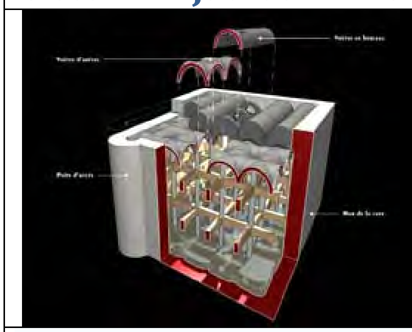
Cisterns are commonly used in areas where water is scarce, either because it is rare or because it has been depleted due to heavy use. Early on, the water was used for many purposes including cooking, irrigation, and washing. Present day **cisterns** are often only used for irrigation due to concerns over water quality. **Cisterns** today can also be outfitted with filters or other water purification methods when the water is meant for consumption. It is not uncommon for cisterns to be open in some way in order to catch rain or to include more elaborate rain-catching systems. It is recommended in these cases to have a system that does not leave the water open to mosquitoes or algae, which are attracted to the water and then potentially carry disease to nearby humans.

Some **cisterns** sit on the top of houses or on the ground higher than the house, and supply the running water needs for the house. They are often supplied not by rainwater harvesting, but by wells with electric pumps, or are filled by manual labor or by truck delivery. Very common throughout Brazil, for instance, they were traditionally made of concrete walls (much like the houses, themselves), with a similar concrete top (about 5 cm. thick), with a piece that can come out for water filling and be re-inserted to keep out debris and insects. Modern cisterns are manufactured of plastic (in Brazil with a characteristic bright blue color, round, in capacities of about 10k and 50k liters). These **cisterns** differ from water tanks in the sense that they are not completely enclosed and sealed with one form, rather they have a lid made of the same material as the cistern, which is removable by user.

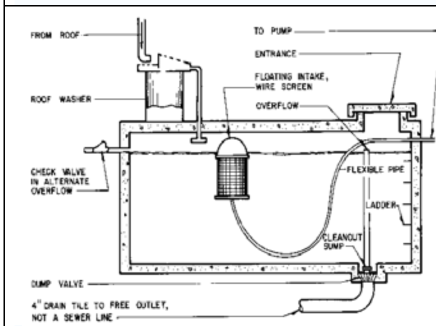
To keep a clean water supply, the cisterns must be kept clean. It is recommended to inspect them regularly, keep them well-enclosed, and to occasionally empty them and clean them with an appropriate dilution of chlorine and to rinse them well. Well water must be inspected for contaminants coming from the ground source. City water has up to 1ppm (parts per million) chlorine added to the water to keep it clean, and in many areas can be ordered to be delivered directly to the cistern by truck (a typical price in Brazil is BRL$50, USD$20 for 10k liters). If there is any question about the water supply at any point (source to tap), then the cistern water should not be used for drinking or cooking. If it is of acceptable quality and consistency, then it can be used for (1) toilets, and housecleaning; (2) showers and hand washing; (3) washing dishes, with appropriate sanitation methods, and for the highest quality, (4) cooking and drinking. Water of non-acceptable quality for the before mentioned uses may still be used for irrigation. If it is free of particulates but not low enough in bacteria, then boiling may also be an effective means to prepare the water for drinking.

Many greenhouses use cisterns to help meet their water needs, especially in the USA. Some countries or regions, such as Bermuda and the U.S. Virgin Islands have laws that require rainwater harvesting systems to be built alongside any new construction, and cisterns can be used in these cases. Other countries, such as Japan, Germany and Spain, also offer financial incentives or tax credit for installing cisterns. Cisterns may also be used to store water for firefighting in areas where there is an inadequate water supply.

Cistern El Jadida in Morocco



Modern Cistern



Modern Cistern Diagram

Yerebatan Sarnıcı, Istanbul, 138 m x 65 m, 80.000 m³, Justinian I., 523-542

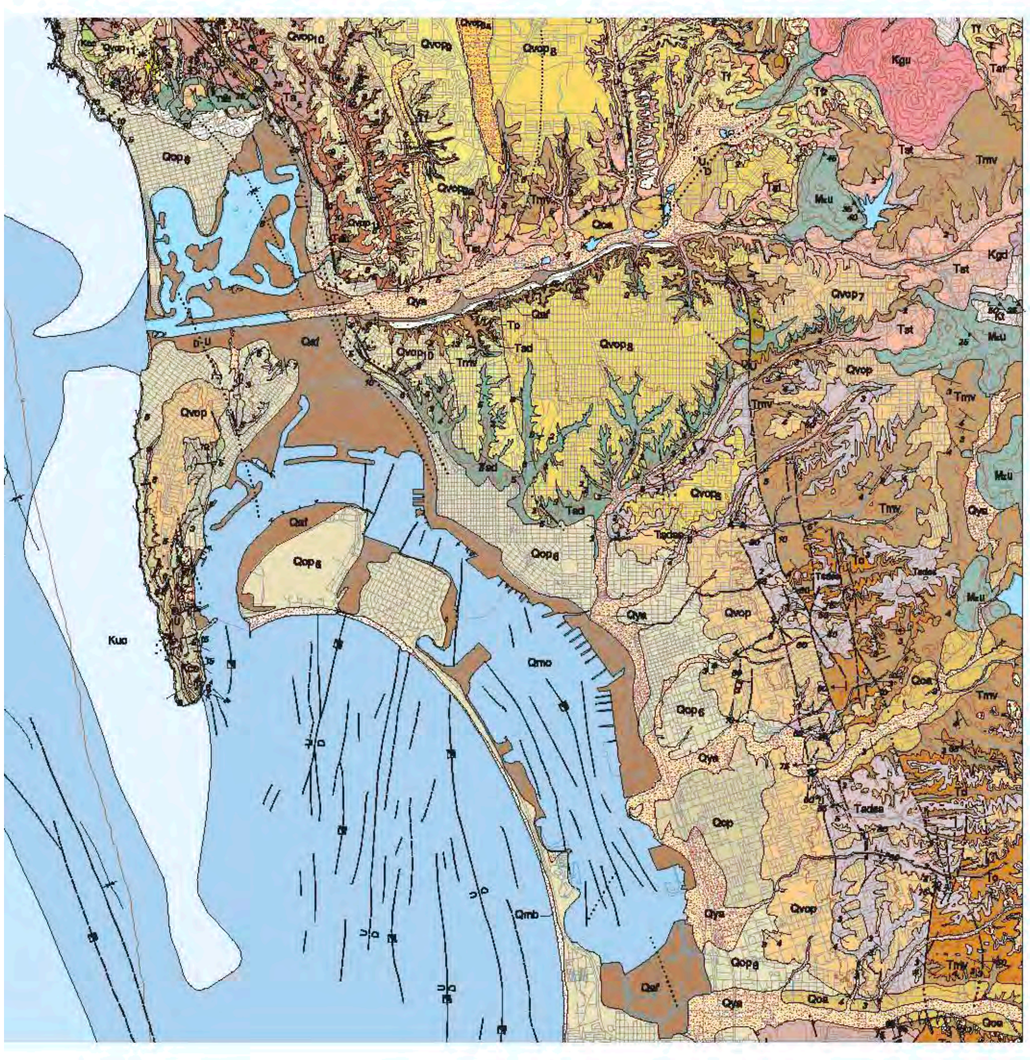


Figure 6 – Reclaimed Public Trust Tidelands are shown in the color Brown as Quaternary Artificial Fill (Qaf).

The areas of undocumented fill (Qaf) in the City of San Diego includes Port tidelands around San Diego Bay, where the liquefiable soils can be replaced by Cistern Structural Foundations embedded into formational soils.

Proposed projects in the planning stage include the North Embarcadero Vision Plan (NEVP) project, the Chula Vista Bayfront Master Plan project, and the San Diego International Airport (SDIA)/Lindbergh Field Intermodal Transportation Center.

Future projects may include the city-owned Sports Arena in the Midway area, and the Kinder-Morgan Fuel spill at Qualcomm Stadium.

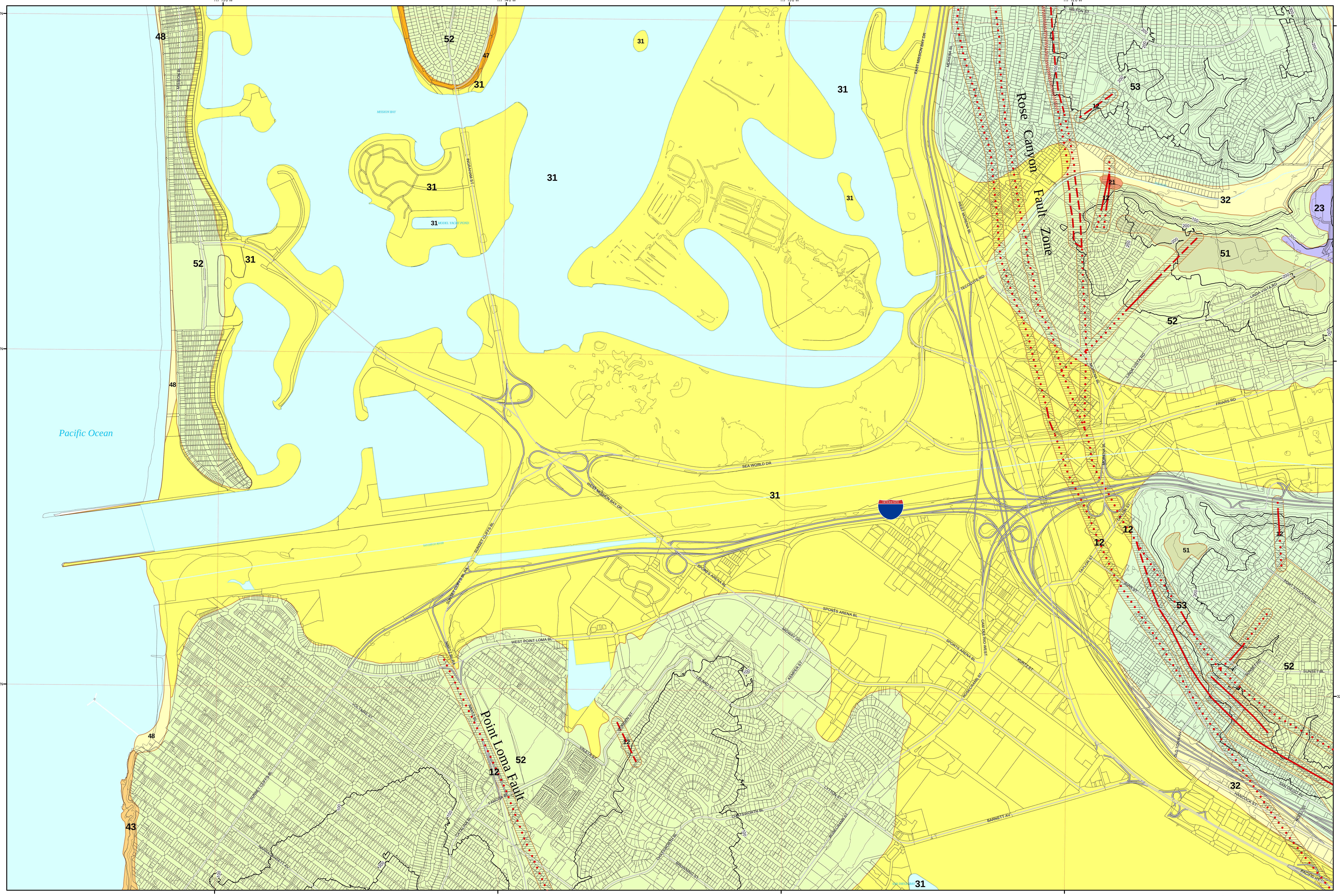
If our proposed water-proof subterranean multi-purpose NFL Chargers Stadium/ Convention Center Phase III Expansion/ Cistern Structural Foundation (NFLCS/CC/CSF) is built, then the great idea of using Cisterns under new development projects on reclaimed tidelands and liquefiable soils to collect, capture, and clean urban storm water runoff can be used county-wide as an example of Green Engineering Design.

Geological Map of the San Diego 30' x60' Quadrangle, California. Compiled by Michael P. Kennedy and Siang S. Tan, 2005, by the California Geological Survey (CGS).

ftp://ftp.consrv.ca.gov/pub/dmg/rgmp/prelim_geo_pdf/sandiego_map2_ai9.pdf

Areas in Yellow

Areas in Yellow are Hydraulic Fills subject to Liquefaction.



LEGEND

Geologic Hazard Categories

FAULT ZONES

- 11 Active, Alquist-Priolo Earthquake Fault Zone
- 12 Potentially Active, Inactive, Presumed Inactive, or Activity Unknown
- 13 Downtown special fault zone

LANDSLIDES

- 21 Confirmed, known, or highly suspected
- 22 Possible or conjectured

SLIDE-PRONE FORMATIONS

- 23 Friars: neutral or favorable geologic structure
- 24 Friars: unfavorable geologic structure
- 25 Ardath: neutral or favorable geologic structure
- 26 Ardath: unfavorable geologic structure
- 27 Otay, Sweetwater, and others

LIQUEFACTION

- 31 High Potential -- shallow groundwater major drainages, hydraulic fills
- 32 Low Potential -- fluctuating groundwater minor drainages

COASTAL BLUFFS

- 41 Generally unstable Numerous landslides, high steep bluffs, severe erosion, unfavorable geologic structure
- 42 Generally unstable Unfavorable bedding plains, high erosion
- 43 Generally unstable Unfavorable jointing, local high erosion
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- 51 Level mesas -- underlain by terrace deposits and bedrock nominal risk
- 52 Other level areas, gently sloping to steep terrain, favorable geologic structure, Low risk
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Water (Bays and Lakes)

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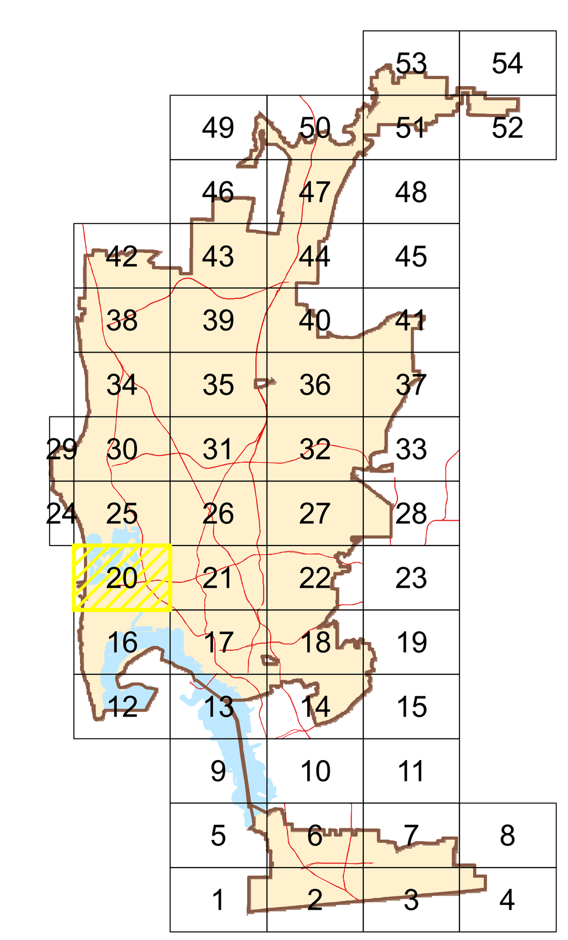
- Fault
- Inferred Fault
- Concealed Fault
- Shear Zone

Index Map



SanGIS Basemap Accuracy

SanGIS Land (Lot) basemap data for the City of San Diego tested 20.7' horizontal accuracy at the 95% confidence level.

This data meets the ASPRS Standard for Class 1 Map Accuracy at a scale of 1:12,000 (1"=1,000').

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City of San Diego
SEISMIC SAFETY STUDY
Geologic Hazards and Faults

Areas in Yellow are Hydraulic Fills subject to Liquefaction.

Development Services Department

Feet: 0 400 800 1,600 2,400

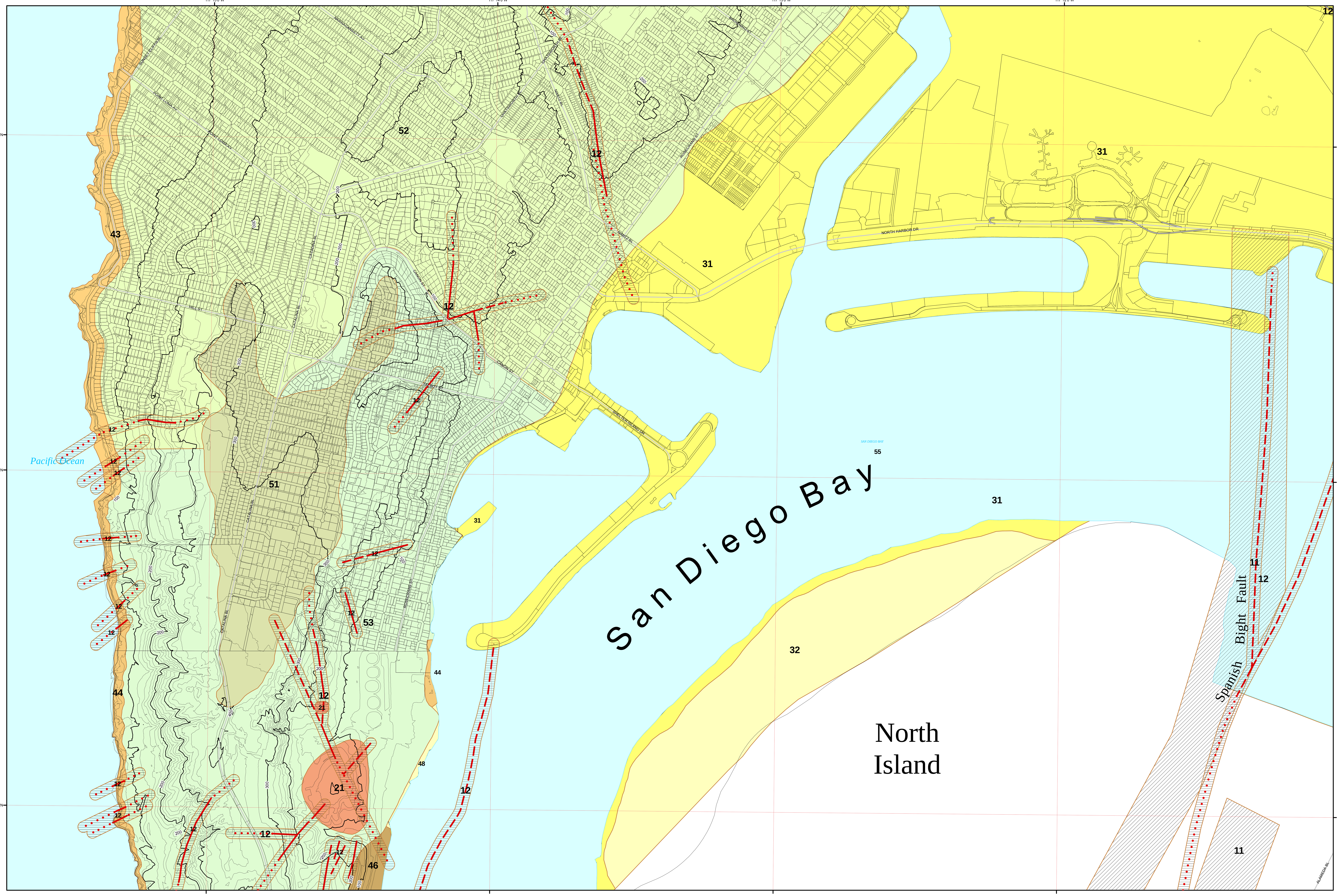
Meters: 0 120 240 480 720 960

GRID TILE: 20

GRID SCALE: 800

DATE: 4/3/2008

Areas in Yellow are Hydraulic Fills subject to Liquefaction.



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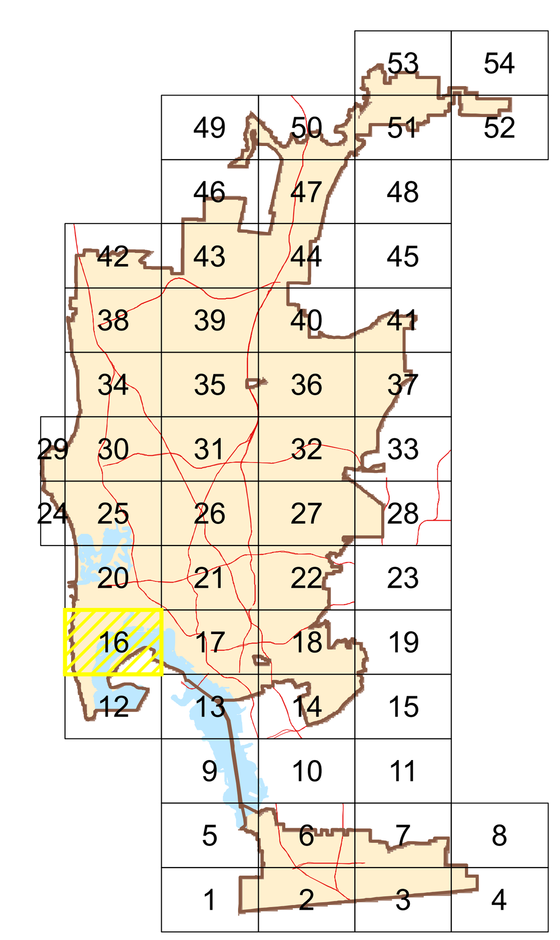

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Development Services Department

0 400 800 1,600 2,400 Feet

0 120 240 480 720 960 Meters

GRID TILE: 16

GRID SCALE: 800

DATE: 4/3/2008

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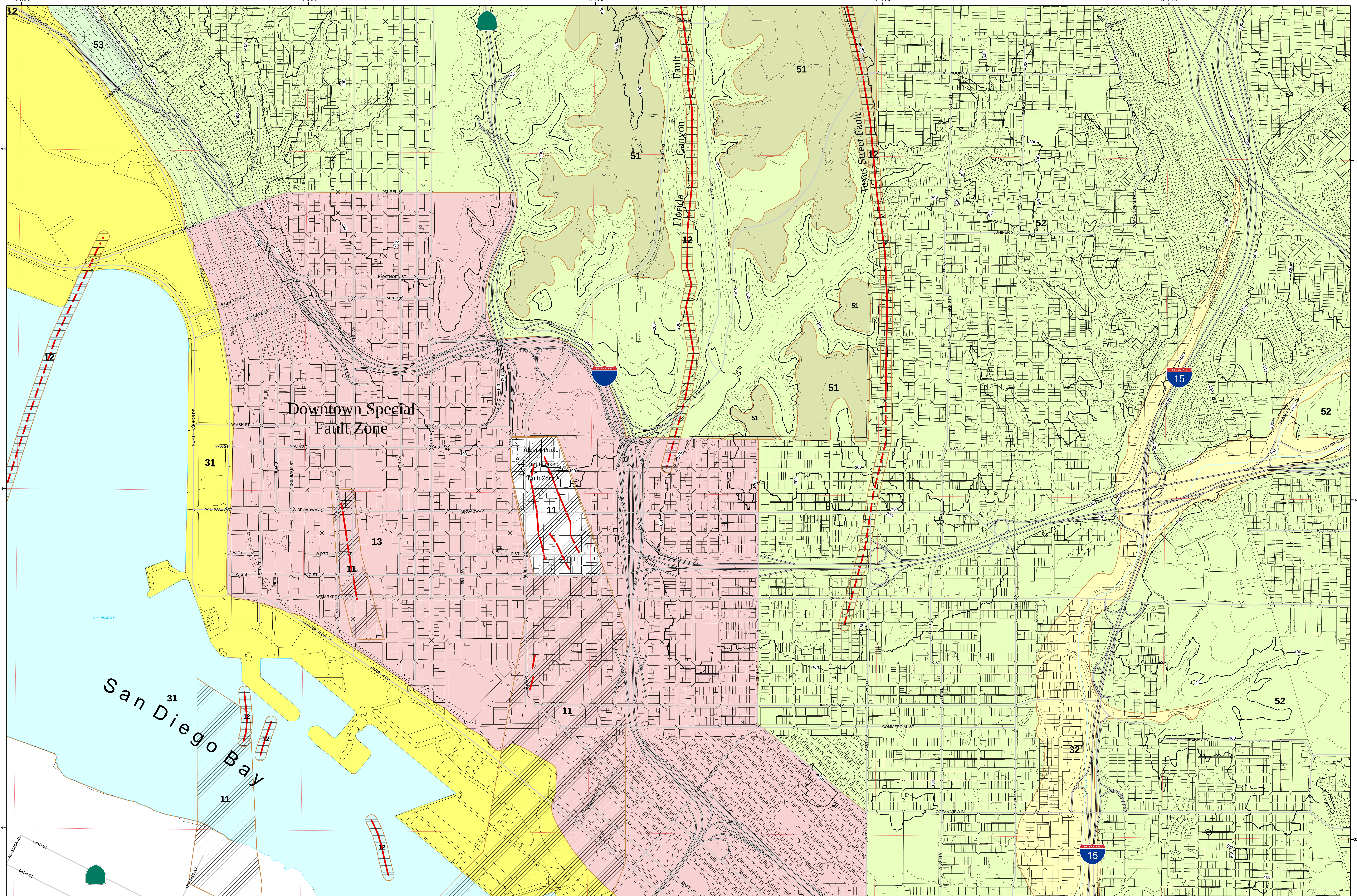

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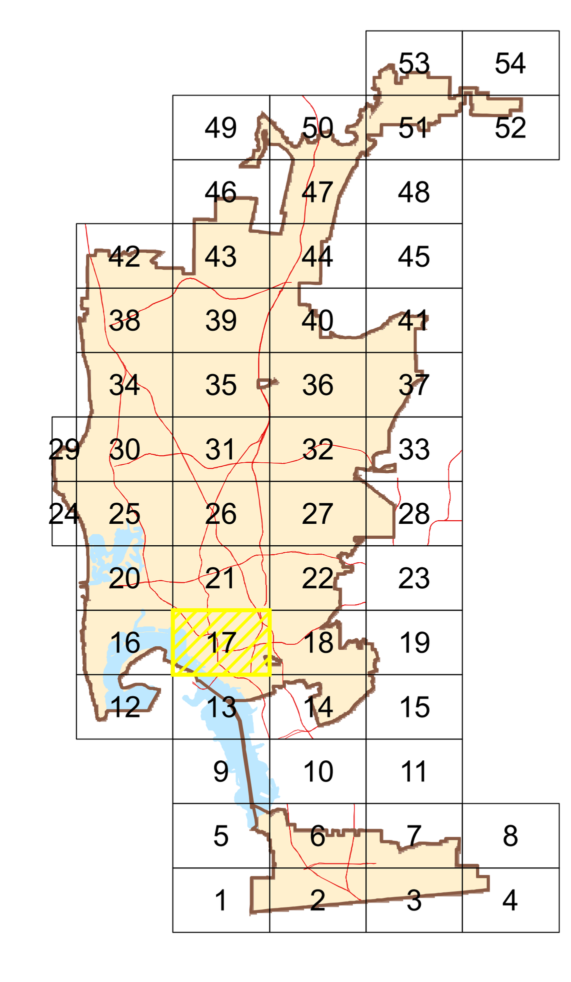

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Geologic Hazards and Faults

Development Services Department

0 400 800 1,600 2,400 Feet

0 120 240 480 720 960 Meters

GRID TILE: 17

GRID SCALE: 800

DATE: 4/3/2008

Table 2: Status of External Fraud, Waste and Abuse Reporting Fiscal Year 2022-23

No.	Incident Type	Case #	Received	Date Started	Status/Outcome	Date Closed
1	Abuse	PPY004	1/13/20	1/13/20	Open/Unresolved	Pending
	An allegation stating that SANDAG is allowing for unsafe traffic circles, ignoring, and lying to the SANDAG Board of Directors, and evading the Brown Act. The matter is on hold and pending additional information that OIPA has requested from the complainant. As of 4/07/22, no additional information has been provided by complainant.					
2-5	Combination of Allegations (GM, Waste, and Abuse)	PY001-22, PY003-22, PY004-22, PY006-22	07/27, 02/02, 02/08,02/14	Not started	Open	Pending
	An allegation stating that SANDAG, the City of San Diego and Consultants working on the Bike Project are grossly mismanaging, wasting, and abusing public dollars. The claim includes four different complaints filed through the fraud, waste, and abuse hotline. The matter includes concerns that the project has doubled in estimated cost. Additionally, there are allegations that in some areas that have been completed, the contractors failed to ensure that proper safety guidelines be followed including proper signage and advanced posting of work task.					
6	Combination of Allegations (Waste, GM, Abuse)	PY007-22	02/25/22	03/16/22	Open	Pending
	An allegation regarding misuse and abuse by a SANDAG consultant/contractor. The claim is regarding abuse of billing, overreaching of authority and failure to adhere to the terms of the contract. The claimant states that these actions by the contractor have been ongoing for many years.					
7-8	Combination of Allegations (GM, Abuse, COI, Quid Pro-Quo)	PY009-22, PY012-22	02/17/22, 08/04/22	Not started	Open	Pending
	An allegation regarding misuse and abuse by a SANDAG consultant/contractor and prior SANDAG employee. The claim is regarding abuse of power, conflict of interest (COI), overreaching of authority and financial gain by prior employee and contractor. Claimant provides detail of a "this for a that" agreement. On 8/04/22 a complaint was filed relating to this same contractor. The accusation is related and will be investigated together. PY013-22 claims that the contractor violated SANDAG's DBE program and that SANDAG DBE was informed, was provided support yet ignored the matter. The complainant who was a subcontractor claims that there were also matters involving conflict of interest.					
9	Public Safety Issue	002-23	08/7/22	Not Started	Open	Pending
	Complainant alleges that since 2006, for 16 years, she has had ongoing concerns regarding Seismic Safety on SANDAG, Port, Airport, and City of San Diego public funded projects. Specifically, for SANDAG, the concern is Seismic Safety concerns on the Rose Canyon Fault Zone (RCFZ) on SANDAG's Headquarters and SDMTS Bus Maintenance Facility in downtown San Diego, the double tracking over the San Diego River, the Old Town Station, and the limited fault investigations for only 3 bridges along the Mid-Coast Corridor, and the new stations and Transit Oriented Development (TOD) housing projects adjacent new trolley stops. The Complainant alleges that in the past SANDAG stated they were not confirming or denying active faulting along the full Mid-Coast corridor					

	or the bridges over the San Diego River due to budget constraints. The ask is to require all SANDAG, Airport, Port, and City fault investigations to have third-party approvals. With the fault investigation reports and approvals sent to the State Geologist within 30 days of approval. Second, reconvene the Caltrans 2006 Coronado Fault Technical Advisory Panel (TAP) or reconvene or contact Caltrans's Seismic Advisory Board (SAB) for free Seismic guidance and approvals for public funded projects on liquefiable soils. Additional State Seismic guidance and approvals should be required for SANDAG's proposed Airport connectivity project for a new subway/trolley to the airport, Central Mobility Hub (CMH), and new City Hall complex, the Navy Broadway Complex (NBC), Seaport Village, and SANDAG's new Headquarters and SDMTS Bus Maintenance Facility.

Table 3: Status of Internal Fraud, Waste and Abuse Reporting Fiscal Year 2022-23

No.	Incident Type	Case #	Received	Date Started	Status/Outcome	Date Closed
10	Combination of Allegations	PY010-22	03/8/22	03/25/22	Open	Pending
	An allegation of employee misuse of SANDAG Vehicle.					
11	Combination of Allegations	PY011-22	03/10/22	Not started	Open	Pending
	An allegation of employee misuse of SANDAG minor equipment used while working remotely and otherwise. Information and detail regarding the matter was provided.					
12	Theft of Time	PY008-22	03/08/22	Not started	Open	Pending
	Allegations of a current SANDAG employee and theft of time. Claimant states and provides examples of the employee and theft of time including coming in late, leaving early, etc. OIPA had planned a time audit, but due to limited resources this has been pending review. However, this matter will be individually reviewed to determine if actions should be taken.					
13	Misuse and Abuse	001-23	07/22/22	8/9/22	Open	Pending
	Allegation of misuse and abuse of public funds. Complainant alleged that SANDAG has paid out hundreds of thousands to employees over the past years that were unreasonable material amounts. Complainant provided dollar amounts for various past employees that were released from their duties at SANDAG yet were at will. Complainant demanded that the matter be reviewed as the amounts were material and the employees were at will. The complainant alleged that the polices should be changed and the Board should set more perimeters around how SANDAG management spends public funds.					

April 25, 2022

tinyurl.com/20220425a

SANDAG, 401 B Street, Suite 800, San Diego, California 92101
Clerk@sandag.org hasan.ikhrata@sandag.org coleen.clementson@sandag.org
Ryan Kohut, (619) 595-5339, ryan.kohut@sandag.org
Omar Atayee, (619) 595-5319, omar.atayee@sandag.org
Keith Greer, (619) 699-7390, keith.greer@sandag.org

Subject: Sabotage of SANDAG's Airport Connectivity On-Airport Rail Access Project and Central Mobility Hub CMH) Funding by the San Diego County Regional Airport Authority (SDCRAA) and San Diego International Airport (SDIA).

References: The following References are Attached and Linked Below.

May 31, 2016. SDCRAA and SDIA Letter to US DOT Regarding FAA Policy
"Comments, Proposed Policy Amendment Regarding PFC Eligibility of Ground Access Projects Meeting Certain Criteria, Docket No. FAA-2016-10334"
https://downloads.regulations.gov/FAA-2016-6596-0024/attachment_1.pdf

June 16, 2016. SDCRAA and SDIA Letter to US DOT Regarding FAA Policy
"Supplemental Comments, Proposed Policy Amendment Regarding PFC Eligibility of Ground Access Projects Meeting Certain Criteria, Docket No. FAA-2016-6596"
https://downloads.regulations.gov/FAA-2016-6596-0040/attachment_1.pdf

January 12, 2021. Federal Aviation Administration (FAA) Memorandum. 18 Pages
"FAA Passenger Facility Charge PFC 75-21 Eligibility of On-Airport Rail Access Project"
https://www.faa.gov/airports/pfc/pfc_updates/media/pfc_75_21_rail_access_policy.pdf

Dear SANDAG:

Great news. As referenced above and linked below, on January 12, 2021, the United States Department of Transportation (DOT) and the Federal Aviation Administration (FAA) made a dramatic change on the use of FAA Passenger Facility Charge (PFC) Funding Policy for On-Airport Rail Access Projects. The previous FAA Policy required that "*airport ground access projects must be for the **exclusive use** of airport patrons and airport employees*."

The new 2021 FAA Policy allows the use of PFC funds for On-Airport ground access projects that are **not exclusive** to the airport. This new FAA Policy is fantastic. It allows for more flexibility and local control of normally restricted FAA Airport Revenue for full funding of On-Airport rail projects, people movers, and Intermodal connections including a Central Mobility Hub (CMH). Please notify the SANDAG Board Members of this transformative policy change.

Using this new 2021 Federal FAA Policy, in order to fully fund SANDAG's Airport Connectivity Project consists of a Central Mobility Hub (CMH) and direct transit connections to the Airport; the project **needs to be On-Airport by acquiring of a Right-of-Way (ROW), or annexing adjacent San Diego Unified Port District (SDUPD) land** east from the airport to the train tracks. From Washington Street to Laurel Street, and North Harbor Drive. Through the same $1 lease the airport already pays since 2002. The alternative of siting a CMH in downtown San Diego would not allow FAA PFC funding to be used. http://tinyurl.com/20220419a

"**Policy Statement**… II. Eligibility… *FAA has reconsidered this interpretation and determined the 2004 exclusive use policy is unduly limiting. FAA supports the use of PFC to "encourage the development of intermodal connections on airport property between aeronautical and other transportation modes and systems to serve air transpiration passengers and cargo efficiently and effectively and promise economic development. 49 U.S.C. 47101(a)(5).""*
https://www.govinfo.gov/content/pkg/USCODE-2020-title49/pdf/USCODE-2020-title49-subtitleVII-partB-chap471-subchapI-sec47101.pdf

"III. PFC eligibility for a railway serving an exclusive use, on-airport station and then extending to serve additional stations beyond the airport*. Airport rail access projects serving an exclusive use, on-airport station and then extending to serve additional stations beyond the airport may be eligible for PFC funding… Policy: an eligible airport ground access project is one meeting the following conditions: (1) The road or facility may only extend to the nearest public highway or facility of sufficient capacity to accommodate airport traffic;* ***(2) the access road or facility must be located on the airport or within a right-of-way acquired by the public agency****; and (3) the access road or facility must exclusively serve airport traffic… 69 FR 6366, 6367.*
Under this new policy, on-airport rail access projects no longer will be treated identically to road access projects, ***and a portion of a rail access project may be eligible even if the rail project in its entirety serves more than exclusively airport traffic.*** *Three preferred methodologies for calculating the portion of the project eligible for PFC funding are:*
(1) prorating the eligible cost based on the forecast ratio of airport to non-airport ridership;
(2) calculating the cost to build a hypothetical stand-alone people mover system connecting the airport's terminal(s) to a regional transit system, which would otherwise meet the requirements of the 2004 PFC Policy; or
(3) calculating the difference between the cost of a line that bypasses the airport and the cost of a through-line configuration."
https://www.faa.gov/airports/pfc/pfc_updates/media/pfc_75_21_rail_access_policy.pdf

This great new 2021 FAA Passenger Facility Charge (PFC) Policy Change was secretly **Sabotaged and Opposed** by the San Diego County Regional Airport Authority (SDCRAA) and San Diego International Airport (SDIA) leadership; in the referenced and attached 2016 Comment Letters on the FAA Policy Change. Written by the previous SDIA Airport President and CEO Thella Bowens. Thankfully the FAA pushed back, and thwarted the SDCRAA and SDIA plans to continue to **Hoard** FAA Airport Revenue. I cannot find any SDCRAA SDIA Agenda Items on this subject of the FAA PFC Policy Change. It may be that Airport staff wrote these letters without SDCRAA Board approval. Or the Board knew and directed staff to write the letters. Either way, the public and other elected officials in San Diego County were unaware. Excerpts from the Comments letters include the following:

May 31, 2016. "*The San Diego County Regional Airport Authority is the operator of San Diego International Airport (SDIA).* ***We are submitting comments regarding our opposition to the proposed change to Federal Aviation Administration (FAA) policy that would allow for the use of Passenger Facility Charges (PFCs) to fund airport rail access projects located on airport property that do not exclusively serve an airport… Opening up eligibility for projects such as rail access that involve outside agencies may potentially bring pressure to participate in funding a project that is not a high priority at SDIA****… Also, one of the typical features of airport access projects is that the benefits are often split between airport users and others. Because of this, project costs are allocated between the airport and partnering agency or entity.* ***A flawed methodology to allocate costs can lead to an incorrect share of costs being attributed to the airport****. The proposed change to PFC eligibility for rail access suggested three cost allocation methodologies: 1) Incremental Cost Comparison; 2) Separate System Comparison; and 3) Prorated Costs Based on Ridership*

Forecast. We believe that all of these methodologies have drawbacks."
https://downloads.regulations.gov/FAA-2016-6596-0024/attachment_1.pdf

June 16, 2016. *"**Political Influence**. **There is no mechanism for airports to resist local political pressures to use PFCs to fund rail projects in close proximity to airports. Without strict controls on the use of PFCs**, airports- whether municipal/county-owned or governed by an independent authority- **could be pressured to use PFC revenues to build projects that have little or no value to airports and their stakeholders.** City or county-owned airports, in particular, could be subject to local influence by elected officials and regional leaders. **For example, a transfer of adjacent property interest to the airport through a right-of-way could increase the apparent PFC eligibility for the 'on-airport' portion of a city or county owned rail system. As a result, airports would have to hope that the FAA rejects PFC applications to which the airport was opposed.** Revenue diversion regulations were designed to help protect airports from undue political influence. **Expanding the eligibility of PFC use, as has been proposed, would begin to open the door to using PFCs on non-airport/aviation projects if not strictly defined**... One of the three proposed methodologies (eligibility based on ridership) is unverifiable and can subject the airport to an unwarranted share of costs. **The people mover method could create unwarranted and astronomical cost eligibility…**"* https://downloads.regulations.gov/FAA-2016-6596-0040/attachment_1.pdf

For Grandfathered Airport Revenue Diversion status, San Diego International Airport (SDIA) sponsor is the San Diego Unified Port District (SDUPD). SDIA is 1 of 12 Grandfathered Airports on State Tidelands that includes the Port Authority of New York and New Jersey (PANYNJ). The La Guardia Airport (LGA) Access Improvement Project by PANYNJ is very similar to San Diego Airport Connectivity project. Linked below is the FAA Record of Decision (ROD) for new transit stations from LGA Airport, and a new a 3-mile Subway Transit Corridor (STC), located On-Airport and Off-Airport. With Automated People Movers (APM) to directly connect the Airport to the local rail system using PFC funding. Due to the use of FAA PFC funding, the LGA Access Improvement Project was subject to the Federal NEPA EIS process. *"The Proposed Action would connect two on-Airport stations at LGA with a transfer station at Willets Point. The off-Airport station would provide connections to the Mets–Willets Point stations of the* [Long Island Railroad] *LIRR Port Washington Branch and the New York City Transit (NYCT) Subway Flushing Line (7 Line)."*
https://www.faa.gov/airports/environmental/environmental_documents/lga/media/EIS-ROD-LGA-NY-Access-Improvement-2021-07-21.pdf

In conclusion, this is great news that a Non-Exclusive, On-Airport Central Mobility Hub (CMH), Subway Transit Corridors (STC), and Transit Station On-Airport can be fully funded using FAA Passenger Facility Charges (PFC). In addition, portions of Off-Airport Subway Transit Corridors (STC) and Stations can also be funded by PFC. Full funding can only be realized by acquiring Airport Right-of-Ways (ROW), or annexing adjacent land to create new On-Airport property. Therefore, the Port Headquarters location is still a **Superior Alternative** for the CMH because it is located between the airport and the closest rail connection. A downtown CMH would be excluded from PFC funding. In 2002, SB-1896 *"transferred planning and land use responsibilities for airport land from the SANDAG or its successor to the Authority."*
https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200120020SB1896
Due to the purposeful funding sabotage, SANDAG should request the Public Utility Code (PUC) laws be changed, to give back Airport planning and development and the associated Billions in Cash for Regional transportation project funding to SANDAG. Please contact me with questions.

Regards, Katheryn Rhodes, Civil Engineer RCE 62730 laplayaheritage@gmail.com 619-402-8688

SAN DIEGO
INTERNATIONAL AIRPORT
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May 31, 2016

Docket Management Facility
U.S. Department of Transportation
1200 New Jersey Avenue SE.
West Building Ground Floor, Room W12-140
Washington, DC 20590-0001.

Re: Comments, Proposed Policy Amendment Regarding PFC Eligibility of Ground Access Projects Meeting Certain Criteria, Docket No. FAA-2016-10334

The San Diego County Regional Airport Authority is the operator of San Diego International Airport (SDIA). We are submitting comments regarding our opposition to the proposed change to Federal Aviation Administration (FAA) policy that would allow for the use of Passenger Facility Charges (PFCs) to fund airport rail access projects located on airport property that do not exclusively serve an airport.

Generally, we consider an expansion of PFC eligibility for projects to be positive, as the ability to fund a greater variety of projects is beneficial for overall airport development and the associated plan of finance. Over $1 billion of PFC revenue at SDIA is committed through 2036 to pay for bonds used for a major terminal expansion completed in 2013. This leaves very little in uncommitted PFCs to be used for other projects. Opening up eligibility for projects such as rail access that involve outside agencies may potentially bring pressure to participate in funding a project that is not a high priority at SDIA. Although we may gain additional PFC revenue in the future from increased passenger growth or from an increase in the $4.50 PFC level, we anticipate not being able to address all future facility needs with the available PFCs.

Also, one of the typical features of airport access projects is that the benefits are often split between airport users and others. Because of this, project costs are allocated between the airport and partnering agency or entity. A flawed methodology to allocate costs can lead to an incorrect share of costs being attributed to the airport. The proposed change to PFC eligibility for rail access suggested three cost allocation methodologies: 1) Incremental Cost Comparison; 2) Separate System Comparison; and 3) Prorated Costs Based on Ridership Forecast. We believe that all of these methodologies have drawbacks.

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We appreciate your consideration of our comments regarding the proposed policy amendment regarding PFC eligibility of ground access projects meeting certain criteria, and hope you find them helpful.

Please contact me at 619.400.2444 or via e-mail at tbowens@san.org if you need additional information or clarification regarding our comments.

Sincerely,

Thella F. Bowens
President/CEO

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https://downloads.regulations.gov/FAA-2016-6596-0040/attachment_1.pdf

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https://www.regulations.gov/comment/FAA-2016-6596-0040

https://www.regulations.gov/comment/FAA-2016-6596-0036
The American Society of Civil Engineers supports the proposed rule change. Airports ought to be allowed to use PFC funds for ground access projects in which the airport is not the terminus of the rail line (assuming PFC funds pay for only the portion of the rail costs that benefit airport passengers, as the three proposals would). This rule change would give airports more flexibility in utilizing locally collected PFC funds for the benefit of airport users.

June 16, 2016

Docket Management Facility
U.S. Department of Transportation
1200 New Jersey Avenue, SE
West Building Ground Floor, Room W12-140
Washington, DC 20590-0001

Re: Supplemental Comments, Proposed Policy Amendment Regarding PFC Eligibility of Ground Access Projects Meeting Certain Criteria, Docket No. FAA-2016-6596

On May 31, 2016, the San Diego County Regional Airport Authority submitted comments opposing the proposed change to FAA policy to allow for the use of Passenger Facility Charges (PFCs) to fund rail access projects that do not exclusively serve an airport. This supplemental letter provides additional comments outlining in more detail reasons that the current PFC eligibility rules should not be amended as proposed in Docket No. FAA-2016-6596.

Intended Use of PFCs

PFCs were established to be used for three purposes: 1) preserve or enhance safety, security, or capacity of the national airport system; 2) reduce noise from an airport that is part of such a system; or 3) furnish opportunities for enhanced competition between or among air carriers. The proposed use of PFCs for a rail line does not meet any of those three purposes.

Except for Grandfathered Airports who are allowed to use Airport Revenue off site for Transportation in general.

Political Influence

There is no mechanism for airports to resist local political pressures to use PFCs to fund rail projects in close proximity to airports. Without strict controls on the use of PFCs, airports - whether municipal/county-owned or governed by an independent authority – could be pressured to use PFC revenues to build projects that have little or no value to airports and their stakeholders. City or county-owned airports, in particular, could be subject to local influence by elected officials and regional leaders. For example, a transfer of adjacent property interest to the airport through a right-of-way could increase the apparent PFC eligibility for the 'on-airport' portion of a city or county owned rail system.

As a result, airports would have to hope that the FAA rejects PFC applications to which the airport was opposed. Revenue diversion regulations were designed to help protect airports from undue political influence. Expanding the eligibility of PFC use, as has been proposed, would begin to open the door to using PFCs on non-airport/aviation projects if not strictly defined.

Cost Allocation Methodologies

The FAA's proposed change to PFC eligibility for rail access outlines three different allocation methodologies: 1) Incremental Cost Comparison; 2) Separate System Comparison; and 3) Prorated Costs Based on Ridership Forecast. Having multiple methodologies could cause issues to arise between the project sponsor and the FAA during review of an application. FAA staff could struggle

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with approving a project based on a methodology for which they have no reference point. One of the three proposed methodologies (eligibility based on ridership) is unverifiable and can subject the airport to an unwarranted share of costs. The people mover method could create unwarranted and astronomical cost eligibility. The best method of the three - the incremental cost method – still has the potential to inflate the cost eligibility beyond what it actually should be. Notwithstanding these concerns, the identification of one cost allocation method would allow a better framework for FAA to evaluate a project, and would be commensurate with other eligibility formulas, such as the two choices for terminal project eligibility (square footage or specific cost).

Except for Grandfathered Airports who are allowed to use Airport Revenue off site for Transportation in general.

Airport Improvement Program Funding

There should exist a requirement that airports who use PFCs for rail and similar projects must forego AIP discretionary funds. Although there could be some limitation on that exclusion (e.g. funding levels not to exceed the amount received the year prior to adding rail project to their Airport Capital Improvement Plan). Airports using PFCs for rail projects should also be excluded from participating in the Letter of Intent (LOI) Program.

We appreciate your consideration of these additional comments regarding the proposed policy amendment regarding PFC eligibility of rail access projects and hope that you find them helpful.

Please contact me at (619) 400-2444 or via e-mail at tbowens@san.org if you need additional information or clarification regarding our comments.

Sincerely,

Thella F. Bowens
President/CEO

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https://www.faa.gov/airports/pfc/pfc_updates/media/pfc_75_21_rail_access_policy.pdf
https://downloads.regulations.gov/FAA-2016-6596-0024/attachment_1.pdf
https://downloads.regulations.gov/FAA-2016-6596-0040/attachment_1.pdf

Grandfathered Airports allow for normally restricted FAA Airport Revenue Diversion for 12 Grandfathered Airport Sponsors including SDIA, with the Port as the Airport Sponsor.

Federal Aviation Administration

Memorandum

PFC = Passenger Facility Charge.

Date: January 12, 2021

To: Regional Airports Directors, 610 Branch Managers, and ADO Managers

From: Robert J. Craven, Director, Office of Airport Planning and Programming, APP-1

Subject: INFORMATION: PFC Update, PFC 75-21

PFC 75-21. Eligibility of on-airport rail access projects

This PFC Update letter provides guidance on the *Passenger Facility Charge (PFC) Program: Eligibility of on-airport rail access*. This Policy amends FAA policy previously published in 2004, *Notice of Policy Regarding Eligibility of Airport Ground Access Transportation Projects for Funding Under the Passenger Facility Charge Program* (69 FR 6366) (the 2004 Policy), to make rail lines that do not exclusively serve the airport PFC eligible, and provides several methodologies for calculating the PFC-eligible costs. All other ground access projects using PFC funds continue to follow the 2004 Policy.

FAA's PFC Order (FAA Order 5500.1, Chapter 1, section 1-22(d)) notes differences between PFC and Airport Improvement Program (AIP) eligibility. This PFC Update further clarifies that when using PFC funds, rail line eligibility is now treated differently than when using AIP funds. There is no change to AIP policy on ground access project eligibility, as outlined in Table P-3 of the AIP Handbook.

This Update also modifies section 4-6(e) of the PFC Order, which currently states that airport ground access projects must be for the exclusive use of airport patrons and airport employees. Under the 2020 Policy, on-airport rail access projects no longer will be treated identically to road access projects, and a portion of a rail access project may be eligible even if the rail project in its entirety serves more than exclusively airport traffic.

For further information, please contact APP-510 at (202) 267-3831.

Background

Section 123(e) of Public Law 108-176, Vision 100-Century of Aviation Reauthorization Act (December 12, 2003) directed FAA to publish a policy on the eligibility of ground access projects for PFC funding. The 2004 Policy was published on February 10, 2004 (69 FR 6366). The 2004 Policy presented the relevant statutory requirements as well as FAA's regulations and guidance on PFC-funded ground access transportation projects in a consolidated form.

The 2004 Policy restated the agency's longstanding policy that a surface transportation project must meet the following conditions to be eligible for AIP or PFC (see also FAA Order 5100.38D, Appendix P, Table P-3) funding:

(1) the road or facility may only extend to the nearest public highway or facility of sufficient capacity to accommodate airport traffic;
(2) the access road or facility must be located on the airport or within a right-of-way acquired by the public agency; and
(3) the access road or facility must exclusively serve airport traffic.

In addition, the 2004 Policy stated that the "eligibility criteria for access roads" would be used "to judge eligibility of rail and fixed guideway systems." The first and second elements are relatively straightforward to apply and evaluate. The third element, exclusive use, requires more explanation. The origin of this exclusivity element is an FAA policy, later codified by Congress, that expressly applied only to roads. 49 U.S.C. 47102(28). The 2004 Policy stated that "exclusive use of airport patrons and employees means that the facility can experience no more than incidental use by non-airport users." 69 FR 6368.

The 2004 Policy also stated that "[r]elated facilities, such as acceleration and deceleration lanes, exit and entrance ramps, lighting, equipment to provide operational control of a rail system or people mover, and rail system or people mover stops at intermediate points on the airport are eligible when they are a necessary part of an eligible access road or facility…." 69 FR 6367. In addition, "the public agency must retain ownership of the completed ground access transportation project. The public agency may choose to operate the facility on its own or may choose to lease the facility to a local or regional transit agency for operation within a larger local or regional transit system." 69 FR 6367.

In the past, before and after the publication of the 2004 Policy, FAA found that almost all rail stations located on-airport were eligible for PFC funding under agency guidelines, because they were exclusively used by airport patrons and employees. However, under the 2004 Policy whether the right-of-way or rail line itself met the exclusive use element depended upon the configuration of the rail line. If the configuration terminated at the airport, then it met the exclusive use element. Thus, to meet the terms of the 2004 Policy, some on-airport stations were connected to an off-airport railway system via a spur line.

If the railway was a through-line where the airport station was not the terminus, however, it failed to meet the exclusive use element.

In 2014, FAA received a request for the use of PFC revenue to fund an on-airport rail station and related railway, where the railway would not exclusively serve airport traffic as interpreted in the 2004 Policy. The railway would not terminate at the airport station but continue beyond the airport property to other stations. The agency reconsidered whether the 2004 Policy's exclusive use element, as applied to rail access projects, is unduly limiting, restricting the approval of PFC funds for some airport ground access projects that are otherwise consistent with statutory limitations and the agency's mission to "encourage the development of intermodal connections on airport property between aeronautical and other transportation modes and systems to serve air transportation passengers and cargo efficiently and effectively and promote economic development." 49 U.S.C. 47101(a)(5).

FAA's consideration of the request highlighted the competing policy goals. When a public agency extends the railway beyond the airport, it provides more transit options for more travelers and increases the utility of the system. This positive outcome is consistent with FAA's policy of encouraging intermodal connections. A paradoxical consequence of this intermodal enhancement, however, is that funding options diminish pursuant to the 2004 Policy.

As noted earlier, the 2004 Policy was based on FAA Order 5100.38B (May 31, 2002) and related guidance that determined PFC and AIP eligibility for access roads. However, there are fundamental differences between railway systems and road systems. With road systems, all that is needed to facilitate efficient access to the air transportation system is a direct connection from the airport to a main thoroughfare or population center, as individual drivers can then choose their own path to their destination. The roads used by airport visitors are typically part of a broader system that may be funded, constructed, and maintained by multiple levels of government or private entities for multiple purposes and journeys. Given the open and variable nature of road systems, it is critical for FAA to apply strict eligibility criteria that tie the funding of the on-airport project to the exclusive use of the airport. Without such criteria, users of the infrastructure could benefit from federally approved funds designed to improve access to the national air transportation system without ever intending to visit, or actually visiting, the airport. Moreover, the exclusive use requirement as applied to roads is mandated by statute. 49 U.S.C. 47102(28).

On-airport rail access projects, on the other hand, are planned, funded, constructed, operated, and used differently than on-airport road projects. By their nature, passenger rail and rail transit aggregate passenger traffic along fixed routes with a limited number of stops, each with their own justification and purpose. Users of road infrastructure have more flexibility and control in determining their route than users of rail, who are limited in their options. Non-airport users of rail are not taking advantage of the airport portions of a railway system by choice, but are likely to be passing through the airport because they cannot use the railway system to their destination without doing so. Thus, the distributed network of roads, as compared to the fixed path of rail, justifies the differentiated treatment that Congress has now ordained.

In addition, FAA has observed an increasing number of circumstances and physical configurations in which continued adherence to the 2004 Policy's interpretation of "exclusive use" for rail projects may not appropriately balance competing policy goals. Indeed, rigid application to rail projects of the exclusive use policy that is now mandated by statute for roadway systems has frustrated FAA's own objectives as set forth in 49 U.S.C. 47101(b)(5) and (6).

FAA's analysis is further informed by changes in population and demographic trends that have occurred since issuance of the 2004 Policy. Many airports that were originally constructed on the periphery of population centers are now ensconced as suburban growth has extended to and beyond the airport. It may no longer make sense for a downtown railway or transit line to terminate at the airport, where there exists a pool of potential users beyond the airport. However, under the 2004 Policy, which equates on-airport rail access projects with "access roads," extending railway access beyond the airport so that these populations can also access the airport precludes the use of federally approved funds, such as PFCs, for significant portions of the project since the line would go beyond the airport and no longer serves airport traffic exclusively.

To modify the exclusivity element for the on-airport portion of rail access projects, on May 3, 2016, FAA published a proposed policy titled Passenger Facility Charge (PFC) Program: Eligibility of Ground Access Projects Meeting Certain Criteria (81 FR 26611) (hereinafter 2016 Proposed Policy). In the Proposed Policy, FAA solicited comments on its proposal to amend the existing policy to consider the eligibility of rail access projects that are located on-airport but may not exclusively serve airport traffic. FAA's proposed amendment is consistent with the agency's mission to encourage the development of intermodal connections on airport property. The proposal also identified three proposed methodologies by which an airport could calculate PFC-eligible costs of a rail access project serving that on-airport station that then extends to serve off-airport stations.

Following publication of the 2016 Proposed Policy, the President signed the Reauthorization Act of 2018 (Pub. L. 115-254, section 123 (Oct. 5, 2018) (hereinafter "Reauthorization Act")). Section 123 of the Reauthorization Act provides:

> Not later than 6 months after the date of enactment of this Act, the Administrator of the Federal Aviation Administration shall, after consideration of all public comments, publish in the Federal Register a final policy amendment consistent with the notice published in the Federal Register on May 3, 2016 (81 FR 26611).

Discussion of Comments and Final Policy

FAA received comments from 40 commenters including air carriers, airport operators, government entities, rail authorities, transit authorities, trade associations, and private individuals (Docket number FAA-2016-6596). Commenters included:

- Trade Associations: Airlines For America (A4A), Southern Rail Commission, International Air Rail Organization, International Air Transport Association (IATA), Airports Council International - North America (ACI-NA), American Association of Airport Executives (AAAE), Regional Plan Association (RPA), United States Travel Association, and the American Society of Civil Engineers (ASCE)
- Air carriers: Delta Air Lines
- Airport operators: Greater Orlando Airport Authority (FL), San Diego Regional Airport Authority (CA), Los Angeles World Airports (CA), New Orleans International Airport (LA), Metropolitan Washington Airports Authority (DC), San Diego International Airport (CA), Phoenix Mesa Airport Authority (AZ), City of Phoenix Aviation Department (AZ), Lee County Port Authority (FL)
- Government entities: City of College Park (GA), City of Austin (TX), San Bernardino Associated Governments (CA), New York City Economic Development Corporation (NY)
- Rail Authorities: Louisiana Super Regional Rail Authority (LA), National Railroad Passenger Corporation (AMTRAK)
- Transit Authorities: Utah Transit Authority (UT), Los Angeles County Metropolitan Transportation Authority (CA)
- Thirteen Individuals

Most comments were supportive of the proposed policy. Some commenters expressed a preference for one methodology over another, but none offered alternatives, and none specifically argued against any of the three methodologies. Many commenters (including the Metropolitan Washington Airports Authority (MWAA), AMTRAK, Greater Orlando International Airport, New Orleans International Airport, the United States Travel Association, Utah Transit Authority, and Phoenix Mesa Airport) supported a change that would give public agencies the flexibility to determine the most efficient ways to use PFC revenues and, in doing so, encourage the development of intermodal transportation systems. Two members of AAAE stated that expanding PFC eligibility for certain on-airport rail access projects will allow airports to accommodate increasing passenger levels and reduce landside congestion.

However, some commenters (such as the Greater Orlando Airport) expressed concern that two of the methodologies would introduce ambiguity by analyzing a theoretical project that may never have been planned or analyzed in sufficient detail. Similar concern was expressed that the assumptions and costing methodologies used for the proposed project and a theoretical alternative could open arguments resulting in conflicting conclusions. Some commenters were also concerned that the prorated methodology could result in skewed forecasts and inaccurate cost allocations over time. In some instances, commenters (such as Delta Air Lines and IATA) were concerned that this proposal could result in a subsidy to greater regional transit systems by airport users.

1. Concerns about Proposed Methodologies to Estimate Eligible Costs

In the 2016 Proposed Policy, FAA identified three methodologies by which an airport could calculate PFC-eligible costs of a railway serving an exclusive use, on-airport station that then extends to serve off-airport stations. The three methodologies were:

Except for Grandfathered Airports who are allowed to use Airport Revenue off site for Transportation in general.

(1) a determination of a prorated amount based on a forecasted ratio of airport to non-airport users;
(2) a determination of the cost to build a hypothetical stand-alone people mover system connecting the airport's terminal(s) to a regional transit system, which would otherwise meet the requirements of the 2004 PFC Policy; or
(3) a determination of the incremental costs, calculated by comparing the cost of a through line configuration with the cost of a line that bypasses the airport.

Most of the comments dealt with the mechanics of how the assumptions involved in these methodologies would be developed and how they would be applied to ascertain PFC eligibility. Some commenters (San Diego County Regional Airport Authority, A4A and others) questioned FAA's reliance on cost estimates used for two of the three methodologies. Some commenters (Greater Orlando Airport Authority, San Diego County Regional Airport Authority) stated that cost estimates, and ultimately cost comparisons, will introduce ambiguity and variability resulting in disputed estimates and assumptions. They indicated that a cost estimate for a theoretical proposed layout may lack the robustness that one would need to make a proper cost analysis, thereby leading to over inflation of the eligibility of the project.

FAA response: FAA routinely makes determinations on cost reasonableness based on PFC Update 06-50.1, dated September 8, 2006. Independent cost estimates are another tool FAA has used when assessing uncertain cost data that could result in substantial shift in project costs (up or down). Furthermore, FAA routinely assesses potential alternative project costs and planning assumptions when reviewing airport master plans, and to some extent environmental studies. FAA anticipates its evaluation of the cost estimates and planning assumptions for rail access projects to be equally robust. FAA historically has relied on assistance from the Federal Transit Administration (FTA) when assessing cost estimates.

The Greater Orlando Airport Authority questioned the use of theoretical alternatives that may not have been envisioned as a means to determine project eligibility. Other commenters (including an individual and A4A) expressed similar concerns about conducting a cost analysis utilizing alternatives. They stated that the cost to serve the airport would require more infrastructure and would inevitably cost more than a direct route that would bypass the airport. In their view, comparing the cost of a shorter bypass railway that may never really have been envisioned versus a longer route required to serve the airport will lead to a pre-determined outcome and blanket eligibility for higher PFC eligible costs.

Except for Grandfathered Airports who are allowed to use Airport Revenue off site for Transportation in general.

FAA response: The preferred methodology determines PFC eligibility based on a prorated amount of airport to non-airport users. FAA has determined that this approach is the appropriate measure for PFC eligibility for most projects and should be the presumptive method used by the public agency. An alternative methodology should be used only in the event the public agency determines the preferred methodology is inadequate to establish eligible costs. To permit FAA to adequately consider PFC-eligible costs, a cost analysis using an alternative methodology would require documentation of sufficient planning and detailed, conceptual cost estimates.

MWAA asked FAA to clarify the second methodology, i.e., the cost for a stand-alone people mover system. MWAA argues the through-airport railway project should be eligible for up to the same level of PFC funding as the airport people mover project.

FAA response: MWAA's interpretation is consistent with FAA's intent. The stand-alone people mover system methodology is an approach that could potentially be used to identify eligible costs, and the eligibility would be based on the estimated people mover costs.

An individual commented that both a through-airport railway project and a people mover project will include an exclusive use airport station so the cost of the airport station should not be included in the calculations.

FAA Response: The public agency should prepare cost estimates for the on-airport portions of both the through-airport project and the people mover project. The people mover project may include one or more airport stations, and possibly an additional station on the regional transit system if that station is located within the airport boundary. The through-airport project may include one or more stations located close to the airport terminals.

An individual commented that the full cost of a dedicated people mover system providing access to the terminal should include any additional stops and stations such as passenger parking and rental car facilities in the cost methodology. Thus, the separate system methodology must consider these additional elements as well.

FAA Response: The theoretical case and the proposed case alternatives should be as comparable as possible, considering the same functional elements unless the physical and geometric realities of the alternatives dictate otherwise. In some cases, additional components may be necessary for purposes of the calculation.

Some commenters (A4A, San Diego County Regional Airport Authority, and Regional Plan Association) discussed the difficulty in determining a ridership percentage using a prorated forecast of airport to non-airport ridership, noting that it is difficult to predict ridership percentages before a project is developed.

FAA Response: FAA will base the prorated share of the project cost on the public agency's ridership forecast (e.g., a metropolitan planning organization's travel forecast models). FAA may coordinate ridership projections with FTA for its evaluation before PFC eligibility is determined.

MWAA suggested that additional clarification is needed for the definition, or application, of the term "ridership." MWAA's view is that ridership should be based on the ridership taking place within the boundaries of an airport, and should not include additional ridership occurring completely outside the airport and elsewhere on the regional transit system.

FAA Response: Only passengers riding to and from the airport station and the next immediate off-airport station (in either direction) should be included when counting or forecasting airport versus non-airport ridership.

A4A stated FAA should publish and accept comment on ridership forecasts that are used to support a prorated ridership PFC eligibility cost.

FAA Response: Ridership forecasts and any other supporting information must be included in the information presented in the PFC public notice and air carrier consultation meeting to meet the requirements of 14 CFR 158.23 and 158.24. Therefore, in accordance with 14 CFR 158.23(c)(2), carriers will have the ability to comment as A4A advocates. Furthermore, for capital-intensive programs such as a new railway system, public agencies are subject to public comment processes for environmental reviews or master planning activities as well. Interested parties will have the opportunity to comment through all those processes.

A4A stated that FAA should not adopt any methodology for determining PFC eligibility that is not described in the 2016 Proposed Policy, and that the agency must provide public notice and comment before any new eligibility solution is adopted.

FAA Response: This policy outlines three methodologies that may be used to determine PFC eligible costs for a railway serving an exclusive use, on-airport station that then extends to serve an off-airport station. FAA recognizes that it cannot anticipate every circumstance, so this policy preserves discretion to consider unique situations, thus correcting a significant shortcoming of the 2004 Policy. FAA may consider public notice and comment if a public agency proposes to use a substantially different methodology. Nevertheless, a unique methodology would have to be described and supported with detailed information for the PFC public notice and air carrier consultation meeting to meet the requirements of 14 CFR 158.23 and 158.24.

2. Unintended Subsidies

Some commenters (Delta Air Lines, IATA) were concerned that the added eligibility for through-airport rail access projects would shift user fees intended for the airport system to other non-airport related infrastructure.

FAA Response: Airports have broad latitude to determine whether to impose a PFC and for which projects to use PFC revenues, with the notable caveat that, per 49 U.S.C. 40117(d)(4), airports must ensure airside needs are met before imposing a PFC above $3.00 for use on terminal and landside projects. Moreover, under 49 U.S.C. 40117(a) and (d), before a project can be funded with PFC revenue, it must meet certain eligibility requirements and must be supported with adequate justification. Landside access projects, such as a railway to an on-airport station, can meet the justification standard if the project preserves or enhances capacity in accordance with 49 U.S.C. 40117(d) and 14 CFR 158.15. The project can do this by providing additional capacity to support airside and terminal capacity or reducing roadway traffic congestion, thus making the airport more attractive to airline passengers, particularly in an area with multiple airports.

IATA commented that revenue generated from airport user-funded rail access projects should be recovered and distributed to the airport and its users.

FAA Response: The passengers who choose to use the railway system to get to the airport (and the airlines they patronize) benefit from the overall system. FAA acknowledges it may be administratively difficult to ask the transit system operator to segregate revenues or expenses on any individual segment of the system. While FAA is not including the revenue segregation as IATA suggested, nothing in this policy precludes a public agency and its local transit system operator from entering into such an agreement.

Delta Air Lines commented that an airport sponsor’s grant assurances prevent revenue from being used for non-aviation purposes. It stated that PFC revenue should not be used for intermodal projects if there are airside or terminal projects that will provide greater and more direct benefits to the aviation passengers paying those fees.

FAA Response: FAA may approve PFC-eligible ground access projects only if those projects are adequately justified and have met at least one PFC objective (in accordance with 49 U.S.C. 40117(d) and 14 CFR 158.15). In addition, when a public agency requests PFC approval of an eligible surface transportation project funded by a PFC above $3.00, FAA is required to determine that the public agency has made adequate provision for financing the airside needs of the airport (including runways, taxiways, aprons, and aircraft gates). 49 U.S.C. 40117(d)(4); 14 CFR 158.17(a)(3).

3. Significant Contribution

A4A asked that "FAA reiterate in the final policy that that both the 'adequate justification' and 'significant contribution' conditions (depending on the proposed PFC level and size airport) are legal requirements that must be met in order to approve a PFC application, and also should ensure these criteria are strengthened and strictly applied in light of the proposal to loosen exclusivity." In addition, A4A commented that "FAA must apply its 'adequate justification' requirement separately to all sections of the proposed on-airport tracks." It also expressed concern that FAA has not established definitive guidance on the significant contribution criteria and that such criteria threshold needs to reflect a higher burden.

FAA Response: For all projects being considered for PFC funding, FAA must determine that it is PFC eligible, adequately justified, and will meet at least one PFC objective per 49 U.S.C. 40117 and 14 CFR 158.15. As stated previously, ground access projects, such as a railway to an on-airport station, can meet the justification standard if the project preserves or enhances capacity in accordance with 49 U.S.C. 40117(d) and 14 CFR 158.15. If the railway project consists of multiple sections, FAA will consider the specific factors of each section, as well as the methodology used, to determine that the project is adequately justified.

Section 121 of the Reauthorization Act has amended the PFC statute by eliminating the significant contribution test. FAA is still required to determine that the public agency has made adequate provision for financing the airside needs of the airport (including runways, taxiways, aprons, and aircraft gates), 49 U.S.C. 40117(d)(4), when reviewing eligible surface transportation projects funded by PFCs above $3.00.

Delta Air Lines expressed concern about approving all projects in a PFC application with a calculated PFC level greater than $3.00 when the significant contribution criteria was met with airside projects at one airport, but the ground access project not meeting the significant contribution criteria is at a different airport controlled by the same public agency.

FAA Response: As stated previously, section 121 of the Reauthorization Act eliminated the significant contribution test. Nevertheless, FAA must be able to determine that it is PFC eligible, adequately justified, and will meet at least one PFC objective as per 49 U.S.C. 40117(d) and 14 CFR 158.15.

4. General

Some commenters (San Diego County Regional Airport Authority (SDCRAA), A4A) were concerned that adding more PFC eligibility for rail access projects may bring added pressure from local authorities to seek PFC funding for non-economically justified projects that are not a high priority. SDCRAA stated "without strict controls on the use of PFCs, airports – whether municipal/county-owned or governed by an independent authority – could be pressured to use PFC revenues to build projects that have little or no value to airports and their stakeholders. City or county-owned airports, in particular, could be subject to local influence by elected officials and regional leaders."

FAA Response: As stated previously, the public agency retains the authority regarding the proposed use of its PFC revenue to address its short and long-term capital needs at the airport. All projects must be PFC eligible, adequately justified, and meet at least one PFC objective per 49 U.S.C. 40117(d) and 14 CFR 158.15.

The Southern Rail Commission recommended FAA expand the eligibility requirements to include operating assistance to local transit agencies, passenger rail authorities, and State governments based on the proration method to be used for rail access project eligibility.

FAA Response: Under 49 U.S.C. 40117(a)(3) and (b), operating assistance is not eligible for PFC funding. There is one statutory exception that allows for PFC revenue to be used for certain "routine work to preserve and extend the useful life of runways, taxiways, and aprons at nonhub airports and airports that are not primary airports, under guidelines issued by the Administrator …." 49 U.S.C. 47102(3)(H). But, that statutory exception is not broad enough to permit FAA to expand the requirements as the Southern Rail Commission recommends.

One AAAE member commented that expanded rail eligibility without an increase in the PFC collection level would limit the effectiveness of the proposed policy.

FAA Response: An increase to the PFC collection level is outside the scope of this policy, as it requires congressional action. Nevertheless, FAA has determined a primary benefit of this policy is that a public agency may be able to use PFC revenue more cost-effectively than before because it could avoid the need to construct a PFC-eligible spur line or separate on-airport people mover system to connect to the regional transit system.

The New York City Economic Development Corporation asked that FAA consider whether the absolute prohibition on funding train tracks off airport property makes sense considering the vast differences in airport sizes. The restriction would place a burden on airports with smaller footprints even though the deviation off airport property may be significantly less than that required to serve an airport with a larger footprint.

FAA Response: The policy is consistent with FAA's statutory authorities. Airport development is defined, in part, to include "constructing, reconstructing, or improving an airport … for the purpose of transferring passengers, cargo, or baggage between the aeronautical and ground transportation modes on airport property." 49 U.S.C. 47102(3)(I) (emphasis added).

https://www.law.cornell.edu/uscode/text/49 https://www.law.cornell.edu/uscode/text/49/47102 49 U.S.C 47102(3)(I)
49 U.S.C. 47102 :(3)"airport development" means the following activities, if undertaken by the sponsor, owner, or operator of a public-use airport:
(I) constructing, reconstructing, or improving an airport, or purchasing nonrevenue generating capital equipment to be owned by an airport, for the purpose of transferring passengers, cargo, or baggage between the aeronautical and ground transportation modes on airport property."

5. Suggested Special Approval Conditions

A4A urged FAA to make clear certain policy conditions will apply upon approval of the final policy. It asked FAA to stipulate the following:

(1) this new policy is limited to on-airport rail access projects only, and no changes are being made for other ground access projects such as roadways;
(2) this new policy will only affect future project approvals;
(3) adequate justification and significant contribution are legal requirements that must be met; and
(4) the new policy does not apply to eligibility and funding under the AIP program.

FAA Response: Two of the policy conditions requested by A4A are incorporated into this final policy: 1) this policy is limited to on-airport rail access projects only, and no changes are being made for other ground access projects, such as roadways; and 2) this new policy will only affect future project approvals. Regarding the other two policy conditions, note first that the significant contribution test was eliminated by the Reauthorization Act. Second, this policy is intended to be narrowly focused on the use of PFC funds. Even though the 2016 Proposed Policy indicated this approach would apply to both PFC and AIP, AIP requirements and prioritization limit funding for rail access projects. In addition, since the publication of the Proposed Policy, most of FAA's focus and the focus of public comment has been in the area of PFCs. In summary, FAA does not contemplate a broader use of AIP funds under this policy.

A4A also commented that FAA should consider providing an agency legal opinion in the docket rescinding the previous opinions referenced in the 2004 Policy and clarifying that railway and roadway projects have different eligibility criteria, at least as to exclusivity.

FAA Response: The legal opinions referenced or cited in the 2004 Policy, such as the PFC Record of Decision, Application No. 96-03-U-00_EWR (Nov. 6, 1996) and the FAA Assistant Associate General Counsel Letter, ADAP Eligibility of High-Speed Rail Service On-Airport (Mar. 15, 1971), remain relevant only to the extent they are consistent with the statement of policy that we promulgate today.

In accordance with the preceding discussion, though consideration of the various stakeholders' comments helped clarify this policy amendment, FAA adopts the 2016 Proposed Policy without material changes. This final policy is consistent with the mandate under section 123 of the Reauthorization Act and with intermodal policy under 49 U.S.C. 47101(b)(5) and (6).

This policy amends the 2004 Policy for consideration of an application to use PFC revenue for a rail access project serving an exclusive use, on-airport station that then extends to serve additional stations beyond the airport. Under this policy, FAA treats rail access projects differently from roads, which is consistent with 49 U.S.C. 40117(a)(3) and (b), 47102(28), 47119(a), and section 123 of the Reauthorization Act. Nevertheless, both exclusive-use stations and tracks (i.e., the railway and related infrastructure) are PFC-eligible costs under either the 2004 Policy or this policy.

Regarding rail stations, those stations located on-airport remain fully eligible for PFC funding. Regarding railway and related infrastructure, those projects that i) are located on-airport and ii) exclusively serve airport traffic remain fully eligible for PFC funding. This policy expands potential eligibility to include the on-airport portion of rail lines even if the railway and infrastructure serve stations other than those on the airport, provided the public agency's cost analysis demonstrates the portion of the proposed project adequately estimates the eligible costs that exclusively serves the airport.

This policy provides three preferred methodologies for calculating the portion of such projects eligible for PFC funding, but a public agency could use a different methodology to demonstrate the portion of the proposed project that exclusively serves the airport. The three methodologies are:

(1) prorating the eligible cost based on the forecast ratio of airport to non-airport ridership;
(2) calculating the cost to build a hypothetical stand-alone people mover system connecting the airport's terminal(s) to a regional transit system, which would otherwise meet the elements of the 2004 PFC Policy; or
(3) calculating the difference between the cost of a line that bypasses the airport and the cost of a through-line configuration.

FAA has determined, and most commenters agree, that the proration methodology is the most straightforward approach. This approach using forecasts that are reasonably justified should be adequate for most projects and should be the presumptive method used by the public agency. If, however, the public agency determines that the proration methodology would not adequately estimate the eligible costs, then the public agency may use one of the other two methodologies provided for in the 2020 Policy discussed in the "Statement of Policy." FAA anticipates using another methodology will require significant planning, cost detail, and justification for FAA to make an eligibility determination. In addition, FAA may consider other cost eligibility methodologies on a case-by-case basis if unique circumstances warrant.

The options provided are permissive, not mandatory, and are non-exclusive. This guidance does not constitute a regulation, and is not legally binding in its own right. It will not be relied upon as a separate basis by FAA for affirmative enforcement action or other administrative penalty. This guidance will not affect rights and obligations under existing statutes and regulations

This guidance will not impose any additional costs, significant or otherwise, on public agencies seeking to use Passenger Facility Charges. Airports or local transit agencies will have already conducted extensive alternatives analysis for a through-airport rail line, including the preparation of station-level ridership forecasts conceptual or schematic cost estimates, and therefore the use of the preferred methodology for calculating PFC eligibility would not create any extra workload or cost for the airport or any other entity. Airports that choose to use the stand-alone people mover system or incremental cost methodologies would also presumably do so only if such estimates were readily available from other studies, rather than developing them only for the purpose of calculating PFC eligibility.

Policy Statement

I. Applicability

The following policy is applicable only to PFC funding for rail access projects that serve an exclusive use, on-airport station and then extend to serve off-airport stations. The use of PFC revenue to finance rail access projects that terminate at an airport, and all other ground access projects, continues to follow FAA's Notice of Policy Regarding Eligibility of Airport Ground Access Transportation Projects for Funding Under the Passenger Facility Charge Program (69 FR 6366) published on February 10, 2004.

II. Eligibility

Historically, on-airport railway stations are eligible for PFC funding, because they are for the exclusive use of airport patrons and employees. However, eligibility for the right-of-way or railway itself depended upon the configuration of the railway. If the configuration terminated at the airport, such as a spur line, FAA found that it was eligible for PFC funding. If the railway was a through-line where the airport station was not the terminus, it was not.

FAA has reconsidered this interpretation and determined the 2004 exclusive use policy is unduly limiting. FAA supports the use of PFC funds to "encourage the development of intermodal connections on airport property between aeronautical and other transportation modes and systems to serve air transportation passengers and cargo efficiently and effectively and promote economic development." 49 U.S.C. 47101(a)(5). Consistent with the statutory and regulatory limitations of the PFC program, on-airport railway stations, right-of-way, and railways are eligible for PFC funding as described in this policy.

III. PFC eligibility for a railway serving an exclusive use, on-airport station and then extending to serve additional stations beyond the airport

Airport rail access projects serving an exclusive use, on-airport station and then extending to serve additional stations beyond the airport may be eligible for PFC funding. The 2004 Policy was issued in question and answer format. FAA stated under the heading "How Is PFC Eligibility Established?" that as a matter of policy: an eligible airport ground access project is one meeting the following conditions:

> (1) The road or facility may only extend to the nearest public highway or facility of sufficient capacity to accommodate airport traffic;
> (2) the access road or facility must be located on the airport or within a right-of-way acquired by the public agency; and
> (3) the access road or facility must exclusively serve airport traffic.

69 FR 6366, 6367.

Under this new policy, on-airport rail access projects no longer will be treated identically to road access projects, and a portion of a rail access project may be eligible even if the rail project in its entirety serves more than exclusively airport traffic. Three preferred methodologies for calculating the portion of the project eligible for PFC funding are:

(1) prorating the eligible cost based on the forecast ratio of airport to non-airport ridership;
(2) calculating the cost to build a hypothetical stand-alone people mover system connecting the airport's terminal(s) to a regional transit system, which would otherwise meet the requirements of the 2004 PFC Policy; or
(3) calculating the difference between the cost of a line that bypasses the airport and the cost of a through-line configuration.

FAA has determined the proration methodology is the most straightforward and reliable methodology and, therefore, it should be the presumptive method used by the public agency. If, however, the public agency determines that using a prorated amount based on ridership methodology would not adequately estimate the eligible costs, the public agency may use one of the other methodologies. A cost analysis using another methodology should be supported with documentation of sufficient planning and defensible, conceptual cost estimates for FAA to make an eligibility determination. FAA may consider other cost eligibility methodologies on a case-by-case basis if unique circumstances warrant.

IV. Calculating eligible PFC funding using a prorated ridership methodology

Prorating the cost of a railway project serving an exclusive use, on-airport station and then extending to serve off-airport stations based on a forecast ratio of airport to non-airport ridership is generally the most straightforward and reliable methodology to use in calculating the cost of the project eligible for PFC funding. Its reliability is based, in part, on its simplicity. The proration method looks only to ridership and avoids the consideration of hypothetical rail configurations; configurations that should be vetted for reasonableness in the first instance, and also that should be accompanied by reliable cost estimates. Because this methodology relies on a forecast of future ridership, the forecast should be based on reasonable assumptions. FAA will rigorously review the proposed forecast and applied ratio of airport to non-airport ridership.

In addition, FAA may seek advice from other Federal agencies as to the reasonableness of the forecast and may publish the forecast for public comment. Therefore, it is critical for the public agency to submit the forecast well in advance of submitting the PFC application. The public agencies using this methodology should make the forecast available during the public notice and air carrier consultation process. The burden of justifying the forecast is on the public agency.

V. Calculating eligible PFC funding using a cost analysis of a separate stand-alone people mover system

In limited circumstances, a public agency or FAA may conclude that a prorated ridership methodology does not adequately estimate the PFC-eligible cost of a project given local circumstances and considerations.

An alternative cost analysis could analyze the cost of a people mover system that connects with the regional transit system. The analysis should only include the capital development and related planning, environmental, and design costs of each option. The eligible cost is the cost of the through option not to exceed the cost of the hypothetical people mover system.

FAA will analyze, and make a determination based on, the materials in the airport's PFC application. Limiting costs for the analysis to those for capital development and related planning, environmental, and design costs ensures that the analysis is made consistent with PFC eligibility and allowable cost criteria in 14 CFR part 158. The burden of justifying the underlying assumptions and costs in this approach is on the public agency.

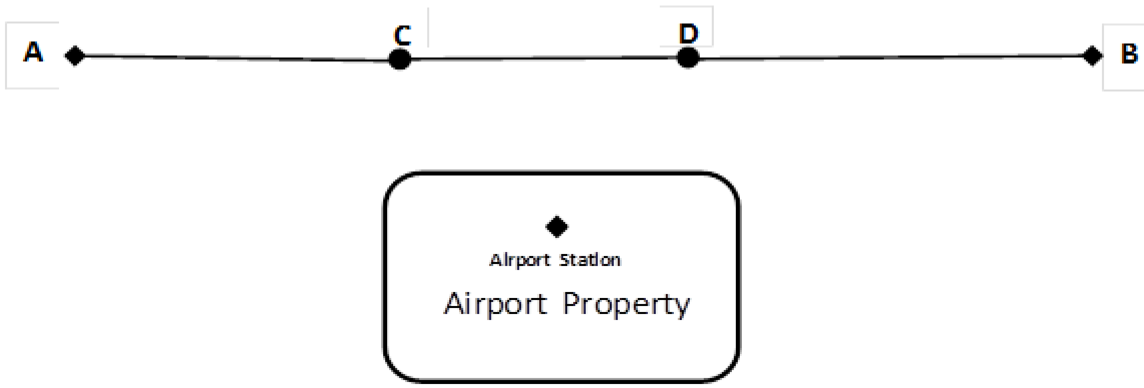
VI. Calculating eligible PFC funding using a calculation to determine the incremental costs of a railway that would benefit only the airport passengers and employees

A public agency may have better planning and cost detail from a metropolitan transit agency for a bypass option that does not serve the airport than it would for a separate people mover system serving the airport. In such instances, the public agency could use an approach that calculates those project related costs that are directly related to benefiting only the airport passengers and employees.

Detailed Discussion of Incremental Cost Alternative:

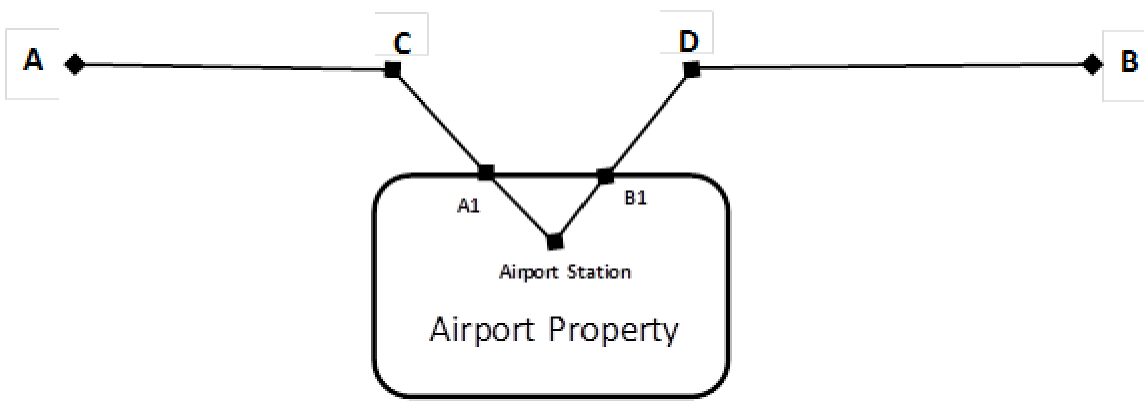
- For this alternative, FAA considers a rail line that bypasses the airport (C to D)

Track that Bypasses the Airport



- FAA then considers a proposed modification of that line which does serve the airport (C-A1-Airport Station- B1-D).

Track that Includes the Airport Station



- The cost difference between the two scenarios would be the costs specifically attributed to serving the airport passengers and airport employees (i.e., incremental costs). This cost difference is determined and that amount caps the eligibility. 14 CFR 158.13(a).
- The eligible amount then equals the costs of the on-airport property rail lines not to exceed the calculated cap (A1-Airport Station-B1).

The public agency should provide sufficient planning and cost detail for both options for FAA to determine the accuracy and reasonableness of the incremental costs. Such information should include cost elements such as the land or right-of-way acquisition costs as well as the railway and supporting infrastructure costs. The burden of justifying the underlying assumptions and costs in this approach is on the public agency.

VII. Review of ridership forecasts

A key consideration in determining the PFC eligibility is the forecast of future airport and non-airport ridership for airport use rail access projects. FAA will evaluate, but not approve or disapprove, the forecasts provided by the public agency. FAA will consider the reliability of the forecast to complete the project evaluation. FAA will use the following considerations typically used by the Federal Transit Administration (FTA) when reviewing project forecasts:

1) the properties of the forecasting methods;
2) the adequacy of current ridership data to support useful tests of the methods;
3) the successful testing of the methods to demonstrate their grasp of current ridership;
4) the reasonableness of inputs (demographics, service changes) used in the forecasts; and
5) the plausibility of the forecasts for the proposed project.

FTA provides guidance on forecast methods and related review timelines on its website, https://www.transit.dot.gov/funding/grant-programs/capital-investments/travel-forecasts. Public agencies should consider the difficulty in accurately predicting airport versus nonairport ridership. If the forecast is not carefully developed and overstates airport ridership, it can result in the PFC revenue being improperly used for the prorated airport ridership cost, creating an unwanted subsidy. On the other hand, the forecast could underestimate airport ridership potentially underutilizing PFC funding. In determining a prorated ridership ratio, the forecast should only consider the ratio of airport to nonairport ridership to and from the airport terminal station and the next immediate off-airport station in both directions, not the entire railway ridership. To the extent possible, ridership forecasts should be supported with passenger surveys. FAA may consult FTA or other agencies in its review of ridership forecasts.

VIII. Rail Access and Airport Land Acquisition

In applying this policy, FAA will work to ensure that airports do not use PFCs to acquire land and expand rail access beyond what is eligible, adequately justified, and meets at least one PFC objective as per 49 U.S.C. 40117(d) and 14 CFR 158.15. PFC eligible costs are limited to on-airport, railway access projects. All PFC approvals are subject to evaluation under the National Environmental Policy Act. FAA already has safeguards in place to ensure that PFCs are not used to acquire land for rail access that is not for airport use. Further, airports are expected to ensure their airside needs are met before using PFC revenues for terminal and landside projects (49 U.S.C. 40117(d)(4)).

From:	Kirsten Uchitel
To:	Lauren Lee
Subject:	Amendment Comment
Date:	Friday, January 27, 2023 11:32:25 AM
Attachments:	NOP_and_ScopingLetter12_9_2022.pdf BullockToSANDAG_RE_ScopingTheSEIR_for RUC_RemovalRfromThe2021RTP.doc Ref1_AdoptedBikePedRUC_Resolution 22-01 3-14-22.pdf Ref2_RoadUseChargeLetter.pdf Ref3_MBullock-Plat-FP-EA-796315-Deriving_Climate_Stabilizing30March20-R3.docx Ref4_AG_LetterToSANDAG_2021.PDF Ref5_2020LDV_ClimateStabilizingVrsCARB_AWMA - Copy.pdf Ref6_2020PlatformClimate-TransV2.doc Ref7_DividendAccount2020v2.doc Ref8_BullockEUEC2021_ParkingOscCivicCenter.pptx Ref9_DividendAccountParkingRFI3.docx Ref10_ACE CEO Wants to Provide the Solution - Copy.pdf

From: mike_bullock@earthlink.net <mike_bullock@earthlink.net>
Sent: Monday, January 9, 2023 2:09 PM
To: Kirsten Uchitel <Kirsten.Uchitel@sandag.org>
Cc: Hasan Ikhrata <Hasan.Ikhrata@sandag.org>; 'Mike Bullock' <mike_bullock@earthlink.net>
Subject: Scoping the SEIR for Removing the RUC from the 2021 RTP

Kirsten Uchitel, Associate Regional Planner
SANDAG
401 B Street, Suite
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Via E-mail: Kirsten.Uchitel@sandag.org
Subject: Scoping the SEIR for Removing the RUC from the 2021 RTP AND the NOP letter from SANDAG dated December 9, 2022.
Associate Regional Planner Uchitel,
I appreciate the opportunity to comment on the subject and the ***Notice of Preparation of Supplement to the Environmental Impact Report for the 2021 Regional Plan and Public Scoping Meeting Notice*** letter, dated December 9th, 2022. I have attached the letter, for the convenience of any reader of this email. It is the first attached file.
Please find attached my comment letter. It is the second attached file.
I have also attached all 10 of the letter's references. They are in order and named to show their reference number.
Thank you for your leadership in performing your critical work. Thank you for reading this material and for providing the comments and response. Please let me know if you would like to meet to discuss this letter or related topics.

Highest regards,

Mike Bullock
1800 Bayberry Drive
Oceanside, CA 92054
760 421 9482

Former California Democratic Party Delegate, 76th Assembly District (author of 2 adopted resolutions and 5 Platform changes)
Former Elected (now Associate) Member of the San Diego County Democratic Party Central Committee (author of 5 adopted resolutions)

Final title before leaving Aerospace: ***Senior Staff Systems Engineer***

Air and Waste Management Association published and presented papers:
Author, ***The Development of California Light-Duty Vehicle (LDV) Requirements to Support Climate Stabilization: Fleet-Emission Rates & Per-Capita Driving***
Author, ***A Climate-Killing Regional Transportation Plan Winds Up in Court: Background and Remedies***
Co-author, ***A Plan to Efficiently and Conveniently Unbundle Car Parking Cost***

Quotes from the Secretary General of the UN:

1. We have a Code Red Climate Emergency
2. We are solidly on a path to an unlivable planet
3. We are driving towards Climate Hell with our foot on the accelerator
4. We are dangerously close to the point of no return

Mike Bullock
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January 10, 2023

Kirsten Uchitel, Associate Regional
Planner SANDAG
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San Diego,
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Via E-mail: Kirsten.Uchitel@sandag.org
Subject: Scoping the SEIR for Removing the RUC from the 2021 RTP AND the NOP letter from SANDAG dated December 9, 2022.

SANDAG,

I appreciate the opportunity to comment on this important subject.

<u>Introductory Comments</u>

Removing the RUC from the 2021 RTP is a major change. As will be shown in this letter, there are many indications that it would be ill-advised. If the SEIR exposes this truth, the SANDAG Board could relent and the SANDAG staff could get on with the work of producing the 2025 RTP, with an improved RUC and implementing the 2021 RTP. The state RUC should be

- a replacement for the state gas tax,
- means based,
- designed to protect privacy,
- value-priced, with a dynamic congestion pricing algorithm to ensure free flow on at least some lanes, and
- implemented as soon as possible, in recognition of our 2030 climate stabilization requirement to significantly reduce per-capita driving (to be shown.)

The 2025 RTP could add in additional charging if needed in coordination with the state. Reference 1 has more information on why we need a RUC. It also describes many of the needed RUC characteristics. Reference 2 shows the strong support from the environmental community for a RUC.

As will be shown, doing a legal SEIR will require that SANDAG learn how to do an RTP that achieves the first-occurring climate stabilization requirement. Learning that will help SANDAG understand that the 5 Big Moves (the 2021 RTP) can be a framework allowing the changes we so desperately need. SANDAG will learn what is important (supporting climate stabilization at a livable level) and how it can be done.

<u>Comments on the Subject (NOP) Letter</u>

Project Description

SANDAG has not taken the physical reality of our climate emergency seriously and has not considered the fact, from the cumulative-effect standpoint (what would happen if all the RTPs did exactly what SANDAG's RTP does), that its work could be, and helping to cause our Earth's climate to destabilize. Climate destabilization is a process that, from a practical, human-survival standpoint, is unbounded in its harm to life on our planet. Human survival requires climate stabilization. That fact is relevant to your work because light-duty vehicles, or LDVs is the category that emits the most GHG, in our County, in our state, and in our nation. This information is not provided in the Project Description section.

Not taking the physical reality of our climate crisis seriously is shown in the letter's ***Project Description*** paragraph because it suggests to the reader (mostly by omission) that all that is important about this project is meeting the SB 375 targets, without even hinting to the reader that failing to reduce emissions from light-duty vehicles (LDVs) enough, in time, would have a potentially disastrous impact on our physical world and the prospect of human survival. That unmentioned impact, climate destabilization, is an "Environmental Impact" and there is no justification for ignoring it. How soon and by how much we must reduce our emissions to avoid climate destabilization is a question that can only be answered by climate scientists. Therefore, SANDAG has the responsibility to find and use the most accurate, fact-based climate stabilization requirements. Note the use of the word "requirement" instead of "target". Systems engineers and other serious problem-solvers write "Requirements Documents." They do not write "Targets Documents". "Targets" specified to ensure human survival should be renamed "requirements", by SANDAG.

Page 6 of Reference 3 shows that the first-occurring climate stabilization requirement is for the year of 2030. The second one occurs in 2045 and it is generally thought to be net-zero emissions. However, what happens in 2045 won't matter if our failure to achieve the 2030 requirement sets off climate-destabilization.

There is no reason to think that the CARB-provided, SB 375 targets support climate stabilization. The current state mandate for 2030 is 40% below our 1990 emission level. However, the state attempted to change this to 65%. That attempt failed in the State Senate by several votes. Reference 3 contains a calculation, based on a unambiguous statement in a reference document signed by our best climate scientists, that shows that the real value is 80%. What is SANDAG's determination regarding the 2030 requirement? No one knows and that makes SANDAG's work in violation of CEQA law. Recall that the articles in the paper on the COP-25, COP-26, and COP-27 discussions refer to commitments to reduce GHG emissions in 2030. SB 375 is obsolete since its target year is 2035.

SANDAG has been ignoring the critical need to achieve climate stabilization for many years. They should have realized that climate stabilization is important when the State of California sued them in 2011. In Reference 4, the AG of California (Harris) states in Footnote 21:

> ***The DEIR therefore does not find the RTP/SCS's failure to meet the Executive Order's goals to be a significant impact. This position fails to recognize that Executive Order S-3-05 is an official policy of the State of California, established by a gubernatorial order in 2005, and designed to meet the environmental objective that is relevant under CEQA (climate stabilization). SANDAG thus cannot simply ignore it.***

What is relevant here is the point I have been making and that SANDAG has been ignoring: ***The environmental object that is relevant under CEQA is climate stabilization.*** And furthermore, SANDAG thus cannot legally continue to ignore it. In case some reader gains comfort from the fact that S-3-05 was designed, back in 2005, to support climate stabilization, It should be noted that S-3-05 is hopelessly out of date. GHG emission reductions that were hoped for back in 2005 have not taken place and our knowledge about anthropogenic climate change has improved. The S-3-05 requirement for 2050 we now know must now be achieved by the industrialized world by 2030.

How do we achieve climate stabilization? We avoid climate destabilization. And how do we do that? We achieve the climate-stabilization requirements: the one for 2030 and the one for 2045. As a practical matter, SANDAG only needs to focus on the 2030 requirement because the 2045 requirement will be relatively easy if we achieve the 2030 requirement.

EIR Scope

It says that a lead agency, like SANDAG, may prepare a Supplemental EIR when some conditions from CEQA Guidelines (Section 15162) require it, but only if ("and"):

> ***only minor additions or changes would be necessary to make the previous EIR adequately apply to the project in the changed situation***

The problem here is that SANDAG has kept itself and everyone else in the dark about where the 2021 RTP LDV emissions fall, relative to the 2030 climate-stabilization requirement. Therefore, as far as anyone relying on the current EIR knows, it may be that removing the RUC causes the LDV emissions to move from less than the 2030 climate-stabilization requirement to more than the 2030 climate-stabilization requirement. If that is true, the cumulative effect principle means that the outcome would go from acceptable (climate stabilization), with the RUC, to catastrophic (destabilization), without the RUC. That would mean that what may have seemed like a minor change to the RTP would cause an enormous and catastrophic change in the environmental outcome. Later in this letter there are many reasons provided to conclude that removing the RUC is a very large and a very environmentally harmful change.

There is also the matter of illegality. The previous EIR ignored any mention of the environmental impact of climate destabilization. No one sued SANDAG over this omission. Does this mean that the previous EIR was legal? I assume that there is a time limit on when a suit can be filed and that the time limit has expired. Therefore, one might be required to act as if the previous EIR was legal. However, the previous EIR is getting changed. Does this mean that the illegal behavior (the behavior of ignoring climate destabilization) that resulted in the FEIR of the project with the RUC is acceptable in the SEIR for the project without the RUC? It is not, based on the words above. Illegal behavior that resulted in the original project cannot be allowed in the changed project, because of the word "adequately". Again, here are the key words from above with the highlight added:

> ***only minor additions or changes would be necessary to make the previous EIR <u>adequately</u> apply to the project in the changed situation***)

Since the environmental impact of destabilization must be considered, an SEIR is not appropriate unless it does an analysis of the project with and without the RUC, considering their impact on climate destabilization. No EIR or SEIR is adequate if it ignores the environmental impact of destabilizing the earth's climate. No one should think that SANDAG's geography is too small to matter to a global outcome. The principle of "cumulative effects" disallows that form of escapism. Like it or not, the SEIR scope must include a full analysis of the changed RTP's impact on climate stabilization.

Any sort of EIR must consider "Environmental Impacts" that are not trivial. Climate destabilization is tremendously impactful. An issue of *Scientific American* said that it would cause a "devastating collapse of the human population". One can reasonably assume that the direct cause of this collapse would be a loss of habitat, resulting in mass starvation, and that many species would suffer the same fate. This is not a trivial environmental impact.

Given all this, there is almost a comical aspect of the list of potential impacts and calling them "environmental resources", on Page 2. There are 19 of them listed, from

"Aesthetics and Visual Resources" to "Wildfire". The eighth one down is "Greenhouse Gas Emissions." That is an odd "environmental resource." More to the point, the listing hides the unique and disastrous outcome of increasing GHG. No other of the "resources" on the list will cause human extinction, except, for some of them, because they will themselves result in more GHG. GHG is a killer, because our current atmospheric CO2 level is 420 PPM, whereas before the industrial revolution started in was at around 280 PPM. We are in very dangerous territory.

This section is another example of how SANDAG is covering up the physical reality of our climate emergency and has apparently not considered the fact, from the cumulative-effect standpoint (what would happen if all the RTPs did exactly what SANDAG's RTP does), that its work could be helping to cause our Earth's climate to destabilize, a process that, from a practical, human-survival standpoint, is unbounded in terms of how bad it would get. Human survival requires climate stabilization.

<u>More Facts About Why SANDAG Must Stop Ignoring Climate Destabilization</u>

Here are some quotes from the Secretary General of the UN about our climate crisis:

1.) ***We have a Code Red Climate Emergency***
2.) ***We are solidly on a path to an unlivable planet***
3.) ***We are driving towards Climate Hell with our foot on the accelerator***
4.) ***We are dangerously close to the point of no return***

The "point of no return" refers to a point where a climate destabilizing process gets so large in magnitude that we have no way to stop it. We are "solidly on a path" to having that happen. The only way to get off that path is to achieve the 2030 climate-stabilization requirement. SANDAG needs to do the right thing, from both a moral and a legal standpoint.

<u>Scope: The SEIR Must Correctly Assess the 2021 RTP with the RUC Removed</u>

To adequately evaluate the change (RUC removal), climate destabilization must be considered for both the 2021 RTP with the RUC and for the 2021 RTP without the RUC. Pretending that climate destabilization can be ignored is never adequate and is never legal under CEQA. As clearly stated by the California AG back in 2011, repeated from above:

> ***The environmental object that is relevant under CEQA is climate stabilization.***

This brings up the question of how SANDAG could evaluate the climate stabilization impacts of the 2021 RTP with and without the RUC.

Here's how. To result in climate stabilization, an RTP must conform to a set of enforceable measures that would cause cars and light-duty trucks (LDVs) to achieve the 2030 climate-stabilization requirement. The only way to check such conformity is to have a plan that contains a set of enforceable measures that causes LDVs to achieve the 2030 climate-stabilization requirement and to have the derivation of the plan. The derivation would show the relationships between the measures and the resulting GHG emission level. The plan would also show the derivations of the relationships. No such plan is unique. Using the derivations and the relationships, any proposed RTP could be evaluated to see if it would reduce emissions enough to achieve the 2030 requirement. A plan could also be adjusted to achieve the 2030 requirement. The adjustments could take the form of adding mitigation measures or adjusting the plan's existing measures to increase their emission reductions.

But there is a problem. SANDAG has no such plan and does not know of a set of derivation that would make it relatively easy to evaluate plans for their climate stabilization impact.

If CARB has such a plan and set of derivations, they are not sharing it. They make authoritative statements asserting that electrification of LDVs cannot happen fast enough and that therefore we also need significant reductions in our per-capita driving. However, they do not share their work that makes that conclusion.

I have done the derivation and created a plan that would cause LDVs to achieve the 2030 requirement. It is Reference 3. It is peer reviewed and has been presented at many Air and Waste Management Association Conferences. For example, the following words were emailed to me from the AWMA:

> *On behalf of the Air & Waste Management Association (A&WMA) Technical Council, we are pleased to confirm that your abstract submission #796315, entitled "Deriving a Climate-Stabilizing Solution Set of Fleet-Efficiency and Driving-Level Enforceable Measures for Light-Duty Vehicles in California", has received a favorable review, and is accepted as a platform for presentation at A&WMA's 113th Annual Conference and Exhibition (ACE). The conference will be held June 29-July 2, 2020, in San Francisco, California. Your assigned session is entitled "Transportation Policies for Climate Change" and is preliminarily scheduled for Tuesday, 6/30/2020 between 1:30 pm-3:10 pm.*

Using the derivations, it would not be too difficult for you to evaluate the 2021 plan, both with and without the RUC. It would also show you how the 2025 RTP could be constructed to achieve the 2030 climate-stabilization requirement.

Documenting that the 2021 RTP EIR Did Not Consider the Impact of Climate Stabilization

Incorrect Primary Task

Chapter 1 introduces the 5 “Big Moves,” an approach which seems to reflect a recognition that we need fundamental change. However, before the strategies are identified, a falsehood is suggested. The falsehood it suggests is that the primary task is to enhance mobility while achieving “state and federal requirements”, regarding climate change and air pollution.

It says, regarding the 5 Big Moves (emphasis added in bold type):

> *These interdependent strategies are designed to address the greatest transportation and mobility challenges that we face: safety and traffic congestion, social inequities, and* ***state and federal requirements to reduce greenhouse gas (GHG) emissions and air pollution****.*

That statement shows a fundamental misunderstanding of the climate emergency that we face. By far, our greatest “mobility challenge” is to design and adopt a regional transportation plan (RTP) that will guarantee that the GHG emissions from *cars and light-duty trucks* (the “Light-Duty Vehicle” or “LDV” category called out in SB 375) will meet the climate-stabilizing requirements provided by climate science. The first climate-stabilizing requirement is for LDVs to emit GHG at no more than 80% below the level they emitted in 1990, by no later than the end of 2030 (Reference 3). If we meet the 2030 requirement, the later requirement will be relatively easy. The later requirement is to have LDVs and all other GHG emitters emit no more than what can be offset by carbon sequestration (AKA “net zero). This is the “net zero” emission level of 2045. Often, governments only speak of the “net zero” requirement of 2045 (or 2050, the older value), without mentioning the more-difficult 2030 requirement.

Primary Challenges Misstated

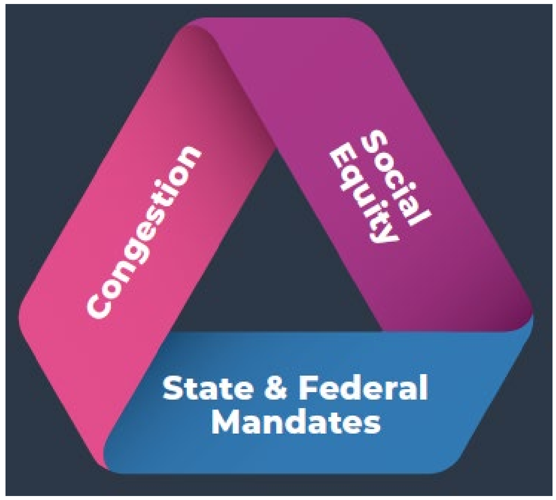
Figure 1 is from Section 1 of the EIR of the 2021 RTP (with the RUC). It is said to show our “three primary challenges”

Our *Code Red Climate emergency* is mankind’s primary challenge. It means that our *Region’s* primary challenge is to do its part to ensure that the emission of GHG from our LDVs in 2030 support climate stabilization. Their emissions must be 80% lower than they were in 1990.

Reference 3 shows how that can be done. We will need to significantly reduce VMT, as proven in Reference 3 and as will be shown in Table 1. When that is done, there will be no congestion and, given that fact, it is not correct to assert that *Congestion* is a primary challenge. *Social Equity* is a goal, like “*Democracy*” or “*Equal Opportunity*” that we must always move towards, as fast as we can. However, when “*Social Equity*” is discussed in the context of our Anthropogenic climate change problem, the harm of living close to pollution caused by our reliance on fossil fuels is often mentioned. That harm will be reduced and, in some cases (refineries will be closed) eliminated, if we meet our climate-change challenge. The largest “*Social Inequity*” would be climate destabilization because it would cause a “devastating collapse of the human population” to quote from the June 2008 issue of *Scientific American’s* article, *Ethics and Economics of Climate Change*. Many reliable sources write that human extinction will be an outcome of climate change failure, which is the path we are on now. This will be the ultimate *inequity* if it happens and make no mistake, it will probably happen.

Climate destabilization, as described in Reference 3, will end most life forms (not microbiology perhaps, however) and almost certainly our own species. This environmental impact must be fully explained in a legal EIR or SEIR. The EIR for the 2021 RTP has no such discussion or explanation.

Figure 1 The DEIR's Erroneous Claim of "Three Primary Challenges", for our Region



Need to Reimagine

Chapter 1's Page 7 statement that there is an "urgent need to reimagine our regional transportation system" is correct.

Reimagine Example Left Out

That is one of the places (Chapter 1's Page 7) where SANDAG should state that we must stop widening freeways. Instead of widening freeways, as called for in the current, fatally flawed, version of the *Transnet* sales tax, we should be reducing the size of our freeways. The well-understood principal of *Induced Traffic Demand* informs us that adding more lanes will not reduce congestion, but it will increase VMT. *Induced Traffic Demand* also informs us that removing lanes will not increase congestion, but it will decrease VMT. As shown in Reference 3 and Table 1 of this letter, we must reduce VMT. The *Transnet Ordinance* can be changed in an emergency. We have an emergency.

Vision, Goals, Strategies, and Actions Are Useless if Our Earth's Climate is Destabilized

Page 13 starts a discussion which seems to be written for some other planet or for some other time on our planet. Climate destabilization would lead to a collapse of our human population and eventual extinction. Therefore, Page 13's

- *Vision, Goals, Strategies, and Actions*

must be replaced with

- *A Requirement, Vision, Goals, Strategies, and Actions*,

The *Requirement* is to ensure that our transportation system supports the climate-stabilization requirement of 2030, as shown in Figure 4 of this letter. Reference 3 shows how this can be done, for LDVs. Most of the fleet-efficiency requirements are shown in Table 1 of this letter. (All of the needed fleet-efficiency requirements are described in Reference 3.) Table 1 also shows the driving reduction that is computed in Reference 3. It is a 32% reduction in per-capita VMT, with respect to year 2005. It's expressed using the SB 375 conventions for expressing driving reductions. Even though SB 375 states that it is about a *GHG* reduction, it is really about a *VMT* reduction, because SB 375 clearly states that the Metropolitan Planning Organizations (MPOs, like SANDAG) can take no credit for GHG reductions accomplished by the state. The state has the fleet-efficiency responsibility. The Metropolitan Planning Organizations (MPOs, like SANDAG) have the responsibility to reduce driving. Therefore, the SB 375 reductions in LDV GHG must be produced by SANDAG measures to reduce LDV VMT. In other words, SANDAG's responsibility is to reduce driving.

The Fatal Flaw of Not Saying What's Important

On Page 13 of Chapter 1 of our 2021 RTP, it says, "The 2021 Regional Plan reduces per capita GHG emissions from cars and light duty trucks by 20% below 2005 by 2035". The document does not say whether-or-not this is enough to support climate stabilization. Tragically, it is *not* enough to support climate stabilization. The 2030 climate-stabilization requirement is derived in Reference 3 and is shown in Figure 4 of this letter.

Similarly, Chapter 1 lists key goals, policies, and Executive Orders that were considered. They are shown here in Figure 2.

The problem is that the document is supposed to be sufficient to support an EIR, which is to say it must report on the environmental impacts of what is being done. The environmental impacts are what will happen in the physical world, not in the legislative or judicial world. To figure out what will happen in the physical world, the resulting emissions need to be compared to what the climate scientist are telling us we must accomplish if we want to stabilize the climate at a livable level.

That information is nowhere to be found in the current 2021 RTP or its DEIR. That is clearly illegal because the decision makers and the public need to understand what will happen to our planet if all transportation planning followed the path described by SANDAG as in the "cumulative effects" consideration.

The "cumulative impacts" consideration means that no one can get by using an argument that a discretionary project being considered is "too small to matter".

Figure 2 is an admission of guilt (climate-stabilization failure) because it is described as containing SANDAG's "key goals". No climate-stabilization requirement is listed. SANDAG might be, technically, within CEQA law for the 2045 to 2050 requirement of zero net emissions because this happens to be covered by the EO B-55-18 executive order. However, SANDAG needs to state that zero net emissions by 2045 is our second climate-stabilizing target and that is covered by EO B-55-18. Where SANDAG clearly is in violation of CEQA law is that it does not state that the industrialized world's first climate-stabilization requirement (target), which is for 2030, is to emit GHG at no more than 80% below what we emitted in 1990, as is derived in Reference 3 and shown on Slides 10 and 11 of Reference 5. SANDAG needs to redo its RTP using a Plan like that shown in Reference 3, besides doing a revised EIR for the 2021 RTP and an SEIR for the 2021 SEIR with the RUC removed.

Figure 2 SANDAG's Admission of Climate-Stabilization Failure Because These Do NOT Cover Achieving the Industrial World's 2030 Climate-Stabilizing Target.

Key State goals, policies, and Executive Orders considered in the 2021 Regional Plan:

- SB 375 and SCS Program and Evaluation Guidelines
- California Assembly Bill 805 (Gonzalez Fletcher, 2017): Identification of disadvantaged communities, inclusion of strategies to reduce pollution exposure in those communities, and use of a skilled and trained workforce
- 2017 Regional Transportation Plan Guidelines for Metropolitan Planning Organizations[5]
- California Transportation Plan 2050
- California Senate Bill 32 (Pavley, 2016): Reduce GHG emissions 40% below 1990 levels by 2030
- EO B-55-18: Carbon Neutrality by 2045
- EO S-3-05: Reduce GHG emissions 80% below 1990 levels by 2050
- EO N-79-20: 100% zero-emission vehicle sales by 2035
- EO N-82-20: Conserve at least 30% of California's land and coastal waters by 2030

Achieving the industrialized world's 2030 Climate-Stabilizing Requirement would obviously be a "Key policy" and accomplishment for SANDAG. Figure 2 and the stated organization of the DEIR means that there is no need for me to read further to know that SANDAG has made no effort to consider what it would take for the RTP to conform to achieving the 2030, climate-stabilizing requirement. Page 13 of Chapter 1 of the 2021 RTP presents the RTP's Visions and Goals. There is nothing there about stabilizing the climate at a livable level. That is shown in Figure 2, which is taken from Chapter 1 of the RTP.

Also, Chapter 2 is defined by what is written on Page 15 of Chapter 1. It says there that Chapter 2, the Transportation Plan's Regional Sustainable Community Strategy

(SCS, which is required by SB 375), describes “the land use strategies, and programs that will achieve our Vision and Goals.”

Chapter 1 of the 2021 RTP describes SANDAG’s “Vision and Goals”. None of them include achieving the 2030 climate-stabilizing requirement, or “target”.

Figure 3 SANDAG’s Admission of Climate-Stabilization Failure, Because These Statements, From Page 19 of the RTP’s Chapter 2, Show that the SCS Does Not Come Close to Achieving the Industrial World’s 2030 Climate-Stabilizing Target.

> **Sustainable Communities Strategy**
>
> The 2021 Regional Plan includes a Sustainable Communities Strategy (SCS), as required by California Senate Bill 375 (Steinberg, 2008) (SB 375), for the San Diego region. This SCS describes coordinated transportation and land use planning that exceeds the state’s target for reducing per capita GHG emissions set by the California Air Resources Board. The state-mandated target is a 19% reduction in per capita GHG emissions from cars and light duty trucks, compared with 2005, by 2035. The 2021 Regional Plan achieves a 20% reduction by then.

The title of this letter’s Figure 3 is true because Reference 3 shows that even with an extremely aggressive schedule of fleet electrification (such as 70% of new car sales be for electric cars, by 2024, as shown in Table 1 of this letter), the per-capita driving reduction needs to be 32% by 2030, which is far larger than the 20% by 2035 documented in Figure 3. Because SANDAG cannot take credit for fleet efficiency improvements, the phrase “GHG Emissions”, used in Figure 3, is actually “VMT”.

The 2021 RTP’s Chapter 3 covers financing. The 30 appendices provide the details and background of how the “Vision and Goals”, which do not include the 2030 climate-stabilizing requirement, are achieved.

How to Design an RTP that Contributes to Climate Stabilization

RTPs that achieve the 2030 requirement must be built using the mathematical relationships that that connect the fleet efficiency in year 2030 and the per-capita driving in 2030 with the 2030 climate-stabilization requirement. The math must also account for the percent of our electricity that is renewable, in 2030.

Therefore, the math must derive the following two items:

- So-called, “fleet efficiency” (CO_2 emitted per mile of all the LDVs on the road, for a given year), given the percent of electricity that is from renewables) and
- per-capita driving

that will, taken together, achieve the “80% below 1990 level by 2030” requirement.

The peer-reviewed Reference 3 does this. It shows 4 cases of fleet-efficiency requirements and the per-capita driving that could be allowed, given the 2030, climate-stabilization requirement stated above.

For the benefit of readers that don't want to look at Reference 3, here is Table 1, showing the primary results of 4 cases:

Table 1 4 Cases that Support the 2030 Climate-Stabilizing Requirement

Note: Purple denotes difficult; red, impossible.

	Case Designations			
	Balanced_1	Balanced_2	2005 Driving	Mary Nichols
% Renewable Electricity	85.0%	90.0%	90.0%	90.00%
% ZEVs, Year 2016	2.0%	2.0%	2.0%	2.70%
% ZEVs, Year 2017	2.0%	2.0%	2.0%	2.70%
% ZEVs, Year 2018	3.0%	3.0%	3.0%	5.11%
% ZEVs, Year 2019	4.0%	4.0%	4.0%	7.53%
% ZEVs, Year 2020	8.0%	8.0%	8.0%	9.94%
% ZEVs, Year 2021	20.0%	15.0%	82.0%	12.35%
% ZEVs, Year 2022	35.0%	25.0%	97.0%	14.76%
% ZEVs, Year 2023	55.0%	45.0%	99.0%	17.18%
% ZEVs, Year 2024	80.0%	70.0%	99.0%	19.59%
% ZEVs, Year 2025	94.0%	95.0%	99.0%	22.00%
% ZEVs, Year 2026	97.0%	97.0%	99.0%	37.60%
% ZEVs, Year 2027	98.0%	98.0%	99.0%	53.20%
% ZEVs, Year 2028	99.0%	99.0%	99.0%	68.80%
% ZEVs, Year 2029	99.0%	99.0%	99.0%	84.40%
% ZEVs, Year 2030	99.0%	99.0%	99.0%	100.00%
% Reduction in Per-Capita Driving With Respect to Year 2005	32.0%	32.0%	0%	50.5%

We are falling behind in our sales of ZEVs. The plan needs to be updated to reflect on that failure. The problem with having no plan is that we will almost certainly fail since it is always politically easier to do less. Without understanding the consequences, doing less will be selected. The only difference between the "Balanced_1" case and the "Balanced_2" case is that the percentage of electricity that is from renewables goes from 85% to 90%. That improvement allows the per-cent of new cars that are ZEVs to increase at a less-difficult pace.

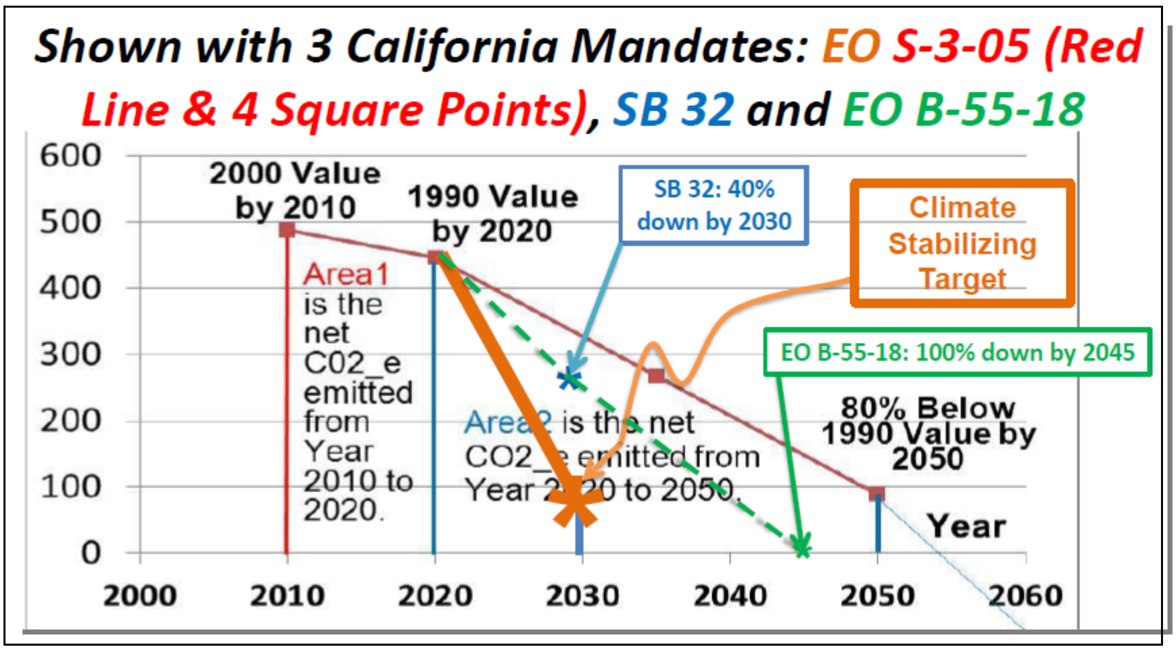
The "2005 Driving" case is done to prove that it is not feasible. It proves that we must reduce driving. CARB now says the same thing, but they do not show how they reached that conclusion.

The Mary Nichols case is based on published statements made by the retired CARB Chair. CARB may not understand the need for the more difficult 2030 requirement of

80% below 1990 by 2030. Therefore, former-Chair Nichols probably did not understand that her fleet-electrification schedule would need per-capita driving to drop 50.5%, which would be very difficult. CARB and the state of California officials working on this problem may have been thinking that if we achieve the net-zero requirement by 2045, the earth's climate will not destabilize. In any case, SANDAG cannot go along with such misinformation.

The derivation of the 2030 climate-stabilizing requirement (target) is shown on Page 6 of Reference 3. Reference 5 is used to present Reference 3. The derivation of the 2030 climate-stabilizing requirement (target) is shown on Slides 11 and 12 of Reference 5. That result is shown here in Figure 4, where it can be contrasted with the inadequate state mandates.

Figure 4 The 2030 Climate Stabilization Target Compared to State Mandates



It should be noted that Reference 3 is exactly what the most important environmental-advocacy organization in California, the California Democratic Party (the CDP, AKA the CADEM), has in its Platform. The Party Platform is their official policy. This can be seen in Reference 6, where it says, "*Demand a state plan specifying how cars and light-duty trucks can meet climate-stabilizing targets by defining enforceable measures to achieve necessary fleet efficiency and per-capita driving limits*."

SANDAG has no such Plan. Given our climate emergency, any project that needs an EIR, that has to do with driving, needs such a Plan. If any discretionary project that has to do with driving needs an EIR, such as the RTPs being considered here (with and without a RUC and perhaps a third which can be shown to achieve the 2030 requirement) cannot be shown to conform to such a Plan, then it must be assumed to be contributing to climate destabilization.

Critical Information for Any Regional Transportation Plan (RTP)

Many of the fatal errors of Chapter 1, and the 2021 RTP/EIR in general, can be attributed to the RTP not accounting for the parameters of humanity's Code Red Climate Emergency, as if those parameters play no role in writing an EIR for the 2021 Regional Transportation Plan, with or without the RUC.

At the front of any 2021 RTP's EIR, the information shown in Figures 4 through 7 should be included and accounted for.

Figure 4 shows the climate-stabilizing target for 2030. Figure 5 shows the rise of the world's atmospheric CO2 over the last 50 years.

Figure 6 shows both the

- atmospheric temperature (averaged over a year and averaged over the earth, derived from an isotope analysis) and
- atmospheric CO2 (from air bubbles in ice-core samples),

over 800,000 years. It could be noted that our species is only around 300,000 years old.

Figure 6 shows that when climate deniers say that climate is always changing and so therefore climate change is natural, they are correct, except for one important fact. There is nothing natural about the outrageous, recent run-up of atmospheric CO2, to over 420 PPM, in such a short time shown on the far-right side of Figure 6. The slope is so steep that it appears to be an instantaneous spike, on the far-right side of Figure 6.

Figure 7 shows just 1% (which is 1,000 years) of the distance on Figure 6, from current time to the first 100,000 years into the past. For Figure 7, the conventions have been switched: the red line is the earth's atmospheric CO2 and temperature is the blue line. Figure 7 shows that the CO2 spike is the result of our combustion of fossil fuels because its beginning coincides with the start of our industrial revolution. Figure 7 covers the time of the development of our civilization. It shows that everything was normal until about 150 years ago, which is the start of our industrial revolution, when we started to burn fossil fuels. By doing extensive calculations, we know how much CO2 we have produced from the combustion of fossil fuels. Then, by directly measuring the atmospheric CO2 and the acidity of the oceans, we know where that CO2 currently resides. We also know that atmospheric CO2 traps heat. There is no doubt that we have an Anthropogenic Global Warming (AGW) catastrophe in the making. We are living in a spike of CO2. Neither the magnitude nor the slope have occurred in millions of years. Achieving climate-stabilizing requirements (targets) is our only hope.

It should also be clearly stated that LDVs, by far, emit more GHG than any other category of emission. Electricity emits the 2nd most. However, there is a good chance that we can achieve the 2030 climate-stabilization requirement that is derived in Reference 3 and 5 (shown in Figure 4) for the category of electricity. Unfortunately, that cannot be said for LDVs. The implementation of the plan specified in Reference 3, or some other similar plan, is our only hope, for LDVs.

Figure 5 Atmospheric CO2, Increasing Over Recent Decades

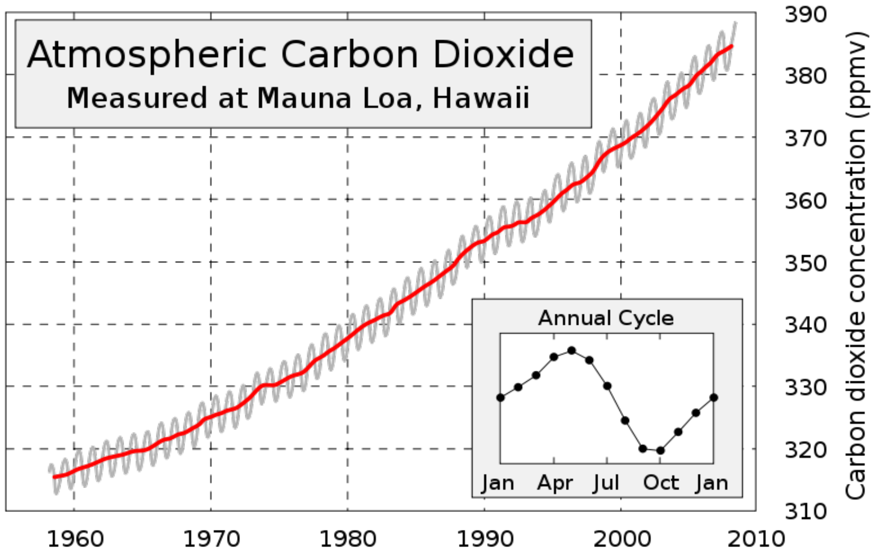


Figure 6 Atmospheric CO2 and Mean Temperature, from 800,000 Years Ago, with Current CO2 Spike

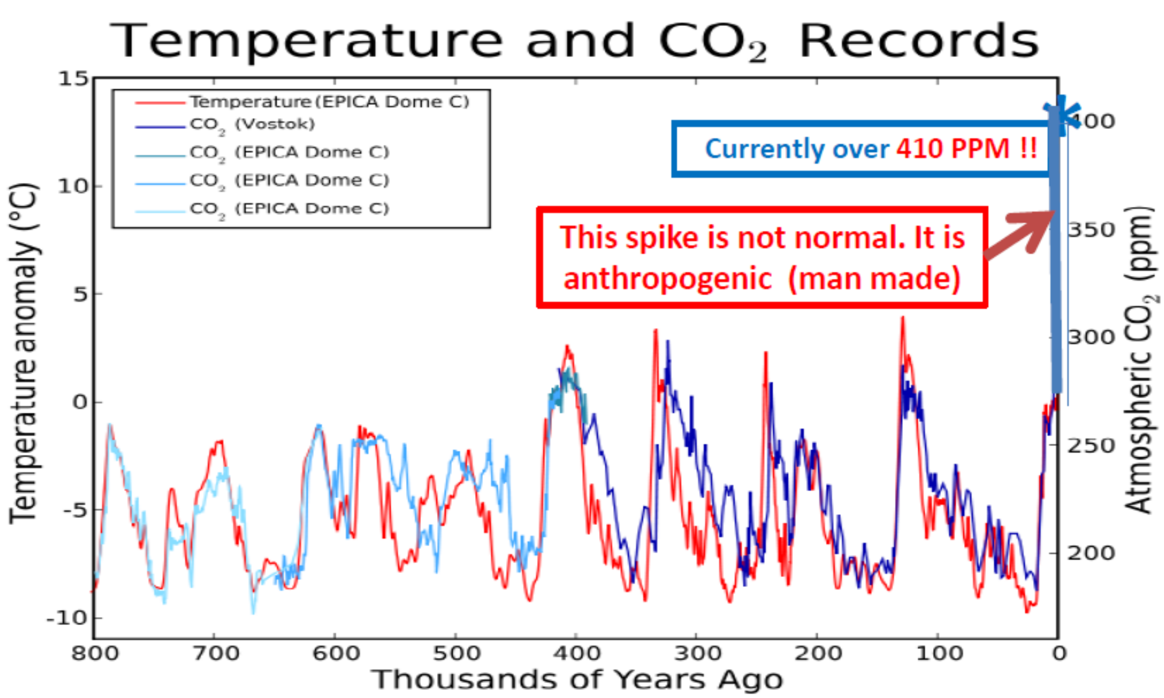
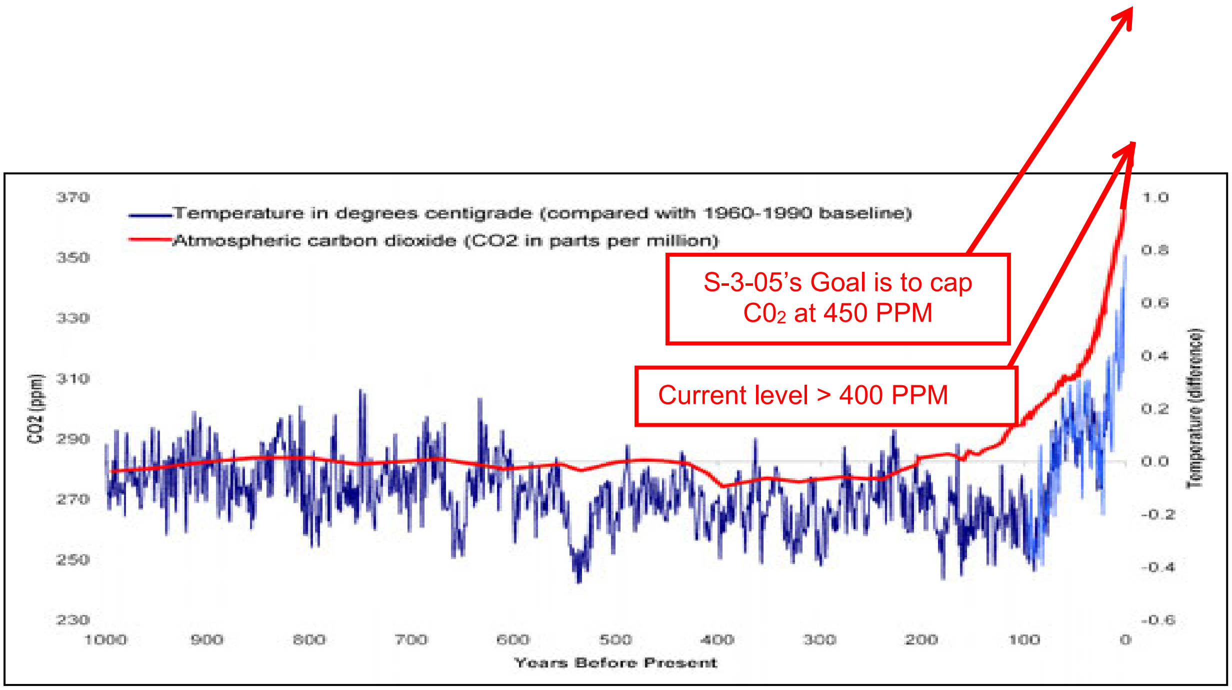


Figure 7 Atmospheric CO2 and Mean Temperature, Over the Last 1,000 Years



Measures to Reduce 2030 Driving

The 2030 climate-stabilizing requirement that is shown above in Figure 4 and is described repeatedly in this letter can be achieved by LDVs. To do that requires using a set of aggressive, fleet-efficiency mitigation measures, that are defined in Reference 3, and a set of driving-reduction mitigation measures, that are identified in Table 2 and described in Reference 3.

The first line of Table 2, "Legislated (SB 375) Plans to Reduce Driving" reflects an assumption that the RTPs in California, which are often required to achieve around 19% by 2035, will achieve 12% by 2030.

The second line of Table 2 is a well-done RUC. SANDAG's 2025 RTP should include a state RUC that replaces the state gas tax, is means based, and has the other characteristics that are shown in Reference 1.

The third line of Table 2 is a measure that SANDAG could implement for its own employees, using a third-party vendor that will then work hard to earn the trust of SANDAG employees, so that the vendor can cite that trust and use it to sell the car-parking system to other employers that want to do the best they can for their employees and want to be recognized for their commitment to sustainability. The car parking system would unbundle the cost of parking with a fully automated car parking system that provides earnings to those that are losing money because the parking is being provided or to those for whom the parking is built. The same car parking system works for all types of parking, although the algorithms that compute earning differ by type, such as on-street, and the various categories of off-street such as employee parking, parking at apartments, parking at shopping centers, parking at mixed use developments, parking at transit station, parking at big box stores and grocery stores, and so on. The parking system is fully described in References 7 and 8.

Table 2 Enforceable Measures to Reduce 2030 Per Capita Driving By 32% With Respect to 2005 Per Capita Driving

California designs and implements this

Local governments do this with a 3rd party vendor

Driving-Reduction Requirments	Per-Cent Reduction	Factor
Legislated (SB 375) Plans to Reduce Driving	12%	0.88
Value-Priced Road Use Charge (RUC)	10%	0.90
Value-Priced Parking (Unbundling the Cost)	8%	0.92
Transfer Highway Expansion Funds to Transit	2%	0.98
Increase Height & Density by Transit Stations	2%	0.98
"Complete Streets", "Road Diet" (walk/bike)	1%	0.99
Pay-to-Graduate Bicycle Traffic-Skills Class	1%	0.99
Bicycle Projects to Improve Access	1%	0.99
	Product of Factors	**0.68**
	% Reduction	**32%**

Reference 7 defines Table 2's 3rd line's Value-Priced, car-parking system for all types of parking and even includes a congestion-pricing algorithm. Reference 8 describes the system with an emphasis on employee car parking and how the system could earn extra money for all employees. Reference 9 is a Draft *Requirements Document* that would support an RFP process to identify the best 3rd party vendor to design, install, and operate the car-parking system. The selected 3rd party vendor would also be good at financing, building, and operating solar canopies; selling electricity to energy districts; and financing, building, and operating charging stations. These tasks need to be added to Reference 9. SANDAG and other MPOs need to lobby California to identify a vendor to design and implement such a system, ASAP. SANDAG and our municipal governments could have a vendor do this for their employees. The technology is ready. The Executive Director of ACE Parking has reviewed the parking system described in References 7 and 8. Reference 10 documents that he interested in providing this solution.

<u>Consideration of the EIR for the 2021 RTP</u>

If the SEIR is going to be "adequate", it must correct the errors in the EIR that it is building on, before considering the change. This section presents some of the problems with the EIR for the 2021 RTP.

Executive Summary

Table ES-1, ***Summary of Environmental Impacts and Mitigation Measures***

The GHG-3 line says:

> ***GHG-3 Conflict with or impede achievement of an at least 30% reduction in per capita GHG emissions from the entire on-road transportation sector by 2035 compared to existing conditions (2016)***

There are no mitigation measures and yet the “Level of Significance After Mitigation” is shown to be “Less-than-significant impact in 2035.”

California did not meet its 2020 EO S-3-05 target, which was our 1990 emission level, until around 2019. (This was a case were California achieved a target early.) Therefore, our emission in 2016 exceeded our 1990 level of emission. Therefore, only achieving a “*30% reduction in per capita GHG emissions from the entire on-road transportation sector by 2035 compared to existing conditions (2016)*” would be an unmitigated environmental disaster. If other MPOs followed this example, we would be unable to stabilize our climate because we would be well past our (the industrialized world’s) 2030 climate-stabilizing requirement, of 80% below our 1990 level.

The line for GHG-5 is too vague, in terms of mitigation measures. To have any hope of achieving significant reductions by 2030, measures need to be mature enough to start soon. The mitigation measures shown in this line are little more than wishful thinking. As San Diego County Superior Court Judge Taylor wrote in a ruling in favor of the plaintiffs in their CEQA complaint against the County’s woefully inadequate Climate Action Plan, “enforceable measures are needed now”. That ruling was issued 9 years ago. SANDAG too often does not listen to me or others that urge enforceable measures that can be started now.

SANDAG instead seems to like words like (these are also from the GHG-5’s, “mitigation measures”):

> *TRA-2 Achieve Further VMT Reductions for Transportation and Development Projects*”,

How would that be done? The “measure” is too ill defined to have any value.

Alternative 3 should be improved upon to conform with Reference 3 and then implemented as fast as possible. TRANSNET need to be modified to align with the improved-upon Alternative 3.

The Proposed Plan’s 2035 reduction of 20% is so small that it would help to bring about an environmental disaster.

Phased Next OS Network Improvements and Investments, Page 2-66

Considering our 2030 climate-stabilization target and the derivations of Reference 3, the car-parking system described in References 7 through 9 needs to have numerous successful implementations and be well on the way to being widely implemented by 2025. The words “dynamic curb management”, for 2035, is not encouraging. The car-parking system proposed by this letter and since 2010 by this author certainly includes dynamic curb management. However, SANDAG needs to reach out to get help on this important aspect of the Next OS. I hope we can meet soon.

Likewise, on Pages 2-66 to 2-67 and on Page 2-71 to 2-72, there are hopeful signs that SANDAG could help to foster the changes we need. I would love to meet to discuss these topics.

Climate Change Destabilization Could Include our Weather

Page 3-1 has a description of our current climate and how climate change could change our weather. It needs a statement that destabilization of climate systems (such as the melting of our permafrost or unleashing large amounts of methane from beneath our artic region, or burning up an enormous expanse of forests, including our Amazon rain forest) could cause much larger variations if these destabilizing systems accelerate and set off other climate-destabilizing systems. The freeze experienced by Texas and measurement of 120 Degrees in Canada show that, when it comes to climate, we are already in uncharted territory. The description of San Diego County’s “current climate” needs a statement that, given the fact that our atmospheric CO2 is at 420 PPM, when it should be at 280 PPM, we really don’t know what might be possible, in terms of current weather.

Mitigation Measures for *Existing* Development

On Page 4-3, it says, “The EIR includes three broad types of mitigation measures: (1) plan- and policy-level mitigation measures assigned to SANDAG; (2) mitigation measures for transportation network improvements and programs, assigned to SANDAG and other transportation project sponsors; and (3) mitigation measures for development projects implementing regional growth and land use changes, which local jurisdictions implement.”

This will be too little too late, and it is an arbitrary decision to do what is easiest. It does not make sense, given the fact of our Code Red Climate Emergency, as explained in this letter. For example, TDM (Transportation Demand Management) Ordinances need to apply to *existing* developments. SANDAG should provide no help to municipal governments that fail to have a powerful TDM plan for their own employees, to set an example, for other employers. The TDM would include the car-parking system described in Reference 7 through 9. SANDAG should do this for their own employees, ASAP, using Reference 9 to start the generation of a Systems Definition document to support an RFP process to identify a good 3rd party vendor.

4.8’s Paragraph on “Global Climate Change”

This paragraph needs to quantify what we have done to our earth’s atmospheric level of CO2_e. We should be at 280 PPM. We are at 420 PPM. This letter’s Figures 5, 6, and 7 should be included. The text should make it clear that we are living in a dangerous CO2 spike.

The paragraph should make the difference between climate change (before the spike) and Anthropogenic climate change (within the spike) clear to the reader.

Thank you for including the 280 PPM and 413 PPM (in 2020) levels in the paragraph on Carbon Dioxide. This needs to be elevated to the first paragraph with the plots. The plot of 800,000 years, showing how outrageous it is that we have created the spike of CO2, needs to be shown.

The discussion at the top of Page 4.8-6 should introduce the reader to the concept of “destabilization” or going over a “climate tipping point” or a “climate cliff.” It is a lie by omission to not state that we are in line to experience a devastating collapse of the human population, leading to extinction. Our Code Red Climate Emergency should not be hidden. We are in great danger. Some say climate change is an existential threat. In fact, it is a near certainty that anthropogenic climate change will end our existence. Theoretically we could still stabilize the climate at a livable level. We should not give up. However, given what is needed by 2030, along with the public’s general disinterest in the details, it is highly unlikely we will avoid climate destabilization, and this will lead to our demise.

Section 4.8: Greenhouse Gas Emissions

4.8.4 Significance

CEQA’s Appendix G asks as follows:

> *VII. GREENHOUSE GAS EMISSIONS. Would the project:*
>
> *a) Generate greenhouse gas emissions, either directly or indirectly, that may have a significant impact on the environment?*

Considering cumulative effects of the proposed RTP, the answer is yes, especially for LDVs. The next question about conflicting with an applicable plan does not matter, given the result of the “letter a” criterion.

Section XVII also applies because it explicitly mentions cumulative impacts and asks:

> c) *Does the project have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly?*

Nothing short of a full exchange of nuclear weapons could be worse for people than climate destabilization.

From OPR’s Reference 9 with emphasis added:

> Each public agency that serves as a CEQA lead agency should develop its own approach to performing a climate change analysis for projects that generate greenhouse gas emissions. A consistent approach should be applied for the analysis of projects, and the analysis must keep pace

with scientific knowledge and regulatory schemes. (*Cleveland National Forest Foundation v. San Diego Assn. of Governments*, *supra*, 3 Cal.5th at 519.) For these projects, compliance with CEQA entails three basic steps: identify and quantify the greenhouse gas emissions; determine the significance of those emissions **in the context of climate change**; and if the impact is found to be significant, identify alternatives and/or mitigation measures that will reduce the impact below significance.

“In the context of climate change” means that the climate science must be applied to the situation. From that, to be legal, a project that will have significant impacts on driving, including its feasible (technologically possible and cost effective) mitigation measures, must conform to a plan showing how LDVs can achieve our climate-stabilizing targets, especially our 2030 target because it occurs so soon. This again shows the importance of Reference 3 or some other such Plan.

Thank you for Tables 4.8-7 and 4.8-8 showing the importance of reducing VMT.

Table 4.8-9 is key. However, its results are insufficient to support climate stabilization. Reference 3 shows we need a 32% value by 2030, which is 5 years sooner than 2035.

Figure 8 shows that the DEIR does not consider what the climate scientists are telling us, which is what we must achieve to stabilize the climate at a livable level. The state mandates shown are not enough to achieve our 2030 climate-stabilizing requirement, which is to emit at a level that is no more than 80% below our 1990 emission level.

Figure 8 SANDAG’s DEIR Section on GHG Does Not Consider Achieving the Industrial World’s 2030 Climate-Stabilizing Target.

7.2.9 GREENHOUSE GAS EMISSIONS

Compared to existing conditions, the proposed Plan's GHG emissions would decrease for all horizon years (2025, 2035, and 2050). Under maximum theoretical buildout conditions, regional growth and land use change would result in some increases in GHG emissions, but there would still be net decreases compared to existing conditions.

Development under the maximum theoretical buildout scenario would likely continue in a similar pattern as under the proposed Plan, which encourages compact development, supporting rather than impeding adopted Climate Cation Plans (CAPs), GHG reduction plans, and/ or sustainability plans relevant to the proposed Plan. Because 2030 GHG emissions under the proposed Plan are higher than the AB 32-based regional reference point, emissions under maximum theoretical buildout are expected to continue to exceed this reference point, which would be a significant impact related to conflicts with AB 32.

Under maximum theoretical buildout, development would likely continue in a similar pattern as under the proposed Plan, which encourages compact development, although per capita GHG emissions from passenger vehicles would somewhat increase. However, the maximum theoretical buildout scenario would likely still achieve, and not conflict with, Senate Bill (SB) 375's per capita GHG emission reduction targets set by the California Air Resources Board (CARB) for the San Diego region.

The proposed Plan would be inconsistent with the State's ability to achieve 2045 and 2050 reference points of net zero and 5.2 million metric tons of carbon dioxide equivalence ($MMTCO_2e$), respectively (based on the goals of Executive Orders S-3-05 and B-55-18). Because GHG emissions would be higher under maximum theoretical buildout, these inconsistencies, which are a significant impact, would be worse. As with the proposed Plan, this would be reduced with the mitigation identified in Section 4.8, *Greenhouse Gas Emissions*, but impacts would remain significant and unavoidable.

The second paragraph states that the 2030 emissions under the proposed Plan are higher than the AB 32-based regional reference point. Figure 4 of this letter shows that this means the 2030 value is worse than the SB 32 value (40% down from the 1990 value) which is much more emission than the climate-stabilizing value of 80% down.

<u>CARB Scoping Plan Comments Regarding the Need to Reduce VMT More Than Specified in SB 375 and The Need for a RUC</u>

The following statements are from the recently completed CARB Scoping Plan https://ww2.arb.ca.gov/sites/default/files/2022-12/2022-sp.pdf . They show that it is very ill-advised to remove the RUC from the 2021 RTP because, as shown in Reference 3, it is critical that we reduce VMT.

Footnotes have been deleted; highlights and notes have been added

> ***<u>Vehicle Miles Traveled</u>***
> ***Transforming the transportation sector goes beyond phasing out combustion technology and producing cleaner fuels. Managing total demand for transportation energy by reducing the miles people need to drive, daily, is also critical as the state aims for a sustainable transportation sector in a carbon neutral economy. Though GHG emissions are declining due to cleaner vehicles and fuels, rising VMT can offset the effective benefits of adopted regulations. Even under full implementation of Executive Order N-79-20 and CARB's Advanced Clean Cars II Regulations, with 100 percent ZEV sales in the light-duty vehicle sector by 2035, a significant portion of passenger vehicles will still rely on ICE technology, as demonstrated in Figure 4-2 above. Accordingly, VMT reductions will play an indispensable role [Bullock's note: Reference 3 shows that the per-capita reduction in VMT, with respect to 2005, the SB 375 reference year, is 32%! Note that our population in 2030 will be considerably more than it was in 2005. We have wasted a lot of money on freeway expansion and have more lanes than we had back in 2005.] in reducing overall transportation energy demand and achieving the state's climate, air quality, and equity goals. [Bullock's note: I wonder if climate stabilization plays a role in setting these "goals". In other words, is human survival valued by CARB?] After a significant pandemic-induced reduction in VMT during 2020, passenger VMT has steadily climbed back up and is now closing in on pre-pandemic levels. Driving alone with no passengers remains the primary mode of travel in California, amounting to 75 percent of the mode share for daily commute trips. Conversely, the transit industry, which was significantly impacted during the lockdown months, and has struggled to recover; ridership only averages two-thirds of pre-pandemic levels, and service levels also lag behind. Sustained VMT reductions have been difficult to achieve for much of the past***

decade, in large part due to entrenched transportation, land use, and housing policies and practices. [Bullock note: widening freeways and the systems used (underpriced and "free") for having drivers pay for road use and pay for parking use are the worst "practices." CARB does not even mention having a concern about "free" parking, EXCEPT in Appendix D and E.] Specifically, historic decision-making favoring single-occupancy vehicle travel has shaped development patterns and transportation policy, generating further growth in driving (and making transit, biking, and walking less viable alternatives). These policies have also reinforced long-standing racial and economic injustices that leave people with little choice but to spend significant time and money commuting long distances, placing a disproportionate burden on low-income Californians, who pay the highest proportion of their wages on housing and transportation. While CARB has included VMT reduction targets and strategies in the Scoping Plan and appendices, these targets are not regulatory requirements, but would inform future planning processes. CARB is not setting regulatory limits on VMT in the 2022 Scoping Plan; the authority to reduce VMT largely lies with state, regional, and local transportation, land use, and housing agencies, along with the Legislature and its budgeting choices. [Bullock note: they could have mentioned that CARB does set requirements for VMT reductions as specified by SB 375.] Appendix E (Sustainable and Equitable Communities) elaborates on reasons for reducing VMT and identifies a series of policies that, if implemented by various responsible authorities, could help to achieve the recommended VMT reduction trajectory included in this Scoping Plan (and related mode share increases for transit and active transportation). These policies aim to advance four strategic objectives:

1. Align current and future funding for transportation infrastructure with the state's climate goals, preventing new state-funded projects from inducing significant VMT growth and supporting an ambitious expansion of transit service and other multimodal alternatives.
2. Move funding for transportation beyond the gasoline and diesel taxes and implement fuel-agnostic pricing strategies [Bullock note: They can't bring themselves to say, "replace the state gas tax with a means-based RUC"?) that accomplish more productive uses of the roadway network [Bullock note: They can't bring themselves to say, "congestion pricing"?) and generate revenues to further improve transit and other multimodal alternatives [Bullock note: the words in red show that CARB does not understand what will not work politically.]
3. Deploy autonomous vehicles, ride-hailing services, and other new mobility options toward high passenger-occupancy and low VMT-

impact service models that complement transit and ensure equitable access for priority populations.
4. Encourage future housing production and multi-use development in infill locations and other areas in ways that make future trip origins and destinations closer together and create more viable environments for transit, walking, and biking.

The pace of change to reduce VMT must be accelerated. [That is not possible if they don't understand the need for good pricing systems. However, Appendix E shows they may understand this.] Certainly, structural reform will be challenging, but California has demonstrated time and again that it possesses the collective leadership and commitment to break away from ideas that no longer represent Californians' values and their aspirations for the many generations to come.

Strategies for Achieving Success:

1. ***Achieve a per capita VMT reduction of at least 25 percent below 2019 levels by 2030 and 30 percent below 2019 levels by 2045. [Where is it shown that this will achieve success? Where do they define "success."]***
   2. ***Achieve a per capita VMT reduction of at least 25 percent below 2019 levels by 2030 and 30 percent below 2019 levels by 2045. [Where is it shown that this will achieve success? Where do they define "success. However, this far exceeds the SB 375 requirements.]***
   3. ***Reimagine new roadway projects that decrease VMT in a way that meets community needs and reduces the need to drive. [Bullock's Note: If a roadway project reduces the number of lanes, congestion will return to its former level (due to induced traffic demand, in reverse] but there will be less VMT and GHG.]***
   4. ***Invest in making public transit a viable alternative to driving by increasing affordability, reliability, coverage, service frequency, and consumer experience.***
   5. ***Implement equitable roadway pricing strategies based on local context and need, reallocating revenues to improve transit, bicycling, and other sustainable transportation choices. [Bad politics and not necessary.]***
   6. ***Expand and complete planned networks of high-quality active transportation infrastructure.***
   7. ***Channel the deployment of autonomous vehicles, ride-hailing services, and other new mobility options toward high passenger-occupancy and low VMT-impact service models***

that complement transit and ensure equitable access for priority populations.

8. ***Streamline access to public transportation through programs such as the California Integrated Travel Project.***
9. ***Ensure alignment of land use, housing, transportation, and conservation planning in adopted regional plans, such as regional transportation plans (RTP)/ sustainable communities strategies (SCS), regional housing needs assessments (RHNA), and local plans (e.g., general plans, zoning, and local transportation plans), and develop tools to support implementation of these plans.***
10. ***Accelerate infill development and housing production at all affordability levels in transportation-efficient places, with a focus on housing for lower-income residents.***

The Sustainable Communities Section of CARB's Scoping Plan, Appendix E, With the Same Conventions As Above, Showing the Need for a RUC

Appendix E https://ww2.arb.ca.gov/sites/default/files/2022-11/2022-sp-appendix-e-sustainable-and-equitable-communities.pdf.pdf

3.2.2 Objectives To achieve this vision, the State should lead efforts to:

1. ***Authorize and implement roadway pricing strategies and reallocate revenues to equitably improve transit, bicycling, and other sustainable transportation choices. Pricing strategies take many forms and can include fees for miles driven, cordon fees for operating vehicles in designated areas, parking fees [OMG, they said "parking".], fees on congestion impact of ride-hailing services, and dynamic fees on highway lanes [They can't just say "dynamic congestion pricing"?] and other strategic roads to manage congestion. Authorizing transportation pricing strategies is essential to promote more efficient use of cars and to further transit and active transportation improvements. Pricing strategies present an opportunity to fund the transportation system in a more equitable and fiscally sustainable way than current funding sources, promote more efficient functioning of existing infrastructure, and fund new transportation options, especially for those who do not own a vehicle or do not drive. Some recent analyses indicate California will not meet its climate goals without implementing equitable roadway pricing [So it is tragic that SANDAG may remove (!) the RUC from its 2021 RTP, at***

great trouble and great expense.] strategies as these strategies are projected to achieve up to 27 to 37 percent of the needed per capita VMT reduction. The four largest MPOs have included multiple pricing strategies in their adopted sustainable communities strategies (SCSs) to reduce regional GHG emissions. Pricing strategies would need to be implemented with an emphasis to ensure equitable outcomes, and in accordance with local needs and context. In particular, pricing strategies need to consider the potential travel options available for low income and other disadvantaged populations to ensure they are not unduly impacted by the strategy. Actions: · Permit implementation of a suite of roadway pricing strategies by 2025 in support of adopted SCSs. [Note the 2025 year. I have been telling SANDAG that 2030 is too late because our first-occurring climate stabilization requirement is 2030.]

2. ***Prioritize addressing key transit bottlenecks and other infrastructure investments to improve transit operational efficiency over investments that increase VMT. Offering high-quality transit services that represent a viable alternative to driving will require multiple coordinated efforts. The proposed investments to expand service capacity and increase frequencies (described in Strategy Area 1) will be ineffective if those transit vehicles end up stuck in traffic or have limited space to operate efficiently. Transit agencies and local jurisdictions across California should come together to identify, plan, and implement strategies to prioritize transit speeds and reliability over general roadway level of service and private car needs. Those strategies, which include capital investments in the strategic redistribution of the right-of-way, signaling, and supportive traffic regulations, should be prioritized in federal and State funding programs and local investment plans.***
   Actions: ·
   1. ***Permit the conversion of general-purpose lanes to transit-only lanes or toll lanes and full facility tolling of state-owned facilities.***
   2. ***Establish requirements to demonstrate that addressing transit bottlenecks and other transit efficiency investments are a priority in local jurisdiction and transit agency investment plans, such as a prerequisite for overall transportation project funding eligibility.***

3. ***Develop and implement a statewide transportation demand management (TDM) framework with VMT mitigation requirements for large employers and large developments.*** ***The goal of TDM is to provide people with information, incentives, and other support programs that help them utilize sustainable transportation options such as transit, ridesharing, bicycling, and walking and rely less on cars. A strategic point of focus for TDM program implementation could be large employers (more than 100 employees), which often incentivize driving alone by offering free parking, gas stipends, and similar perks, and do not offer similar levels of support to employees to take transit, ride their bicycle, or walk. Employer-based TDM strategies are needed to achieve widespread implementation for the State to meet its climate goals, including commute trip reduction programs, ride-sharing programs, on-site bicycle facilities, vanpool and shuttle services, transit fare subsidies, and parking cash-out. [Note: parking cash-out is better than "free"; however, it is a half-baked idea. The system proposed in the San Diego County lawsuit against the County's CAP is a fully thought out system that the CEO of ACE parking would like to provide.] Another strategic point of focus for TDM programs could be large developments, particularly new ones, that through decisions such as their location, design, transportation, parking infrastructure, and their treatment and general interaction with their surrounding environment ingrain high or low VMT travel patterns for decades to come.***

   Actions:

1. ***End the State's subsidies for employee parking and take additional actions to move away from subsidizing public spaces for car parking more generally while expanding efforts to promote pedestrian, bicycle, and transit travel. As the State of California employs over 200,000 people, it can expand its TDM programs [This is what I have been telling CARB and others, for years.], which currently vary by agency and employee union.***
2. ***Build on existing resources to further support the development and enforcement of local TDM ordinances and help begin developing a statewide TDM framework. ["Help begin"? No, we need to do this ASAP. The Climate Clock ticks!]***

<u>SANDAG Executive Director's Comments, Regarding RUC Removal</u>

Executive Director Ikhrata is recognized as an expert in the field of transportation. What follows was provided by *The Voice of San Diego*, an on-line publication.

> ***Morning Report: Ikhrata Says the State Isn't Serious About Climate if It Approves SANDAG Plan Without Driving Fee***
>
> *SANDAG CEO Hasan Ikhrata said state regulators will tell him a lot when they decide whether a long-term transportation plan for San Diego can comply with California's environmental goals even if it doesn't include a controversial measure he's championed to charge drivers for every mile they drive.*
>
> *The board of SANDAG has told him to strip the driving fee from the region's transportation plan. That plan would eventually need approval from the state's air resources board, certifying that it meets a requirement to slash greenhouse gas emissions.*
>
> *Ikhrata said if the state approves the plan without the fee, it's an indication that the state's climate change regulations are a fantasy.*
>
> *"I will be very happy because that would actually kind of clarify to me that this is not a serious discussion," he said. "I mean, let's face it. If the state wants to go that way, I'm willing to tell my colleagues at the state, 'Thank you. You clarified for me where you really stand.'"*
>
> *Ikhrata made those comments in a new, long-form podcast interview with Voice of San Diego.*
>
> *In the interview, he also said that he would probably not be interested in continuing to lead the agency if they adopt such a plan.*
>
> *He also argued that any board member who claims to support climate change and transit but opposes a driving fee, or a similar alternative, isn't being serious.*
>
> *"It's wishful thinking to think that you're going to have a plan that changes behavior and reduces greenhouse gas emissions for real, without a pricing mechanism," he said.*
>
> *Listen to the full interview here.*

References

The referenced documents were attached to the email sent with this letter. They are all available from Mike Bullock at mike_bullock@earthlink.net

In Closing

Thank you for your leadership in performing your critical work. Thank you for reading this material and for providing the comments and response as required for a comment letter on a DEIR, EIR, or NOP/Scoping letter. Please let me know if you would like to meet to discuss this letter or related topics.

Highest regards,

Mike Bullock
1800 Bayberry Drive
Oceanside, CA 92054
760 421 9482

Former California Democratic Party Delegate, 76th Assembly District (author of 2 adopted resolutions and 5 Platform changes)
Former Elected (now Associate) Member of the San Diego County Democratic Party Central Committee (author of 5 adopted resolutions)

Final title before leaving Aerospace: ***Senior Staff Systems Engineer***

Air and Waste Management Association published and presented papers:
Author, ***The Development of California Light-Duty Vehicle (LDV) Requirements to Support Climate Stabilization: Fleet-Emission Rates & Per-Capita Driving***
Author, ***A Climate-Killing Regional Transportation Plan Winds Up in Court: Background and Remedi****es*
Co-author, ***A Plan to Efficiently and Conveniently Unbundle Car Parking Cost***

Quotes from the Secretary General of the UN:

1.) We have a Code Red Climate Emergency
2.) We are solidly on a path to an unlivable planet
3.) We are driving towards Climate Hell with our foot on the accelerator
4.) We are dangerously close to the point of no return

.

Resolution 22-01

Resolution of the Oceanside Bicycle and Pedestrian Committee in Support of Replacing the State Gas Tax with a Means-Based Road Use Charge (RUC) that Protects Privacy

WHEREAS, (1) Greenhouse gas (GHG) emissions must be significantly reduced by 2030 to mitigate a climate catastrophe; (2) about 40% of California's GHG is emitted by on-road vehicles; and (3) even given the most ambitious estimates for fleet efficiency and fleet electrification, to support climate-stabilization requirements, it will be necessary to reduce per-capita driving; and furthermore,

WHEREAS, (1) California's current road-use fees (our gas tax, our toll roads and our bridge-use tolls) do not currently cover the full cost of operating and maintaining roads, and gas tax revenues are projected to further decrease as vehicles become more efficient and/or electric powered; (2) having the full cost of motor vehicle road use hidden from users decreases incentives to bicycling and walking, thereby increasing driving and, thus adding significantly to air pollution, congestion, sprawl, and GHG emissions; (3) an assessment conducted by the California Transportation Commission (CTC) found that 58 percent of our state's roads are in need of maintenance, 20 percent of our bridges need major or preventive maintenance, and 6 percent of our bridges require replacement; (4) roads and bridges are our most important cycling infrastructure; and (5) a RUC has been shown to be feasible by the CTC; and finally,

WHEREAS, (1) our gas tax is our most significant road-use fee; (2) state-mandated increases in battery-electric vehicles will reduce gas-tax revenue; (3) a gas tax is inherently regressive because low-income drivers tend to drive older, less fuel-efficient cars; and (4) a gas tax does not account for time, place, driver income, vehicle weight, vehicle pollution level, or instantaneous roadway congestion;

THEREFORE, BE IT RESOLVED, that the Oceanside Bicycle and Pedestrian Committee supports <u>replacing</u> the state gas tax with a road-use charge (RUC) pricing and payout system that (1) would cover all road-use costs; (2) would protect the economic interests of low- and middle-income drivers by use of a progressive price structure that also recognizes the needs of rural drivers; (3) would protect privacy by requiring a search warrant to obtain location or travel information and has built in safeguards against unauthorized data use; (4) would include an instantaneous congestion-pricing algorithm; (5) would ensure that the per-mile price incentive to drive energy-efficient cars would still be sufficient to support necessary fleet electrification; (6) would ensure that cyclists and pedestrians are not charged under the system, given that they contribute no emissions or wear-and-tear on the road system, and they help alleviate congestion.

BE IT FURTHER RESOLVED, that this support be communicated to the City of Oceanside.

Approved by a majority vote of those present at the March 14, 2022 Committee Meeting:

Tom Lichterman — March 14, 2022

Tom Lichterman, Chairman — Date

November 17, 2021

SANDAG Board of Directors
401 B Street
San Diego, CA 92101

RE: Road Use Charges

Dear Chair Blakespear and SANDAG Board Members:

Recently there has been some public discussion of a proposed Road Use Charge (RUC), also known as a Vehicle Miles Traveled Fee (VMTF) included in the funding discussion in the current draft of the Regional Plan. The undersigned members of the Quality of Life Coalition support the concept of a Road Use Charge as part of a funding solution for transportation projects. We believe that a revised RUC would be more effective and equitable than current approaches to transportation funding, as explained below.

First, it is important to acknowledge that we already have a road use charge, known as the gas tax. There are both state and federal excise taxes included in the price we pay for gasoline and diesel fuel. These taxes have been in place for many years. Originally, they covered much of the cost of building and maintaining roads. However, because they were defined as cents per gallon, they failed to keep pace with inflation, and their real value has been steadily declining. They now cover only about one third of the costs of building and maintaining our road network. The rest of the cost must be taken from other tax revenue such as income, property, and sales taxes.

When the gas tax was first imposed, it was a reasonable approximation of road use. People who drove more, or who drove heavier vehicles, paid more. As fuel economy started to improve after the oil price shocks of the 1970's, the gas tax became less equitable as drivers of newer, more efficient cars paid less, and drivers of less efficient cars paid more.

That gradual decline in both equity and effectiveness was accelerated by the introduction of hybrid cars, which saw huge gains in fuel efficiency, and finally completely upended by the introduction of all-electric cars. Drivers of plug-in battery electric cars pay no gas tax at all, although they continue to contribute to wear and tear of the road network.

The current system is patently unfair and unsustainable. Roads are expensive and must be maintained. Gas tax revenue will continue to decline toward insignificance, even as the cost of maintaining our highway network continues to rise. Drivers of older internal combustion engine (ICE) cars will be paying a larger and larger share of the costs.

Transportation planners at the Federal Government and many states, including California, are looking at potential ways to implement an equitable revenue stream to replace the current falling gas taxes. It is clear that some other form of Road Use Charge will need to be implemented to replace the current Gas Tax RUC.

Various approaches are under consideration, but there is not currently a detailed proposal to replace the existing system. Opponents are citing various "issues" based on speculation about what a system might look like. We believe that it is more important to identify the characteristics that would be desirable in a replacement for the current RUC.

Here are some suggestions about what a replacement RUC should do:

Equity

Low-income drivers tend to drive older, less fuel-efficient cars, and therefore pay for a disproportionate amount of road maintenance and repair. On the other hand, EVs are expensive and inaccessible for many, and will be accessed first by higher-income drivers, who will avoid paying for road maintenance and repair under the current gas tax system.

The RUC should cover a substantial fraction, but not all, of the costs. Everyone benefits from having a network of roads, including people who never drive on them, so some of the cost should be covered by general revenue.

The RUC implementation should allow for adjustments for a variety of factors to ensure fairness.

All road users should pay their fair share of the costs. The RUC should be based on the number of miles driven, and not how the vehicle is powered. Heavier vehicles cause more road wear and damage, so they should pay more.

Local Control

A portion of the RUC should be collected and disbursed locally, not at the whim of politicians in Sacramento or DC. SANDAG is best positioned to collect and distribute local RUC proceeds because they are governed by the Board members, who are accountable to the voters.

For More Information

As you may know, California has conducted a pilot project to learn more about Road Use Charges. Participants:

- Drove more than 37 million miles,
- 73 percent felt that road charging was more equitable than a gas tax,
- 87 percent of participants found the pilot to be easy,
- 85 percent were overall satisfied with the pilot, and,
- 91 percent expressed willingness to participate in another road charge pilot.

Much more information about the pilot program is contained in the final report at:
https://dot.ca.gov/-/media/dot-media/programs/road-charge/documents/rcpp-final-report-a11y.pdf

Caltrans has a web site with information on road use charges at https://caroadcharge.com/about

The Pew Trust reported in September on a new expansion of the pilot program at: https://www.pewtrusts.org/en/research-and-analysis/blogs/stateline/2021/09/28/california-expands-road-mileage-tax-pilot-program

For more detailed analysis on Road Use Charges, please see the Information and Technology Innovation Foundation's policy makers guide on Road Use Charges. (https://itif.org/publications/2019/04/22/policymakers-guide-road-user-charges) It concludes with:

"Road user charges are the most viable and sustainable long-term 'user pay' option for the federal government to both raise adequate and appropriate revenues and provide the federal share of funding for the nation's surface transportation system.

David Grubb, Transportation Chair, Sierra Club San Diego

Pam Heatherington, Board Member, The Environmental Center of San Diego

Bee Mittermiller, Transportation Co-Chair, San Diego 350

Steven Gelb, Transportation Co-Chair, San Diego 350

William Rhatigan, Advocacy Manager, San Diego County Bicycle Coalition

Noah Harris, Transportation Policy Advocate, Climate Action Campaign

Deriving a Climate-Stabilizing Solution Set of *Fleet-Efficiency* and *Driving-Level* Requirements, for Light-Duty Vehicles in California

Paper #796315

Mike R. Bullock
Retired Satellite Systems Engineer, 1800 Bayberry Drive, Oceanside, CA 92054

ABSTRACT

An Introduction is provided, including the importance of light-duty vehicles (LDVs: cars and light duty trucks) and the top-level LDV requirements to limit their carbon dioxide ("CO2") emissions.

Climate crisis fundamentals are presented, including its cause, its potential for harm, California mandates, and a greenhouse gas (GHG) reduction road map to avoid disaster.

A 2030 climate-stabilizing GHG reduction target value is calculated, using statements by climate experts. The formula for GHG emissions, as a function of per-capita driving, population, fleet CO2 emissions per mile, and the applicable low-carbon fuel standard is given. The ratio of the 2015 value of car-emission-per-mile to the 2005 value of car-emission-per-mile is obtained.

Internal Combustion Engine (ICE) mileage values from 2000 to 2030 are identified, as either mandates or new requirements. A table is presented that estimates 2015 LDV fleet mileage.

Zero Emission Vehicle (ZEV) parameters are given. Methods are derived to compute equivalent 2030 mileage. Four cases are defined and overall equivalent mileage is computed for each. Those equivalent fleet mileage values are used to compute their corresponding required per-capita driving reductions, with respect to 2005. Measures to achieve the most reasonable per-capita driving reduction are described, with reductions allocated to each measure.

A conclusion is presented.

INTRODUCTION

Humanity's top-level requirement is to stabilize our climate at a livable level. This top-level requirement must flow down to cars and light-duty trucks, also known as Light-Duty Vehicles (LDVs), due to the significant size of their emissions. As an example, LDVs emit 41% of the GHG in San Diego County[1].

From a systems engineering perspective, the needed top-level LDV requirements are an upper bound on greenhouse gas (GHG) emissions per mile driven, applicable to all of the vehicles on the road, in the year of interest, and an upper bound on per-capita driving, given population growth. These two upper bounds must achieve the climate-stabilizing GHG emission target level. This paper will do a calculation of required driving levels, based on calculations of how clean our cars and fuels could be, predicted population growth, and the latest, science-based, climate-stabilizing target, or requirement. All three categories of LDV emission-reduction strategies will be used: cleaner cars, cleaner fuels, and less driving. Four cases will be considered.

BACKGROUND: OUR CLIMATE PREDICAMENT

Basic Cause

Our climate crisis exists primarily because of these two facts[2]: First, our combustion of fossil fuels puts “great quantities” of CO_2 into our atmosphere; second, atmospheric CO_2 traps heat.

California’s Primary CO2_e Emission-Reduction Mandates

California’s Governor’s Executive Order S-3-05[3] is based on the greenhouse gas (GHG) reduction limits that were recommended by climate scientists, for industrialized nations, in 2005. In 2005, climate scientists believed that if the industrialized nations of the world achieved the reduction-targets of S-3-05 (and other nations did something less), the Earth’s climate could be stabilized at a livable level, with a reasonably high level of certainty. More specifically, this executive order aims for an average, over-the-year, atmospheric, temperature rise of “only” 2 degree Celsius, above the preindustrial temperature. It attempts to do this by limiting atmospheric CO_2_e to 450 PPM by 2050 and then reducing emissions further, so that atmospheric levels would come down to more tolerable levels in subsequent years. The S-3-05 emission targets are the 2000 emission level by 2010, the 1990 level by 2020, and 80% below the 1990 level by 2050.

It was thought that if the industrialized world achieved S-3-05 (and the non-industrialized world achieved an easier task), there would be a 50% chance that the maximum temperature rise will be less than 2 degrees Celsius, thus leaving a 50% chance that it would be larger than 2 degrees Celsius. A 2 degree increase would put over a billion people on the planet into a position described as “water stress” and it would mean a loss of 97% of our coral reefs.

There would also be a 30% chance that the temperature increase would be greater than 3 degrees Celsius. A temperature change of 3 degree Celsius is described in Reference 3 as being “exponentially worse” than a 2 degree Celsius increase.

The second California climate mandate is AB 32, the *Global Warming Solutions Act of 2006*. It includes provisions for a cap and trade program, to ensure meeting S-3-05’s 2020 target, which is to be emitting at no more than the 1990 level of emissions. AB 32 was to continue after 2020. AB 32 required CARB to always implement measures that achieved the maximum *technologically feasible and cost-effective* (words taken from AB 32) greenhouse-gas-emission reductions.

In 2015 Governor Brown signed B-30-15. This Executive Order established a mandate for 40% below 2020 emissions by 2030, as can be seen by a Google search. If S-3-05 is interpreted as a straight line between its 2020 and its 2050 targets, then the B-30-15 target of 2030 is the same as the S-3-05 implied target of 2035, because 2035 is halfway between 2020 and 2050 and 40% is halfway to 80%. More recently, California adopted SB 32, which made achieving B-30-15 legally binding. Finally, in 2018, the Governors Executive Order B-55-18 established a mandate of zero net emissions by the year 2045.

California achieved the second GHG emission target of S-3-05 (to emit at the 1990 level by 2020) in 2018, which is two years early. However, the world emission levels have, for most years, been increasing, contrary to the S-3-05 trajectory. Because the world has been consistently failing to follow S-3-05's 2010-to-2020 trajectory, if California, still wants to lead the way to human survival, it must do far better than S-3-05, going forward, as will be shown.

Failing to Achieve these Climate Mandates

What could happen if we fail to achieve S-3-05, AB 32, and B-30-15 or if we achieve them but they turn out to be too little too late and other states and countries follow our example or do less?

It has been written[4] that, "A recent string of reports from impeccable mainstream institutions - the International Energy Agency, the World Bank, the accounting firm of PricewaterhouseCoopers - have warned that the Earth is on a trajectory to warm by at least 4 Degrees Celsius and this would be incompatible with continued human survival."

It has also been written[5] that, "Lags in the replacement of fossil-fuel use by clean energy use have put the world on a pace for 6 degree Celsius by the end of this century. Such a large temperature rise occurred 250 million years ago and extinguished 90 percent of the life on Earth. The current rise is of the same magnitude but is occurring faster."

Pictures That Are Worth a Thousand Words

Figure 1 shows (1) atmospheric CO_2 (in blue) and (2) averaged-over-a-year-then-averaged-over-the surface-of-the-earth, atmospheric temperature (in red). This temperature is with respect to a recent preindustrial revolution value. The data starts 800,000 years ago. It shows that the current value of atmospheric CO_2, which is over 410 PPM, far exceeds the values of the last 800,000 years. It also shows that we might expect the corresponding temperature to eventually be over 12 degrees above preindustrial temperatures. This would bring about a human disaster[3, 4, 5].

Figure 2 shows the average yearly temperature (in blue) with respect to the 1960-to-1990 baseline temperature. It also shows atmospheric levels of CO_2 (in red). The CO2 spike of Figure 1 is seen on Figure 2 to be an accelerating ramp up, starting at the time of our industrial revolution. The S-3-05 goal of 450 PPM is literally "off the chart", in Figure 2. Figure 2 shows that, as expected, temperatures are starting to rise along with the rising levels of CO_2. The large variations in temperature that are observed are primarily due to the random nature of the amount of solar energy being received by the earth.

FURTHER BACKGROUND: CALIFORNIA'S SB 375 AND AN IMPORTANT DATA SET

As shown in the Introduction, LDVs emit significant amounts of CO_2. The question arises: will driving need to be reduced or can cleaner cars and cleaner fuels arrive in time to avoid such behavioral change? Steve Winkelman, of the Center for Clean Air Policy (CCAP), worked on this problem and his results probably inspired California's SB 375.

SB 375, the *Sustainable Communities and Climate Protection Act of 2008*

Under SB 375, the California Air Resources Board (CARB) has given each Metropolitan Planning Organization (MPO) in California driving-reduction targets, for the years 2020 and 2035. "Driving" means yearly, per capita, vehicle miles travelled (VMT), by LDVs, with respect to 2005. The CARB-provided values are shown at this Wikipedia link, http://en.wikipedia.org/wiki/SB_375. It is important to note that although this link and many other sources show the targets to be "GHG" and not "VMT", SB 375 clearly states that the reductions are to be the result of the MPO's Regional Transportation Plan (RTP), or, more specifically, the Sustainable Communities Strategy (SCS) portion of the RTP. Nothing in the SCS will improve average mileage. That will be done by the state and federal governments by their Corporate Average Fleet Efficiency (CAFÉ) standards and any other laws or regulations that they might adopt. The SCS can only reduce GHG by reducing VMT.

Figure 1 Atmospheric CO_2 and Mean Temperature from 800,000 Years Ago

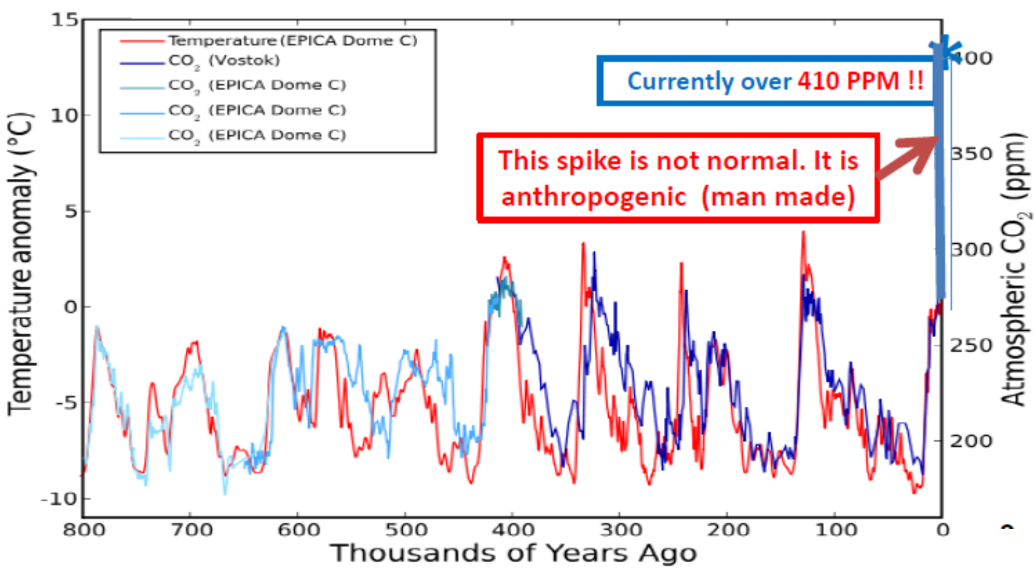
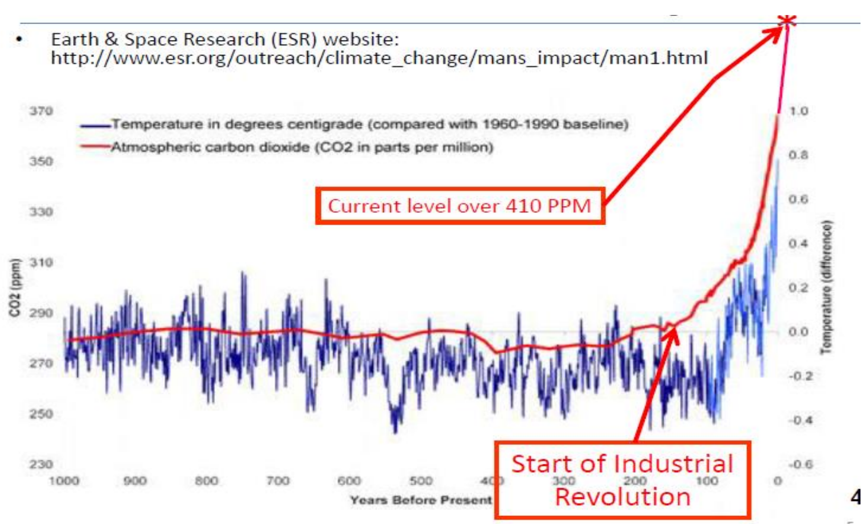


Figure 2 Atmospheric CO_2 and Mean Temperature, Over the Last 1,000 Years



Under SB 375, every Regional Transportation Plan (RTP) must include a section called a Sustainable Communities Strategy (SCS). The SCS must include driving reduction predictions corresponding to the CARB targets. Each SCS must include only *feasible* transportation, land use, and transportation-related policy data. If the SCS driving-reduction predictions fail to meet the CARB-provided targets, the MPO must prepare an Alternative Planning Strategy (APS). An APS uses *infeasible* transportation, land use, and transportation-related policy assumptions. The total reductions, resulting from both the SCS and the APS, must at least meet the CARB-provided targets.

Useful Factors from Steve Winkelman's Data

Figure 3[6].shows 5 variables as a percent of their 2005 value and also the 1990 emission value (turquoise) related to the 2005 CO2 emission value (the blue line). All of the variables are for LDVs. The year 2005 is the baseline year of SB 375. The red line is the Caltrans prediction of VMT. The purple line is California's current mandate for a Low Carbon Fuel Standard (LCFS). The LCFS also can be used to get the equivalent mileage from the actual mileage by dividing the actual mileage by the LCFS. The LCFS can be used to get the equivalent CO2 per mile driven by multiplying the actual CO2 per mile driven by the LCFS. As shown, by 2020, fuel in California must emit 10% less per gallon than in 2005. As written above, the turquoise line is the 1990 GHG emission in California. As shown, it is 12% below the 2005 level. This is important because S-3-05 specifies that in 2020, state GHG emission levels must be at the 1990 level. The green line is the C02 emitted per mile, as specified by AB 1493, also known as "Pavley 1 and 2" named after Senator Fran Pavley. The values shown do not account for the LCFS. The yellow (or gold) line is the S-3-05 mandate, referenced to 2005 emission levels. The blue line is the product of the red (miles), the green (CO2 per mile), and the purple line (LCFS, which reduces emission per mile) and is the percentage of GHG emissions compared to 2005. Since VMT is not being adequately controlled, the blue line is not achieving the S-3-05 line. Figure 3 shows that driving must be reduced. For this reason, Steve Winkelman can be thought of as the true father of SB 375.

<u>Figure 3</u> The S-3-05 Trajectory (the Gold Line) AND the CO_2 Emitted from Personal Driving (the Blue Line), where that CO_2 is a Function (the Product) of the California-Fleet-Average CO_2 per Mile (the Green Line), The Predicted Driving (VMT, the Red Line), and the Low-Carbon Fuel Standard (the Purple Line)

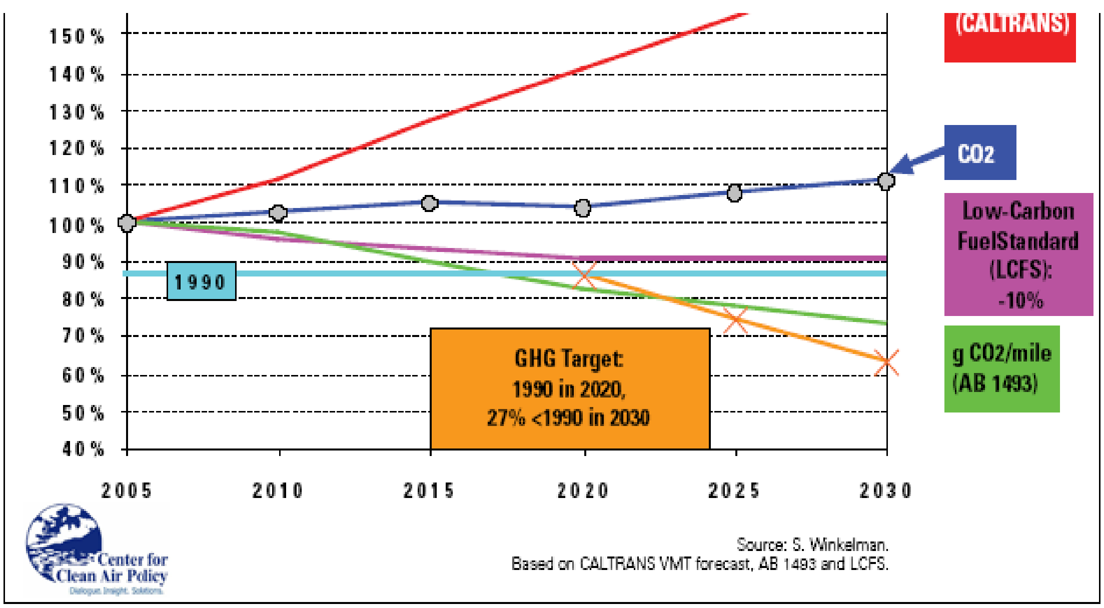


Figure 3 provides inspiration for a road map to climate success for LDVs. Climate-stabilization targets must be identified (from the climate scientists) and achieved by a set of requirements that will increase fleet efficiency and another set that will reduce per-capita driving.

THE DERIVATION OF CALIFORNIA'S TOP-LEVEL LDV REQUIREMENTS TO SUPPORT CLIMATE STABILIZATION

It is clear that more efficient (less CO2 emitted per mile) LDVs will be needed and this can be achieved with appropriate requirements. Significant improvements in efficiency will be needed if driving reductions are going to remain within what many people would consider politically achievable. Mileage and equivalent mileage will need to be specified. A significant fleet-fraction of Zero-Emission Vehicles (ZEVs, either Battery-Electric LDVs or Hydrogen Fuel Cell LDVs) will be needed. Since mileage and equivalent mileage are more heuristic than CO2 emissions per mile, they will be used in the derivations. CO2 per mile driven will not appear in the final equations.

Since the SB-375 work used 2005 as the reference year, that convention will be used. It will be assumed that cars last 15 years.

GHG Emission Target to Support Climate Stabilization

The primary problem with S-3-05 is that California's resolve and actions have been largely ignored by other states, our federal government, and many countries. Therefore, rather than achieving 2000 levels by 2010 (the first target of S-3-05) and 1990 levels by 2020 (the 2nd target of S-3-05), world emission has been increasing for nearly all of the years since 2010. (California, on the other hand achieved its 1990 emission level in 2018. This is two years sooner than the 2nd target of the S-3-05 requirement.) Reference 7 states on Page 14 that the required rate of reduction, if commenced in 2020, would be 15%. That rate means that the factor of 0.85 must be achieved, year after year. If this were done for 10 years, the factor would be $(0.85)^{10} = 0.2$, by 2030. This reduction of 80% down from the 2020 value matches the 2050 target requirement of S-3-5, which is 80% below the 1990 value. According to S-3-05, the 2020 emission value should be the same as the 1990 emission value. As noted above, the S-3-05 emission of 2050 was designed to support capping atmospheric CO2 at 450 PPM[3]. "Capping" means that the sum of all emissions (anthropogenic and natural) equals the sum of all sequestration (mostly photosynthesis.) Therefore, the author of the Reference 7 statement wanted the world to achieve the third target of S-3-05 to get the atmospheric CO2 to stop going up 20 years sooner than what S-3-05 was written to achieve. This shows the urgent nature of our climate crisis. Therefore, if California wants to do its part by setting an example for the world, the correct requirement for California is to achieve emissions that are reduced to 80% below California's 1990 value by 2030. The world's reduction rate is not anywhere near the needed 15% as we move towards the end of 2020. Therefore, the target, of 80% below 1990 levels by 2030 is considered to be correct for California. Reference 7 also calls into question the advisability of aiming for a 2 degree Celsius increase, given the possibilities of positive feedbacks that would increase warming. This concern for positive feedbacks is another reason that this paper will work towards identifying LDV requirement sets that will support LDVs achieving 80% below the 1990 value by 2030.

Thinking that LDVs can, for some reason, fail to achieve this target is dangerous thinking. As stated above, LDVs emit, by far, the most CO2 of all categories.

Notes on Methods

The base year is 2005. An intermediate year of 2015 is used. The car efficiency factor of 2015 with respect to 2005 is taken directly from Figure 3. The car efficiency factor of 2030 with respect to 2015 is derived herein, resulting in a set of car-efficiency requirements.

It is assumed that cars last 15 years. This is equivalent to assuming that the effect of the cars that last more than 15 years, thus increasing emissions, will be offset by the effect of the older cars that don't last as long as 15 years, thus reducing old-car emissions. As will be seen, there will also have to be some sort of an additional action to remove many of the older Internal Combustion Engine cars that are 15, through just 8 years old. Natural attrition will take care of some of this since as cars get older the probability that they will be taken out of service increases. However, some sort of "cash for gas guzzlers" program will be needed. How this is done is not covered in this paper. This is not unique. As another example, the car manufacturers will have to figure out how to produce the needed cars and batteries.

Primary Variables Used

Table 1 defines the primary variables that are used.

Fundamental Equations

The emissions are equal to the CO2 per mile driven multiplied by the per-capita driving multiplied by the population, since per-capita driving multiplied by the population is total driving. This is true for any given year.

Future Year k: $$\boldsymbol{e_k = c_k * d_k * p_k} \qquad \textbf{(Eq. 1)}$$

Base Year i: $$\boldsymbol{e_i = c_i * d_i * p_i} \qquad \textbf{(Eq. 2)}$$

Dividing both sides of Equation 1 by equal values results in an equality. The terms on the right side of the equation can be associated as shown here:

$$\boldsymbol{\frac{e_k}{e_i} = \frac{c_k}{c_i} * \frac{d_k}{d_i} * \frac{p_k}{p_i}} \qquad \textbf{(Eq. 3)}$$

Table 1 Variable Definitions

Variable Definitions	
$\boldsymbol{e_k}$	**LDV Emitted C02, in Year "*k*"**
$\boldsymbol{L_k}$	**Low Carbon Fuel Standard (LCFS) Factor that reduces the Per-Gallon CO2 emissions, in Year "*k*"**
$\boldsymbol{C_k}$	**LDV CO2 emitted per mile driven, average, in Year "*k*", not accounting for the Low Carbon Fuel Standard (LCFS) Factor**
$\boldsymbol{c_k}$	**LDV CO2 emitted per mile driven, average, in Year "*k*", accounting for the Low Carbon Fuel Standard (LCFS) Factor**

p_k	**Population, in Year "*k*"**
d_k	**Per-capita LDV driving, in Year "*k*"**
D_k	**LDV Driving, in Year "*k*"**
M_k	**LDV Mileage, miles per gallon, in Year "*k*"**
m_k	**LDV Equivalent Mileage, miles per gallon, in Year "*k*" accounting for Low Carbon Fuel Standard (LCFS) Factor, so this is M_k/L_k**
N	**Number of pounds of CO2 per gallon of fuel but not accounting for the Low Carbon Fuel Standard (LCFS) Factor**

Since CO2 per mile ("c") is a constant (use "A", noting that it is equal to about 20 pounds per gallon) multiplied by the number of Gallons ("G") and since number of gallons is distance (use "D") divided by mileage (use "m"), then c = A*D/m. this shows that the ratio of the "c" values in different years is going to be equal to the reciprocal of the "m" values in those different years because the other variables will cancel out. Therefore:

To work with mileage: $$\frac{m_i}{m_k} = \frac{c_k}{c_i} \qquad \textbf{(Eq. 4)}$$

Putting Equation 4 into Equation 5 results in the following equation:

$$\frac{e_k}{e_i} = \frac{m_i}{m_k} * \frac{d_k}{d_i} * \frac{p_k}{p_i} \qquad \textbf{(Eq. 5)}$$

Showing the base year of 2005, the future year of 2030, introducing the intermediate year of 2015 and the year of 1990 (since emissions in 2030 are with respect to the 1990 value) results in Equation 6.

$$\frac{e_{2030}}{e_{1990}} * \frac{e_{1990}}{e_{2005}} = \frac{c_{2030}}{c_{2015}} * \frac{c_{2015}}{c_{2005}} * \frac{d_{2030}}{d_{2005}} * \frac{p_{2030}}{p_{2005}} \qquad \textbf{(Eq. 6)}$$

The ratio on the far left is the climate-stabilizing target, which is the factor of the 2030 emission to the 1990 emission. It has been shown that this is 0.20 or 80% less. The next ratio is the emission of 1990 compared to 2005. It is the turquoise line of Figure 3, which is 0.87. The first ratio on the right side of the equation is the fleet emission per mile in 2030 compared to the value in 2015. This ratio will be derived in this report and it will result in a set of car-efficiency requirements. Moving to the right, the next ratio is the car efficiency in 2015 compared to 2005. It can obtained by multiplying the purple line 2015 value times the green line 2015 value, which is 0.90 * 0.93. The next term, still going from right to left, is the independent variable. It is the per-capita driving reduction required, with respect to the 2005 level of driving. The final term on the far right is the ratio of the population in 2030 to the population in 2005. Reference 8 shows that California's population in 2005 was 35,985,582. Reference 9 shows that California's population in 2030 is predicted to be 42,263,654. Therefore,

$$p_{2030}/p_{2005} = 42263654 \div 35985582 = 1.17446076 \qquad \textbf{(Eq. 7)}$$

Putting in the known values results in Equation 8:

$$\mathbf{0.20 * 0.87 = \frac{c_{2030}}{c_{2015}} * 0.90 * 0.93 * \frac{d_{2030}}{d_{2005}} * 1.17446076} \quad \textbf{(Eq. 8)}$$

Combining the values, solving for the independent variable (the per-capita driving ratio), and changing from emission-per-mile to equivalent-miles-per-gallon results in the following:

$$\mathbf{\frac{d_{2030}}{d_{2005}} = 0.177004896 * \frac{m_{2030}}{m_{2015}}} \quad \textbf{(Eq. 9)}$$

With the coefficient being so small, it is doubtful that we can get the equivalent mileage in 2030 to be high enough to keep the driving ratio from falling below one. The mileage of the 2015 fleet will be based on the best data we can get and by assuming cars last 15 years. The equivalent mileage in 2030 will need to be as high as possible to keep the driving-reduction factor from going too far below 1, because it is difficult to reduce driving too much. The equivalent mileage will be dependent on the fleet-efficiency requirements in the near future and going out to 2030. Those requirements are among the primary results of this report.

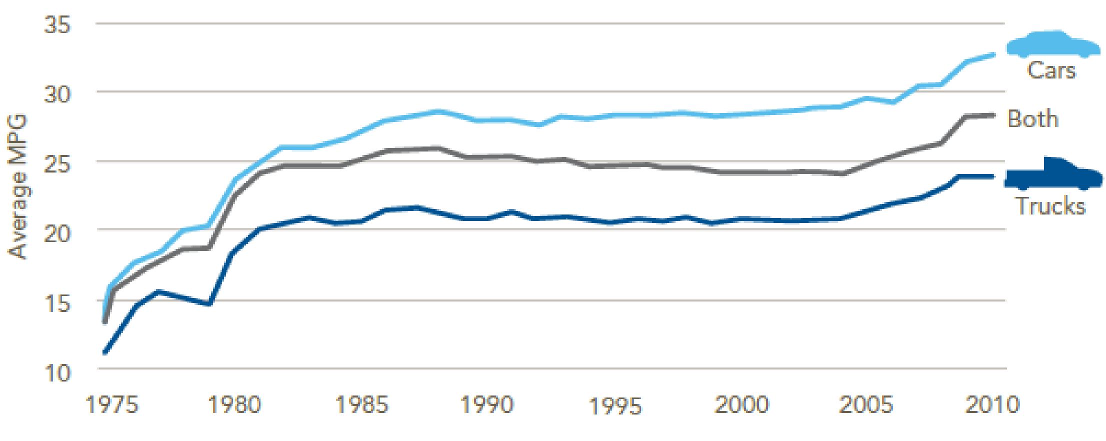
Internal Combustion Engine (ICE) Mileage, from Year 2000 to Year 2030

The years from 2000 to 2011 are taken from a plot produced by the PEW Environment Group,

http://www.pewenvironment.org/uploadedFiles/PEG/Publications/Fact_Sheet/History%20of%20Fuel%20Economy%20Clean%20Energy%20Factsheet.pdf

The plot is shown here as Figure 6. The "Both" values are used.

Figure 4 **Mileage Values From the PEW Environment Group**



The values from 2012 to 2025 are taken from the US Energy Information Agency (EIA) as shown on their website, http://www.c2es.org/federal/executive/vehicle-standards#ldv_2012_to_2025. They are the LDV Corporate Average Fleet Efficiency (CAFÉ) values enacted into law in the first term of President Obama. From 2025 to 2030, it is assumed that the yearly ICE improvement in CAFÉ will be 2.5 MPG.

Overall Mileage of California's LDV Fleet in 2015

Table 2 uses these values of the Internal Combustion Engine (ICE) LDV mileage to compute the mileage of the LDV fleet in 2015. It assumes that the fraction of ZEVs being used over these years is small enough to be ignored. The 100 miles driven, nominally, by each set of cars, is an arbitrary value and inconsequential in the final calculation, because it will divide out. It is never-the-less used, so that it is possible to compare the gallons of fuel used for the different years. The "f" factor could be used to account for a set of cars being driven less. It was decided to not use this option by setting all of the values to 1. The Low Carbon Fuel Standard (LCFS) values are taken from Figure 3. The gallons of fuel are computed as shown in Equation 10, using the definition for L_k that is shown in Table 2.

$$\boldsymbol{Gallons\ Used\ per\ f * 100\ miles\ = \frac{f x 100}{(\ CAFE\ MPG)/L_k}} \qquad \textbf{(Eq. 10)}$$

As shown in Table 2, using the definitions in Eq. 9:

$$\boldsymbol{m_{2015}\ = 27.63}$$

If it is deemed acceptable to have per-capita driving in 2030 be reduced 32% with respect to 2005 driving, then the left side of Eq. 9 becomes 0.68 and it is possible to use Eq. 9 to solve for the 2030 mileage as:

$$\boldsymbol{m_{2030} = (27.63) * 0.68 * \left(\frac{1}{0.177004896}\right) = 106.1462} \qquad \textbf{(Eq. 11)}$$

Likewise if it is decided that the per-capita driving in 2030 should equal the per-capita driving in 2005 then:

$$\boldsymbol{m_{2030} = (27.63) * 1.00 * \left(\frac{1}{0.177004896}\right) = 156.0974} \qquad \textbf{(Eq. 12)}$$

These values will provide the targets for the tables that compute the mileage values for 2030.

How ICE Mileage Values Will Be Used with ZEV Equivalent Mileage Values

To have LDVs achieve our climate-stabilizing target, after 2015, the net (computed using both ICE and ZEV vehicles) mileage values for each year will need to greatly improve by having a significant fraction of ZEVs. The ICE CAFÉ standards are used in this report as just the ICE contribution to fleet MPG. The ICE MPG values are inadequate by themselves and will therefore need to become less important; the ZEVs sales will need to overtake the ICE sales.

Federal requirements will need to change significantly. Currently, federally-mandated corporate average fuel efficiency (CAFÉ) standards have been implemented, from 2000 to 2025. These standards require that each corporation produce and sell their fleet of cars and light-duty trucks in the needed proportions, so that the combined mileage of all of the cars they sell (total miles driven in all cars sold in the year of interest divided by the total gallons used by all those cars, for any arbitrary distance) at least meets the specified mileage.

Table 2 Calculation of the Fleet MPG for 2015

LDV Set	Years Old	Model Year	CAFE MPG	LCFS Factor L_{Year}	Factor Driven f	Gallons Used Per f*100 Miles
1	14-15	2001	24.0	1.0	1.0	4.17
2	13-14	2002	24.0	1.0	1.0	4.17
3	12-13	2003	24.0	1.0	1.0	4.17
4	11-12	2004	24.0	1.0	1.0	4.17
5	10-11	2005	25.0	1.0	1.0	4.00
6	9-10	2006	25.7	.9933	1.0	3.87
7	8-9	2007	26.3	.9867	1.0	3.75
8	7-8	2008	27.0	.9800	1.0	3.63
9	6-7	2009	28.0	.9733	1.0	3.48
10	5-6	2010	28.0	.9667	1.0	3.45
11	4-5	2011	29.1	.9600	1.0	3.30
12	3-4	2012	29.8	.9533	1.0	3.20
13	2-3	2013	30.6	.9467	1.0	3.09
14	1-2	2014	31.4	.9400	1.0	2.99
15	0-1	2015	32.6	.9333	1.0	2.86
					Sum of Gallons:	54.29
					Miles = 100*Sum(f's):	1500
					MPG = Miles/(Sum of Gallons):	27.63

The car companies want to maximize their profits while achieving the required CAFÉ standard. In California, the car companies are already be required to sell a specified number of electric vehicles, which have a particularly-high, equivalent-value of miles-per-gallon. If the laws are not changed, this situation will allow companies to take advantage of their ZEV vehicles to sell more low-mileage, high-profit cars and light-duty trucks, and still achieve the federal CAFÉ standard.

It will be better to apply the CAFÉ standards to only the ICEs and then require, in addition to the CAFÉ standards, that the fleet of LDVs sold achieve some mandated fraction of ZEVs. The ZEVs will get ever-improving equivalent mileage, as our electrical grid is powered by a larger percent of renewable energy. In other words, their equivalent mileage is not fixed, but will improve over the years. Requirements developed here are for 2030. Therefore a high percentage of all the electricity generated in the state, including both the "in front of the meter" (known as the "Renewable Portfolio Standard" or "RPS") portion and the "behind the meter" portion is assumed to come from sources that do not emit CO2. The values of 85% and 90% are assumed. The values become one of the important fleet-efficiency requirements for cases that are considered. Hopefully these assumptions are reasonable. San Diego's Climate Action Plan (CAP) was the first to specify 100% renewable energy by 2035. Many other cities have followed San Diego's lead in this regard.

How to Compute the ZEV Equivalent Mileage Values

To calculate the equivalent mileage of the 2030 fleet of LDVs, it is necessary to derive a formula to compute the equivalent mileage of ZEVs, as a function of the percent of electricity that is generated without emitting CO2 (the mixed case), the equivalent ZEV mileage if the electricity is from 100% fossil fuel (the "West Virginia" case), and the equivalent ZEV mileage if the electricity is from 100% renewable sources (the ideal case), which is not infinity because it is assumed that the manufacturing of the car emits CO2. The variable definitions in Table 3 are used.

Table 3 Variables Used in the Calculation of ZEV Equivalent Mileage

Variable	Definition
m_z	**ZEV Equivalent mileage**
m_{zr}	**ZEV Equivalent mileage if the electricity is from renewables**
m_{zf}	**ZEV Equivalent mileage if the electricity is from fossil fuels**
r	**fraction of electricity generated from renewable sources**
G	**Gallons of equivalent fuel used**
D	**Arbitrary distance travelled**
Num	$m_{zr} * m_{zf}$
Den	$r * m_{zf} + (1 - r) * m_{zr}$

The derivation of the equation for equivalent ZEV mileage is based on the notion that the ZEV can be imagined to travel "r" fraction of the time on electricity generated from renewables and "(1-r)" fraction of the time on fossil fuel. If the vehicle travels "D" miles, then, using the definitions shown in Table 4, the following equation can be written.

$$G = \frac{r * D}{m_{zr}} + \frac{(1-r) * D}{m_{zf}} \qquad \textbf{(Eq. 13)}$$

$$m_z = D/G = D/\left(\frac{r * D}{m_{zr}} + \frac{(1-r) * D}{m_{zf}}\right) \qquad \textbf{(Eq. 14)}$$

Dividing the numerator and the denominator by D and multiplying the numerator and the denominator by the product of the two equivalent mileage values (m_{zr} and m_{zf}) results in Equations 31.

$$m_z = m_{zr} * m_{zf}/\left(r * m_{zf} + (1 - r) * m_{zr}\right) \qquad \textbf{(Eq. 15)}$$

Using the definitions in Table 3:

$$m_z = Num/(Den\ ) \qquad \textbf{(Eq. 16)}$$

Table 4 shows 3 assignments of assumed values in which the fraction of electricity generated from renewables is varied and the results, using Equations 15 and 16, results in the three values of ZEV equivalent mileage. This shows the urgent need to move towards cleaner electricity.

Table 4 Variable Assignment and the Resulting ZEV Mileages

m_{zr}	m_{zf}	r	1-r	Num	Den	m_z
5000	70	0.80	0.20	350000.00	1056.00	331.44
5000	70	0.85	0.15	350000.00	809.50	432.37
5000	70	0.90	0.10	350000.00	563.00	621.67

Additional Variables Needed to Compute the Overall Equivalent Mileage in 2030, Taking Into Account Bothe ICEs and ZEVs

Table 5 shows the additional definitions that will be used in the calculation of 2030 overall mileage.

Table 5 Additional Variables Used in the Calculation of 2030 LDV Mileage

Variable	Definition
D_i	Distance travelled by ICE vehicles
D_z	Distance travelled by ZEV vehicles
G_i	Gallons of equivalent fuel used by ICE vehicles
G_z	Gallons of equivalent fuel used by ZEVs

Computing an LDV Overall Equivalent Fleet Mileage, for the *Balanced_1* Case

Table 6 shows the calculation for the overall equivalent mileage for all the cars on the road, in the year of 2030, for the *Balanced_1* case.

The name, *Balanced_1*, comes from the attempt to *balance* the difficulty of achieving the fleet efficiency-related requirements with the difficulty of achieving the driving-reduction related requirements. The *Balanced_*1 case assumes that electricity is 85% renewable, which is also difficult.

There will also be a *Balanced_*2 case that assumes that electricity is 90% renewable. Both the *Balanced_1* and the *Balanced_ 2* cases assume that it is reasonable to have per-capita driving in 2030 reduced 32%, with respect to 2005 per-capita driving. That assumption, along with the 85% renewable electricity assumption, was used to select the z values of Table 6 to result in the Equation 11 value of overall 2030 mileage, which is 106.1263 Miles Per Gallon (MPG). From Table 4, 85% renewable electricity results in a ZEV equivalent mileage of 432.37 MPG. That value of equivalent ZEV mileage in 2030, when electricity is 85% renewable, is used for all of the ZEV model years, for this case. Note that this is overlooking the fact that not all BEVs are equally efficient. In order to simplify this analysis, the Table 4 values of m_{zr} and m_{zf} are considered to be applicable to all the ZEV models. Therefore, the 432.37 MPG value can be divided into each D_z value to compute the corresponding G_z value, in all of the model years being considered.

To reduce the miles driven in poor-mileage ICE's, the "f" factor is used. For example, if "f" is set to 0.30, as it is in 2016, then the miles driven is reduced by 70%. Achieving the required "f" values may require some type of "cash-for-gas-guzzlers" program. However, it could also be noted that when older cars are second or third cars in multi-car families in which family members have the luxury of choosing which car to drive, family members will usually choose the car that is cheaper to operate, thus making the "f" factors easier to achieve. Finally, the Low Carbon Fuel Standard (LCFS) is assumed to continue to improve from the currently mandated value of 0.9 by the end of 2019. This is another method of reducing the CO2 emissions of the ICE vehicles.

For the ICE vehicles, the G_i values are computed as the D_i value divided by the equivalent MPG value. The equivalent MPG is the CAFÉ MPG divided by the LCFS factor.

It is arbitrarily assumed that the cars, for each year being considered (the models for that year, both ZEVs and ICEs), go a total of 100 miles. Although this is an extremely small fraction of the actual miles that will be driven, it doesn't change the result because the number of gallons of equivalent gasoline is always proportional to miles. The fraction of cars that are ZEVs ($\boldsymbol{z}$) is used to divide up this value of 100 Miles. However, the factor "f" reduces the miles driven by the ICE vehicles and this brings down the total miles driven for the years in which the "f" term is less than 1. For each year, the total miles per gallon (MPG) is computed as the total miles driven divided by the total gallons used. However, this value is not used in the calculation of the entire fleet equivalent mileage. The overall equivalent mileage is computed as the total miles driven divided by the total gallons used, where these quantities are summed over all of the 15 categories (years) of LDVs.

The following formulas are used to compute the overall equivalent mileage in 2030, of all of the LDVs on the road.

For the ICE calculations, for 2016, where

- "L_k" is defined in Table 1 (LCFS factor for year "k") and is the value in the "LCFS" column of Table 6 and
- "$\boldsymbol{z}$" is from the "$\boldsymbol{z}$" column and is the fraction of cars sold in the year that are ZEVs and
- "m_i" is the value from the CAFÉ MPG column:

$$\boldsymbol{D_i = 100 * f * (1 - z\,)} \quad \textbf{(Eq. 17)}$$

$$\boldsymbol{G_i = D_i/(m_i\ /\ L_{2016})} \quad \textbf{(Eq. 18)}$$

For the ZEV calculations:

$$\boldsymbol{D_z = 100 * z} \quad \textbf{(Eq. 17)}$$

$$\boldsymbol{G_z = D_z/(432.37)} \quad \textbf{(Eq. 18)}$$

In updating this report from its 2015 version, the fleet fraction of ZEVs ("$\boldsymbol{z}$"), from 2015 to 2019, had to be reduced to approximate the low values that actually occurred from 2015 to 2019. However, in 2020, it is assumed that the fraction will be at least as large as 8%, which is not such a trivial value. If it is actually larger than 8%, then there will be some margin built into the requirements derived in this report.

Table 6 Calculation of 2030 LDV Mileage Assuming the *Balanced_1* Case

Year	ICE Parameters and Calculations						ZEVs			Yearly Totals		
	CAFÉ MPG	LCFS	Eq. MPG	f	D_i	G_i	z	D_z	G_z	Total Miles	Total Gallons	2030 MPG
2016	34.3	.9267	37.01	.3	29.4	0.7943	.02	2	.005	31.40	0.7989	39.30
2017	35.1	.9200	38.15	.4	39.2	1.0275	.02	2	.005	41.20	1.0321	39.92
2018	36.1	.9133	39.53	.5	48.5	1.2271	.03	3	.007	51.50	1.2340	41.73
2019	37.1	.9067	40.92	.6	57.6	1.4077	.04	4	.009	61.60	1.4169	43.47
2020	38.3	.9000	42.56	.7	64.4	1.5133	.08	8	.019	72.40	1.5318	47.26
2021	40.3	.8500	47.41	.8	64.0	1.3499	.20	20	.046	84.00	1.3961	60.17
2022	42.3	.8000	52.88	.9	58.5	1.1064	.35	35	.081	93.50	1.1873	78.75
2023	44.3	.8000	55.38	1.0	45.0	0.8126	.55	55	.127	100.00	0.9398	106.40
2024	46.5	.8000	58.13	1.0	20.0	0.3441	.80	80	.185	100.00	0.5291	188.99
2025	48.7	.8000	60.88	1.0	6.0	0.0986	.94	94	.217	100.00	0.3160	316.48
2026	51.2	.8000	64.00	1.0	3.0	0.0469	.97	97	.224	100.00	0.2712	368.70
2027	53.7	.8000	67.13	1.0	2.0	0.0298	.98	98	.227	100.00	0.2565	389.93
2028	56.2	.8000	70.25	1.0	1.0	0.0142	.99	99	.229	100.00	0.2432	411.17
2029	58.7	.8000	73.38	1.0	1.0	0.0136	.99	99	.229	100.00	0.2426	412.20
2030	61.2	.8000	76.50	1.0	1.0	0.0131	.99	99	.229	100.00	0.2420	413.15
Sum of Miles and then Gallons of Equivalent Fuel:										**1235.60**	**11.64**	
Equivalent MPG of LDV Fleet in 2030:										***106.17***		
Sum of ZEV Miles = **795**. Fraction of Miles Driven by ZEVs = **64.3%**												

There is probably some margin from the 2016 to 2019 values as well. The difficult values are for 2022, 2023, and 2024, with 2024 requiring that ZEV sales are 80% of all the cars purchased in California. The purple color of the **z** values denotes difficulty. This shows that the government will need to require that the car companies achieve the **z** values or buy credits from a company such as Tesla, which sells 100% ZEVs.

The Table 6 ***z*** values were put into an EXCEL spread sheet that looks like Table 6. It produced the values shown in Table 6. The values were selected to try to get to the 106.1462 value that was computed in Eq. 11.

Using the result of 106.17 MPG into Equation 9, gives the following result:

$$\frac{\boldsymbol{d_{2030}}}{\boldsymbol{d_{2005}}} = \mathbf{0.17700} * \frac{\boldsymbol{m_{2030}}}{\boldsymbol{m_{2015}}} = \mathbf{0.17700} * \frac{\mathbf{106.17}}{\mathbf{27.63}} = \mathbf{0.68016} \qquad \textbf{(Eq. 19)}$$

This is the 32% reduction desired. It will be difficult to achieve. However, the required schedule of ZEV adoption is also difficult. The values of *z* from the years 2021 to 2025 will be at least as difficult as achieving the 32% reduction. This situation motivates the next case. If electricity could be made cleaner sooner, the years from 2021 to 2025 could be less difficult.

Computing an LDV Overall Equivalent Fleet Mileage, for the *Balanced_2* Case

The *Balanced_2* case is shown in Table 7.

The *Balanced_2* case is the same as the *Balanced_1* case except it includes an assumption that electricity is 90% renewable in 2030 instead of 85%. Table 7 shows the results using that assumption, which becomes a requirement for this case. For the *Balanced_2* case, the values of *z* are once again assigned to achieve the desired driving-reduction value of 32%.

From the second line of Table 4, this means that the equivalent mileage of the ZEV vehicles is 621.67 MPG.

Eq. 18 becomes:

$$\boldsymbol{G_z} = \boldsymbol{D_z}/(\mathbf{621.67}) \qquad \textbf{(Eq. 20)}$$

This is used to compute the gallons of equivalent fuel from the distance, for the ZEV vehicles in Table 7.

The Table 7 ***z*** values were put into an EXCEL spread sheet that looks like Table 7. It produced the values shown in Table 7. The *z* values were selected to try to get to the 106.1462 value that was computed in Eq. 11.

Using the Table 7 result of 106.22 MPG into Equation 9, gives the following result:

$$\frac{d_{2030}}{d_{2005}} = 0.17700 * \frac{m_{2030}}{m_{2015}} = 0.17700 * \frac{106.22}{27.63} = 0.68045 \qquad \text{(Eq. 21)}$$

Table 7 Calculation of 2030 LDV Mileage Assuming the *Balanced_2* Case

Year	ICE Parameters and Calculations						ZEVs			Yearly Totals		
	CAFÉ MPG	LCFS	Eq. MPG	f	D_i	G_i	z	D_z	G_z	Total Miles	Total Gallons	2030 MPG
2016	34.3	.927	37.01	.3	29.4	0.7943	.02	2	.003	31.40	.7975	39.37
2017	35.1	.920	38.15	.4	39.2	1.0275	.02	2	.003	41.20	1.0307	39.97
2018	36.1	.913	39.53	.5	48.5	1.2271	.03	3	.005	51.50	1.2319	41.81
2019	37.1	.907	40.92	.6	57.6	1.4077	.04	4	.006	61.60	1.4141	43.56
2020	38.3	.900	42.56	.7	64.4	1.5133	.08	8	.013	72.40	1.5262	47.44
2021	40.3	.850	47.41	.8	68.0	1.4342	.15	15	.024	83.00	1.4584	56.91
2022	42.3	.800	52.88	.9	67.5	1.2766	.25	25	.040	92.50	1.3168	70.25
2023	44.3	.800	55.38	1.0	55.0	0.9932	.45	45	.072	100.00	1.0656	93.84
2024	46.5	.800	58.13	1.0	30.0	0.5161	.70	70	.113	100.00	.6287	159.05
2025	48.7	.800	60.88	1.0	5.0	0.0821	.95	95	.153	100.00	.2349	425.62
2026	51.2	.800	64.00	1.0	3.0	0.0469	.97	97	.156	100.00	.2029	492.84
2027	53.7	.800	67.13	1.0	2.0	0.0298	.98	98	.158	100.00	.1874	533.52
2028	56.2	.800	70.25	1.0	1.0	0.0142	.99	99	.159	100.00	.1735	576.42
2029	58.7	.800	73.38	1.0	1.0	0.0136	.99	99	.159	100.00	.1729	578.45
2030	61.2	.800	76.50	1.0	1.0	0.0131	.99	99	.159	100.00	.1723	580.31
Sum of Miles and then Gallons of Equivalent Fuel:										1233.60	11.61	
Equivalent MPG of LDV Fleet in 2030:										***106.22***		
Sum of ZEV Miles = **761**. Fraction of Miles Driven by ZEVs = **61.7%**												

This is the 32% reduction desired. It will be difficult to achieve. However, the required schedule of ZEV adoption is also difficult. The values of $\boldsymbol{z}$ from the years 2021 to 2025 will be at least as difficult as achieving the 32% reduction. However, they are easier to achieve than the values needed in the *Balanced_1* Case. This quantifies the benefit of increasing the renewable fraction of electricity from 85% to 90%.

Computing an LDV Overall Equivalent Fleet Mileage, for the *2005_Driving* Case

When climate change and transportation policies are discussed, the opinion that we should simply electrify our fleet as soon as possible is often expressed. The idea is that the per-capita driving level does not have to be reduced, if we electrify our fleet fast enough. The relationships developed in this paper enable an analysis to see how this would work. This gives rise to the *2005_Driving* Case. For this case, it is assumed that electricity is 90% renewable.

From the third line of Table 4, this means that the equivalent mileage of the ZEV vehicles is 621.67 MPG. Therefore, the relationship shown in Eq. 20 is used.

The *2005_Driving* case is shown in Table 8.

For the *2005_Driving* case, the values of z are assigned to achieve the overall equivalent mileage (MPG) value computed in Eq. 12, which is 156.0974, because that value was computed for there being no change in the per-capita driving from the 2005 value.

Using the result of 155.99 MPG into Equation 9, gives the following result:

$$\frac{d_{2030}}{d_{2005}} = 0.17700 * \frac{m_{2030}}{m_{2015}} = 0.17700 * \frac{155.99}{27.63} = 0.99930 \qquad \textbf{(Eq. 22)}$$

This is the 0% reduction desired. However, the required schedule of ZEV adoption is not possible. Jumping from 8% in 2020 to 82% in 2021 defies reason. It appears that our best bet, to do our part to avoid human extinction, is to proceed with the assumption (and thus requirement) that we are going to have to reduce per-capita driving, as shown in either the *Balanced_1* or the *Balance_2* case.

Computing an LDV Overall Equivalent Fleet Mileage, for the *Mary_Nichols* Case

Mary Nichols was first appointed to the California Air Resource Board (CARB) in 1975 and became Chair in 1979. After leaving CARB, she founded the Los Angeles Chapter of the Natural Resources Defense Council (NRDC) in 1989. She was reappointed to the position of Chair of

CARB in 2007 by Governor Arnold Schwarzenegger and she is still serving in that position today.

Table 8 Calculation of 2030 LDV Mileage Assuming the *2005_Driving* Case

Year	ICE Parameters and Calculations						ZEVs			Yearly Totals		
	CAFÉ MPG	LCFS	Eq. MPG	f	D_i	G_i	z	D_z	G_z	Total Miles	Total Gallons	2030 MPG
2016	34.3	.9267	37.01	.3	29.4	.7943	.02	2.0	.003	31.40	0.7975	39.37
2017	35.1	.9200	38.15	.4	39.2	1.0275	.02	2.0	.003	41.20	1.0307	39.97
2018	36.1	.9133	39.53	.5	48.5	1.2271	.03	3.0	.005	51.50	1.2319	41.81
2019	37.1	.9067	40.92	.6	57.6	1.4077	.04	4.0	.006	61.60	1.4141	43.56
2020	38.3	.9000	42.56	.7	64.4	1.5133	.08	8.0	.013	72.40	1.5262	47.44
2021	40.3	.8500	47.41	.8	14.4	.3037	.82	82.0	.132	96.40	0.4356	221.29
2022	42.3	.8000	52.88	.9	2.7	.0511	.97	97.0	.156	99.70	0.2071	481.42
2023	44.3	.8000	55.38	1.0	1.0	.0181	.99	99.0	.159	100.00	0.1773	563.99
2024	46.5	.8000	58.13	1.0	1.0	.0172	.99	99.0	.159	100.00	0.1765	566.72
2025	48.7	.8000	60.88	1.0	1.0	.0164	.99	99.0	.159	100.00	0.1757	569.23
2026	51.2	.8000	64.00	1.0	1.0	.0156	.99	99.0	.159	100.00	0.1749	571.84
2027	53.7	.8000	67.13	1.0	1.0	.0149	.99	99.0	.159	100.00	0.1741	574.23
2028	56.2	.8000	70.25	1.0	1.0	.0142	.99	99.0	.159	100.00	0.1735	576.42
2029	58.7	.8000	73.38	1.0	1.0	.0136	.99	99.0	.159	100.00	0.1729	578.45
2030	61.2	.8000	76.50	1.0	1.0	.0131	.99	99.0	.159	100.00	0.1723	580.31
Sum of Miles and then Gallons of Equivalent Fuel:										1254.20	**8.04**	
Equivalent MPG of LDV Fleet in 2030:										***155.99***		
Sum of ZEV Miles = **990.0** Fraction of Miles Driven by ZEVs = **78.9%**												

The following quote[13] inspires the *Mary_Nichols* Case:

Regulations on the books in California, set in 2012, require that 2.7 percent of new cars sold in the state this year be, in the regulatory jargon, ZEVs. These are defined as battery-only or fuel-cell cars, and plug-in hybrids. The quota rises every year starting in 2018 and reaches 22 percent in 2025. Nichols wants 100 percent of the new vehicles sold to be zero- or almost-zero-emissions by 2030

The mathematical relationships developed in this paper make it possible to determine the driving reduction that would be required if it is desired to stabilize the climate at a livable level, assuming the schedule of fleet electrification implied by the above quote. Electricity is required to be 90% renewable. The results of the *Mary_Nichols* Case are shown in Table 9.

The corresponding driving reduction is computed using Eq. 9.

$$\frac{d_{2030}}{d_{2005}} = 0.177005 * \frac{m_{2030}}{m_{2015}} = 0.177055 * \frac{77.24}{27.63} = 0.495 \quad \textbf{(Eq. 14)}$$

This means that the per-capita driving will need to be about 50% less in 2030 than in year 2005. It is not known if CARB understands this.

The official policy of the California Democratic Party (CDP) is expressed in its Platform. A statement that applies to this report and to CARB can be viewed by looking at the California Democratic Party (CDP) website, then select “About Us”, “Standing Committees”, “Platform Committee”, “2020 Platform”, and finally “Energy and Environment Plank”. In that Plank, the following statement is found

- *Demand a state plan specifying how cars and light-duty trucks can meet climate-stabilizing targets by defining enforceable measures to achieve necessary fleet efficiency and per-capita driving limits;*

However, your author’s efforts to get CARB to do such a “state plan”, or to convince a state legislator to write legislation to direct CARB to do such a plan, have not been successful.

If CARB would do such a plan or would consider the results of this report, they would perhaps decide to push for a more ambitious fleet electrification schedule and would also push for state legislation and regulation to enact measures to reduce VMT.

Preliminary Conclusions Drawn from the Results of the Four Cases Run

Table 10 is a summary showing the most important results of the four cases considered. The purple-colored entries denote difficult requirements; red denotes nearly impossible.

Considering the *Balance_1* and the *Balanced_2* cases and the fleet electrification schedules for each, it is first concluded that California needs to work to get its electricity to be at least 85% renewable by 2030 and furthermore that getting it to be 90% from renewables by 2030 would make the electrification schedule much easier.

Table 9 Calculation of 2030 LDV Mileage Assuming the *Mary_Nichols* Case

	ICE Parameters and Calculations						ZEVs			<u>Yearly Totals</u>		
Year	CAFÉ MPG	LCFS	Eq. MPG	f	D_i	G_i	z	D_z	G_z	Total Miles	Total Gallons	2030 MPG
2016	34.3	.9267	37.01	.3	29.2	.7886	.027	2.7	.004	31.89	0.7930	40.22
2017	35.1	.9200	38.15	.4	38.9	1.0201	.027	2.7	.004	41.62	1.0245	40.63
2018	36.1	.9133	39.53	.5	47.4	1.2003	.051	5.1	.008	52.56	1.2086	43.49
2019	37.1	.9067	40.92	.6	55.5	1.3560	.075	7.5	.012	63.01	1.3681	46.06
2020	38.3	.9000	42.56	.7	63.0	1.4814	.099	9.9	.016	72.98	1.4974	48.74
2021	40.3	.8500	47.41	.8	70.1	1.4790	.124	12.4	.020	82.47	1.4988	55.02
2022	42.3	.8000	52.88	.9	76.7	1.4509	.148	14.8	.024	91.48	1.4746	62.03
2023	44.3	.8000	55.38	1.0	82.8	1.4957	.172	17.2	.028	100.00	1.5233	65.65
2024	46.5	.8000	58.13	1.0	80.4	1.3834	.196	19.6	.032	100.00	1.4149	70.67
2025	48.7	.8000	60.88	1.0	78.0	1.2813	.220	22.0	.035	100.00	1.3167	75.95
2026	51.2	.8000	64.00	1.0	62.4	0.9750	.376	37.6	.060	100.00	1.0355	96.57
2027	53.7	.8000	67.13	1.0	46.8	0.6972	.532	53.2	.086	100.00	0.7828	127.75
2028	56.2	.8000	70.25	1.0	31.2	0.4441	.688	68.8	.111	100.00	0.5548	180.25
2029	58.7	.8000	73.38	1.0	15.6	0.2126	.844	84.4	.136	100.00	0.3484	287.05
2030	61.2	.8000	76.50	1.0	0.0	0.0000	1.000	100.0	.161	100.00	0.1609	621.67
Sum of Miles and then Gallons of Equivalent Fuel:										**1236.00**	**16.00**	
Equivalent MPG of LDV Fleet in 2030:										***77.24***		
Sum of ZEV Miles = **457.9**. Fraction of Miles Driven by ZEVs = **37.0%**												

Certainly, achieving a 32% reduction in driving in 2030 compared to the 2005 level will be difficult. However, increasing the rate of fleet electrification, from what is shown in the *Balanced_1* and *Balanced_2* cases (***z***, in Tables 6 and 7) would be even more difficult.

Table 10 **Four-Case Summary of Requirements**

	Case Designations			
	Balanced_1	Balanced_2	2005 Driving	Mary Nichols
% Renewable Electricity	85.0%	90.0%	90.0%	90.00%
% ZEVs, Year 2016	2.0%	2.0%	2.0%	2.70%
% ZEVs, Year 2017	2.0%	2.0%	2.0%	2.70%
% ZEVs, Year 2018	3.0%	3.0%	3.0%	5.11%
% ZEVs, Year 2019	4.0%	4.0%	4.0%	7.53%
% ZEVs, Year 2020	8.0%	8.0%	8.0%	9.94%
% ZEVs, Year 2021	**20.0%**	15.0%	**82.0%**	12.35%
% ZEVs, Year 2022	**35.0%**	25.0%	**97.0%**	14.76%
% ZEVs, Year 2023	**55.0%**	**45.0%**	99.0%	17.18%
% ZEVs, Year 2024	**80.0%**	**70.0%**	99.0%	19.59%
% ZEVs, Year 2025	94.0%	95.0%	99.0%	22.00%
% ZEVs, Year 2026	97.0%	97.0%	99.0%	37.60%
% ZEVs, Year 2027	98.0%	98.0%	99.0%	53.20%
% ZEVs, Year 2028	99.0%	99.0%	99.0%	68.80%
% ZEVs, Year 2029	99.0%	99.0%	99.0%	84.40%
% ZEVs, Year 2030	99.0%	99.0%	99.0%	100.00%
% Reduction in Per-Capita Driving With Respect to Year 2005	**32.0%**	**32.0%**	0%	**50.5%**

Besides that, it should be recognized that California alone cannot stabilize our earth's climate. California's best hope is to set an example for other states and other countries. Taking too many of the world's production of electric vehicles will not work. For a more specific example, lithium batteries may be in short supply and so it may be counterproductive for California to have more than its fair share, thus preventing other states and countries from electrifying their fleet at the required rate. The rates of electrification shown for the *Balanced_1* and the *Balanced_2* cases are aggressive enough, as shown by the purple-colored entries.

California needs to adopt a set of requirements to achieve the 32% reduction. If CARB wants to work to have California legislate requirements to achieve the *Mary Nichol*'s case of a 50% reduction in driving, that would also work and allow more electric cars to go to other states and countries. However the 50% reduction in per-capita driving might be politically impossible at this time.

Since the 32% reduction seems prudent, it begs the question as to what this means in terms of roadway congestion.

The net (as opposed to the per-capita) driving change, going from 2005 to 2030 can be computed by multiplying the per-capita driving factor corresponding to the 32% reduction, which is 0.68, by the population factor of 1.1744, computed in Equation 7. The product of these two values is 0.7986. This means that, even with the 17% increase in California's population, the net driving will have to drop by the factor of about 0.80, or by 20%. If this LDV-driving-reduction requirement (of 0.68) is selected, all of California's transportation money can be used to improve transit, improve active transportation (mainly walking and biking), and maintain, but not expand, roads. There can be little or no congestion because California highway capacity now is larger than it was in 2005 while the state's net driving must drop by 20%.

ACHIEVING THE REQUIRED DRIVING REDUCTION OF THE *BALANCED_1* AND THE *BALANCED_2* CASES

As shown in Equation 19, for the *Balanced_1* case, and in Equation 21 for the *Balanced_2* Case, in 2030, the per-capita driving will need to be 32% below the 2005 value. As shown in this link, https://en.wikipedia.org/wiki/Sustainable_Communities_and_Climate_Protection_Act_of_2008 , California's Metropolitan Planning Organizations (MPOs) are adopting Region Transportation Plans (RTPs) that will achieve reductions in year 2020 and 2035. The convention adopted in this report for these reductions, specifically the per-capita driving reduction with respect to the per-capita driving in 2005, matches the SB 375 convention. As shown in the link, the targets, for year 2035, range from 0% for the Shasta MPO to 16% for Sacramento Area Council of Governments. However, it may be true that some of the 2035 requirements have been revised upwards, to be as large as 19% for some MPOs. Since the climate stabilization target year here is 2030 instead of 2035, and to be reasonably conservative, it is assumed here that the state (this is for all MPOs) will achieve a 12% reduction in per-capita driving, in 2030, compared to 2005. This leaves approximately 20% to be achieved by new requirements.

The title of each of the following subsections contains the estimated per-capita driving reduction each strategy will achieve, by 2030.

Reallocate Funds Earmarked for Highway Expansion to Transit and Consider Transit-Design Upgrades (2%)

San Diego County has a sales tax measure called "TransNet", which allocates approximately one-third for highway expansion, one-third for transit, and one-third for road maintenance. It has a provision that allows for a reallocation of funds, if supported by at least two-thirds of SANDAG Board members, including a so-called weighted vote, where governments are given a portion of 100 votes, proportional to their population. This requirement would be to reallocate the TransNet amount, earmarked for highway expansion, to transit and to do similar reallocations throughout California.

This money could be used to fund additional transit systems; improve transit operations; and/or fund the redesign and implementation of the redesign of existing transit systems. The redesign could include electrification and automation (including automation of fare collection and such features as screening passengers to prevent them from boarding if they have a fever or are in a "test positive" database) or even upgrading to a different transit technology.

A Comprehensive Road-Use Charge (RUC) Pricing and Payout System to Unbundle the Cost of Operating Roads (10%)

Comprehensive means that pricing would be set to cover all costs (including road maintenance and externalities such as harm to the environment and health); that privacy and the interests of low-income drivers doing necessary driving would be protected; that the incentive to drive fuel-efficient cars would be at least as large as it is under the current fuels excise tax; and finally, as good technology becomes available, congestion pricing is used to protect critical driving from congestion.

The words *payout* and *unbundle* mean that some of the money collected would go to people that are losing money under the current system.

User fees (gas taxes and tolls) are not enough to cover road costs[10] and California is not properly maintaining its roads. Reference 10 shows that in California user fees amount to only 24.1% of what is spent on roads. Besides this, the improved mileage of the ICEs and the large number of ZEVs mean that gas tax revenues will drop precipitously.

This RUC system could be used to help reduce the ICE LDV miles driven in 2016 to 2022, as shown in the "f" column of Tables 6 through 9. This system could probably be implemented in less than 2 years if the urgency of our climate crisis is recognized..

Unbundling the Cost of Car Parking (8%)

Unbundling the cost of car parking[11] throughout California is conservatively estimated to decrease driving by 8%, based on Table 1 of Reference 11. That table shows driving reductions that occur in response to introducing a price, for 10 cases. Its average reduction in driving is 25% and its smallest reduction is 15%. However, these numbers are for individual cases whereas the 8% is the decrease in driving in California, due to introducing value pricing where there is a zero price today, or where the price is below its value price. These concepts are explained in Reference 11.

The first such systems should be installed by a (RFP is Request for Proposal) RFP-process-identified, third-party vendor, such as Google, Qualcomm, Uber, or Lime Bicycle, for municipal government employees, as part of the government's Climate Action Plan. The system would be operated for the financial gain of the employees, with a hard requirement in the RFP that even employees that continue to drive every day would at least break even. The winning third-party vendor would be skilled at monetizing parking whenever it is not being used by the employees and skilled at monetizing data. The parking system would be fully automated, like Uber, except with a more useful phone app that would find the best parking at the user-specified price and walk-distance. The parking would be available to all drivers driving a car registered in the system. Briefly stated, the system is value priced, shared, automated, and provides earnings to all the people that are effectively losing wages or paying higher costs because the parking is being provided. The vendor would also be good at expanding the system both geographically and over all types of uses, in an economically disruptive way; as Uber and Lyft did to the taxi cab industry. The system would be as easy to use as "free" parking, once the car is registered. It would utilize congestion pricing to protect the desired maximum-occupancy rate.

Good Bicycle Projects

The best criterion for spending money for bicycle transportation is the estimated reduction in driving per the amount spent. The following strategies may come close to maximizing this parameter.

Projects to Improve Bicycle Access (1%)

All of the smart-growth neighborhoods, central business districts, and other high-trip destinations or origins, both existing and planned, should be checked to see if bicycle access could be substantially improved with either a traffic calming project, a "complete streets" project, more shoulder width, or a project to overcome some natural or made-made obstacle. For example, in some cases, long stretches of freeways cut off bicycle passage on surface streets that are perpendicular to the freeway. In some of these cases, a bicycle bridge over the freeway would be cost effective.

League-of-American-Bicyclist-Certified (LCI) Instruction of "Traffic Skills 101" (1%)

Most serious injuries to bike riders occur in accidents that do not involve a motor vehicle[12]. Most car-bike accidents are caused by wrong-way riding and errors in intersections; the clear-cut-hit-from-behind accident is rare[12].

After attending *Traffic Skills 101*, students that pass a rigorous written test and demonstrate proficiency in riding in traffic and other challenging conditions, in passing an on-road-riding test, would be paid for their time and effort.

As an example of what could be done in San Diego County, if the average class size was 3 riders per instructor and each rider passes both tests and earns $100 and if the instructor, with overhead, costs $500 dollars, for a total of $800 for each 3 students, that would mean that $160M could teach $160M/$800 = 200,000 classes of 3 students, for a total of 600,000 students. The population of San Diego County is around 3 million.

Eliminate or Greatly Increase the Maximum Height and Density Limits Close to Transit Stops that Meet Appropriate Service Standards (2%)

As sprawl is reduced, more compact, transit-oriented development (TOD) will need to be built. This strategy will incentivize a consideration of what level of transit service will be needed, how it can be achieved, and what levels of maximum height and density are appropriate. Having no limits at all is reasonable if models show that the development can function without harming the existing adjacent neighborhoods, given the level of transit service and other supporting transportation policies (such as car parking that unbundles the cost and supports the full sharing of parking[12]) that can be assumed.

Complete Streets (Streets designed for all users), “Road Diets”, and “Traffic Calming”, Such as Replacing Signalized Intersections with Roundabouts (1%)

These projects will encourage active transportation, such as bicycling and walking. These projects also fit well with the addition of TOD and increasing density. They will reduce speeds and therefore reduce noise. The noise reduction and increased safety will encourage people to want to live on and around the redesigned arterials where they would not want to have lived before. People will also be more inclined to shop and to work in such surroundings.

Net Driving Reduction from All Identified Strategies

By 2030, the sum of these strategies should be realized as shown in Table 11.

CONCLUSION

The urgency of our climate crisis dictates that California should develop plans such as the cases considered in this paper for a climate-stabilizing target year of 2030. The state needs to select a case and move forward with legislation and implementation. The cases considered in this paper indicate that California should achieve electricity that is at least 85% from renewable sources and a per-capita driving reduction of at least 32% with respect to 2005 driving levels. The eight driving-reducing requirements described in this paper are an example of how this could be done.

Table 11 Requirements to Achieve a 32% Reduction in 2030 Per-Capita Driving, with Respect to 2005

Driving Reduction Requirements	Percent Reduction	Factor
Legislated (SB 375) Plans to Reduce Driving	12%	0.88
Value-Priced Road Use Charge (RUC)	10%	0.90
Value-Priced Parking (Unbundling the Cost)	8%	0.92
Transfer Highway Expansion Funds to Transit	2%	0.98
Increase Height & Density by Transit Stations	2%	0.98
"Complete Streets", "Road Diet" (walk/bike)	1%	0.99
Pay-to-Graduate Bicycle Traffic-Skills Class	1%	0.99
Bicycle Projects to Improve Access	1%	0.99
Product of Factors		0.68
% Reduction		**32%**

ABREVIATIONS AND ACRONYMS

AB 1493	California's Assembly Bill 1493
AB 32	California's Assembly Bill 32
APS	Alternative Planning Strategy
CAFE	Corporate Average Fleet Efficiency
CARB	California Air Resources Board
CBD	Center for Biological Diversity
CEQA	California Environmental Quality Act
CCAP	Center for Clean Air Policy
CNFF	Cleveland National Forest Foundation
SB 375	California's Senate Bill 375
CO_2	Carbon Dioxide
CO_2_e	Carbon Dioxide Equivalent GHG
EHM	"Extra Heroic Measures" LDV Case
GEO	Governor's Executive Order
ICE	Internal Combustion Engine LDV
kW-h	Kilo Watt-hour
LCFS	Low Carbon Fuel Standard
LDV	Light-Duty Vehicle
MPO	Metropolitan Planning Organization
Pavley	Senator Pavley's AB 1493
PPM	Parts per Million
RPS	Renewable Portfolio Standard
RTP	Regional Transportation Plan
S-3-05	Governor's Executive Order S-3-05
SANDAG	San Diego Association of Governments
SCS	Sustainable Community Strategy
TransNet	San Diego County sales tax

GHG	Greenhouse gas	**URL**	Universal Resource Locator
GW-h	Giga Watt-Hours	**VMT**	Vehicle Miles Travelled
HM	"Heroic Measures" LDV Case	**ZEV**	Zero Emission Vehicle LDV

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KEYWORDS

Driving, climate, mandates, S-3-05, SB 375, RTP, CEQA, Unbundled, GHG, CAFÉ, ZEVs

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September 16, 2011

Honorable Jerome Stocks
Chair, Board of Directors
San Diego Association of Governments
401 B Street, Suite 700
San Diego, CA 92101

RE: **Draft Environmental Impact Report for 2050 Regional Transportation Plan and Sustainable Communities Strategy**

Dear Chairman Stocks and Honorable Members of the Board:

Attorney General Kamala D. Harris submits the following comments on the Draft Environmental Impact Report (DEIR) prepared for the San Diego Association of Governments' (SANDAG) 2050 Regional Transportation Plan and Sustainable Communities Strategy (RTP/SCS).[1] While we recognize the difficulty of SANDAG's task – to prepare the first SCS in the State as required by SB 375[2] – our review of the DEIR for the RTP/SCS has revealed some significant legal problems, as set forth below. We believe that SANDAG has the ability to correct these problems and improve the RTP/SCS, which will benefit not only the San Diego region, but will help to set the standard for other Metropolitan Planning Organizations across California.

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[1] The Attorney General submits these comments pursuant to her independent power and duty to protect the environment and natural resources of the State from pollution, impairment, or destruction, and in furtherance of the public interest. (See Cal. Const., art. V, § 13; Gov. Code, §§ 12511, 12600-12612; *D'Amico v. Bd. of Medical Examiners* (1974) 11 Cal.3d 1, 14-15.) This letter is not intended, and should not be construed, as an exhaustive discussion of the DEIR's compliance with the California Environmental Quality Act (CEQA).
[2] Senate Bill 375 (Chapter 728, Statutes of 2008).

Comments on the DEIR

Localized Air Pollution

The SANDAG region has some of the most serious local air quality problems in the State and the nation – in substantial part caused by vehicle emissions. The harm from these pollutants is not necessarily distributed equally throughout the region, but may be more concentrated in communities immediately adjacent to large-scale industrial and commercial development and major transportation corridors, and may more particularly affect certain segments of the population. As discussed below, our review of the DEIR indicates that SANDAG has set too low a bar for determining whether the air quality impacts of its RTP/SCS are significant, and, further, has failed to analyze the impacts of projected increases in pollution on communities that are sensitive or already overburdened with pollution, in violation of CEQA.

Background: Pollutants of Concern in the San Diego Air Basin

It is well established that "[t]he significance of an activity depends upon the setting." (*Kings County Farm Bureau v. City of Hanford* (1990) 221 Cal.App.3d 692, 718 [citing Cal. Code Regs., tit. 14, § 15064, subd. (b)]; see also *id.* at 721.) Accordingly, the significance of any added pollutant emissions must be judged in the context of an air basin that already exceeds health-based federal air quality standards. (See *ibid.*) The San Diego area was ranked by the American Lung Association this year as having the seventh worst ozone problem, and the fifteenth worst particulate pollution problem, in the nation.[3] Pollutants of concern in the San Diego air basin include ozone, the chemical commonly called "smog," which may permanently decrease lung function;[4] and particulate matter, which impairs lung function and can exacerbate asthma. Small particulate matter (2.5 microns in size or less), a component of diesel exhaust, is of particular concern, because it can penetrate deeply into the lungs, bypassing the body's defenses, and can carry carcinogens on the surface of the particles.

The seriousness of the localized air pollution problem as it exists today in the region can hardly be overstated. The area exceeded the health-based federal ozone standard on 24 days in 2009, and it exceeded the federal particulate standard on 4 days. The basin exceeded the more stringent California standard for ozone on 127 days in 2009, and the fine-particulate standard on 78 days. The area has a history of failing to meet applicable air quality objectives. The San Diego Air Pollution Control District (APCD) stated in its 2009 Regional Air Quality Strategy (RAQS) that it has not consistently met the Health and Safety Code's 5% per year ozone reduction target during any year during the 2003-2006 time period, and that the APCD expects reductions of only about 3% per year during the 2006-2009 time period. (San Diego APCD 2009-RAQS, p. 2.)

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[3] American Lung Association, *State of the Air 2011*, at pp. 11, 13.

[4] Gauderman, et al., *The Effects of Air Pollution on Lung Development from 10 to 18 Years of* Age (Sept. 9, 2004) 351 The New England Journal of Medicine 1057-1068.

SANDAG's Focus on "Conformity" with the State Air Pollution Plans Fails Adequately to Address the Region's Serious Air Quality Problems.

Where an area exceeds federal air quality standards for air pollutants, federal law allows funding of the individual transportation projects listed in an RTP only if the RTP "conforms" to a federally approved state plan to meet those federal standards. The DEIR's analysis of whether localized air pollution resulting from the RTP/SCS is significant under CEQA focuses almost exclusively on whether such conformity is achieved. There are significant problems with this limited approach, which substitutes a determination of whether certain federal laws are met for SANDAG's obligation under CEQA to conduct a thorough analysis of the actual effects on the air and on public health that will result from the addition of the many hundreds of miles of highway expansion and extensions that are in the RTP/SCS.

California's most recent federally approved plan was prepared in 2007, and therefore does not reflect current conditions. The DEIR acknowledges that the federal EPA is expected to soon reclassify the San Diego Air Basin as in "serious" nonattainment of the federal ozone standard, a designation that requires attainment of the federal standard by June of 2013. (DEIR, p. 4.3-6.) Demonstrating conformity with the 2007 plan emissions budgets does not, by itself, show that relevant health effects created by the new pollution generated by the RTP/SCS have been analyzed and disclosed, or even that the relevant federal standards will be met. Instead, EPA's reclassification of the air basin as having worse air quality, and the imposition of such a short deadline for meeting the federal ozone standard, indicates a more serious air pollution problem that may require more stringent control measures to protect the public health.[5]

In addition, the DEIR fails to analyze whether the California standard for ozone, more stringent than the federal standard, will be met during the life of the RTP/SCS, or what the RTP/SCS's contribution to current or future violations of that standard will be. The DEIR appears to rely solely on the RAQS to meet the state ozone standard. (See DEIR at p. 4.3-29-30.) Yet, as noted, the region has not consistently met the RAQS 5% per year ozone reduction target. The fact that U.S. EPA is expected to reclassify the Basin as in "serious" nonattainment of the less stringent federal ozone standard would indicate that the RAQS standards have not been enough to prevent deteriorating air quality. Thus, any assumption that the RAQS will consistently achieve the 5% reduction target in the future is unsupported, and any assertion that the RAQS will attain the state ozone standard at a time certain unfounded. A full analysis is

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[5] Even if conformity with federal standards in state-approved plans were an appropriate benchmark for significance under CEQA, the DEIR does not contain a quantitative analysis, using the most recent available air quality measurements as the baseline, to determine whether the federal air quality standards will actually be met, and what the public health consequences would be of adding the expected pollutant load from the RTP/SCS to existing conditions. (DEIR, at p. 4.3-14.)

needed to show that the emissions caused by the RTP/SCS at different time points during its life will not contribute significantly to violations of the state ozone standard in the San Diego Air Basin.

SANDAG Has Failed Adequately to Address Impacts to Public Health and Communities Already Burdened with Pollution.

We commend SANDAG for including in its DEIR a chapter entitled "Environmental Justice." (DEIR, ch. 4.06.) That section appears to focus primarily on the RTP/SCS's effect on access to transit by traditionally underserved communities. SANDAG has, however, failed to analyze other equally, if not more, significant effects of the RTP/SCS on communities currently experiencing environmental injustice. The principal omission of the DEIR is the lack of any discussion of the impacts of the increased air pollution that will result from carrying out the RTP/SCS on communities already severely impacted by air pollution. As noted, CEQA requires that the significance of environmental impacts be considered in context. (*Kings County Farm Bureau, supra,* 221 Cal.App.3d at 718.) Such context may appropriately include (1) whether the region includes communities or subpopulations that may be particularly sensitive to increases in pollution; and (2) whether such communities or groups are already at or near their capacity to bear any additional pollution burden.

The DEIR does not identify whether the area affected by the RTP/SCS includes particularly sensitive communities that will be affected disproportionately by the acknowledged increase in pollution. "[A] number of studies have reported increased sensitivity to pollution, for communities with low income levels, low education levels, and other biological and social factors. This combination of multiple pollutants and increased sensitivity in these communities can result in a higher cumulative pollution impact." (Office of Environmental Health Hazard Assessment, *Cumulative Impacts: Building a Scientific Foundation* (Dec. 2010), Exec. Summary at p. ix.)[6] Research in other parts of California has shown that disadvantaged and minority communities are often exposed to unhealthful air more frequently and at higher levels than other groups.[7] Identifying these communities is an essential part of describing the relevant CEQA setting.

Once such communities are identified, SANDAG must analyze how the health of the residents in these communities would be expected to be particularly affected. As discussed, residents already are experiencing serious air pollution that is impacting health and welfare, and it is reasonable to assume that these effects currently are more concentrated in certain areas of the region, for example, in communities adjacent to large-scale industrial or commercial operations or transportation corridors used by heavy-duty trucks. In addition, viewed at the individual community scale, there may be synergistic adverse effects. For example, research

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[6] Available at http://oehha.ca.gov/ej/cipa123110.html.

[7] Hall and Brajer, *The Benefits of Meeting Federal Clean Air Standards in the South Coast and San Joaquin Valley Air Basins* (2008) at 22-23.

has shown that increases in greenhouse gas emissions may result in localized ozone increases; such increases have been observed in California.[8]

We believe that particulate pollution may be of special concern to already burdened communities. As discussed, diesel particulate emissions have serious health effects, since they impact respiratory function and can exacerbate asthma. Further, diesel particulates are known to the State of California to cause cancer,[9] and have been listed by the Air Resources Board (ARB) as a toxic air contaminant.[10] The DEIR shows that particulate matter pollution will increase over the life of the RTP/SCS. (DEIR, Table 4.3-5, p. 4.3-25.) It also reports that the ARB estimated in 2000 – over a decade ago – that a subset of particulate pollution, fine particulates emitted by diesel vehicles, created an additional cancer risk of 720 cancer cases per one million persons exposed in the San Diego Air Basin. (DEIR, p. 4.3-8.) For comparison purposes, a private business must provide a warning if it exposes individuals to a chemical that poses an increased cancer risk of ten cases in one million people exposed. (Cal. Code Regs, tit. 27, § 25703(b).)

Despite this high cancer risk, and the DEIR's own recognition that particulate pollution will increase over the life of the RTP/SCS, the DEIR does not analyze what public health effects the increase in particulate matter will cause. Nor does it estimate what portion of the increase in particulate pollution will be carcinogenic diesel particulate matter, and disclose the public health effects that increase may cause. Such an analysis is required under CEQA, so that both the decision maker and the public can know the full consequences of the decision being made. (*Bakersfield Citizens for Local Control v. City of Bakersfield* (2004) 124 Cal.App.4th 1184, 1219-1220.) We are especially concerned that no analysis is presented either of the current risk from particulate pollution, nor of the impact of the projected increase in particulate pollution, on already overburdened or sensitive communities. Given the increase in particulate emissions shown in the DEIR, given the emphasis in the RTP/SCS on the Goods Movement Strategy for the San Diego region (RTP/SCS, Chapter 6), and given the DEIR's recognition that much of this goods movement will be accomplished by diesel trucks (DEIR, p. 4-16-8; see, also, RTP/SCS, Tech. Appdx. 4, p. 4 [estimating that roads and truckways will carry 90% by volume of goods through the region]), it is incumbent on SANDAG to fully analyze the public health consequences of the RTP/SCS in general, and of the Goods Movement Strategy, in particular.[11]

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[8] Jacobson, *Enhancement of Local Air Pollution by Urban CO2 Domes* (2010) Environ. Sci. Technol. 2497-2502. This phenomenon is of concern because, as discussed, under the RTP/SCS, vehicle miles travelled (VMT) trends up as the total number of vehicles on the road increases. (DEIR, pp. 4.12-16, 4.12-21, 4.12-24; contrast with Table TA 3.1, showing an overall decrease of 1% in VMT by 2050.) Increases in VMT cause increased emissions of greenhouse gases, which may in turn exacerbate localized pollution.

[9] Cal. Code Regs., tit. 27, § 27001.

[10] Cal. Code Regs., tit. 17, § 93000.

[11] See *Bakersfield Citizens for Local Control v. City of Bakersfield* (2004) 124 Cal.App.4th 1184, 1219-1220, cited above.

The goal of an RTP/SCS is a sustainable community, and no community can be sustainable unless its public health is protected. Thus, while the inclusion of a separate chapter of the DEIR on environmental justice is commendable, the current analysis is deficient, and should be redone and expanded to disclose the full scope of the air pollution and public health consequences of the RTP/SCS, and to propose mitigation measures for those consequences that are proportional to the seriousness of the impacts. (*City of Marina v. Board of Trustees of the California State University* (2006) 39 Cal.4th 341, 361-62.) We would be happy to work with SANDAG in making this part of the DEIR more meaningful.

<u>SANDAG Has Failed Adequately to Consider Feasible Mitigation for Localized Air Quality Impacts.</u>

Although it finds the RTP/SCS's impacts on localized air pollution to be significant, the DEIR proposes almost no mitigation measures to reduce or offset these impacts. Instead, the DEIR states that "mitigation measures at the program level is [sic] infeasible" for ozone precursors and carbon monoxide, and defers all mitigation for these pollutants to individual project-level CEQA processes. (DEIR, pp. 4.3-46, 4.3-47, 4.3-48.) CEQA requires that project changes or mitigation either be adopted or shown through substantial evidence to be infeasible; the DEIR, however, does not make such a showing.

The DEIR offers virtually no evidence that program-level mitigation is actually infeasible, and the mitigation measures it does propose lack certainty and are incomplete. For example, compliance with future local land use plans (the scope of which is not now known) is identified as the only feasible mitigation for ozone-related impacts. (DEIR, p. 4.3-48.) Mitigation for fine particulate matter is not discussed separately from mitigation for coarse particulates, despite their different sizes, health impacts, and sources. The dust control measures in the DEIR are not shown to be effective against fine particulates, which come more from industrial processes and fuel combustion than from ground disturbance. The DEIR's treatment of mitigation for conventional air pollution does not comply with CEQA's substantive mandate to mitigate all significant impacts. (Pub. Resources Code, §§ 21002, 21081(a).)

It is vital for the health of the San Diego region's public that all feasible mitigation be adopted and carried out to prevent further deterioration of the already unhealthy air, and it is also vital for the region's economy. Research shows consistently that the costs of reducing pollution are far outweighed by clean-air benefits such as increased worker productivity, increased agricultural outputs, and reductions in mortality and illness that result from cleaner air.[12] The research cited above -- finding minority communities more severely affected by air pollution -- also calculated the significant costs associated with polluted air in other air basins. Costs ranged

[12] On a nationwide basis, the Office of Management and Budget has estimated that the benefits of clean air regulations outweigh the costs by a ratio of about four to one. OMB, "Informing Regulatory Decisions: 2003 Report to Congress on the Coasts and Benefits of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities."

from $1,250 per person per year in the South Coast Air Basin to $1,600 per person per year in the San Joaquin Valley Air Basin, due to increased health care costs and emergency room visits, missed work and school days, and even premature deaths.[13] CEQA mandates that SANDAG improve its analysis of the feasibility of localized air pollution mitigation, and the economic benefits of cleaner air and healthier communities must be considered in the feasibility calculus.

Climate Change Impacts: Greenhouse Gas Emissions

Before discussing the DEIR's treatment of GHG emissions, it is important first to establish the relevant context for evaluating significance. The climate is affected by the concentration of GHGs in the atmosphere. The concentration of carbon dioxide, the primary GHG, has increased from approximately 280 parts per million (ppm) in pre-industrial times to well over 380 ppm, according to the National Oceanic and Atmospheric Administration's (NOAA) Earth Systems Research Laboratory.[14] Almost all of the increase is due to human activities (such as fossil fuel use).[15] The current rate of increase in carbon dioxide concentrations is about 1.9 ppm/year; present carbon dioxide concentrations are higher than any time in at least the last 650,000 years.[16] GHGs persist in the atmosphere for decades and in some cases millennia.[17]

The atmosphere and the oceans are reaching their capacity to absorb GHGs without significantly (and perhaps abruptly) changing the Earth's climate. California is already seeing the effects of climate change. As the Resources Agency observed in its 2009 report, we already are experiencing sea level rise, coastal erosion, increased average temperatures, more extreme hot days and increased heat waves, fewer shifts in the water cycle, and increases in the frequency and intensity of wildfires. (Resources Agency, *2009 Climate Adaptation Strategy* at p. 3.)[18] These effects are expected to increase with rising GHG levels in the atmosphere.

The burdens of climate change will not be shared equally. Future climate scenarios are expected to disproportionately affect, for example, the urban poor, the elderly and children, traditional societies, agricultural workers and rural populations. (Office of Environmental Health Hazard Assessment, *Indicators of Climate Change in California: Environmental Justice Impacts* (Dec. 2010) at p. 2.)[19]

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[13] Hall and Brajer, at 5.
[14] See http://www.epa.gov/climatechange/science/recentac.html.
[15] *Id.*
[16] *Id.*
[17] Intergovernmental Panel on Climate Change, *Frequently Asked Questions*, FAQ 10.3 (2007), available at www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-faqs.pdf.
[18] Available at http://www.climatechange.ca.gov/adaptation/.
[19] Available at http://oehha.ca.gov/multimedia/epic/epic123110.html.

In order to stabilize the climate and avoid the most catastrophic outcomes of climate change, we must substantially reduce our annual GHG emissions over time, achieving a low-carbon future by midcentury. California has memorialized this overarching environmental objective in law. Under AB 32[20], by 2020, California must reduce its total statewide greenhouse gas emissions to the level they were in 1990. (Health & Saf. Code, § 38550). To achieve AB 32's 2020 target, total statewide greenhouse gas emissions must be reduced by approximately 15 percent from current (2008) levels. AB 32 implements Executive Order S-03-05 (2005),[21] which set the statewide 2020 target as an interim step to reducing statewide emission levels, by 2050, to 80 percent below 1990 levels. "The 2020 goal was established to be an aggressive, but achievable, mid-term target, and the 2050 greenhouse gas emissions reduction goal represents the level scientists believe is necessary to reach levels that will stabilize climate." (Air Resources Board (ARB), Scoping Plan at p. 4.)[22]

The emissions reductions required to reach our statewide climate objective are substantial. In the longer term, we must reduce our total GHG emissions by approximately four percent per year between 2020 and 2030, and our per capita emissions by slightly less than five percent per year during the 2020 to 2030 period, with continued reductions required through midcentury. (These reductions required are graphically illustrated by the chart from ARB's Scoping Plan, attached to this letter as Exhibit A.) One of the prime objectives of SB 375, a law supporting and complementary to AB 32, and of the requirement for Sustainable Communities Strategies, is to create a long-term downward trajectory for GHG emissions in California through transportation and land use strategies.

Given the seriousness of the climate change problem, and the enormity of our GHG reduction task, we are greatly concerned that, when viewed in context, the RTP/SCS seems to be setting the region on a course that is inconsistent with the State's climate objectives. Specifically, per capita GHG emissions from cars and light-duty trucks <u>increase</u> as compared to the previous year after 2020 (see RTP, Table 301 at p. 3-3), while AB 32 requires that we must aggressively and steadily <u>reduce</u> total per capita GHG emissions during this time period. (See Exhibit A.) Moreover, the total number of vehicle miles travelled (VMT) driven in the San Diego region will steadily increase over the life of the RTP/SCS over the 2010 baseline by 10%, 32% , and 51% in 2020, 2035, and 2050, respectively. (DEIR, pp. 4.12-16, 4.12-21, 4.12-24;

[20] Cal. Health and Safety Code, § 38,500, *et seq.*
[21] The DEIR states that the Executive Order "does not constitute a 'plan' for GHG reduction, and no state plan has been adopted to achieve the 2050 goal." (DEIR, pp. 4.8-29 to 4.8-30.) The DEIR therefore does not find the RTP/SCS's failure to meet the Executive Order's goals to be a significant impact. This position fails to recognize that Executive Order S-3-05 is an official policy of the State of California, established by a gubernatorial order in 2005, and designed to meet the environmental objective that is relevant under CEQA (climate stabilization). SANDAG thus cannot simply ignore it.
[22] Available at http://www.arb.ca.gov/cc/scopingplan/document/adopted_scoping_plan.pdf. The Scoping Plan was readopted by ARB on August 24, 2011.

contrast with Table TA 3.1.) Under the most optimistic figures presented in the DEIR, total VMT will drop only 1% over current levels by 2050. Moreover, the DEIR predicts that the 14.33 million metric tons of greenhouse gases (expressed as MMT of carbon dioxide equivalent) emitted by cars and light duty trucks in 2010 (DEIR, p. 4.8-5) will fall to 12.04 MMT in 2020 (DEIR, p. 4.8-20), based largely on statewide tailpipe and fuel standards, but will then begin rising again, to 12.94 MMT in 2035 and 14.74 MMT in 2050. (DEIR, pp. 4.8-23, 4.8-25, respectively.) Thus, although SANDAG will meet the SB 375 goals for per capita GHG targets for cars and trucks set for it by ARB in 2020 and 2035, the DEIR shows that total GHG emissions from cars and light-duty trucks in 2050 will increase over the 2010 emissions level.

The DEIR finds the impact of the RTP/SCS on GHG emissions to be not significant in 2020 (DEIR, p. 4.8-20), significant in 2035 (DEIR, p. 4.8-23), and significant in 2050 (DEIR, p. 4.8-25). SANDAG must, however, make a determination whether the project as a whole has significant climate change impacts. We believe strongly that it does. What the DEIR shows is that the suite of strategies relied on by SANDAG, which include a heavy reliance on roadway expansion projects, does not deliver GHG reductions that are sustainable in the long term. In fact, infrastructure and land use decisions made in the early years of the RTP/SCS may lock in transportation inefficiencies and preclude any realistic possibility of meeting the Executive Order's goal of an 80% reduction in GHG emissions. The DEIR states that "[t]otal land-use based GHG emissions in 2050 are projected to be 21.85 MMT CO2e, or 50 percent greater than GHG emissions in 2010 (Table 4.8-11)." (DEIR at p. 4.8-24.) The DEIR should address the impact of the draft RTP/SCS on this important long-term policy in greater detail.

The DEIR is legally deficient for the additional reason that it does not analyze potential changes to the project design or specific mitigation measures for the GHG emissions impacts from land use; it makes only a generalized promise to prepare future RTPs "to incorporate policies and measures that lead to reduced GHG emissions." (DEIR, p. 4.8-35.) Further, the DEIR proposes some mitigation measures for GHG emissions attributable to transportation, but does not include any transportation mitigation that relates to land use, nor does it show that any such measures would be infeasible. We believe that CEQA requires much more analysis of potential mitigation measures, and that postponing this discussion and analysis until future RTP/SCS's and individual projects is a violation of CEQA's substantive provisions. (Public Res. Code §§ 21002, 21081(a); see *Communities for a Better Environment v. City of Richmond* (2010) 184 Cal.App.4th 70, 89-96.) SANDAG has the authority to approve the RTP/SCS even if it will have substantial environmental impacts, and CEQA will not second-guess the wisdom of that choice, so long as substantial evidence supports SANDAG's findings. (Public Res. Code § 21081(b).) However, SANDAG may not approve an environmentally damaging project until and unless it has adopted all feasible mitigation measures or shown that further mitigation – including land use mitigation – is infeasible. The DEIR does not yet do so.

We recognize that this is the first SCS prepared in California, and that SANDAG is charting new territory. However, the legal requirements of CEQA, including the requirement to mitigate significant impacts to the extent feasible, are not satisfied simply because the RTP/SCS meets the targets contained in SB 375 for 2020 and 2035. CEQA demands a full analysis and all feasible mitigation of every significant impact resulting from the implementation of the RTP/SCS, throughout the full life of the Plan. The DEIR does not now provide this for GHG emissions.

Comments on RTP/SCS

Although we are not commenting directly on the legal adequacy of the RTP/SCS under SB 375, we concur in the comments submitted to SANDAG by the California Office of Planning and Research (OPR). As discussed above, we are particularly concerned that per capita greenhouse gas (GHG) emissions associated with cars and light-duty trucks (and associated co-pollutants like particulate matter) begin to rise after 2020. (See OPR comment letter at pp. 3-4; Draft RTP at p. 3-3, Table 3.1; see also DEIR at Tables 4.3-5, p. 4.3-25.) As OPR notes, this "implies that future growth will be unavoidably less transportation efficient, which counters SB 375's underlying purpose." (OPR comment letter at p. 3.) If the RTP/SCS in fact runs counter to SB 375's purpose to reduce transportation-related GHG emissions over time, this would bear on whether the effects of the plan should be considered significant under CEQA.

In addition, OPR's comments discuss a failure of the DEIR and RTP/SCS to fully disclose the methodology by which VMT was projected, making it difficult or impossible for the lay public to determine for itself whether the information presented in the two documents is accurate and supported by substantial evidence. This lack of transparency is also a crucial flaw under CEQA, a statute whose purposes include accountability as to governmental decisions that affect the environment. (*Laurel Heights Improvement Ass'n v. Regents of the University of California* (1989) 47 Cal.3d 376, 392 [holding that "the EIR . . . is a document of accountability" for the public officials who certify it].)

Conclusion

We appreciate the difficulty of preparing the first SCS in California. We believe that SANDAG has not yet prepared a DEIR on the RTP/SCS that fully satisfies CEQA's requirements, and urge SANDAG to redo several parts of the DEIR, as described in our comments herein. This RTP/SCS presents SANDAG with an opportunity to integrate transportation and land-use planning in a way that reduces GHG emissions and harmful air pollution, and that produces other benefits such as increased mobility and better public health for all the region's residents, particularly its sensitive and already overburdened communities. We would be happy to work with SANDAG to take the additional steps needed to take full advantage of this opportunity. We appreciate your consideration of our comments.

Sincerely,

Timothy R. Patterson

TIMOTHY R. PATTERSON by SLD
Supervising Deputy Attorney General

Susan L Durbin

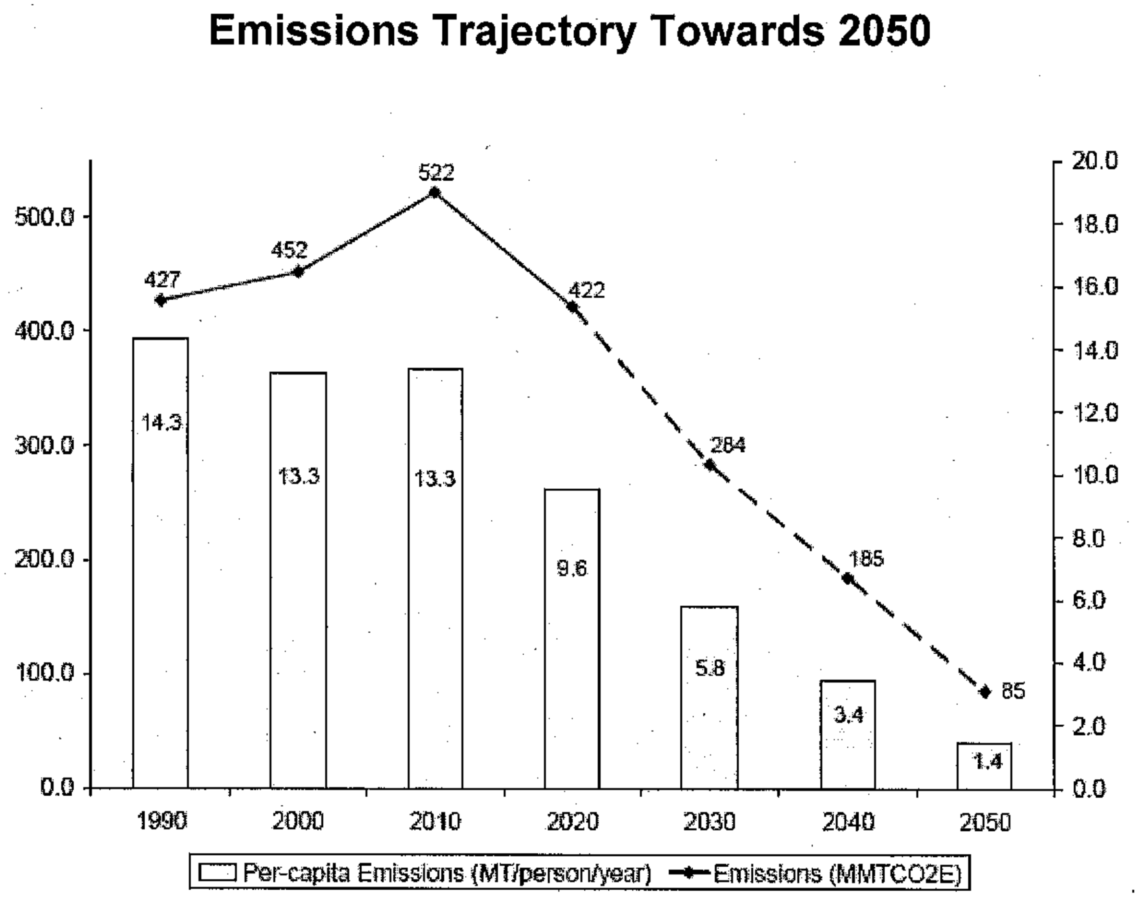
SUSAN DURBIN
Deputy Attorney General

For KAMALA D. HARRIS
Attorney General

cc: Gary Gallegos, Executive Director, San Diego Association of Governments
Julie D. Wiley, General Counsel, San Diego Association of Governments

Attachment

EXHIBIT A



(ARB, Scoping Plan, Figure 6, at p. 118.)

Deriving a Climate-Stabilizing Solution Set of Fleet-Efficiency and Driving-Level Requirements, for Light-Duty Vehicles in California

AWMA Paper 796315

Mike R. Bullock

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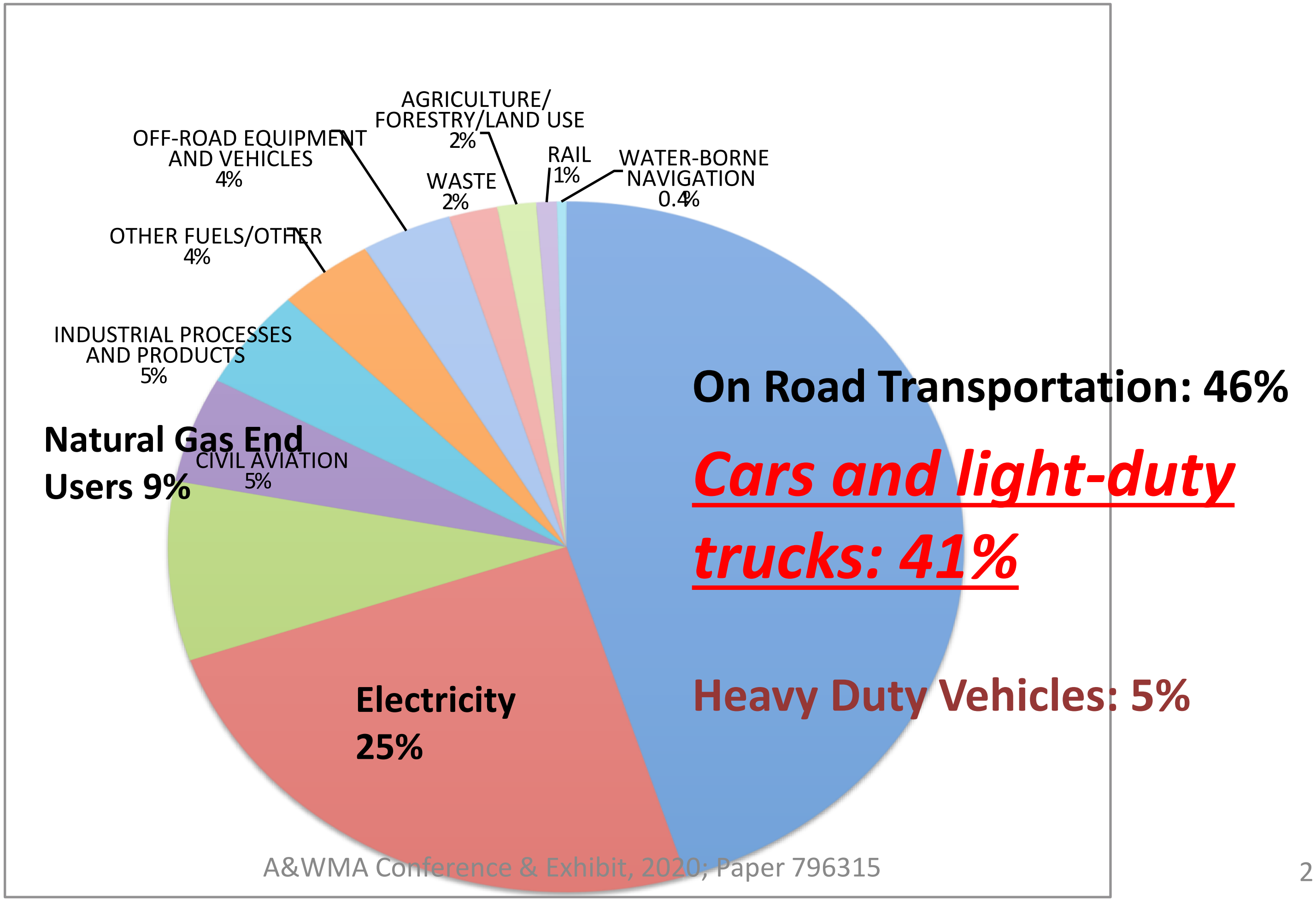
Why pick on cars?

Greenhouse Gas (GHG) Emissions, SD County

Source: Energy Policy Initiatives Center (EPIC, USD)

http://www.sandiego.edu/EPIC/ghginventory/GHG-On-Road1.pdf.pdf



Why is there a Climate Problem?

Any Earth Science text book*
contains the following facts:

- **Atmospheric CO2 traps heat**
  - CO2 Molecules absorb and then emit, in a random direction, infrared radiation, heat given off by the Earth's surface
  - This effect is significant
- **Combustion of fossil fuels adds great quantities of CO2 to our Earth's atmosphere**
  - The amount of C02 in the atmosphere is well known
  - Our yearly emissions are well known

*** For example, Page 539 of *Earth Science*, Tarbuck and Lutgens, Tenth Edition, published by Prentice Hall, 2003.**

How Bad Could It Get?

- *Scientific American* June 2008 issue
  - 550 PPM CO2 possible in several decades
  - This could (5% probability) lead to 8 Deg. Celsius of warming
  - 8 Deg. Celsius could lead to "a devastating collapse of the human population, perhaps even to extinction"
- December 24/31 2012 Issue of Nation magazine:

A recent string of reports from impeccable mainstream institutions-the International Energy Agency, the World Bank, the accounting firm of PricewaterhouseCoopers-have warned that the Earth is on a trajectory to warm by at least 4 Degrees Celsius

[4 Degrees Celsius] would be *incompatible with continued human survival*.

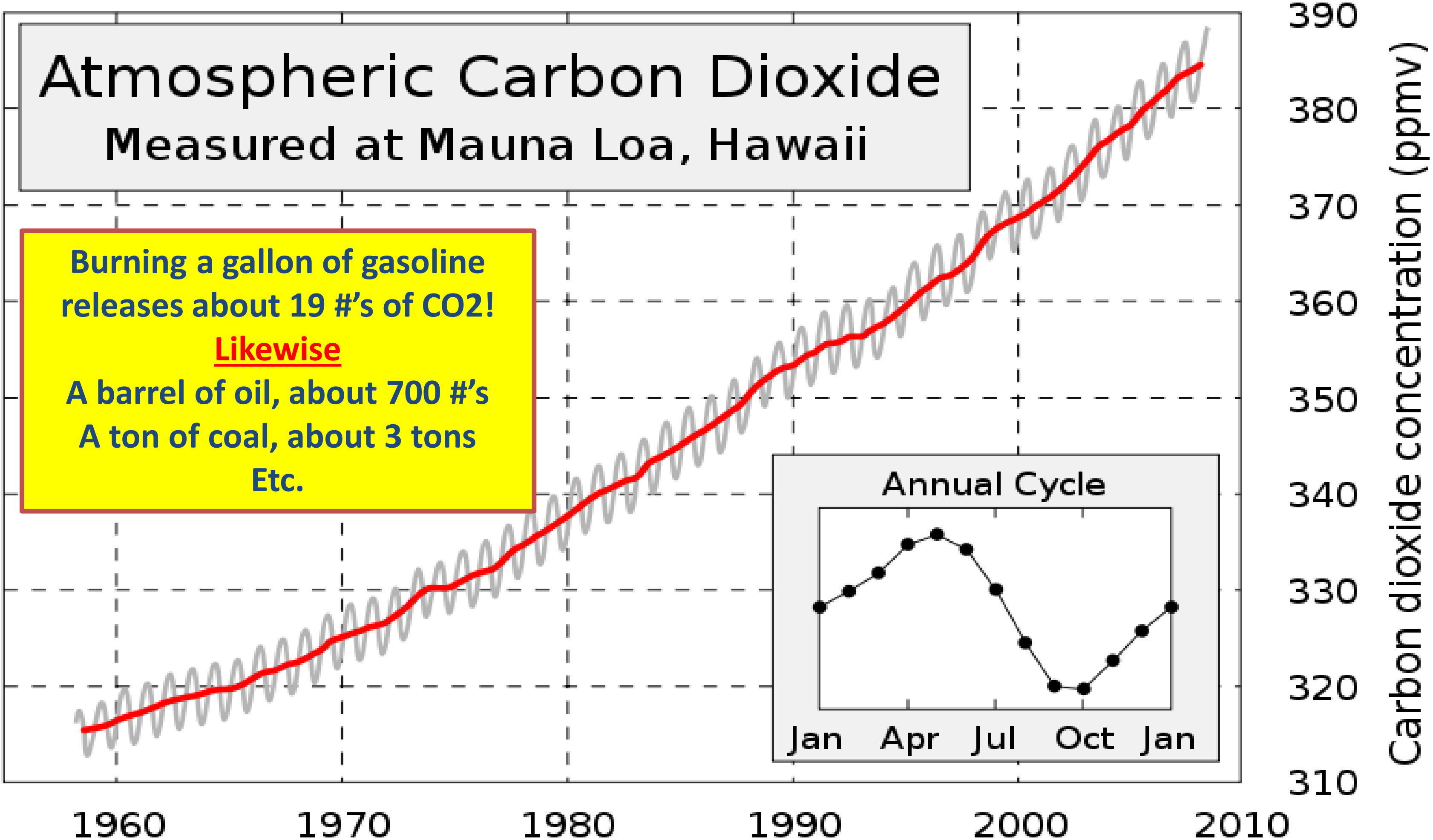
Winter, ***UU World*** magazine (p. 57) " Lags in the replacement of fossil-fuel use by clean energy use have put the world on a pace for 6 degree Celsius by the end of this century. Such a large temperature rise occurred 250 million years ago and extinguished 90 percent of the life on Earth. The current rise is of the same magnitude but is occurring faster. We must reduce or eliminate all uses of fossil fuels.

Climate Data

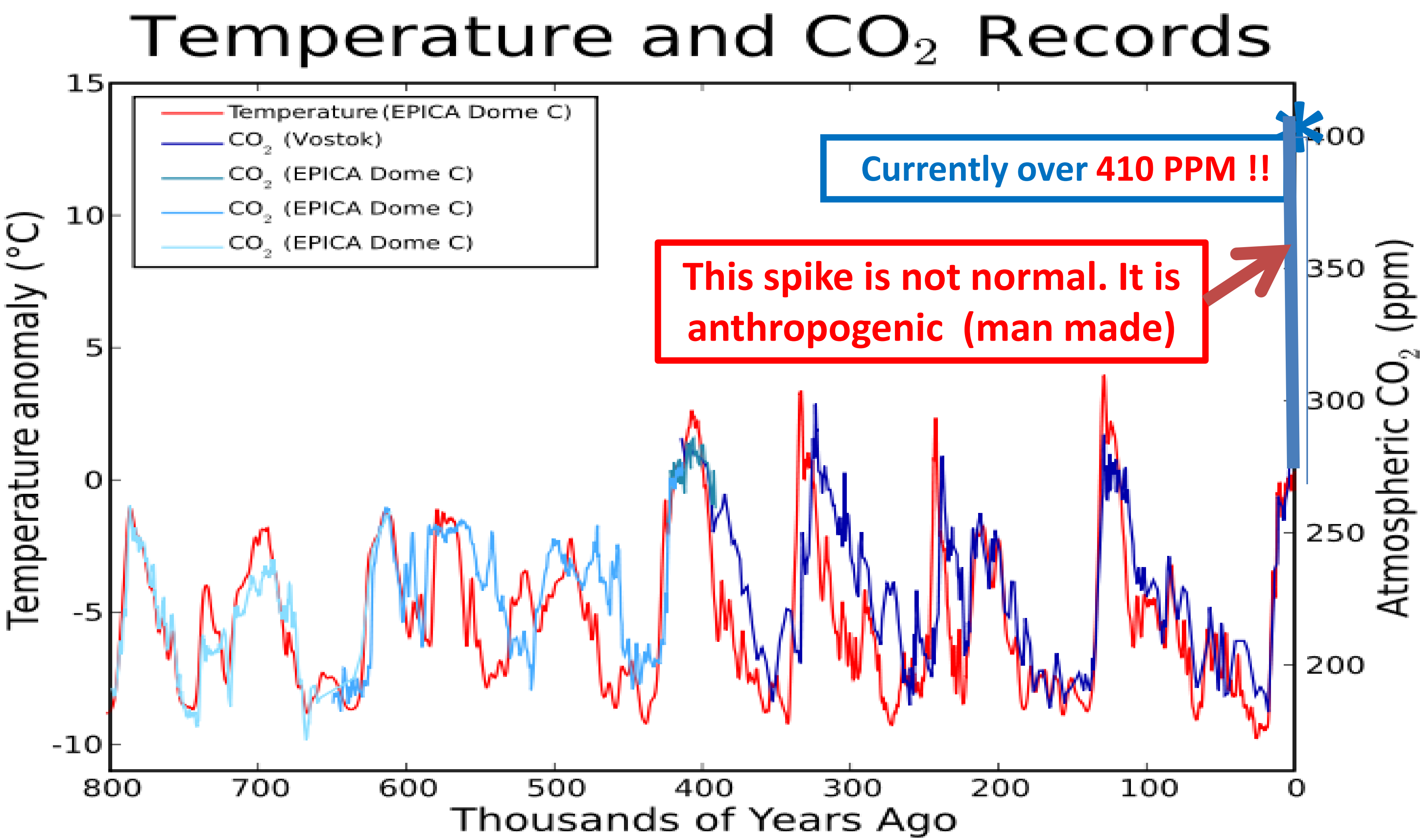
Currently around 415 PPM! *

- Keeling Curve:

http://en.wikipedia.org/wiki/An_Inconvenient_Truth#Scientific_basis



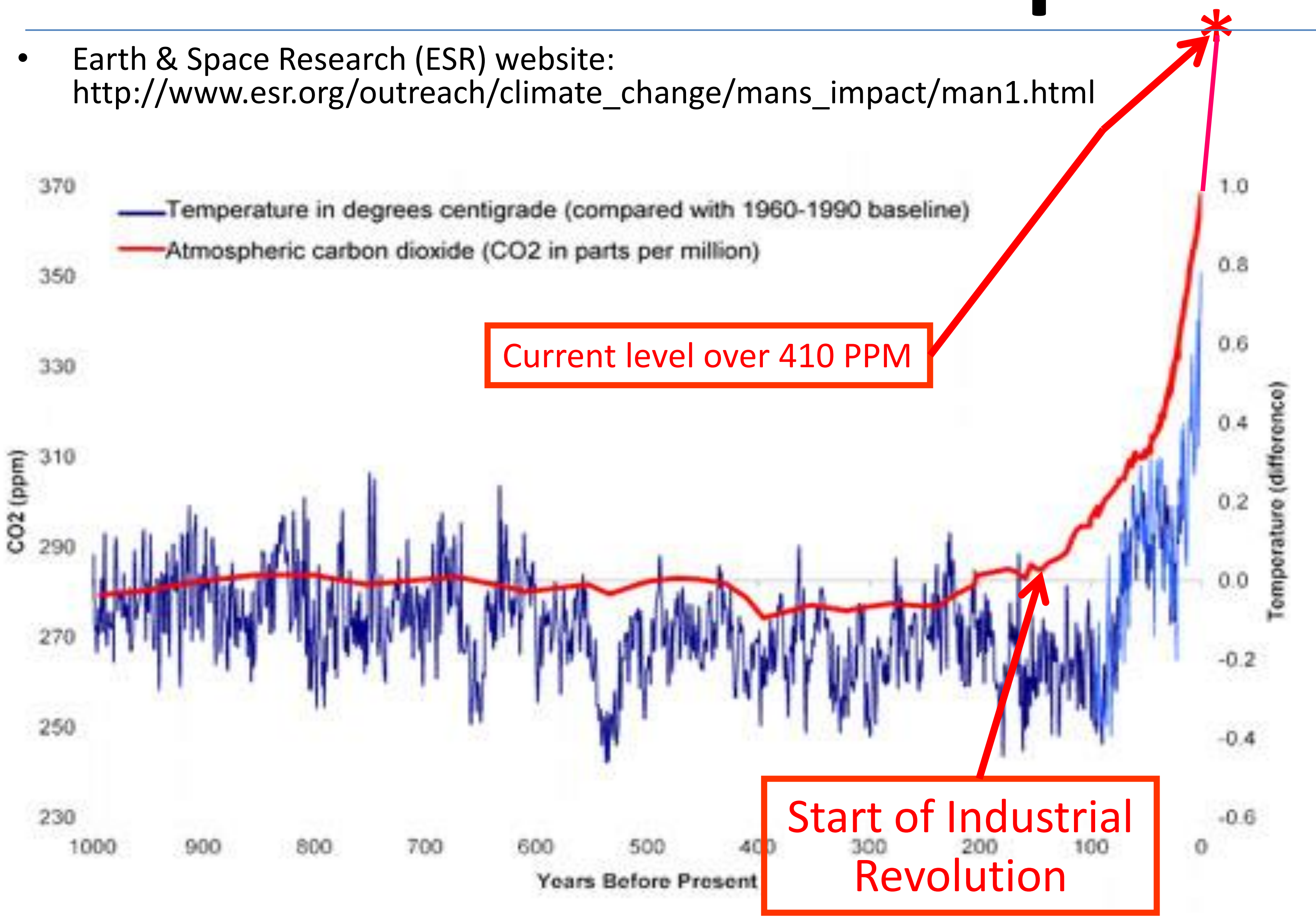
Climate Change, Mostly Normal



A&WMA Conference & Exhibit, 2020; Paper 796315

Let's Zero In on that Spike

- Earth & Space Research (ESR) website: http://www.esr.org/outreach/climate_change/mans_impact/man1.html



A&WMA Conference & Exhibit, 2020; Paper 796315

Fixing the Problem page 1 of 2

We must stabilize the value of the earth's atmospheric CO_2_e

CO_2_e Emissions

Sequestration (Photosynthesis)

$E_N + E_A + E_{WFB}$ > → Positive Slope; = → Zero Slope; < → Negative Slope S

E_N — **N**atural: rotting, fire, digestion. respiration

E_A — **A**nthropogenic: combustion of fossil fuel, methane, other

E_{WFB} — **W**arming **F**eed **B**ack: such as methane from melting permafrost

S — **Growth of plants on Earth**

The Warming Feed Back term, E_{WFB}, is the wild card. It must not become dominant.

Fixing the Problem page 2 of 2

We must stabilize the value of the earth's atmospheric CO2_e. Here is Step 1:

If Anthropogenic emissions were sufficiently low, the slope would be zero, thus capping the value of the Earth's atmospheric CO2_e. To achieve this, industrialized nations must limit their emissions to 80% below their 1990 levels.

Warning: The Warming Feed Back terms must not become dominant.

BRIEF OF SCIENTISTS AMICUS GROUP AS *AMICI CURIAE* IN SUPPORT OF PLAINTIFFS-APPELLANTS SEEKING REVERSAL

DANIEL M. GALPERN
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USCA Case #13-5192 Document #1465822 Filed: 11/12/2013

A. Parties and *Amici*. Except for the following, all parties, intervenors, and *amici* appearing before the district court and in this Court are listed in the Brief for Plaintiffs-Appellants. **James Hansen**, David Beerling, Paul J. Hearty, Ove Hoegh-Guldberg, Pushker Kharecha, Valérie Masson-Delmotte, Camille Parmesan, Eelco Rohling, Makiko Sato, Pete Smith, and Lise Van Susteren are *amici curiae* in this appeal (referred to hereinafter as “Amici Scientists.”).

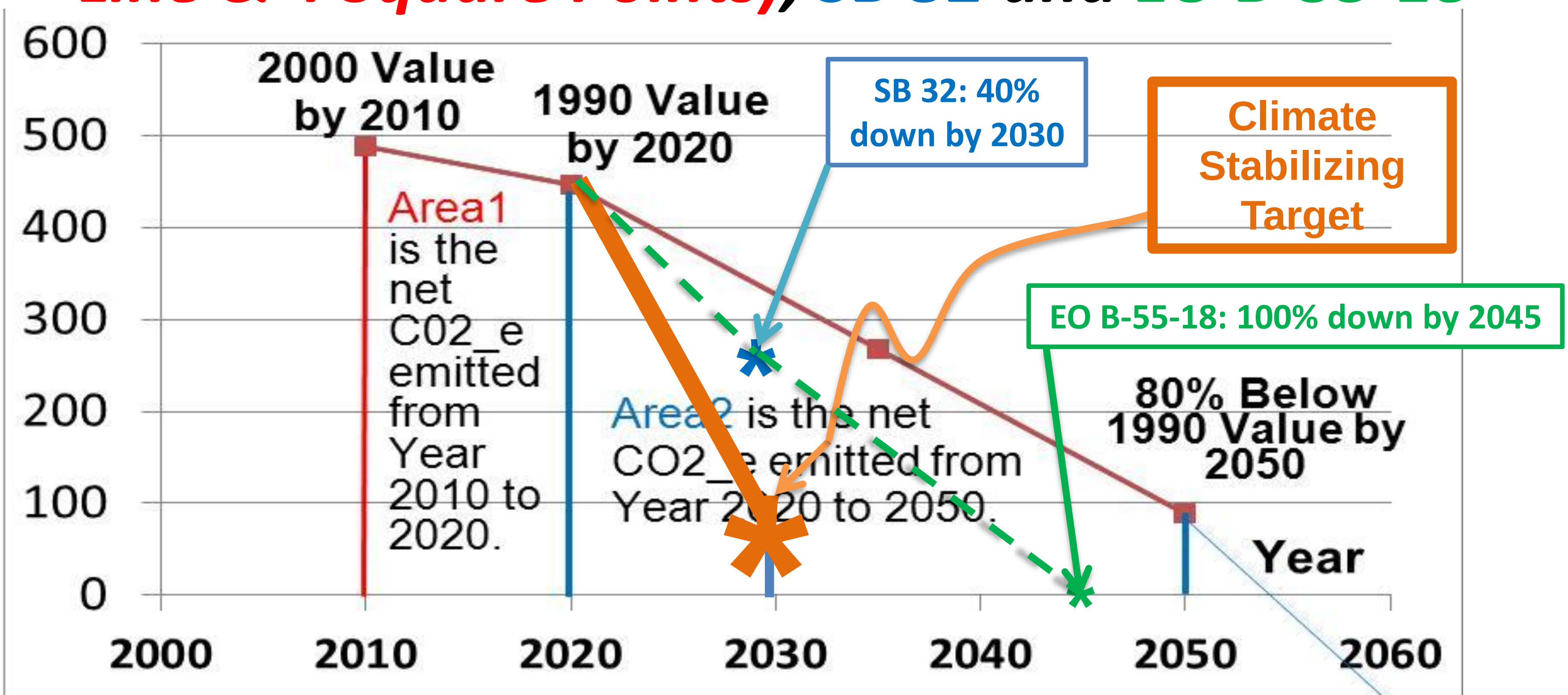
From the Climate Scientists

From Page 21: . . . the required rate of emissions reduction would have been about 3.5% per year if reductions had started in 2005, ***while the required rate of reduction, if commenced in 2020, will be approximately 15% per year.***

- My math:
  - 15% means a factor of 0.85, year after year
  - Consider the 10 years from 2020 to 2030
  - $(.85)^{\mathbf{10}}$ = .20, which is 80% down
  - Other articles, describing Hansen's work: "**decarbonization by 2030**"

New Climate-Stabilization Prescription

Shown with 3 California Mandates: EO S-3-05 (Red Line & 4 Square Points), SB 32 and EO B-55-18



How, for LDVs:

Deriving a Climate-Stabilizing Solution Set of Fleet-Efficiency and Driving-Level Requirements, for Light-Duty Vehicles in California

We have the climate scientist's target. We must now derive the LDV Requirements.

Notes on Methods

- Base year 2005
- Intermediate year 2015
- Car Efficiency Factor from 2005 to 2015
  - Steve Winkelman's data
  - http://www.nrdc.org/globalWarming/sb375/files/sb375.pdf
- Car Efficiency Factor, 2015 to 2030
  - Derived in paper (and here)
  - Results in car-efficiency requirements
- Cars last 15 years

From a California law (***SB 375***) giving per-capita driving reduction targets to be achieved in Regional Transportation Plans

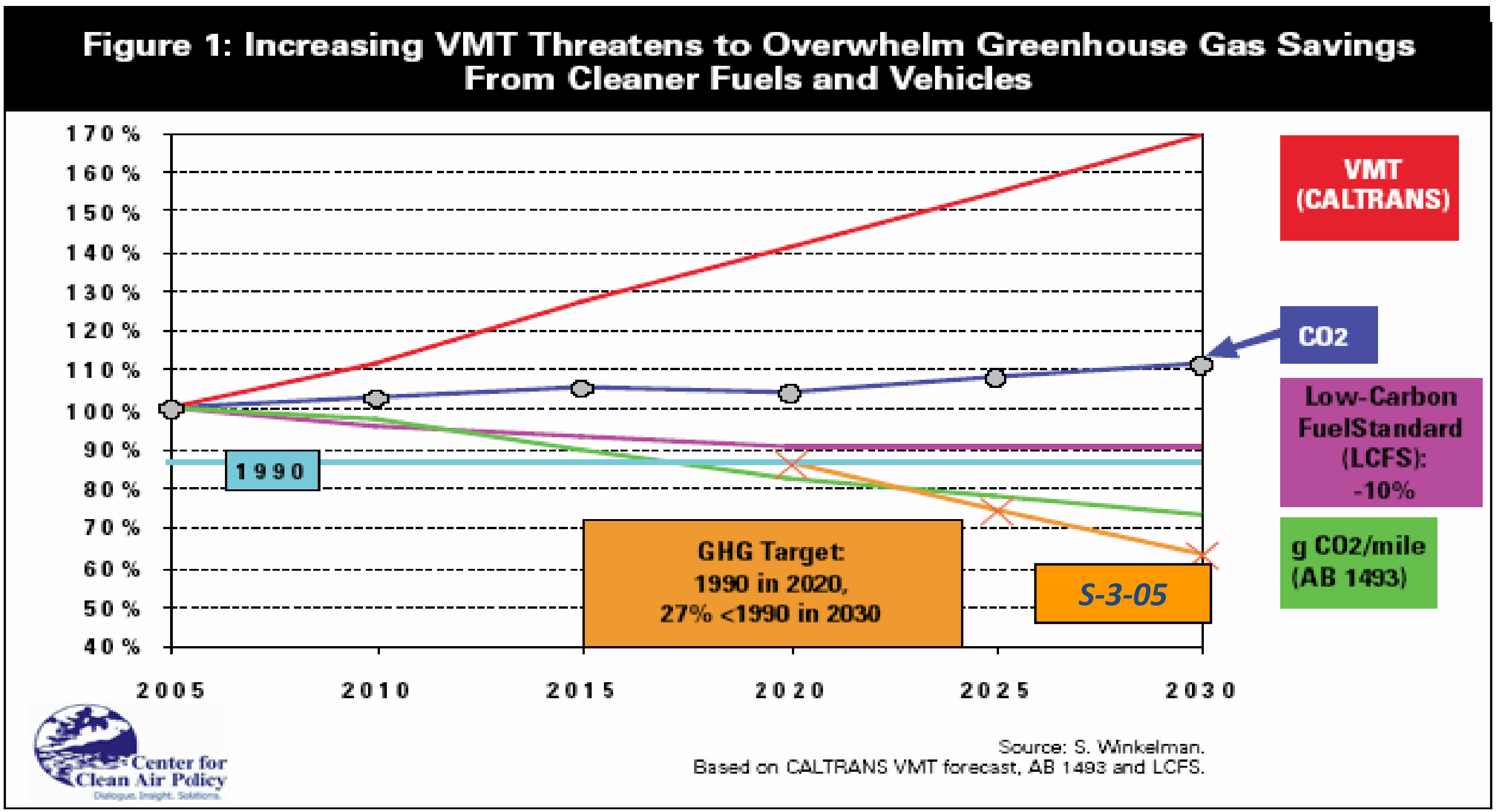
Report on ***SB 375*** See its Table 1.

Cars that survive beyond 2030 are balanced out by those that don't survive to 2030.

Data Relating 1990, 2005, & 2015 Data

Purple (Low carbon fuel), Green (C02/Mile), & Gold (S-3-05)

Figure 1, from: http://www.ecovote.org/sites/default/files/pdf/sb375.pdf



Variables

Definitions	
e_k	LDV Emitted C02, in Year "k"
L_k	Low Carbon Fuel Standard (LCFS) Factor that reduces the Per-Gallon CO2 emissions, in Year "k" (k is denotes Year 2030)
C_k	LDV CO2 emitted per mile driven, average, in Year "k", not accounting for the Low Carbon Fuel Standard (LCFS) Factor
c_k	LDV CO2 emitted per mile driven, average, in Year "k", accounting for the Low Carbon Fuel Standard (LCFS) Factor
p_k	Population, in Year "k"
d_k	Per-capita LDV driving, in Year "k"
D_k	LDV Driving, in Year "k"
M_k	LDV Mileage, miles per gallon, in Year "k"
m_k	LDV Equivalent Mileage, miles per gallon, in Year "k" accounting for the Low Carbon Fuel Standard (LCFS) Factor, so this is M_k/L_k
N	Number of pounds of CO2 per gallon of fuel but not accounting for the Low Carbon Fuel Standard (LCFS) Factor

Fundamental Equations

Future Year k: $\boldsymbol{e_k} = c_k * d_k * p_k$

Base Year i: $\boldsymbol{e_i} = c_i * d_i * p_i$

$$\frac{\boldsymbol{e_k}}{\boldsymbol{e_i}} = \frac{\boldsymbol{c_k}}{\boldsymbol{c_i}} * \frac{\boldsymbol{d_k}}{\boldsymbol{d_i}} * \frac{\boldsymbol{p_k}}{\boldsymbol{p_i}}$$

To work with mileage: $\frac{\boldsymbol{m_i}}{\boldsymbol{m_k}} = \frac{\boldsymbol{c_k}}{\boldsymbol{c_i}}$

Solution Overview

“k” denotes Year 2030
“i” denotes Year 2005

Car Efficiency Factor
From existing mileage requirements and the ***requirements defined herein***

From existing and predicted population

$$\frac{e_k}{e_i} = \frac{m_i}{m_k} * \frac{d_k}{d_i} * \frac{p_k}{p_i}$$

From the known 1990-to-2005 factor and the **Climate-Stabilizing-Target, which is the factor of 2030 emissions to 1990 emissions**

The Independent Variable
It becomes the ***required per-capita driving reduction with respect to 2005 driving***

Solution Using Intermediate Year of 2015

From the **Climate-Stabilizing-Target**, **which is the factor of 2030 emissions to 1990 emissions**

Car Efficiency Factor
From existing mileage requirements and the ***requirements defined herein***

From Winkelman. It is the product of the factor from the green line and the purple line.

From known and predicted populations

$$\frac{e_{2030}}{e_{1990}} * \frac{e_{1990}}{e_{2005}} = \frac{c_{2030}}{c_{2015}} * \frac{c_{2015}}{c_{2005}} * \frac{d_{2030}}{d_{2005}} * \frac{p_{2030}}{p_{2005}}$$

Taken from the Winkelman data: the known 1990-to-2005 factor of emissions (the light blue line)

The Independent Variable
It becomes the ***required 2030 per-capita driving reduction with respect to 2005 driving***

Putting In the Easy-to-Get Values

From the **Climate-Stabilizing-Target**, **which is the factor of 2030 emissions to 1990 emissions ("80% down")**

Car Efficiency Factor
From existing mileage requirements and the ***requirements defined herein***

From Winkelman. It is the product of the factor from the green line and the purple line. There is less CO2 per mile, thanks to the LCFS

From known and predicted populations

$$0.20 * 0.87 = \frac{c_{2030}}{c_{2015}} * 0.90 * 0.93 * \frac{d_{2030}}{d_{2005}} * 1.17446$$

Taken from the Winkelman data: the known 1990-to-2005 factor of emissions (the light blue line)

This ratio is the Independent Variable.
It is the *required per-capita 2030 driving reduction with respect to 2005 driving*

Combining the Easy-to-Get Values, Solving for the Independent Variable, and Changing the 2015-to-2030 Car Efficiency from CO2-Per-Mile to Equivalent-Miles-Per-Gallon

$$0.17700 = \frac{c_{2030}}{c_{2015}} * \frac{d_{2030}}{d_{2005}}$$

$$\frac{d_{2030}}{d_{2005}} = 0.17700 * \frac{c_{2015}}{c_{2030}}$$

$$\frac{d_{2030}}{d_{2005}} = 0.17700 * \frac{m_{2030}}{m_{2015}}$$

Equivalent Mileage in 2030 is what we make it. **It better be as high as possible, because a large driving reduction will be difficult.**
= "NUMERATOR MILEAGE"

The required per-capita 2030 driving with respect to 2005 driving

2015 Fleet Mileage is computed
= "DENOMINATOR MILEAGE"

Some Requirements Defined to Achieve 2030 Fleet Equivalent-Mileage

- Low-Carbon Fuel Standards (LCFS)
- Corporate Average Fuel Efficiency (CAFÉ) Standards from 2015 to 2030
- Driving Reduction Factors (f_n) for bad-mileage years (Year n)

Both California's existing and extended, "L_k"

Existing, to 2025
Specified to 2030

- For example, 0.75 means 25% less driving
- ***Cash for Gas-guzzlers?***

Three More Requirements

Defined to Achieve 2030 Fleet Equivalent-Mileage

- CAFÉ Standards only apply to Internal Combustion Engine (ICE) LDVs
- New Requirement: Fraction of fleet sold that must be ***Zero Emission Vehicles*** (ZEVs)
- In 2030, only 15%, or (the other case) 10% of electricity is from fossil fuels

Define “*z*” to be the fraction of fleet sold that must be ZEVs

Fleet Mileage for Intermediate Year 2015

LDV Set	Years Old	Model Year	CAFE MPG	LCFS Factor L_{Year}	Factor Driven f	Gallons Used Per f*100 Miles
1	14-15	2001	24.0	1.0	1.0	4.17
2	13-14	2002	24.0	1.0	1.0	4.17
3	12-13	2003	24.0	1.0	1.0	4.17
4	11-12	2004	24.0	1.0	1.0	4.17
5	10-11	2005	25.0	1.0	1.0	4.00
6	9-10	2006	25.7	.9933	1.0	3.87
7	8-9	2007	26.3	.9867	1.0	3.75
8	7-8	2008	27.0	.9800	1.0	3.63
9	6-7	2009	28.0	.9733	1.0	3.48
10	5-6	2010	28.0	.9667	1.0	3.45
11	4-5	2011	29.1	.9600	1.0	3.30
12	3-4	2012	29.8	.9533	1.0	3.20
13	2-3	2013	30.6	.9467	1.0	3.09
14	1-2	2014	31.4	.9400	1.0	2.99
15	0-1	2015	32.6	.9333	1.0	2.86
Sum of Gallons:						54.29
Miles = 100*Sum(f's):						1500
MPG = Miles/(Sum of Gallons):						27.63

Computed DENOMINATOR MILEAGE

ZEV Derivation Variables

Variable	Definition
m_z	ZEV Equivalent mileage (miles per equivalent gallon)
m_{zr}	ZEV Equivalent mileage if the electricity is from 100% renewables
m_{zf}	ZEV Equivalent mileage if the electricity is from 100% fossil fuels
r	fraction of electricity generated from sources not emitting CO2
G	Gallons of equivalent fuel used
D	Arbitrary distance travelled
Num	$m_{zr} \times m_{zf}$
Den	$r \times m_{zf} + (1 - r) \times m_{zr}$

ZEV Derivation

$$G = \frac{r \times D}{m_{zr}} + \frac{(1 - r) \times D}{m_{zf}}$$

$$m_z = D/G = D/(\frac{r \times D}{m_{zr}} + \frac{(1 - r) \times D}{m_{zf}})$$

$$m_z = m_{zr} \times m_{zf}/(r \times m_{zf} + (1 - r) \times m_{zr})$$

$$m_z = Num/(Den\ )$$

m_{zr}	m_{zf}	r	1-r	Num	Den	m_z
5000	70	0.80	0.20	350000.00	1056.00	331.44
5000	70	0.85	0.15	350000.00	809.50	432.37
5000	70	0.90	0.10	350000.00	563.00	621.67

Four Variable Definitions & Selecting a Target Numerator Mileage Value

Variable	Definition
D_i	Distance travelled by ICE vehicles
D_z	Distance travelled by ZEV vehicles
G_i	Gallons of equivalent fuel used by ICE vehicles
G_z	Gallons of equivalent fuel used by ZEVs

This previously-derived equation was used.

$$\frac{d_{2030}}{d_{2005}} = 0.17700 * \frac{m_{2030}}{m_{2015}}$$

The driving reduction, $\frac{d_{2030}}{d_{2005}}$, was set to 0.68, corresponding to a 32% reduction in driving.

Then, using the previously-computed $\mathbf{m_{2015}}$ = 27.63 mile per gallon (MPG), the ***Numerator Mileage (m_{2030})*** was computed to be around **106 MPG**.

Finally, the ***z*** values were selected in the following table, by trial and error, to get the ***Numerator Mileage (m_{2030})*** to be close to that **106 MPG** value.

"Balanced_1", 85% Renewable Electricity

			ZevMileage =		432.37		So $G_z = D_z$ / 432.37					
Year	ICE Parameters and Calculations						ZEVs			Yearly Totals		
	CAFÉ MPG	LCFS	Eq. MPG	f	D_i	G_i	z	D_z	G_z	Total Miles	Total Gallons	2030 MPG
2016	34.3	0.9267	37.01	0.3	29.4	0.7943	0.02	2	0.005	31.40	0.7989	39.30
2017	35.1	0.9200	38.15	0.4	39.2	1.0275	0.02	2	0.005	41.20	1.0321	39.92
2018	36.1	0.9133	39.53	0.5	48.5	1.2271	0.03	3	0.007	51.50	1.2340	41.73
2019	37.1	0.9067	40.92	0.6	57.6	1.4077	0.04	4	0.009	61.60	1.4169	43.47
2020	38.3	0.9000	42.56	0.7	64.4	1.5133	0.08	8	0.019	72.40	1.5318	47.26
2021	40.3	0.8500	47.41	0.8	64.0	1.3499	0.20	20	0.046	84.00	1.3961	60.17
2022	42.3	0.8000	52.88	0.9	58.5	1.1064	0.35	35	0.081	93.50	1.1873	78.75
2023	44.3	0.8000	55.38	1.0	45.0	0.8126	0.55	55	0.127	100.00	0.9398	106.40
2024	46.5	0.8000	58.13	1.0	20.0	0.3441	0.80	80	0.185	100.00	0.5291	188.99
2025	48.7	0.8000	60.88	1.0	6.0	0.0986	0.94	94	0.217	100.00	0.3160	316.48
2026	51.2	0.8000	64.00	1.0	3.0	0.0469	0.97	97	0.224	100.00	0.2712	368.70
2027	53.7	0.8000	67.13	1.0	2.0	0.0298	0.98	98	0.227	100.00	0.2565	389.93
2028	56.2	0.8000	70.25	1.0	1.0	0.0142	0.99	99	0.229	100.00	0.2432	411.17
2029	58.7	0.8000	73.38	1.0	1.0	0.0136	0.99	99	0.229	100.00	0.2426	412.20
2030	61.2	0.8000	76.50	1.0	1.0	0.0131	0.99	99	0.229	100.00	0.2420	413.15
Sum of Miles and then Gallons of equivalent fuel:										1235.60	11.64	
Equivalent MPG of LDV Fleet in 2030: 106.17												
ZEV Miles Driven = 795.0					Fraction of Miles Driven by ZEVs =					64.3%		

Computed NUMINATOR MILEAGE

Computing the Ratio of Per-Capita 2030 Driving to Per-Capita 2005 Driving

Equivalent Mileage in 2030 = "**NUMERATOR MILEAGE**"

$$\frac{d_{2030}}{d_{2005}} = .1770 * \frac{106.17}{27.63} = .68$$

2015 Fleet Mileage was computed before **= "DENOMINATOR MILEAGE"**

The factor of 0.68 means there is a 32% reduction in per-capita driving, from 2005 to 2030.

Again, for the next case, the ***z*** values were selected by trial and error, to get the 106 MPG value, corresponding to a 32% decrease in driving.

“Balanced_2”, 90% Renewable Electricity

			ZevMileage =		621.67	So $G_z = D_z$ / 621.67				
Year	ICE Parameters and Calculations						ZEVs			Yearly Totals		
	CAFÉ MPG	LCFS	Eq. MPG	f	D_i	G_i	z	D_z	G_z	Total Miles	Total Gallons	2030 MPG
2016	34.3	0.927	37.01	0.3	29.4	0.7943	0.02	2	0.003	31.40	0.7975	39.37
2017	35.1	0.920	38.15	0.4	39.2	1.0275	0.02	2	0.003	41.20	1.0307	39.97
2018	36.1	0.913	39.53	0.5	48.5	1.2271	0.03	3	0.005	51.50	1.2319	41.81
2019	37.1	0.907	40.92	0.6	57.6	1.4077	0.04	4	0.006	61.60	1.4141	43.56
2020	38.3	0.900	42.56	0.7	64.4	1.5133	0.08	8	0.013	72.40	1.5262	47.44
2021	40.3	0.850	47.41	0.8	68.0	1.4342	0.15	15	0.024	83.00	1.4584	56.91
2022	42.3	0.800	52.88	0.9	67.5	1.2766	0.25	25	0.040	92.50	1.3168	70.25
2023	44.3	0.800	55.38	1.0	55.0	0.9932	0.45	45	0.072	100.00	1.0656	93.84
2024	46.5	0.800	58.13	1.0	30.0	0.5161	0.70	70	0.113	100.00	0.6287	159.05
2025	48.7	0.800	60.88	1.0	5.0	0.0821	0.95	95	0.153	100.00	0.2349	425.62
2026	51.2	0.800	64.00	1.0	3.0	0.0469	0.97	97	0.156	100.00	0.2029	492.84
2027	53.7	0.800	67.13	1.0	2.0	0.0298	0.98	98	0.158	100.00	0.1874	533.52
2028	56.2	0.800	70.25	1.0	1.0	0.0142	0.99	99	0.159	100.00	0.1735	576.42
2029	58.7	0.800	73.38	1.0	1.0	0.0136	0.99	99	0.159	100.00	0.1729	578.45
2030	61.2	0.800	76.50	1.0	1.0	0.0131	0.99	99	0.159	100.00	0.1723	580.31
Sum of Miles and then Gallons of equivalent fuel:										1233.60	11.61	

Equivalent MPG of LDV Fleet in 2030: 106.22

ZEV Miles Driven = 761.0 Fraction of Miles Driven by ZEVs = 61.7%

Computed NUMINATOR MILEAGE

Selecting a Target Numerator Mileage Value to Get a 0% Reduction in Driving

This previously-derived equation was used.

$$\boxed{\frac{d_{2030}}{d_{2005}} = 0.17700 * \frac{m_{2030}}{m_{2015}}}$$

The driving reduction, $\frac{d_{2030}}{d_{2005}}$, was set to 1.00, corresponding to a 0% reduction in driving.

Then, using the previously-computed $\mathbf{m_{2015}}$ = 27.63 mile per gallon (MPG), the ***Numerator Mileage (m_{2030})*** was computed to be around **156 MPG**.

Finally, the ***z*** values were selected in the following table, by trial and error, to get the ***Numerator Mileage (m_{2030})*** to be close to that **156 MPG** value.

"2005 Driving Case", 90% Renewable Electricity

		Zev mileage =	621.67	So $G_z = D_z$ / 621.67								
	ICE Parameters and Calculations						ZEVs			Yearly Totals		
Year	CAFÉ MPG	LCFS	Eq. MPG	f	D_i	G_i	z	D_z	G_z	Total Miles	Total Gallons	2030 MPG
2016	34.3	0.9267	37.01	0.3	29.4	0.7943	0.02	2.0	0.003	31.40	0.7975	39.37
2017	35.1	0.9200	38.15	0.4	39.2	1.0275	0.02	2.0	0.003	41.20	1.0307	39.97
2018	36.1	0.9133	39.53	0.5	48.5	1.2271	0.03	3.0	0.005	51.50	1.2319	41.81
2019	37.1	0.9067	40.92	0.6	57.6	1.4077	0.04	4.0	0.006	61.60	1.4141	43.56
2020	38.3	0.9000	42.56	0.7	64.4	1.5133	0.08	8.0	0.013	72.40	1.5262	47.44
2021	40.3	0.8500	47.41	0.8	14.4	0.3037	0.82	82.0	0.132	96.40	0.4356	221.29
2022	42.3	0.8000	52.88	0.9	2.7	0.0511	0.97	97.0	0.156	99.70	0.2071	481.42
2023	44.3	0.8000	55.38	1.0	1.0	0.0181	0.99	99.0	0.159	100.00	0.1773	563.99
2024	46.5	0.8000	58.13	1.0	1.0	0.0172	0.99	99.0	0.159	100.00	0.1765	566.72
2025	48.7	0.8000	60.88	1.0	1.0	0.0164	0.99	99.0	0.159	100.00	0.1757	569.23
2026	51.2	0.8000	64.00	1.0	1.0	0.0156	0.99	99.0	0.159	100.00	0.1749	571.84
2027	53.7	0.8000	67.13	1.0	1.0	0.0149	0.99	99.0	0.159	100.00	0.1741	574.23
2028	56.2	0.8000	70.25	1.0	1.0	0.0142	0.99	99.0	0.159	100.00	0.1735	576.42
2029	58.7	0.8000	73.38	1.0	1.0	0.0136	0.99	99.0	0.159	100.00	0.1729	578.45
2030	61.2	0.8000	76.50	1.0	1.0	0.0131	0.99	99.0	0.159	100.00	0.1723	580.31
Sum of Miles and then Gallons of equivalent fuel:										1254.20	8.04	

Equivalent MPG of LDV Fleet in 2030: 155.99

ZEV Miles Driven = 990.0

Fraction of Miles Driven by ZEVs = 78.9%

Computed NUMINATOR MILEAGE

Computing the Ratio of Per-Capita 2030 Driving to Per-Capita 2005 Driving

Equivalent Mileage in 2030 is what we made it by selecting the "z" values in the previous table. = "**NUMERATOR MILEAGE**"

$$\frac{d_{2030}}{d_{2005}} = .1770 * \frac{155.99}{27.63} = 1.00$$

2015 Fleet Mileage was computed **= "DENOMINATOR MILEAGE"**

For the next case, the ***z*** values were taken from a published article describing values selected by the Chair of the California Air Resources Board, Mary Nichols.

“Mary Nichols Case”, 90% Renewable Electricity

		Zev Mileage =		621.67	So $G_z = D_z$ / 621.67					
	ICE Parameters and Calculations					ZEVs			Yearly Totals		

Year	CAFÉ MPG	LCFS	Eq. MPG	f	D_i	G_i	z	D_z	G_z	Total Miles	Total Gallons	2030 MPG
2016	34.3	0.9267	37.01	0.3	29.2	0.7886	0.027	2.7	0.004	31.89	0.7930	40.22
2017	35.1	0.9200	38.15	0.4	38.9	1.0201	0.027	2.7	0.004	41.62	1.0245	40.63
2018	36.1	0.9133	39.53	0.5	47.4	1.2003	0.051	5.1	0.008	52.56	1.2086	43.49
2019	37.1	0.9067	40.92	0.6	55.5	1.3560	0.075	7.5	0.012	63.01	1.3681	46.06
2020	38.3	0.9000	42.56	0.7	63.0	1.4814	0.099	9.9	0.016	72.98	1.4974	48.74
2021	40.3	0.8500	47.41	0.8	70.1	1.4790	0.124	12.4	0.020	82.47	1.4988	55.02
2022	42.3	0.8000	52.88	0.9	76.7	1.4509	0.148	14.8	0.024	91.48	1.4746	62.03
2023	44.3	0.8000	55.38	1.0	82.8	1.4957	0.172	17.2	0.028	100.00	1.5233	65.65
2024	46.5	0.8000	58.13	1.0	80.4	1.3834	0.196	19.6	0.032	100.00	1.4149	70.67
2025	48.7	0.8000	60.88	1.0	78.0	1.2813	0.220	22.0	0.035	100.00	1.3167	75.95
2026	51.2	0.8000	64.00	1.0	62.4	0.9750	0.376	37.6	0.060	100.00	1.0355	96.57
2027	53.7	0.8000	67.13	1.0	46.8	0.6972	0.532	53.2	0.086	100.00	0.7828	127.75
2028	56.2	0.8000	70.25	1.0	31.2	0.4441	0.688	68.8	0.111	100.00	0.5548	180.25
2029	58.7	0.8000	73.38	1.0	15.6	0.2126	0.844	84.4	0.136	100.00	0.3484	287.05
2030	61.2	0.8000	76.50	1.0	0.0	0.0000	1.000	100.0	0.161	100.00	0.1609	621.67
Sum of Miles and then Gallons of equivalent fuel:										1236.00	16.00	

Equivalent MPG of LDV Fleet in 2030: 77.24

ZEV Miles Driven = 457.9 Fraction of Miles Driven by ZEVs = 37.0%

Computed NUMINATOR MILEAGE

Computing the Ratio of Per-Capita 2030 Driving to Per-Capita 2005 Driving

Equivalent Mileage in 2030 is what resulted from the Mary Nichols statement. It is the "**NUMERATOR MILEAGE**"

$$\frac{d_{2030}}{d_{2005}} = .1770 * \frac{77.24}{27.63} = .495$$

2015 Fleet Mileage was computed = "**DENOMINATOR MILEAGE**"

CARB may not understand that the fleet electrification schedule suggested by their Board Chair would require that per-capita driving be about half what it was in 2005, if LDVs are to achieve climate-stabilizing targets.

Net Driving Decrease with Respect to 2005 Driving for the "Balanced" Cases

(Per-Capita Driving Factor) x (Population Factor) = Net Driving Factor

This factor corresponds to the 32% reduction in per-capita driving

(.68) x (1.1744) = .80

Therefore, even though the population will grow 17%, <u>net driving must decrease by 20%</u>.

Therefore, why add highway lanes?

We need enforceable measures to reduce driving so much there will be no more congestion!

4 Cases that Support Climate Stabilization

Note: Purple denotes difficult; red, impossible.

	Case Designations			
	Balanced_1	**Balanced_2**	**2005 Driving**	**Mary Nichols**
% Renewable Electricity	**85.0%**	**90.0%**	**90.0%**	**90.00%**
% ZEVs, Year 2016	2.0%	2.0%	2.0%	2.70%
% ZEVs, Year 2017	2.0%	2.0%	2.0%	2.70%
% ZEVs, Year 2018	3.0%	3.0%	3.0%	5.11%
% ZEVs, Year 2019	4.0%	4.0%	4.0%	7.53%
% ZEVs, Year 2020	8.0%	8.0%	8.0%	9.94%
% ZEVs, Year 2021	**20.0%**	15.0%	**82.0%**	12.35%
% ZEVs, Year 2022	**35.0%**	25.0%	**97.0%**	14.76%
% ZEVs, Year 2023	**55.0%**	**45.0%**	99.0%	17.18%
% ZEVs, Year 2024	**80.0%**	**70.0%**	99.0%	19.59%
% ZEVs, Year 2025	94.0%	95.0%	99.0%	22.00%
% ZEVs, Year 2026	97.0%	97.0%	99.0%	37.60%
% ZEVs, Year 2027	98.0%	98.0%	99.0%	53.20%
% ZEVs, Year 2028	99.0%	99.0%	99.0%	68.80%
% ZEVs, Year 2029	99.0%	99.0%	99.0%	84.40%
% ZEVs, Year 2030	99.0%	99.0%	99.0%	100.00%
% Reduction in Per-Capita Driving With Respect to Year 2005	**32.0%**	**32.0%**	0%	**50.5%**

Enforceable Measures to Reduce 2030 Driving by 32% With Respect to 2005

California designs and implements this

Local governments do this with a 3rd party vendor

Driving-Reduction Requirments	Per-Cent Reduction	Factor
Legislated (SB 375) Plans to Reduce Driving	12%	0.88
Value-Priced Road Use Charge (RUC)	10%	0.90
Value-Priced Parking (Unbundling the Cost)	8%	0.92
Transfer Highway Expansion Funds to Transit	2%	0.98
Increase Height & Density by Transit Stations	2%	0.98
"Complete Streets", "Road Diet" (walk/bike)	1%	0.99
Pay-to-Graduat e Bicycle Traffic-Skills Class	1%	0.99
Bicycle Projects to Improve Access	1%	0.99
Product of Factors		**0.68**
% Reduction		**32%**

These enforceable measures are described in the AWMA paper.

An Important Pricing Strategy

A Road-Usage-Charge (RUC) Pricing & Payout System

THEREFORE, BE IT RESOLVED, that the Democratic Club of Carlsbad and Oceanside (DEMCCO) supports a road-usage charge (RUC) pricing & payout system that would (1) cover all road-use costs, including the environmental & health costs caused by driving; (2) mitigate impacts on low-income users; (3) protect privacy; (4) include congestion pricing; (5) keep the per-mile price incentive to drive energy-efficient cars at least as large as it is with today's fuel excise tax; and (6) send its earnings to all citizens and institutions that are currently losing money by subsidizing road use.

Another Important **Pricing** Strategy

A good car-parking system: value-priced (with congestion pricing), shared, automated, and providing earnings to those losing money because the parking is being provided.

The first such systems should be installed by a third-party vendor (such as **Google, Qualcomm, Uber, or Lime Bicycle)**, selected by a RFP (Request for Proposal) process, for municipal government employees, as part of the government's **Climate Action Plan**. It would be operated for the financial gain of the employees. The RFP would specify that even employees that continue to drive every day would at least break even. The winning third-party vendor would be skilled at monetizing parking, whenever it is not being used by the employees; at monetizing data; and at expanding the system. The system would be automated with a useful phone app to find the best parking at the user-specified price and walk-distance.

From: https://www.cadem.org/body/Final-CDP-Platform-2020-11.16.2019.pdf

From the 2020 California Democratic Party (CDP) Platform

- Work to ensure that all graduating high school students are climate literate, including knowing
  - reasons for anthropogenic climate change and its potential for harm;
  - the difference between climate stabilization and destabilization;
  - climate-stabilizing greenhouse gas (GHG) reduction targets;
    - the basis for those targets, and
    - the measures needed to achieve them; and
  - the primary categories of emissions, including the most problematic category: cars and light-duty trucks;
- Demand a state plan specifying how cars and light-duty trucks can meet climate-stabilizing targets by defining enforceable measures to achieve necessary fleet efficiency and per-capita driving limits;
- Demand Regional Transportation Plan (RTP) driving-reduction targets, shown by science to support climate stabilization;
- Work for equitable and environmentally-sound road and parking operations; smart growth; “complete streets”; teaching bicycling traffic skills; and improving transit, from local systems to high-speed rail;
- Support the design and implementation of a single, environmentally-sound technology system that will collect and distribute fees for the use of roads, parking, and transit that is both economically fair and convenient and protects user privacy and the interests of low-income users;
- Work for the electrification of all trucking and transit systems;
- Work to ensure that freeway expansion projects are subordinate to more sustainable alternatives that will result in more jobs and growth.

From the 2016 & 2018 Platform (*Dividend Account Parking*)

- Work for shared, convenient, and value-priced parking, operated with a system that provides earnings to those paying higher costs or receiving a reduced wage, due to the cost of providing the parking.

Please email comments or questions to **mike_bullock@earthlink.net**

Dividend-Account Parking: Feasible & Enforceable Mitigation

Updated from Air and Waste Management Association Paper 2010-A-554-AWMA

Mike R. Bullock
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ABSTRACT

Bundled-cost and *bundled-benefit* car-parking systems (generally called "free parking") are defined, showing that they are not free and that they increase the drive-alone mode, since non-drivers lose just as much money as those that use the parking.

Dividend-Account Parking (DAP) is defined as a parking system in which all of the parking spaces are *shared* by all drivers that are driving a car that is registered in the system. "Registered" means that the car can be associated with a person having an *account* in the system. The parking is *value-priced*, with an option for a *congestion pricing overlay*. The critical final feature is that the earnings (*dividends*) are given to the people, for whom the parking is built, such as employees, shoppers, residents of apartments or condominiums, students, or train riders. It is stated that this system is defined in the California Democratic Party (CDP) Platform, making it the official policy of the largest political, environmental, and public-policy-advocacy organization in California. It is also at the center of the Sierra Club's lawsuit against the San Diego County's Climate Action Plan (CAP). The court has found in multiple rulings that DAP is feasible mitigation.

Motivations for change are provided, mostly based on an Air and Waste Management Association paper, *Climate-Stabilizing California Light-Duty-Vehicle (LDV) Requirements*. The following is shown:

1. Parking reform is needed, since fleet electrification, while critically needed (ASAP), cannot, under even the most wildly-optimistic assumptions, achieve the needed GHG emission reduction, for light-duty vehicles (LDVs), soon enough to achieve climate-stabilizing targets.
2. Per-capita driving must be reduced.

It is asserted that parking reform has a large role to play.

DAP is presented as a feasible, enforceable, mitigation measure for any Climate Action Plan or for any application where sustainability is a goal.

100 word summary:

Bundled-cost and *bundled-benefit* car-parking systems (erroneously called "free") are defined, showing that they are not free and that they increase the drive-alone mode, since non-drivers lose just as much money as drivers, due to the parking.

Dividend Account Parking (DAP) is presented as a mitigation measure for any Climate Action Plan (CAP) or for any application where sustainability is a goal. The parking is shared, convenient, fully automated, and value priced with a congestion-pricing algorithm. Earnings go to those losing money because the parking is provided.

Motivations are provided, based on an Air and Waste Management Association (AWMA) paper.

Dividend-Account Parking (DAP) is defined as a parking system in which all of the parking spaces are *shared* by all drivers that are driving a car that is registered in the system. "Registered" means that the car can be associated with a person having an *account* in the system. The parking is *value-priced*, with an option for a *congestion pricing overlay*. The critical final feature is that the earnings (*dividends*) are given to the people, for whom the parking is built, such as employees, shoppers, residents of apartments or condominiums, students, or train riders. It is stated that this system is defined in the California Democratic Party (CDP) Platform, making it the official policy of the largest political, environmental, and public-policy-advocacy organization in California. It is also at the center of the Sierra Club's lawsuit against the San Diego County's Climate Action Plan (CAP). The court has found in multiple rulings that DAP is feasible mitigation.

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It is asserted that parking reform has a large role to play.

DAP is presented as a feasible, enforceable, mitigation measure for any Climate Action Plan or for any application where sustainability is a goal.

It shows documented driving reductions due to the pricing of parking. It notes that although the benefits of priced and shared parking are known, such parking has not been widely implemented, due to understandable concerns. It states that a system solution, called *Dividend-Account Parking*, can overcome these concerns, because it would be is easy to use, share, understand, and support. The system operates the parking to maximize the financial gain of those losing money because of the parking. Eight background informational items are provided, including how value-priced parking would help California achieve greenhouse gas (GHG) reduction targets. Arguments for less parking, shared parking, and priced parking are made. Barriers to progress are identified. The fair pricing of parking is described. Seven goals of *Dividend-Account Parking* are listed. Eleven definitions and concepts that define *Dividend-Account Parking* are given. This includes a method to compute a baseline price of parking and how to adjust that price instantaneously to keep the vacancy above 15%. That price adjustment implements "Congestion Pricing." This information is sufficient to support a "Request for Proposal" (RFP) process to get a *Dividend-Account Parking* design. An implementation strategy is provided.

INTRODUCTION:

It has been well established that appropriately priced parking will significantly reduce driving[1]. Most case studies presented in Table 1 are evaluations of the most general type of "car-parking cash-out": *a program that pays employees extra money each time they get to work without* *driving*. They show that a price differential between using parking and not using parking will significantly reduce driving, even when transit is described as poor. Since driving *must* be reduced[2], the pricing of parking is desirable.

Shared parking is also recognized as desirable because it can sometimes result in less parking being needed.

Although the advantages of pricing and sharing parking have been recognized for many years, these practices are still rare. This paper identifies some of the reasons for this lack of progress. The pricing and sharing method of this paper has a natural transparency and ease of use that would reduce many of the concerns. This paper also suggests that those governments that have the necessary resources can take the lead role in developing and implementing the described systems. These governments will recover their investments, over time.

This paper describes how parking facilities could be tied together and operated in an optimum system, named *Dividend Account Parking (DAP)*. The description of *Dividend Account Parking (DAP)* is sufficient to support a "Request for Proposal" process, leading to full implementation.

There are two distinct parts to *Dividend Account Parking (DAP)*. The first is how to set the price. The second is how to distribute the earnings. Briefly, the earnings go to the individuals in the group for whom the parking is built.

Table 1 Eleven Cases of Pricing Impact on Parking Demand

Location	Number of Workers @ Number of Firms	1995 $'s Per Mo.	Parking Use Decrease
Group A: Areas with poor public transportation			
West Los Angeles	3500 @ 100+	$81	15%
Cornell University, Ithaca, NY	9000 Faculty & Staff	$34	26%
San Fernando Valley, Los Angeles	850 @ 1	$37	30%
Costa Mesa, CA	Not Shown	$37	22%
	Average for Group	**$47**	**23%**
Group B: Areas with fair public transportation			
Los Angeles Civic Center	10,000+ @ "Several"	$125	36%
Mid-Wilshire Blvd, Los Angeles	1 "Mid-Size" Firm	$89	38%
Washington DC Suburbs	5,500 @ 3	$68	26%
Downtown Los Angeles	5,000 @ 118	$126	25%
	Average for Group	**$102**	**31%**
Group C: Areas with good public transportation			
U. of Washington, Seattle, WA	50,000 employees, students	$18	24%
Downtown Ottawa, Canada	3,500 government staff	$72	18%
Bellevue, WA	430 @ 1	$54	39%*
Average for Group, except Bellevue, WA Case*		**$45**	**21%**
Overall Average, Excluding Bellevue, WA Case*			**25%**

* Bellevue, WA case was not used in the averages because its walk/bike facilities also improved and those improvements could have caused part of the decrease in driving.

PERTINENT BACKGROUND INFORMATION

- Vehicle miles traveled (VMT) are a major cause of global warming and pollution[2, 3].
- California's Metropolitan Planning Organizations (MPOs) will need to adopt strategies that reduce vehicle miles traveled (VMT), in order to meet SB375 GHG reduction targets, to be issued by the California Air Resources Board in late 2010, for years 2020 and 2035[2].
- The appropriate pricing of parking is one of the least costly documented tools to reduce VMT.
- New technologies, such as sensors feeding computer-generated billing, offer the potential to efficiently bill drivers for parking and alert law enforcement of trespassers.
- Reformed parking policies can increase fairness, so that, for example, people who use transit or walk do not have to pay higher prices or suffer reduced wages, due to parking.
- Methods to unbundle parking cost are inefficient unless they support the spontaneous sharing of parking spaces. Shared parking with unbundled cost would ultimately allow cities to require significantly less parking.
- Typical systems of timed parking and metered parking are far from ideal. Parking has no automated record keeping, so it is difficult to know where there is too much or too little.
- Good policies will eventually let cities turn parking minimums into parking maximums.

A GLIMPSE INTO A POSSIBLE FUTURE

Jason is driving to work for the first time in several years. He has decided to save money by carrying home a new 3-D, big-screen computer, which he plans to purchase at a store near his office after work. He wanted to avoid paying delivery charges.

Things have been changing around his office development since they unbundled the cost of parking at the near-by train station. Many people who caught the early trains and lived close to the station stopped driving and parking in the best parking spaces; demand for housing close to the station went up; and wealthy riders, who insisted on driving, did so, confidant that they could always find parking as close to the platform as their schedules required, due to congestion pricing. Who would have guessed how much those people were willing to pay? It was shocking. Parking-lot earnings, paid to round-trip train riders, meant that the net cost to ride the train went significantly down. Ridership and neighborhood vitality both went significantly up. All Jason knew was that the price to park at his office had been going up yearly because of increased land values. His parking-lot earnings from his office had been increasing almost every month, due to the ripple effect of train riders parking off-site at cheaper parking. Some of them were using his office parking.

As he pulls out of his driveway, he tells his GPS navigation unit his work hours (it already knew his office location), the location of the store where he plans to buy the computer, and his estimated arrival and departure times at the store. He tells the GPS unit he wants to park once, park no more than 1 block from the store, walk no more than 1 mile total, and pay no more than an average of $2 per hour to park. He is not surprised to hear the GPS tell him that his request is impossible. He tells the GPS he will pay an average of $3 per hour and learns that the GPS has located parking.

It guides him into a church parking lot. He hopes the church will use his money wisely. The GPS tells him the location of a bus stop he could use to get to work and the bus's next arrival time at the stop. With automatic passenger identification and billing, the bus has become easy to use, except that it is often crowded. Jason gets out of the car and walks to work, with no action required regarding the parking.

Three weeks later, when Jason gets his monthly statement for his charges and income for automotive road use, transit use, parking charges, and parking earnings, he finds that the day's parking did indeed cost about $30 for the 10 total hours that he parked. He notes that the parking-lot earnings for his office parking averaged about $10 per day that month. He then notices the parking lot earnings from the store, where he spent about $1000 dollars. He sees that the parking-lot earnings percent for the store that month was 1.7%, giving him about $17. So for the day, Jason only spent a net of about $3 on parking. Then he realized that he should have had the computer delivered after all. If he would have bicycled that day, as he usually did, he would have still gotten the $27 earnings from the two parking facilities and he would have paid nothing for parking. So the choice to drive cost him $30. He remembers that the delivery would have only been $25 dollars. Oh well. He enjoyed his before-work and after-work walks.

THE CASE FOR LESS PARKING

Less parking will support more compact development.[1] This makes walking and biking more enjoyable and less time consuming. There would certainly be less "dead space", which is how parking lots feel to people, whether they arrive by car or not, after they become pedestrians.

Since parking can be expensive, less parking can reduce overhead costs significantly, such as leasing expense and parking-lot maintenance cost. Less overhead means more profit and less expense for everyone. A need for less parking can create redevelopment opportunities at existing developments and reduce project cost at new developments.

At new developments, car-parking costs could prevent a project from getting built.[2]

THE CASE FOR SHARED PARKING

Shared parking for mixed uses means that less parking is needed. For example, shared parking could be used mostly by employees during the day and mostly by residents at night.

Fully shared parking means that very little parking would be off limits to anyone. In a central business district with shared parking, drivers would be more likely to park one time per visit, even when going to several locations. Pedestrian activity adds vitality to any area.

THE CASE FOR APPROPRIATELY-PRICED PARKING

[1] This is especially true of surface parking, which only accommodates 120 cars per acre.

[2] On September 23, 2008, a panel of developers reviewed the Oceanside, Ca. "Coast Highway Vision" http://www.ci.oceanside.ca.us/pdf/chv_finalvisionstrategicplan.pdf. Parts of this plan were described as smart growth.

At the review, developer Tom Wiegel said, "Parking is the number 1 reason to do nothing," where "do nothing" meant "build no project." The other developers at the meeting agreed.

To Reduce Driving Relative to Zero Pricing

Traditional Charging or Paying Cash-out Payments

As shown in the Introduction, this relationship (pricing parking reduces driving) is not new.[3]

Using results like Table 1, at least one study[4] has used an assumption of widespread pricing to show how driving reductions could help meet greenhouse gas (GHG) target reductions. Dr. Silva Send of EPIC http://www.sandiego.edu/epic/ghgpolicy/ assumes that all work locations with 100 employees or more in San Diego County will implement cash-out, to result in 12% less driving to work. Currently, almost all employees in San Diego County "park for free", unless they happen to work in a downtown core area.

Current, Best-Practice "Unbundling"

The "best-practice" use of the phrase, "unbundled parking cost", is to describe the case where either the cost of parking, for the case of a condominium, or the rent for parking, for the case of an apartment, is separated from either the purchase price and common fees or the rent of the dwelling unit.

This gives the resident families the choice of selecting the number of parking spaces they would like to rent or buy, including the choice of zero. This would tend to reduce the average number of cars owned per dwelling unit and, in this way, would also tend to reduce driving. Its major drawback is that this method does not encourage sharing.

To Increase Fairness and Protect the US Economy

It is stated above that almost all employees in San Diego County "park for free". Of course there is really no such thing as "parking for free". So-called "free parking" always reduces wages or increases costs. At a work site, it reduces everyone's wage, even those employees that never drive. At an apartment complex, so-called "free parking" increases the rent. Therefore, "free parking" at work or at apartments violates the fundamental rule of the free market, which is that people should pay for what they use and not be forced to pay for what they do not use. Parking should at least be priced to achieve fairness to non-drivers.

The US economy would also benefit. Reductions in driving would lead to reductions in oil imports, which would reduce the US trade deficit.[4]

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[3] For many years the Victoria Transport Policy Institute (VTPI) has been recognized as a source of reliable information on "Transportation Demand Management", or TDM.

From http://www.vtpi.org/tdm/tdm72.htm#_Price_Parking:

> Even a relatively small parking fee can cause significant travel impacts and provide significant TDM benefits.

"TDM Benefits" refers to the many public and private benefits of having fewer people choosing to drive.

[4] From http://en.wikipedia.org/wiki/Balance_of_trade#Warren_Buffett_on_trade_deficits, Warren Buffet wrote in 2006,

> "The U.S. trade deficit is a bigger threat to the domestic economy than either the federal budget deficit or consumer debt and could lead to political turmoil. Right now, the rest of the world owns $3 trillion more of us than we own of them."

BARRIERS TO PROGRESS

Given all this, it might seem that the widespread pricing of parking should have happened by now. However there are barriers. In 2007, a majority of the City Council of Cupertino, Ca. indicated that they wanted their City Manger to negotiate reduced parking requirements with any company that would agree to pay sufficient cash-out payments. To this date, no company, including Apple Inc., has expressed an interest. Most companies probably perceive cash-out as expensive. Even if they realize they could get a reduced parking requirement in exchange for paying sufficient cash-out amounts and even if the economics worked in support of this action (quite possible where land is expensive), they want to stay focused on their core business, instead of getting involved in new approaches to parking, real estate, and redevelopment.

On the other hand, simply charging for parking and then giving all the employees a pay raise is probably going to run into opposition from the employees, who will feel that they would be losing a useful benefit.

In addition, neighbors fear the intrusion of parked cars on their streets. Permit parking, which could offer protection, is not always embraced. City Council members know that a sizable fraction of voting citizens believe that there can actually never be too much "free parking", Professor Shoup's famous book[5] notwithstanding. Some Council members probably feel that way themselves.

It doesn't help that current methods of charging for downtown parking are often very inefficient.[5] For example, downtown Oceanside, California has parking meters that will only accept coins. Besides this, all their on-street, downtown parking is timed, with maximums from 10 minutes to 4 hours. These time limits are enforced by a city employee, who applies chalk from a tire to the street and then records the time. However, by watching the time and moving their car soon enough, drivers can avoid getting a ticket. Of course, they could instead drive to the mall and not have to worry about having coins or elapsed time since parking. It is not surprising that downtown merchants often object to charging for parking.

In summary, those that resist charging for parking, *based on their perceptions*, include

- Companies, *who fear the complexity and expense of paying cash-out payments*;
- Employees, *who fear losing a current benefit*;
- City leaders, *who fear the political repercussions*;
- Downtown patrons, *who dislike the inconvenience and worry*;
- Downtown business owners, *who fear that it will drive away customers*.

THE COST, VALUE, AND FAIR PRICE OF PARKING

Estimated and Actual Capital Cost

Surface Parking

One acre of surface parking will accommodate 120 cars. Land zoned for mixed use is sometimes expensive. At $1.2 million per acre, the land for a single parking space costs $10,000. Construction cost should be added to this to get the actual, as-built cost of each parking space.

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[5] According to Bern Grush, Chief Scientist of Skymeter Corporation http://www.skymetercorp.com/cms/index.php, often two-thirds of the money collected from parking meters is used for collection and enforcement costs.

Estimated cost can be determined by using appraised land value and construction estimates. For new developments, after the parking is constructed, it is important to note the actual, as-built cost.

Parking-Garage Parking

One acre of parking-garage will accommodate considerably more than 120 cars. The construction cost of the garage and the value of its land can be added together to get the total cost. Dividing that total cost by the number of parking spaces yields the total, as-built cost of each parking space. Adding levels to a parking garage may seem like a way to cut the cost of each parking space, for the case of expensive land. However, there is a limit to the usefulness of this strategy because the taller the parking garage, the more massive the supporting structural members must be on the lower levels, which increases total cost. Parking-garage parking spaces are often said to cost between $20,000 and $40,000. The actual costs should be noted.

Underground Parking

In order to compute an estimate for the cost of a parking space that is under a building, it is necessary to get an estimate of the building cost with and without the underground parking. The difference, divided by the number of parking spaces, yields the cost of each parking space. The cost or value of land plays no role in the cost of this parking. However, it does not follow that this parking is cheap. Underground parking spaces are often said to cost between $60,000 and $90,000 dollars each. Although there will be an “as built” cost of the building with the parking, there will never be an “as built” cost of the building without the parking. However, after the construction is done, the estimate for the cost of the underground parking should be reconsidered and re-estimated if that is needed. The final, best-estimate cost should be noted.

Value

Initially, value and cost are the same. For surface parking and parking-garage parking, the value would initially be the same as the as-built cost. For underground parking, the value would initially be the same as the best-estimate cost. However, over time, the value must be updated. Both construction costs and land-value costs will change. The value assigned to a parking place should always be based on the current conditions.

Fair Pricing

Parking space “values”, as described above, must first be converted to a yearly price by using a reasonable conversion factor. This conversion factor could be based on either the “cost of money” or the “earnings potential of money”. It is expected that this conversion factor would be 2% to 5% during times of low interest rates and slow growth; but could be over 10% during times of high-interest and high growth. For example, if the surface parking value is $12,000 and it is agreed upon to use 5% as the conversion factor, then each parking spot should generate $600 per year, just to cover capital costs. The amount needed for operations, collection, maintenance, depreciation, and any special applicable tax is then added to the amount that covers capital cost. This sum is the amount that needs to be generated in a year, by the parking space.

The yearly amount of money to cover capital cost needs to be re-calculated every year or so, since both the value and the conversion factor will, in general, change each year. The cost of operations, collection, maintenance, depreciation, and any special applicable tax will also need to be reconsidered.

Once the amount generated per year is known, the base price, per unit year, can be computed by dividing it (the amount generated per year) by the estimated fraction of time that the space will be occupied, over a year. For example, if a parking space needs to generate $900 per year but it will only be occupied 50% of the time, the time rate charge is $1800 per year. This charge rate per year can then be converted to an hourly or even a per-minute rate. The estimated fraction of time that the parking is occupied over a year will need to be reconsidered at least yearly.

NEW DEFINITIONS TO PROMOTE AN OBJECTIVE VIEW OF PRICING

- The "fair price" means the price that accounts for all costs.
- The "baseline amount of driving" means the driving that results from the application of the fair price.
- "Zero transportation demand management" ("zero TDM") is the amount of demand management that results when the fair price is used. It will result in the baseline amount of driving.
- "Negative TDM" refers to the case where the price is set below the fair price. This will cause driving to exceed the baseline amount. Since TDM is commonly thought to be an action that reduces driving, it follows that negative TDM would have the opposite effect.
- "Positive TDM" refers to the case where the price is set above the fair price. This would cause the amount of driving to fall below the baseline amount.

Clearly, so-called "free parking" is an extreme case of negative TDM. The only way to further encourage driving would be to have a system that pays a driver for the time their car is parked.

GOALS OF THE "DIVIDEND ACCOUNT PARKING" CAR-PARKING SYSTEM (FORMERLY "*INTELLIGENT PARKING")*

- There is only one third-party vendor (or several, collaborating so closely that users are unaffected compared to a single operator) operating all parking. ("All parking" does not include driveways and garages in single-family homes.) *Dividend Account Parking* is designed and installed by regional or state government, using low-bid contractors, with design and start-up costs covered by the overhead portion of collection fees.

- Nearly all parking is shared. Almost always, anyone can park anywhere. Those who want exclusive rights to parking will pay "24/7" (all day, every day).

- Parking is operated so that the potential users of parking will escape the expense of parking by choosing to not use the parking. This characteristic is named "unbundled" because the cost of parking is effectively unbundled from other costs.

- Parking is priced and marketed to eliminate the need to drive around looking for parking.

- Parking at any desired price is made as easy as possible to find and use.

- Records of the use of each parking space are kept, to facilitate decisions to either add or subtract parking spaces.

- The special needs of disabled drivers, the privacy of all drivers, and, if desired, the economic interests of low-income drivers are protected.

DEFINITIONS & CONCEPTS OF *DIVIDEND ACCOUNT PARKING (DAP)*

Parking Beneficiary Groups

There are at least 7 types of beneficiary groups. Note that in all cases, members of beneficiary groups must be old enough to drive.

1.) People who have already paid for the capital cost of parking. An example of this type of beneficiary group would be the owners of condominiums, where parking has been built and the cost is included in the price of the condominium. Note that although they have technically already paid for the parking, if they borrowed money to pay for some portion of the price, the cost is built into their monthly payment. This illustrates why the value of parking and the cost of borrowing money (rate of return on money) are key input variables to use to compute the appropriate base, hourly charge for parking.

2.) People who are incurring on-going costs of parking. An example of this type of beneficiary group is a set of office workers, where the cost of ‘their” parking is contained in either the building lease or the cost of the building. Either way, the parking costs are reducing the wages that can be paid to these employees.[6]

3.) People who are purchasing or renting something where the cost of the parking is included in the price. Examples of this beneficiary group are people that rent hotel rooms, rent an apartment, buy items, or dine in establishments that have parking.

4.) People who own off-street parking as a business. They could be the individual investors or could be a government or government-formed entity.

5.) People who are said to benefit from parking, even though the money for the parking has been supplied by a source that may have very little relationship to those that are said to benefit. An example of this group would be train riders that make round trips from a station which has parking that is said to be “for riders”. Students at a school with parking would be another example.

6.) People who are considered by many to be the logical beneficiaries of on-street parking. Owners of single-family homes are the beneficiaries of the parking that is along the boundaries of their property. The same status is given to residents of multi-family housing.

7.) Governments. Since they build and maintain the streets, they should get a significant benefit from on-street parking.

Unbundled Cost and Spontaneous Sharing

“Unbundled cost” means those who use the parking can see exactly what it costs and those who don’t use the parking will either avoid its cost entirely or will get earnings to make up for the hidden parking cost they had to pay. This conforms to the usual rule of the free market where a person only pays for what they choose to use. Unbundled cost is fair.

“Spontaneous sharing” means that anyone can park anywhere at any time and for any length of time. Proper pricing makes this feasible.

How to Unbundle

The method of unbundling can be simply stated, using the concept of “beneficiary group” as discussed above. First, the fair price for the parking is charged. The resulting earnings[7] amount is

[6] Such parking is often said to be “for the benefit of the employees”. Defining this beneficiary group will tend to make this statement true, as opposed to the common situation where the employees benefit only in proportion to their use of the parking.

[7] The earnings amount is the revenue collected minus the collection cost and any other costs that will have to be paid due to the implementation of *Dividend Account Parking (DAP)*. The costs associated with the parking, paid *before*

given to the members of the beneficiary group in a manner that is fair to each member. Methods are described below.

Why this Supports Sharing

Members of a beneficiary group benefit financially when "their" parking is used. They will appreciate users increasing their earnings. They are also not obligated to park in "their" parking. If there is less-expensive parking within a reasonable distance, they might park there, to save money. This is fine, because all parking is included in the *Dividend Account Parking (DAP)* system.

Computing the Earnings for Individuals

Dividend Account Parking (DAP) must be rigorous in paying out earnings[7]. For a mixed use, the total number of parking spaces must first be allocated to the various beneficiary groups. For example in an office/housing complex, 63.5% of the parking might have been sold with the office. If so, the housing portion must be paying for the other 36.5%. For this case, it would follow that the first step is to allocate 63.5% of the earnings to the workers and 36.5% to the residents.

How the monthly earnings are divided up among the members of the beneficiary group depends on the beneficiary group type. For each member, the group's total monthly earnings amount is always multiplied by a quantity and divided by the sum (the sum is the denominator) of that quantity, for all members.

For example, for each employee, the multiplier is the number of hours that the employee worked over the month while the denominator is the total number of hours worked by all employees over the month. At a school, for each student, the numerator is the total time spent at the school, over the month, while the denominator is the sum of the same quantity, for all the students.

For a train station with parking being supplied for passengers that ride on round trips of one day or less, the numerator is the passenger's monthly hours spent on such round trips, over the month; while the denominator is the total number of hours spent by all passengers on such round trips, over the month. Radio Frequency Identification (RFID) units on passengers could support an automated calculation of monthly charges for fares, as well as monthly hours on round trips.

At a shopping center, the numerator is the sum of the money spent by the shopper, over the month, while the denominator is the total amount of money spent by all shoppers over the month.

At a condominium, the numerator is the number of parking places that were paid for (directly or indirectly) by the resident family and the denominator is the total number of parking places at the condominium project; similarly, for apartment complexes.

Where Earnings Are Low

The goal is that if someone doesn't park, they don't pay, either directly or indirectly, because the earnings that they get will balance out their losses (like reduced wages, for example). However, charging for parking that few want to use will not sufficiently compensate the people that have been forced, or are being forced, to pay for such parking. The only remedy in this case is to redevelop the parking or lease the parking in some other way, for storage, for example. The

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the implementation of *Dividend Account Parking (DAP)*, should *not* be subtracted from the revenue because they will continue to be paid as they were before the implementation of *Dividend Account Parking (DAP)*. Therefore, these costs will continue to reduce wages and increase the prices of goods and services.

earnings from the new use should go to those that are in the beneficiary group that was associated with the low-performing parking.

Why This Method of Unbundling Will Feel Familiar to Leaders

Developers will still be required to provide parking and will still pass this cost on, as has been discussed. There will be no need to force an owner of an exiting office with parking to break his single business into two separate businesses (office and parking).

Parking beneficiaries are identified that conform to traditional ideas about who should benefit from parking.[8]

Unbundling the Cost of On-Street Parking

The revenue from on-street parking in front of businesses will be split evenly between the city and the business's parking beneficiaries. All of the earnings from on-street parking in front of apartments or single-family homes will be given to the resident families.[9]

Special Considerations for Condominiums

Unbundling for a condominium owner means that, although their allocated amount of parking has added to their initial cost, their allocated amount of parking also earns money for them. Unbundling for a condominium could also mean that an owner can choose to have control over a single or several parking places. Such parking spaces could be equipped with a red light and a green light. If the red light is lit, this will mean that the space is not available for parking, except for the person who is controlling the spot. If the green light is lit, it will mean that the space is available to anyone. A space that is being reserved with a red light is charged at the full price to the condominium owner that has control over the space. The owner that controls these spaces can change the state of the parking space (available or not available) by either a phone call, on line, or at any pay station system that might be in use for the system. After condominium owners experience the cost of reserving a space for themselves, they might give up on the idea of having their own, personal, unshared parking space; especially since *Dividend Account Parking (DAP)* will give most owners and their guests all the flexibility they need in terms of parking their cars.

Some people think that condominium parking should be gated, for security reasons. However, parking within parking garages needs to be patrolled at the same frequency level as on-street parking, which is enough to ensure that crime around either type of parking is very rare. Cameras can help make parking garages that are open to the public safe from criminal activity.

Special Considerations for Renters

Unbundling for renters means that, although their allocated amount of parking increases their rent, their allocated amount of parking also earns money for them. Therefore, their traditional rent (includes parking) is effectively reduced by the money earned by those parking spaces allocated to them. Renters will be motivated to either not own a car or to park in a cheaper

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[8] Showing exactly where parking earnings go will reduce the political difficulties of adopting pay parking in a democracy where the high cost of parking is often hidden and rarely discussed.

[9] Although governments own the streets, often, back in history, developers paid for them and this cost became embedded in property values. Admittedly, how to allocate on-street parking earnings is somewhat arbitrary. With congestion pricing and efficient methods, governments may earn significantly more than they are under current practices.

location. Parking in a cheaper location is not a problem because all parking is part of the *Dividend Account Parking (DAP)* system. Renters will welcome anyone to park in "their" parking, because it will increase their earnings.

Special Considerations for Employers

At first, companies may want the option of offering "free parking" to their employees so as to be able to compete with traditional job sites. This means giving employees that drive every single day an "add-in" amount of pay so that the sum of the add-in and their parking-lot earnings equals their charge, for any given monthly statement. The operator of the parking, which sends out statements, can pay out the "add in" amount, in accordance with the company's instruction. The company will then be billed for these amounts. There could be no requirement for the company to provide any such "add-in" amount to the employees that don't drive every day. This would allow the company to treat its every-day drivers better than other employees and so this would be a negative TDM. However, this economic discrimination would be substantially less than the current, status-quo, economic discrimination, where drivers get "free" parking and non-drivers get nothing.

Clusters of Parking

Clusters are a contiguous set of parking spaces that are nearly equal in desirability and thus can be assigned the same price. They should probably consist of from 20 to 40 spaces. For off-street parking, they could be on either side of the access lane to the parking spaces, so that an observer could see the 20 to 40 cars, and get a feel for the vacancy rate. At a train station, clusters will normally be organized so that their parking spaces are approximately an equal distance from the boarding area. On-street clusters would normally conform to our current understanding of what a block is, which is to say from one cross street to the next cross street. The width of the street and the length of the block should be taken into account in defining on-street clusters of parking and in deciding if the parking on either side of the street should or should not be in the same cluster of parking spaces.

Examples of Good and Bad Technology

Parking Meters or Pay Stations

Parking meters are a relic of an earlier period, before computers. Pay stations do not add enough usefulness to merit their inclusion in *Dividend Account Parking (DAP)*, except as a bridge technology. Once good systems are set up, pay stations should cost additional money to use because of their expense. It would be best to devise an implementation strategy that will minimize their use when the system is first put into effect and will take them out of service as soon as possible.

Radio Frequency Identification Backed Up by Video-Based "Car Present" and License Recognition

Government will eventually enter into an RFID (Radio Frequency Identification) age. Organizers of large athletic events already have. Organizers that put on large open-water swims, foot races, and bike rides have routinely used RFID for many years.[10] An RFID vendor in San Diego[11]

[10] For example, over 20,000 people ran the 2008 Bay-to-Breakers foot race in San Francisco. Each runner had a "chip" in their shoe lace. Each runner's start time and finish time were recorded and all results were available as soon as the last runner crossed the finish line.

states that passive RFID units cost less than $5, are reliable, are durable, and they could be used to identify cars as well as people. He also sees no problem in implementing most of the features of *Dividend Account Parking (DAP)*.[12]

Automatic Data Collection and Sending Out Statements

Note that the "back end database" of Dr. Carta's written statement[12] refers to the ability to send statements of earnings and billing to students.[13]

Putting it Together

Certainly, government, and in particular transit agencies and parking agencies, could use RFID-based technology. For example, when a person with an RFID unit which is tied to a billable address or a credit card with an open account gets on a bus or a train, they should not have to pay at that time, visit a pay station, or "swipe a card" that has a positive balance. Utility customers that pay their bills are not required to pre-pay. The same courtesy should be extended to transit riders, people that drive on roads, people that get parking-lot earnings, and people that park cars. There should be one monthly bill or statement, for all four activities.

Global Positioning Systems GPS

An alternative model is to have GPS systems in cars that would detect the car's parking location, that location's current charge rate, and would perform all of the charging functions in the car. The only information the parking-lot-enforcement system would need is whether or not a car being parked is owned by a bill-paying owner. The car owner's responsibility would be to pay the bills indicated by the box in the car. The box would need to process a signal that a bill had been paid. It would also need to process pricing signals.

Not Picking Winners

The purpose of this report is to describe what an ideal system would do, *not* how it is done. How a proposed system works is left to the systems, software, and hardware engineers that work together to submit a proposal based on this description of what an ideal system does.

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[11]David R. Carta, PhD, CEO Telaeris Inc., 858-449-3454

[12] Concerning a Final Environmental Impact Report-approved and funded new high school in Carlsbad, California, where the School Board has signed a *Settlement Agreement* to consider "*unbundled parking*", "*cash-out*", and "*pricing*", Dr. Carta wrote, in a January 13th, 2010 written statement to the Board,

> I wanted to send a quick note discussing the technical feasibility of tracking cars into a lot without impacting students or requiring the need for gates. Mike Bullock and I have discussed this project; it can be accomplished straightforwardly by utilizing Radio Frequency Identification and/or Video Cameras integrated with automated license recognition systems. The cars would need to register with the system at the start, but it would be fairly painless for the users after the initial installation. The back end database system can also be implemented both straightforwardly and at a reasonable price.
>
> This is not necessarily a recommendation of the proposal for unbundled parking. Rather it is strictly an unbiased view of the technical feasibility of the proposal to easily and unobtrusively track cars, both registered and unregistered, into a fixed lot.

[13] In an earlier email on this subject, Dr. Carta wrote,

> This is not too tough - we probably would integrate with a service that already sends physical mail from an electronic submission instead of re-inventing this wheel.

Privacy

Privacy means that no one can see where someone has parked, without a search warrant. Also, the level of the detail of information that appears on a bill is selected by the customer.[14]

Ease of Use for Drivers

For credit-worthy drivers that have followed the rules of the system, pay parking will not require any actions other than parking. Paying for all parking fees over a month is then done in response to a monthly billing statement. Parking will feel to the consumer like a service provided by a municipality, such as water, energy, or garbage. One important difference is that users belonging to a "beneficiary group" will get an earnings amount in their monthly statement. Those that earn more than what they are charged will receive a check for the difference. This ease of use will make all parking less stressful.

Base Price

Off-Street

Off-street parking is priced so that even if demand does not threaten to fill the parking beyond 85%, the money generated will at least equate to an agreed-upon return on the parking value and pay all yearly costs. Equation 1 shows the calculation of the hourly rate.

$$r_{BaselineHourly} = \frac{(r_{Investment} \times v_{Parking}) + c_{YOPD}}{(n_{HoursPerYear} \times f_{TO})} \qquad \textbf{(Eq. 1)}$$

where:

$r_{BaselineHourly}$	=	the computed baseline hourly rate to park
$r_{Investment}$	=	yearly return on investment, such as .06
$v_{Parking}$	=	value of a parking space, such as (parking garage) $40,000
c_{YOPD}	=	yearly operations[15] plus depreciation, per space, such as $100
$n_{HoursPerYear}$	=	number of hours per year, 24 x 365 = 8760 Hours per Year
f_{TO}	=	fraction of time occupied, such as 0.55.

For the example values given, the base hourly rate of parking, to cover the cost of the investment, operations[15], and depreciation is $0.519 per hour. This could be rounded up to $0.52 per hour. This price could also be increased to result in positive TDM, to reduce driving more than the fair-price, zero-TDM amount.

On-Street

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[14] License plates that have no RFID tags fail to use the best technology to accomplish the primary purpose of license plates, which is to identify and help intercept cars used in a crime. Identifying cars is a legitimate government goal. Protecting privacy is also a legitimate goal. Both goals can be realized with good laws, good enforcement, and good systems engineering.

[15] This includes money for policing, cleaning, maintenance, any applicable parking tax, and all collection costs. Collection costs will need to include an amount to recover the development and installation costs of *Dividend Account Parking (DAP)*.

If on-street parking is located within walking distance (one-quarter mile) of off-street parking, its base price is set equal to the closest off-street parking's base price. Otherwise, it is set to some agreed-upon value, like fifty cents per hour. However, on-street parking has a special meaning for downtown merchants and for neighborhoods, two powerful political forces in any city. Merchants that have few cars parking on their street, even though it is permitted, are probably failing in their businesses. They would like free parking to help draw visitors to their store front. Neighborhoods that are not impacted by parking would probably prefer no pricing. For these reasons, for any on-street parking cluster, no price is charged until the cluster occupancy reaches 50%. (Time of day is irrelevant.)

Congestion Pricing

The time-rate price of parking is dynamically set on each cluster of parking, to prevent the occupancy rate from exceeding 85% (to reduce the need to drive around looking for parking). An 85% occupancy rate (15% vacancy) results in just over one vacant parking space per city block[5]. If the vacancy rate is above 30%, the price is left at the baseline hourly rate. If vacancies fall below 30%, the price can be calculated in a stair-step method, such as shown in Table 2.

Equation 2 is an alternative method.

In either case, the total charge is time parked, multiplied by the time-averaged, time-rate price. The base multiplier would be adjusted to be just large enough to keep the vacancy rate from falling below a desired level, such as 15%, so it is always easy to find parking.

Table 2 Hourly Rates for 2 Base Multipliers and a Baseline Hourly Rate of $0.52

Vacancy Rate	Base Multiplier = 2			Base Multiplier = 2.5		
	Multiplication		Hourly Rate	Multiplication		Hourly Rate
	Formula	Value		Formula	Value	
Above 30%	2^0	1	$0.52	2.5^0	1	$0.52
25% to 30%	2^1	2	$1.04	2.5^1	2.5	$1.30
20% to 25%	2^2	4	$2.08	2.5^2	6.25	$3.25
15% to 20%	2^3	8	$4.16	2.5^3	15.625	$8.13
10% to 15%	2^4	16	$8.32	2.5^4	39.0625	$20.31
5% to 10%	2^5	32	$16.64	2.5^5	97.6563	$50.78
Below 5%	2^6	64	$33.28	2.5^6	244.1406	$126.95

$$r_{HourlyRate} = r_{BaselineHourly} \times \left(B^{(30-V)/5}\right), for\ V < 30;\ r_{BaslineHourly}, otherwise \quad \textbf{(Eq. 2)}$$

where:

$r_{HourlyRate}$ = the congestion-priced hourly rate to park

$r_{BaselineHourly}$ = the baseline hourly rate to park, such as $0.52 per hour (taken from from Eq. 1.

B = the base of the multiplier being computed, such as 2.50

V = the vacancy rate percent, such as 17.5, for 7 vacancies in a cluster of 40 spaces, 100*(7/40) = 17.5

For the example values given, the hourly rate of parking would be $9.88 per hour.

Pricing Predictions and Notifications

Drivers will develop strategies for their routine trips. The computer system that keeps records of parking use will also provide help for users. The *Dividend Account Parking (DAP)* website will direct a user to an appropriate cluster of parking if the user provides the destination location or locations, the time and date, and the hourly rate they wish to pay. If the walk is going to be long, the website could suggest using transit to get from the cheaply-priced parking to the destination. In such cases, the website may also suggest using transit for the entire trip.

Another user option is to specify the time, location, and the distance the user is willing to walk. In this case, the computer would give the cheapest cluster of parking available at the specified walk distance. The price prediction would be provided.

All price predictions would also have a probability of correctness associated with them. If a user can show that a computer has predicted a much lower price than what actually occurred, with a sufficiently high probability, it would be reasonable to charge the user the predicted price rather than the actual price.

Websites could routinely inform viewers when occupancy rates are expected to be unusually high, due to a special event (for example, a sporting event). The parking system website will always give current and predicted hourly rates for all locations. The hourly rates of parking will also be available at a phone number and possibly at pay stations. The base-price hourly rate, for any parking cluster, would be stable and could therefore be shown on signs. Parking garage entrances could have large video screens showing both predicted and existing price. Users will also learn to look at parking and judge whether congestion pricing applies, or could apply, while their car is parked. It would not be long before these capabilities are added into GPS navigation systems.

Prepaid RFID

To be inclusive, pay stations or convenience stores will offer a pre-paid RFID that can be set on the dashboard of a car. This will support drivers with poor credit or drivers who have not obtained the necessary equipment to support the normal, trouble-free methods. This will also work for drivers that do not trust the system to protect their privacy for a certain trip (by removing or disabling the permanent RFID) or for all trips. No billing would occur.

Enforcement

The system would notify the appropriate law enforcement agency if an unauthorized car was parked. Authorized cars would need either a pre-paid RFID or equipment indicating that their owners had *Dividend Account Parking (DAP)* accounts and were sufficiently paid up on their bills.

IMPLEMENTATION

This description of *Dividend Account Parking (DAP)* will help to implement efficient parking systems. Parking at train stations, schools, and government buildings could introduce many of these concepts. This description of *Dividend Account Parking (DAP)* is sufficient to support a “Request for Proposal” process, which could lead to full implementation. Widespread installation should be done by a government agency, to minimize actions required on the part of the private sector. Laws would simply require the cooperation of all private-sector and government entities.

SUMMARY

A parking plan, *Dividend Account Parking (DAP)* has been described.

1. Technology will make it easy to use for most drivers.
2. Its parking is almost always shared, to support mixed uses.
3. It unbundles cost by charging and having earnings go to the parking beneficiaries.
4. Traditional groups, such as single-family home owners, employees, tenants, train riders, and students benefit from parking. The benefit is equal for drivers and non-drivers.
5. Baseline prices are computed primarily from the value of the parking and an agreed-upon rate of return. On-street parking is free until it is half full, at which time its base price often matches that of the closest off-street parking.
6. For all parking, price is dynamically increased to guarantee availability. Earnings are therefore only limited by what people are willing to pay.
7. Technology helps drivers find parking and decide if they want to drive or use transit.
8. Prepaid RFIDs provide service to those who have poor credit or don’t want to be billed.
9. Disabled and perhaps low-income drivers will have accounts that allow them to park at reduced prices and perhaps avoid congestion pricing. Specially designated spots might also be required for disabled drivers.
10. The system will provide reports showing where additional parking would be a good investment and where it would be wise to convert existing parking to some other use.
11. Privacy will be protected. Law enforcement officials would need a search warrant to see where someone’s car has been parked. The level of detail on billing would be selected by the car’s owner.
12. Implementations could begin in carefully selected locations and expand.

Global warming, air pollution, trade deficits, and fairness are some of the significant reasons that governments have a responsibility to implement *Dividend Account Parking (DAP)*.

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KEYWORDS

A&WMA, Parking, Unbundled, Shared, TDM, cash-out, pricing, beneficiary, greenhouse gas, GHG, GPS, RFID

Eliminating the Harm **of Bundled-Cost or Bundled-Benefit Parking**

- **Definitions of Parking Systems**
- **New System: *Dividend-Account Parking***
    - **Motivations for change**
    - **Definition and features**
    - **A demonstration project**

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A ***Bundled-Cost*** Parking System

The most common of all parking systems. Erroneously called "free"

The cost of the parking is hidden within some other payment, such as:

- **Rent**
- **Train fare (at least 1 train station with so-called "free" parking)**
- **Price of consumer items, including food**

A Bundled-Benefit Parking System

The 2nd most common of all parking systems. Erroneously called “free”

The parking is part of a benefit package being provided, such as:

- Compensation for work
- Public or private education

Bundled-Cost **and** ***Bundled-Benefit*** **systems take** ***money*** **from people without their knowledge or consent.**

They increase the choice to drive alone.

Sierra Club California: Appropriate pricing of parking is the least costly way to reduce vehicle miles travelled.

Bundled-Cost or *Bundled-Benefit* systems should be replaced with the *DAP* Car-Parking system!

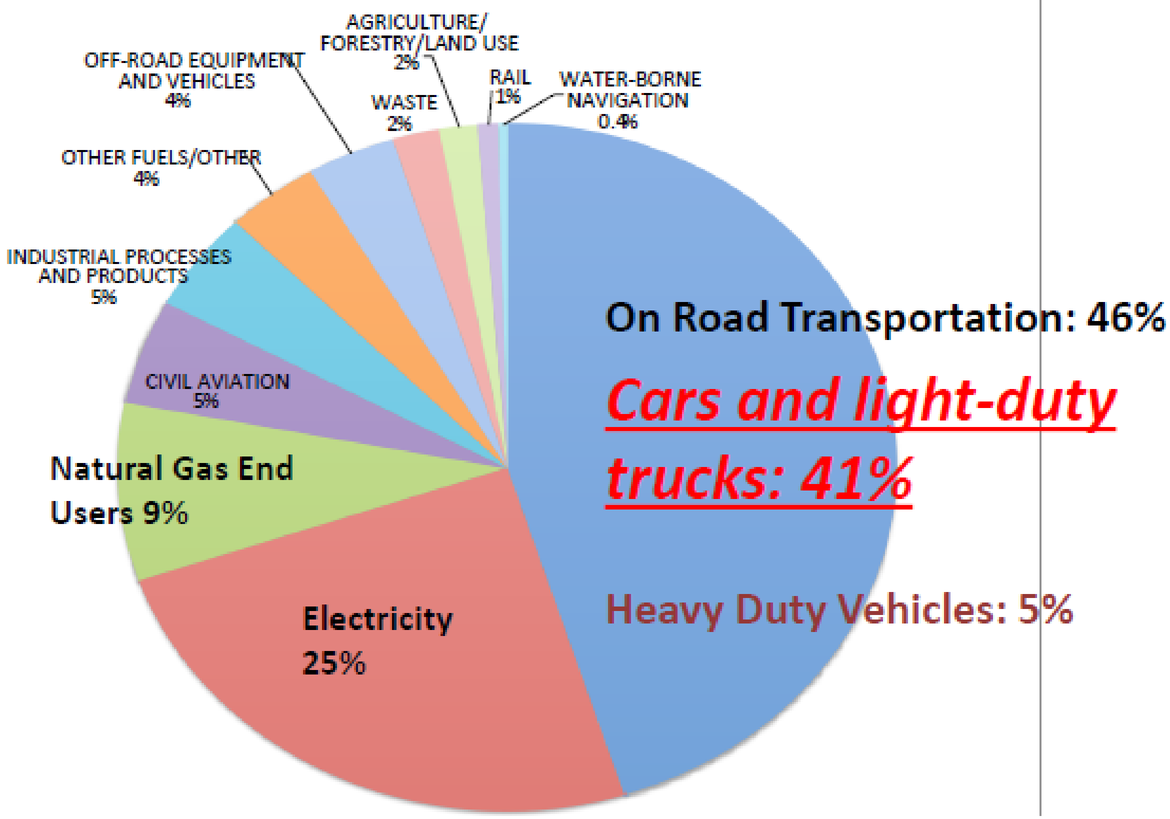
Dividend Account Parking (DAP)

Brief System Definition

1. Automated (nothing to do; just park)
2. Value-priced, with a congestion-pricing option
3. It generates earnings for those who are losing money because of the parking
4. Cars parked are associated with an Account
5. Parking is available to those having an Account (shared parking)

Motivation for Change, 1 of 4

Cars and Light-duty vehicles (LDVs) emit the most GHG of any category



Motivation for Change, 2 of 4

- ***Fleet Efficiency Will Not Come Soon Enough*, as shown in this peer-reviewed report:**

2020 Air & Waste Management Association (AWMA) Report

Deriving Climate-Stabilizing Solution Sets of Fleet-Efficiency and Driving-Level Requirements, for California Light-Duty Vehicles*

***Available upon request from mike_bullock@earthlink.net**

Motivation for Change, 3 of 4

Climate-Stabilizing Requirements, for Four Cases

Difficult but possible

	Case Designations			
	Balanced_1	Balanced_2	2005 Driving	Mary Nichols
% Renewable Elecricity	85.0%	90.0%	90.0%	90.00%
% ZEVs, Year 2016	2.0%	2.0%	2.0%	2.70%
% ZEVs, Year 2017	2.0%	2.0%	2.0%	2.70%
% ZEVs, Year 2018	3.0%	3.0%	3.0%	5.11%
% ZEVs, Year 2019	4.0%	4.0%	4.0%	7.53%
% ZEVs, Year 2020	8.0%	8.0%	8.0%	9.94%
% ZEVs, Year 2021	**20.0%**	15.0%	**82.0%**	12.35%
% ZEVs, Year 2022	**35.0%**	25.0%	**97.0%**	14.76%
% ZEVs, Year 2023	**55.0%**	**45.0%**	99.0%	17.18%
% ZEVs, Year 2024	**80.0%**	**70.0%**	99.0%	19.59%
% ZEVs, Year 2025	94.0%	95.0%	99.0%	22.00%
% ZEVs, Year 2026	97.0%	97.0%	99.0%	37.60%
% ZEVs, Year 2027	98.0%	98.0%	99.0%	53.20%
% ZEVs, Year 2028	99.0%	99.0%	99.0%	68.80%
% ZEVs, Year 2029	99.0%	99.0%	99.0%	84.40%
% ZEVs, Year 2030	99.0%	99.0%	99.0%	100.00%
% Reduction in Per-Capita Driving With Respect to Year 2005	**32.0%**	**32.0%**	0.0%	**50.5%**

Driving as much as we did in 2005 might seem nice, but these % ZEV jumps are not possible

Air Resources Board Mary Nichols has a nice electrification schedule but it would require a <u>very difficult reduction in driving.</u>

Motivation for Change, 4 of 4

Requirements to Achieve the Needed 32% Reduction in Per-Capita Driving, With Respect to 2005

Driving-Reduction Requirments	Per-Cent Reduction	Factor
Legislated (SB 375) Plans to Reduce Driving	12%	0.88
Value-Priced Road Use Charge (RUC)	10%	0.90
Dividend Account Parking	**8%**	**0.92**
Transfer Highway Expansion Funds to Transit	2%	0.98
Increase Height & Density by Transit Stations	2%	0.98
"Complete Streets", "Road Diet" (walk/bike)	1%	0.99
Pay-to-Graduate Bicycle Traffic-Skills Class	1%	0.99
Bicycle Projects to Improve Access	1%	0.99
	Product of Factors	**0.68**
	% Reduction	**32%**

A *Dividend-Account Parking System* for Oceanside's Civic Center Garage

A System to Eliminate the Harm of Bundled-Benefit Car Parking for City Employees

300 North Coast Highway

- **Top-Level Outcome & Overview**
- **Some Top-Level Calculations**
- **Who gets to use the system**
- **Overcoming problems & perceptions**
- **Outcomes of a new incentive**
- **Cash flow ("Hey, where does the $$ come from?")**

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Top-Level Outcomes

- Employees that drive every day, break even **(Lose no money!)**
- Employees get *paid to not drive* **(Make more money!)**
- Fewer employees drive, reducing Greenhouse Gas (GHG) emissions **(Less GHG!)**

Overview

- Fully-automated parking system, implemented by a 3rd-party vendor (RFP selection process)
- operated for the financial gain of employees
  - Earnings = Money Generated Minus Vendor Earnings
  - Earnings go to employees
- Price is cost per minute
  - Such as 1.85 cents per minute (= $1.11 per hour= $10 per 9 hours at the workplace)
- An employee's **Earnings** ("**Dividend**") is proportional to their time at the work site

Calculations of an Employee's Earnings

- An employee's earning is proportional to time spent at work (automatic collection of enter/exit times, using employee RFID)

Definitions to Compute an Employee's Monthly Earnings	
$T_{Employee}$	The Employee's Monthly Time at the Work Site
$T_{AllEmployees}$	Total Monthly Time at the Work Site, All Employees
$E_{AllEmployees}$	Total Monthly Earnings from the Employee Parking

$$\text{Employee Earnings} = E_{AllEmployees} \times (T_{Employee} / T_{AllEmployees})$$

“Add In” Payment so Those that Drive Every Day Will Lose No Money

Note: This is for an individual employee

The employee’s Parking Payment =

The employee’s Earnings – The employee’s parking charge + The employee’s “Add In”

“Add In” is zero, unless it must take on a positive value so that the employee loses nothing

“Add In” payments will be easily covered by Dividend Account Parking parkers that are not employees.

Charge, Earnings, & Add-In, Payment *For Each Employee*

- **Charge**
  - Total Minutes Parked x Cost per Minute
- **Earnings**
  - As shown on earlier slide (proportional to employee's time spent at work)
- **Add-In**
  - If **Charge** > **Earnings**, **Add-In** = **Charge** – **Earnings**
  - **Otherwise, Add-In = zero**
- **Payment** = **Earnings** – **Charge** + **Add-In**

Who Gets To Use Dividend-Account Parking

- ***<u>Anyone</u>*** (not necessarily an employee) driving a car registered in the system
  - There is a person with an account associated with the car
  - The car will be identified
    - License plate reader and/or
    - RFID tag not needed
  - Account can be established on the spot, in less than 5 minutes: credit card info and license number

Employee Behavior 1 of 2

Employees Must Park in Their Parking Lot if they Drive to Work

Measures to Reduce "Cheating" = Parking in the Neighborhood

Not stated in presentation to stay within 15 minutes

Russ was worried!

- Soft, pre-emptive measure: messaging
  - **Perceived integrity** is every employee's responsibility
  - **Insufficient perceived integrity** can cost employees
    - Reduced chance of promotion
    - Smaller pay raises
    - More chance of terminated employment
  - Parking free in the neighborhood will not be tolerated
  - The City wants to be a good neighbor: this is the reason for off-street parking ordinances

Employee Behavior 2 of 2

Employees Must Park in Their Parking Lot if they Drive to Work

Measures to Reduce "Cheating" = Parking in the Neighborhood

Not stated in presentation, to stay within 15 minutes

- Soft, pre-operational measure: data collection
  - Operate the system for a time, perhaps even a year, before actually collecting or distributing money
  - Self-identified non-drivers are recognized, thanked, and asked to provide details as to how they are getting to work without driving
- Soft, In-Operation Mode: New non-drivers are thanked and interrogated as to how they do it
- **Hard: cameras or RFID sensors can identify employees walking into the work perimeter from the neighborhoods**

Russ was worried!

Difficult-to-Not-Drive Example

Fictional, Simplified Case with Pricing and Payout Considered per Day, *Page 1*

- Employment Center (factory and office)
- Outside Hemet, California
- 100 employees; parking lot has 100 spaces
- No Transit, 110-degree temperature with poor roads for biking, culture of not car-pooling
- Before installing
  - 99 drive
  - 1 bikes

Difficult-to-Not-Drive Example

Fictional, Simplified Case with Pricing and Payout Considered per Day, *Page 2*

- Dividend-Account Parking charges $10/day
- After installing
  - 99 drive
  - 1 bikes
- Total collected each day: $990
- Each employee gets $9.90 earnings per day ($990/100)
- Each driver loses 10 cents per day
- The "crazy" bike rider gets $9.90 per day extra

Hey, isn't this an improvement? I would say the "crazy" bike rider is earning his money!

If another employee bikes, the drivers would lose 20 cents per day and the bike riders would get $9.80 per day. If the company president rented out the 2 extra spaces for $10 per day, the drivers would lose nothing and the bike riders would get $10 per day. Biking would increase by 100%! **What's wrong with that?**

Results of 3 Actions, Including Cash-out

Case (#1), Reference Patrick Siegman's article in Bicycle Pedestrian Federation

- Company: CH2M Hill
  - Location: Bellevue, WA (Seattle suburb)
  - Engineering Firm with 430 employees
- Actions
  - $54/month (1995 $'s), *to not drive*
  - Improved Transit
  - Improved Bike/Ped facilities

CH2M Hill Work Trips

Mode	*Before*	*After*
Drive Alone	**89%**	**54%**
Carpool	**9%**	**12%**
Bus	**1%**	**17%**
Bike, Walk	**1%**	**17%**
	100%	*100%*

Since these changes are brought about by more than just cashout, this case is not used in the tabulation of cashout results (next chart)

Cash-Out Results

(11 Locations, 3 Groups, 1995 Dollars)

Money Matters !!!!!

- Reference: *How to Get Paid to Bike to Work: A Guide to Low-traffic, High- Profit Development* by Patrick Siegman*. Published in *Bicycle Pedestrian Federation of America*, 1995.
- 3 Largest Responses
  - 38%, 36%, 31%
- 3 Smallest Responses
  - **15%** , 18%, 24%
- Responses are the *change;* car vacancy rates would be larger

*Patrick Siegman, of Nelson Nygaard

Impact of Financial Incentives on Parking Demand			
Location	**Scope**	**1995 dollars per mo.**	**Parking Use Decrease[1]**
Group A: Areas with little or no public transportation			
CenturyCityDistrict, West Los Angeles	3500 employees at 100+ firms	$81	15%
Cornell University, Ithaca, NY	9000 faculty & staff	$34	26%
San Fernando Valley, Los Angeles	1 employer, 850 employees	$37	30%
Costa Mesa, CA		$37	22%
Average for Group		**$47**	**23%**
Group B: Areas with fair public transportation			
Los Angeles Civic Center	10000+ employees, several firms	$125	36%
Mid-Wilshire Blvd., Los Angleles	1 mid-size firm	$89	38%
Washington DC Suburbs	5500 employees at 3 worksites	$68	26%
Downtown Los Angeles	5000 employees, 118 firms	$126	25%
Average for Group		**$102**	**31%**
Group C: Areas with good public transportation			
University of Washington, Seattle Wa.	50,000 faculty, staff & students	$18	24%
Downtown Ottowa, Canada	3500+ government staff	$72	18%
Bellevue, WA	1 firm with 430 employees	$54	39%[2]
Average for Group, but not Bellevue Washington		**$45**	**21%**
Over All Average, Excluding Bellevue Washington			**25%**

[1] **Parking vacancy would be higher!** [2] **Not used, since transit & walk/bike facilities also improved.**

Dividend-Account Parking, Oceanside

Civic Center Parking Garage

Money Flow Calculations

Simplifying Assumptions:

1. Workers work 8 hours, with a one-hour lunch, for 9 total hours at the work location, each day they work
2. They only work from 8 AM to 5 PM
3. Evening hours, when parking can earn money from the public, are (only) from 5 PM to 9 PM
4. Week-end workers also work on weekdays, for a total of 7*9 = 63 hours, at the work location, per week

Dividend-Account Parking

Money Flow Calculations

Notation Conventions	
Letters	**Meaning**
N	Number
DAP	Dividend Account Parking
VP	Value Priced
WE	Week End
WD	Week Day
WH	Work Hours, Meaning 8 AM to 5 PM
AH	After Hours, Meaning 5 PM to 9 PM

Dividend-Account Parking

Money Flow Calculations

Assume This is the "Value-Price" of the Parking

Use $10 per 9 Hours at the Work Site

Value	Units
1.8519	Cents per Minute
1.11	Dollars per Hour

Dividend-Account Parking

Money Flow Calculations

Assumed Values Used in the Following Performance Assesment		
Description	**Name**	**Value**
Number of parking places	N_DAP	250
Number or employees	N_Emp	250
% employees that drive on week day & week end	%Drive	80
Value-price to park, per 9 hours day (8 hours work + lunch)	VP_9Hrs	$ 10.00
% employees that work on Sat. and on Sun.	%WE	20
Yearly bonus paid to all workers	Y_Bonus	$100.00
Non-Workers Use This Per-Cent of the Parking That Is Not Used by Workers		
Week Day, Work Hours	%NonWrkWDWH	50
Week Day, After Hours (5 to 9)	%NonWrkWDAH	30
Week End, Work Hours	%NonWrkWEWH	50
Week End, After Hours (5 to 9)	%NonWrkWEAH	30

Dividend-Account Parking

Money Flow Calculations

Calculations to get the Weekly Earnings From Employees & the Weekly "AddIns" Required, per Employee			
Description	**Formula**	**Name**	**Value**
Number of Employees That Drive on a Week Day	N_Emp * %Drive / 100	**N_DrWD**	200
Money From Employees on a Week Day	VP_9Hrs * N_DrWD	**$_AllE_WD**	$ 2,000
Number of Employees That Work on a Week End	N_Emp * %WE / 100	**N_WrkWE**	50
Number of Employees Driving on a Week-End Day	N_WrkWE * %Drive / 100	**N_DrWE**	40
Money From All Employees Each Week-End Day	VP_9Hrs * N_DrWE	**$_AllWE**	$ 400
Weekly Money From Employees From Both the Week End & the Week Days	5 * $AllE_WD + 2 * $_AllWE	**$_AllE**	$ 10,800
Total Hours at This Location Per Week	N_Emp * 9 * 5 + N_Emp * %WE / 100 * 9 * 2	**HrsPerWeek**	12150
Weekly Earnings for an Employee at the Location for 45 Hours	$_AllE * 45 / HrsPerWeek	**PerWeek45**	$ 40.00
AddIn for an Employee at the Location for 45 Hours per Week	5 * VP_9Hrs - PerWeek45	**AddIn45**	$ 10.00
Weekly earnings for an employee at the location for 63 hours	$_AllE * 63 / HrsPerWeek	**PerWeek63**	$ 56.00
Per Week AddIn for an Employee at the location for 63 Hours per week	7 * VP_9Hrs - PerWeek63	**AddIn63**	$ 14.00

Dividend-Account Parking

Money Flow Calculations

Calculation of the Weekly Amount Generated by Spaces Not Used by Workers, Week Day Work Hours (8 to 5)			
Description	**Formula**	**Name**	**Value**
Spaces Available for Non-Workers, Work Day, Work Hours	N_DAP - N_DrWD	**S_4NW_WDWH**	50
Spaces Used by Non-Workers, Work Day Work Hours	S_4NW_WDWH * %NonWrkWDWH / 100	**SNW_WDWH**	25
Money from Spaces Used by Non-Workers Per Day	SNW_WDWH * VP_9Hrs	**$NW_WDWH**	$ 250
Money from Spaces Used by Non-Workers Per Week	5 * $NW_WDWH	**W$NW_WDWH**	$ 1,250

Dividend-Account Parking

Money Flow Calculations

Calculation of the Weekly Amount Generated by Spaces Not Used by Workers, Week Day After Hours (5 to 9)			
Spaces Available for Non-Workers, Work Day, 5 to 9, AKA After Hours	N_DAP	**S_4NW_WDAH**	250
Spaces Used by Non-Workers, Week Day After Hours	S_4NW_WDAH * %NonWrkWDAH / 100	**SNW_WDAH**	75
Money From Spaces Not Used by Workers, Week Day After Hours	(4/9) * VP_9Hrs * SNW_WDAH	**$NW_WDAH**	$ 333
Money per Week from Spaces Not Used by Workers, Week Day After Hours	5 * $NW_WDAH	**W$NW_WDAH**	$ 1,667

Dividend-Account Parking

Money Flow Calculations

Calculation of the Weekly Amount Generated by Spaces Not Used by Workers, Week End Work Hours (8 to 5)			
Spaces Available for Non-Workers, Week End Work Hours	N_DAP - N_DrWE	**S_4NW_WEWH**	210
Spaces Used by Non-Workers, Week End Work Hours	S_4NW_WEWH * %NonWrkWEWH / 100	**SNW_WEWH**	105
Money From Spaces Used by Non-workers Per Week-End Day, Work Hours	SNW_WEWH * VP_9Hrs	**$NW_WEWH**	$ 1,050
Money From Spaces Used by Non-workers On the Week End After Hours, Per Week	2* $NW_WEWH	**W$NW_WEWH**	$ 2,100

Dividend-Account Parking

Money Flow Calculations

Calculation of the Weekly Amount Generated by Spaces Not Used by Workers, Week End After Hours (5 to 9)			
Spaces Available for Non-Workers, Week End After Hours	N_DAP	**S_4NW_WDAH**	250
Spaces Used by Non-Workers, Week End After Hours	S_4NW_WDAH*%NonWrk WDAH/100	**SNW_WDAH**	75
Money From Spaces Used by Non-workers Per Week-End Day After Hours	4/9 * SNW_WDAH * VP_9Hrs	**$NW_WDAH**	$ 333
Money From Spaces Used by Non-workers on Week-End Days After Hours, Per Week	2 * $NW_WDAH	**W$NW_WDAH**	$ 667

Dividend-Account Parking

Money Flow Calculations

The Weekly Earnings From Non-Employees, the Weekly "AddIns" Required, the Weekly Surplus Generated, the Yearly Surplus, and the Yearly Surplus After Giving Employees a $100 Per Year Bonus			
Description	**Formula**	**Name**	**Value**
Weekly Money Earned by the spaces not taken by workers	W$NW_WDWH + W$NW_WDAH + W$NW_WEWH + W$NW_WEAH	**W$NW**	$ 5,683
Weekly Money Required to Pay All of the AddIn Amounts	N_DrWD * AddIn45 + N_DrWE * AddIn63	**AddInPerWeek**	$ 2,560
Weekly Money Left Over After Paying Add Ins	W$NW - AddInPerWeek	**$PerWeek**	$ 3,123
Yearly Money After Paying Add Ins From the Money From Non-Workers	52 * $PerWeek	**$PerYear**	**$ 162,413**
Yearly Money After Paying Add Ins and Also a $100 Bonus Per Year for Each Employee	$PerYear - $100 * N_Emp	**$PerYear**	**$ 137,413**

Dividend-Account Parking

Money Flow Calculations

3 Cases of Dividend-Account Parking Performance Oceanside Civic Center Garage			
	Baseline	**Worse**	**Better**
% employees that drive on week day & week end	80%	85%	75%
% employees that work on Sat. and on Sun.	20%	25%	15%
% Parking Not Used by Workers, That is Used by Non-Workers			
Week Day, Work Hours	50%	45%	55%
Week Day, After Hours (5 to 9)	30%	25%	35%
Week End, Work Hours	50%	45%	55%
Week End, After Hours (5 to 9)	30%	25%	35%
Yearly Amount Left Over After Paying Add-Ins	**$162,413**	**$125,242**	**$210,374**
Amount Left After Paying Add-Ins & $100 Bonus	**$137,413**	**$100,242**	**$185,374**

Conclusion 1

Given our climate emergency, we need this parking system to spread to all parking, to include offices, on-street, apartments, "big box", shopping centers, and mixed use.

Conclusion 2

Society needs a corporation to specialize in managing and optimizing parking

Skills Needed Include:

1. Data collection, computing, marketing, archiving, transferring money, protecting privacy, and generating financial statements
2. Monetizing unused parking and data
3. **Financing and building solar canopies, roof top solar, and charging stations**
4. **Selling electricity**

Conclusion 3

This could be an enforceable mitigation measure in a city's Climate Action Plan, to reduce driving, perhaps in its Transportation Demand Management (TDM) Section.

Back up Slides

Conclusion & Path Forward

- A big part of the needed 32% reduction needs to come from car-parking reform.
- The first step could be a demonstration project of a car-parking system, at a work location.

From the California Democratic Party (CDP) 2018 Platform

From: https://www.cadem.org/our-party/standing-committees/body/CDP-Platform-2018.pdf

Transportation Sub-Plank Statement

- Work for **shared**, convenient, and **value-priced** parking, operated with a system that **provides financial support** to those paying higher costs or getting a reduced wage, due to the cost of providing the parking ***Note: this is DAP!***

1500-Character Extended Abstract

The presentation starts with the definition of two commonly-used, car-parking systems: the bundled-price system and the bundled-cost system. The flaws of these systems are exposed. The Dividend Account Parking (DAP) parking system is introduced; with the motivation for its implementation: the importance of cars in reducing GHG and how DAP fits into a plan to ensure that cars support climate-stabilization.

The rest of the slides present a specific DAP proposal, in downtown Oceanside, CA, for city employees. Outcomes, an overview, and a definition of DAP are given. Charge & payout formulations are specified. Methods to prevent cheating are described. A brief, simplified example of a DAP implementation is shown, where it would be difficult to not drive to work, showing DAP to still be a good choice. Results from cases of car parking cash-out (where employees are paid to get to work without driving) are given, showing that if a price differential (between driving and not driving to work) is introduced (DAP does this), driving alone to work is significantly reduced.

Money cash flow calculations are presented, using reasonable simplifying assumptions and then reasonably-conservative assumptions of how much money could be earned from employee parking, whenever it is not being used by an employee. The results from three cases ("Baseline", "Worse", and "Better") are shown.

Twenty six back up slides appear, but they are NOT part of the presentation.

Measures to Get 32%

Estimated Reduction

- Predictions, Regional Transportation Plans **10%**
- Stop expanding most roads and all freeways **2%**
  - No need, Eliminate congestion with less driving
- Reallocate freeway-expansion $$$ to **transit** **2%**
- **Payment methods**, **to increase fairness & choice**
  - Demonstration projects: Dividend-Account Parking
  - **Legislation**
    - Replace Bundled-Cost or Bundled-Benefit Parking **8%**
    - Equitable and environmentally-sound road-use fees **8%**
- **Smarter growth**, complete streets, bike classes **2%**

32%

Climate Literacy

THEREFORE BE IT RESOLVED, that the California Democratic Party reinforces the need for all high school students to know, before they graduate, and elected officials to know, acknowledge, and address, as soon as possible, (1) both the existence of and the reason for anthropogenic climate change; (2) its potential for harm; (3) the difference between stabilizing the climate at a livable level and destabilization; (4) science-based, climate-stabilizing, GHG reduction targets; (5) the primary variables and considerations in identifying those targets and (6) the approximate amount of life style and technology change required to achieve those climate-stabilizing targets.

XXX Implementation Example

The City could have the vendor operate the system, for the first 10 years. Over those years, the vendor would be motived to debug the system and continue to look for operational efficiencies. The vendor could receive 10% of the revenue, for the first 5 years; 5% of the revenue, for the next 3 years; and 2%, for the final 2 years. If 600 cars are parked for 8 hours, 200 days per year, at 50 cents per hour, then the yearly revenue would be $480,000. The vendor would collect $240,000 over the first 5 years, $72,000 over the next 3 years, and $28,800 over the last two years.

How Bad Could It Get?

Governor Brown to the Pope:

Humanity must

Reverse Course*	**or**	***Face Extinction***

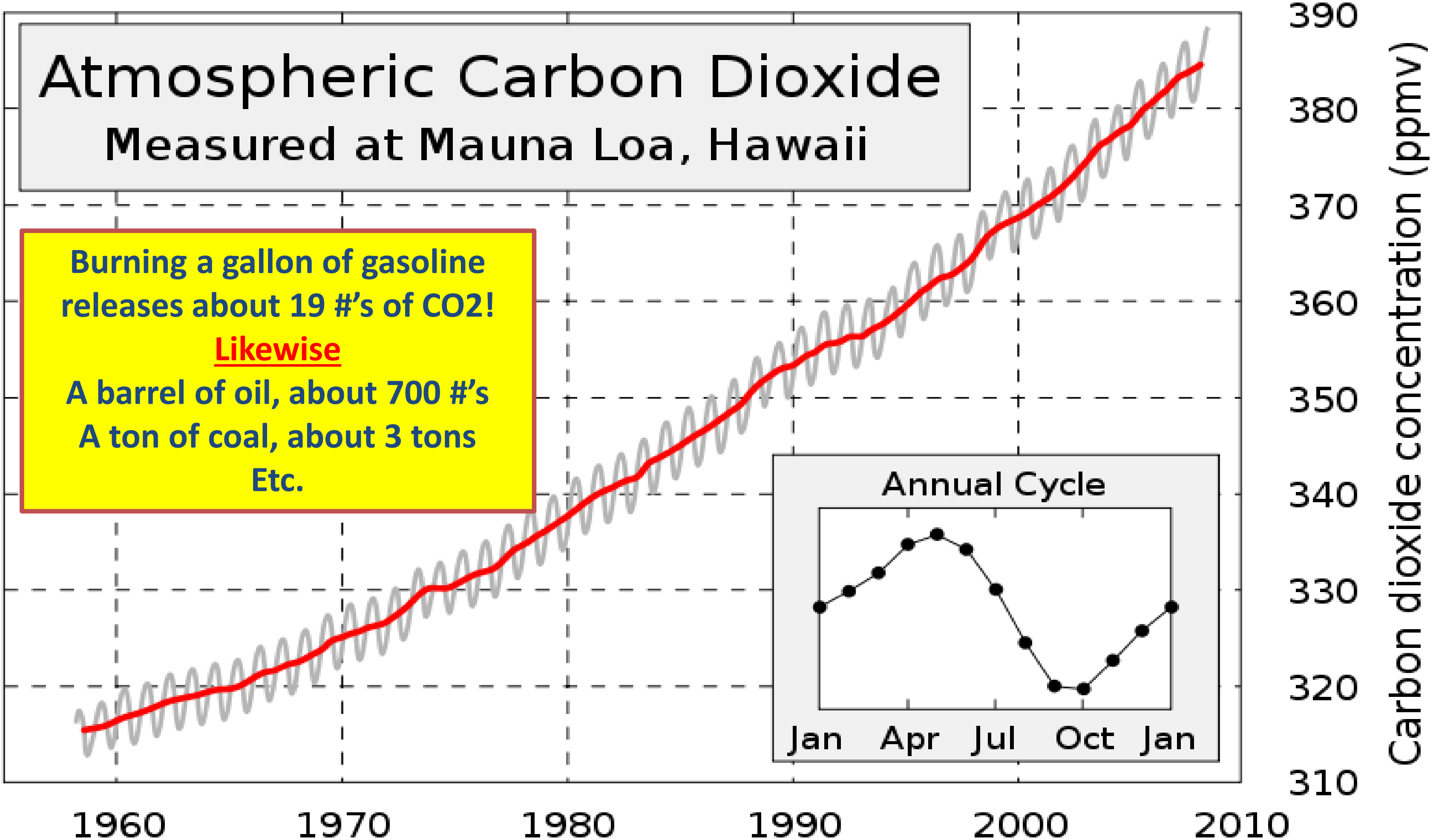
*** *Must be quantified***

Climate Data

- Keeling Curve:

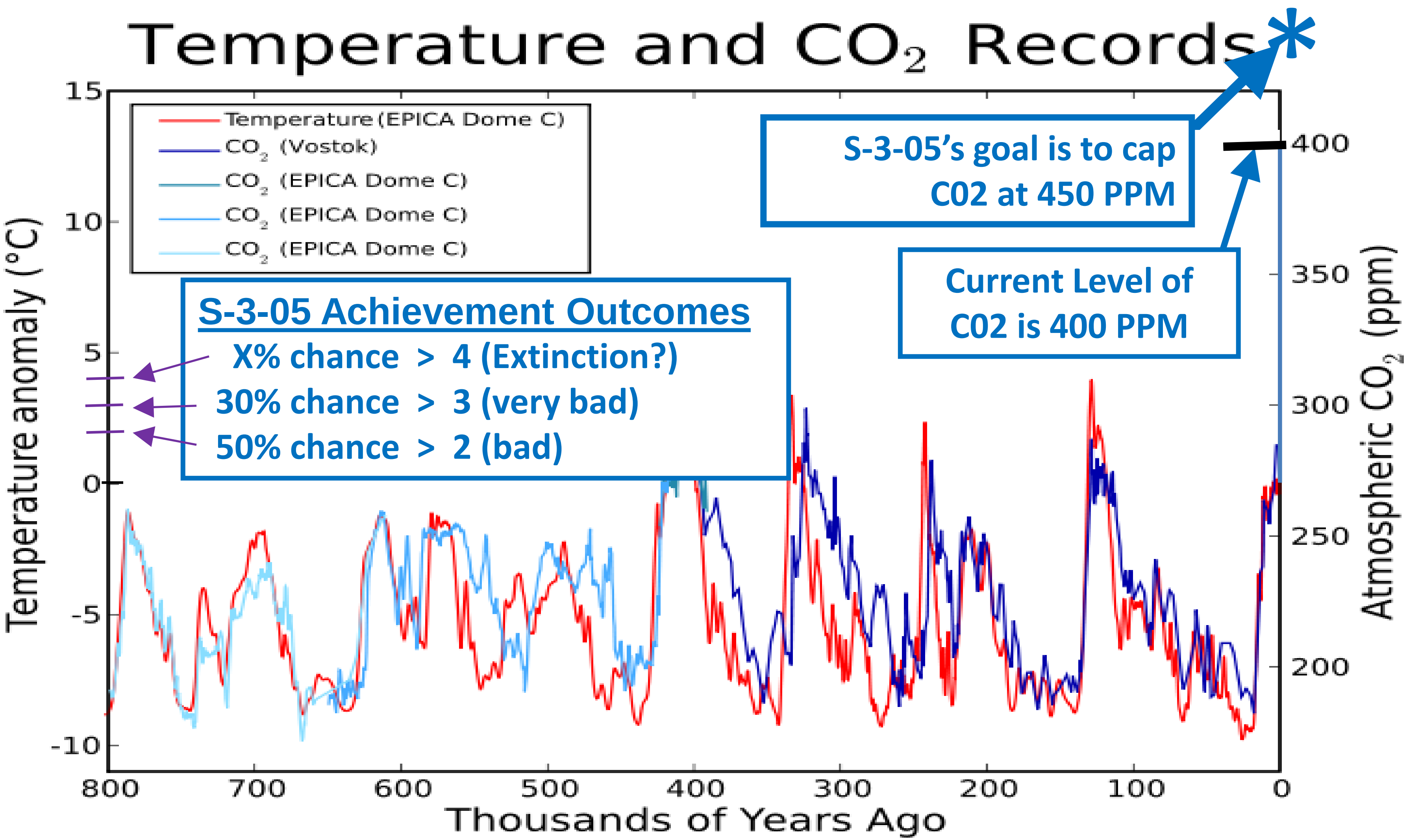
  http://en.wikipedia.org/wiki/An_Inconvenient_Truth#Scientific_basis

Currently 400 PPM! *



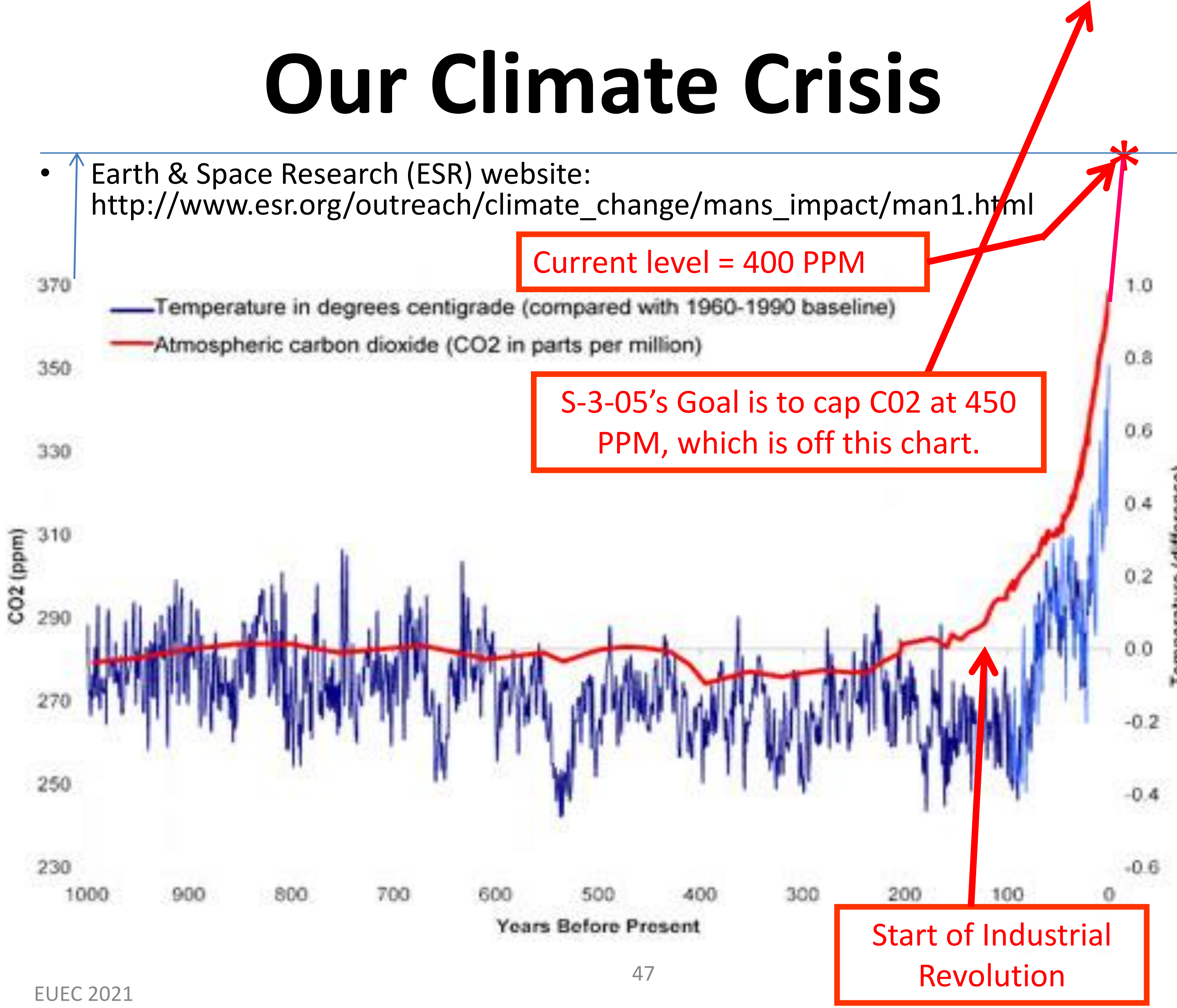
Our Climate Crisis

- From: http://en.wikipedia.org/wiki/An_Inconvenient_Truth#Scientific_basis



Our Climate Crisis

- Earth & Space Research (ESR) website: http://www.esr.org/outreach/climate_change/mans_impact/man1.html



Fixing the Problem

We must stabilize the value of the earth's atmospheric CO2_e

CO2_e Emissions

Sequestration (Photosynthesis)

E_N + E_A + E_{WFB}

> → **Positive Slope**

= → Zero Slope

< → **Negative Slope**

S

Natural: rotting, fire, digestion. respiration

Anthropogenic: combustion of fossil fuel, methane, other

Warming **F**eed **B**ack: such as methane from melting permafrost

Growth of plants on Earth

The Warming Feed Back term is the wild card. It must not become dominant.

If Anthropogenic emissions were to be sufficiently low (80% below 1990 levels has been allocated to developed countries), the slope would be zero, thus capping the value of the Earth's atmospheric CO2_e

Motivation for Change

- Fairness to individuals
  - Costs no longer hidden
  - Costs avoided or recovered, by not using parking
- Less driving, to reduce environmental harm
  - Motivates choosing alternative modes
  - Less driving to find parking
- Cost Effective Development
  - Less parking needed reduces land and building costs

Goals, 1 of 2

- One agency operates all parking
- Nearly all parking is shared
- Parking costs are effectively unbundled
  – From wages and rents
  – From costs of goods and services
- No change to how parking gets built
  – Generally, municipalities require & developers build

Goals, 2 of 2

- Priced right
  - Value Priced: Base price derived from costs
  - Driver demand determines a congestion price
- No need to search for parking
  - Directions to parking that meets user's needs
  - Accurate price predictions
- Each parking space's use is archived
  - Supports informed decisions
- Privacy and the needs of the disabled are supported

Definitions and Methods, 1 of 6

- Definition & Examples of ***Parking Beneficiary Group***
  - Owners
    - Private investors or governments operating public parking
  - Those losing money due to provided parking
    - Employees
    - Apartment renters or condominium owners
    - Hotel or restaurant patrons
    - Shoppers
  - Those offered specific parking
    - Driving-age students at a school with parking
    - Driving-age train riders using a station with parking

Definitions and Methods 2 of 6

- How to Effectively Unbundle the Cost or the Benefit
  - Price charged per minute
    - Base price rate established to cover all costs
    - Congestion price rate
      - Dynamically set as a function of occupancy rate
      - Charge is time average, if rate changes, while car is parked
  - Parking generally available to all drivers
  - Earnings distributed to members of ***Beneficiary Group***
    - Calculation of individual’s earnings depends on situation

Definitions and Methods, 3 of 6

- Calculation of monthly earnings
  - If parking is provided for several groups, each group's portion of the earnings is proportional to its original contribution to cost (Mixed use case)
  - Each beneficiary group's total is divided up among its members
    - Condominium owners: proportional to spaces effectively purchased
    - Renters: proportional to spaces effectively renting
    - Shoppers: proportional to money spent
    - Employees or students of driving age: proportional to time spent at work or school
    - Train riders of driving age: proportional to time spent on round trips

Definitions and Methods, 4 of 6

- For congestion pricing, *define* ***Cluster of Parking***
  - 20 to 40 contiguous spaces nearly equal in desirability
  - Assigned the same price
- Pricing
  - Base price
    - Covers all costs $r_{BaselineHourly} = \frac{(r_{Invesment} \times v_{Parking}) + c_{YOPD}}{(n_{HoursPerYear} \times f_{TO})}$
    - Report's Page 13 & 14 provides details
  - Congestion price, for each cluster

$$r_{HourlyRate} = r_{BaselineHourly} \times \left(B^{(30-V)/5}\right), for\ V < 30;\ r_{BaslineHourly}\ , otherwise$$

- *B* is nominally 2; adjusted to keep vacancy above 15%
- *V* is the vacancy % rate (Report's Eq. 2, Table 2, Pages 14 & 15)

Definitions and Methods, 5 of 6

- Pricing predictions
  - For any set of dates, start times, durations, and destinations
  - Availability of predictions
    - Broadcast into navigational units
    - Website or phone
- Help to find desired parking
  - Driver gives times and locations and stipulates . . .
    - Max price, to get space at minimum walk distance
    - Max walk distance, to get space at minimum price
  - Voice-activated navigational system for ease and safety

Definitions and Methods, 6 of 6

- Monthly statements
  - All parking charges and earnings
    - First, within state
    - Then, within nation
    - Finally, within North and South America
  - Customer selects presentation detail
    - Less detail for ease and more privacy
    - More detail to know and adjust parking decisions
  - Packaged with other statements
    - All utilities, transit use, road use

Implementation Plan, 1 of 3

- Prototype design
  - Most likely a Climate Action Plan Mitigation Measure
- Requirements document to support request for proposal (RFP)
- Winning proposal leads to design
  - Hardware selection and design
  - Software generation
- Prototype installation
  - Most likely a Climate Action Plan Mitigation Measure
  - Debug
  - Adjustments to satisfy stakeholders

Implementation Plan, 2 of 3

- Government agency develops and executes full installation strategy
  - To minimize impact on institutions
  - To maximize early success and driving reductions
    - Large employment centers with "free" parking
    - Train stations with large, "free" parking lots
  - Supported by new law that requires cooperation but very little effort, from . . .
    - Private and public institutions
    - Individuals

Implementation Plan, 3 of 3

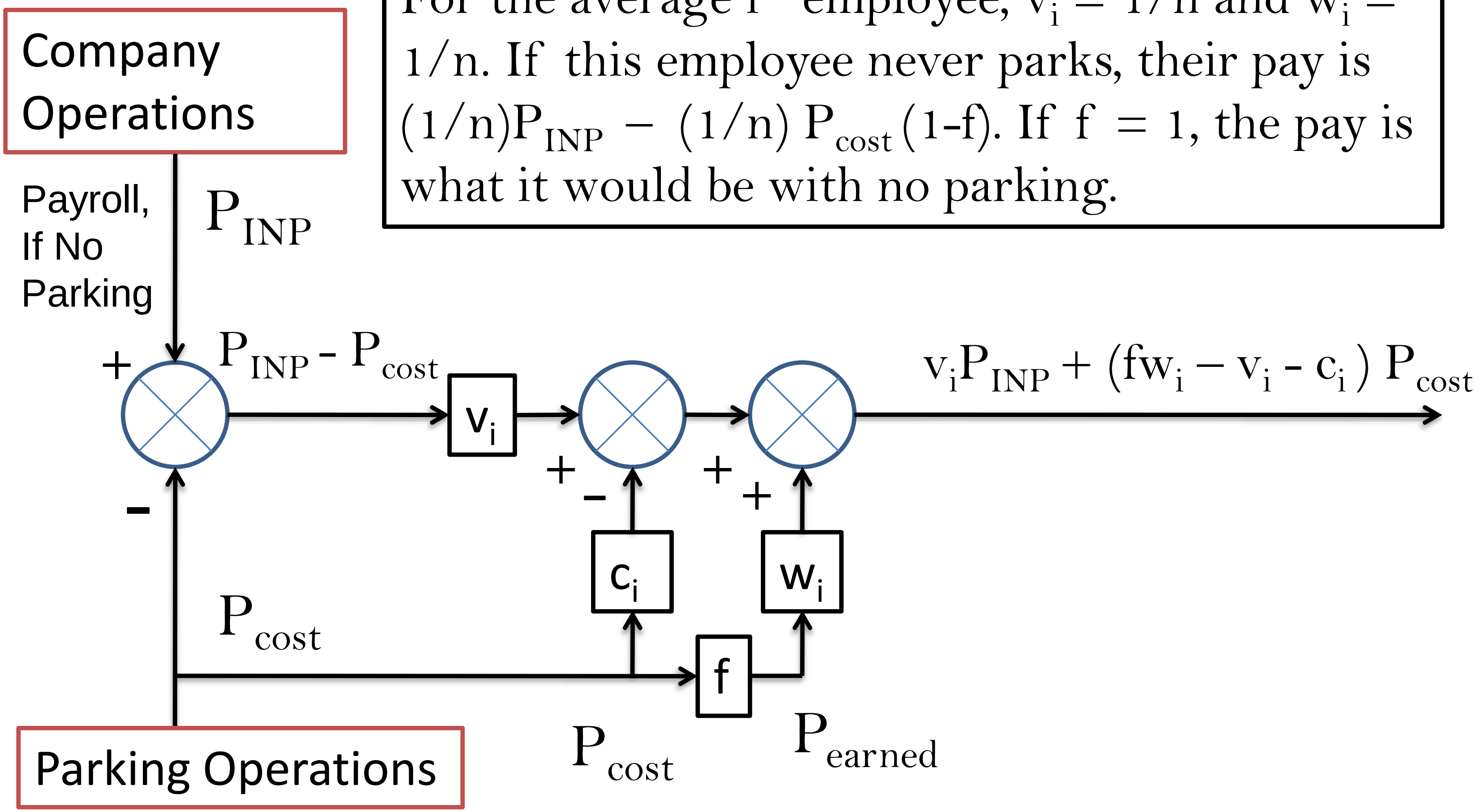
- Basis for a new law supporting installations
  - To provide equal protection of the law
    - Government has required parking for 50 years
    - Those driving less than average often lose money
  - Prototype will have demonstrated feasibility
  - Global warming considerations show subsidized parking to be a public nuisance
    - Global warming will likely cause a human catastrophe
    - Short term strategies are critical
    - Electric cars and getting most electricity from renewables will take decades
    - Properly pricing parking is relatively cheap and quick (5 years)

Unbundle Flow Diagram Definitions

Variable	Definition
P_{INP}	Company payroll if there were no parking costs
P_{cost}	Total parking cost. Price will be sized to recover this.
P_{earned}	Parking earnings equals parking cost minus collection cost
v_i	Employee value. Fraction of available pay. For the average employee, 1/n
c_i	Fraction of parking cost paid. Zero, if the employee never parks.
f	Parking earnings divided by parking cost. Close to 1 for efficient collection
w_i	time worked divided by total time worked of all employees. If average, this is 1/n.

Unbundle Flow Diagram

For the average i^{th} employee, $v_i = 1/n$ and $w_i = 1/n$. If this employee never parks, their pay is $(1/n)P_{INP} - (1/n)\,P_{cost}(1\text{-}f)$. If $f = 1$, the pay is what it would be with no parking.



Mike Bullock, 1 of 2

- Personal
  - Married, two daughters, 3 grand daughters, 1 grandson
    - Daughter Laura Bullock White (Berkeley)
    - Heidi Bullock (Oceanside)
  - Moved from Cupertino to Oceanside in April 2007
  - Oceanside home (1800 Bayberry Dr) and 4-plex (506 N. Ditmar)
  - Swims with and competes for Oceanside Swim Masters
- Education
  - BSEE, Lamar University
  - MSE, University of Texas at El Paso
- Professional
  - Lockheed Martin Systems Engineer, 1971 to 2007
    - Last 2 years, Space Based Infrared System (SBIRS, satellite to detect and track missiles)
    - 10 Years previous: Milstar (communication satellite)
      - Verification of antenna pointing accuracy
      - Antenna pointing calibration

Mike Bullock, 2 of 2

- Most Recent Activities
  - California Democratic Party
    - Delegate, 76^{TH} AD
    - Elected member of the San Diego County Central Committee
    - CDP Resolutions and Platform

San Diego County's Climate Action Plan Misadventures

- The Sierra Club proposed Dividend-Account parking, as a demonstration project for County employees
- The County argued it was infeasible
- Superior Court Judge Taylor ruled that the County failed to show it was infeasible
- The County appealed on a 3-2 vote
- This is the 2nd failed CAP for the County. The first was ordered rescinded on the same issue and resulted in a published Appellant Court Ruling

DRAFT

These entities or others may become interested in issuing a Request for Information as described herein

City of Encinitas in cooperation with the cities of Oceanside, Carlsbad, Solana Beach, and Del Mar, the United States Marine Corps Base at Camp Pendleton, and North County Transit District

REQUEST FOR INFORMATION (RFI) OR A REQUEST FOR AN INDICATION OF INTEREST (RFIOI) IN RESPONDING TO AN RFI

Design, Install, and Operate a Dividend-Account Car Parking System at Selected Work Locations for Employees

CM RFI 18-XX

Date Issued: Month j, 2018 or 2019
Questions Due: Month k, 2018, 5:00 PM
Proposals Due: Month l, 2018, 2:00 PM

IF YOU DID NOT DOWNLOAD, OR DIRECTLY RECEIVE THIS DOCUMENT FROM THE XXX WEBSITE AT WWW.xxx.GOV/BIDS, YOU ARE NOT LISTED AS AN OFFICIAL DOCUMENT HOLDER FOR THIS SOLICITATION AND WILL NOT BE NOTIFIED BY THE CITY OF ADDENDA ISSUED. YOU MUST ACKNOWLEDGE ANY ADDENDA ISSUED IN YOUR SUBMITTAL OR RISK BEING CONSIDERED NON RESPONSIVE. PLEASE BE SURE TO VISIT THE WEBSITE ABOVE TO REGISTER AS A DOCUMENT HOLDER FOR THIS SOLICITATION.

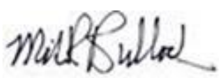
City of XXX
City Manager’s Department – Environmental Services
Attn: YYY

Table of Contents

I. INTRODUCTION

The City of Encinitas, or one of the other entities shown above, may want, at some future date, to request information that will aid in the selection of a vendor for a possible Dividend-Account Car-Parking System Demonstration pilot on behalf of the themselves and other entities, such as Oceanside, Carlsbad, Encinitas, Solana Beach, and Del Mar, the United States Marine Corps Base at Camp Pendleton, and the North County Transit District (collectively referred to as “Partners”). The Partners may seek to evaluate the benefits, effectiveness, and popularity of a Dividend-Account Car Parking System for employees in the north coastal region of San Diego County through the operation of a temporary pilot program lasting from twelve (12) to thirty-six (36) months. It could become the goal of the Partners to determine whether permanent Dividend-Account Car-Parking systems would be successful in our region based on the outcome of a pilot program. Partners may decide to be actively coordinating with the San Diego Association of Governments (SANDAG), the agency that may be leading regional Dividend-Account Car-Parking Systems coordination around topics including data collection and monitoring, public outreach, policy/regulations. The partners are more likely to want to proceed if there is an identified interest on the part of vendors to respond to an actual RFI. To save time, the rest of this document is written as if one of the Partners has already decided to issue an RFI. However, that is not currently the case. This document, perhaps best described as Request for Indication of Interest has been adapted from a dock-less bike share RFI. Thank you for considering this concept. Please indicate if you would be interested in designing and operating such a system.

Mike Bullock



Oceanside, CA 92054
760-754-8025; Cell: 760-421-9482

A. Location

The study area includes the cities of Oceanside, Carlsbad, Encinitas, Solana Beach, and Del Mar, and the United States Marine Corps Base at Camp Pendleton, all of which are located in northern San Diego County along the coast. The region has a mild climate with average temperatures ranging from the mid-60s in the winter to mid-80s in the summer. The terrain is relatively flat along the coast, particularly when traveling in the north-south directions. Each of the cities have dense urban centers of varying sizes with grid street plans and relatively flat terrain. Generally, most of the cities in the study area have more hilly terrain and a suburban layout east of Interstate 5 (I-5). The combined population of the cities is approximately 365,000 and the combined geographical area of the cities is approximately 106 square miles. Highway 101 runs along the coast through each of the cities for a contiguous distance of approximately 20 miles. Highway 101 is one of the most popular bicycling routes in the San Diego region. North County Transit District (NCTD) operates two rail lines and 34 bus routes throughout North County. Thirteen rail and/or bus transit centers are located within the study area. Total annual NCTD ridership is approximately 10.7 million passengers. The Camp Pendleton Marine Corps base is located just north of Oceanside and serves as a major employer for both enlisted and non-enlisted personnel. The southwest corner of the base adjacent to Oceanside Harbor and west of I-5 features relatively flat terrain and could benefit from increased biking connections.

Table 1: General information about the region

	Population[1]	Employment[2]	Size (sq. mi.)	Coastline (mi.)
Oceanside	175,948	35,662	42	3.5
Carlsbad	112,930	66,596	39	6.3
Encinitas	61,928	22,443	20	6
Solana Beach	13,494	7,843	3.6	1.5
Del Mar	4,274	3,474	1.8	2.9

[1]SANDAG Current Estimates, 2016
[2]U.S. Census Bureau, 2015

B. Background

The cities in the North County coastal region of San Diego County are increasingly aware of the need to reduce local greenhouse gas (GHG) emissions to limit the effects of climate change while offering viable transportation alternatives to driving alone. Many of the cities have adopted Climate Action Plans (CAPs) or are in the process of developing CAPs. CAPs establish environmental initiatives by which cities aim to achieve GHG emissions reduction goals and targets. Transportation, especially travel via single occupancy vehicle, is a major source of GHG emissions in North County. Facilitating safe, convenient, and affordable alternative transportation options is often a component of these plans and initiatives. Car parking systems that increase economic fairness and choice, compared to bundled-employee-benefit car parking systems (erroneously called “free parking”) at places of employment will reduce single occupancy vehicle (SOV) commuting and increase the need for first/last mile solutions. For this reason, this RFI will be provided to those firms that would benefit from increasing the demand for first/last mile solutions.

The Marine Corps Mobility Transformation Strategy calls for demonstration projects at installations like Camp Pendleton to meet official business mobility with capabilities that are smarter, more efficient, more accessible, and cheaper.

Partners will seek to coordinate with SANDAG on Dividend-Account Car-Parking Systems data analysis while ensuring the selected Dividend-Account Car-Parking Systems vendor can meet data sharing requirements that assist in quantifying the impacts of Dividend-Account Car-Parking Systems on vehicle miles traveled (VMT), access to transit, economic development, and other benefits.

Offering and promoting programs, like Dividend-Account Car-Parking Systems, that replace vehicle trips with active transportation and/or transit trips, is one of the ways the Partners can help to reduce emissions while offering more efficient and more affordable transportation modes for residents, employees, and visitors. A Dividend-Account Car-Parking System is a system which operates employee car parking for the financial gain of the employees by value-pricing the parking and distributing the earnings, which are the revenue minus a fair cost of operation, among employees. The earnings are provided in proportion to the time an employee spends on the work premises. There may also be an “add in” payment provided by either the employer or from a grant, such as a Greenhouse Gas Reduction Fund (GGRF) grant, sized so that an employee that continues to drive every day will lose no money under the system. This system will in effect pay each employee an additional amount of income for each day they get to work without relying on the single occupancy vehicle (SOV) mode. See Reference 1 for more details on the Dividend-Account Car Parking System. The References are listed at the end of Section II, Request for Information.

C. Purpose and Objectives of the RFI

The purpose of this Request for Information (RFI) is to identify vendors with the resources to pilot a Dividend-Account Car-Parking System program in the Partners’ jurisdictions, in accordance with the objectives set forth in this RFI.

The Partners seek a qualified vendor to design, establish, implement, operate, and maintain an innovative, valuable, and mutually-beneficial Dividend-Account Car-Parking System pilot program. The pilot should enable and encourage residents, employees, and visitors to affordably and conveniently travel by car pool, transit, active transportation or some combination of these modes. The pilot should also facilitate a decrease in vehicular parking demand, vehicular traffic, and (GHG) emissions, while promoting active and healthy transportation options.

Qualified vendors are invited to submit proposals based on the information provided in this RFI.

This RFI is a mechanism for gathering information and does not constitute a binding procurement process, however, selection of goods and/or services may result from information obtained through this RFI process, where deemed appropriate. The Partners, jointly or individually, are not obligated to make an award or issue a Request for Proposal as part of this process. In addition, the Partners, in their sole discretion, may decide to engage in direct question and answer sessions with one or more vendors and may decide to enter into an agreement or issue permits based upon those discussions/interviews or a resulting proposal.

If a single demonstration pilot project or multiple demonstration pilot projects were successful, given the severity of our anthropogenic climate change crisis, it is anticipated that other employers will decide to install Dividend-Account car-parking systems. Since municipal governments are required under CEQA to adopt General Plan Updates (GPUs) that include, perhaps using a Climate Action Plan, a set of enforceable measures that will achieve climate-stabilizing targets, and since cars and light-duty trucks (LDVs) are the largest category of GHG emissions, it is further anticipated that municipal governments will, over time, update their off-street parking ordinances to include requirements for Dividend-Account Car Parking systems. Reference 2 shows that this system is adaptable to all types of parking. A selected vendor would have access to a market of more than 365,000 residents living in the north coastal region, more than 135,000 employees that work in the region, and others that visit the region for leisure.

Potential Dividend-Account Car-Parking Systems program marketing opportunities may include, but are not limited to: being listed as a preferred vendor on the Partners websites, co-branded sustainability campaigns, signage, event sponsorship, press releases, and social media announcements.

D. Obtaining RFI Documents

The website for this RFI and related documents is: PlanetBids (http://www.encinitasca.gov/bids). All correspondence will be posted on the PlanetBids website. It is the responsibility of Proposers to check the website regularly for information updates and RFI clarifications, as well as any RFI addenda. To submit a proposal, a Proposer must be registered with the City of Encinitas as a vendor. To register as a vendor, go to the following link (http://www.encinitasca.gov/bids), and then proceed to the "New Vendor Registration" link. All addenda will be available on the PlanetBids website.

E. RFI Contact

The City of Encinitas will receive questions and information requests on this RFI up to **5:00 p.m. on some TBD Month "n", 2018**. All questions regarding the RFI documents shall be submitted through PlanetBids. All project correspondence will be posted on the PlanetBids website. It is the responsibility of the Proposers to check the website regularly for information updates, clarifications, and addenda.

II. REQUEST FOR INFORMATION or REQUEST FOR INDICATION OF INTEREST

This section describes the information being requested by the Partners to learn about prospective **Dividend-Account Car-Parking System ("System")** vendors and optionally to select a vendor to operate in the Partners' jurisdictions. Interested vendors must include all information outlined below in a submitted proposal.

A. Dividend-Account Car-Parking System ("System") Pilot Program Requirements

Vendors responding to this RFI must describe their proposed system that is capable of providing the following services and shall describe these services in their submission:

1. System pilot program(s), as described in Reference 1, to include the following installed and maintained capabilities:
2. A capability to establish and maintain a database of System Vehicles, System Members, System Parking and System Accounts. A System Account includes the mailing name and address of a person that has agreed to receive payments and pay bills that are the result of the implementation of the System and the actions taken by the person, or some other person driving the System Vehicle or System Vehicles, as described herein. Such a person is a "System Member." A "System Vehicle" is one that can be identified when it is parked in the System and one that is associated with a System Account and System Member. A System Member may take responsibility to pay for the cost of parking for multiple System Vehicles.
3. A capability to provide an easy method for Employees and others to become System Members by establishing a System Account with their chosen System Vehicles.
4. A capability to provide signage to designate System Parking areas well enough to prevent nearly all accidental entries by unauthorized vehicles, meaning vehicles that are not System Vehicles.
5. A capability to provide written materials to explain to employees and others that may want to become System Members how the System will work and why it is an important improvement to economic fairness and environmental outcomes, assuming a reasonable level of cooperation with the City and other affected groups, such as City vendors and sub-contractors.
6. A capability to operate the system for an agreed-upon amount of time, with no money exchanges, to establish a pre-install database of commute behavior including using questionnaires to determine how non-drivers say they are getting to work.
7. A capability to identify a System Vehicle within a minute of its being parked in a System Parking space and to store the System Vehicle identifier and the time it was recognized as being parked.
8. A capability to recognize when a System Vehicle exits a System Parking space, within a minute and to store the vehicle identifier and the recognized exit time.
9. A capability to identify vehicles that are NOT System Vehicles when they are in the System Parking area and are therefore trespassing, while they are in the System Parking area.
10. A capability to record the start time and end time of the trespassing vehicle's trespassing, to within an accuracy of 1 minute, as well as its license plate image, sufficient to support a conviction of trespassing.
11. A capability to send the license plate of the trespassing vehicle and its start time and end time of its trespassing to law enforcement officials with 5 minutes of the recorded start time of the trespass.
12. A capability to provide notice and evidence of this trespassing in real time and as stored

information for law enforcement so that they can then ticket and prosecute the owners of any and all vehicles that have been illegally parked in a System Parking space. It is anticipated that this would include the capture and storage of the license plate numbers of the vehicles that are parked in the System Parking lot whenever it is the case that the vehicle is not a System Vehicle.

13. A capability to compute an instantaneous charge rate (cost per minute) for the case of an application of “congestion pricing”, whereby an agreed-upon base price is increased by an agreed-upon congestion-pricing algorithm, designed to prevent the occupancy rate from exceeding an agreed-upon upper bound value, such as 90% occupied. An example of such an algorithm is in Reference 2.
14. A capability to compute and store the time that the charge rate changes, for the case of an application of a congestion-pricing algorithm. Note that this time is called the Rate Change Time. At these times, the rate could either increase, by the addition of a car being parked in a System Space or the rate could be decreased, by the subtraction of a car in a System Space.
15. A capability to accumulate a total charge for each System Member, where the total charge is the sum of the products of each parked duration time over which a fixed charge rate applies and the length of that time duration, for all the System Vehicles associated with the System Member, over a month. This total charge is called the System Member Monthly Charge (“SMMC”). Note that the Member may or may not be an employee.
16. A capability to compute the total charges, for all System Members over a month for the System. This amount is the Total System Monthly Charge (“TSMC”).
17. A capability to compute a Total System Monthly Earnings (“TSME”), which is the TSMC, reduced by a agree-to amount, such as 5%, where the 5% is taken out of the TSMC to cover the operator’s expenses.
18. A capability to record all the times an employee enters and leaves the work premises. One way to do this is to require employees to have an RFID. There may also be an GPS or a license plate reading solution. Note that a privacy requirement will prevent this information from being shared, with the employer, for example, with the exception of providing it to a law enforcement person, in the event a warrant is signed by a presiding judge.
19. A capability to use the times an employee enters and leaves the work premises to compute the time, over a month, an employee has spent at or within the work premises. This time is known as the Employee Monthly Time (“EMT”).
20. A capability to compute the total time all employees spent at the premises over a month, to be known as the Total Employee Monthly Time (“TEMT”).
21. A capability to compute an Employee’s Monthly System Earnings (“EMSE”) as the Total System Monthly Earnings (“TSME”), multiplied by the employee’s Employee Monthly Time, EMT divided by the TEMT. This is also described in Reference 1.
22. A capability to compute an Employee’s Add-In “EAI”, as follows. If the employee’s System Member Monthly Charge, SMMC, value is greater than the employee’s earnings, TSME; then, for that case, the EAI is equal to the employee’s SMMC minus the employee’s TSME. If the employee’s System Member Monthly Charge, SMMC value is not greater than the employee’s earnings, TSME; then the employee’s EAI is equal to zero. This is also described in Reference 1.
23. A capability to accept Employee’s Add-In, EAI money from the Employer, with the

expectation that the money would originate from a grant funded by, for example, the Greenhouse Gas Reduction Fund (GGRF), or could come from the Employer's budget, as a Climate Action Plan (CAP) or other expense. It could also be generated by converting some "free" parking to be a different Account Parking System Parking (System Parking), thereby generating new money to the City.

24. A capability to compute an employee's monthly payment ("EMP"), as follows: It is equal to the Employee's Monthly System Earnings, EMSE plus the employee's Add-In, EAI minus the System Member Monthly Charge, SMMC. This is also described in Reference 1.
25. A capability to automatically send out monthly statements to all System Members. System Members who are not employees will receive a bill if they have parked in the System parking during the month. The bill will then be for the member's SMMC. Each employee will receive a statement showing SMMC, EMSE, and EAI. If the employee's EAI is zero, then the employee will receive a payment in the form of cashable check for the employee's EMP. This is also explained in Reference 1.
26. A capability to protect employee privacy where privacy means that the employee's data will never be shared, with the sole exception of sharing with law enforcement officials in accordance with a valid court order requesting the data. For example, at no time will the data be shared with other employees, including those working in the management of the employer that is providing the employee parking that is the System Parking.
27. A capability to protect System Member privacy where privacy means that the System Member's data will never be shared, with the sole exception of sharing with law enforcement officials in accordance with a valid court order requesting the data.
28. A capability to allow visitors, vendors, and others, that are identified by the Company management, to be treated as employees. There could also be "visitor" parking that is not associated with the System.
29. A capability to identify System Vehicles that are parked in the visitor parking or other inappropriate parking places, since it is expected that it will required as a part of City Policy that System Vehicles that are associated with employees will be required to be parked in the System Parking. Since employees are earning money from the System Parking, it would be inappropriate for them to not use the System Parking. This information would be shared with City Management, as soon as it is collected.
30. A capability to perform regular inspection, maintenance, and repair of all System Parking facilities and associated capabilities often enough to eliminate nearly all system failures.
31. A capability to perform vendor-managed methods of enforcement.
32. A capability to have demonstrated secured financial backing with the ability to operate at full capacity for the life of the pilot program and beyond with a sustainable business model.
33. A capability to provide close coordination with all Partners, including real-time sharing of System Parking data collected, active promotion of the Dividend-Account Car-Parking Systems program in coordination with each Partner, and timely response to any complaints received or requests made by the Partners and Dividend-Account Car-Parking Systems users. Describe the type of data that is collected and can be provided to the Partners. Promotion and advertisement of the Dividend-Account Car-Parking Systems program must comply with all Partners' municipal codes and ordinances.
34. A capability to offer a Dividend-Account Car-Parking Systems program that can be deployed, operated, managed, and maintained by the vendor at no cost, except for the

possibility of the EAI payments, to the Partners and with minimal oversight needed from the Partners.

35. A capability to establish and operated multiple Dividend-Account Car-Parking Systems programs including for for cases other than employee parking, as described in Reference 2, that can be deployed, operated, managed, and maintained by the vendor at no cost, except for the EAI payment, for employee parking, to the Partners and with minimal oversight needed from the Partners.
36. A capability to conform to contract specifications, including general liability insurance, worker's compensation, automobile liability insurance, indemnification, and termination clauses. Sample contract attached.

B. Proposal Elements

Vendors interested in responding to this RFI must prepare a proposal that includes the following information:

1. Describe how drivers can become System Members.
2. Provide a detailed System maintenance plan.
3. Describe the vendor's capability to provide data and reports to the Partners, including raw and summarized data. Summarized data could include both user data (e.g., demographics, trip purpose, repeat usage, percent of trips starting and ending in close proximity to transit, mode shift, and transit usage) and trip data (e.g., average trip length, average trip time, trip start and end hotspots, trip path, estimated GHG emissions per trip). Ideally, this data should be provided via a publicly accessible API in your suggested General Dividend-Account Car-Parking Systems Feed Specification (GBFS) format. Describe vendor's ability to collect quantitative and qualitative data and report out findings from users (e.g. in-app surveys).
4. Describe how the vendor will employ anti-theft and anti-vandalism measures to ensure Systems do not pose a nuisance to the community.
5. Since the establishment of Dividend-Account Parking systems will increase bike usage, describe how the vendor will address bicycle safety concerns, including helmet use, riding at night and other safety concerns that may or may not be regulated by state vehicle codes.
6. Describe how the Dividend-Account Car-Parking Systems program may operate in conjunction with existing bike rental businesses operating in the Partners' cities.
7. Describe the vendor's plans for future growth and expansion, including possible anticipated increases in demand for good car parking systems as the public becomes more aware of the threat of anthropogenic climate change and how good systems improve economic fairness, etc.
8. Provide an estimated timeline for a twelve-to-twenty-four-month pilot Dividend-Account Car-Parking System program, including any needed permitting, set-up, promotion, advertising, maintenance and servicing, data delivery to Partners, summary and reporting on the outcome of the pilot program and possible continuation of the program.

9. Describe a recommended minimum Dividend-Account Car-Parking Systems size for the North County Coastal operating area.

10. Describe strategies for effectively educating users on proper System Parking use and the reason that society needs to improve the way we pay for the use of car parking.

11. Describe any approach you would recommend to enhance access and fairness for disadvantaged communities.

12. Describe time required to deploy a Dividend-Account Car-Parking Systems pilot program if selected based on System Parking size, etc.

13. Describe an approach to increasing the use of Dividend-Account Parking to include most city car parking, then across City boundaries, and then across County, State, and international boundaries, with the final system being one wherein nearly all System Vehicles have a single, world-wide, System Account.

References Providing Additional Description

1. ***Eliminating the Harm of Bundled-Cost or Bundled-Benefit Parking***, Presentation to the 2018 Energy Utility Environment Conference (EUEC), Mike Bullock, March 2018
2. ***A Plan to Efficiently and Conveniently Unbundle Car Parking Costs***, paper presented to the Air and Waste Management Association (AWMA) Conference in 2010, Mike Bullock and Jim Stewart, June 2010
3. ***Oceanside Civic Center Garage Space Allocation***, EXCEL Spread Sheet, Bullock, based on a file provided by Oceanside staff, July 2018

III. INSTRUCTIONS

A. Proposal Due Date

Proposals must be submitted electronically no later than **5:00 p.m. on TBD Month 2018 or 2019**. Proposals must be submitted electronically via the PlanetBids system used to download the RFI. The maximum file size for submittal is 50 megabytes, and the file type shall be Portable Document Format (PDF). The electronic system will close submissions exactly at the date and time set forth in the RFI or as changed by addenda.

B. Proposal Acceptance

Respondents are responsible for submitting and having their submittal accepted before the closing time set forth in this RFI or as changed by addenda. NOTE: Pushing the submit button on the electronic system may not be instantaneous; it may take time for the Respondent’s documents to upload and transmit before the submittal is accepted. It is the Respondent’s sole responsibility to ensure their document(s) are uploaded, transmitted, and arrive in time electronically. The City of Encinitas will have no responsibility for submittals that no not arrive in a timely manner, no matter what the reason.

C. Page Limit

No submissions exceeding twenty-five (25) pages will be accepted (excluding attachments). In addition, attachments may not exceed twenty-five (25) pages. The City of Encinitas discourages "padding" of proposals with brochures, extensive literature, and boilerplate material not applicable to a pilot Dividend-Account Car-Parking Systems program.

D. Proposal Format

Proposals must be organized in the following format and include the following content:

1. Letter of transmittal signed by an individual authorized to bind the proposing entity stating the firm has read and will comply with all terms and conditions of the RFI.

2. General information about the firm, including the size of the organization, location of offices, number of years in business, organizational chart, name of owners and principal parties, number and position titles of staff.

3. Qualifications of principals, project managers and key personnel who would be assigned to this project. Include their position in the firm, and types and amount of relevant experience operating a Dividend-Account Car-Parking Systems program or similar program. Identify the primary contact that will be the overall project manager. Resumes are not required, but may be included as attachments. The selected respondent may not substitute personnel without written authorization from the Partners.

4. A work plan that establishes the Respondent's understanding of, and ability to satisfy Partners' objectives. Respondent shall succinctly describe the proposed approach for implementing a Dividend-Account Car-Parking Systems program, outlining the activities, including innovative ideas that would be undertaken in completing the various tasks and specifying who would perform them.

5. A preliminary estimated schedule for deployment of a pilot Dividend-Account Car-Parking Systems program. Show all critical paths, major milestones, and decision points in pilot schedule.

6. A list of the municipal or other government agencies your firm has worked with during the past three years. Provide the following information for at least one operational system that has at least some of the similar components as would a Dividend-Account Car-Parking System program that is managed by the respondent:

   a) Name, address, and telephone number of the agency;
   b) Time period for the project;
   c) Brief description of the scope of the services provided;
   d) Identify the staff members on the project and their specific responsibilities; and
   e) Person and contact information for a reference.

IV. PROPOSAL EVALUATION

A. Proposal Evaluation

A review committee comprised of representatives from each of the potential Partner cities will judge the merit of proposals received in accordance with the general criteria defined herein. Failure of proposers to provide in their proposal any information requested in this RFI may result in disqualification of the proposal. The sole objective of the review committee will be to select the proposal that is most responsive to the Partners' needs. The Partners reserve the right to elect to not proceed with a pilot Dividend-Account Car-Parking System program and reject all proposals received through this RFI process.

1. Experience of the vendor and proposed staff. Experience of project staff with similar scope of services. Level of education, training, licensing and certification of staff

2. Approach to the project. Demonstrated understanding of the Partners' needs and solicitation requirements. Approach is well organized and presented in a clear, concise and logical manner.

3. Availability and proposed use of technology and methodologies. Quality control and thoroughness is well defined.

4. Capability to Perform. Ability to complete work within deadlines. Availability and continuity of staff during the course of the project, if selected. Unsatisfactory past performance with the City of Encinitas (or any of the Partner cities) may be considered as determined by the City of Encinitas (or any of the Partner cities) in their sole and absolute discretion.

5. Relevant Experience. Experience in performing similar services for organizations of similar size to the Partner cities. Experience with public agencies. Years of experience with these types of services.

6. Innovation. Innovative ideas on the development, operation, promotion, and sustainability of Dividend-Account Car-Parking System programs.

B. Final Negotiation

As reflected above, vendor selection will be based on a combination of factors as determined to be in the best interest of the Partners. After evaluating the proposals and discussing them further with the finalists, or the tentatively selected vendor, the City of Encinitas reserves the right to further negotiate the proposed program.

V. CONDITIONS GOVERNING THIS PROCUREMENT

A. Scope Changes, Additions and Deletions

All changes in proposal documents shall be through written addendum and furnished to all proposers. Verbal information obtained otherwise will NOT be considered in the evaluation process.

B. Rejection of Proposals

The City of Encinitas reserves the right to reject any or all Proposals and to waive informalities and minor irregularities in Proposals received and to accept any portion of Proposal or all items of Proposal if deemed in the best interest of the City of Encinitas to do so.

C. Proprietary Information

Any restrictions on the use of data contained within a Proposal must be clearly stated in the Proposal itself. Proprietary information submitted in response to this RFI will be handled in accordance with applicable City of Encinitas Procurement Regulations and the California Public Records Act.

D. Response Materials Ownership

All materials submitted regarding this RFI become the property of the City of Encinitas. Responses may be reviewed by any person at Proposal opening time and after final selection has been made. The City of Encinitas has the right to use any or all ideas presented in reply to this request, subject to the limitations outlined in Proprietary Information above. Disqualification of a proposer does not eliminate this right.

E. Acceptance of Proposal Content

The contents of the Proposal of the successful proposer will become contractual obligations if contractual agreements action ensues. Failure of the successful proposer to accept these obligations in a permit to operate, purchase agreement, purchase order, contract, delivery order or similar acquisition instrument may result in cancellation of the award and such proposer may be removed from future solicitations.

F. Cost of Proposal Preparation

The City of Encinitas shall not be liable for any pre-contractual expenses incurred by any submitting vendor. Each submitting vendor shall protect, defend, indemnify, and hold harmless the City of Encinitas from any and all liability, claims or expenses whosoever incurred by, or on behalf of, the entity participating in the preparation of its response to this RFI. Pre-contractual expenses are defined as expenses incurred by vendors in:

1. Preparing the proposal in response to this RFI;
2. Cost to acquire a permit; and
3. All other expenses incurred by a vendor related to preparation of proposal or establishment of a Dividend-Account Car-Parking System program.

G. Interview

Interviews with the top respondents may be requested. The selection of vendors invited to interview will be solely based on the Partners' discretion. The vendors asked to interview will be notified in advance.

ATTACHMENT 1

Sample License Agreement for Dividend-Account Parking Services

This License Agreement for Dividend-Account Car-Parking Sytsem Services ("Agreement") is made this this day of September 2017, by and between the City of Encinitas ("City") and ___ ("Dividend-Account Car-Parking System Vendor").

RECITALS

1. A goal of City is to provide safe and affordable multi-modal transportation options to all residents, reduce traffic congestion, and maximize carbon free mobility.
2. Dividend-Account Car-Parking System services are a component to help the City achieve its transportation goals and the City desires to make this System available to residents and those who work or otherwise drive and park in the City.
3. Dividend-Account Car-Parking System Vendor proposes to operate a Dividend-Account Car Parking program within the City at an agreed-to location with an agree-to number of System parking spaces within the designated location or locations. As an example, based on Reference 3, there could be 239 spaces designated as System Parking, out of a total of 284 spaces in the Oceanside Civic Center Parking Garage. Note further, that if there are 259 employees that work for the City and are given parking spaces, there would be a need to establish 20 additional System Parking spaces outside of the Oceanside Civic Center Parking Garage.
4. Dividend-Account Car-Parking System Vendor will abide by all City ordinances and rules governing the use of public space.
5. Dividend-Account Car-Parking System Vendor possesses the technology necessary to install operate, maintain, and expand such a system and multiple systems as demand expands.

AGREEMENT

1. Initial Term. This Agreement is effective for twelve to eighteen months from the date of execution ("Initial Term, Phase 1"), which will include a duration of installation during which no money is exchanged so as to establish a baseline of modal splits for employee commuting, and then a year of full operation to document the modal split changes and an estimated amount of greenhouse gas (GHG) emissions saved by the program. At the conclusion of the Initial Term Phase 1, the Agreement may be extended by mutual written agreement of the parties for an additional two-year term (Initial Term, Phase 2), subject to any new terms agreed between the parties, unless either party notifies the other party of its intent not to continue with the Agreement no later than 30 days before the expiration of the Initial Term, Phase 1 and Phase 2.
2. Exclusive Operator. During the Initial Term's Phase 1 and Phase 2, the City designates Dividend-Account Car-Parking Systems Vendor as the exclusive provider of the System services within its city limits. This designation is personal to Dividend-Account Car-Parking Systems Vendor and may not be assigned or transferred to any party. This exclusivity provision shall expire and not be renewed past the Initial Term's Phase 1 and Phase 2 unless agreed in writing by the parties.

3. Use of City Property. City authorizes Dividend-Account Car-Parking Systems Vendor to use ("License") City property, including the public right-of-way and System Parking areas that are suitable, solely for the purposes set forth in Section 4 of this Agreement. This authorization is not a lease or an easement, and is not intended and shall not be construed to transfer any real property interest in City Property.

4. Permitted Use. Dividend-Account Car-Parking System's System Members may use City Property solely for parking System Vehicles. The City Property is maintained by the City. Dividend-Account Car-Parking Systems Vendor may operate an agree-to amount of System Parking places on City Property as set forth in Exhibit A. If at any time during the term of the Agreement Dividend-Account Car-Parking Systems Vendor desires to place additional System Parking within the City limits, Dividend-Account Car-Parking Parking Systems Vendor must request and receive authorization from the city to do so in writing. The City may limit the number of System Parking places upon identifying a potential harm to public health or safety. Dividend-Account Car-Parking Systems Vendor shall not place or attach any personal property, fixtures, or structures to City Property without the prior written consent of City.

    a. Use of City Property and Dividend-Account Car-Parking Systems Vendor's operations within the City, shall, at a minimum: a) not adversely affect City Property or the City's streets, or sidewalks; b) not adversely affect the property of any third parties; c) not inhibit pedestrian or vehicular movement, as applicable, within City Property or along other property or rights-of-way owned or controlled by the City; d) not create conditions which are a threat to public safety and security. Dividend-Account Car-Parking Systems Vendor shall instruct its customers not to park or leave any System Vehicle where they would impede pedestrian or vehicular traffic.

    b. Upon termination of this Agreement by either party, Dividend-Account Car-Parking Systems Vendor shall, at its sole cost and expense, immediately restore City Property to a condition which is visually and structurally indistinguishable from the immediately surrounding area.

5. System Parking. The City, at its own discretion, may support the System with the installation of signs and painting to further the orderly operation of the System Parking.

6. Condition of City Property

    a. City makes City Property available to Dividend-Account Car-Parking Systems Vendor in an "as is" condition. City makes no representations or warranties concerning the condition of City Property or its suitability for use by Dividend-Account Car-Parking Systems Vendor or its customers, and assumes no duty to warn either Dividend-Account Car-Parking Systems Vendor or the System Members concerning conditions that exist now or may arise in the future.

    b. City assumes no liability for loss or damage to Dividend-Account Car-Parking Systems System Members. Dividend-Account Car-Parking Systems Vendor agrees that City is not responsible for providing security at any location where Dividend-Account Car-Parking Systems Vendor's System Vehicles are parked, and Dividend-Account Car-Parking Systems Vendor hereby waives any claim against City in the event Dividend-Account Car-Parking System's System Vehicles or other property are lost, stolen, or damaged.

7. Maintenance and Care of Portion of City Property; Dividend-Account Car-Parking Systems Vendor shall be solely responsible for: (i) maintaining City Property to the City standards applicable for use by the Dividend-Account Car-Parking Systems Vendor as

permitted under Section 3; and (ii) obtaining from the City any applicable permits or approvals required by the City. Dividend-Account Car-Parking Systems Vendor shall exercise due care in the use of City Property and shall be responsible for maintaining City Property in good condition and repair. Dividend-Account Car-Parking Systems Vendor shall not act, or fail to act, in any way that result in excessive wear or damage to City Property. Dividend-Account Car-Parking Systems Vendor expressly agrees to repair, replace or otherwise restore any part or item of real or personal property that is damaged, lost or destroyed as a result of the Dividend-Account Car-Parking Systems Vendor's use of City Property. Should the Dividend-Account Car-Parking Systems Vendor fail to repair, replace or otherwise restore such real or personal property, Dividend-Account Car-Parking Systems Vendor expressly agrees to pay City's costs in making such repairs, replacements or restorations. The obligations under this Section apply to all City facilities, infrastructure, or appurtenances located on City Property.

8. Operations & Maintenance. Dividend-Account Car-Parking Systems Vendor will cover all maintenance costs for the System and maintenance to minimum level of service and reporting outlined in Exhibit A.

9. License Fee. The parties intend to agree to a license fee before the Agreement may be extended beyond the Initial Term.

10. Indemnification. Dividend-Account Car-Parking Systems Vendor shall defend, pay, indemnify and hold harmless City, its officers, officials, employees, agents, invitees, and volunteers (collectively "City Parties") from all claims, suits, actions, damages, demands, costs or expenses of any kind or nature by or in favor of anyone whomsoever and from and against any and all costs and expenses, including without limitation court costs and reasonable attorneys' fees, resulting from or in connection with loss of life, bodily or personal injury or property damage arising directly or indirectly out of or from or on account of:

    a. Any occurrence upon, at or from City Property or occasioned wholly or in part by the entry, use or presence upon City Property by Dividend-Account Car-Parking Systems Vendor or by anyone making use of City Property at the invitation or sufferance of Dividend-Account Car-Parking Systems Vendor, except such loss or damage which was caused by the sole negligence or willful misconduct of City.

    b. Use of Dividend-Account Car-Parking Systems Vendor's System Parking by any individual, regardless of whether such use was with or without the permission of Dividend-Account Car-Parking Systems Vendor.

11. Insurance. Dividend-Account Car-Parking Systems Vendor shall procure and maintain for the duration of this agreement insurance against claims for which Dividend-Account Car-Parking Systems Vendor has indemnified the City pursuant to Section 10 of this Agreement. Dividend-Account Car-Parking Systems Vendor shall maintain general liability and automobile liability insurance policies with limits of no less than one million dollars ($1,000,000.00) per occurrence for bodily injury or death, personal injury and property damage, and two million dollars ($2,000,000.00) aggregate. Each insurance policy shall name the City as an additional insured and it shall be endorsed to state that:

    (i) coverage shall not be suspended, voided, or cancelled by either party, or reduced in coverage or in limits except after thirty (30) calendar days prior written notice by certified mail, return receipt requested, has been given to City; and (ii) for any covered claims, the Dividend-Account Car-Parking Systems Vendor's insurance coverage shall be primary insurance as respects the City and any insurance or self-insurance maintained by the City shall be in excess of the Dividend-Account Car-Parking Systems Vendor's insurance and shall not contribute with it. The insurance required to be provided herein, shall be procured by an insurance company approved by City, which approval shall not be unreasonably withheld. Additionally, before Dividend-Account Car-Parking Systems Vendor shall employ any person or persons in the performance of the Agreement, Dividend-Account Car-Parking Systems Vendor shall procure a policy of workers' compensation insurance as required by the Labor Code of the State of California, or shall obtain a certificate of self-insurance from the Department of Industrial Relations.

12. Compliance with Law. Dividend-Account Car-Parking Systems Vendor at its own cost and expense, shall comply with all statutes, ordinances, regulations, and requirements of all governmental entities applicable to its use of City Property and the operation of its System program, including but not limited to laws governing operation of vehicles. If any license, permit, or other governmental authorization is required for Dividend-Account Car-Parking Systems Vendor's lawful use or occupancy of City Property or any portion thereof, Dividend-Account Car-Parking Systems Vendor shall procure and maintain such license, permit and/or governmental authorization throughout the term of this Agreement. City shall reasonably cooperate with Dividend-Account Car-Parking Systems Vendor, at no additional cost to City, such that Dividend-Account Car-Parking Systems Vendor can properly comply with this Section and be allowed to use City Property as specified in Section 4, above.

13. Business License. Dividend-Account Car-Parking Systems Vendor is required to obtain and maintain a City Business License during the duration of this Agreement.

14. Required Reports. Dividend-Account Car-Parking Systems Vendor shall provide reports to the City concerning utilization of its System Parking not less than monthly, and shall cooperate with the City in the collection and analysis of any aggregated data concerning its operations.

15. No Joint Venture. Nothing herein contained shall be in any way construed as expressing or implying that the parties hereto have joined together in any joint venture or liability company or in any manner have agreed to or are contemplating the sharing of profits and losses among themselves in relation to any matter relating to this Agreement.

16. Termination. This Agreement may be terminated prior to the expiration date set forth in Section 1, above, upon the occurrence of any of the following conditions:

    a. Upon delivery of written notice from City to the Dividend-Account Car-Parking Systems Vendor terminating this agreement for any reason, or for no reason, by giving at least sixty (60) days' notice to the Dividend-Account Car-Parking Systems Vendor of such termination.

    b. An attempt to transfer or assign this Agreement.

    Dividend-Account Car-Parking Systems Vendor shall not terminate this Agreement without first by giving at least 180 days' written notice of plans for termination.

17. Amendment. This Agreement may be amended by mutual agreement of the parties. Such amendments shall only be effective if incorporated in written amendments to this agreement and executed by duly authorized representatives of the parties.

18. Applicable Law and Venue. The laws of the State of California shall govern the interpretation and enforcement of this Agreement. Any action to interpret or enforce the terms or conditions of this Agreement shall be brought in the Superior Court for the County of San Diego, or in the United States District Court for the Southern District of California. Dividend-Account Car-Parking Systems Vendor hereby waives any right to remove any such action from San Diego County as is otherwise permitted under

California Code of Civil Procedure Section 394.

19. Counterparts. This Agreement may be executed simultaneously or in any number of counterparts, each of which shall be deemed an original, but all of which together shall constitute one and the same agreement.

IN WITNESS WHEREOF THE PARTIES HERETO have executed this Agreement on date first above written.

CITY OF ENCINITAS	**DIVIDEND-ACCOUNT CAR-PARKING SYSTEMS VENDOR**
______________________________	______________________________
Karen Brust, City Manager	[Title]
______________________________	______________________________
Date	Date

ATTEST:

____

City Attorney

Exhibit A

Description of Dividend-Account Car-Parking Systems Vendor’s Service Level Agreement

The following performance indicators shall be met and reported to help the City measure our success serving its citizens and improving the livability and mobility of Encinitas. Dividend-Account Car-Parking Systems Vendor will maintain it’s System in an excellent state of functionality and repair, with a minimum of error-free operation 95% of the time.

Performance Indicator	Description	Measurement Tool	Minimum Performance Standard	Reporting Frequency
App & customer service support portal: phone and internet. The portal will support the establishment of an account and editing an account	A new account can be entered and audited. It can be edited and an audit can verify the edits. The time and method of the submissions can be retrieved	Tool to audit accounts either by name or unique account number	Accurate 99.5% uptime.	monthly
Ability to set the value price of the parking, a per minute value	The system can accept a “value price” and use the number as described in this report	Tool to audit the fact of and the proper use of the value price	Accurate 99.5% uptime.	monthly
Ability to set the base multiplier, which is used in the congestion pricing algorithm as shown in Table 2 of Reference 2. It is expected to be a number between 1.5 and 2.5. It can be adjusted upwards if the parking is getting too full too often	The system can accept a “base multiplier” and use the number as described in Table 2 of Reference 2.	Tool to audit the fact of and the proper use of the value base multiplier	99.5% of the time	monthly
Ability to report out monthly statements	A feature to display each statement that	Interface to allow a specification of	Statements can be viewed and verified for accuracy with an accuracy of 99.5%	monthly

	was sent out to all employees and all users that are not employees, to verify accuracy	account and month to view the statement that was mailed, for verification		
Ability to accept money into an account and to pay earnings and “add-ins”, out of the account, as described in this report	Most of the money accepted will be car-parking charge but there will also money that is sent in to cover the “Add-in” payments. Most of the money will be via an automated transfere as is done for dockless bike rentals. However, an ability to accept a mailed check will also be required	Transactions will be put into a file that can be audited	Money transfers will occur and be observable with an accuracy of 99.5%	Monthlyt
Ability to report out the percent of employees at their work location that are using their allocated parking over any duration, from specific days to longer specified durations	This tool supports a request for the percent of employees that are at work without using car parking in the employee parking spaces	Software interface that will show the results on a screen and allows for the result file to be stored or printed	Functional 99.5% of the time	monthly

Ability to report out the total amount charged to employees, paid to employees as earnings and, separately, as “add ins”, over any duration, from specific days to longer specified durations	This tool supports a request for the described data	Software interface that will show the results on a screen and allows for the result file to be stored or printed	Functional 99.5% of the time	monthly
Parking spot usage rate	The monthly use rate is reported for any single parking place or for a set of parking places	The result can be viewed on screen or in a file that can be stored or printed	Data collection failure would be reported within two (2) hours during business hours between 8am to 8pm Monday through Friday except for State and Federal holidays. Direct 24/7 contact line for true emergencies, either by phone, text, and/or email Failure outside of business hours reported within two hours (2) of start of business hours	Monthly
System failure detected or reported by a member	Error either automatically reported to the person responsible and their back-ups, as a text on their phones and an email to their computer, to include the error report time	A program collects the time of the data error recognition and the time of the correction	Within two (2) hours during business hours between 8am to 8pm Monday through Friday except for State and Federal holidays. Direct 24/7 contact line for true emergencies, either by phone, text, and/or email For complaint outside of business hours, within two hours (2) of start of business hours	Monthly

From: Keith B. Jones
To: mike_bullock@earthlink.net
Subject: Re: Oceanside Transit Center: Housing Retail Office = need for an intelligent car-parking system
Date: Friday, March 11, 2022 2:51:00 PM
Attachments: image001.jpg

Mike,

Happy Friday afternoon to you. Thank you for your thoughtful and well crafted response.

Yes, please feel free to share ACE's interest in participating in an opportunity to provide these parking solutions.

Have a great weekend,
Keith

Keith B. Jones
Owner | ACE Parking
ACE Parking
645 Ash Street
San Diego, CA 92101
T: 619.233.6624

On Sat, Mar 5, 2022 at 5:41 PM <mike_bullock@earthlink.net> wrote:

> Keith,
>
> Thank you so much for getting back to me.
>
> No, there is no RFP.
>
> However, the North County Transit District (NCTD), the agency doing the Transit Center project, has a representative on the Oceanside Bike-Ped Committee who seems interested. The Bike-Ped Committee supports the Dividend Account Parking (DAP) system. The Chair of the NCTD, Tony Krantz, who is an Encinitas Councilman, should be supportive, but I have not presented to him. I have presented to the Mayor of Encinitas.
>
> I have put more work into this for the City of Oceanside, for their Civic Center

Parking Garage, which is supposed to be City Employee parking, but is also free to the public. On Thursdays, when Oceanside has its Farmers Market, late-arriving employees sometimes find no vacant parking and then park in the neighborhood. Oceanside is not planning to issue an RFP. However, I may be able to coax one out of them if they know you are interested. I need 3 votes and I estimate that I have only 1 right now. However, several on the Council have expressed interest in the Dividend Account Parking (DAP) system. At the Oceanside Climate Action Plan (CAP) meeting, where I was hoping to get three votes, only one Council Member expressed interest. If DAP were installed at the Civic Center Parking Garage, the Transit Center should follow. They are about 4 blocks away.

Most realize that our climate emergency is getting more acute. However, no city has ever done this, and it is tough to ask an elected official to do something new. Most Climate Action Plans have a Transportation Demand Management (TDM) ordinance, where DAP would fit.

Oceanside has parking meters and pay-station parking close to the Civic Center Parking Garage and close to the Transit Center. Both the parking meter parking and the pay-station parking could be automated with DAP, so the user could take their pick. I predict that younger people would tend to choose DAP; older drivers would tend to use the meters and the pay station. Over time, DAP would win out.

Regarding climate, humanity needs the private sector to do the design and operation of the needed systems (parking and roads.) (Where would we be without Elon Musk?)

Would it be OK for me to disclose your interest in submitting a proposal for a DAP system RFP? Your interest would be important, it seems to me. I have also raised this issue in Encinitas and Carlsbad. Barbara and I were strategizing on how to introduce this to San Diego, when the pandemic hit. San Diego is known to have a poor Climate Action Plan when it comes to driving. Driving is the category that emits the most GHG. A reduction of 10% at a location would be very significant and be a good verification of the system. And employees would have to be pleased with the new system.

The County might be interested, especially if they knew you were interested. DAP was ruled to be a feasible mitigation measure in the lawsuit against their first CAP. There are 3 members on the BOS who claim to be very concerned about climate. You have probably read about their “framework for decarbonization by 2035.” After nearly 10 years of trying, the County still has no legal CAP.

Ukraine (Putin) has presented another argument for having meaningful TDM measures to reduce gasoline use. In any case, any measure adopted would need to increase choice and equity. DAP would do that.

Regards,

Mike Bullock
1800 Bayberry Drive
Oceanside, CA 92054
760-421-9482

Former California Democratic Party Delegate, 76th Assembly District

Former Elected (now Associate) Member of the San Diego County Democratic Party Central Committee

Satellite Systems Engineer, 36 years (Now Retired)

Air and Waste Management Association published and presented papers:

Author, ***The Development of California Light-Duty Vehicle (LDV) Requirements to Support Climate Stabilization: Fleet-Emission Rates & Per-Capita Driving***

Author, ***A Climate-Killing Regional Transportation Plan Winds Up in Court: Background and Remedi****es*

Co-author, ***A Plan to Efficiently and Conveniently Unbundle Car Parking Cost***

From: Keith B. Jones <kjones@aceparking.com>
Sent: Thursday, March 3, 2022 2:06 PM
To: mike_bullock@earthlink.net
Subject: Fwd: FW: Oceanside Transit Center: Housing Retail Office = need for an intelligent car-parking system

Mike,

Good afternoon. Barbara Bry sent me your email regarding Oceanside Transit Center. Is there an RFP for the car parking you suggest I respond to?

Thanks,

Keith

Keith B. Jones
Owner | ACE Parking
ACE Parking
645 Ash Street
San Diego, CA 92101
T: 619.233.6624

---------- Forwarded message ---------
From: **Barbara Bry** <bbry@blackbirdv.com>
Date: Sun, Feb 27, 2022 at 6:36 PM
Subject: FW: Oceanside Transit Center: Housing Retail Office = need for an intelligent car-parking system
To: Keith Jones <kjones@aceparking.com>

Fyi, from Mike Bullock, hope you're having a great time visiting islands!

Barbara Bry

Chief Operating Officer

Chief Financial Officer

Blackbird Ventures

(858) 248-9465

https://www.linkedin.com/in/barbarabry/

From: Mike Bullock <mike_bullock@earthlink.net>
Date: Sunday, February 27, 2022 at 4:24 PM
To: Barbara Bry <bbry@blackbirdv.com>
Subject: Oceanside Transit Center: Housing Retail Office = need for an intelligent car-parking system

http://enewspaper.sandiegouniontribune.com/infinity/article_share.aspx?guid=0dbb7ab6-0514-4bc1-b06b-4d7d1894f882

Please forward this to Keith. Would he submit a response to an RFP if the NCTD issued one for a good car-parking system? This is a bit of a chicken and egg situation.

Putin gives us one more reason to stop using a car-parking system that incentivizes driving. Our climate emergency is all the reason we need.

We need a car parking vendor to take over the world of bad car-parking systems.

Mike

From: Kirsten Uchitel
To: Lauren Lee
Subject: Amendment Comment
Date: Friday, January 27, 2023 11:32:45 AM
Attachments: SANDAG Amended RP scope comments 1.9.23.pdf

From: Robert Efird III <robert.efird@carlsbadca.gov>
Sent: Monday, January 9, 2023 3:39 PM
To: Kirsten Uchitel <kirsten.uchitel@sandag.org>
Cc: Eric Lardy <Eric.Lardy@carlsbadca.gov>; Scott Donnell <Scott.Donnell@carlsbadca.gov>
Subject: City of Carlsbad 2021 Regional Plan Amendment SEIR NOP Comments

Kirsten:

Please see attached for the City of Carlsbad's NOP comments for the 2021 Regional Plan Amendment SEIR.

Please let me know if you have any questions.

Thanks,

City of Carlsbad

Robert Efird, AICP, LEED Green Associate
he/him/his
Principal Planner
Community Development Department
Advance Planning & Special Projects
City of Carlsbad
1635 Faraday Ave.
Carlsbad, CA 92008

www.carlsbadca.gov | robert.efird@carlsbadca.gov
442-339-5148 (o) | 760-602-8560 (f)

City of Carlsbad

January 9, 2023

SANDAG
Attn: Kirsten Uchitel
401 B Street, Suite 800
San Diego, CA 92101

City of Carlsbad comments on Notice of Preparation of Supplement to the Environmental Impact Report for the 2021 Regional Plan

Dear Ms. Uchitel:

Thank you for the opportunity to provide comments on the scope and content of the SEIR underway for an amendment to the 2021 Regional Plan. The amendment is necessary to implement SANDAG Board direction to prepare a focused amendment to the 2021 Regional Plan without the regional road usage charge (Project), and an environmental analysis for the Board's consideration. The city is familiar with the Project and this NOP, having provided comments on the 2021 Regional Plan prior to its adoption and attending the scoping meeting on December 21, 2022. Below are considerations the city would like to submit as SANDAG moves forward with the preparation of its SEIR:

1. At the scoping meeting, SANDAG noted its intent to analyze several environmental topic areas in the SEIR, including air quality, energy, greenhouse gas emissions, noise and vibration, and transportation. Land use as well as population and housing are two other topic areas that should be considered. If the removal of the road user charge may result in further adjustments to SANDAG's land use alternatives to meet Greenhouse Gas reductions, analysis should include a study of inconsistencies and impacts to Carlsbad's adopted land use plans and policies and/or induce unplanned population growth.

2. Please ensure the SEIR considers the impact of proposed alternatives to the city's land use plans, including the General Plan, Habitat Management Plan, and Local Coastal Program.

3. Please ensure the SEIR considers the impact of proposed alternatives to the McClellan-Palomar Airport Land Use Compatibility Plan (adopted by the county Airport Land Use Commission and amended Dec. 1, 2011) and the constraints identified therein. Alternatives included in the previous plan assumed housing in locations that were inconsistent with this plan.

Should you have any questions, please contact me at eric.lardy@carlsbadca.gov or 442-339-2712.

Sincerely,

Eric Lardy

ERIC LARDY
City Planner

From:	Kirsten Uchitel
To:	Lauren Lee
Subject:	2021 Amendment Comment
Date:	Friday, January 27, 2023 11:20:58 AM

From: Tanner Perfect <tperfect2593@gmail.com>
Sent: Friday, December 16, 2022 3:03 PM
To: Kirsten Uchitel <kirsten.uchitel@sandag.org>
Subject: VMT tax

My name is TANNER PERFECT
and I do not agree with or support the proposed
Vehicle Miles Traveled tax.

From:	Kirsten Uchitel
To:	Lauren Lee
Subject:	2021 Amendment Comment
Date:	Friday, January 27, 2023 11:23:18 AM
Attachments:	22.12.21 TDBSANDAG.pdf

From: vote@obsoft.net <vote@obsoft.net>
Sent: Wednesday, December 21, 2022 4:01 PM
To: Kirsten Uchitel <kirsten.uchitel@sandag.org>
Cc: Clerk of the Board <ClerkoftheBoard@sandag.org>; Kirsten Uchitel <kirsten.uchitel@sandag.org>
Subject: Climate Issues

SANDAG,

Please find some recent articles regarding dalting with CLimate Damage for interested parties

Tim Bilash
Del Mar, CA

Comment

Policies that support degrowth include the provision of high-quality, affordable public housing, such as that in Vienna.

Degrowth can work – here's how science can help

Jason Hickel, Giorgos Kallis, Tim Jackson, Daniel W. O'Neill, Juliet B. Schor, Julia K. Steinberger, Peter A. Victor & Diana Ürge-Vorsatz

Wealthy countries can create prosperity while using less materials and energy if they abandon economic growth as an objective.

The global economy is structured around growth – the idea that firms, industries and nations must increase production every year, regardless of whether it is needed. This dynamic is driving climate change and ecological breakdown. High-income economies, and the corporations and wealthy classes that dominate them, are mainly responsible for this problem and consume energy and materials at unsustainable rates[1,2].

Yet many industrialized countries are now struggling to grow their economies, given eco-

pandemic, Russia's invasion of Ukraine, resource scarcities and stagnating productivity improvements. Governments face a difficult situation. Their attempts to stimulate growth clash with objectives to improve human well-being and reduce environmental damage.

Researchers in ecological economics call for a different approach – degrowth[3]. Wealthy economies should abandon growth of gross domestic product (GDP) as a goal, scale down destructive and unnecessary forms of production to reduce energy and material use, projected to cost US$93 billion by 2025, but so far the costs are building slowly enough that members of Congress are allowing NASA small annual budget increases for it. The rise of powerful private companies such as Elon Musk's SpaceX, based in Hawthorne, California, has brought new public enthusiasm for space exploration, as well as new ways of delivering it. NASA has contracted SpaceX to deliver Artemis astronauts to the lunar surface using the enormous Starship, with which Musk dreams of colonizing Mars.

And then there is the looming influence of China, which has just finished building the main phase of its first space station and might be planning to land astronauts on the Moon in the 2030s. To the more hawkish members of the US Congress, sending astronauts to other worlds is once again a geopolitical statement. A not-insignificant reason for the revival of human space exploration is that it is once more being seen as a space race.

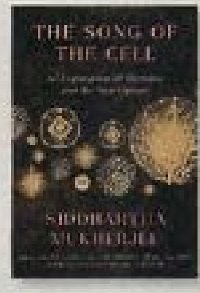
Some remain unconvinced that Artemis is fit for purpose. Critics such as Lori Garver, a former NASA deputy administrator, says the agency could move faster and more nimbly in its partnerships with aerospace companies. Many would prefer NASA to forget deep space and spend more time and money on Earth, including space-based climate monitoring. Such comments echo criticisms from the 1960s, when much of the US public wanted the government to focus not on the space race, but on Earth-bound problems such as civil rights.

Despite those criticisms, the launch of the Artemis I mission on 16 November has given the programme a huge boost. NASA's new Moon rocket – a Frankenstein's creature cobbled together from previous rocket programmes, including the one started by George W. Bush – sent the as-yet uncrewed Orion capsule to orbit the Moon, to see how it would hold up in the hostile environment of deep space. The second Artemis mission should fly around the Moon no earlier than 2024, this time with astronauts on board. The third mission will land people on the Moon – including the first woman and the first person of colour.

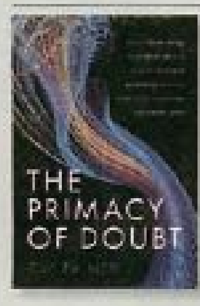
What permanent significance that will have is anyone's guess. But it does mean that, after half a century, we are finally recapturing some of the wonders of human space exploration. We are once again seeing live streams from lunar orbit – not from a robotic orbiter, but from a capsule that is steered remotely by humans and will one day carry them. We are seeing the pale blue dot of Earth, in the cold depths of interplanetary space, in real time, contextualizing our fragile presence on a vulnerable planet. These might be smaller steps for humankind than they once seemed – but they are steps, nevertheless.

Alexandra Witze writes for *Nature* from Boulder, Colorado.

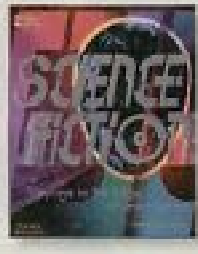
Books in brief



The Song of the Cell
Siddhartha Mukherjee *Scribner* (2022)
In 1837, botanist Matthias Schleiden and zoologist Theodor Schwann saw an "uncanny" microscopic similarity between plant and animal tissues: they had discovered the unity of the cell across living beings. This complex portrait illuminates cells' roles in immunity, reproduction, sentience, cognition, repair and rejuvenation, malfunctions such as cancer, and treatments such as blood transfusions, drawing on author Siddhartha Mukherjee's varied experience as an immunologist, stem-cell scientist, cancer biologist and medical oncologist.

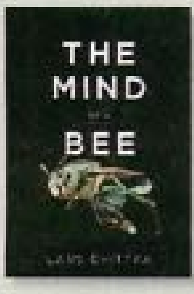


The Primacy of Doubt
Tim Palmer *Basic* (2022)
Anyone intrigued by the uncertainty of weather forecasts will appreciate this important, if complicated, book. Physicist Tim Palmer has spent much of his career researching ensemble prediction – using many models with varying initial conditions, rather than a single model. Here he ranges over climate change, conflicts, consciousness, financial crashes and pandemics. Uncertainty is, he argues, more complicated than is often assumed; in his view, inspired by physicist Richard Feynman, doubt is the primary essence of knowing.



Science Fiction
Ed. Glyn Morgan *Thames & Hudson* (2022)
"Science and science fiction spark off one another endlessly," writes Ian Blatchford, director of the Science Museum Group, in his introduction to this stunningly illustrated companion to an exhibition at London's Science Museum, edited by curator Glyn Morgan. Many scientists have written science fiction, including Isaac Asimov, Arthur C. Clarke, James Lovelock and Carl Sagan. And this can influence science: Clarke's 1965 short story 'Dial 'F' for Frankenstein' helped inventor Tim Berners-Lee to imagine the 1990s World Wide Web.

COVID-19
Hugh Pennington *Polity* (2022)
Perhaps the most remarkable aspect of COVID-19 is the speed of vaccine development. This was enabled by the success of genome sequencing, including the Human Genome Project, essentially completed in 2003. COVID-19 is therefore the first "postgenomic pandemic", notes microbiologist Hugh Pennington in his informative, if sometimes technical, short study. Yet many other aspects resemble previous pandemics, as he discusses – mask wearing caused controversy during the 1918–19 influenza pandemic, for example.



The Mind of a Bee
Lars Chittka *Princeton Univ. Press* (2022)
A bee flying through a meadow is bombarded with stimuli – colour patterns, scent mixtures and electric fields – from multiple flowers of several species. It must attend only to the most productive. While visiting 1,000 flowers, it might reject 5,000 others that are unfamiliar or that it knows to be unrewarding at that time of day. Such facts fill ecologist Lars Chittka's devoted, accessible analysis. They show that bees' minds are much more complex than generally recognized, and might even have consciousness. **Andrew Robinson**

hard drive available to the computer, it could handle the computation in a few days. Now, Pan Zhang, a statistical physicist at the Institute of Theoretical Physics at the Chinese Academy of Sciences, and colleagues have shown how to beat Sycamore in a paper in press at *Physical Review Letters*.

Following others, Zhang and colleagues recast the problem as a 3D mathematical array called a tensor network. It consisted of 20 layers, one for each cycle of gates, with each layer comprising 53 dots, one for each qubit. Lines connected the dots to represent the gates, with each gate encoded in a tensor—a 2D or 4D grid of complex numbers. Running the simulation then reduced to, essentially, multiplying all the tensors. "The advantage of the tensor network method is we can use many GPUs to do the computations in parallel," Zhang says.

Zhang and colleagues also relied on a key insight: Sycamore's computation was far from exact, so theirs didn't need to be either. Sycamore calculated the distribution of outputs with an estimated fidelity of 0.2%—just enough to distinguish the fingerprintlike spikiness from the noise in the circuitry. So Zhang's team traded accuracy for speed by cutting some lines in its network and eliminating the corresponding gates. Losing just eight lines made the computation 256 times faster while maintaining a fidelity of 0.37%.

The researchers calculated the output pattern for 1 million of the 9 quadrillion possible number strings, relying on an innovation of their own to obtain a truly random, representative set. The computation took 15 hours on 512 GPUs and yielded the telltale spiky output. "It's fair to say that the Google experiment has been simulated on a conventional computer," says Dominik Hangleiter, a quantum computer scientist at the University of Maryland, College Park. On a supercomputer, the computation would take a few dozen seconds, Zhang says—10 billion times faster than the Google team estimated.

The advance underscores the pitfalls of racing a quantum computer against a conventional one, researchers say. "There's an urgent need for better quantum supremacy experiments," Aaronson says. Zhang suggests a more practical approach: "We should find some real-world applications to demonstrate the quantum advantage."

Still, the Google demonstration was not just hype, researchers say. Sycamore required far fewer operations and less power than a supercomputer, Zhang notes. And if Sycamore had slightly higher fidelity, he says, his team's simulation couldn't have kept up. As Hangleiter puts it, "The Google experiment did what it was meant to do, start this race." ■

U.S. CLIMATE POLICY

Ambitious bill leads to 40% cut in emissions, models show

But more action is needed to reach Biden's pledge to halve greenhouse gas emissions by 2030

By **Erik Stokstad**

For climate advocates in the United States, the past month felt like a roller coaster. In early July, negotiations in Congress on clean energy legislation of historic proportions collapsed, and the effort seemed doomed. But backroom talks continued and last week key senators suddenly announced an agreement on a $369 billion bill that would provide the most climate funding ever seen in the United States. "It was the best kept secret, potentially, in Washington history," says Leah Stokes, a political scientist at the University of California (UC), Santa Barbara.

The backers—Senate Majority Leader Chuck Schumer (D-NY) and Senator Joe Manchin (D-WV)—who had initially balked at the cost—announced that the draft bill would ensure U.S. carbon dioxide (CO_2) emissions would fall by 40% by 2030, compared with 2005.

Sponsors of the bill, which must still pass the full Senate and the House of Representatives, might be expected to oversell its impact. But energy and climate modelers have now scrutinized its 725 pages and concluded the 40% claim is about on target. They plugged major provisions, including subsidies for renewable energy and tax cuts for electric vehicles, as well as controversial incentives for the fossil fuel industry, into their models. Three models now agree that if the bill's provisions are carried out, U.S. greenhouse gas emissions would fall by perhaps 40% by 2030, although only part of that stems from the bill alone. One model also finds that the renewable energy subsidies will likely create 1.5 million jobs and prevent thousands of premature deaths from air pollution, especially in disadvantaged communities.

"It's a historic step, no doubt about it," says Marshall Shepherd, an atmospheric scientist at the University of Georgia and former head of the American Meteorological Society. "It really does a lot to enhance the transition to a renewable energy economy."

U.S. emissions have been falling by about 1% per year since 2005, when they peaked, largely because of replacing coal power with wind and solar, as well as natural gas, and rising fuel economy in light cars. But this pace is nowhere near fast enough to meet President Joe Biden's goal of a 50% to 52% cut in emissions by 2030 relative to 2005. Officials pledged that dramatic

Research highlights

SHARP LASER BEAM IMAGES ORGANS IN EXQUISITE 3D DETAIL

A needle-shaped laser beam boosts the performance of a biomedical imaging method called photoacoustic microscopy.

Photoacoustic microscopy uses laser-induced vibrations in biological tissue to make images of that tissue's structure. The method has many applications, from detecting blood-flow dynamics to identifying cancer cells. But it has a disadvantage. Its depth of field — the distance between the closest and farthest objects that are in focus — is quite limited. As a result, it can usually visualize only one thin layer of tissue in high resolution at a time.

Rui Cao at the California Institute of Technology in Pasadena and his colleagues developed a type of photoacoustic microscopy that uses a long, ultra-thin laser beam. They found that this approach provides a depth of field that can be up to 14 times longer than previously achieved. Consequently, the method can generate high-resolution images of samples with uneven surfaces and high-quality 3D depictions of organs.

The researchers say that using a similar needle-shaped laser beam in other microscope technologies could also improve their depth of field.

Nature Photon. https://doi.org/grc2zk (2022)

TURKISH CARVINGS COULD BE FIRST COMIC STRIP

An 11,000-year-old carving in Turkey is the earliest known portrayal of a narrative scene.

Archaeologists have uncovered other etched images in southeastern Turkey from the Neolithic period, which in the Near East stretched roughly from 10,000 BC to 7,000 BC and includes the transition from nomadic life to settlements. But, unlike previously identified images, the latest discovery consists of two adjacent panels with a progressing storyline.

Eylem Özdoğan at Istanbul University in Turkey found the panels carved on the side of a limestone bench while excavating a building at the Sayburç archaeological site. The right panel features a male figure facing forwards, its shape protruding from the flat surface. The individual is flanked on each side by a leopard gazing towards it (pictured). In the left panel, another male figure holds a snake or rattle while approaching a bull.

Because the panels sit side by side and portray similar narratives — people encountering dangerous animals — they probably represent a progressing scene from a story. The author says that these works are the first known examples of an extended narrative.

Antiquity **96**, 1599–1605 (2022)

PERSONALIZED T CELLS TACKLE DEADLY SKIN CANCER

In a clinical trial, personalized anti-cancer treatment prolonged the time that people with advanced melanoma live without further tumour spread.

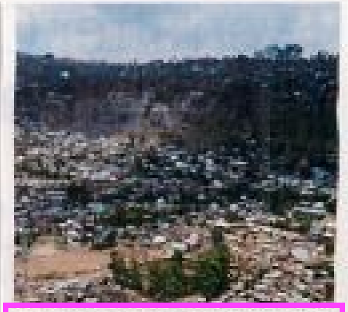
For therapy based on tumour-infiltrating lymphocytes (TILs), immune cells called T cells are harvested from a person's tumour and multiplied in the laboratory. The patient has chemotherapy to kill their remaining T cells and then gets an infusion of the lab-grown cells.

Maartje Rohaan at the Netherlands Cancer Institute in Amsterdam and her colleagues ran a clinical trial to compare TILs therapy with ipilimumab, a standard immune-boosting therapy for late-stage melanoma (pictured, a melanoma cell). Both treatment groups contained 84 people.

In the 6 months after treatment, tumours disappeared in 20% of people who received TILs and in 7% of those who took ipilimumab. In the same period, there was no tumour spread in 53% of those who had TILs and 21% of those who took ipilimumab.

The results suggest that TILs therapy can be used as a first- or second-line treatment for people with advanced melanoma.

N. Engl. J. Med. **387**, 2113–2125 (2022)



SLUGGISH LANDSLIDE SPEEDS UP AS CITY EXPANDS

A slow-motion landslide has been creeping for decades down the hills of Bukavu in the Democratic Republic of the Congo — but it is accelerating as the city grows.

Bukavu's population has more than quadrupled since 1995, driven in part by people fleeing violence in nearby regions. The city (pictured) was founded on the shores of Lake Kivu and has sprawled uphill. One-third of Bukavu is built on large, deep landslides, some of which are still active.

Antoine Dille at the Royal Museum for Central Africa in Tervuren, Belgium, and his colleagues used images from satellites and aeroplanes to study seven decades of activity of a large landslide in Bukavu. They found that over the decades, the slide has been gradually speeding up, particularly after changes in the flow of groundwater near the surface.

But the city's growth has accelerated that destabilization: the spread of buildings and roads changes how water drains. Residents could reduce the risk of a devastating fast collapse by improving the flow of surface water, the authors say.

Nature Geosci. **15**, 1048–1055 (2022)

Comment

Steel coils in a plant in Duisberg, Germany, produced using methods with low carbon dioxide intensity.

Going net zero for cement and steel

Paul Fennell, Justin Driver, Christopher Bataille & Steven J. Davis

It is possible – and crucial – to green the building blocks of the modern world.

Cement and steel are essential ingredients of buildings, cars, dams, bridges and skyscrapers. But these industries are among the dirtiest on the planet. Production of cement creates 2.3 billion tonnes of carbon dioxide per year, and making iron and steel releases some 2.6 billion tonnes – or 6.5% and 7.0% of global CO_2

That's in part owing to the large quantities in which these materials are used: concrete is the second-most-consumed product on the planet, after clean water. It's also thanks to their carbon-intensive methods of production. The chemical reactions involved give off CO_2, as does burning fossil fuels to deliver the extreme temperatures required in the manufacturing processes.

Cleaner ways of making and using cement and steel are urgently needed. The world must reach net-zero carbon emissions by 2050, even as industrial demand is growing and energy prices are spiking. Infrastructure, technology transfer and mechanisms for reducing financial risks must be established to allow

Here, we highlight nine priorities for research and action. Steel manufacturing processes need a rethink; cement's biggest gains will require carbon capture and storage (CCS). Together, these steps could take steel close to being carbon neutral and cement to becoming a carbon sink.

Use the latest technologies

Ensuring that production plants are fitted with the best available technology offers immediate gains. Improving insulation of industrial plants can save 26% of the energy used; better boilers cut energy needs by up to 10%; and use of heat exchangers can decrease the power demands of the refining process by 25% (ref. 2). Old, more modern facilities, so industries become more efficient over time. However, gains diminish as industries mature and improvements become incremental. Today, the most efficient cement plants can squeeze only 0.04% of energy savings per year by upgrading technologies[3]. More needs to be done.

Use less

Smaller quantities of steel and cement can be used for the same job. Today, the world produces 530 kilograms of cement and 240 kilograms of steel per person per year. Small but significant changes to building codes and education for architects, engineers and contractors could reduce demand for cement by up to 26% and for steel by 24%, according to the International Energy Agency[4]. Many building codes rely on over-engineering for safety's sake. That margin could be limited by using modern materials and computer modelling to whittle down designs to use only the necessary amount of resources. Alternative materials with a smaller carbon footprint for a given use, such as aluminium, might replace steel in some products, including cars. Professionals would have to shift their practices and re-train.

Reinvent steel production

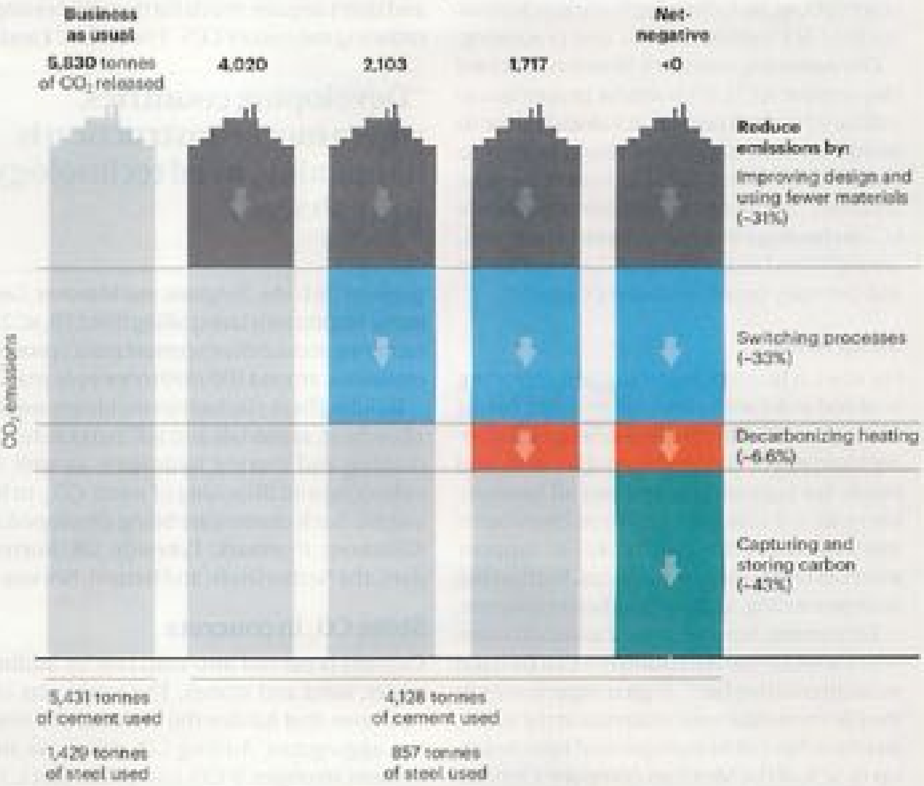
Carbon is at the core of conventional steel production. Coke (derived from coal) fuels blast furnaces in which iron ores are chemically reduced to metallic iron at temperatures of up to 2,300 °C. Coke burns to produce carbon monoxide, which reduces the ore to iron and CO_2. Molten iron is then refined into steel, usually in a coal-fired furnace, but sometimes (especially when recycling scrap) in an electric arc furnace (EAF). The process emits about 1,800 kilograms of CO_2 or more per tonne of steel.

Other substances can be used to reduce the ores. About 5% of the world's steel is already made through 'direct reduced iron' (DRI) processes that don't require coke and typically use hydrogen and CO (derived from methane or coal). By using methane-derived gas and renewable electricity to power an electric furnace, such steel plants emit about 700 kilograms of CO_2 per tonne of steel[5] – 61% less than coke-based ones.

Better still, using only hydrogen for DRI should reduce CO_2 emissions to 50 kilograms or less per tonne of steel – a 97% reduction. Firms in Europe, China and Australia are piloting such plants, with several slated to open in 2025 or 2026. The challenge is that this process requires a lot of hydrogen.

DECARBONIZING A SKYSCRAPER

It takes around 5,400 tonnes of cement and 1,400 tonnes of steel to construct a 30-storey high-rise building that is about 100 metres tall. Producing these materials releases 5,830 tonnes of carbon dioxide. That can be brought to below zero by four steps: using fewer materials, switching production processes, using low-carbon heat sources and carbon capture and storage.



almost tripling global hydrogen production, from 60 to around 135 million tonnes annually. And most cheap hydrogen today comes from natural gas, which releases CO_2. A greener option – splitting water with electrolysers – is around 2.5 times as expensive. Costs should come down as more plants are built.

> **"Together, these steps could take steel close to being carbon neutral and cement to becoming a carbon sink."**

Other options are worth pursuing. In 2004, the Ultralow-CO_2 Steelmaking Consortium – 48 companies and organizations in 15 European countries – evaluated the options. Tata Steel, based in Jamshedpur, India, built a pilot plant in 2010 in the Netherlands for one advanced steel-making process, still based on coal but simplified to make carbon capture easier. The falling price of green hydrogen – produced using renewable energy – is now

One promising alternative to hydrogen is using electricity to reduce iron ore through electrolysis. This method is being explored by Boston Metal in Massachusetts, and Luxembourg-based Arcelor Mittal.

Reinvent cement

Production of ordinary Portland cement – the most common type of cement – begins with the calcination of limestone, which is heated to temperatures above 850 °C to form lime and CO_2. The lime is combined with sand and clay in a 1,450 °C kiln to create clinker. A few other ingredients are mixed in to make cement. About 60% of the emissions from a top-quality plant come from the calcination reaction, and most of the rest from burnt fuel. In total, the process produces about 800 kilograms of CO_2 per tonne of cement[6] in an average plant, and 600 kilograms in a best-in-class plant.

Cement can be made without limestone. Magnesium oxychloride cement (called sorel), for example, has been around since 1867, but it hasn't been commercialized because it has a low water tolerance. Dozens of cement varconstruction, however, building codes, designs and practices will have to be altered to account for these materials' different strengths and properties. This will take more than a decade.

Another option is replacing some of the clinker with more sustainable materials[7]. Common ones include blast-furnace slag and ash from coal-fired power stations. But those materials will become scarce when fossil fuels are phased out. Researchers are investigating other options, including slag from recycled iron made in EAFs and from DRI EAF steel processing.

One promising example is limestone calcined clay cement (LC^3). With similar properties to ordinary Portland cement, it's already close to being commercialized and would be easy to switch to. Up to half of the clinker in it can be replaced[8]. Some companies already include LC^3 technology in their net-zero strategies, among them French company LafargeHolcim and Germany-based Heidelberg Cement.

Swap fuels

For steel, it is tempting to suggest replacing coal and coke with charcoal or other forms of biomass. But there are challenges. Growing biomass for energy can conflict with land needs for agriculture, and not all biomass harvests are sustainable. Wood charcoal is too weak (compared with coke) to support material layers in blast furnaces. Rethinking steel processing, as above, is a better solution.

For cement, however, municipal solid waste – or carefully sorted rubbish – can be used as an alternative fuel[9]: high temperatures in the kiln incinerate toxic materials in the waste, and the ashes can be incorporated into clinker. Up to 57% of the Mexican company Cemex's energy in cement plants in the United Kingdom is derived from these alternative fuels, and UK company Hanson's alternative-fuel consumption is at 52%. This strategy should be encouraged, including by passing appropriate regulations at a national level.

Capture carbon

CCS – taking CO_2 and locking it away underground – will be essential to lowering cement-production emissions, and is important for steel, too.

CCS is relatively advanced in some other industries. The Norwegian state oil company Equinor has operated a CCS project since the late 1990s, burying around one million tonnes of CO_2 per year. But the technology is underused; just 0.1% of all global emissions are currently captured and stored. Only a few steel and concrete plants are trialling CCS. For example, one modern DRI steel plant in Abu Dhabi has used CCS since 2016. CCS must be scaled up rapidly.

One major issue is that the stream of CO_2 needs to be more than 99.9% pure to reduce costs for compressing and storing the gas. Typical steel- and cement-plant flues consist of about 30% CO_2; the cost is mainly nitrogen and steam. One option for the cement industry is to burn fuel in a mixture of oxygen and recycled flue gas, leaving a relatively pure stream of CO_2. But this is challenging: it involves sealing a very hot, rotating kiln.

Another way to isolate CO_2 from the calcination process is to heat the limestone indirectly (through a wall) so that emissions from heating are separated from those from the limestone. The emissions from limestone are nearly pure and don't require much further processing, reducing the cost of CCS. The LEILAC 1 and 2 projects (in Lixhe, Belgium, and Hanover, Germany, respectively) are trialling this: LEILAC 2 is capturing about 20% of a cement plant's process emissions, around 100,000 tonnes per year[10].

> **"Developing countries, where most construction is happening, need technology to be shared."**

Building heavy industries in clusters would allow heat, materials and infrastructure for making and storing hydrogen, as well as collecting and disposing of waste CO_2, to be shared. Such clusters are being developed at Kalinborg, Denmark; Tyneside, UK; Rotterdam, the Netherlands; and Bergen, Norway.

Store CO_2 in concrete

Cement is turned into concrete by adding water, sand and stones. The water sets off reactions that harden the material and bind the aggregates. Adding CO_2 can make the cement stronger. If CO_2 comprises just 1.3% of the weight of concrete, the material's hardness can increase by around 10%. That reduces the amount of cement needed in a structure – along with net emissions – by about 5%.

Optimizing carbon capture in concrete is an active area of research. Leaders such as CarbonCure in Dartmouth, Canada, are already injecting CO_2 in concrete at a large scale: it reports that it has delivered nearly 2 million truckloads of CarbonCure concrete, saving 132,000 tonnes of CO_2.

Cement and concrete both absorb CO_2 from the air by converting calcium-based components back into limestone. The potential there is huge: in theory, roughly half of the process CO_2 emissions from cement manufacturing could be re-absorbed. But the materials would have to be ground up at the end of their lives to make the concrete particles smaller so that CO_2 can diffuse in better. That's expensive – and it requires energy.

Because the amount of CO_2 that could be taken up by crushed concrete is uncertain, this is not yet included in emissions inventories from the United Nations Framework Convention on Climate Change. But the UK government is looking into it, in collaboration with the Mineral

Products Association in London, and the Globa Carbon Project has begun including it in it annual carbon budgets. We urge caution, t avoid disincentivizing CCS and more traceabl means of reducing cement's carbon footprint

Recycle steel

Steel can be efficiently recycled using an EAF One-quarter of steel production today is base on recycled scrap. Globally, recycled produc tion is expected to double by 2050 (ref. 11) reducing emissions by 20–25% from today (depending on how the electricity is produced)

However, it is not currently possible to recy cle steel endlessly. 'Tramp' species – undesir able compounds (particularly copper) – build up. Their accrual can be slowed by better sort ing scrap and by redesigning products so tha copper wiring is easier to remove.

Subsidize changes

Together, the potential of these eight steps is vast (see 'Decarbonizing a skyscraper'). Bu further economic hurdles must be overcome i low-carbon heavy industries are to reach meg atonne-per-year scales of production.

Limestone is the source of most of the carbon dioxide emissions from cement production.

Hydrogen-only DRI plants for steel and CCS facilities for cement exist only at pilot to early commercial stages. Scaling them up is expensive and risky. Low-carbon products lack competitive advantage and markets. Developing countries, where most construction is happening, need technology to be shared and implementation of mechanisms to lessen financial risks.

One step in the right direction is a small refund under the European Union Emissions Trading Scheme (ETS) for swapping fossil fuels with biomass or hydrogen, or for undertaking CCS. That's not enough. Conditional, scaled government subsidies – similar to feed-in tariffs, which incentivize investment in wind and solar technologies – would be more effective[12].

Full decarbonization with CCS is expected to double the cost of Portland cement, now about US$100 per tonne. Cement subsidies would need to match that. Zero-emissions steel is expected to cost 20–40% more than standard steel, which is typically about $600 per tonne – so steel subsidies would need to reach $240 per tonne. For the EU, we estimate that could cost up to $200 billion over 10 years.

Governments could use tax or ETS revenue to fund those costs. Users and manufacturers will be less affected. Decarbonized steel would add just 0.5–2% to the price of a vehicle, and up to 15% of the cost of constructing a building (which itself is only 1–3% of total property value)[13].

Policies should be put in place to encourage these developments. The time has come for steel and cement production to help, rather than hinder, the race to net zero.

The authors

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The authors declare no competing interests.
Supplementary information accompanies this article: see

Comment

A gas flare at an oil well in North Dakota.

Make greenhouse-gas accounting reliable – build interoperable systems

Amy Luers, Leehi Yona, Christopher B. Field, Robert B. Jackson, Katharine J. Mach, Benjamin W. Cashore, Cynthia Elliott, Lauren Gifford, Colleen Honigsberg, Lena Klaassen, H. Damon Matthews, Andi Peng, Christian Stoll, Marian Van Pelt, Ross A. Virginia & Lucas Joppa

Global integrated reporting is essential if the planet is to achieve net-zero emissions.

In March, the United Nations took its first meaningful step to hold investors, businesses, cities and regions accountable for reducing greenhouse-gas emissions, when UN secretary-general António Guterres asked an expert panel to develop standards for 'net-zero' pledges by these groups. A challenge now is how to count emissions coherently.

Nations, companies and scientists each use different, disjointed methods to tally greenhouse-gas emissions. These numbers cannot easily be compared or combined. The existing patchwork of greenhouse-gas inventories is woefully inadequate. From governments to businesses, information on these emissions is inconsistent, incomplete and unreliable.

To design effective carbon taxes, border tariffs and other zero-carbon policies or investments, the numbers need to be reconcilable across all levels, from product supply chains all the way up to planetary scale. The sum of national emissions should tally with growth in atmospheric carbon dioxide and estimates of carbon sinks.

We are researchers and practitioners from academia, industry and non-profit organizations who have developed a vision for an integrated global system of greenhouse-gas 'ledgers' that can balance the books of emissions and removals across the planet. Using interoperable accounting methods adapted from the financial sector, this system must create inventories of greenhouse gases emitted by nations and companies, catalogue emissions embodied in global supply chains and track fluxes of these gases in and out of ecosystems. Recent advances in remote sensing and digital technologies put this vision within reach. Here we outline a road map for doing so.

Global patchwork

Greenhouse-gas accounting is the measurement, analysis and reporting of data on emissions and removals of gases such as CO_2

and methane that cause climate change. The atmospheric concentration of greenhouse gases is the bottom line. It holds humanity to account for how we use our remaining 'carbon budget' – the total amount of CO_2 that can be emitted over a period of time while avoiding a dangerous rise in global temperatures above a certain threshold.

Scientists monitor global carbon sources and sinks. For example, the Global Carbon Project measures, analyses and reports flows of CO_2, methane and nitrous oxide into and out of the atmosphere from human activities (such as transport, industry and land use) and natural environments (such as forests, soils and oceans)[1].

At the national level, governments follow UN guidelines to self-report emissions from human activities in their territories. Most rely on tables of 'emissions factors' for these calculations. These factors give typical rates of greenhouse-gas emissions for various activities, such as using different energy sources or producing particular farm crops.

Businesses, cities and other non-state actors follow other standards adapted from UN guidelines (such as ghgprotocol.org). These also rely on emissions factors to count direct and indirect emissions from supply chains and the use of products. For example, when a company makes a pair of jeans, it must account for its own emissions from sewing and delivering the trousers to stores. It should also count emissions from growing the cotton and converting it to fabric, as well as laundering by the consumer and the ultimate disposal of the clothing. Often, more than 80% of a company's emissions are indirect.

Inconsistent and incomplete ledgers, among both businesses and governments, prevent accurate assessments of decarbonization policies and investments. For example, adding ethanol produced from maize (corn) to petrol might not provide any carbon benefit when emissions from land-use change and other activities involved in its production are accurately counted[2].

Reliability constraints

Emissions of CO_2 from fossil fuels and industry can be tallied with relatively high confidence. But it is difficult to account reliably for non-CO_2 gases and for emissions across the land sector and in supply chains and carbon offsets (see 'Carbon accounting: five fixes'). Inventories are rife with measurement errors, inconsistent classification and gaps in accountability.

Poor data can lead to inaccurate emission factors, such as when emissions are measured at only a few locations over brief time intervals. For example, one analysis in February used the latest satellite data to show that methane emissions from the energy sector were 70% higher than those reported by national accounts, which use emissions factors that are based on

from fossil-fuel operations[3].

Data gaps and inconsistent application of accounting standards lead to widespread undercounting of emissions. For example, only one-third of suppliers provide information on their indirect emissions to customers[4], leading companies to report different levels of emissions for similar activities. In the technology sector, proper inclusion of indirect emissions from purchased goods and product usage can double emissions estimates[4].

Inconsistent classifications make it hard to compare emissions. For example, following UN guidelines, many national inventories classify conservation areas as managed lands. The carbon absorbed there is then considered as human-derived removal, which can be used to offset fossil-fuel emissions. Scientists, by contrast, classify emissions and removals from conservation lands as natural[5].

Ambiguity in human versus natural sources of some emissions leads to gaps in accountability. For example, wildfire emissions are typically classified as natural, and are thus not counted in national, provincial or corporate ledgers, even though they can be significant[6]. According to California's Air Resources Board, the state's emissions from wildfires in 2020 exceeded those generated from electricity. In Canada in 2018, British Columbia's wildfires emissions were three times greater than all other emissions in the province combined (see go.nature.com/3zewvna).

The atmospheric impact of nature-based carbon removal is poorly quantified. For example, evaluations of steps to increase forest cover must account for the possibility that such changes might have occurred anyway, that they might be reversed by fire, or that they could cause more forest clearance elsewhere. These risks are captured inconsistently in current accounting practices[7].

Insufficient transparency creates opportunities for misrepresentation, by making it difficult to use scientific observations to verify emissions reported by businesses. For instance, in 2021, the Oil and Gas Climate Initiative, which represents about 30% of oil and gas producers globally, reported that methane emissions by its members were 0.2% of gas production[8]. Without disclosure of the underlying data, this low value is difficult to reconcile with scientific assessments, which range from 3.7% (ref. 9) to 9.4% (ref. 10) of gas production in different regions.

Scientific uncertainties limit how observations can be used for verification. For example, the amount of carbon taken up by forests and soils can vary from year to year in ways that are difficult to predict, and can differ by more than annual increases in human-caused emissions[11].

There is also little oversight. Under the Paris climate agreement, nations' self-reported emissions are reviewed but rarely verified independently. For companies, nearly all greenhouse-gas reporting is voluntary and not externally reviewed.

Some progress

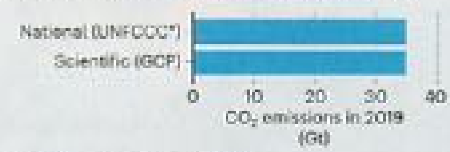
Things are getting better. At the UN's COP26 climate meeting in November 2021, new rules were established to prevent double counting in international carbon-offset markets. The International Sustainability Standards Board (ISSB) was launched to support the financial sector in reporting sustainability metrics consistently. In 2023, the Greenhouse Gas Protocol will issue corporate-accounting guidance for land use and carbon removal.

CARBON ACCOUNTING: FIVE FIXES

The following steps will lead to better accuracy.

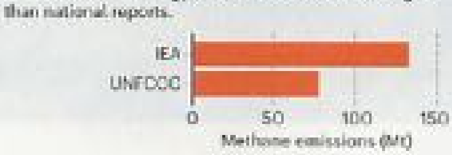
Use reliable measures

Carbon dioxide emissions from fossil fuels, based on the type and quantity of fuel combusted, are reliably measured across national and scientific inventories.



Invest in new data streams

Using satellite data, the IEA showed that global methane emissions in the energy sector in 2021 were 70% higher than national reports.



Harmonize reporting practices

Businesses struggle to track emissions along their value chains. Consistent reporting requirements would help.

Use consistent classifications

National inventories classify carbon absorption in conservation areas as human-derived, reducing their overall tally for human-derived emissions.

Narrow scientific uncertainties

Natural variations in yearly CO_2 absorption by land complicates detection of anthropogenic emissions and removals. Monitoring and modelling can help.

*UNFCCC, UN Framework Convention on Climate Change; GCP, Global Carbon Project; Gt, gigatonnes; IEA, International

Smoke from wildfires plagued San Francisco in September 2020. The effect on regional emissions tallies can be significant.

this year, the US Securities and Exchange Commission proposed a rule mandating that corporations disclose information on their emissions; the United Kingdom and European Union are advancing similar rules.

And scientific uncertainties are narrowing. Satellites can now provide measurements of atmospheric greenhouse-gas concentrations almost in real time. Remote sensing and advanced analytics help to track terrestrial emissions more accurately, with increasing global coverage[12].

Digital tools that automate greenhouse-gas accounting are proliferating. Platforms are emerging from companies such as SAP, Salesforce and Microsoft (where A.L. and L.J. work) to allow businesses to combine data on their activities with emissions factors compiled from government, private and non-profit sources. These tools are reducing the time and expertise needed for such accounting.

But much work remains. Even with improved standards and mandatory reporting, many companies and nations might not have the resources to be able to comply. Digital platforms are at risk of facilitating inaccurate emissions accounting if underlying data are unreliable. National and corporate accounting systems often use outdated emissions factors and data. Scientific studies are often misaligned with national and corporate accounting needs. Data across corporate, national and planetary ledgers are difficult to compare, combine and share.

Global integration

We propose a more holistic approach, in which

company, city or nation — is one node of an interconnected global system. From consumers choosing low-carbon products to nations imposing regulations on trade, decisions require information drawn from multiple ledgers to reliably assess the consequences for the planetary carbon budget. For example, emissions data from thousands of products and companies would be needed to fully implement a carbon border adjustment mechanism. (This levies a carbon tariff on imports to protect domestic companies from competition by producers in countries with weaker climate policies.)

Interoperability is key. The capacity to exchange data and process information from multiple sources is essential for integrated emissions accounting, just as it underpins the financial sector[12]. Most businesses worldwide use the eXtensible Business Reporting Language (XBRL) for digital financial reporting to regulators and investors. XBRL, which is free and managed by an international not-for-profit consortium, provides an open standard for defining terms, exchanging data between information systems and creating shared, searchable data repositories. With XBRL, financial information can be rapidly and accurately aggregated, transmitted and analysed. This facilitates transactions across borders, enables peer-to-peer transactions and extends access to the financial system to communities that are underserved by banks.

A similar system for greenhouse-gas accounting, with emissions data for products held in interoperable repositories, would make it easier to track emissions across value chains.

direct purchasing and investment towards low-carbon innovations more effectively. Interoperability would allow reporting platforms to access the most current and reliable data. Oversight and accountability would be improved. Greater transparency would build public confidence.

Scientists would gain access to larger, more compatible data sets at higher temporal and spatial resolution. Artificial intelligence (AI) and machine learning could be used, for example, to update and tailor emissions factors to changing conditions and local contexts. As a result, forecasting of the impacts of policies and climate change itself would improve.

Next steps

Four components are essential for this system to work.

Data. Researchers and practitioners need to assess the opportunities for and constraints on improving the quality of data and data products in greenhouse-gas accounting, especially concerning land, non-CO_2 gases, offsets and indirect emissions. Those engaged in all aspects of greenhouse-gas measurement, accounting and reporting, from product to planetary scales, should first identify which data gaps most undermine the reliability of emissions accounting. They should ask: where should investments in research and development be targeted to close gaps? What are the best prospects for improvements using the latest technologies? How can new data streams and knowledge be most rapidly integrated into emissions-accounting infrastructure? And how

Interoperability. Protocols and principles for enabling the interoperability of a digital infrastructure for greenhouse-gas accounting need to be agreed. This should be done in an open and inclusive process overseen by an independent governing body, such as the ISSB in partnership with the UN.

Three sets of protocols will be needed. First, technical and syntactic rules are required that specify how information is to be read by humans and machines. Data must be formatted for seamless exchange between ledgers, platforms and data libraries. A starting point could be the Sustainability Accounting Standards Board's proposed XBRL-based guidelines for corporate sustainability reporting.

Second, there need to be clearer definitions of the myriad metrics and terms used so that systems can unambiguously exchange information — known as semantic interoperability. Examples include how uncertainty is quantified, how offsets are classified and how emissions are parsed between managed or unmanaged lands. An ontology will be required to align the meanings of terms. A common set of metrics must be agreed, which will provide the greenhouse-gas record of any entity. This would mirror the US health sector's Common Clinical Data Set for any patient.

Third, protocols and principles for institutional interoperability are needed. These include policies and regulations to facilitate data exchange across borders and between companies. Different frameworks need to be harmonized. Decisions need to be made on how to govern AI and distributed digital ledgers (such as blockchain) within the system.

Trust. Greenhouse-gas reports must be trusted by decision-makers, regulators and the public. Transparency is key. Data on emissions, removals and progress by nations and companies towards their commitments should be publicly available in an interoperable, machine-readable form. This could be achieved by collecting emissions reporting in one global registry, or in an interoperable network of national registries (through the UN Framework Convention on Climate Change) and sectoral ones (such as the disclosure system CDP; https://cdp.net). Open access to data would enable independent verification, for example by comparing reported emissions with satellite-based measurements, as the Verify project has done for countries in the EU from 2018 to 2022 (see https://verify.lsce.ipsl.fr).

Although companies have legitimate privacy concerns related to business operations, these could be overcome by standards for emissions audits that maintain confidentiality. Audits must go beyond confirming that the correct procedures were followed, and should encompass checks on the quality and completeness of the data. Transparency and independent verification are needed to assure the trustworthiness of emissions data, as well as the emissions factors and other data products used in accounting.

Finance. New funding models are needed to support the generation of emissions data and information products as digital public goods. Current models have limitations. For example, private satellite services delay the release or degrade the resolution of public versions to protect profits. And government research and philanthropic seed money are neither sufficient nor appropriate for operationalizing emissions data and accounting services.

Public–private partnerships could offer a solution. For example, the US National Weather Service uses application programming interfaces to make real-time data available to businesses that package and market data products to consumers. Philanthropists fund collaborations between academic, government and industry partners, such as MethaneSat, Carbon Monitor and Carbon Mapper, to track methane and CO_2 emissions. Blended-finance models, which leverage public funds and loan guarantees to reduce risk and attract capital investment to sustainable development projects, could be adapted for greenhouse-gas information systems. Challenges to be overcome include intellectual-property rights and data sovereignty.

> **"Transparency and independent verification are needed to assure the trustworthiness of emissions data."**

Such steps will make greenhouse-gas accounting more reliable. That alone won't solve the climate crisis, but it is essential for implementing strategies that could.

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Atmospheric science

Cause of the 2020 rise in atmospheric methane

George H. Allen

Atmospheric methane concentrations rose unexpectedly during the lockdowns of 2020. It now seems that this was due to warm, wet weather in the Northern Hemisphere and, ironically, a slowdown in air-pollutant emissions. See p.477

The mysterious acceleration in the growth of atmospheric levels of methane (CH_4) in 2020 received widespread media attention and has been a topic of ongoing speculation (see go.nature.com/3xvv5at). This acceleration was puzzling, considering that methane emissions decreased as a result of the economic slowdown during the COVID-19 pandemic lockdowns. On page 477, Peng *et al.*[1] make considerable headway in explaining the cause of the phenomenon.

Methane is a potent greenhouse gas that is responsible for about one-fifth of the atmospheric warming associated with human activities[2]. Its atmospheric concentration has nearly tripled since pre-industrial times, from 700 parts per billion (p.p.b.) to more than 1,900 p.p.b. today[3] (see also go.nature.com/3xmldx4). During 2007–19, the concentration rose at a rate of 7.3 ± 2.4 p.p.b. per year. Then, in 2020, the methane growth rate increased dramatically to 15.1 ± 0.4 p.p.b. per year. This jump surprised some scientists, given that the pandemic lockdowns were thought to have reduced anthropogenic methane emissions.

Knowledge of the sources and sinks of methane in the atmosphere is key to understanding the causes of changing methane concentrations. The largest sources of methane in the atmosphere are wetlands, freshwater areas, agriculture, fossil-fuel extraction, landfills and waste, and fires[2]. Once in the atmosphere, methane persists for an average of nine years (ref. 4) before it breaks down through reaction with short-lived hydroxyl radicals (OH*), which are the main sink for methane. Small changes in OH* concentration cause large changes in the methane sink.

Peng *et al.* analysed the causes of the anomalously high atmospheric methane growth observed in 2020 by combining two approaches: bottom-up and top-down methane estimates. Bottom-up estimates involve using inventories of methane sources and sinks and then applying process-based models to estimate the amount of methane entering and exiting the atmosphere. Top-down estimates typically use an atmospheric-inversion model to infer the spatial distribution of methane fluxes by extrapolating from observations of atmospheric methane.

By updating and expanding bottom-up inventories, Peng *et al.* show that there was only a slight decrease in anthropogenic methane emissions (those associated with fossil fuels, agriculture, landfill and waste) in 2020 compared with 2019. Wetland emissions rose sharply because of unusually warm and wet weather in the Northern Hemisphere, especially in the Arctic, whereas emissions due to fires dropped in 2020. Emissions from other natural sources of methane (freshwater and melting permafrost) remained relatively unchanged. Cumulatively, the bottom-up estimates account for only about half (47 ± 16%) of the observed increase in atmospheric methane growth rate from 2019 to 2020.

To assess the changes in the atmospheric methane sink in 2020, the authors adopted a top-down approach using an atmospheric-inversion model to simulate the chemistry and physics of the atmosphere. This model accounts for the formation and chemical interactions of OH*, as well as the lower-than-normal emissions from fires and reduced fossil-fuel combustion that accompanied the pandemic lockdowns. The levels of OH* in the atmosphere depend in part on the concentrations of carbon monoxide and nitrogen oxides, pollutants that are released from fossil-fuel combustion. Reduced emissions of carbon monoxide and nitrogen oxides decrease OH* concentrations, thereby increasing methane levels. Ultimately, the top-down estimate indicates that the reduced OH* sink accounted for approximately half (53 ± 10%)

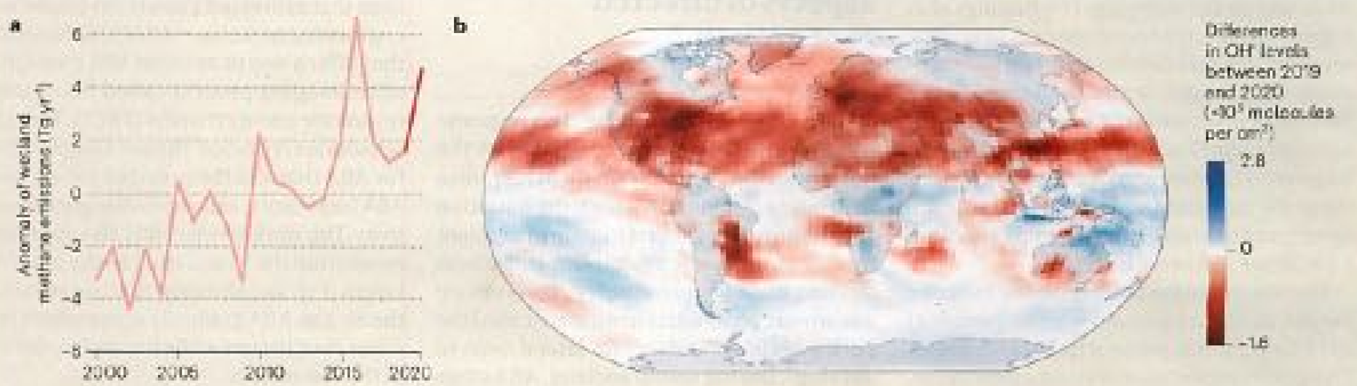

Figure 1 | The main contributors to the rapid increase in atmospheric methane concentrations in 2020. Peng *et al.*[1] quantified changes in the sources and sinks of atmospheric methane between 2019 and 2020, to establish why methane levels increased so quickly when human activities had been curtailed by pandemic lockdowns. **a**, About half of the increase was due to a rise in emissions from Northern Hemisphere wetlands associated with high temperatures and precipitation in that region in 2020. Data shown

measured emissions and the historical annual average) at latitudes of 30° N to 90° N, measured in teragrams of methane per year (1 Tg is 10^{12} grams). **b**, The other approximately half of the increase was due to an overall reduction in global atmospheric levels of hydroxyl radicals (OH*, which break down methane), caused by reduced levels of atmospheric pollutants. The map shows the difference in OH* levels (molecules per cubic centimetre) between 2019 and 2020, plotted across the globe. (Graphics adapted from Fig. 2a and of the observed growth in atmospheric methane in 2020.

Scientists often struggle to balance top-down and bottom-up methane estimates. Peng and colleagues' study is remarkable in that it successfully matches the two estimates in a geographically accurate analysis. The findings allow us to understand the relative contributions from changes in sources and the OH˙ sink during the pandemic.

Despite these advances, some sources of uncertainty remain. For example, Peng *et al.* used only rough estimates for methane emissions from freshwater areas (lakes, reservoirs, ponds, rivers) and melting permafrost, which are thought to be major sources of natural emissions — arguably, just as important as wetlands[2]. A more refined approach that considered, for example, the length of time for which lakes were covered by ice in 2019 compared with that in 2020 would have produced a more accurate emissions estimate. To be fair to the authors, there is still substantial uncertainty associated with estimates of methane emissions from these sources, making it difficult to incorporate such emissions into methane budgets.

Generally, it remains challenging to achieve a predictive understanding of the complex sources, sinks and feedbacks in the global methane budget. More field observations are needed to constrain bottom-up estimates, and more observations from networks of surface sensors and satellites are required to better constrain atmospheric-inversion models — particularly in Central and South Asia, the Middle East, Africa and tropical South America, as the authors recognize.

Peng and colleagues' findings imply that wetland methane emissions are sensitive to a warmer, wetter climate, and thus might fuel a positive feedback loop between methane emissions and global warming. The findings also suggest that future improvements in air quality, resulting in reduced emissions of carbon monoxide and nitrogen oxides, could extend the lifetime of methane in the atmosphere. Thus, a greater reduction in methane emissions than is currently targeted would be required to meet the goal of the United Nations 2015 Paris climate agreement to keep global warming to within 1.5 °C of pre-industrial levels.

The concentration of atmospheric methane surged again (see go.nature.com/3xm1dx4) to 18.2 ± 0.5 p.p.b. per year in 2021 — another mysterious acceleration without a clear cause, and the fastest rate of increase ever recorded. Further investigations into the sources and sinks of methane are clearly needed.

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Plant sciences

How roots go with the flow

Christa Testerink & Jasper Lamers

How do environmental cues steer the branching of plant roots? Insights into how water availability shapes root growth reveal an unexpected mechanism behind the hormone-mediated regulation of this process.

Plants need their roots to branch out in different directions so that they can explore the soil in their search for nutrients and water. Writing in *Science*, Mehra *et al.*[1] have uncovered the system that determines whether the main root of a plant invests in a new side branch for exploration or continues growing and waits for a better opportunity for side branching. The regulation of this process depends on water flow in the root.

In natural soils, plants experience variation in water availability. When root tips that are growing downwards lose contact with moist soil (for example, in an air gap), they respond by halting the formation of side (lateral) roots that branch out horizontally until contact of the root tip with moisture is re-established. The suppression of root branching in air gaps

> **"This principle might have relevance for other aspects of directed root growth."**

in soil is called xerobranching[2]. This response was previously proposed to depend on the hormone ABA, which is made in response to drought. ABA inhibits both the initiation and the growth[3] of lateral roots in many plant species, including the model plant *Arabidopsis thaliana*, maize (corn) and barley[2]. The hormone auxin must accumulate in what are called the pericycle cells of the root for lateral roots to develop[4]. During xerobranching, ABA stops the formation of lateral roots by inhibiting auxin accumulation[2].

Mehra *et al.* confirmed that when the roots of tomato and maize plants cross an air cavity in soil, they need ABA for a xerobranching response — ABA-deficient plant mutants made lateral roots in air gaps. To predict how water flows through the root depending on exter-

simulations. Their findings indicate that wher there is sufficient water, it flows in an inwarc direction, and when the roots are exposed tc drought, the flow is reversed. In drought, a water-stressed root depends on water from shoots that reach the root tissues through a water-conducting internal tissue network called the vasculature (or vascular tissue). On the basis of these results, the authors hypothesized that ABA would travel with this water flow from the vasculature to the outer root tissues if the root crosses an air gap.

Previously, xerobranching could be studiec only in soil, which limits the options for using *A. thaliana*, high-throughput analyses anc tools such as plants with fluorescent marker because of the opacity of the soil. To overcom these constraints, the authors developed a lat oratory approach to mimic root exploratic over an air gap using an *in vitro* plate assa Mehra and colleagues used this set-up explore the role of ABA in *A. thaliana* see lings that expressed a newly developed set o engineered proteins — ABACUS2 biosensors that offer a way to monitor ABA through use of an imaging process called fluorescence resonance energy transfer (FRET). These bio sensors are reported[5] to have a higher affinity for ABA than did the previous generation o ABA biosensors, and so provide greater sensi tivity. This work revealed that ABA does indeec move from the vasculature to the outer roo layers (Fig. 1a), showing that, on traversing the air gap, ABA gradually accumulates in th outer root tissues while becoming depletec in the vasculature.

Next, the authors investigated plants wit signalling deficiencies in ABA arising fron mutations in the *SnRK2* gene family. As wa the case for plants with mutations affectin ABA production, the mutant plants did no show xerobranching. To elucidate which tis sues require ABA signalling, Mehra and col leagues selectively restored ABA signalling i

Article

Wetland emission and atmospheric sink changes explain methane growth in 2020

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Atmospheric methane growth reached an exceptionally high rate of 15.1 ± 0.4 parts per billion per year in 2020 despite a probable decrease in anthropogenic methane emissions during COVID-19 lockdowns[1]. Here we quantify changes in methane sources and in its atmospheric sink in 2020 compared with 2019. We find that, globally, total anthropogenic emissions decreased by 1.2 ± 0.1 teragrams of methane per year (Tg CH_4 yr^{-1}), fire emissions decreased by 6.5 ± 0.1 Tg CH_4 yr^{-1} and wetland emissions increased by 6.0 ± 2.3 Tg CH_4 yr^{-1}. Tropospheric OH concentration decreased by 1.6 ± 0.2 per cent relative to 2019, mainly as a result of lower anthropogenic nitrogen oxide (NO_x) emissions and associated lower free tropospheric ozone during pandemic lockdowns[2]. From atmospheric inversions, we also infer that global net emissions increased by 6.9 ± 2.1 Tg CH_4 yr^{-1} in 2020 relative to 2019, and global methane removal from reaction with OH decreased by 7.5 ± 0.8 Tg CH_4 yr^{-1}. Therefore, we attribute the methane growth rate anomaly in 2020 relative to 2019 to lower OH sink (53 ± 10 per cent) and higher natural emissions (47 ± 16 per cent), mostly from wetlands. In line with previous findings[3,4], our results imply that wetland methane emissions are sensitive to a warmer and wetter climate and could act as a positive feedback mechanism in the future. Our study also suggests that nitrogen oxide emission trends need to be taken into account when implementing the global anthropogenic methane emissions reduction pledge[5].

Methane (CH_4) contributes 15–35% of the increase in radiative forcing from greenhouse gases emitted by human activities[6]. The atmospheric methane growth rate (MGR) has been high over the past decade, probably owing to the combined increases in fossil fuel and microbial sources[7–11]. In 2020, the MGR observed from surface sites of the NOAA Global Monitoring Laboratory (GML) network reached 15.1 ± 0.4 parts per billion per year (ppb yr^{-1}), the highest value from 1984 to 2020 (Extended Data Fig. 1)[12]. The MGR was larger in the Northern than in the Southern Hemisphere, which suggests at first glance an increase of northern sources (Fig. 1). A similar, abnormally large, growth rate of 14.8 ppb yr^{-1} was also detected from total column concentration measurements (XCH_4) by the Greenhouse Gases Observing Satellite (GOSAT; Supplementary Fig. 1). In the same year, the coronavirus pandemic led to a strong reduction of fossil fuel use, probably accompanied by a drop of CH_4 emissions by 10% from oil and gas extraction, according to reports from the International Energy Agency (IEA)[1] and regional estimates of emissions over extraction basins, such as the Permian Basin[13]. The reduced combustion of carbon fuels[14] and lower fire emissions[15] also caused less carbon monoxide (CO) and nitrogen oxides (NO_x) to be released to the atmosphere during the first half of 2020[16,17]. Both CO and NO_x affect the atmospheric concentration of the hydroxyl radical (OH), which is the main sink of CH_4. Even a small change in OH has a large impact on the MGR[8]. Meanwhile, the atmospheric CH_4 concentration also feeds back on the OH available to remove air pollutants such as CO and NO_x (refs. [18,19]). Reduced CO emissions should increase the concentration of OH, whereas reduced NO_x emissions should decrease OH (ref. [5]), except in very polluted areas[20]. Thus, the net effect of COVID-19 emission changes on the MGR is uncertain. In addition, the year 2020 was exceptionally hot from early spring to late summer over northern Eurasia, a sensitive region for CH_4 emissions from biogenic sources such as wetlands, permafrost slumps and arctic lakes, which are expected to emit more CH_4 as the temperature increases. Determining whether the high MGR anomaly in 2020 was due to less atmospheric removal resulting from a decrease in OH or to enhanced biogenic sources is key to developing our understanding of the complex interplay of the anthropogenic and natural drivers of

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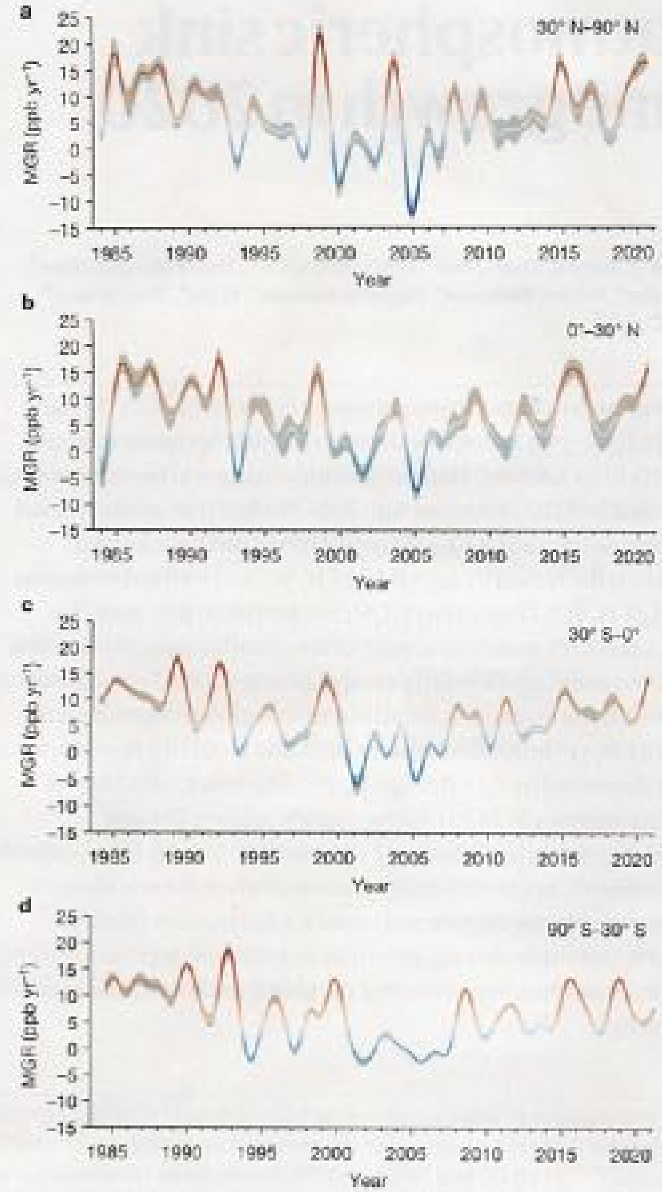

Fig. 1 | Atmospheric MGRs of four latitudinal bands. a–d, The annual growth rate is derived from weekly average marine surface atmospheric methane concentrations at NOAA's surface sites in the four latitudinal bands following a previous work[45]. The colours correspond to the annual growth rate: warm colours for higher growth rate and cool colours for lower growth rate. The grey shaded area shows the standard deviation of the annual growth rate.

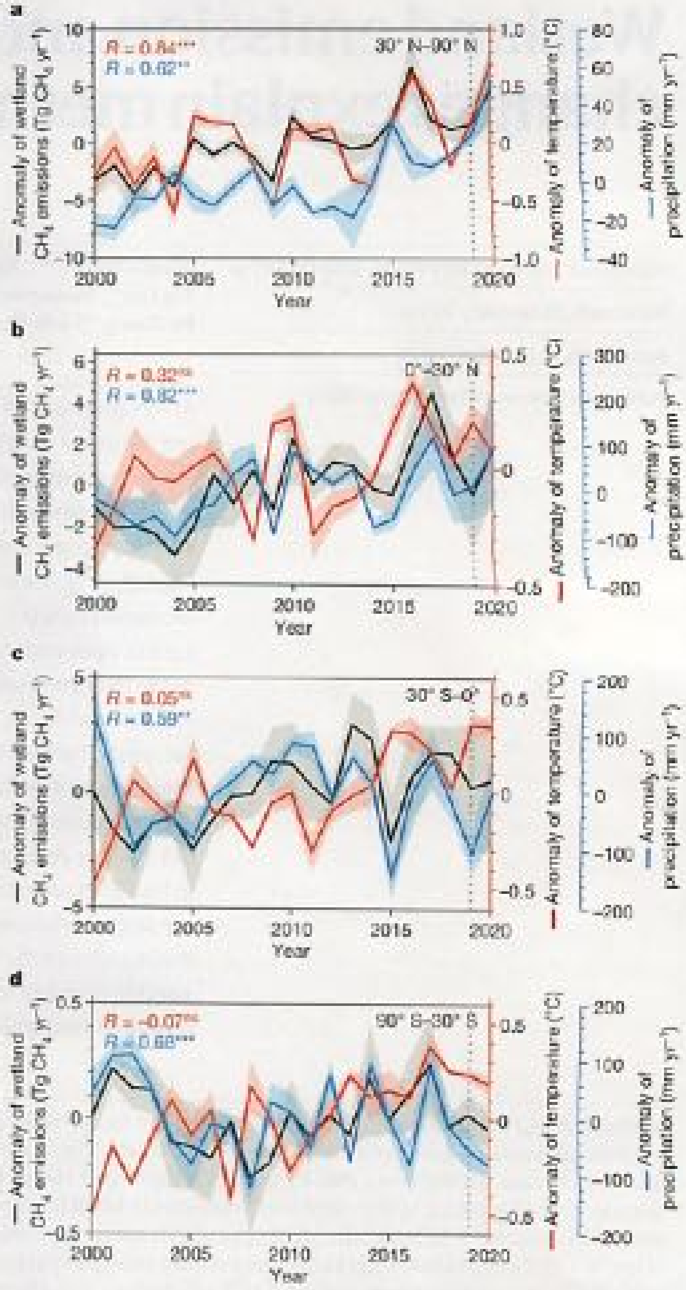

Fig. 2 | Wetland methane emissions and temperature and precipitation in the four latitudinal bands during the period 2000–2020. a–d, The black lines show the anomalies of average wetland emissions simulated from the two WEMs with four climate forcing. The temperature anomalies over wetlands, from CRUTSv4.05, ERA5 and MERRA2, and the precipitation anomalies over wetlands, from these three datasets and MSWEP, are shown in red and blue, respectively. The shaded area shows the standard deviation of 12 simulations for wetland emissions (eight from ORCHIDEE-MICT and four from LPJ-wsl, see Methods). The correlation coefficients between wetland emissions and temperature (red) and precipitation (blue) are also marked in the upper left of each panel, with *** for $P < 0.001$, ** for $P < 0.01$ and ns for not significant. The vertical dashed line marks the year of 2019 for reference.

the methane budget required for the upcoming Global Stocktake of the Paris Agreement. Here we combined bottom-up and top-down approaches to understand the high MGR anomaly in 2020 relative to 2019 and quantified anomalies in the surface sources and in the global atmospheric OH sink.

A bottom-up view of emission anomalies

First, we estimated the change in anthropogenic CH_4 emissions in 2020 from the fossil fuel, agriculture and waste sectors. To do so, we combined national greenhouse gas inventories (NGHGIs) submitted to the United Nations (UN) Framework Convention on Climate Change (UNFCCC) for Annex-I countries and the updated Emissions Database for Global Atmospheric Research (EDGAR) v6.0 inventory[21] with new

(FAO)[23] of the UN for other countries (see Methods). In the category of fossil fuel extraction activities, global coal production decreased by 4.6% in 2020 compared with 2019, and global oil production and natural gas production decreased by 7.9% and 3.8%, respectively[22]. We inferred a decrease of CH_4 emissions from oil and natural gas (-3.1 Tg CH_4 yr^{-1})

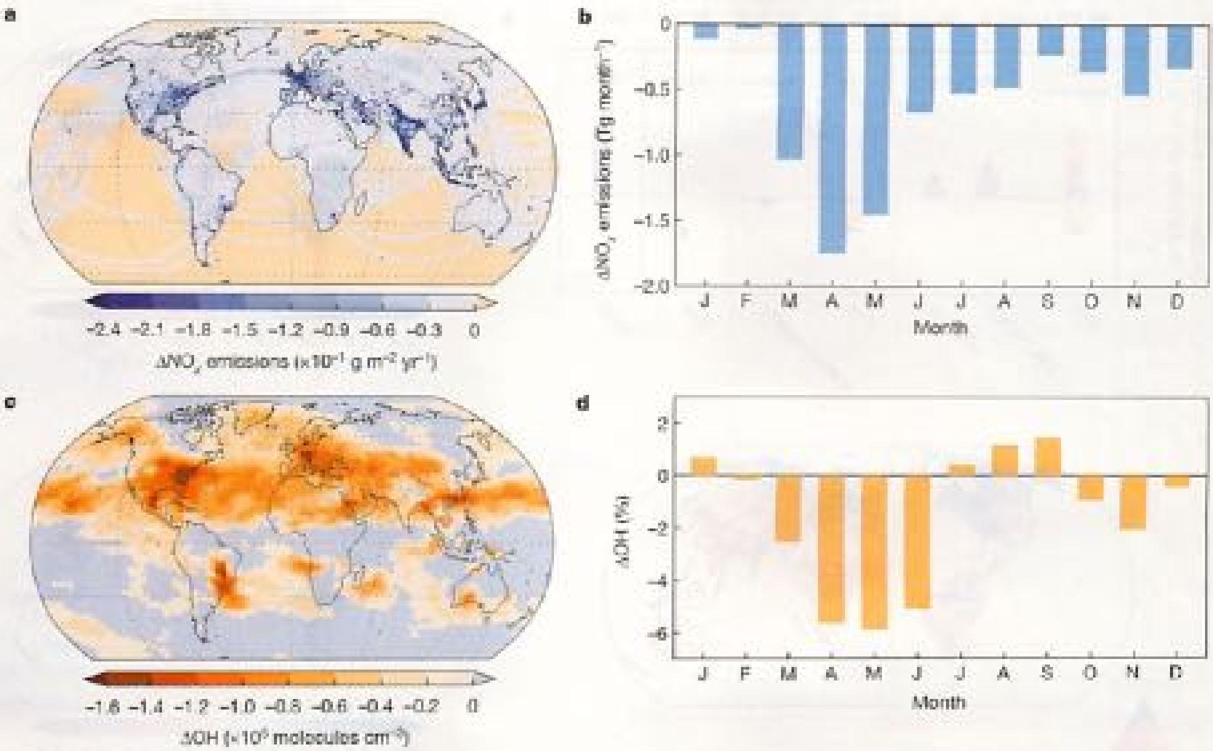

Fig. 3 | Anomaly of NO_x emissions and tropospheric hydroxyl radical (OH) in 2020 relative to 2019. a,**c**, Spatial patterns of NO_x emissions anomaly (ΔNO_x emissions; **a**) and OH anomaly (ΔOH; **c**) in 2020 relative to 2019. **b**,**d**, Difference in monthly global NO_x emissions (**b**) and monthly tropospheric OH (**d**) between 2020 and 2019. The NO_x emissions data are from the Community Emissions Data System dataset[18].

the global rice cultivation area slightly increased according to FAO[23] by 1% (+0.5 Tg CH_4 yr^{-1}), and an increase in livestock stock and slaughter numbers was reported as well (+1.6 Tg CH_4 yr^{-1}). Statistical data are not yet available for the waste sector for non-Annex-I countries, so we used the linear trends from EDGAR v6.0 for 2014–2018 to project a small global increase of +1.0 Tg CH_4 yr^{-1} in 2020 compared with 2019. In summary, the anthropogenic CH_4 emissions in 2020 decreased by 1.2 ± 0.1 Tg CH_4 yr^{-1} (± standard deviation, hereinafter) (Extended Data Fig. 2), which at steady state would lead only to a 0.4 ± 0.0 ppb yr^{-1} decrease of growth in the atmosphere relative to 2019, based on the conversion factor of 2.75 Tg CH_4 ppb^{-1} (ref. [24]). This shows that the observed MGR anomaly of 5.2 ± 0.7 ppb yr^{-1} in 2020 compared with 2019 (15.1 ± 0.4 ppb yr^{-1} of MGR in 2020 relative to 9.9 ± 0.6 ppb yr^{-1} of MGR in 2019) must be attributed to a change of natural emissions and/or OH sink.

We then estimated biogenic and fire CH_4 emissions in 2020 from bottom-up models. The year 2020 was wetter than normal in northern and tropical regions (Supplementary Fig. 2), and extremely warm in northern Eurasia from early spring to late summer[25] (Extended Data Fig. 3). Two satellite-based fire emission datasets, the Global Fire Assimilation System (GFAS) and the Global Fire Emissions Database (GFED4.1s), consistently show that the global fire emissions in 2020 were lower by 6.5 ± 0.1 Tg CH_4 yr^{-1} than in 2019 (Extended Data Fig. 4). The southern tropical regions (30° S–0°) dominated the 2020 decrease in fire emissions in both datasets, although in the USA there were fewer fires in the first half of the year but more in the second half of the year[26]. The GFAS data show that eastern Siberia had higher fire emissions in 2020 compared with 2019, by 0.4 Tg CH_4 yr^{-1}. This anomaly is related to the heatwave in the region (Extended Data Fig. 3)[25], where the fire season advanced by two months in 2020 and began in May[27]. Globally, fire emissions appear to have dropped in 2020 compared with 2019, implying other processes must explain the large positive MGR anomaly in 2020.

We found that most wetland areas of the world were exposed to warmer and wetter conditions in 2020 than normal years (Fig. 2 and Extended Data Fig. 3). Northern wetlands were exposed to warmer temperatures (+0.43–0.58 °C) relative to 2019 as shown in Fig. 2 (Supplementary Table 1). Precipitation over global wetlands[28] had a 2–11% annual increase relative to 2019, mainly in the northern high latitudes and in the tropics (Supplementary Table 1). With increased precipitation, an expansion of wetland area and more shallow water tables promoting emissions are expected. In addition, the earlier soil thaw and later soil freeze in 2020 resulted in a longer emission season in the high northern wetlands (Supplementary Fig. 3), and possibly in increased emissions from permafrost and thermokarst lakes. To quantify wetland emissions from 2000 to 2020, we used two process-based wetland emission models (WEMs) forced by different climate datasets (see Methods). These models show that wetland emissions significantly and positively correlate with precipitation in the tropics (30° S–30° N)[29] and in the southern extra-tropics (90° S–30° S) and with both temperature and precipitation in northern wetlands (30° N–90° N) (Fig. 2). Warmer and wetter wetlands over the Northern Hemisphere in 2020 (Supplementary Table 1) increased emissions by 6.0 ± 2.5 Tg CH_4 yr^{-1} relative to 2019, dominating the net increase in global wetland emissions (6.0 ± 2.3 Tg CH_4 yr^{-1}) in 2020 (Extended Data Fig. 5). The spread in the estimates of WEMs is mainly due to differences in wetland area related to differences in the precipitation forcing (Supplementary Fig. 2), and partly to model structure, even though the two models have similarities in parameterizations. With a 4% increase in precipitation over wetlands from the Multi-Source Weighted-Ensemble Precipitation (MSWEP) precipitation field, which merges gauge, satellite, and reanalysis data to obtain accurate precipitation estimates[30,31], wetland emissions increased by 5.8 ± 1.5 Tg CH_4 yr^{-1}. Using root-zone soil moisture from Global Land Evaporation Amsterdam Model (GLEAM) v3.5a[32] as a proxy to calculate the expansion of wetland areas in 2020 (see Methods), we found a larger wetland emission increase of 7.4–9.3 Tg CH_4 yr^{-1}, mainly in the Northern Hemisphere (Extended Data Fig. 5). Observed land liquid water mass change from the GRACE-FO satellite[33] confirms

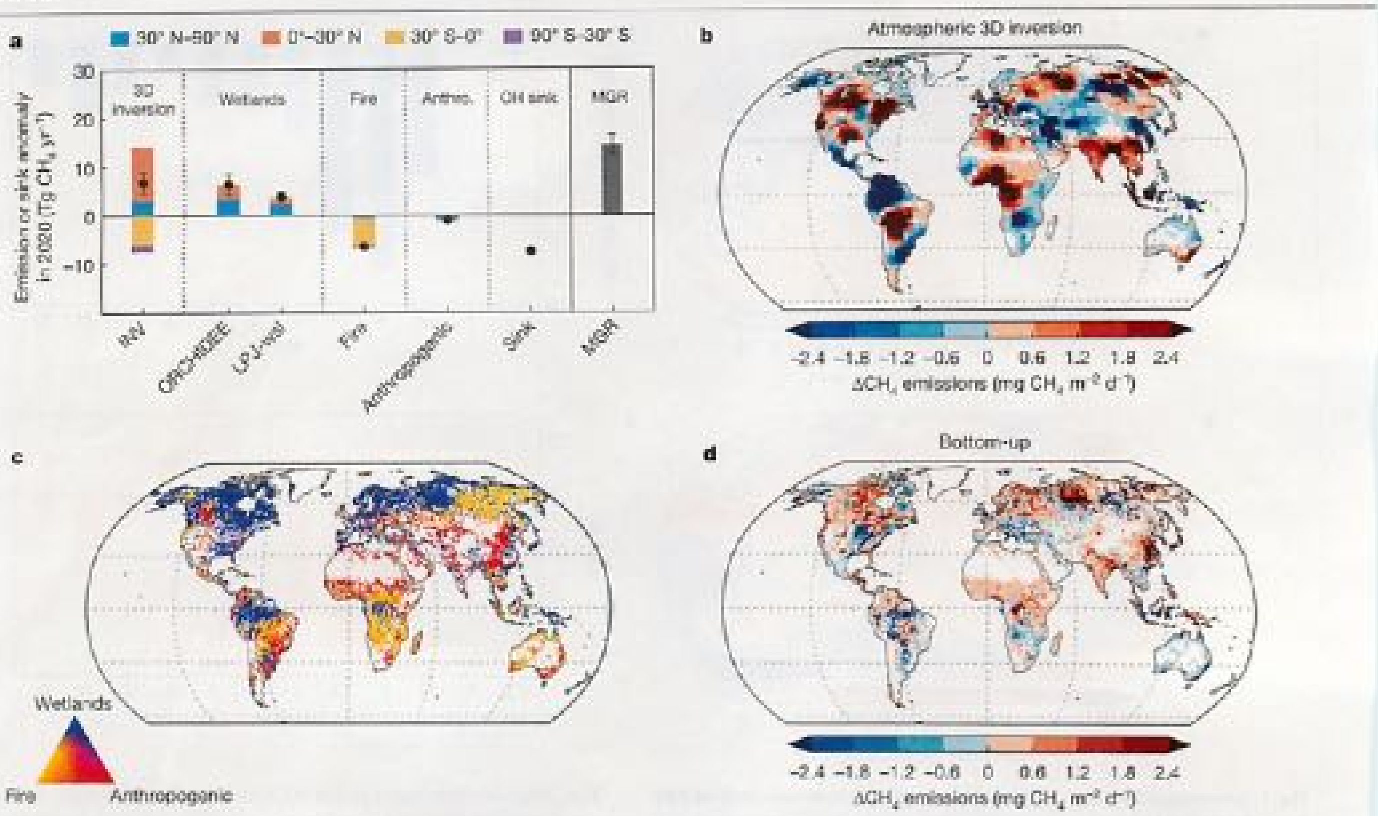

Fig. 4 | Methane emissions and sink anomaly in 2020 relative to 2019. **a**, Methane emissions anomaly of four latitudinal bands derived from atmospheric 3D inversions with OH field from LMDZ-INCA simulations (INV), wetland emissions anomaly from two WEMs, fire emissions anomaly from GFED4.1s and GFAS, and anthropogenic (Anthro.) emissions anomaly. The black dots show the net changes in global CH_4 emissions between 2020 and 2019. The sink anomaly is calculated by a 1.6 ± 0.2% decrease in OH in INV. The observed MGR anomaly (14.4 ± 2.0 Tg CH_4 yr^{-1}) from surface sites is defined as the difference in MGR between 2020 (15.1 ± 0.4 ppb yr^{-1}) and 2019 (9.9 ± 0.6 ppb yr^{-1}) with a conversion factor of 2.75 Tg CH_4 ppb^{-1}. The error bars represent one standard deviation. **b**, Spatial pattern of emissions anomaly from top-down INV. **c**, Spatial distribution of contribution sources (wetlands, fire and anthropogenic) to change in emissions derived from bottom-up estimates. **d**, Spatial pattern of emissions anomaly from bottom-up estimates including wetland, fire and anthropogenic emissions.

that wetlands water storage increased in the Northern Hemisphere. The increase in soil moisture over wetlands in the Northern Hemisphere simulated by the two WEMs is less than the liquid mass change observed from GRACE-FO, especially north of 30° N (Supplementary Figs. 4 and 5), suggesting that the expansion of Northern Hemisphere wetlands or the water table levels—and thus emissions in 2020—may be underestimated by WEMs. Overall, it is probable that wetland emissions made a dominant contribution to the soaring level of atmospheric methane in 2020, although there is uncertainty regarding the magnitude of the contribution, mainly owing to uncertainty in the precipitation data.

According to our ensemble of bottom-up estimates, an increase in wetland emissions (6.0 ± 2.3 Tg CH_4 yr^{-1}) does not fully explain the increased methane emissions (14.4 ± 2.0 Tg CH_4 yr^{-1}) inferred from the MGR anomaly (5.2 ± 0.7 ppb yr^{-1}) between 2020 and 2019 under the assumption that the sink remains unchanged. Considering a decrease in anthropogenic emissions of 1.2 Tg CH_4 yr^{-1} and fire emissions of 6.5 Tg CH_4 yr^{-1}, even with our largest estimate of wetland emissions (9.4 Tg CH_4 yr^{-1}), the bottom-up budget is still not closed, revealing a missing source anomaly of more than 12.7 Tg CH_4 yr^{-1}, which must be attributed to a decrease in the atmospheric CH_4 sink, to additional sources such as lakes or permafrost or to extra-wetland emissions that were missed by the WEMs.

Atmospheric constraints in 2020

The increase in wetland emissions is mainly located in the Northern Hemisphere, whereas the decrease in fire emissions is mainly in southern tropical regions, and so we expect that the MGR in the Northern Hemisphere should be higher than the MGR in the Southern Hemisphere. Indeed, the latitudinal averaged growth rate of methane observed from the surface sites confirms that the Northern Hemisphere had a higher growth rate than the Southern Hemisphere in 2020 (Supplementary Fig. 6). The GOSAT data, which provide an MGR integrated over the whole column, and are thus much less sensitive to changes in the depth of the boundary layer at continental stations, also show a similar latitudinal pattern to the data from the surface sites, with a peak in the column growth rate at 10° N–50° N (Supplementary Fig. 7).

To quantify the spatial and temporal distribution of emission anomalies in 2020 from atmospheric observations, we used a three-dimensional (3D) atmospheric inversion assimilating surface CH_4 observations from a total of 103 stations (see Methods). Inversions have the advantage over bottom-up methods to match the observed MGR and gradients between all stations. We performed a 3D atmospheric inversion (INV) that prescribes changes in the OH concentration field, as simulated by a full chemistry transport model (LMDZ-INCA)[34,35] with realistic CO, hydrocarbons and NO_x anthropogenic emissions derived from gridded near-real-time fossil fuel combustion data that include lockdown-induced reductions in 2020[36,37]. The chemistry transport model is driven by meteorology from ECMWF ERA5 data[38] and biomass burning emissions from GFED4.1s[25]. Figure 3 shows a decrease in NO_x emissions by 6% in 2020 relative to 2019, which is particularly apparent in the spring (March, April and May) when COVID-19 lockdown measures were imposed in many Northern Hemisphere countries (Extended Data Fig. 6). The decrease in global NO_x emissions in 2020 relative to 2019 was seven times larger than the decreasing trend from 2005 to 2019 (Supplementary Figs. 8 and 9). Both the global NO_x emissions and satellite-derived tropospheric NO_2 concentration from Ozone Monitoring Instrument (OMI) in 2020 were the lowest during the period 2005–2020 (Supplementary Fig. 9). Our chemistry transport model LMDZ-INCA produced a globally averaged 1.6% decrease in annual tropospheric OH concentration in 2020 relative to 2019. The decrease in monthly tropospheric OH reached as high as 6% in April, May and June (Fig. 3d) over the Northern Hemisphere (0°–60° N; Extended Data Fig. 7), suggesting that the drop of NO_x emissions in 2020 outweighed the effects of a decrease in anthropogenic and fire CO emissions (Supplementary Fig. 10) and made OH lower. To independently verify this modelled decrease of global OH in 2020, we used a 12-box model to infer changes in OH[9,39] by simultaneously optimizing OH concentration and the emissions of two HFC and one HCFC species (HCFC-141b, HFC-32 and HFC-134a) using atmospheric observations of these three species from the NOAA and AGAGE networks including the latest data for 2020. This diagnostic of OH is based on the premise that errors in the prior emissions should be largely independent between the three gases, but errors in OH will be correlated for all of them (see Methods). The box model shows a net decrease in OH of 1.6–1.8% in 2020 relative to 2019 after the optimization. This estimate of the OH decrease in 2020 is independent and consistent with the full chemistry model simulation.

Prescribed with the decrease of OH and its spatial pattern from the chemistry transport model, the INV gives a global increase of 6.9 ± 2.1 Tg CH_4 yr^{-1} for surface emissions and a decrease of 7.5 ± 0.8 Tg CH_4 yr^{-1} for the weaker atmospheric CH_4 sink. Considering the uncertainty of the decrease in OH and of the observed MGR[12], the global increase in surface emissions and decrease in the atmospheric CH_4 sink contributed, respectively, 47 ± 16% and 53 ± 10% of the total positive MGR anomaly in 2020 relative to 2019 (Fig. 4). The global increase of surface emissions is decomposed into an increase in the Northern Hemisphere of 14.3 Tg CH_4 yr^{-1}, partly offset by a decrease in the Southern Hemisphere of 7.4 Tg CH_4 yr^{-1} (Fig. 4a). The spatial pattern of emission anomalies produced by INV confirms enhanced emissions in northern North America, and western and eastern Siberia hinted by the bottom-up wetland models. In the Northern Hemisphere, our maximum bottom-up estimate of the increase in wetland emissions (11.2 Tg CH_4 yr^{-1}) is, however, smaller than the solution of INV. This suggests that either wetland models underestimated emissions, possibly because of underestimated soil water content (see above), too deep water table, missed emissions from small wetlands and/or other sources spatially collocated with northern wetlands such as lake and pond emissions[40], aquaculture emissions[41] and thawing permafrost slump emissions[42]. The largest temperature anomaly of the past two decades was also indeed found over permafrost regions in 2020, particularly in Russia (Extended Data Fig. 3a and Supplementary Fig. 11), which could have increased methane emissions from upland permafrost soils[43] and lakes, including thermokarst lakes[44]. Estimation of changes in emissions from lakes (including reservoirs) and permafrost shows limited contributions from these two sources (<0.1 Tg CH_4 yr^{-1}) to fill the gap in the emission changes between bottom-up and top-down approaches, although with large uncertainties (Supplementary Information). We note that owing to the sparse atmospheric networks in Central and South Asia, Middle East, Africa and tropical South America (Supplementary Fig. 12), the inferred fluxes and therefore flux changes in these regions may have large uncertainties. The evaluations against independent observations revealed that emission changes over large latitudinal bands or at hemispheric scales are robustly constrained (Supplementary Figs. 13–18). In addition, an extension of our 3D inversion and analyses to cover the period 2015–2020 also showed similar attribution of the MGR anomaly in 2020 (Supplementary Fig. 19).

In summary, our results show that an increase in wetland emissions, owing to warmer and wetter conditions over wetlands, along with decreased OH, contributed to the soaring methane concentration in 2020. The large positive MGR anomaly in 2020, partly due to wetland and other natural emissions, reminds us that the sensitivity of these emissions to interannual variation in climate has had a key role in the renewed growth of methane in the atmosphere since 2006. The wetland methane–climate feedback is poorly understood, and this study shows a high interannual sensitivity that should provide a benchmark for future coupled CH_4 emissions–climate models. We also show that the decrease in atmospheric CH_4 sinks, which resulted from a reduction of tropospheric OH owing to less NO_x emissions during the lockdowns, contributed 53 ± 10% of the MGR anomaly in 2020 relative to 2019. Therefore, the unprecedentedly high methane growth rate in 2020 was a compound event with both a reduction in the atmospheric CH_4 sink and an increase in Northern Hemisphere natural sources. With emission recovery to pre-pandemic levels in 2021, there could be less reduction in OH. The persistent high MGR anomaly in 2021 hints at mechanisms that differ from those responsible for 2020, and thus awaits an explanation. Our study highlights that future improvements in air quality with reduced NO_x emissions may increase the lifetime of methane in the atmosphere[5], and therefore would require more reduction of methane emissions to achieve the target of Paris Agreement.

Online content

Any methods, additional references, Nature Portfolio reporting summaries, source data, extended data, supplementary information, acknowledgements, peer review information; details of author contributions and competing interests; and statements of data and code availability are available at https://doi.org/10.1038/s41586-022-05447-w.

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THE UNRECOGNIZED VALUE OF GRASS

By **Bianca Lopez, Pamela J. Hines,** *and* **Caroline Ash**

Grasses are highly diverse, yet only six or seven grass species provide most of the calories that humans consume. Domestication of grasses as crops began some 10,000 years ago and continues today to optimize the genetic basis of traits useful for crop cultivation. Techniques to maximize yields and utility of staple grain crops still dominate modern agriculture. In addition to cultivated fields and pastures, grassy ecosystems (both Poaceae and Alismatales) cover large swaths of the planet, forming terrestrial grasslands and submarine meadows. Grasslands create and stabilize fertile soil; store carbon; generate oxygen; and provide animal habitat, building materials, and food. Even so, these species and systems are often undervalued. Land-use conversion and climate change pose threats, as do climate change mitigation efforts that prioritize carbon stored in trees over that stored in grasslands. Nevertheless, grasses could offer solutions to many of our societal challenges, if only we would fully recognize their diversity and value.

Meadows of Neptune seagrass (*Posidonia oceanica*) were once widespread throughout the Mediterranean but are threatened by climate change and human activities.

PERSPECTIVE

The history and challenge of grassy biomes

Grassy biomes are >20 million years old but are undervalued and under threat today

By **Caroline A. E. Strömberg**[1] *and* **A. Carla Staver**[2,3]

Grassy biomes—from the steppes of Mongolia to the savannas of Tanzania—are predicted to be the ecosystems hardest hit by the ongoing climate and land use crises. The history of humans has been profoundly intertwined with grassy biomes. *Homo* evolved in the savannas 2 million years ago (Ma), and agricultural societies arose through the domestication of grasses, such as wheat and barley, 10,000 years ago. These grass crops, as well as corn and rice, remain dominant staple foods globally (*1*). Livestock production also centers in areas that were once (and sometimes still are) native grasslands. Grassy biomes harbor distinct and diverse sets of plants and animals that have adapted to these environments through millions of years of evolution (*2*). As the biodiversity and economic prominence of grassy biomes are increasingly being recognized, there is a demand for better understanding of their past and present function to inform policy and management.

Grassy biomes are biogeographically widespread, accounting for >25% of all land on Earth, including 35% of the tropics and subtropics. The emergence of grassy systems during the Cenozoic (the past 66 million years) was complex, shaped by climate, soils, fire, and herbivory in ways that are not fully understood (see the figure). Clarifying these mechanisms will be key for managing the fate of grassy biomes under ongoing and future environmental changes that are driven by human activities.

Grasses, defined as plant species in the family Poaceae, originated by the Late Cretaceous (100 Ma) (*3*) but did not become ecologically dominant until >70 million years later, in the later Cenozoic. This exceptionally long lag has prompted evolutionary biologists and paleontologists to search for the drivers that allowed grass to reach its current global prominence. Today, most grasses are associated with open-canopy habitats, owing to several traits acquired relatively early in Poaceae evolution (100 to 60 Ma) (*1*, *3*). For example, grasses may have quickly evolved a rapid life cycle and persistent buds, permitting quick regrowth after drought, frost, or disturbances such as fire and grazing. Starting by 55 Ma, several groups of grasses evolved so-called C_4 photosynthesis (as opposed to C_3 photosynthesis), which allows them to prosper in hot and dry areas (*1*). In colder climates, C_3 open-habitat grasses developed the tolerance needed to survive frosts by 30 Ma (*4*). However, although the evolutionary traits suited to open habitats appeared earlier, open-habitat grasses remained ecologically rare until later in the Cenozoic.

Once grasses started spreading across the globe, their takeover was asynchronous and followed continent-specific trajectories. For instance, grassy habitats appeared in North America by 25 Ma but not until 7 Ma in Australia (*5*, *6*). However, the first subtropical grassy biomes were unlike anything observable there today, featuring C_3 open-habitat grasses that today are found in colder regions (*6*). It was not until several million years later that tropical open-habitat C_4 grasses expanded to form grasslands and savannas at low to mid-latitudes (*5*, *7*), roughly coincident with the spread of frost-tolerant grasses at higher latitudes.

Grassy biomes thus emerged during the Cenozoic at different times in different places and, at least in part, for different reasons. Studies in modern grassy biomes suggest that aridity and rainfall seasonality, as well as fire and herbivory, could all favor grasses over trees (*2*), with even larger benefits at lower atmospheric CO_2 concentrations. The fossil record shows that many of these conditions did occur in the late Cenozoic. By 34 Ma, atmospheric CO_2 levels had dropped, and the globe underwent a period of cooling. In many areas, altered atmospheric circulation and mountain uplift (e.g., of the Tibetan Plateau) resulted in aridification or seasonal drought, and fossil evidence indicates increased fire activity near the end of the Cenozoic (*5*). Further, large grassland-type mammal herbivores (e.g., bovids) diversified during the mid- to late Cenozoic (*8*).

Asynchrony in the emergence of grasses on different continents suggests that, although global factors such as low-CO_2 conditions may have spurred the diversification and expansion of open-habitat and especially C_4 grasses (*7*), changes in CO_2 were typically not enough to allow grasses to dominate. A rapidly expanding geochemical and paleontological tool kit has allowed for more detailed insights. Studies have shown that regional changes in climate and fire interacted with existing vegetation to influence trajectories of emerging grass dominance, with divergence across continents. For example, the earliest North American C_3 grassy habitats replaced forests as seasonal drought developed (*6*), and in Australia, C_4 grasses favored by pronounced aridification overtook fire-adapted eucalypt woodlands that had existed there for tens of millions of years before (*5*). By contrast, in South Asia and southwest Africa, more frequent and intense wildfires promoted replacement of fire-sensitive vegetation with grasses (*9*), suggesting a substantial regional, if not global, role for fire.

In addition to environmental conditions, herbivores may also have directly contributed to the spread of grassy vegetation, although the mechanisms are not yet understood. Defense strategies against herbivores by savanna trees, such as growing spines or thorns, evolved concurrently with the spread of grasses and the diversification of bovids in Africa (~17 Ma) but long before fire activity increased (*8*). This suggests that, at least in Africa, herbivores structured grassy biomes before fire did. However, just how important animals were in shaping the evolution of grassy vegetation remains untested and will require adapting methods of estimating past herbivore intensity (such as studying fungal spores in fossilized dung) for Miocene and older samples.

Since they first appeared, grassy biomes have continued to shift in extent, structure, and composition, prompted by advancing and retreating ice sheets during the global Ice Age (2.6 Ma onward). Today, they are widely distributed on every continent except Antarctica, with a range in part associated with aridity and rainfall seasonality. Some 60% of grassy ecosystems receive <750 mm of annual rainfall, most with a dry season that shapes plant physiology. This provides a rationale for the argument that aridity drove late Cenozoic grassland expansion. However, 40% of grassy ecosystems extend into higher-rainfall regions with >750 mm of annual rainfall that can support forests. These moderately wet, or "mesic" grassy ecosystems are biogeographically distinct from semiarid ones, but both are evolutionarily ancient (*1*). Yet, whereas

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SPECIAL SECTION

cal designs offers a promising opportunity to better steer the plasticity mechanisms of human cognition.

We recently discovered that synchronization-dependent neural coding schemes underlie poorer memory function in people aged 60 to 76 years and developed advanced neuromodulation protocols that target these motifs for memory enhancement (see the online figure, top). Before neuromodulation, these individuals showed poorer working memory performance compared with younger adults (*2*). These impairments were found to be associated with reduced theta-gamma phase-amplitude coupling (PAC) in the temporal cortex (*2*). PAC is a well-studied neural coding motif that occurs when the amplitude of a high-frequency rhythm synchronizes with the phase of a low-frequency rhythm. This form of synchronization facilitates the integration of information across spatiotemporal scales within a nested cortical network (*6, 12*). We found that local PAC deficits in the temporal cortex arose because of deficient prefrontal control marked by reduced theta-phase synchronization between the frontotemporal areas. Phase synchronization—when two or more rhythmic neuronal signals tend to cycle with consistent relative phase—is another leading neural coding motif for coordinating spatiotemporal neuronal activity (*1, 6, 12*). These synchronization schemes thus serve as potential targets for neuromodulation to improve memory function.

Guided by electric field modeling, we developed a personalized HD-tACS protocol to rescue theta-phase synchronization in the frontotemporal cortex. The frequency of synchronization was individually determined for each participant to maximize the likelihood of entrainment. Simultaneous in-phase entrainment of both frontal and temporal regions at personalized theta frequencies induced in this manner restored intrinsic frontotemporal theta-phase synchronization, recovered the deficient theta-gamma PAC in the temporal cortex (see the online figure, top), and improved working memory performance in older adults (*2*). Even though neuromodulation was performed for ~25 min, improvements in memory function were sustained for at least 50 min, suggesting that the protocol produced neuroplastic changes outlasting the modulation period (*2*). Moreover, an additional experiment in younger adults with antiphase synchronization of frontotemporal regions demonstrated that memory performance can even be down-regulated. This finding suggests that cognitive function can be bidirectionally manipulated using phase-dependent interregional synchronization.

may be useful in pathologies where overactive memory processes need to be regulated, such as in posttraumatic stress disorder.

Our precision neuromodulation approach identified that it was essential to perform HD-tACS using personalized theta frequencies. By contrast, control experiments with a fixed theta frequency for all participants did not produce any improvements in memory function in older adults. Thus, advances in noninvasive neuromodulation that leverage the spatial and spectral parameters of individual neurophysiology offer a promising opportunity to effectively synchronize large-scale brain rhythms and rapidly improve memory function in older people. Such developments are especially valuable considering the rapidly aging global population and its associated personal, social, health care, and economic costs.

"The rapid reduction in obsessive-compulsive behaviors...lasted for at least 3 months..."

Current theories in biological psychiatry on the nature of compulsivity, including obsessive-compulsive disorder (OCD), view symptoms as outcomes of dysregulated habits and atypical reward processing due to abnormalities in cortico-basal ganglia networks (*13, 14*). In parallel, fundamental neuroscience research has identified a neural signature in the form of medial-frontal beta-gamma rhythms, presumed to arise from the orbitofrontal cortex (OFC) during reward processing (see the online figure, bottom) (*15*). Combining these insights, we proposed that beta-gamma rhythms may constitute the neural code underlying orbitofrontal-striatal interactions that give rise to abnormal reward processing and OCD symptoms. To test this theory, we devised a personalized model-guided HD-tACS protocol for targeting individual beta-gamma rhythms of the OFC (see the online figure, middle) and demonstrated rapid, reversible, frequency-specific modulation of reward-guided choice behavior and learning in healthy young adults (*4*). Next, by repeatedly modulating personalized OFC beta-gamma rhythms over 5 days, we effectively reduced obsessive-compulsive behaviors in a nonclinical population. The rapid reduction in obsessive-compulsive behaviors—including hoarding, ordering, and checking—lasted for at least 3 months (*4*), and the largest improvements were experienced in people with more severe symptoms. These

sonalized neuroscience intervention to people with clinical OCD and other compulsivity disorders, such as behavioral addiction (e.g., gambling, internet), eating disorders, substance use or abuse, and Tourette syndrome. More broadly, because the OFC is increasingly recognized to play a central role in the pathophysiology of mood, anxiety, psychosis, and other major categories of psychiatric disorders (*14*), the noninvasive procedure we developed for selectively modulating OFC beta-gamma rhythms could lay the basis for future nonpharmacological therapeutics that are applicable to a wide range of psychiatric illnesses.

The fields of fundamental and clinical neuroscience have made extraordinary advances in understanding the dynamic structure of the neuronal network activity that underlies cognitive function and dysfunction. Leveraging these insights has allowed us to develop neuromodulation protocols, personalized to individual neurophysiology, that can selectively augment components of rhythmic cortical networks and improve cognitive function and adaptive behavior in a rapid and sustainable fashion. Although it is challenging to predict the future, we are optimistic that personalization rooted in the neuroscience of network dynamics will rise to the forefront of next-generation noninvasive neuromodulation and pave the way toward future use of precision electroceuticals in neurology and psychiatry. ■

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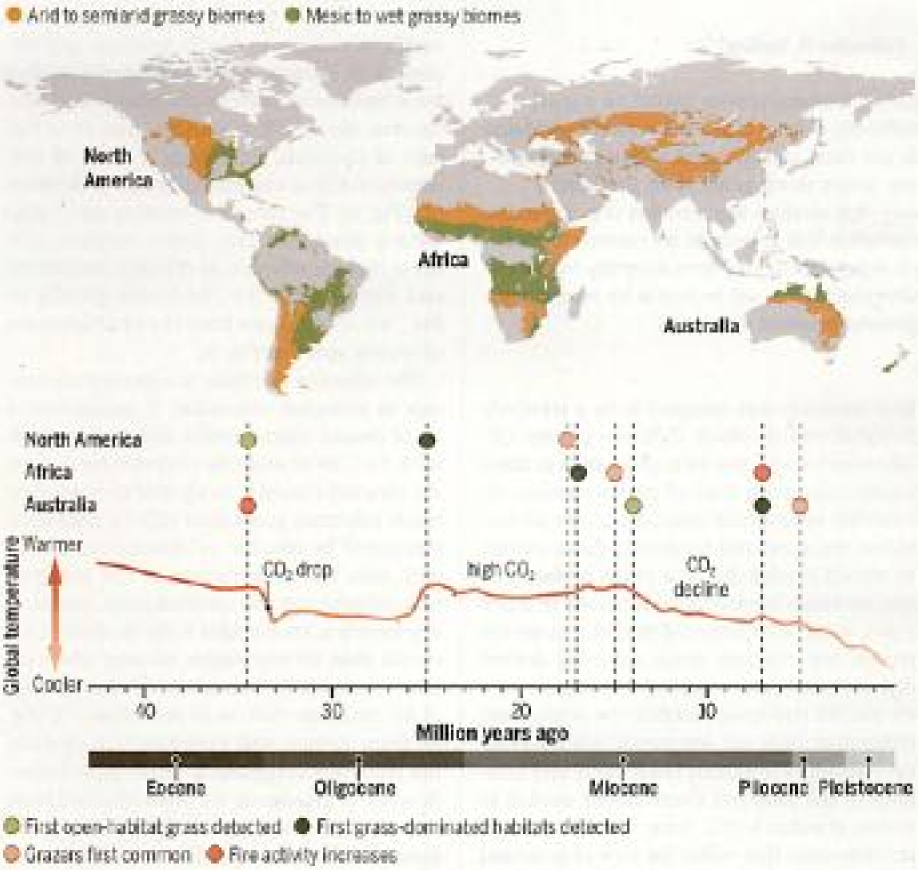
FULL ARTICLE WITH FIGURES AT

The history and legacy of grassy biomes

Grassy biomes exist in a wide range of climates, from cold to hot and arid to wet (top). Although changing environmental conditions through time have shaped their past and present distribution, disturbance regimes (fire, herbivory) and vegetation histories also shaped their evolution and current and future function (bottom).



semiarid savannas are widely accepted as the native vegetation of large areas of the globe, mesic savannas were long assumed to represent degraded forests. Only recently have mesic savannas been acknowledged for their contributions to endemic biodiversity and distinctive ecosystem function.

As their antiquity is increasingly recognized, the ecological processes that promote mesic savanna stability have come into increasing focus (*2*). Fire likely plays an important role in stabilizing mesic savannas, excluding forests by preventing tree establishment or killing trees, thereby favoring grasses. In total, grassy biomes make up >80% of the global burned area annually. Experiments, field observations, and remote sensing analyses all support fire as a mechanism allowing grassy ecosystems to expand into mesic regions. Plant traits are consistent with the history of fire in mesic savannas. The distinct, diverse, and ancient tree and shrub communities (*8*) are well adapted to enduring fires with thick bark, large belowground nonstructural carbohydrate reserves, and bud banks that promote resprouting. In addition to tolerating fire, many grasses actively spread fire (*10*). These fire adaptations have major implications for the ecosystem functioning of grassy biomes. For instance, the large belowground reserves in grassy biomes may mean a substantially larger belowground carbon storage compared with that in other biomes (*11*). Current estimates suggest that grassy biomes hold at least 17% of global biomass carbon (*12*), but this is certainly an underestimate (*11*) that needs to be adequately quantified so that the potential role of grassy biomes as carbon sinks can be fully appreciated.

Herbivores that graze on grass and eat tree leaves also influence grassland function (*13*), especially in semiarid savannas, where grass eaters decrease grass biomass accumulation and tree eaters prevent trees from establishing. Abundant herbivory-related traits have accumulated over evolutionary time in grassland plants, including herbivory defenses in trees (e.g., spines) (*8*) and grass morphologies that withstand intense grazing (e.g., growing from the base instead of from shoot tips and bud banks for resprouting) (*1*). Nevertheless, the importance for grassy biome distributions of herbivory relative to other factors, such as climate and soil conditions, remains an open question.

Overall, evidence is converging around the idea that grassy ecosystems are complex, with ecologies that depend not just on climate but also on interactions and feedbacks with fire and herbivory. These ecologies are profoundly influenced by the evolutionary history and resulting trait diversity of regional biota (*1*). Their complexity makes predicting the responses of grassy biomes to global change a particular challenge. Nonetheless, studies have shown that the combination of CO_2 fertilization, fire suppression, and livestock extensification has resulted in widespread woody encroachment (*14*) and associated degradation of grassy biomes—a trend that will likely continue into the near future.

Grassy biomes are also threatened by ongoing land use conversions and degradation while being among the least protected globally (*2*). For example, 90% of temperate grasslands have been transformed into agricultural or urban areas, with <1% of remnants currently protected from land development. Whereas rainforests in the Amazon have attracted widespread attention from the popular media, the ongoing threat to savannas, especially in Africa, South America, and Asia from afforestation, fire exclusion, and land use conversion, has gone unnoticed. The effects on savanna and grassland biodiversity will be devastating; for instance, 40% of grassland vertebrate species are projected to be lost by 2070 (*15*). Thus, the fate of evolutionarily ancient grassy biomes hangs in the balance, with terminal consequences for their functionally and evolutionarily distinct biota. ■

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REVIEW

Ancient grasslands guide ambitious goals in grassland restoration

Elise Buisson[1]†, Sally Archibald[2], Alessandra Fidelis[3], Katharine N. Suding[4,5]*†

Grasslands, which constitute almost 40% of the terrestrial biosphere, provide habitat for a great diversity of animals and plants and contribute to the livelihoods of more than 1 billion people worldwide. Whereas the destruction and degradation of grasslands can occur rapidly, recent work indicates that complete recovery of biodiversity and essential functions occurs slowly or not at all. Grassland restoration—interventions to speed or guide this recovery—has received less attention than restoration of forested ecosystems, often due to the prevailing assumption that grasslands are recently formed habitats that can reassemble quickly. Viewing grassland restoration as long-term assembly toward old-growth endpoints, with appreciation of feedbacks and threshold shifts, will be crucial for recognizing when and how restoration can guide recovery of this globally important ecosystem.

Grasslands are essential components of Earth's system, supporting a biodiverse array of plants, birds, insects, and other animals and providing important ecosystem services such as pasture forage, water regulation and freshwater supply, erosion control, pollinator health, and carbon sequestration (*1, 2*). Yet high rates of land cover conversion for intensive agriculture and silviculture, combined with woody encroachment and species invasion driven by altered fire and grazing regimes, threaten these systems (*3, 4*). For instance, the Cerrado has been extensively cleared for agriculture, with more than half lost in the past 50 years, exceeding the rate of forest loss in the Brazilian Amazon (*5*). The Great Plains of North America has also lost more than half its original grasslands and continues to lose 2% each year (*6*).

As we enter the United Nations Decade on Ecosystem Restoration, much of the emphasis has been on the restoration of forests (*7*). Ironically, this emphasis presents an additional threat to grasslands: Careless or poorly planned tree-planting efforts in the name of restoration can establish forests in natural grassland and savannah ecosystems. For instance, almost 1 million km^2 of Africa's grassy biomes have been targeted for tree planting by 2030 (*8*). This practice ignores the value of protecting and restoring grasslands.

The conversion and degradation of grasslands can occur rapidly, yet restoring lost ecosystem services and diversity is often a discounted or underestimated challenge. Until recently, grassland assembly was assumed to be a relatively straightforward—albeit difficult—process (*9*): Allow herbaceous species to recolonize, at times augmenting with seed of native species; reestablish appropriate grazing and fire disturbance regimes; and control ruderal, exotic, or woody species. Because many herbaceous species reach reproductive maturity in a few years, it was also assumed that this assembly process was relatively quick, achieving desired diversity and function within several years to a decade. We now know that this view of grassland restoration does not adequately acknowledge the difficulty of restoring biodiversity and functions or the time and interventions needed to restore grasslands (*10*). Here, we review recent developments that widen the view of grassland restoration to include grassland age and development, describe how this lens identifies important but overlooked restoration interventions, and highlight several key unknowns for grassland restoration into the future.

Refining the reference: The old-growth concept for grasslands

Grasslands occur in a range of biogeographical contexts (Fig. 1) including the tropical and subtropical savannas in Africa, Australia, Asia, and South America; the boreal, temperate, and southern prairies in North America; and the steppes in Eurasia. Grasslands have a continuous herbaceous layer of graminoids and herbaceous dicots, either without trees or, in the case of savannas, supporting a range of tree densities with a continuous grassy understory (*3*) (Fig. 2). The processes creating and maintaining grasslands vary across locations (*11*); these include edaphic or climatic conditions and disturbances (i.e., herbivore grazing or fire), all of which can limit the establishment of woody species (Fig. 3).

The reference condition is a cornerstone concept in ecological restoration; it encapsulates a set of desired characteristics and provides guidance for how to evaluate project success, even if a restored system is rarely able to completely reach reference conditions (*12*). In grasslands structured by edaphic or climatic conditions, with soils, low temperatures, or low precipitation constraining tree establishment, grassland is generally acknowledged to be the desired reference state for restoration. In cases where climate is suitable for forests but herbivore grazing or fire maintain them in an open state (*10*) (Fig. 3), more debate and uncertainty surrounds the reference designation. These disturbance-dependent grasslands are often assumed to be a result of deforestation (i.e., derived grasslands; grass-dominated vegetation resulting from human-caused deforestation) in an early successional stage on a forest trajectory (Fig. 4). However, climate suitability for tree growth does not preclude the likelihood that old-growth grasslands exist (or used to exist) in the region (*13*).

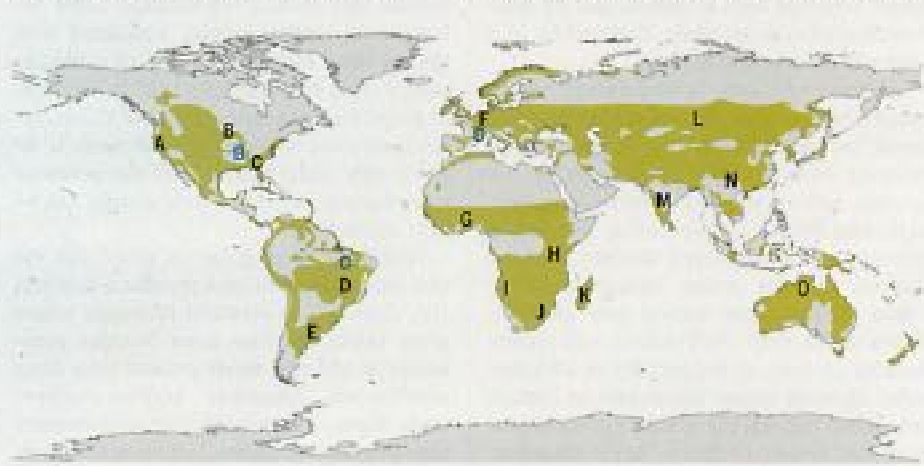

Fig. 1. The distribution of grasslands spans temperate and tropical regions of the globe. Green areas estimate the extent of grassland distribution. We note, however, that all maps of grasslands should be considered imprecise: Grasslands occur mixed within landscapes with other vegetation types and are often disturbed to an extent that masks historic distributions. Letters in black are grasslands represented in Fig. 2; letters in blue are grasslands represented in Fig. 3.

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Moreover, these disturbance-dependent grasslands are often at risk from factors driving woody invasion, rearranging landscape mosaics and shifting grass-forest boundaries (*14*). If afforestation policies under the guise of restoration disregard these dynamics, irreversible damage will occur (*7*).

In forest ecosystems, old-growth forests are often used as references for restoration. These are mature forests composed of large and old trees, large snags, and a diverse tree community with structural complexity, all of which require long time periods to develop. Recent work has made it abundantly clear that the "old growth" concept is not limited to forests (*4*, *11*): Old-growth grasslands, also called ancient or pristine grasslands, assemble over centuries and contain high species diversity, long-lived perennial plants, and a substantial proportion of well-developed belowground structure from which species can resprout after natural disturbance. Old-growth grasslands are unique in their underground structures and biodiversity: They store carbon and reallocate resources aboveground after disturbances and drought. All biogeographic contexts where grasslands are present (Fig. 1) support ancient old-growth grasslands that have persisted for millennia.

As with old-growth forests, there should be little expectation that restored grasslands will ever completely recover to resemble old-growth grasslands. Even so, old-growth grasslands provide a suite of characteristics that can be the aim in restoration: long-lived perennial plants; a complex diversity of belowground structures that enable resprouting after aboveground disturbances such as fire and grazing; and substantial belowground carbon stores. Traditional management can usefully target these old-growth characteristics even in cultural landscapes where grasslands are created and maintained by human activity, and regardless of historical analogs (*15*).

With maps of grasslands contested and overlapping those of forests (*8*, *13*), it can be challenging to determine whether a grassland is one that formed after the degradation of an old-growth grassland (i.e., a secondary grassland; grass-dominated vegetation resulting from the degradation of old-growth grasslands) or a derived grassland formed after deforestation. Paleoenvironmental methods, considering

Fig. 2. The incredible diversity of old-growth grasslands. See Fig. 1 for locations. Whether these grasslands are maintained by disturbance (such as grazing or fire) or are environmentally constrained (EC, edaphic or climatic; see Fig. 3 for details) is indicated within brackets. **(A)** California coastal grasslands on Mount Tamalpais, USA (disturbance). **(B)** Curtis Tallgrass Prairie Restoration, Wisconsin, USA (disturbance). **(C)** Longleaf pine (*Pinus palustris*) savanna, North Carolina, USA (disturbance). **(D)** Grassland in the Espinhaço mountain range, Minas Gerais, Brazil (EC, edaphic + disturbance). **(E)** Subtropical grasslands in Rio Grande do Sul, southern Brazil (disturbance). **(F)** Alpine meadow in the Alps, Vanoise National Park, France (EC, climatic). **(G)** A high-rainfall grassy savanna in Mole National Park, Ghana (disturbance). **(H)** The Serengeti ecosystem in Tanzania (EC, edaphic + disturbance). **(I)** The grasslands in the Kavango Catchment, Angola (EC, edaphic and climatic + disturbance). **(J)** Grassland in the Drakensberg, South Africa (disturbance). **(K)** Grassland and tapia savannas on Ibity mountain, Madagascar (disturbance). **(L)** Petrophytic steppe in Khakassky Zapovednik State Nature Reserve, Russia (EC, climatic). **(M)** Eravikulam Shola grasslands, India (EC, climatic + disturbance). **(N)** Oak savanna in South Yunnan, YuanJiang region, China (disturbance). **(O)** Mesic savanna in the Northern Territory, Australia (disturbance). These grasslands vary widely in composition and structure yet share key characteristics that can guide restoration: high belowground allocation, complex resprouting structures, and unique functional and taxonomic diversity.

lengthy records of pollen, phytoliths, charcoal, and *Sporormiella* fungi specific to herbivore guts, can provide evidence for past grasslands and their disturbance history (*16*). Species composition and functional diversity (e.g., of belowground structures), as well as phylogenetic studies dating the origins of endemic grassland species, can also indicate antiquity and conservation value (*17*, *18*). There are also contexts where grasslands are the desired ecosystem state for cultural or social reasons despite being created or maintained by humans.

Pathways and thresholds of grassland degradation

Grasslands are increasingly degraded by land-use change and altered disturbance regimes, which can fundamentally alter their structure and functioning (Fig. 4). Such degradation increases the need for grassland protection and restoration but can also decrease the capacity of restoring old-growth grassland characteristics.

Grazing and fire are dominant aboveground disturbances that have coevolved with grassland plants, maintaining diversity and function in grasslands (*4*). Changes to these disturbance regimes can gradually alter grasslands. Although this results in the loss of biodiversity and simplification in composition, structure, and functioning, altered grassland often maintains some belowground structures (Fig. 4). Lack of grazers (or of particular suites of grazing species) can homogenize grasslands and increase fire occurrence. On the other hand, overgrazing, particularly in grasslands with no evolutionary history of grazing, can result in loss of basal cover, soil compaction, and increased erosion (*19*). Defining the degradation point in these circumstances is difficult; for instance, naturally occurring "grazing lawns" have many of the biophysical characteristics associated with degradation (low aboveground biomass, soil compaction, sometimes even increased bare ground) even though their unique biodiversity and ecological importance is now increasingly recognized. Fire regimes can also become too frequent or infrequent or occur during the wrong season. The longer these altered disturbance regimes persist, the more risk to belowground structure (e.g., bud banks) that speed recovery. Altered disturbance regimes can also facilitate exotic grass invasion and woody encroachment (*20*), which can compound impacts to belowground structure over time.

The most detrimental disturbances are those that rapidly destroy belowground structure, such as tillage agriculture, mining, and afforestation (*10*, *21*). For instance, 50 years of pine plantation completely eliminated the viable bud bank in a once-open savannah (*22*). Several decades after cultivation or mining, the composition of secondary grassland plant communities remains very different from that of nearby old-growth grasslands, lacking species with poor dispersal abilities and species regenerating from belowground organs (*10*, *23*). Belowground degradation can therefore cause grasslands to cross a hard-to-reverse threshold where restoration may be difficult or impossible within decades of these disturbances. Given the apparent existence of this threshold, it is vital that remaining old-growth grasslands are protected, particularly from the threats that affect belowground processes and structure, as we cannot rely on restoration to guide complete recovery after such degradation.

Interventions toward old-growth characteristics

In contrast to the early successional view of derived grasslands as a stage on their way to forests, restoring old-growth characteristics to altered or secondary grasslands requires attention to the development of a complex belowground structure akin to the aboveground complexity in an old-growth forest (*24*). A synthesis of 31 studies, including 92 time points on six continents, indicates that secondary grasslands may typically require at least a century, and more often millennia, to recover their former species richness (*25*). Even as their richness increases over decades to centuries, these grasslands still lack many characteristic old-growth grassland species and instead support more short-lived, early successional species than their old-growth counterparts. We know less about the timeline for belowground soil and structure development, but it likely corresponds with the timeline

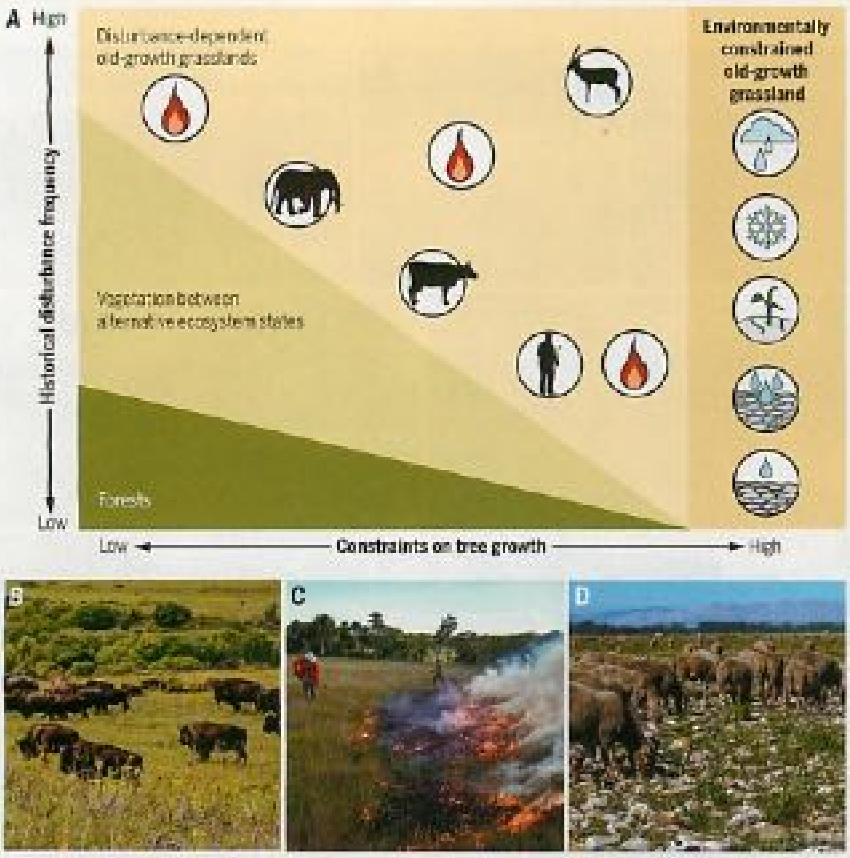

Fig. 3. Interactions among climate, soils, disturbance, and vegetation are key considerations for understanding old-growth grasslands as well as recovery trajectories in secondary grasslands. (A) On most soil types, the existence of disturbance-dependent grasslands (in light rose-color) is determined by interactions between soils and endogenous disturbances (fire, herbivory). Tree recruitment is limited by these disturbances. In environmentally constrained grasslands (in light brown), poor drainage (seasonally saturated or inundated soils), extremely low moisture-holding capacity (shallow, rocky soils), exceptionally low soil fertility, cold temperature, or low precipitation preclude dense tree cover, even in the absence of frequent disturbances. Disturbances and abiotic factors (circles, in no set order) that could result in exclusion of trees are placed as examples in each of the far left zones, respectively. In forests (dark green), dense tree cover constrains fire frequency and grazer abundance by limiting herbaceous plant productivity. The light green state space between disturbance-dependent old-growth grasslands and forests represents unstable vegetation (fire-excluded, tree-encroached grassland) in transition between alternative ecosystem states; old-growth grasslands and forests often co-occur in mosaics in such landscapes. **(B to D)** Examples of grasslands structured by different interactions. (B) Bison grazing in Konza prairie, where fire is needed to suppress woody encroachment. (C) Water saturation of the soil prevents tree establishment and fire maintains diversity in this wet grassland in Jalapão, Northern Brazil. (D) Sheep grazing in a Mediterranean grassland in Southern France, where pastoralism has coevolved with the system in a grassy state since the Holocene.

of these compositional dynamics (25). The increased appreciation of the temporal dimension of grassland assembly emphasizes the need of restoration to accelerate this trajectory and challenges the view that one initial period of active restoration will be sufficient to guide development. We highlight three advances driven by this increased appreciation below.

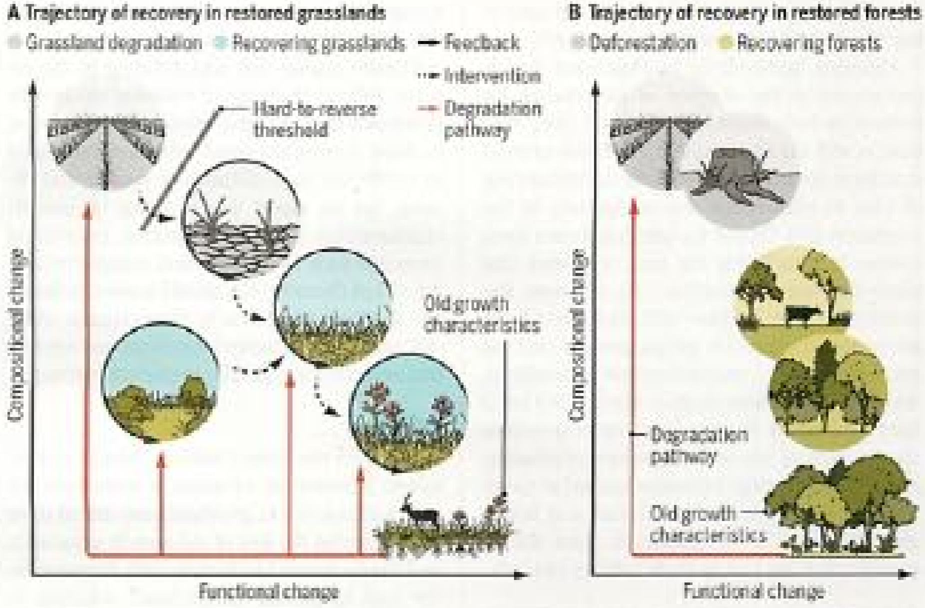

Fig. 4. Degradation pathways can result in differential loss of ecosystem function and diversity to old-growth grasslands, and the recovery of "old-growth" characteristics is dependent on the degree of functional change. Axes of functional and compositional change depict divergence from the reference characteristics [modified from (23)]. **(A)** The trajectory of recovery in restored grasslands (blue spheres) toward old-growth characteristics (lower right) is dependent on the degradation pathways (red arrows, ranging right to left from altered disturbance regimes to land use conversion) as well as vegetation-soil-disturbance feedbacks (black arrows) at each stage of recovery. Substantial belowground disturbance (e.g., tilling) may cause the system to cross a hard-to-reverse threshold (gray line) and woody encroachment shifts feedbacks and can lead to alternative trajectories. Iterative restoration interventions (dashed black arrows) that consider these feedbacks can result in progression back toward old-growth characteristics. **(B)** Forests show similar dynamics, where recovery to old-growth characteristics after deforestation may be hard if not impossible. An early recovery stage after deforestation may be a grassy stage (which we term a derived grassland), yet the recovery trajectory is toward forest. Restoration interventions may accelerate recovery.

Focus interventions on disturbance-vegetation feedbacks

In cases where degradation has not had a catastrophic impact on belowground structure, it may be possible to reestablish broken feedbacks that then can guide recovery (26). Feedbacks among disturbance, vegetation, and belowground soil development have structured grasslands for millennia (4, 27). Disturbance regimes select for functional traits of the vegetation, which then provide feedback to affect the intensity, frequency, and impact of disturbances (28). For instance, fire regimes vary in flammability depending on plant properties, and herbivore pressure varies depending on the quantity and quality of forage and habitat suitability for predator avoidance (27). The response of vegetation to these disturbances varies based on plant traits such as resprout ability, clonal growth, and seed recruitment (26, 28). Feedbacks also extend to soils and soil organisms, as soils determine plant growth but are also products of the plants that grow on them (29).

As feedbacks in degraded grasslands differ in their nature and strength from those with more old-growth characteristics, reestablishing a disturbance regime in degraded grasslands may not result in expected effects of the disturbance or in the intended vegetation responses to the disturbance. Interventions simultaneously addressing disturbance and biota may be the best option to break the feedbacks that constrain recovery. For instance, there are examples of creative use of prescribed fire as a tool to recreate grazing habitat (30), and livestock can be managed in such a way as to initiate grazing habitat that supports large mammalian herbivores (31). Amendments such as biochar and mycorrhizal inoculum can shift the soil environment to be more suitable for native species, characteristics which can be maintained by slow growth and resource cycling of the vegetation (32, 33). As the system recovers, these interventions also need to shift depending how the recovering biota affects disturbance dynamics and vice versa.

Breaking the cycle of invasion: Vegetation change that constrains recovery

Restoration in areas where an altered disturbance regime has resulted in woody encroachment or exotic herbaceous species invasion demonstrate the importance of viewing restoration as a set of interventions that iteratively move the system to a new system state (10, 34). Woody species can strongly influence disturbance regimes, and land managers have resorted to cutting, herbicides, and even plowing to remove trees—with striking consequences for the remaining biodiversity. Extreme fires (firestorms) have been applied in heavily encroached areas using spiral ignitions or extreme weather days to try to reverse the woody cover and reinitiate ecologically relevant feedbacks (35). Once the grassy understory has been reduced to the point that it cannot carry a fire or support grazers, woody encroachment becomes more difficult to reverse (36), requiring the replanting of herbaceous vegetation alongside the initiation of disturbance regime for recovery feedbacks.

When invasive species are grasses, they can often maintain disturbance regimes that benefit short-lived ruderal life histories, preventing transitions to the belowground complexity and allocation that characterize old-growth grasslands (37). High accumulation of litter and standing dead biomass changes local fire behavior, and a dependence on seed recruitment often confers advantage for invasives under this disturbance regime (38). Dominance in the seed bank and difficulty reestablishing long-lived natives can make this feedback particularly difficult to address. One strategy is to enhance the ability for natives to recruit by seed via seed enhancement technology (e.g., seed coating or pelleting aimed at mitigating the conditions that limit establishment) (20), potentially addressing priority effects (i.e., the order in which plants are reintroduced) that influence species dominance in early stages of restoration (39).

Overlooked old-growth grassland species

One important restoration question is how to accelerate or facilitate species turnover toward old-growth species composition and associated belowground function. Worldwide, grasslands are often restored by sowing seeds (40). However, as many species have developed colonization and survival strategies that are based on belowground buds and clonal growth (23, 41) rather than on seeds, additional techniques may be needed to restore old-growth characteristics. Seeding fast-growing species can impede long-term restoration success by creating communities with low resilience to natural disturbance, such as fire, and excluding the longer-lived species from restoration (42). In fact, there may be many grasslands where seeded species maintain dominance long after restoration, spurring reconsideration of whether actions are achieving the desired old-growth structure (*43*).

Although bud-bearing belowground organs can persist in the absence of disturbance for some time in a degraded grassland (*44*), how long is still unclear. Once these belowground structures are gone, we have little understanding of how to reintroduce this component of the vegetation (*24*). Topsoil transfer has shown some success in broadening the type of species that restoration can reintroduce (*45*), yet even this technique favors species with high seed bank allocation. Vegetative propagation—such as micropropagation, transplantation of seedlings, and individual tillers—is often needed (*24*) but is hard to conduct at scale, with open questions about protocols, spatial configuration of planting, and genetic sourcing. Techniques aimed at speeding the establishment of bud banks and belowground organs in a restoration have shown promise but are just in their infancy (*24, 41*).

Global change as a challenge and opportunity

Global climate change frames the emerging perspective of long-term assembly toward old-growth characteristics in grassland restoration. Climate controls the distribution of grasslands in some regions, influences the feedbacks and threshold shifts that determines where grasslands persist, and, in virtually all regions, can have a strong influence on the interventions needed to restore feedbacks (*14, 46*). Depending on the degree to which climate influences these processes, it may also affect the historical approach to the determination of grassland types and disturbance regimes (*12*). For instance, changes such as elevated atmospheric CO_2, which exacerbates invasion of woody species, would require novel disturbance regimes to aim for a grassy state.

Given the strong feedbacks between composition and disturbances in grassland recovery, shifts in climate may exert large influences on the assembly process. In some cases, it may be important to let climate effects shift restoration trajectories, as climate can guide species composition or characteristics to those most able to tolerate future conditions (*47*). Restoration efforts under a climate change scenario may thus target not only which species should be present at a given site, but also functional diversity, soil structure, and the belowground component. In this way, the system may be able to recover from an extreme event, as the presence of a viable bud bank and underground storage organs ensures the resilience of the system (*48*). However, letting climate effects shift restoration trajectories might also be undesirable if it endangers fundamental feedbacks in the trajectory of the system toward old-growth functional characteristics (*46*) by, for instance, selecting for species with greater aboveground allocation characteristics. As belowground complexity is a characteristic that develops over long time horizons, understanding how climate influences priority effects and feedbacks that affect recovery trajectories is critical.

Climate change will add difficulty to the already difficult challenge of restoring old-growth grasslands that resemble specific reference sites, as these ancient grassland references developed in a different time, disturbance regime, and climate. Yet we expect that restoring old-growth characteristics in these situations, prioritizing processes such as belowground complexity and functional diversity (*49*), should enable resilience and facilitate adaptation to future change while still maintaining character, functions, and services that embody these globally important systems.

Outlook

As we enter the United Nations Decade on Ecosystem Restoration, advances in restoration science and practice in grasslands are critical if we are to combat the loss of old-growth grasslands and the decline of biodiversity (*50*). However, in the rush to provide nature-based solutions to tackle climate change, tree planting in grasslands has become synonymous with restoration in many regions (*13*). At the same time, the high demand for arable land continues to spur conversion to agriculture. These are irreversible actions, ignoring the belowground soil-locked carbon storage in these old-growth grasslands as well as the hard road to restore their belowground complexity and their biodiversity once they are lost.

Although there are many challenges ahead, viewing grassland restoration as assembly toward old-growth characteristics with unique biota and belowground complexity will enable us to achieve ambitious restoration goals for Earth's grassy ecosystems. Given that grassland recovery involves strong feedbacks among vegetation, disturbance, and soils, as well as the lengthy time horizon for recovery, future progress depends on creative interventions that focus on iterative management, taking into account changes in grassland assembly over time. Techniques to reestablish species characteristic of old-growth grasslands, given their belowground structure and limited recruitment by seed, will require looking beyond or augmenting traditional seeding techniques. Metrics of belowground complexity and functional diversity will be critical guideposts to track trajectories in development and assess success. We urge conservation initiatives to safeguard against the conversion of old-growth grasslands for tree planting or tillage agriculture, to maintain our ancient biodiverse grasslands with appropriate disturbance regimes, and to emphasize the long-term restoration of grasslands in efforts to restore Earth's biodiversity.

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REVIEW

Molecular, cellular, and developmental foundations of grass diversity

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Humans have cultivated grasses for food, feed, beverages, and construction materials for millennia. Grasses also dominate the landscape in vast parts of the world, where they have adapted morphologically and physiologically, diversifying to form ~12,000 species. Sequences of hundreds of grass genomes show that they are essentially collinear; nonetheless, not all species have the same complement of genes. Here, we focus on the molecular, cellular, and developmental bases of grain yield and dispersal—traits that are essential for domestication. Distinct genes, networks, and pathways were selected in different crop species, reflecting underlying genomic diversity. With increasing genomic resources becoming available in nondomesticated species, we anticipate advances in coming years that illuminate the ecological and economic success of the grasses.

Most people reading this review will have either eaten, stepped on, or burned a grass within the past 24 hours. Humans have been cultivating grasses for at least 10,000 years and likely consumed them for millennia before that. Of the crops that feed the world, the big three—wheat, maize, and rice (Fig. 1)—provide 50% of calories consumed by humans as well as protein and micronutrients, are grown over the widest area, and have the highest economic value (*1*). In addition, so called "orphan crops," such as tef, sorghum, fonio, and various millets, most of which are native to Africa, grow well with less intense agricultural inputs and are poised to be cultivated more widely to serve a warmer, drier planet. Meat, eggs, and dairy products are the products of animals that consume forage, pasture, and prairie grasses.

Moreover, some of the most devastating agricultural weeds, such as Johnson grass in corn fields and barnyard millet in rice fields, are grasses (*2*). Grasses also underpin the beverage industry; the world wouldn't have beer without barley (Fig. 1) or rum without sugarcane, with the latter being used to produce not only sugar but also biofuel (*1*). Turf grasses beautify cultivated landscapes and provide the playing surface for golf courses, tennis courts, cricket pitches, and other sports fields. Grasses such as Miscanthus and switchgrass are being developed for lignocellulosic biomass, and perennial grasses, such as intermediate wheatgrass, may help store carbon below ground. Bamboos (and even giant reeds) are used for construction. Yet despite this diverse repertoire, only a small subset of the ~12,000 species of grasses are used by humans (*2, 3*).

Like orchids, lilies, asparagus, and pineapples, the grasses (family Poaceae or Gramineae) have a single seedling leaf (cotyledon) and are placed in the large clade of monocotyledonous flowering plants (monocots). The grasses constitute ~20% of the ~60,000 species of monocots (*4*). Thus, all grasses are monocots, but most monocots are not grasses. Grasses that produce seed that is cultivated agronomically and eaten by humans and animals are often called cereals.

Morphological and physiological diversity

Grasses are ecologically dominant in vast areas of all the continents except for Antarctica (*2, 5*). Even in areas with some tree cover, grasses form a broad understory. The grass family may have originated more than 80 million years ago, extending its continental reach during the late Miocene grassland expansion (8 million to 3 million years ago), although its current distribution also reflects extensive climatological change since then (*5, 6*).

Broad physiological adaptations permit grasses to thrive in disparate environments. Most grasses are tropical, but one major group, subfamily Pooideae, has spread widely in cool and cold areas, even reaching Antarctica (*7*). Whereas some genetic components of their cold tolerance are widely shared stress responses, others represent the repurposing of loci involved in other physiological responses (*8*). Such loci include ones that regulate the induction of flowering after cold (vernalization), as in winter wheat (*9*). Among the tropical grasses, high-efficiency (C_4) photosynthesis has originated 22 to 24 times (*10*), with the physiological and anatomical bases of the pathway being subtly different each time. Our cultivated cereals are mainly annual, grown for their ability to complete their life cycle (seed to seed) in one growing season, but most species of grasses are perennial (*2*). The genetic mechanisms underlying the shift from perennial to annual are unknown but are likely diverse (*11*).

Genomic diversity

The genomes of grasses are largely collinear for all species in the family, that is, the genes are in roughly the same order (*12*). This broad similarity allows genes identified in one species to be discovered in a second species, permitting the grasses to function as "a single genetic system" (*12*). All grass genomes also share large regions of duplicated genes, which points to a polyploidization event in the common ancestor of the family [e.g., (*13, 14*)]. Polyploidization events have continued to occur frequently throughout the evolution of the family, with some authors estimating that as many as 75 to 80% of the species are recent polyploids (*15*).

Beneath this broadly conserved genome architecture lurks extensive diversity, including variation in nucleotides (single-nucleotide polymorphisms), gene structure, and even the presence or absence of genes [e.g., (*16, 17*)]. The nucleotide differences between two lines of

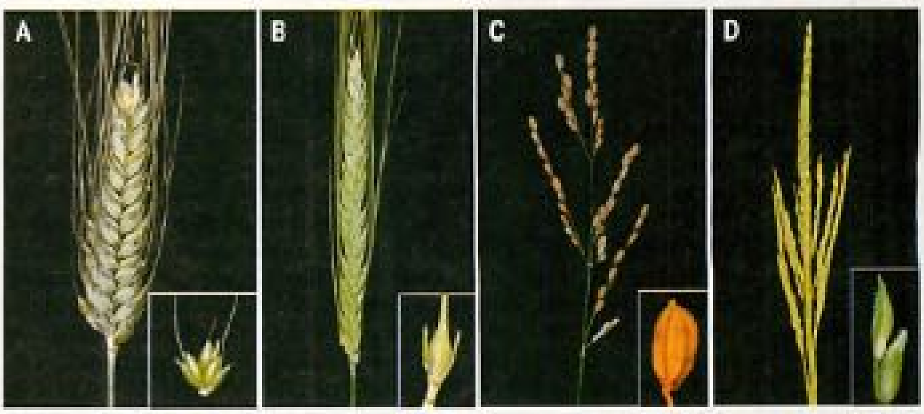

Fig. 1. Diversity of grass inflorescence morphology. (**A**) In wheat, the unbranched spike produces single spikelets (inset) with multiple florets. (**B**) In barley, the unbranched spike produces triplet spikelets (inset). In this two-row variety, only the central spikelet produces a floret. (**C**) Rice has many branches and produces single spikelets (inset) with a single floret. (**D**) Maize produces many branches with paired spikelets (inset) that each produce two florets.

PHOTOS: (A, B, D) ELIZABETH A. KELLOGG; (C) PAULA MCSTEEN

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Zea mays (maize) are greater than those between humans and chimpanzees (*18*). Genes central for plant structure in maize are missing in wheat and rice, and vice versa (*19*). In other words, not all grasses have the same complement of genes, and their morphology is altered accordingly.

The grain: A grass-specific structure

The grass fruit (grain or caryopsis) is the innovation that characterizes all grasses (*2*) (Fig. 2A). The grain develops from fusion of the single seed to the inner wall of the ovary, creating a single solid structure. The wheat "seeds" sold in the grocery store are in fact grains, with the bran made up of the ovary wall plus the seed coat. Within the grain is the young embryo (the germ, in wheat), which is a well-formed little plant with multiple leaf primorida and shoot and root apical meristems (the stem cells that give rise to all organs in the plant) (Fig. 2B). Development of the grass embryo progresses a long way before the fruit is shed from the plant, distinct from that in other closely related monocot families in which the embryo is a globular, scarcely differentiated mass of cells at fruit maturation (*2*).

The grain and the inflorescence that bears it have been the focus of both natural and human selection for grain size and number and dispersal. The starch-filled endosperm and oil-filled embryo of grains made wild grasses an obvious source of food for human ancestors. The early process of converting these wild species into ones that could be cultivated year after year is well known and is described in many biology textbooks. Traits in this familiar "domestication syndrome" may include (i) cultivated plants with grains that are larger than those of their wild ancestors and do not drop off the plant, (ii) lack of dormancy, (iii) loss of awns (wheat, sorghum, oat, rice), and (iv) increased grain number. We will focus on the developmental, cellular, and molecular bases of two of these traits: failure of seed drop (called "loss of shattering") and grain number.

Shattering: Useful in the wild, a liability in cultivation

An early step in grass domestication is selection for mutations that let the plant hold onto its seeds rather than drop them in the dirt. The annual cycle of reaping and planting automatically selected for grains that were held more firmly than those in wild undomesticated plants and, over time [possibly ~1000 years (*20*)], led to domesticated plants in which the flower stalks fail to break easily, so-called nonshattering varieties. Lack of shattering was selected independently in most known domestication events in cereals (*21*).

The close relationship and genomic similarities among the cereal crops suggested that perhaps loss of shattering in wheat, sorghum, rice, and others could have occurred by repeated modifications of the same underlying genes. However, a series of quantitative genetic locus studies (*22*) and subsequent studies that looked at the expression of genes involved in forming the break point itself (abscission zone) have found extensive differences among the crops (*23*). Genes that are mutated in domesticated wheat (*brittle rachis 1* and *2*) are unrelated to those in rice (*shattering4* and *5*), which in turn are distinct from those in sorghum and millet [e.g., *less shattering1*, which is reviewed in (*24*)]. The one exception may be a locus known as *shattering1* (*sh1*) in sorghum (*25*), which is also mutated in domesticated rice and foxtail millet (*22*, *26*). *sh1* is a transcription factor in the YABBY family

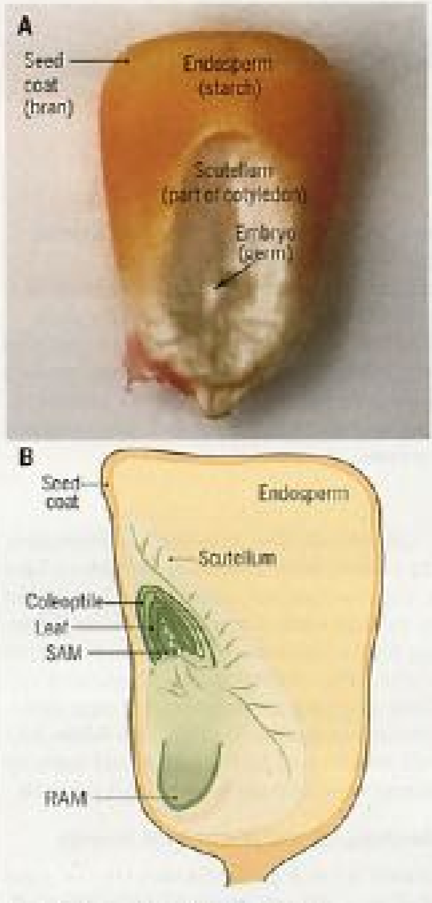

Fig. 2. Grains characterize all grasses.
(A) Photograph of a maize grain indicating the starch-filled endosperm and the seed coat. The scutellum (part of the first leaf or cotyledon) and the embryo are visible on the adaxial side of the kernel. **(B)** Diagram of a longitudinal section through the well-developed maize embryo indicating the coleoptile and scutellum (which make up the first leaf or cotyledon), multiple leaf primordia, the shoot apical meristem (SAM), and the root apical meristem (RAM).

(named for the distinctive DNA binding domain known as a yabby domain), but its precise molecular function remains unknown.

Spontaneous reversal of domestication, in which shattering has been reacquired independently, has created grasses that grow as weeds within the crop; such dedomestication has been documented in at least four lineages of rice, as well as in a few other grasses [reviewed in (*27*)]. The underlying domestication mutations are still present in the newly weedy rice, but the weedy populations have additional mutations that lead to shattering, each using different sets of genes (*28*).

Even among wild grasses, shattering appears to occur by different mechanisms, which may explain the distinct sets of mutations in the different domestication events. The break point forms in different positions in different lineages of grasses (*2*). Breakage occurs below the flower (often called a floret) in many species, such that the grain is shed along with floral organs and subtending bracts, but in other grasses (including the many species of millet), breakage occurs below the clusters of flowers (called spikelets) so that several flowers fall off the plant at once (Fig. 3). In still other species such as wheat and barley relatives, the inflorescence stalk breaks up. Cellular details and cell wall structures also differ among species, but the cell wall differences do not correlate with the location of the abscission zone or with evolutionary relationships (*29*).

Specific sets of genes characterize the abscission zones of rice, *Brachypodium*, and green millet, but the abscission-specific genes are almost completely nonoverlapping (*23*). Only two, a MYB transcription factor and a lysine decarboxylase, are specific to the abscission zone of all species (*23*). *sh1* is commonly upregulated in the abscission zone but is also expressed more widely, suggesting that its function in the abscission zone is part of a larger spikelet developmental network.

Despite years of investigation, the precise process of shattering in grasses remains unknown. Most of the genes that affect the process are transcription factors, often from well-known gene families that affect other aspects of plant development. One compelling hypothesis is that the process of shattering is not a single mechanism but rather a set of mechanisms that have evolved over time.

Grain yield: A diversity of mechanisms

Because a grass flower (floret) produces only one grain (at most), the number and arrangement of flowers directly affect the yield. The number of grains is thus affected by the number of flowers per spikelet, the number of spikelets per branch, and the number of branches per inflorescence, all of which vary among species (Fig. 4). Furthermore, many species have inflorescences that top vegetative branches, called tillers, further contributing to grain yield. Complicating the picture, grain weight and number of grains are generally inversely correlated, so simple selection for more grains leads to more smaller grains (30). Because of the complexity of how flowers are produced, increased grain number can be achieved by any number of different mechanisms.

Domestication and postdomestication breeding of cereals have led to an increase in the number of grains produced (increased yield) compared with that produced by the wild ancestor. For example, hybrid maize bears 16 to 22 rows of kernels around the circumference of the cob, substantially more than the wild ancestor teosinte, which bears only two rows. The number of rows is always an even number because maize produces its spikelets in pairs (Fig. 4), as do all other members of the tribe Andropogoneae, including sorghum, sugarcane, and Miscanthus (2). Paired spikelets have also arisen independently in the related tribes Paspaleae (e.g., seashore paspalum) and Paniceae (e.g., fonio, crab grass). But how do these grasses produce pairs in the first place? The vast majority of grasses, like rice, produce spikelets singly, although another cereal, barley, produces spikelets in triplets. Wheat produces spikelets singly, but mutations can cause the formation of paired or triple spikelets, indicating that wheat has the underlying genetic capacity to produce additional grain. Could understanding these mechanisms be used to increase grain number in cereals or in grasses or orphan crops to be domesticated in the future?

Multiple mechanisms have led to the variation in inflorescence morphology observed in grasses during evolution and domestication (Figs. 1 and 4). Determination of the molecular, cellular, and developmental bases of these phenotypes indicates that similar phenotypes in one species can be caused by different pathways or that orthologous genes can cause different phenotypes in different species. In the following sections, we discuss three mechanisms involved in the diversity of morphology in cereal grasses.

To branch or not to branch

Multiple genetic pathways control branching in grass inflorescences (19). Mutations in these pathways can lead to increased branching and increased grain number, so it is not surprising that these pathways have been selected in the evolution, domestication, and breeding of cultivated cereals. However, a variety of different pathways have been used in different cereals (19). We discuss just two of these pathways below.

In maize, expression of *ramosa2* (*ra2*), which encodes a transcription factor in the lateral organ boundary (LOB) domain family, acts upstream of *ramosa1* (*ra1*), which encodes a zinc-finger transcription factor and controls the abrupt switch from producing branches to producing spikelet pairs [reviewed in (19)]. The expression pattern of *ra1* in *Miscanthus* and sorghum, both of which also produce spikelets in pairs and are in the same clade as maize, also correlates with the branch-to-spikelet pair transition, albeit later, correlating with an increased number of branches (31). However, *ra1* is not found in rice, barley, wheat, or other members of their subfamilies that do not produce spikelets in pairs (19). Conversely, mutations in the ortholog of *ra2* in barley also increase branching and are associated with phenotypic differences between two-row and six-row barley (Fig. 4) (9). Therefore, the genetic network regulated by *ra2* differs between major groups of grasses even though the protein itself is conserved.

Recent progress has been made in understanding the genetic basis for the unbranched spike morphology in wheat and barley by the *compositum1* (*com1*) and *com2* loci [reviewed in (32)]. Whereas *com1* orthologs do not regulate branching in maize and rice (33), the function of *com2* appears to be somewhat conserved. *com2* mutations increase branching and spikelet number in barley and cause the production of paired or, rarely, triple spikelets in "miracle wheat," which is so called because of its increased grain yield (32, 34). Mutations in the orthologous gene also increase branching in maize and rice, but the additional spikelets do not produce florets and are sterile, and hence do not increase yield (35). However, mutations in the promoter of the rice ortholog, which cause reduced rather than complete loss of function, increase spikelet number and yield and thus may be valuable for breeding (36). Evolutionary analysis of *com2* orthologs identified signatures of selection at particular amino acids in rice, wheat, and barley (37), although their functional importance remains to be determined.

Growth suppression

Another mechanism for altering branching would be to suppress the outgrowth of structures that have already been formed. For example, increased expression of several transcription factors, including *teosinte branched1* (*tb1*) and *grassy tillers* (*gt1*), has led to the suppression of tiller buds during domestication in maize, and these transcription factors are proposed to have conserved roles in regulating tiller number in wheat and rice [reviewed in (35)]. *tb1* and *gt1* have been used repeatedly in cereals for different purposes other than tiller number. For example, *gt1* was co-opted in sex determination in maize (38), and orthologs of *tb1* or *gt1* are used in the suppression of spikelets in two-row barley (35). Furthermore, in wheat, loss of function of *tb1* and interactions with flowering-time genes cause production of paired spikelets (39, 40). Thus, changes in expression (or the targets) of transcription factors that cause growth suppression could be very powerful in causing phenotypic changes.

Meristem size matters

One mechanism to increase grain number in maize and rice is to increase the size of the apical inflorescence meristem (41). A conserved signaling pathway involving proteins in the *CLAVATA* (*CLV*) and *WUSCHEL* (*WUS*) families regulates the plant growth hormone, cytokinin, which affects the size and number of stem cells in the meristem. Mutations that affect signaling in the *CLV-WUS* pathway can increase meristem size, row number, and yield in maize and green millet (42, 43) but increase floral organ number in rice (44). Despite these differences, a screen for alleles with signatures of selection in both maize and rice identified the same locus, which increases yield in both species through an

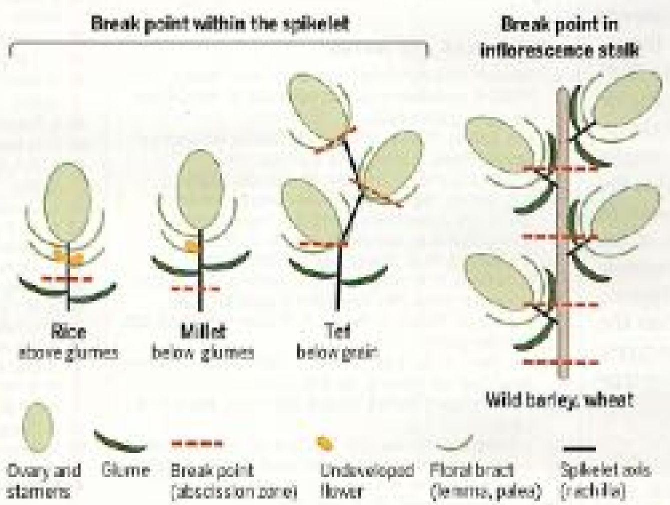

Fig. 3. Diagrams of spikelets (rice, millet, tef) and inflorescence (wheat, barley) showing different positions of break points (abscission zones). Modified leaves known as glumes (dark green arcs) mark the base of the spikelet and provide critical positional landmarks for comparisons. The break-point position above the glumes, as in rice, is common and ancestral in the grass family (23). The position below the glumes, as in millet, predominates in the subfamily Panicoideae. Few grasses break right below the grain, as in teff. The breakable inflorescence stalk is common not only in wild relatives of wheat and barley but also in maize.

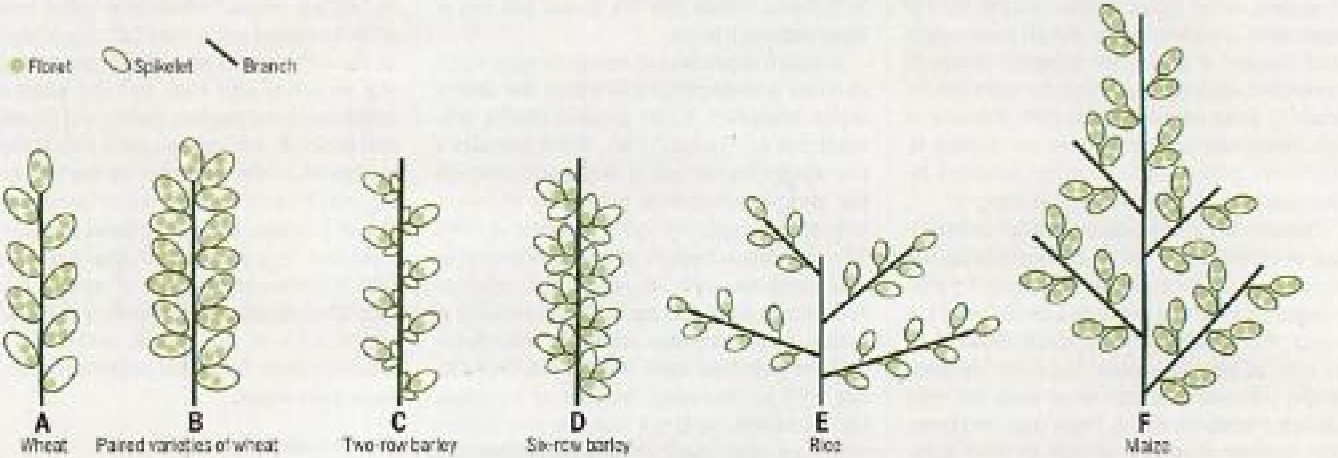

Fig. 4. Mutations that influence spikelet number in cereals provide insights into evolutionary mechanisms. **(A)** In wheat, the unbranched spike produces spikelets with a variable number of florets (average of three). **(B)** Mutations in wheat can cause the production of paired spikelets, similar to maize. **(C)** In two-row barley, only the central spikelet produces a floret. **(D)** In six-row barley, all three spikelets produce a floret and set seed. **(E)** Rice has many branches and produces single spikelets with a single floret. Mutations in rice that increase yield increase branch number and reiterate branches on the branches. **(F)** Maize produces many branches with paired spikelets, each of which produces two florets. Mutations in maize can cause the production of single spikelets, similar to rice and wheat, or can convert spikelet pairs to branches.

increase in cytokinin and cell division (*45*). Mutations that increase cytokinin levels or signaling also increase the number of branches and yield in rice (*46*), and cytokinin has been implicated in branching in barley (*47*). However, the *CLV-WUS* pathway has not yet been functionally characterized in wheat and barley, although it is an obvious target for crop improvement.

Meristems that produce multiple spikelets are larger than single-spikelet meristems. Such meristems include the spikelet-pair meristem in maize, the mutant paired-spikelet or triple-spikelet meristems in wheat, and the triple-spikelet meristem in barley; the latter extends over almost half the circumference of the inflorescence (*48*). In maize, defects in the *CLV-WUS* pathway or the plant growth hormone auxin can cause the production of single instead of paired spikelets (*49*, *50*). It seems likely that similar pathways are involved in the production of the triple-spikelet meristem in barley and in the independent origins of the paired spikelets in grasses. However, multiple ligands, receptors, and transcription factors, and even parallel pathways, converge on the *CLV-WUS* pathway in different meristem types, so the pathways that specify each meristem type in each crop will need to be identified.

Outlook

Grasses are an economic and ecological success story. We speculate that the large endosperm and well-developed embryo that are characteristic of grasses (Fig. 2) gave grains a head start in germination and seedling survival, in both ecological and agricultural settings. Grass genomic diversity provides the raw material for their morphological diversity. Genomic sequencing has provided insights into the genetic basis of domestication and post-domestication breeding of cereal genomes [reviewed in (*51*)], the development of wood in bamboo (*52*), and the multiple independent origins of cold tolerance, photoperiod insensitivity, and C_4 photosynthesis (*7*, *10*). The availability of functional genomics tools (*53*) will provide opportunities to move from genes to networks and to determine which parts of the pathway are conserved and which are species specific. These networks will enable modern-day agriculturists to determine how to domesticate orphan crops such as tef and fonio and to begin to understand how grasses have covered the world.

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REVIEW

Grassland soil carbon sequestration: Current understanding, challenges, and solutions

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Grasslands store approximately one third of the global terrestrial carbon stocks and can act as an important soil carbon sink. Recent studies show that plant diversity increases soil organic carbon (SOC) storage by elevating carbon inputs to belowground biomass and promoting microbial necromass contribution to SOC storage. Climate change affects grassland SOC storage by modifying the processes of plant carbon inputs and microbial catabolism and anabolism. Improved grazing management and biodiversity restoration can provide low-cost and/or high-carbon-gain options for natural climate solutions in global grasslands. The achievable SOC sequestration potential in global grasslands is 2.3 to 7.3 billion tons of carbon dioxide equivalents per year (CO_2e $year^{-1}$) for biodiversity restoration, 148 to 699 megatons of CO_2e $year^{-1}$ for improved grazing management, and 147 megatons of CO_2e $year^{-1}$ for sown legumes in pasturelands.

Grassland ecosystems cover an area of 52.5 million km^2, accounting for ~40.5% of the Earth's land surface excluding Greenland and Antarctica (*1*). Grasslands provide habitats for biodiversity, contribute to food production, and deliver many cultural services (*1*). They also store ~34% of the terrestrial carbon stock (*1*), with ~90% of their carbon stored belowground as root biomass and soil organic carbon (SOC), thus playing a vital role in soil carbon sequestration (*1, 2*). However, grasslands are highly vulnerable to human disturbance (e.g., overgrazing and land-use conversion to agriculture) and climate change (*1–3*). Worldwide, grasslands have undergone severe decreases in biodiversity and ecosystem functions, leading to reductions in SOC storage (*2, 4, 5*). Here, we review the recent advances in our understanding of SOC dynamics, current challenges, and possible solutions to enhance SOC sequestration in global grassland ecosystems. We address three questions: (i) How do key biotic and abiotic factors regulate grassland SOC formation, turnover, and stability?; (ii) how do climate warming, alterations in precipitation, and fire affect SOC storage?; and (iii) how does grazing management affect SOC and how can improved practices result in SOC sequestration?

Mechanisms and drivers of SOC sequestration

In grassland ecosystems, ~60% of net primary productivity is allocated belowground (*6*). Belowground carbon inputs are more often incorporated into SOC than aboveground inputs because of their chemical composition (e.g., aliphatic compounds and root exudates) and their presence in the soil (Fig. 1) (*6*). On average, root carbon inputs have a SOC stabilization efficiency that is five times greater than aboveground carbon inputs (*6*).

Organic carbon in soil is distributed between particulate organic matter (POM) and mineral-associated organic matter (MAOM) fractions, with only a minor portion (1 to 2%) present as dissolved organic matter. POM and MAOM differ in their formation, physical and chemical properties, and mean residence times in soil (*7, 8*). POM is formed from the fragmentation of plant and microbial residues, and therefore is composed of lightweight fragments made of large polymers (Fig. 1). MAOM, by contrast, is formed from single small molecules that are leached from plant residues or exuded from plant roots, which associate to minerals directly (ex vivo) or after microbial assimilation (in vivo) as microbial necromass (*7, 8*). MAOM on average has a lower carbon:nitrogen ratio because of its proportionally higher microbial origin, its longer mean residence time in soils (from decades to centuries) compared with POM (<10 years to decades), and its strong chemical bonding to minerals and physical protection in fine aggregates (*7, 8*). Therefore, MAOM contributes to longer-term carbon sequestration in soil. Root exudates such as dissolved sugars, amino acids, and organic acids are the key pathway to MAOM formation largely through microbial in vivo transformations (Fig. 1) (*8, 9*). Plant aboveground, root, and rhizodeposition inputs exhibit different

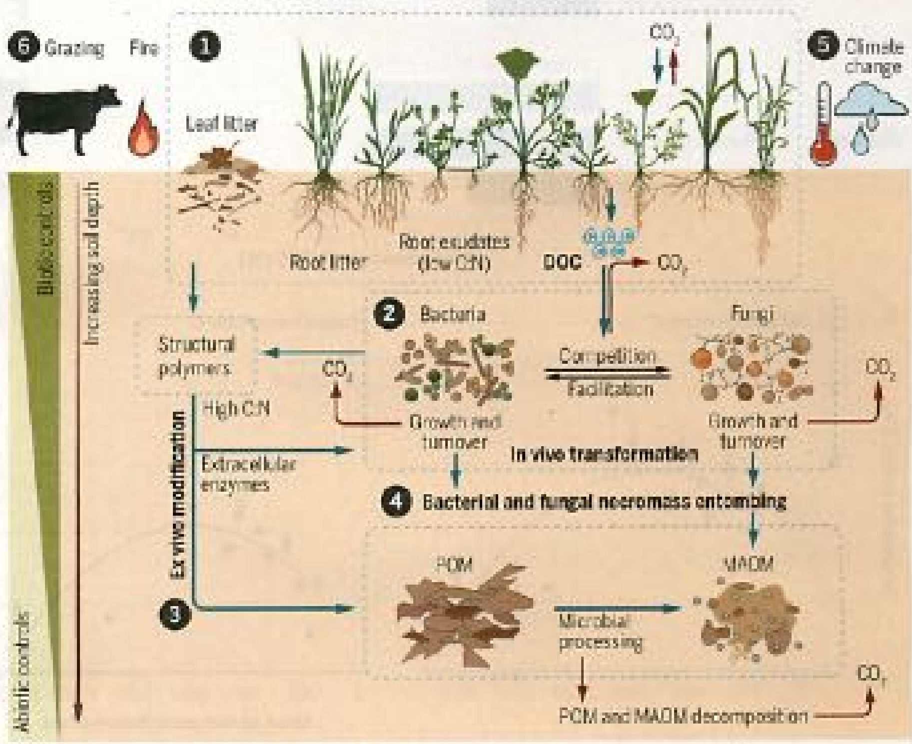

Fig. 1. Conceptual framework for key factors and mechanisms controlling SOC sequestration in grassland ecosystems. (**1**) Plant diversity controls on productivity, biomass allocation, and SOC inputs through litter and root exudates (*6, 13, 14*). (**2**) Key pathway of MAOM formation through microbial in vivo transformation (*8, 17*). (**3**) Pathway of POM formation through microbial ex vivo modification (*8, 17*). (**4**) Microbial necromass carbon (C) accumulation in MAOM (*9, 11*). (**5**) Climate change impacts on SOC sequestration through plant and microbial pathways (*26, 28*). (**6**) Grazing and fire impacts on SOC storage through pathways of plant and animal waste C inputs, compaction, and bioturbation (e.g., trampling and wallowing), microbial in vivo transformation, and microbial ex vivo modification (*33, 36, 38, 46*). C:N, carbon:nitrogen ratio; DOC, dissolved organic carbon.

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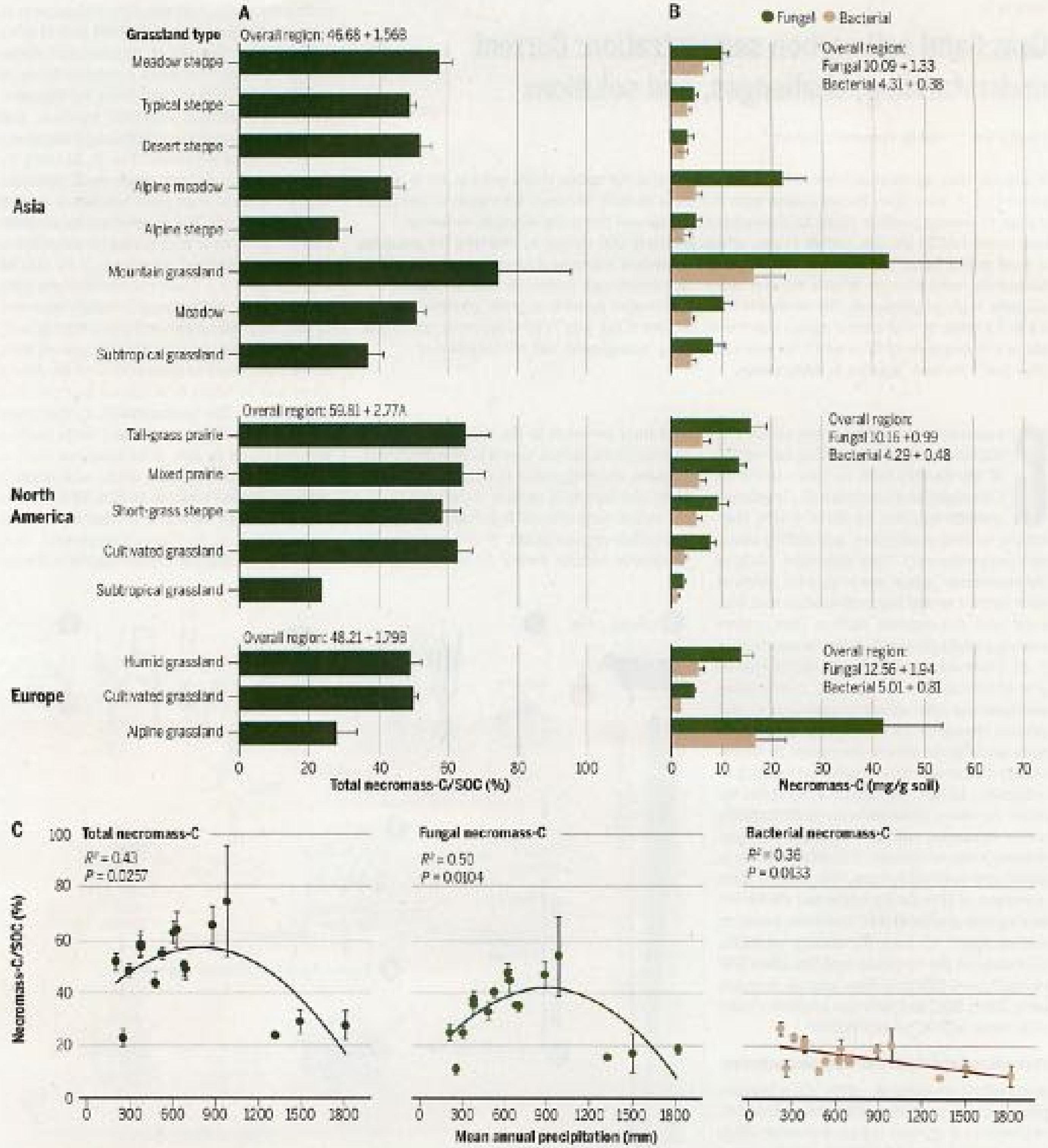

Fig. 2. Patterns and climatic drivers of microbial necromass contribution to SOC. (**A**) Microbial necromass C contribution to SOC. (**B**) Fungal and bacterial necromass C concentrations. (**C**) Relationships of total microbial, fungal, and bacterial necromass C contributions to SOC with mean annual precipitation in the topsoil of grassland systems in Asia, North America, and Europe. Data are from Liang et al. (*17*) and Wang et al. (*18*). Only the topsoil microbial necromass C and corresponding SOC data (n = 223) were used for global and regional synthesis. All data were classified into different grassland types within regions on the basis of sampling site information from the original study. Asia (eight grassland types, n = 122), North America (five grassland types, n = 47), and Europe (three grassland types, n = 54). Within each grassland type, mean and standard error for each variable were calculated across different sampling sites. General linear model analyses were performed to explore whether the total microbial necromass C contribution to SOC and fungal and bacterial necromass C concentrations differ among different regions. Values with different letters are significantly different at the $P < 0.05$ level. Simple linear regression was used to analyze to the relationship of mean annual precipitation with fungal, bacterial, and total microbial necromass C contributions to SOC across all grassland types on the global scale.

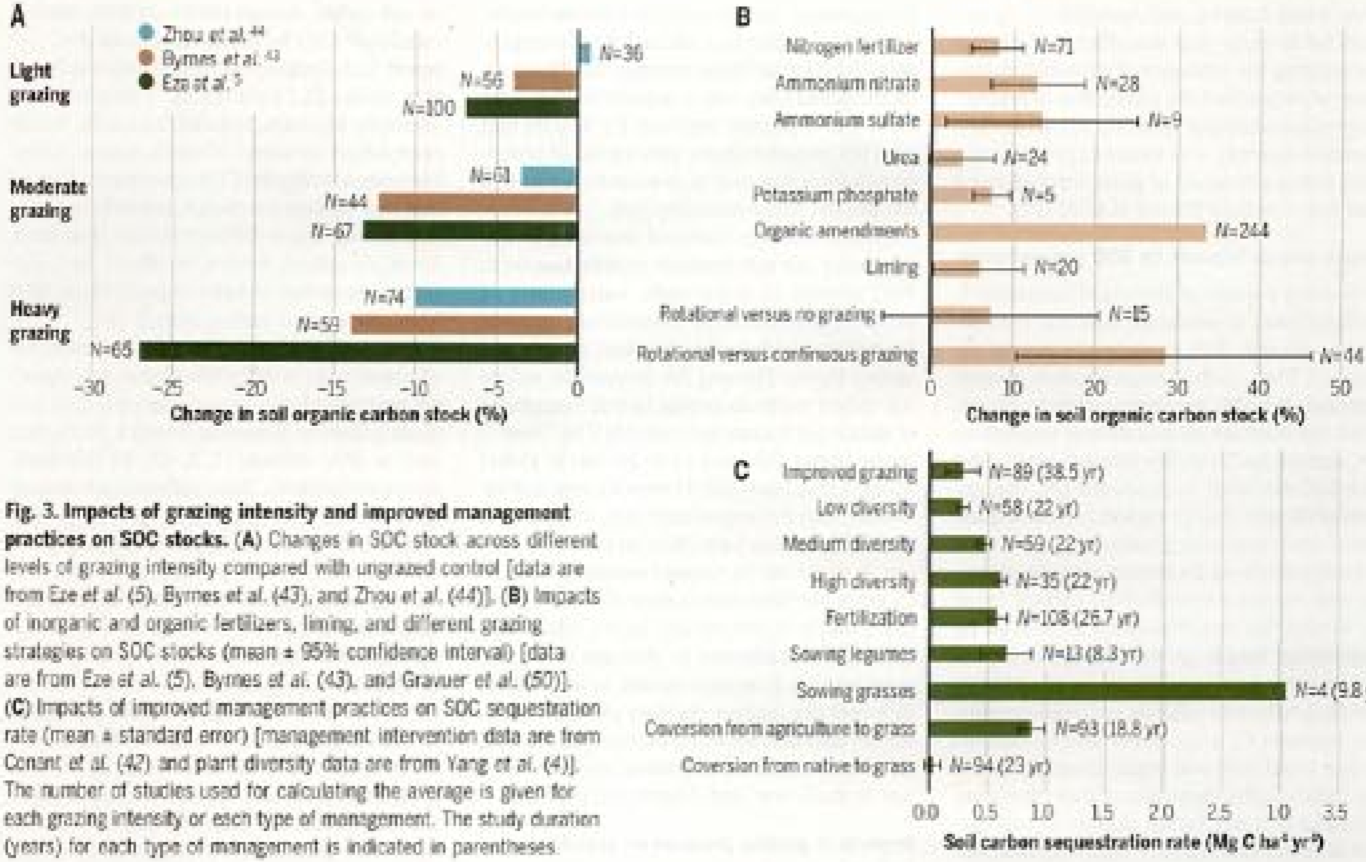

Fig. 3. Impacts of grazing intensity and improved management practices on SOC stocks. (**A**) Changes in SOC stock across different levels of grazing intensity compared with ungrazed control [data are from Eze *et al.* (*5*), Byrnes *et al.* (*43*), and Zhou *et al.* (*44*)]. (**B**) Impacts of inorganic and organic fertilizers, liming, and different grazing strategies on SOC stocks (mean ± 95% confidence interval) [data are from Eze *et al.* (*5*), Byrnes *et al.* (*43*), and Gravuer *et al.* (*50*)]. (**C**) Impacts of improved management practices on SOC sequestration rate (mean ± standard error) [management intervention data are from Conant *et al.* (*42*) and plant diversity data are from Yang *et al.* (*4*)]. The number of studies used for calculating the average is given for each grazing intensity or each type of management. The study duration (years) for each type of management is indicated in parentheses.

POM and MAOM formation efficiencies. Approximately 46% of root exudates, 9% of root tissues, and 7% of aboveground carbon residues are transformed into MAOM, whereas 19% of root litter is transformed into POM across crops, grasses, and trees growing in the field and under controlled laboratory conditions (*10*). Thus, plants with greater carbon allocation to roots contribute more to soil carbon sequestration, particularly the formation of MAOM. However, it remains largely unclear how the contributions of roots (root exudates and root litter) and aboveground inputs to SOC accumulation (POM and MAOM) change with grassland types, soil properties, and climate conditions.

In grassland topsoils, 50 to 75% of SOC is found in MAOM. The average carbon:nitrogen varies from ~10 to ~12 for MAOM and from ~16 to ~18 for POM (*3*); therefore, the accrual of SOC in MAOM requires substantially greater nitrogen than the equivalent accrual in POM (*11*). The formation of POM is primarily driven by climate (temperature and precipitation). By contrast, the accumulation of MAOM is controlled by soil properties such as silt and clay content, cation-exchange capacity, and microbial nitrogen availability, which means that it may saturate (*8*, *12*). In European grasslands, topsoil carbon storage in MAOM saturates at ~50 g C kg^{-1} soil, beyond which the additional increase in SOC storage completely depends upon accrual in POM (*11*). Currently, most European grasslands (80%) are below saturation, indicating a large capacity for SOC sequestration in their topsoils (*11*).

Plant diversity is a key driver of SOC formation and storage (*4*). High plant diversity enhances SOC storage by elevating belowground carbon (i.e., root biomass and root exudates) inputs (*13*, *14*) and promoting microbial growth, turnover, and entombment of necromass (*15*). Maintaining consistently high levels of biodiversity and root carbon inputs is essential for enhancing SOC storage and persistence in grasslands (Fig. 1).

Fungi and bacteria have a strong influence on SOC accumulation, stabilization, and turnover in grasslands (Fig. 1), as in other terrestrial ecosystems (*6*, *16*). Microbial necromass plays an important role in SOC accumulation and stabilization (*9*, *17*). In the topsoil of global grasslands, the contribution of the microbial necromass to total SOC ranges from 23 to 74%, with an average of 50% (Fig. 2A), which is greater than its contribution in agricultural and temperate forest soils (*17*, *18*). The contribution of necromass to SOC changes with soil depth (*18*) and is typically dominated by fungal necromass, with the fungi-to-bacteria necromass carbon ratio ranging from 1.2 to 4.1 across global grasslands (Fig. 2B). This is likely because fungi produce more chemically recalcitrant structural compounds and have greater carbon use efficiency than bacteria (*6*, *16*). Moreover, mycorrhizal fungi, which live in association with plant roots and derive their carbon directly from the plant, can regulate the carbon sequestration capacity in soil. Carbon sequestration capacity per unit nitrogen in soil is 1.7 times greater in ecosystems dominated by ectomycorrhizal fungi–associated plants (e.g., savannas, shrublands, and forests) than in systems dominated by arbuscular mycorrhizal fungi–associated plants (e.g., nonwoody grasslands) because ectomycorrhizal fungi can produce enzymes to degrade organic nitrogen from plant litter (*19*). However, MAOM is relatively higher in ecosystems that are dominated by arbuscular mycorrhizal fungi (*13*), such as grasslands.

Climate regulates the metabolic activity of microbes and thus controls large-scale patterns of microbial necromass and SOC storage (*18*, *20*). At the global scale, cold, moist soils promote the accumulation of microbial necromass carbon. The maximum microbial necromass carbon occurs at a mean annual precipitation of 900 to 1000 mm with a mean annual temperature <0°C (Fig. 2C), indicating high priorities for preserving the current stocks in these systems. Few studies have measured the contribution of microbial necromass carbon to SOC in grassland soils, and data are lacking from

Africa, South America, and Australia (17, 18, 20). Microbial diversity may also affect SOC storage by regulating the efficiency of microbial assimilation of carbon and the production of organo-mineral associations in soils (21). Recently, microbial diversity was found to promote the stabilization efficiency of grass litter–derived POM but to reduce that of MAOM (22).

Climate change impacts on SOC sequestration

Sixty-seven percent of the world's grasslands are distributed in semiarid, arid, and cold climates, with only 23% occurring in humid climates (1). Thus, carbon sequestration in most grasslands is highly sensitive to climate change, which can exert strong and diverse impacts on SOC accrual and stability through plant- and microbial-mediated mechanisms (8). The impacts of climate change on soil carbon sequestration often vary with grassland type, climate, and soil conditions. In semiarid steppe, warming may enhance root-derived carbon input but inhibit the decomposition of MAOM by suppressing fungal growth and soil respiration, resulting in an increase in the MAOM pool (23). In humid tallgrass prairies, warming may increase C_4 grass cover and C_4-derived carbon input into soil organic matter, but it also increases the decay rate of these fractions, resulting in a negligible change in soil carbon sequestration (24). In alpine grasslands, warming-induced permafrost degradation reduces active-layer SOC storage by decreasing the stability of microbial networks and accelerating SOC (and specifically POM) decay (25). A recent meta-analysis demonstrated that long-term (≥5 years) warming increases the ratios of ligninase to cellulase activity and enhances microbial utilization of recalcitrant carbon, leading to a 14% reduction in the topsoil recalcitrant carbon pool (26). However, warming may increase the accumulation of root-derived carbon in the subsoil MAOM pool (27). POM is much more climate sensitive than MAOM (3, 11). The percent change in POM (–12.2%) with climate warming is on average three times greater than that in MAOM (–3.8%) in global grasslands (28). This suggests that grasslands with a high proportion of MAOM will contribute less to soil carbon-climate feedbacks.

Future projected precipitation anomalies and long-lasting droughts (29, 30) will likely influence soil carbon sequestration of grassland ecosystems by altering plant community composition, productivity and carbon allocation, and microbial processes. In the semiarid steppe, increased precipitation promotes soil aggregation by stimulating fungal growth and increasing soil-exchangeable magnesium (23). Precipitation anomalies (increases and decreases) can substantially alter root-to-shoot ratios and vertical root distribution in grasslands (31), thus regulating soil microbial growth and SOC storage. Reduced precipitation strongly suppresses oxidase activity, whereas higher precipitation stimulates the activity of nitrogen-acquisition extracellular enzymes (32). However, on the global scale, only a negative tendency for POM and a positive tendency for MAOM and total SOC concentrations with increased precipitation were observed in grasslands because of the limited data availability (28).

Climate change–induced increases in fire frequency can substantially modify long-term SOC storage in grasslands, particularly in savanna grasslands, by intensifying nutrient limitation, which suppresses plant growth and carbon inputs. Elevated fire frequencies reduce soil carbon stocks on average by 0.21 megagrams of carbon per hectare per year (Mg C ha^{-1} $year^{-1}$) in the upper soil layer (0 to 20 cm) in global savanna grasslands (33). However, a recent study showed that fire suppression (i.e., >60 years of fire exclusion) has little effect on total SOC storage (0 to 60 cm) in tropical savannas because C_4 grass–derived carbon dominates the SOC, particularly in deeper soil layers, where soil carbon is less affected by changes in fire frequencies (34). It remains unclear to what extent different fire regimes regulate plant diversity, above- and belowground biomass allocation, microbial-mediated processes, and SOC storage in shallower and deeper soil profiles.

Impacts of grazing pressure on grassland soil carbon

Natural grasslands are grazed by wild ungulates, which can enhance SOC storage because they graze for short periods of time and move across the landscape. This results in maintained plant cover, diversity and productivity, promotion of species with deep roots, microbial processing with the formation of both POM and MAOM, and soil-mixing processing by soil fauna (35, 36). Increases in ecosystem metabolism and plant labile carbon inputs (e.g., root exudates) are expected to increase both the ex vivo and in vivo formation of MAOM (9, 10, 37). Conversely, increased root inputs and allocation to depth result in higher POM in the subsoil (6, 38). In addition, large herbivores create habitats for many bioturbators (e.g., fossorial mammals and soil macrofauna) to loosen up soil and expose larger aggregates of soil organic matter to organo-mineral interaction by vertical soil mixing (36). However, both the direction and magnitude of effects of large wild herbivores on soil carbon storage can vary strongly with soil nutrient availability, across grasslands, and under different levels of herbivore density. For example, a recent short-term study suggested that nutrient availability strongly moderates the impact of herbivore grazing on soil carbon sequestration in herbaceous grasslands (39). Large herbivore grazing increases the upper-layer soil carbon storage under elevated nutrient (fertilization) conditions but has no effect on soil carbon storage under ambient nutrient conditions (39). Sandhage-Hofmann *et al.* (40) report that elevated elephant densities enhance SOC stocks [4.7 tons (t) ha^{-1}] despite losses of woody biomass in moist, semiarid, wood-encroached savannas of south-central Africa. However, a synthesis of 174 experiments showed that large herbivore exclusion generally increases SOC storage across different biomes (grassland, forest, shrubland, tundra, woodland, etc.), suggesting an overall negative impact of large wild herbivores on soil carbon storage (41).

Livestock grazing is the most common use of grasslands worldwide. Some grasslands are managed to improve forage quantity and quality, thereby increasing livestock production and/or SOC storage (1, 2, 42). In livestock-dominated systems, these pathways are strongly controlled by grazing intensity and rest periods. Continuous livestock grazing reduces plant cover, diversity, and productivity, and thus root inputs and plant- and microbial-mediated SOC formation, while stimulating losses through microbial turnover and erosion caused by increased compaction and reduced cover (1, 2, 43). Eze *et al.* (5) demonstrated that livestock grazing on average decreases SOC stock by 15% across five continents, with the greatest reduction (–22.4%) in SOC stock in the tropics and the least reduction (–4.5%) in temperate grasslands. At the global scale, light grazing (e.g., seasonal and rotational grazing) shows the least negative effects or even promotes soil carbon storage, whereas moderate and heavy (continuous) grazing consistently reduces soil carbon stocks (Fig. 3A) (5, 43, 44). For a given category of grazing intensity, the discrepancy in magnitude of changes in SOC stocks between these studies may partly arise from the lack of quantitative measures of grazing intensity and the difference in data sources (5, 43, 44). Nevertheless, the magnitude and directions of grazing impacts on soil carbon sequestration are context dependent and vary with climate and soil conditions, vegetation properties, livestock type, herbivore diversity, grazing strategies (e.g., continuous versus rotational grazing), and grazing intensity and duration (5, 38, 43–45). The negative impact of increasing grazing intensity on SOC is lessened with greater water availability (5, 44) but is more severe with warmer temperatures and longer grazing duration in temperate grasslands (44). With moderate and heavy grazing, SOC increases in grasslands dominated by C_4 species and decreases in grasslands dominated by C_3 species (45). Sheep grazing generally has a greater negative impact on SOC than cattle grazing, and the reduction in SOC with grazing is substantially greater in topsoil than that in subsoil (44). A mixed cattle and megaherbivore system was shown to be a sustainable management strategy in African savanna ecosystems with high

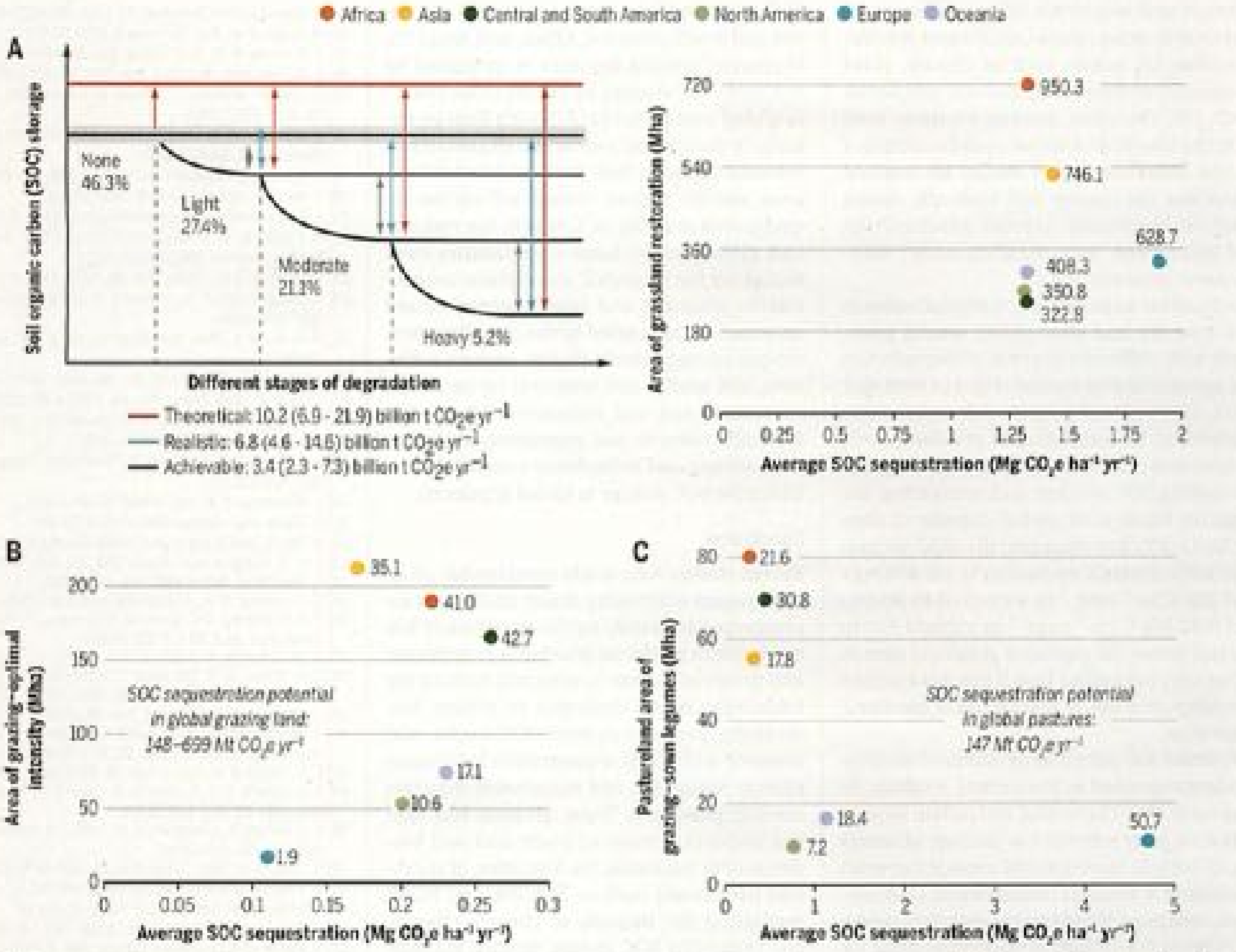

Fig. 4. Soil C sequestration potential of grassland ecosystems at the regional and global scales. SOC sequestration potentials are arranged according to average SOC sequestration rates and area of each management strategy for denoting their relative contributions. (**A**) Capacity and attainability of SOC sequestration by restoring degraded grasslands [data are from White *et al.* (*1*), De Deyn *et al.* (*52*), Deng *et al.* (*54*), and Fargione *et al.* (*53*)]. At the global scale, SOC sequestration potential is presented as theoretical, realistic, and achievable, respectively, based on Chapman (*55*). Means and the 95% confidence intervals (parentheses) are given (left panel). At the regional scale, only achievable SOC sequestration potential are estimated because of the large uncertainties for estimating the theoretical and realistic SOC sequestration potentials in each region. For each region, the mean achievable SOC sequestration potential (Mt CO_2e year^{-1}) is given (right panel). (**B** and **C**) Global SOC sequestration potential (Mt CO_2e year^{-1}) through optimizing grazing intensity in grazing lands and sowing legumes in pasturelands [data are from Griscom *et al.* (*51*)]. Only maximum climate mitigation potential with safeguards for reference year 2030 is shown.

herbivore diversity (*46*). Moreover, rotational grazing consistently shows higher SOC stocks compared with continuous grazing (or free grazing) (*43*), with gains observed specifically in the mineral associated fraction (*47*).

Managing for soil carbon storage in grasslands

Empirical and experimental studies have indicated that improving grassland management can increase SOC storage, thus mitigating carbon losses caused by climate change, long-term overgrazing, and grassland degradation (*2*, *42*, *48*). Management improvements may result in soil carbon accrual through several interrelated mechanisms (Fig. 1). Conversion from croplands to grasslands removes disturbance from tillage and increases root carbon inputs to soil (*6*, *42*). Restoring the biodiversity of degraded grasslands may increase plant production and promote microbial turnover and necromass entombment (*4*, *13*, *15*). Grazing improvement can increase higher-quality root carbon (lower carbon:nitrogen ratios) inputs (*38*) and/or nitrogen retention, thus promoting the formation and persistence of MAOM in soils (*47*). Sowing legumes increases soil carbon and nitrogen inputs by elevating root biomass, root exudates, and fine root turnover (*42*, *49*). Applications of inorganic and organic fertilizers may stimulate primary productivity and high-quality plant carbon inputs to soil, resulting in more efficient microbial carbon use (*5*, *28*, *50*).

A number of management interventions have been adopted to restore grasslands (Fig. 3, B and C). On the global scale, the improved grassland managements increase SOC stocks on average by 0.47 Mg C ha^{-1} year^{-1} (*42*). This suggests that the world's grazing lands, which occupy an area of ~34 million km^2, have substantial potential to increase SOC storage (Fig. 4). Among all improved management practices, conversion from cultivation to grasslands, increasing plant diversity, sowing legumes and grasses, and fertilization are associated with the highest soil carbon sequestration rates (Fig. 3C) (*4*, *42*). Under moderate grazing intensity, the average SOC stock increase (28.4%) is substantially greater with rotational grazing than that with continuous grazing (Fig. 3B). In the southeast United States, grassland soils managed with adaptive multi-paddock grazing that used a high-density-short-duration rotational grazing had more carbon (72.49 Mg C ha^{-1}) and nitrogen (9.26 Mg N ha^{-1}) stocks compared with continuous grazing (64.02 Mg C ha^{-1} and 8.52 Mg N ha^{-1}) in the 0 to 100 cm soil layer (*47*). However, the direction and magnitude of management effects on soil carbon stocks are context specific, depending on factors such as climate, plant community composition, and soil properties (*5, 43, 50*). Therefore, grazing practices need to be implemented with an understanding of context. Moreover, further studies are required to examine the synergy and trade-offs among grassland biodiversity, primary productivity, and soil carbon sequestration under management interventions.

Soil carbon sequestration potential varies in both quantity and attainability among grasslands with different degrees of degradation and across different regions (Fig. 4). Given that ~50% of the global grassland area has been degraded (*1, 2*), restoration of grassland cover and biodiversity is an effective strategy for promoting SOC storage and mitigating the negative impacts of global climate change (*4, 15, 51–53*). For example, the SOC accrual rate with grazing exclusion is on average 0.68 Mg C ha^{-1} $year^{-1}$ in topsoil (0 to 30 cm) and 0.62 Mg C ha^{-1} $year^{-1}$ in subsoil (30 to 100 cm) across 145 degraded grassland sites in China (*54*), indicating that it has not reached saturation over the 27-year period of grassland restoration.

Potential soil carbon sequestration capacities can be categorized as theoretical, realistic, or achievable (*55*). Theoretical soil carbon sequestration capacity refers to the estimate of restoring all soils to their natural capacity or even enhancing it through management interventions, realistic soil carbon sequestration capacity refers to the optimistic value accounting for social and economic constraints, and achievable capacity is the value of a pragmatic scenario based on the current trends (*55*). At the global scale, the mean theoretical, realistic, and achievable capacities of SOC sequestration with grassland restoration are estimated to be 10.2, 6.8, and 3.4 billion t CO_2 equivalents per year (CO_2e $year^{-1}$), respectively (Fig. 4A). At the regional scale, Africa, Asia, and Europe are projected to have the largest achievable capacity of soil carbon sequestration with grassland restoration, with Oceania and North and South America exhibiting the least SOC sequestration potential (Fig. 4A). These global patterns of SOC sequestration potential are primarily caused by the differences in average soil carbon sequestration rate and the area of degraded grassland in different regions. The greater SOC sequestration potential with grassland restoration in Africa and Asia is due to the larger areas of degraded grasslands in these continents, whereas European grasslands have a higher average soil carbon sequestration rate (Fig. 4A). In addition, optimizing grazing intensity (e.g., rotational grazing) is projected to increase soil carbon sequestration potential by 148 to 699 megatons (Mt) CO_2e $year^{-1}$ in global grazing lands (Fig. 4B), with the greatest SOC sequestration potential occurring in Central and South America, Africa, and Asia (*51*). Moreover, sowing legumes is projected to enhance SOC storage by 147 Mt CO_2e $year^{-1}$ in global pasturelands (*51*), with Europe exhibiting the greatest soil carbon sequestration potential caused by both the largest pastureland areas and the highest average soil carbon sequestration rate (Fig. 4C). At both the regional and global scales, large uncertainties exist regarding the projected soil carbon sequestration potential and rate of accrual. These uncertainties are caused by the complex interactions among climate change, human activities, and spatial and temporal variations in ecosystem and soil responses (*51, 53, 56*). Scientific research and management innovations are required in the future to maximize the attainable SOC storage in global grasslands.

Conclusion

Recent studies have made considerable progress toward addressing major challenges associated with identifying the capacity and key mechanisms of various grasslands to sequester and preserve carbon in soils and developing knowledge-based strategies to restore biodiversity, preserve current SOC stocks, and promote additional sequestration for climate change mitigation and sustainable management in grasslands. These advances highlight the important roles of plant and soil biodiversity in regulating the formation of microbial necromass carbon, MAOM, and POM, mediating the impacts of climate change, and promoting SOC storage through management improvements and restoration in global grasslands. They also demonstrate that the impacts of climate change, grazing, fire, grassland restoration, and mitigation solutions on soil carbon sequestration are moderated by multiple context-dependent factors. Future research is needed to address the uncertainty and context dependency of the proposed mitigation solutions and their carbon sequestration potentials and to consider their possible synergies and trade-offs for biodiversity conservation, climate mitigation, and food production.

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REVIEW

The planetary role of seagrass conservation

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Seagrasses are remarkable plants that have adapted to live in a marine environment. They form extensive meadows found globally that bioengineer their local environments and preserve the coastal seascape. With the increasing realization of the planetary emergency that we face, there is growing interest in using seagrasses as a nature-based solution for greenhouse gas mitigation. However, seagrass sensitivity to stressors is acute, and in many places, the risk of loss and degradation persists. If the ecological state of seagrasses remains compromised, then their ability to contribute to nature-based solutions for the climate emergency and biodiversity crisis remains in doubt. We examine the major ecological role that seagrasses play and how rethinking their conservation is critical to understanding their part in fighting our planetary emergency.

Though commonly called grasses, seagrasses are a unique group of submarine flowering plants that belong to the monocotyledon order Alismatales, comprising four families and 72 species. Although they occupy a broad range of niches and are derived from multiple evolutionary lineages (*1*), they all share a connection to marine environments and consistently exhibit features that separate them from all other angiosperms. Seagrasses have adapted to live underwater, where light is limited, where salt and nutrients can be problematic, and where soils can become highly toxic (*2*).

Seagrass diverged from other alismatid monocots ~105 million years ago, and work by Olsen *et al.* (*3*) supports hypotheses that modern seagrass biodiversity can be linked to the materialization of multiple habitats after the Cretaceous-Paleogene extinction event. In the past decade, the seagrass science community has grown (*4*) and revealed the uniqueness of these plants and the importance of the ecosystems that they create (Fig. 1). Seagrasses bioengineer their environment by slowing water flow, trapping particles, and improving the environment within a positive feedback mechanism to facilitate the creation of habitat (*5*). Just like terrestrial plants, their reproduction can be supported by a diverse range of pollinators, such as cumacean crustaceans (*6*), and seed dispersers, such as fish (*7*). Their reproduction is not always sexual—genetic evidence has revealed that vegetative growth has led to the establishment of one single clonal organism spanning >180 km of coastline (*8*). Nitrogen-fixing bacteria living within their roots allow them to colonize nitrogen-poor environments (*9*), and associations with clams (and their bacterial symbionts) have aided their ability to inhabit otherwise toxic sulphide-rich marine soils (*10*). There is also growing evidence of the presence of fungi associated with the roots and rhizomes of seagrasses, indicating that they may play essential roles similar to those of fungal associates of terrestrial plants (*11*).

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Aside from their ecological uniqueness, seagrasses are of increasing interest in a sociopolitical context owing to their potential to help combat the current climate and biodiversity crises that our planet faces. Seagrass meadows also support human well-being by virtue of their role in supporting fisheries, coastal protection, and water filtration (*12*), and action for their conservation supports the fulfillment of the 17 Sustainable Development Goals (SDGs) proposed by the United Nations in 2015. Seagrasses

> **"Compared with...terrestrial grasses and even seaweeds, the body of research within seagrass is magnitudes smaller..."**

also support many species of conservation concern, such as the dugong, green turtle, and manatee (*13*), and provide interacting ecological functioning throughout the coastal seascape (*14*).

To harness the power of seagrass as a nature-based solution to the climate emergency and the biodiversity crisis, seagrass systems must be in a resilient functioning state. Seagrass meadows remain globally threatened by diverse factors, including poor water quality, damage from boats and related activities, aquaculture, and coastal development (*15*). Even in areas where seagrass is protected, extreme climate drivers place seagrass at risk. For example, after a marine heatwave in 2010 to 2011, up to 699 km^2 of seagrass meadow in the Shark Bay Marine Park in Western Australia were lost or damaged, potentially releasing up to 9 Tg of CO_2 back into the atmosphere during the 3 years before regrowth occurred (*16*). Seagrass sensitivity to stressors is acute and may even extend to the effects of anthropogenic noise (*17*). In many places, the risk of seagrass loss and degradation persists (*15*), and its functional state is commonly compromised; unless this can be reversed, the potential for seagrass to contribute to the complex jigsaw of nature-based solutions remains in doubt. In this Review, we reflect on the status of seagrass ecosystems, the major ecological role that they play in the coastal environment, and how rethinking their conservation is critical to allowing them to play a role in reversing climate change.

Global decline, net-zero loss, and achieving net gain

The role that seagrass can have in reversing or mitigating climate change requires consideration of their global biogeochemical contribution. For this, we first need a better understanding of whether seagrasses are currently in a state of net loss, stasis, or net gain globally, along with the parameters that drive their greenhouse gas balance (Fig. 1). The global coverage of seagrass is currently estimated to be 160,387 to 266,562 km^2 (*18*). This range reveals that we have very limited understanding of the actual extent of seagrass populations. We also do not fully understand the extent of the ecological goods and services that seagrass provides, including to biodiversity and coastal protection. Studies have sought to place estimates on seagrass loss at 1 to 7% per year (*19*, *20*) and create global carbon storage estimates of up to 19.9 Pg (*21*, *22*). However, if we do not know how much we have or have had, we cannot hypothesize very well on what has been lost or its associated ecological relevance.

The reported trajectory of seagrass coverage (*20*, *23*) indicates that it may be recovering in some areas; however, this analysis is limited because it only focuses on locations where seagrass is mapped, monitored, and likely affected by some level of conservation action, and it may represent only a fraction of potential and unknown seagrass area. Analyses are also limited by favoring data published in academic journals and excluding available data in the gray literature. A coordinated global effort is required to create meaningful global estimates of seagrass coverage and change that are validated with open data sharing between governments, academics, nongovernmental organizations, and commercial enterprises (*18*). In the UK, a technology-focused consortium is forming to fill the gaps in our knowledge to help drive understanding of the ecological role of seagrasses (*24*), and recommendations for a methodological pathway to improve the global seagrass map have recently been proposed (*18*, *25*).

Seagrass as a nature-based solution

The growing interest in nature-based solutions is necessitating deeper understanding of the ecological role that seagrass meadows play in the context of climate change. Seagrass meadows store and sequester carbon within their sediments over long periods of time at highly efficient rates; however, this role varies over space and time along with factors such as hydrodynamics and species composition influencing

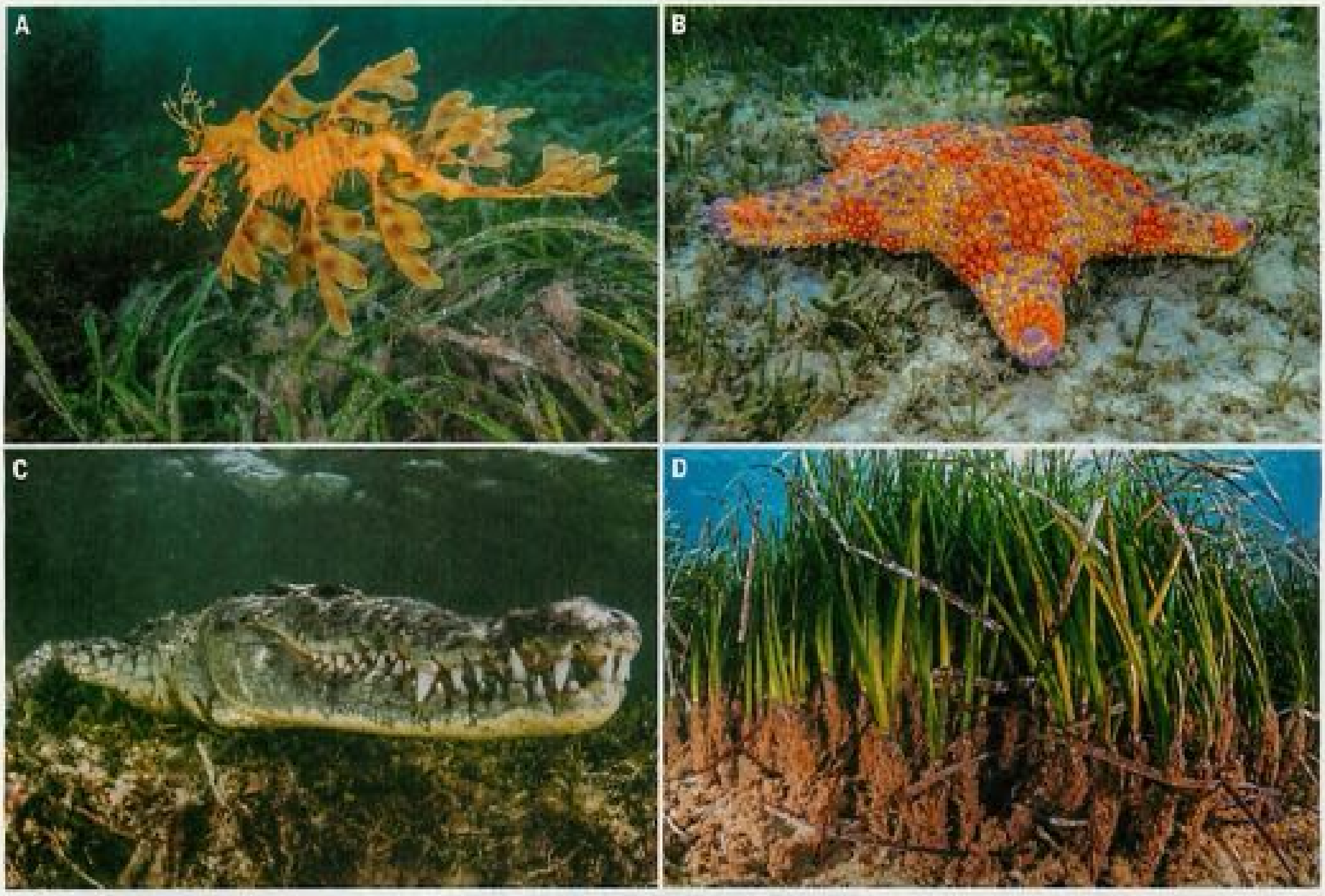

Fig. 1. Seagrass and biodiversity. (**A** to **C**) Seagrass meadows contain biodiverse and enigmatic species assemblages, including the leafy sea dragon (A), sea stars (B), and predators such as crocodiles (C). (**D**) The biodiversity and productivity of seagrass meadows also lead to them storing and sequestering substantial amounts of carbon in their sediments. Seagrass meadows provide habitat in support of biodiversity [(A) to (C)] in coastal waters globally. When healthy and in a balanced state, seagrass can be a great source of many other ecosystem services, such as water filtration, carbon storage (**D**), and coastal defense. Anthropogenic factors, such as coastal development and poor water quality leading to eutrophication of coastal waters, are some of the principal drivers of seagrass decline.

this function. Additionally, despite their more obvious role in the storage of organic carbon, seagrasses, like most vegetation, also produce the greenhouse gases methane (CH_4) and nitrous oxide (N_2O). The balance of these emissions relative to the storage of carbon is of principal importance in the context of their role in influencing climate. Limited understanding exists with respect to whole-seagrass ecosystem greenhouse gas balance (Fig. 2). Available data indicate that seagrasses have broadly lower greenhouse gas emissions of CH_4 and N_2O than comparative coastal and wetland habitats and that low salinity and anthropogenic stressors are major processes driving production (*26*). Similarly, comparison with habitats such as peatlands and mangroves shows seagrasses to be relatively low in CH_4 and N_2O (*27*). However, after seagrass meadow degradation and loss, there exists a potential for high emissions of CH_4 from underlying sediment (*28*). Eutrophication of seagrasses may also drive elevated N_2O emissions. Although scientific understanding in this field is increasing rapidly, our lack of understanding of the drivers of greenhouse gas emissions by plants, least of all by seagrasses (*21*, *27*), contributes to the uncertainties that surround the marketing of blue carbon (*29*).

Although its capacity for carbon storage is of high current interest, human appreciation for the ecological role of seagrasses has changed (*30*). An historic view of seagrasses from the Northern Hemisphere shows their importance in food production and as a raw material. For example, house roofs in Denmark were thatched with dried seagrass (some of which can still be seen), and seagrass detritus was used to fertilize crops (*30*). In the late 1800s, when Indian cotton crops failed, documented discussion by British cotton traders turned to the use of seagrass as an alternative fiber. In North America, companies existed that traded in seagrass as an insulation material, which was subsequently used in the US Capitol building. The Seri people of the Gulf of California collected seagrass seed to create a gruel (*31*). In the 21st century, in many parts of the world, seagrass meadows are a source of food from the gastropod and bivalve mollusks and sea cucumbers that they shelter (*32*). The importance of seagrass habitats as a source of seafood production is both direct and indirect at local and basin-wide scales, with 20% of the world's biggest finfish fisheries having some known association with seagrass (*33*).

Seagrasses also play a fundamental role in the filtration of coastal waters, trapping particles (including microplastics), cycling nutrients, and absorbing nitrogen from the water column (*34*). This filtration role also extends to the removal of bacteria and viruses (*35*–*37*), thus contributing to improved sanitation (*36*) and human health and well-being (*12*). In the Baltic Sea, seagrass meadows have been recorded to contain 63% fewer potentially harmful *Vibrio vulnificus* and *Vibrio cholerae* bacteria compared with nonvegetated areas (*37*).

Additionally, the role of seagrass in protecting coastlines from erosion is substantial and may grow in value with sea level rise and as storms become more frequent (*11*). The locally relevant role of seagrasses in ameliorating low pH from ocean acidification may also increase the value of these marine plants over time (*39, 40*). Although the ecological roles that seagrasses play around the world shift with space and time, the constant across most of the world's seagrasses is that they remain at ecological risk and many are in a perilous state.

What is a pristine, healthy, or balanced seagrass ecosystem?

The extent and function of seagrass meadows are largely manifestations of current and previous human activity. We have limited capacity to appreciate the value of seagrass owing to the scale of alteration and unknown baselines for these systems (*41, 42*). Evidence from ecological feedbacks indicates that seagrass meadows are driven by top-down and bottom-up processes (*43, 44*). Although there is increasing appreciation for how seagrass might be influenced by excess nutrients and various pollutants in our coastal waters, we have limited appreciation for what extreme overexploitation of near-shore environments has done to seagrass meadows. We simply do not know what a so-called pristine meadow looks like, which creates a limited appreciation for the true ecological role of these poorly understood systems. A contributory factor to the poor understanding is the low relative research output on seagrasses [see (*45*)]. However, it is apparent that there has been a profound loss of predators from these systems, whereas numbers of consumers, secondary consumers, and grazers have also been affected (*46*)—in some cases, loss of predators has led to overgrazing (*47, 48*).

In localities where associated biodiversity is high, functional redundancy may serve to protect seagrass meadows (*49*), but with decreasing diversity away from the tropics, such redundancy may be reduced. There is also a growing appreciation for seagrass as a foraging resource for seabirds; this is because they support abundant prey items, such as crustaceans, polychaetes, and fish (*50*). Given the parallel global decline of avifauna with global seagrass, we can only speculate as to what the functional role of loss of seagrass might have once been (*51*).

In recent decades, biodiversity and ecosystem functioning has evolved into a dynamic area of contemporary ecology with a rich body of research. Compared with research in terrestrial grasses and even seaweeds, the body of research within seagrass is magnitudes smaller and is fueled by a smaller community of scientists. We must understand the biodiversity associated with seagrass meadows to be able to develop management programs that secure their ecological functioning under further climate change. Global and regional studies are beginning to transform our knowledge (*44, 52, 53*), but tools such as sequencing environmental DNA need to be more widely applied. Reconstructions using molecular and historical evidence are needed to understand the true ecological potential of these ecosystems, to locate sites for rehabilitation and replanting, and to provide ambition to marine conservation.

Seagrass meadows and the SDGs

Improved protection and restoration of seagrasses require better recognition of the role that they play in supporting people and our planet; the state of seagrasses is symptomatic of the deteriorating state of the overall natural environment (*54*). The United Nations SDGs are a means of framing a response to this emergency by connecting the daily actions and needs of people, institutions, and communities to the sustainability of the planet and transforming these connections into measurable actions for positive environmental, social, and ecological outcomes. Articulating the ecological role of seagrass in terms of ecosystem services and natural capital promotes a scientific vision of what behavioral change might mean for seagrass, whereas the SDGs provide a framework for how change can be perceived by all people. We suggest that, of the 17 SDGs, action for seagrass conservation and restoration can make a meaningful contribution to 16 of these global goals (Fig. 3). We propose that the ecological role and value of seagrass can also be described in these terms to improve and catalyze action to halt and reverse seagrass loss.

Seagrass meadows form globally relevant habitats that support fisheries and associated economic goods; it is in this ecological role that seagrasses play a prominent role in SDGs. Thus, well-managed, sustainably exploited seagrass meadows that are in a state of ecological balance (*32, 33, 55*) will contribute to reducing poverty (*56*), reducing hunger (*32*), responsible consumption and production (*57*), and decent work and economic growth (*58*) (Fig. 3). Sustainably managed seagrass fisheries in many parts of the world also contribute toward gender equality and reducing other inequalities. For example, the role of women is underappreciated in intertidal and near-shore small-scale subsistence fisheries (*59*), of which seagrass meadows are a major component. Inclusion of women in these fisheries is well known to improve community adaptative capacity and resilience (*60*), leading to improved environmental outcomes (*59*).

A major ecological role of healthy seagrass systems is to make the wider environment more conducive for animal life (including humans) in both marine and coastal environments. Seagrass habitats enhance oxygenation in marine sediments; trap particles in the water column, improving water clarity; cycle and store nutrients; and reduce the bacterial and viral load in coastal waters. This creates a three-dimensional environment that harbors biodiversity, baffles wave energy to protect coastlines from erosion, and further enhances the whole coastal seascape for biodiversity (e.g., through the protection of adjacent habitats, such as coral reefs and mangroves).

The bioengineering effect that seagrasses have on their own environment also contributes to

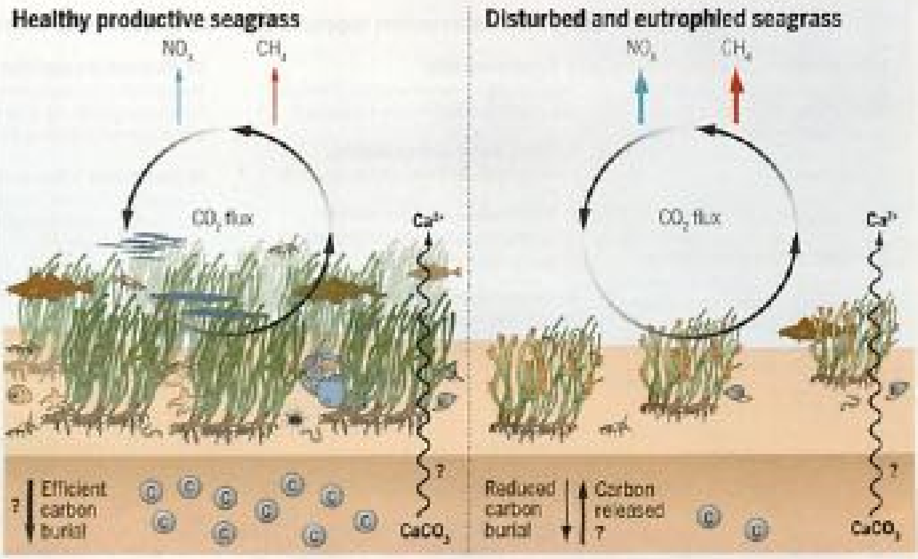

Fig. 2. The greenhouse gas balance of seagrass. There are many competing processes that result in seagrass meadows becoming net sources or sinks of greenhouse gases in our oceans. The left panel illustrates a healthy meadow where net photosynthetic productivity and dense seagrass is leading to rapid trapping and storage of carbon into the sediments. Although we lack a full understanding about greenhouse gas balance in seagrasses and the implications of disturbance, the right panel illustrates how meadow degradation and eutrophication can lead to the remobilization and loss of stored carbon and the potential increased production of CH_4 and N_2O. We also know little about the consequences of calcification by associated fauna within productive seagrass meadows on the overall carbon balance.

SDGs related to clean water and sanitation, good health, and well-being (12). Additionally, there is increasing appreciation of the value of seagrass for storing and sequestering carbon and the potential value of conserving seagrass meadows for climate mitigation (61). We understand that seagrasses enhance life below water, but less-well appreciated is that seagrass systems also enhance life on land by providing resources to shoreline habitats and populations, especially birds (62). The biodiversity present within seagrass meadows, the ecological processes and functions within them, and their relatively easy access also provide educational opportunities for human communities (63).

Without strong partnerships between communities, governments, nongovernmental organizations, and the private sector, seagrass conservation and restoration will not work effectively. The final SDG is about this bigger ambition. In the UK, the conservation charity Project Seagrass is bringing together private sector companies (e.g., CGI and Ocean Infinity), universities (e.g., Swansea and Heriot-Watt), institutes (e.g., NOC), and the government (e.g., the Hydrographic Agency) to map the UK's seagrass meadows. Similar initiatives are happening globally in places such as the Seychelles, Australia, and Indonesia.

Many aspects of the SDGs focus on the human planet, where the role that seagrasses play is changing with respect to a changing climate. With an expanding need to harness the energy of our oceans through wind, waves, and tide, there is increasing potential for new infrastructure to come into conflict with seagrass ecosystems. At the same time, this could lead to improved outcomes for seagrass, especially at a time when there is increasing global recognition of the need to develop strong criteria and indicators for pathways toward nature-positive outcomes. One such mechanism is that adopted in Australia, where marine biodiversity offsetting is accepted as a component of development consent to achieve an ambition of no net loss of biodiversity. A failed push toward tidal lagoon power in the UK provided impetus for seagrass restoration, and there is a growing focus on using seagrass restoration as a means of enhancing fish habitat as an offset to the effect of offshore wind power installations on marine biodiversity. The decline and reduced use of major historic urban coastal infrastructure, such as disused docklands, fisheries ponds, and mill ponds, are typical of many areas of the temperate Northern Hemisphere. The large empty docklands of South Wales provide an exemplary opportunity for seagrass restoration, and in southern Spain, entrepreneurial restaurateurs are bringing disused salt ponds back to life with seagrass for the growth of food products (64).

Charting a pathway to the net recovery of seagrass

Solutions for seagrass conservation and restoration have never been more urgent given the ongoing risks they face (15) and their potential role in helping mitigate climate change and the biodiversity crisis (21). Given the real and immediate threat of runaway climate change that places the future of humanity at risk, we need to rapidly move toward a conservation and restoration model that focuses on achieving global net recovery of seagrass (Fig. 4). Although financial mechanisms are emerging that begin to place monetary value onto seagrass carbon stores and carbon sequestration potential that will enable greater conservation and restorative action, concern exists about the potential for perverse and unintended consequences of such mechanisms (including international ownership of local resources), particularly around their role in supporting livelihoods (56).

It has been argued that avoiding a climate catastrophe requires at least three global transformations that are unprecedented in both magnitude and speed (54). One of these is a transformation of our relationship with nature to one that conserves, restores, and enhances its benefits for people and the planet (54). The SDGs could provide a valuable lens for securing the wider ecological role of seagrass meadows beyond carbon sequestration.

Seagrass habitats are global; estimates of loss are widespread and varied, but there is general agreement that the loss is vast. However, this does mean that there is huge potential for nature-based solutions focused on seagrass restoration. A restored seagrass meadow may take many years and be high cost in terms of

Fig. 3. Seagrass and sustainable development. Conservation and restoration of seagrass meadows and their ecological role can be communicated through the lens of the SDGs, of which seagrasses contribute to 16 of the 17 goals. A major part of this contribution is through the roles that they have as bioengineers and in supporting fisheries.

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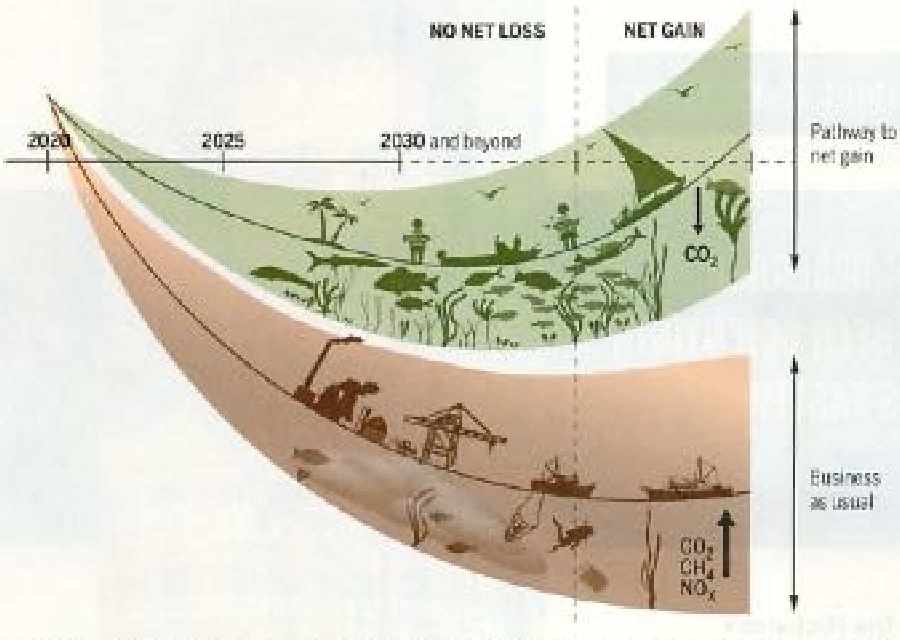

Fig. 4. A trajectory of seagrass recovery. Business as usual: Although seagrass meadows provide extensive ecosystem services and offer a major global opportunity as nature-based solutions, without intervention, they remain on a trajectory of global decline throughout the next century. Pathway to net gain: If major conservation action is taken to halt and reverse seagrass loss and degradation, then seagrasses can provide major contributions to fulfilling the aims of 16 of the 17 SDGs and for providing a major nature-based solution to climate change. Net gain of biodiversity requires avoidance of damage (e.g., legal instruments to halt bottom trawling) or minimization of effects that cannot be avoided, restoration to enhance or recreate habitats after damage (e.g., advanced mooring systems to allow recovery from boat damage), compensation, and recovery to enhance or recreate habitats known to have been historically lost or degraded (e.g., by active replanting). Image uses silhouettes created using symbols from the IAN Library, UMCES, University of Maryland.

labor and infrastructure to become ecologically functional (65, 66). The opportunity provided by seagrass restoration should not detract from the urgent need to protect what we already have. As seagrass meadows become degraded, they not only begin to become net emitters of carbon, but they also release large amounts of nitrogen and sediments into the coastal ecosystem (34), together with any potential contaminants trapped within (e.g., heavy metals or plastics) (67). Achieving no net loss (and ultimately global net gain) of seagrasses requires scientific vision and political will (Fig. 3). This will not be easy, but we know that cumulative and connected conservation of seagrass over large scales can have major economic and environmental benefits (66). In general, plant conservation lags behind the conservation of animals (68), but seagrass could provide a model for how to overcome this so-called plant blindness, especially in the context of nature-based solutions (69).

Seagrasses have previously been described as the "ugly duckling" of marine conservation (70), but their star has risen with increasing interest in their potential to contribute to nature-based solutions to climate change and sustainable development. However, there are substantial ecological, social, and regulatory barriers and bottlenecks to seagrass restoration and conservation because of the scale of the interventions required. We must work inclusively at a local scale but in a globally connected network. Advances in marine robotics, molecular ecology, remote sensing, and artificial intelligence offer new opportunities to solve conservation problems in difficult environments at unprecedented global scales.

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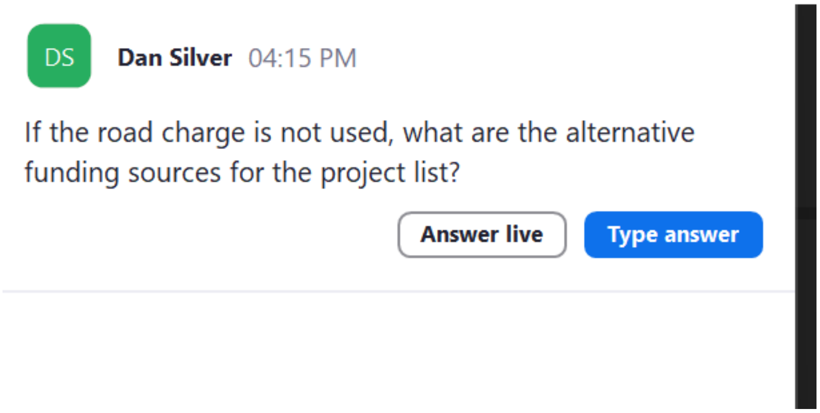
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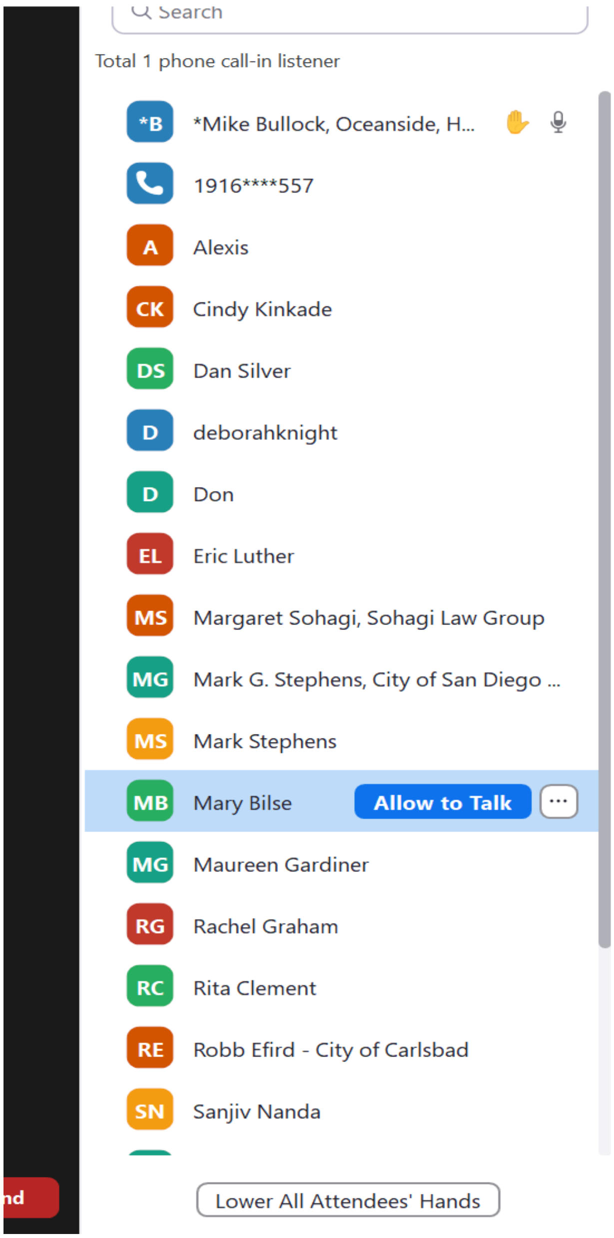
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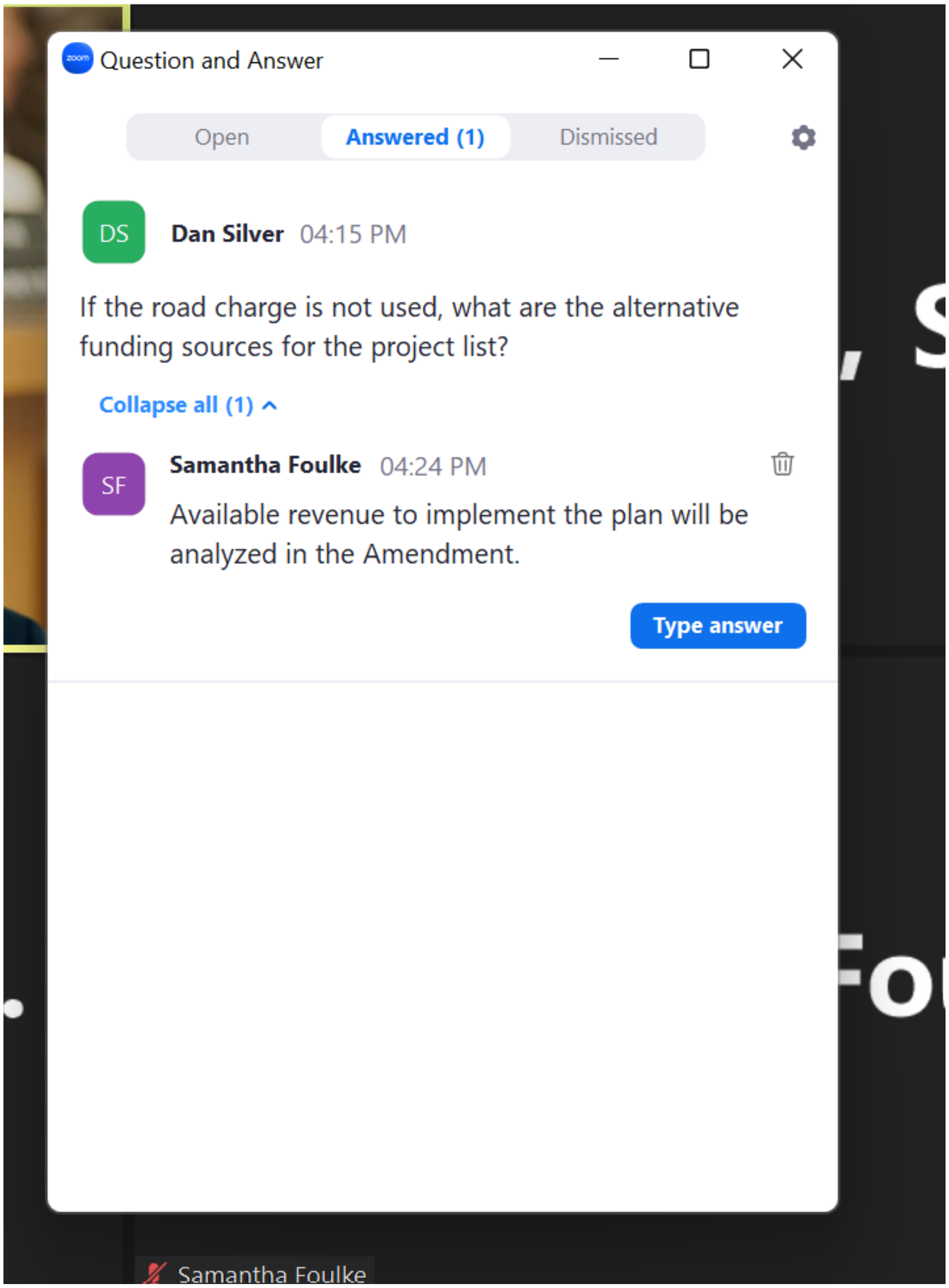
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DS **Dan Silver** 04:15 PM

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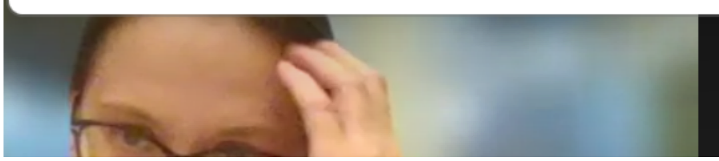
Type answer

TB **tim bilash** 04:45 PM

Wil lwe hacve to download the amendment proposal?



TB **tim bilash** 04:26 PM

I have sent my mentioned articles to the Clerk of the Board and kirsten.uchitel@sandag.org.

Collapse all (1)

SF **Samantha Foulke** 04:31 PM

Thank you, Dr. Bilash, received.

Type answer

TB **tim bilash** 04:45 PM

Wil lwe hacve to download the amendment proposal?

Show all (1)

TB **tim bilash** 04:45 PM

Wil lwe hacve to download the amendment proposal?

Collapse all (1)

SF **Samantha Foulke** 04:46 PM

SANDAG anticipates that the draft amendment will be available in the Spring-Summer 2023 timeframe.

Type answer

TB **tim bilash** 04:46 PM

Where will it be available

tim bilash 04:46 PM

Where will it be available

Samantha Foulke 04:47 PM

The draft amendment and SEIR will be available on the SANDAG website.

***Mike Bullock, Oceanside, He Him** 04:46 PM

Please see the recently completed CARB Scoping Plan. It makes it clear that we MUST decrecrease VMT and we need to price driving. It shows support for a RUC by 2025, in Appendix E. Is the Board part of this meeting?

Keith G

Kirsten

Samant

Saman

***Mike Bullock, Oceanside, He Him** 04:46 PM

Please see the recently completed CARB Scoping Plan. It makes it clear that we MUST decrecrease VMT and we need to price driving. It shows support for a RUC by 2025, in Appendix E. Is the Board part of this meeting?

Collapse all (1)

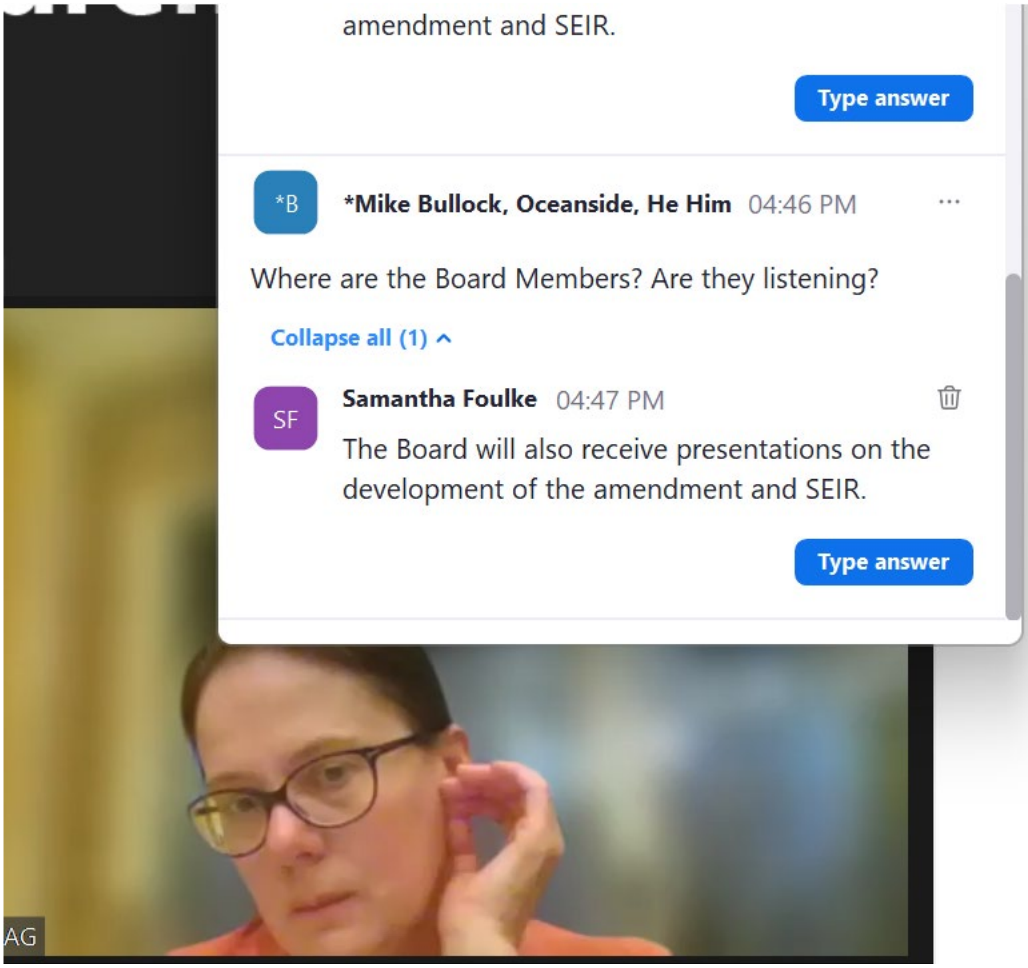
Samantha Foulke 04:48 PM

The Board will also receive presentations on the amendment and SEIR.

Type answer

***Mike Bullock, Oceanside, He Him** 04:46 PM

Where are the Board Members? Are they listening?


amendment and SEIR.
Type answer
*B
*Mike Bullock, Oceanside, He Him 04:46 PM
Where are the Board Members? Are they listening?
Collapse all (1)
SF
Samantha Foulke 04:47 PM
The Board will also receive presentations on the development of the amendment and SEIR.
Type answer
AG