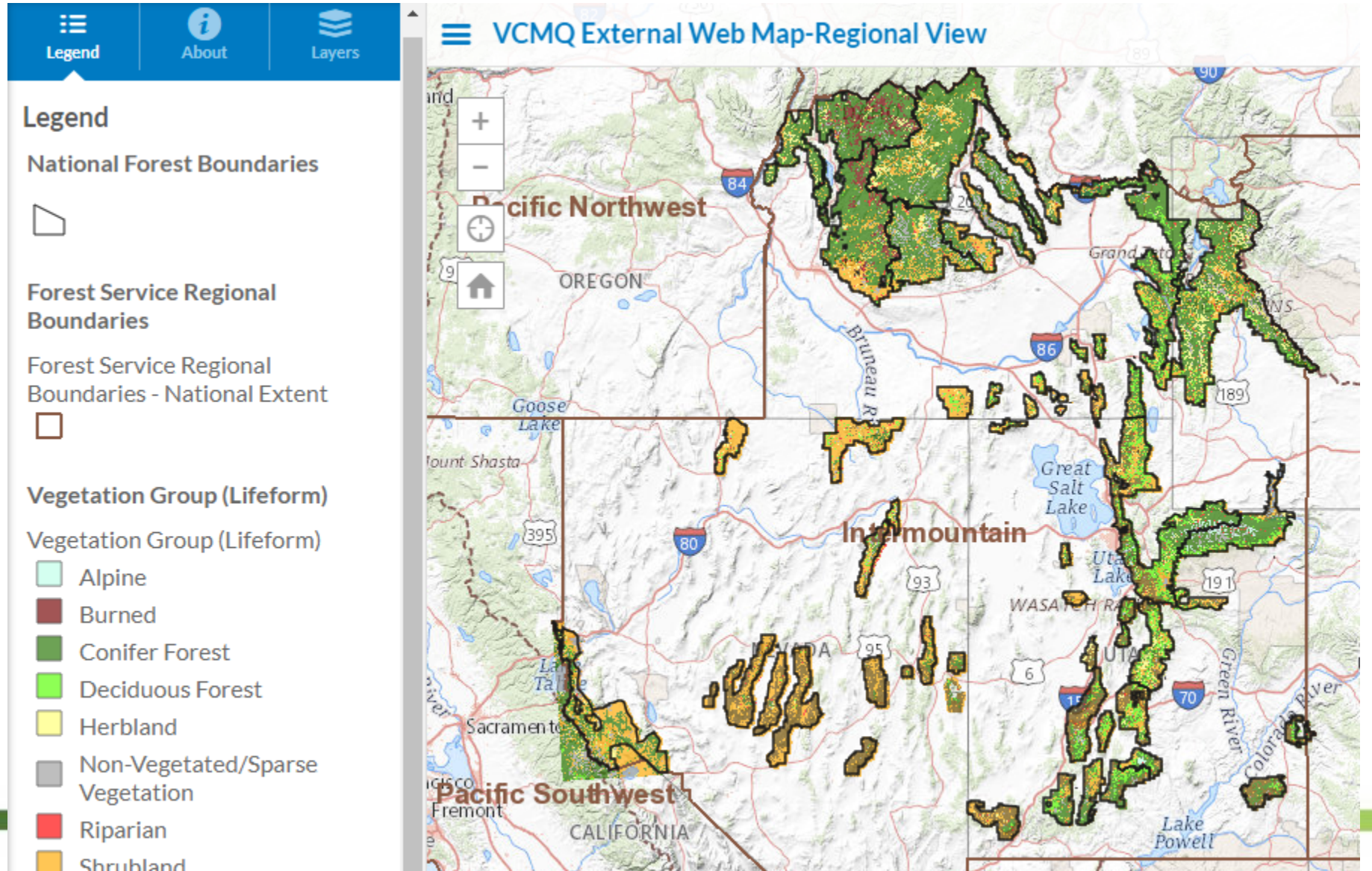
Applications of Carbon and Biomass data in the USDA Forest Service.

Kevin Halverson
Regional Analyst
USDA Intermountain Mountain Region

Presentation at NASA CMS Applications Workshop 2019
Scripps Seaside Forum, La Jolla, CA
Tuesday, November 12, 2019

Intermountain Region: Vegetation



Existing vegetation: Regional statistics

@ 32 million acres

Forest Name	Alpine	Burned	Conifer Forest	Deciduous Forest	Herbland	Sparse Vegetation	Riparian	Shrubland	Woodland
Ashley National Forest	5%	0%	42%	13%	5%	12%	3%	13%	7%
Boise National Forest	0%	11%	60%	1%	3%	2%	2%	21%	0%
Bridger-Teton National Forest	0%	0%	55%	5%	17%	7%	3%	13%	0%
Caribou-Targhee National Forest	0%	0%	50%	14%	5%	3%	1%	20%	7%
Dixie National Forest	0%	0%	30%	10%	2%	3%	1%	19%	35%
Fishlake National Forest	1%	0%	16%	15%	5%	3%	1%	16%	44%
Humboldt-Toiyabe National Forest	0%	0%	13%	3%	2%	3%	1%	45%	33%
Manti-La Sal National Forest	0%	0%	23%	17%	8%	2%	1%	13%	36%
Payette National Forest	0%	18%	64%	0%	9%	3%	1%	5%	0%
Salmon-Challis National Forest	1%	0%	61%	1%	6%	6%	1%	22%	2%
Sawtooth National Forest	1%	0%	41%	5%	5%	8%	2%	36%	3%
Uinta-Wasatch-Cache National Forest	2%	0%	28%	20%	5%	3%	2%	19%	22%
Regional Totals	**1%**	**2%**	**40%**	**7%**	**6%**	**4%**	**1%**	**24%**	**15%**

Description of Work

- Support Broadscale Monitoring Strategy for the Region
- Support Regional Vegetation Mapping Team
- Geospatial Analysis support to Forest Plan Revision Efforts
- Support Shared Stewardship partnerships with States.
- Gear work toward current agency priorities: Active Management Philosophy and ambitious Restoration Goals.

CMS data products being used, or planning to be used

- Evaluation of effectiveness of Landscape Treatment Options and Shared Stewardship initiatives.
- Depictions of current trends on the landscape
- Supplemental product in Data Library
- Evaluation of Existing Vegetation Mapping products
- Fuels mapping
- Broadscale Monitoring
- Forest Plan Revision: Assessment of current state and trends

Application areas being targeted

- Wildfire Hazard
- Water Quality
- Ecological Forecasting
- Air Quality
- Timber Treatment Assessments
- Landscape Prioritization

Policy and decision making timelines related to your work

- Forest Plan Revision Schedule: 12 National Forests. 3 are in Revision
- Annual Review of Regional Vegetation Mapping team budget and Program of Work. Prior to Fiscal Year
- National Office may have timelines for measurement of Priority Landscapes.

Additional carbon data needs/gaps in your work for which the CMS community could contribute data

- Wall-to-wall annual products in Standard GIS raster formats.
- Products that can help us refine coarse-level mapping products such as Forest Insect and Disease and Forest Activities.
- Rangeland products (grass, shrub, woodland).
- Fuels mapping.

Are there any CMS products we can offer for your needs?

- Dashboards for standard reporting
- Products depicting seasonal fluctuations.
- Simple, easy-to-use tools for data access and manipulation for field users.

What are some of the challenges?

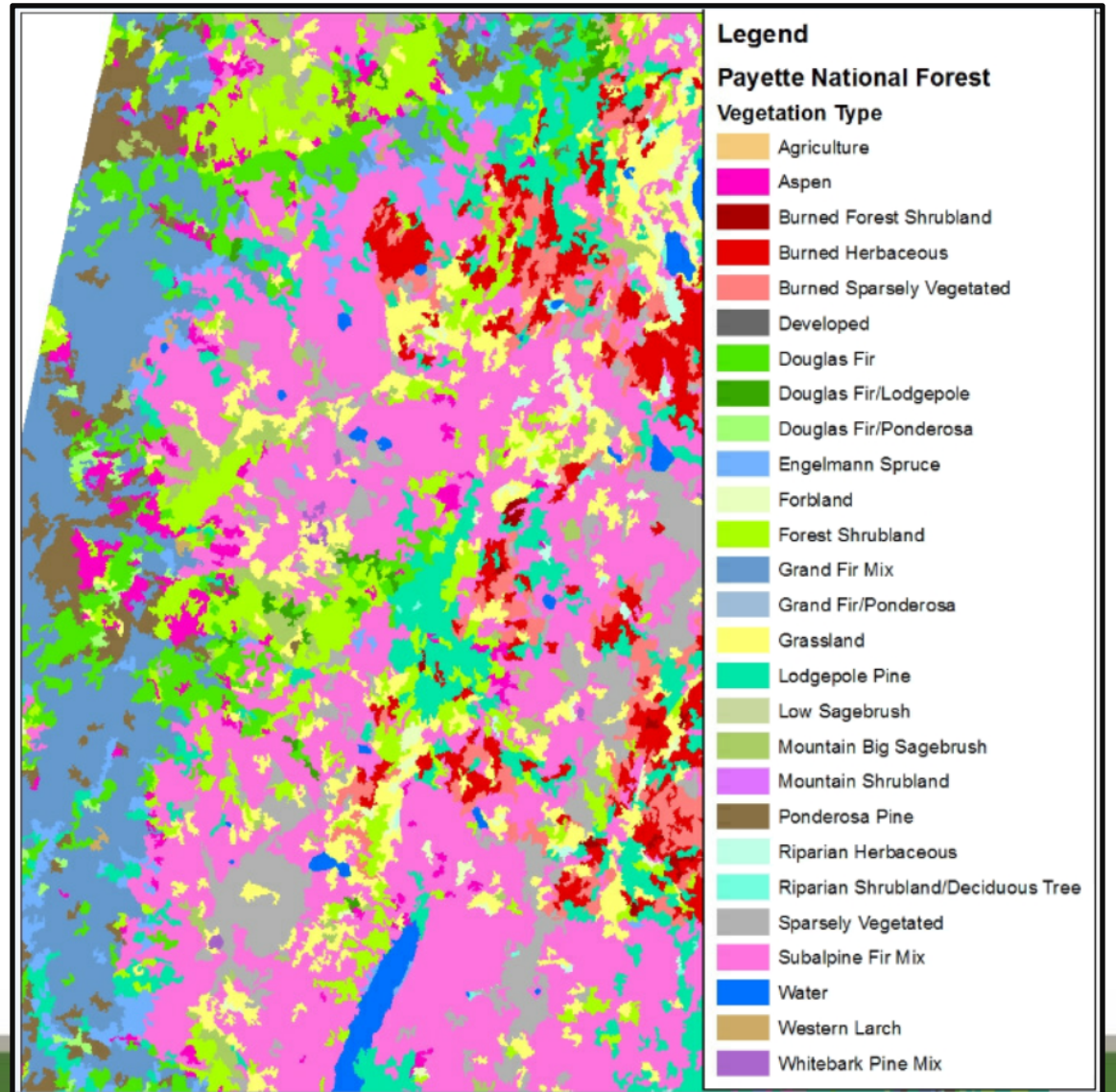
- Teaching Forest Service field managers how to use and apply these products. Many are technologically adverse and wish to do business using the standard techniques.
- Many are overwhelmed by data and data products.
- Lack of analytical capability. Few know how to use raster products.
- Single point access of products for users
- Ability to plan forward with uncertain availability in the future

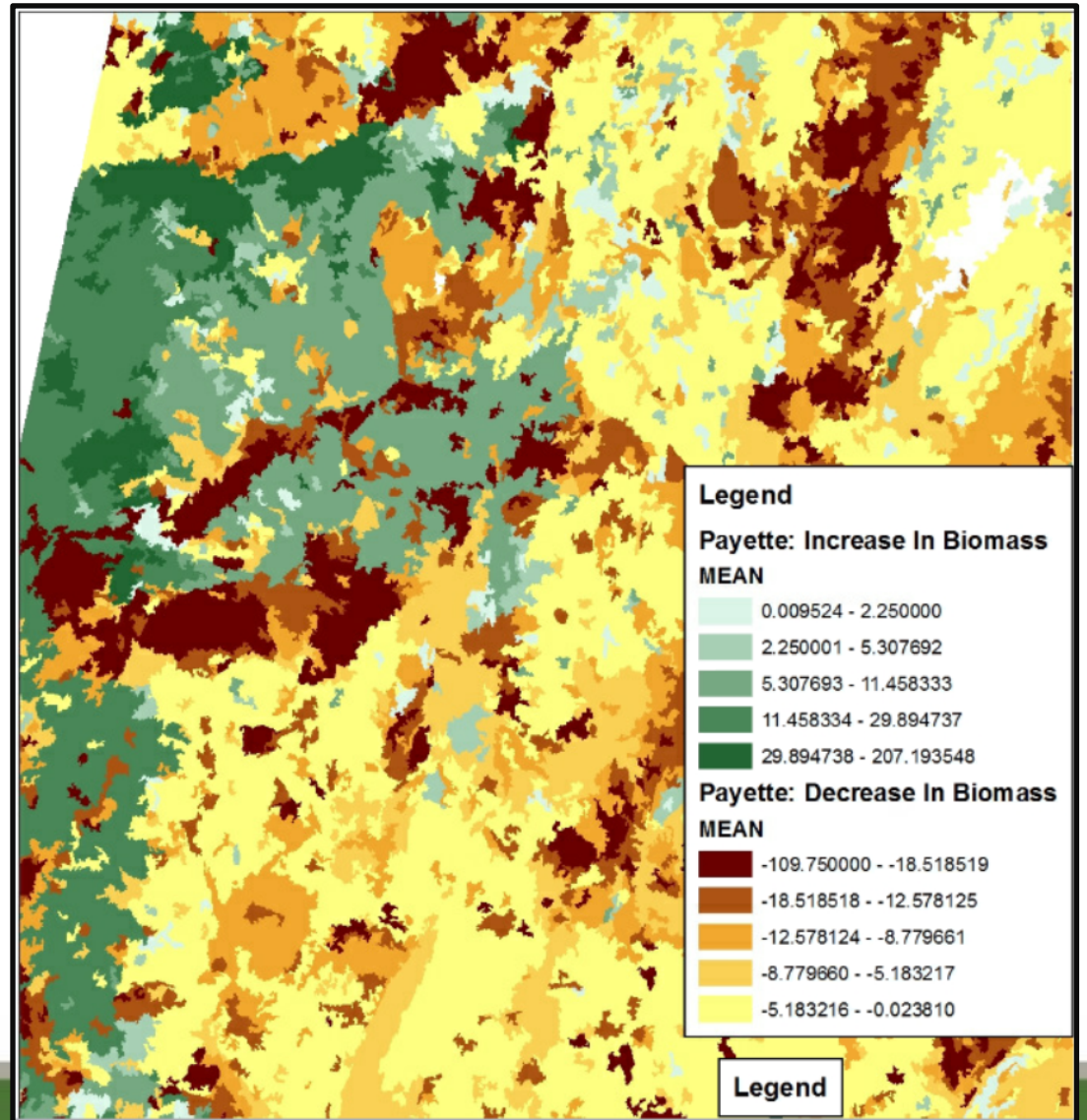
FACTS: USFS Tracking Database

- FACTS is the official database of record of landscape treatments
- Table show sample of treatments based upon average change score of Hudak et al. biomass product on a sample area on the Payette National Forest
- CMS products allow us to understand biomass impacts of common treatments
- CMS Products may provide non-biased metric of intentional change from active management.

ACTIVITY	Average Change	Number of Sample
Two-aged Shelterwood Establishment Cut (w/res) (2A/RH/NFH)	106	10
Two-aged Shelterwood Final Removal Cut (w/res) (2A/NRH/FH)	89	18
Stand Clearcut (EA/RH/FH)	86	56
Stocking Survey	75	500
Slashing - Pre-Site Preparation	72	69
Reforestation Need Created by Fire	71	70
Stand Clearcut (w/ leave trees) (EA/RH/FH)	69	163
Reforestation Need Created by Harvest	68	150
Site Preparation for Planting - Burning	63	28
Plant Trees	62	536
Stand Silviculture Prescription	60	23
Site Preparation for Planting - Mechanical	60	73
Shelterwood Preparatory Cut (EA/NRH/NFH)	60	24
Burning of Piled Material	52	188
Plantation Survival Survey	49	447
Maintenance of Animal Damage Control for Reforestation	48	17
Jackpot Burning - Scattered concentrations	44	14
Salvage Cut (intermediate treatment, not regeneration)	43	18
Single-tree Selection Cut (UA/RH/FH)	41	26
TSI Need Created- Release or Weeding	39	41
Reforestation Need Change due to Stocking Changes	39	22
Certification-Planted	37	570
Improvement Cut	35	36
Piling of Fuels, Hand or Machine	33	120
Site Preparation for Natural Regeneration - Mechanical	32	27
Certification of Natural Regeneration without Site Prep	32	13
Animal Damage Control for Reforestation	32	54
TSI Certification - Release/weeding	31	38
Stand Diagnosis Prepared	31	15
Chipping of Fuels	30	193
Shelterwood Establishment Cut (with or without leave trees) (EA/RH/NFH)	30	41
Tree Release and Weed	29	108
Wildfire - Natural Ignition	29	10
Control of Understory Vegetation	28	42
Yarding - Removal of Fuels by Carrying or Dragging	26	429
TSI Need (precommercial thinning) Eliminated	26	10
TSI Need Created- Precommercial Thin	26	207
Certification of Natural Regeneration with Site Prep	25	33
TSI Certification - Thinning	25	279
Precommercial Thin	23	1106
Commercial Thin	22	465
Rearrangement of Fuels	22	827
Reforestation Need Change due to Other (windthrow, etc)	21	75
Invasives - Pesticide Application	20	886
Underburn - Low Intensity (Majority of Unit)	19	97
Pruning to Raise Canopy Height and Discourage Crown Fire	18	86
Leave Tree Protection	17	119
Fill-in or Replant Trees	17	59
Silvicultural Stand Examination	14	242
Thinning for Hazardous Fuels Reduction	13	156
Seed-tree Removal Cut (w/ leave trees) (EA/NRH/FH)	12	16

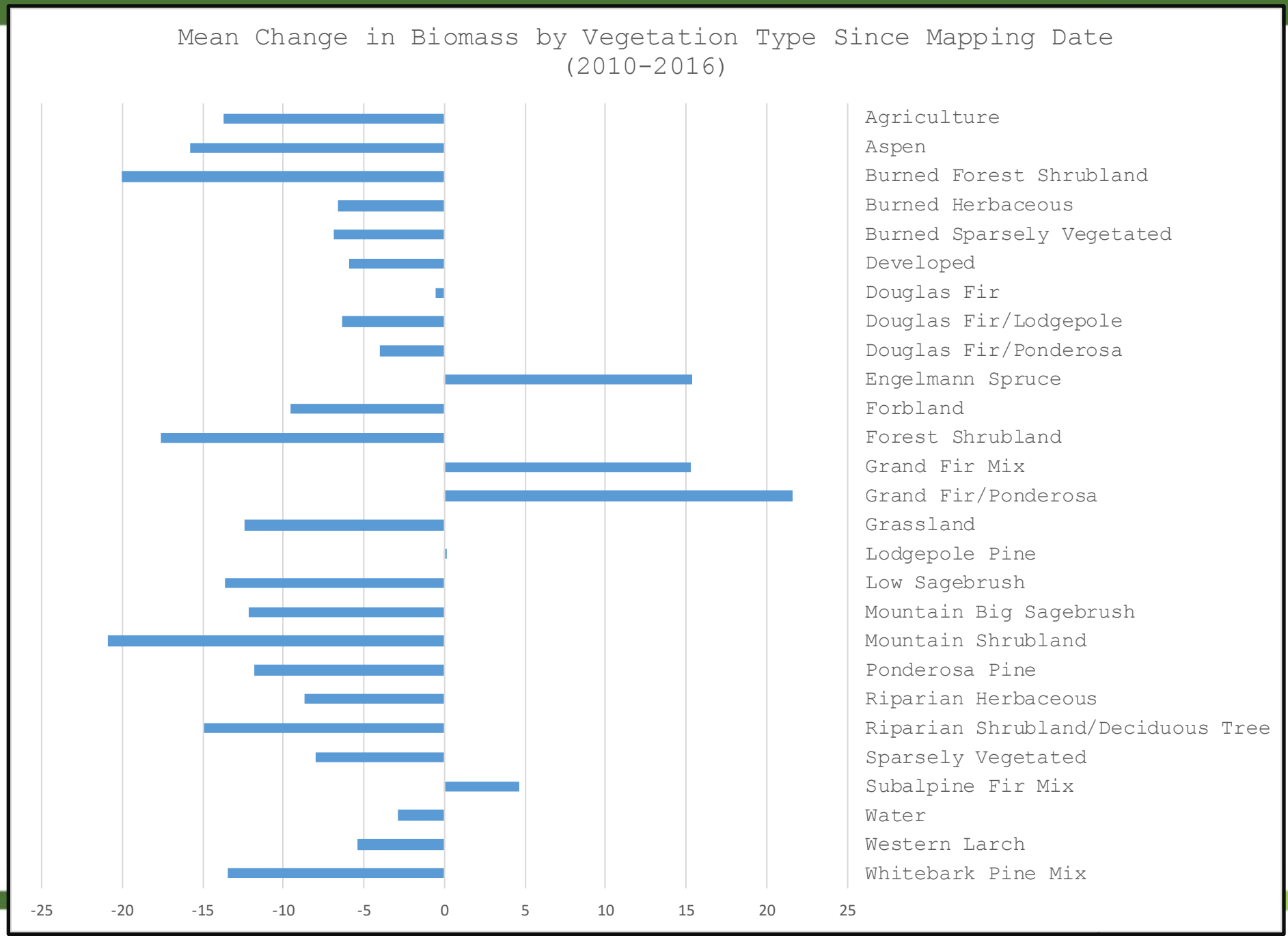
Existing Vegetation Mapping: Updates





Estimating Trends in Vegetation Cover

***Sample Area on the Payette National Forest**



Understanding and Using Forest Carbon Information for Decision-making: National Guidance

Prepared by
Duncan McKinley & Alexa Dugan
Office of Sustainability & Climate

International: Major Decisions Related to Forests

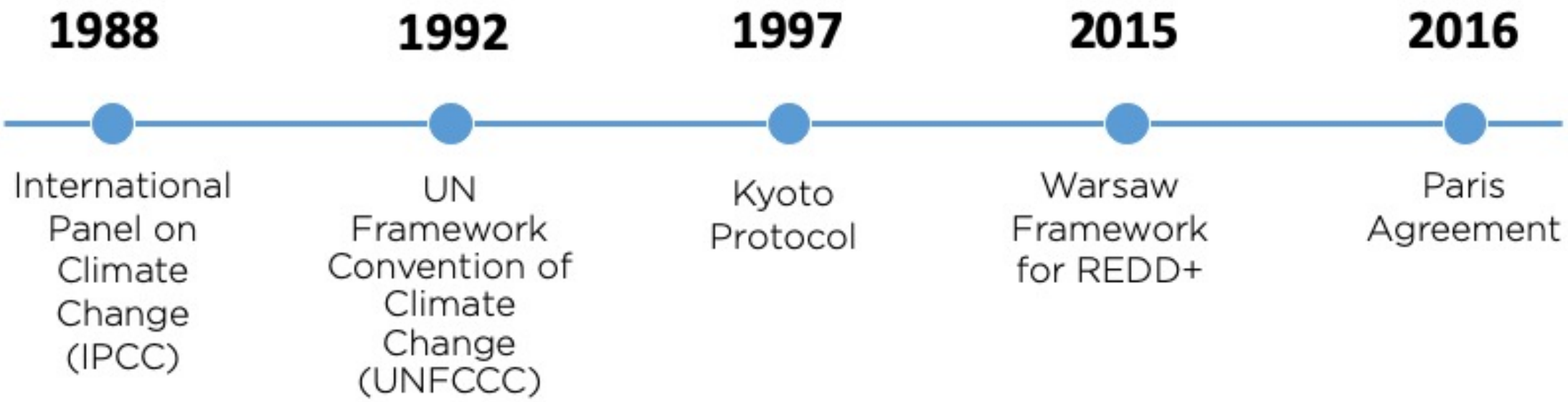


Image source: UNFCCC, 2016

Forest management can produce a carbon benefit

But how?

Three different ways…

1) Increase area of forest land/avoid loss

2) Increase carbon stocks/sequestration in forest ecosystems

3) Increase carbon storage in harvested wood products and displace of fossil fuels:

- Biomass energy
- For more energy-intensive products


What is the Forest Service's role in climate and carbon?
Photo by Mike Ryan

FS Polices and Direction drive the need for data

Previous

1) 2011 Climate Change Performance Scorecard (to measure progress towards goals in CC Roadmap)

- A baseline assessment of carbon stocks
- An assessment of the influence of disturbance and management activities on C stocks?

Current

2) 2012 Planning Rule

- Assessment of carbon stocks

3) NEPA disclosures

- Effects of projects/management on climate (carbon)

Roll-out

4) NEW Sustainability Scorecard

- Carbon is a keystone element

Scorecard Element	Unit Name	Yes/No
Organizational Capacity		
1. Employee Education	Are all employees provided with training on the basics of climate change, impacts on forests and grasslands, and the Forest Service response? Are resource specialists made aware of the potential contribution of their own work to climate change response?	
2. Designated Climate Change Coordinators	Is at least one employee assigned to coordinate climate change activities and be a resource for climate change questions and issues? Is this employee provided with the training, time, and resources to make his/her assignment successful?	
3. Program Guidance	Does the Unit have written guidance for progressively integrating climate change considerations and activities into Unit-level operations?	
Engagement		
4. Science and Management Partnerships	Does the Unit actively engage with scientists and scientific organizations to improve its ability to respond to climate change?	
5. Other Partnerships	Have climate change related considerations and activities been incorporated into existing or new partnerships (other than science partnerships)?	
Adaptation		
6. Assessing Vulnerability	Has the Unit engaged in developing relevant information about the vulnerability of key resources, such as human communities and ecosystem elements, to the impacts of climate change?	
7. Adaptation Actions	Does the Unit conduct management actions that reduce the vulnerability of resources and places to climate change?	
8. Monitoring	Is monitoring being conducted to track climate change impacts and the effectiveness of adaptation activities?	
Mitigation and Sustainable Consumption		
9. Carbon Assessment and Stewardship	Does the Unit have a baseline assessment of carbon stocks and an assessment of the influence of disturbance and management activities on these stocks? Is the Unit integrating carbon stewardship with the management of other benefits being provided by the Unit?	
10. Sustainable Operations	Is progress being made toward achieving sustainable operations requirements to reduce the environmental footprint and increase the resilience of agency operations and assets?	

Current FS Policy

2012 Planning Rule (FSH 1909.12.4)

- Assessment of Carbon Stocks:
  - Role of forests in sequestering carbon
  - Effects of Disturbances & Management on carbon stocks

Focused on stocks and change

Forest Service NEPA Guidance (2009)

- Must consider <u>climate change effects</u>:
  - Effects of projects on climate (*carbon*)
  - Effects of climate on projects

Focused on GHG emissions

* The Forest Service is **<u>not</u>** managing for carbon (i.e., mitigating), rather managing carbon as one of a suite of ecosystem services that forests provide

Differing perspectives on how to conceptualize the forest system is the greatest source of confusion and conflict!

Some big questions that we struggle with that's related to how we view the forest system…

- How to reconcile the scale of decision making (i.e. project or forest level) with best **spatial scale** to evaluate patterns and trends in carbon dynamics?
- How to reconcile the **temporal scale** of decision making with the long-term dynamics of carbon?
- How much **detail** on carbon is necessary to fully inform decision making and make a reasoned choice among alternatives?

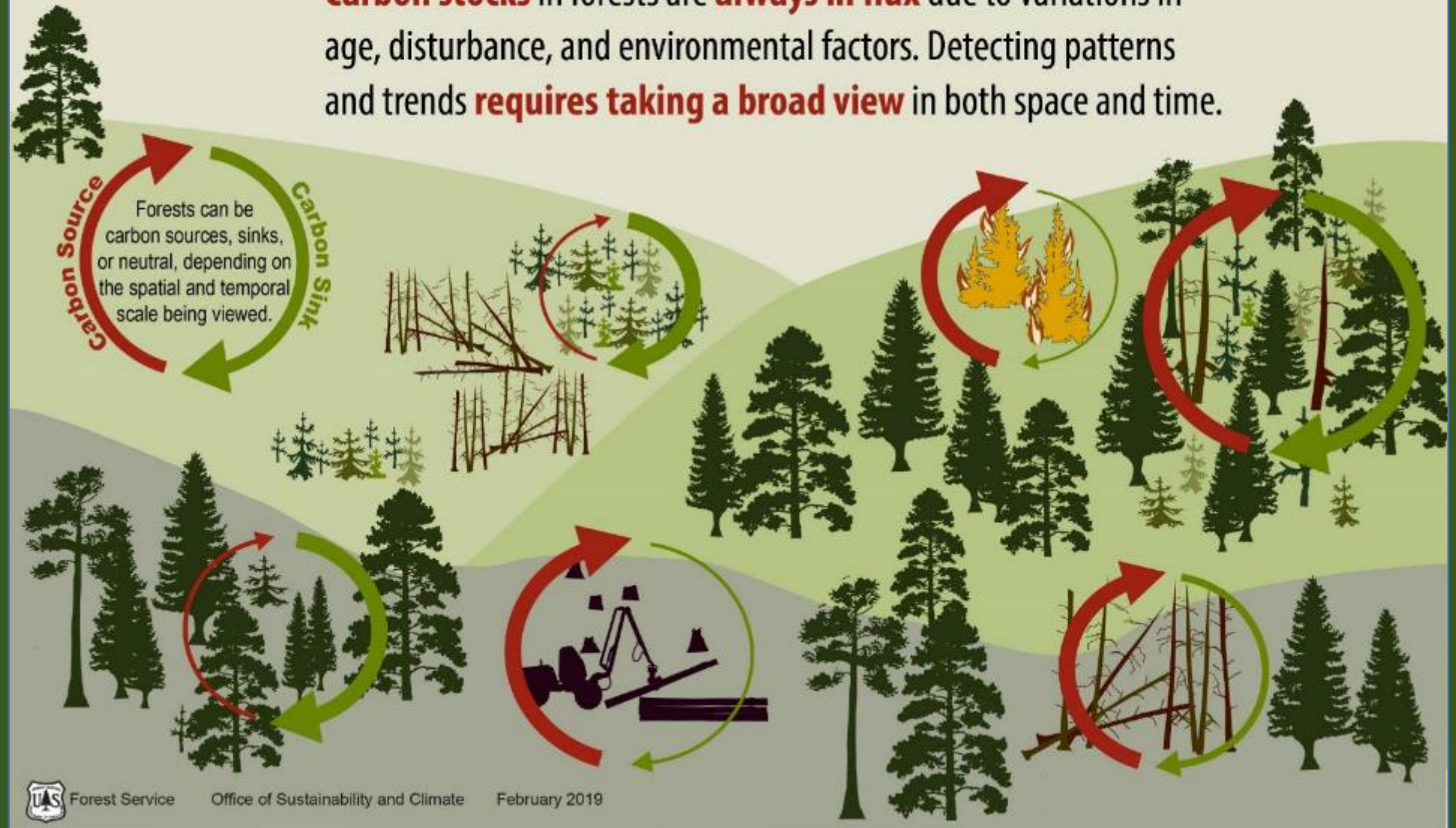

SCALE!!!

USDA United States Department of Agriculture

A spatial and temporal view

Carbon in Time and Space

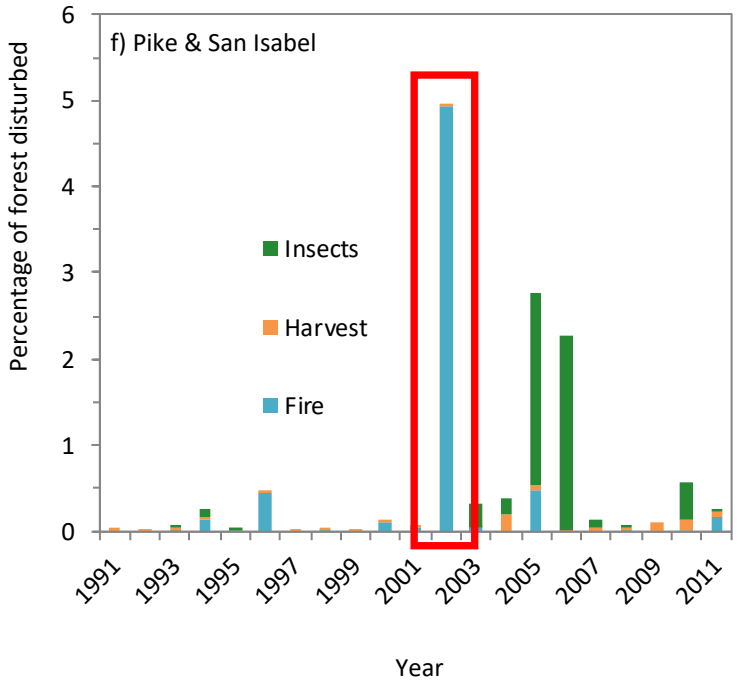
Carbon stocks in forests are **always in flux** due to variations in age, disturbance, and environmental factors. Detecting patterns and trends **requires taking a broad view** in both space and time.



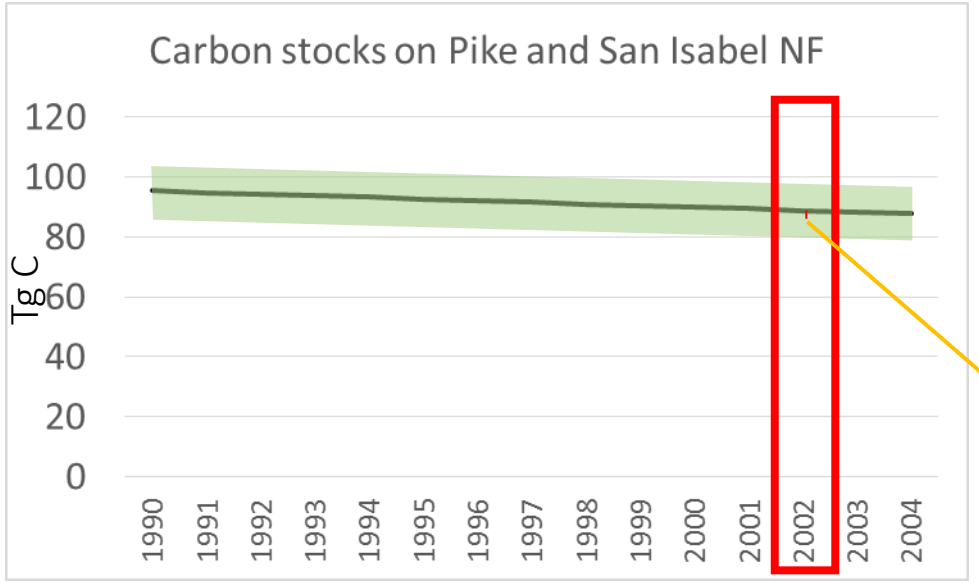
Forest Service Office of Sustainability and Climate February 2019

Detecting changes in carbon stocks after large disturbances: “Hayman fire”

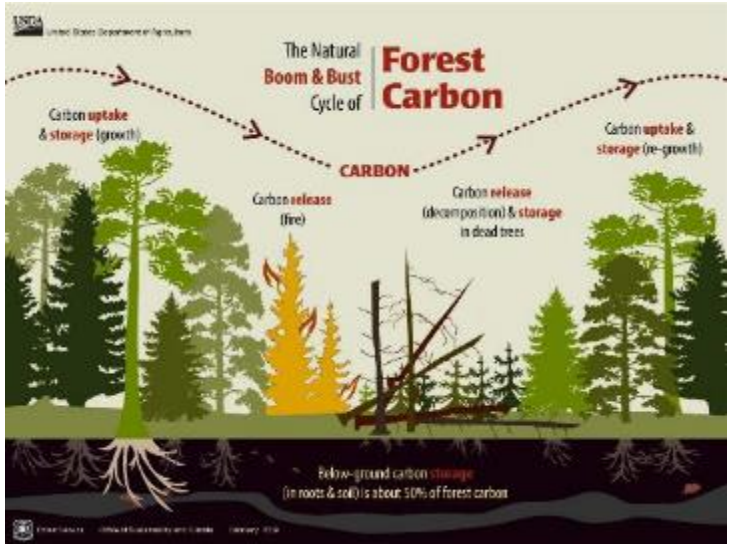
- Burned about 135,000 acres (211 sq. miles) in the Pike & San Isabel National Forest, largest fire in CO state’s history
- Although stunning visually, only about 4.9 percent of the total forested area was affected by fire.
- Assuming high-severity fire on all acres burned, about 1.76 Tg C could have been volatilized during wildfire.
- In 2013, total carbon stocks were 82.7 Tg C ± 8 Tg C
- Consistent downward trend since 1990, suggests broad-scale change



Disturbance assessments



Baseline assessments



Approximate immediate impact of wildfire on carbon stocks

Carbon trends on a regional scale: forest carbon stocks are increasing…

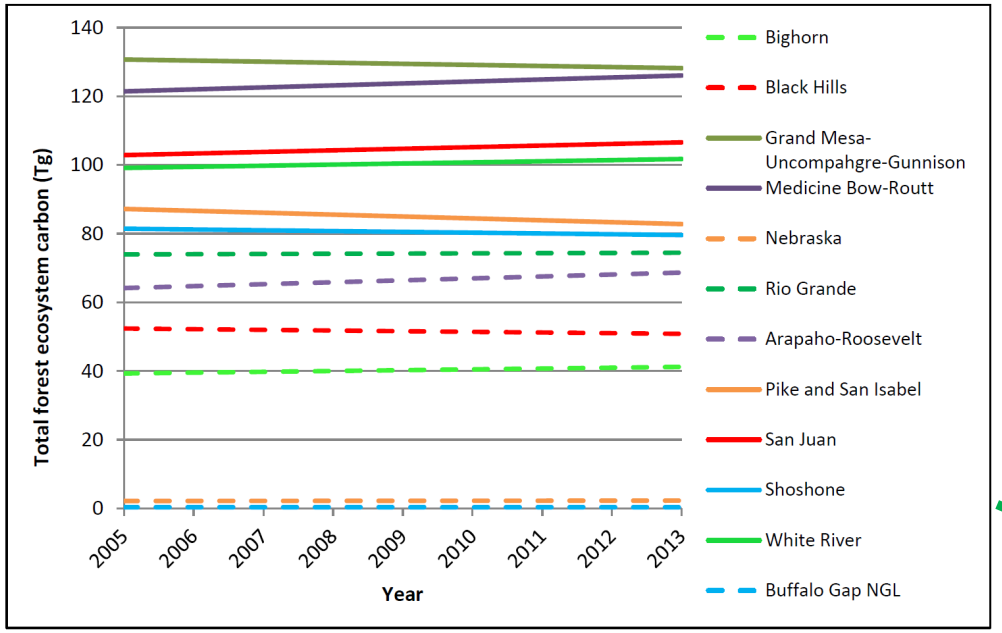
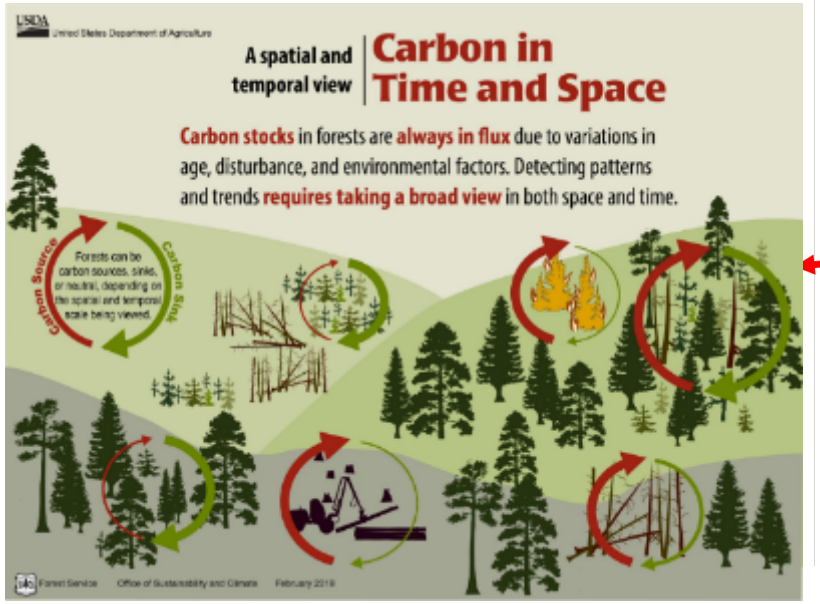


Figure 4. Total forest ecosystem carbon (Tg) for the national forests and grassland in the Rocky Mountain Region from 2005 to 2013.

- Pike & San Isabel and Grande Mesa-Uncompahgre-Gunnision trending downward
- All other forests and region trending upwards



Best scale to identify trends related to environmental change and land-use

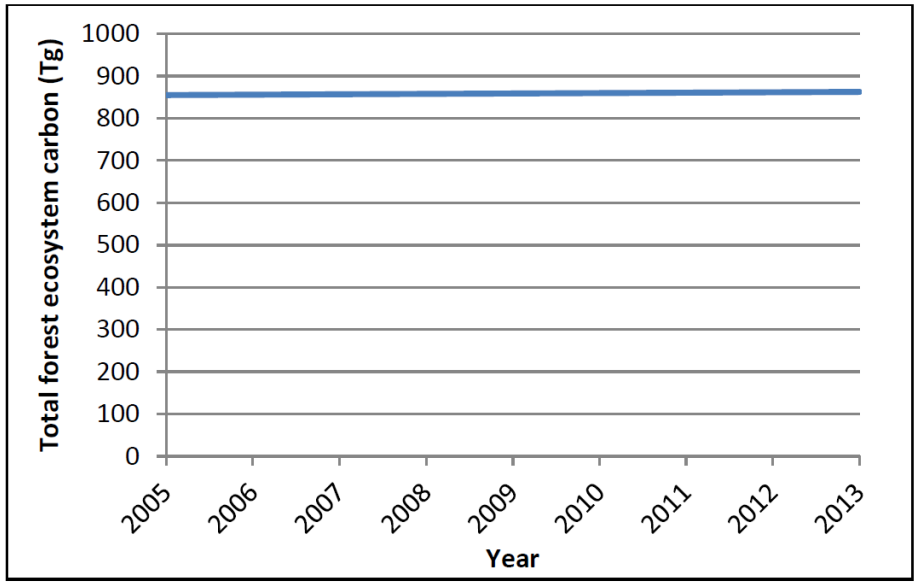
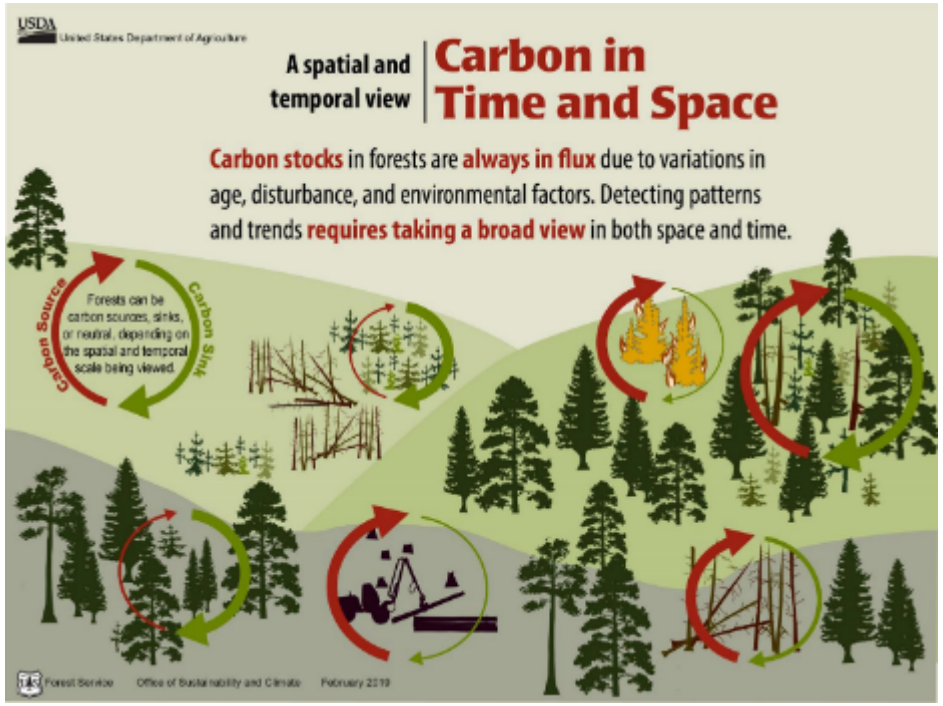


Figure 3. Total forest ecosystem carbon (Tg) for the Rocky Mountain Region from 2005 to 2013.

Can we put *individual* management actions or disturbances in context of forest-level dynamics?

Not in a meaningful way at current level of management!

- Patterns and trends are determined by many events over space and time.
- Massive and sustained human inputs/underlining environmental conditions are needed to move the needle enough (signal) to see effects on carbon.
- Determining the trajectory of carbon (carbon loss or carbon gain) from a cause requires the ability to detect a “signal” from background noise.



Delivering carbon science to inform decision making

Closing Thoughts

What are some positive aspects of CMS data for your work?

- Helps us fill in monitoring data gaps where didn't have data before
- We can use it to depict trends on our National Forests
- Non-biased metric of outcomes of landscape treatments.

Closing Thoughts

What is the next priority in your work? Provide keywords.

- **Shared Stewardship: Collaborating with States on Landscape Prioritization**
- **Active Management: Making decisions about where Restoration Treatments will take place.**
- **Existing Vegetation Mapping updates.**
- **Reforestation Needs Assessments.**

Closing Thoughts

What scientific advancement(s) could contribute to your work?

- **Near-real time product delivery. Refreshed products depicting landscape conditions (green-up, soil moisture, etc.)**
- **Geofencing and Livestock Grazing: The ability to manage livestock with Geospatial Intelligence along with high quality map products.**

Closing Thoughts

What data do you need? When? Be as specific as possible.

- **Disturbance products for die-off and treatments. We need to fill in the gaps.**

Closing Thoughts

- • What are some positive aspects of CMS data for your work?
- • What is the next priority in your work? Provide keywords.
- • What scientific advancement(s) could contribute to your work?
- • What data do you need? When? Be as specific as possible.

Methane in EPA's GHG Inventory

Melissa Weitz
U.S. EPA Office of Air and Radiation
November 12, 2019

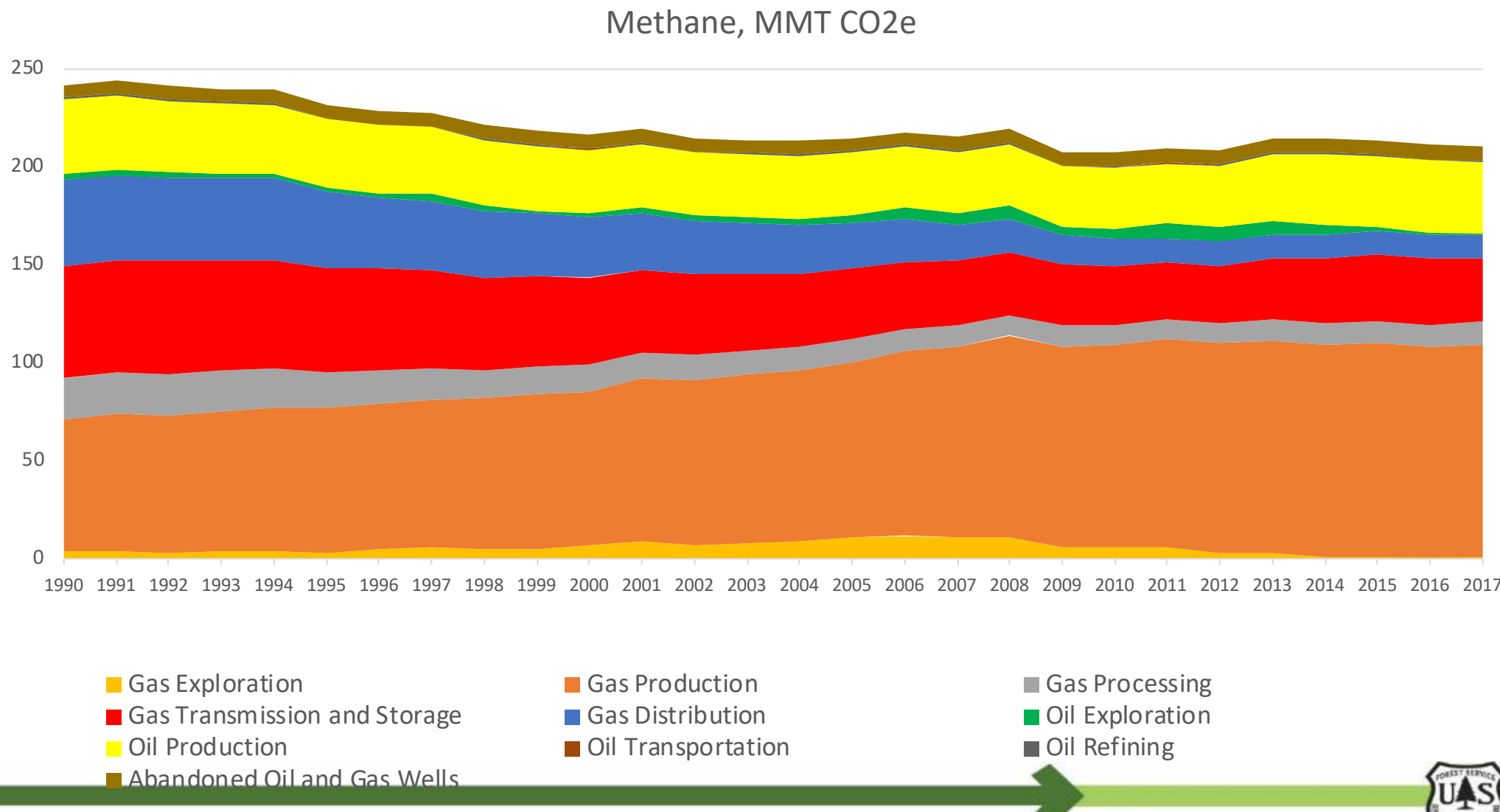
US GHG Inventory background

- Official U.S. estimate of greenhouse gas emissions for reporting to United Nations Framework Convention on Climate Change (UNFCCC)
  - Annual national-level inventory submissions to the UNFCCC since 1994
  - Emission estimates begin in 1990; most current inventory covers 1990-2017
- EPA leads Inventory development, working with several other agencies (e.g., agriculture, energy) to prepare estimates and provide activity data
- Sectors Covered
  - Energy, Industrial Processes, Agriculture, Land-Use Change and Forestry, and Waste
- Gases Covered
  - CO_2, CH_4, N_2O, HFCs, PFCs, NF_3, SF_6
  - Reported in mass of each gas, and as global warming potential (GWP)-weighted CO_2e emissions
- Record of emissions trends over time
- Each year, Inventory undergoes expert review, public review, and UNFCCC review

GHG Inventory methods: Calculating U.S. GHG Emissions from Oil and Gas

- Inventory is stratified into natural gas and petroleum pathways of the industry
  - Natural gas - offshore production, onshore production, gas processing, gas transmission, underground gas storage, LNG storage, LNG import and export terminals, and gas distribution
  - Petroleum – offshore production, onshore production, oil transportation, and refineries
- Oil and gas in inventory covers hundreds of types of sources
- Basic approach is to multiply national activity data by emission factors, e.g.:
  - Miles cast iron pipeline x CH_4 per mile cast iron pipeline
- Data sources: EPA Greenhouse Gas Reporting Program (GHGRP, regulatory program) and research studies
- Input data and assumptions documented on GHG Inventory website

Oil and Gas CH_4 Trends



Updating estimates for Oil and Gas CH_4

- Large amount of data and information newly available
- Opportunity to re-evaluate and make updates to GHG Inventory
- Stakeholder process
  - Webinar
  - Memos
- Public review draft and memo comments

Segment	Last year's 2016 GHGI Estimate	Updates in the 2019 GHGI	Updated 2016 GHGI Estimate
Oil Exploration	2.1 MMT CO2e	• Use of GHGRP data for HF completions • Use of Drilling Info data for wells drilled	0.5 MMT CO2e
Gas Production	106.8 MMT CO_2e	• Use of GHGRP data for gathering pipelines	107.1 MMT CO_2e
Transmission and Storage	32.8 MMT CO_2e	• Use of GHGRP data for transmission pipeline blowdowns • Use of GHGRP data for LNG sources	34.5 MMT CO_2e
Other Segments	60.4 MMT CO_2e	• No revisions (only activity data refreshes)	61.8 MMT CO_2e
Total	**202.1 MMT CO_2e**		**203.9 MMT CO_2e**

External Studies and Updating and Assessing Inventories

Type of Study	Relevance to GHGI	Key Considerations
Measurement of specific activities, processes and equipment (~bottom up)	Direct improvement to GHGI • Expansion of gathering source category • Updates to activity data in production • Updates to transmission and storage and distribution	• Providing information on -Activities taking place at the time of measurements --Representativeness at national / regional levels --General operating conditions versus high emitting events or malfunctions --Controlled versus uncontrolled
Inverse modeling (~top down)	General indication of over- or under-estimates • General support for update (e.g. studies showing high emissions in production areas) • Highlights additional questions related to estimates (e.g. distribution)	• Using the appropriate Inventory comparison • Seasonal/regional variations • Documentation of assumptions and uncertainties • Attribution is a challenge • Limited ability to pinpoint which data inputs need to be improved

CMS data products used

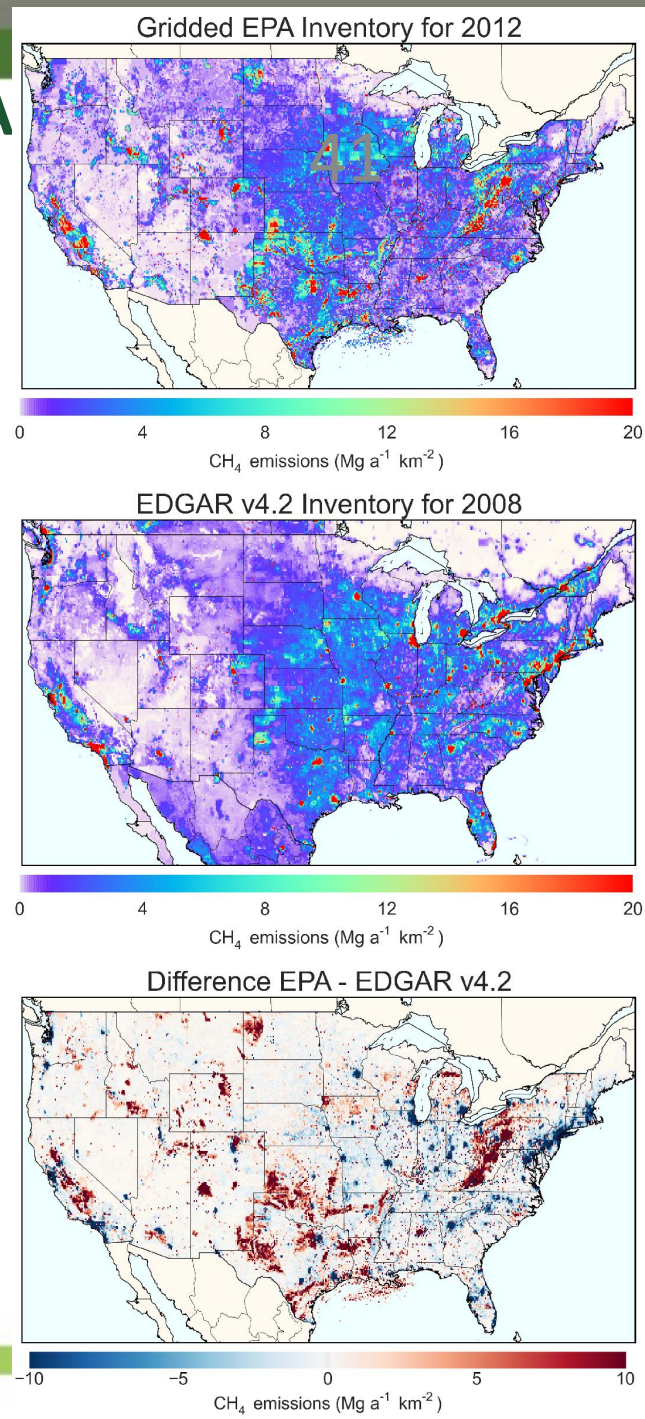
- Gridded CH_4 inventory for U.S. 2012 emissions based on 2016 GHGI
- (planned) Gridded CH_4 inventory for U.S. 2012-2016 emissions

Harvard-EPA CH_4 Inventory Gridding Project

- Inverse studies often relied on the EDGAR inventory as prior since gridded data is required to compare to observations
- Gridding of U.S. GHG Inventory CH_4 emissions developed for 2012 emissions, released in 2016
  - Region-specific EPA emission factors (where available)
  - Spatial allocation on 0.1° x 0.1° grid using national & high resolution datasets
  - Multiple layers of data for emissions from different processes
  - Monthly time resolution
- Since its release, many researchers have used the EPA gridded inventory
- Development of updated gridded inventory, covering 2012-2016 emissions is underway

Comparison of Harvard-EPA Gridded CH_4 Inventory with EDGA

- Prior to development of Gridded CH4 Inventory, researchers used EDGAR 4.2 to compare their observations with “U.S. Inventory” estimates
- Gridding project revealed that EDGAR product was gridding certain emissions incorrectly, making results inconsistent with U.S. GHGI
  - E.g., oil and gas production emissions were not mapped to production areas, but instead to population centers (see missing methane hot spot in Four Corners Region)
- More recent observation study results better align with the Gridded CH_4 Inventory



GHG Inventory Timelines

- GHG inventory is updated annually
  - In April 2020, will publish 1990-2018 GHG Inventory
- Update every year with new data and recalculate previous years
- Typically, we develop draft data updates in summer/fall of each year
- Stakeholder process
- GHG Inventory publication in April of every year
- Throughout the process we track new studies that may be used to update the GHG Inventory

Additional carbon data needs/gaps for which the CMS community could contribute data

- Investigation of the discrepancy between top-down and bottom-up studies
  - More coordination with operators, etc.
- Emission factor data that can be used to update the GHG inventory

Challenges and short-term improvements

- Improved ability to use top-down to inform bottom-up
  - Results usually not at a resolution that can be directly compared to GHG Inventory inputs
- Stakeholder understanding of comparisons of top down studies with GHG Inventory

Closing Slide

- What are some positive aspects of CMS data for your work?
  - Improved understanding of spatial distribution of emissions in our own data
  - Researchers now comparing against the gridded inventory versus another product, which improves confidence that studies are relevant to US GHG Inventory
- What is the next priority in your work?
  - Updating GHG Inventory estimates for gathering and boosting and offshore oil and gas
  - Potential updating estimates for other sources as data become available
    - Distribution meters, end-use leak emissions (appliances, NG vehicles, power plants)
- What scientific advancement(s) could contribute to your work?
  - Assessment of whether top-down studies support updates or conflict with the updates
- What data do you need?
  - Data disaggregated for comparison with GHG Inventory
  - TROPOMI comparisons with gridded inventory (higher resolution improves ability to assess GHG Inventory inputs)
  - Variation is still a question (how do emission vary over time, during the day, week to week, month to month)

Characterizing methane emissions from the largest oil producing basin in the US

Ritesh Gautam
Environmental Defense Fund, Washington DC

- ***Brief Overview of EDF's oil & gas methane science efforts***
- ***CMS products & EDF Collaboration with Daniel Jacob's group at Harvard***
- ***Permian Basin methane emission quantification***

EDF oil & gas methane science efforts

1. **Assessment of methane emissions from US oil & gas supply chain**
   - *EDF Synthesis of recent bottom-up & top-down measurement based results (Alvarez et al. 2018 in Science).*
   - *Permian Basin methane emission quantification.*

2. **International methane studies**
   - *EDF, Climate and Clean Air Coalition (CCAC), Oil and Gas Climate Initiative (OGCI) and European Commission are working together on a series of peer-reviewed scientific studies to measure methane emissions in the oil and gas sector.*
   - *Data collected will help companies and governments prioritize actions and policies to reduce methane emissions.*

3. **MethaneSAT**
   - *EDF leading development of MethaneSAT program.*
   - *Goal- map and quantify methane emissions with an initial focus on the oil/gas production areas.*
   - *Science team at Harvard & SAO. Prime Instrument developer- Ball Aerospace. Launch – 2022.*

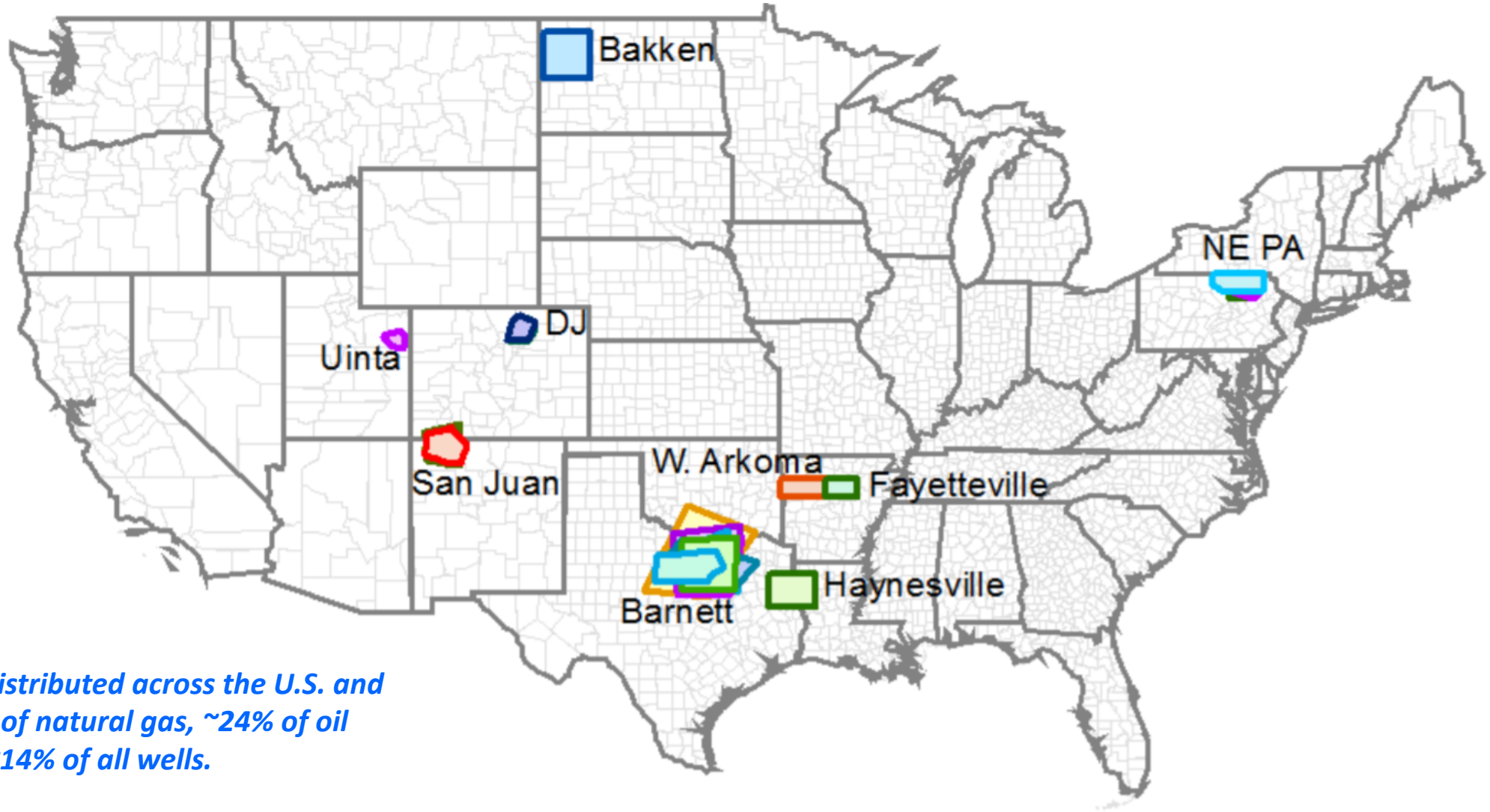
CMS relevant products & EDF Collaboration with Daniel Jacob's group at Harvard

- Daniel Jacob (PI), Yuzhong Zhang (Joint Harvard/EDF postdoc), Jianxiong Sheng (Joint Harvard/EDF postdoc, now at MIT), Tia Scarpelli (PhD Student), Bram Maasakkers (PhD Harvard, now at SRON)

1. **Gridded EPA methane emissions inventory for US (Maasakkers et al. 2016)**
2. **Gridded methane emissions inventory for Mexico (Sheng et al. 2017, Scarpelli et al. in prep)**
3. **Yuzhong's analytical inversion method for the Permian follows the method developed at Harvard through CMS**
4. **Tracking Gas Flaring activity in offshore Mexico using satellite-based multi-pollutant data products (Zhang et al. 2019)**
5. **Globally gridded methane emissions inventory from oil, gas, and coal exploitation based on UNFCCC reports (Scarpelli et al. in review)**

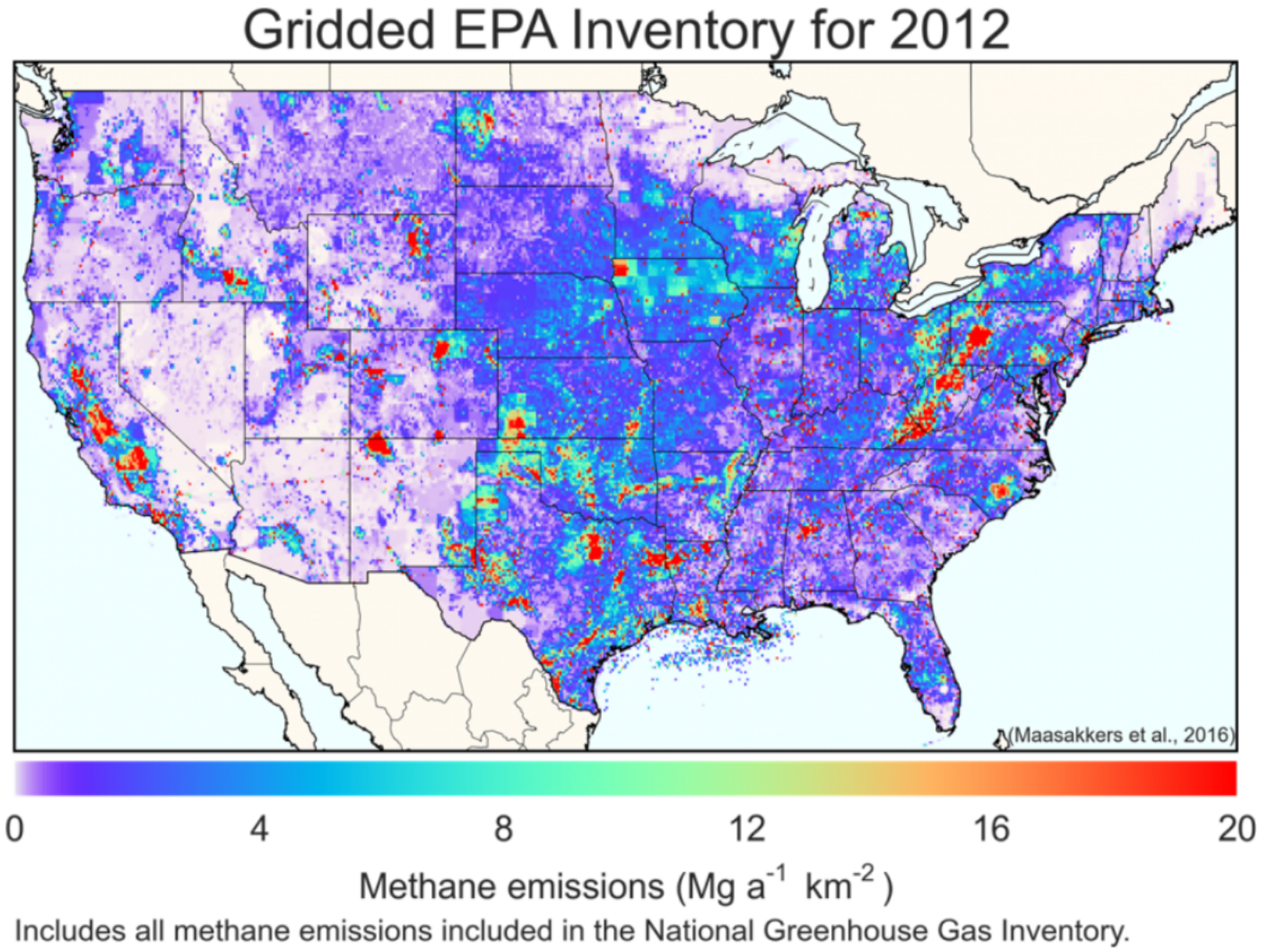
EDF-led US O&G emissions Synthesis study

When scaled up nationally, the Synthesis study indicates US natural gas supply chain emissions to be 13 ± 2 Tg/y (for year 2015), equivalent to 2.3% of gross U.S. gas production (Alvarez et al. 2018).



These areas are distributed across the U.S. and account for ~33% of natural gas, ~24% of oil production, and ~14% of all wells.

Maasakkers et al gridded inventory used to allocate emissions spatially in EDF Synthesis study. Spatially disaggregated emissions were then used to compare Top-Down and Bottom-Up estimates.

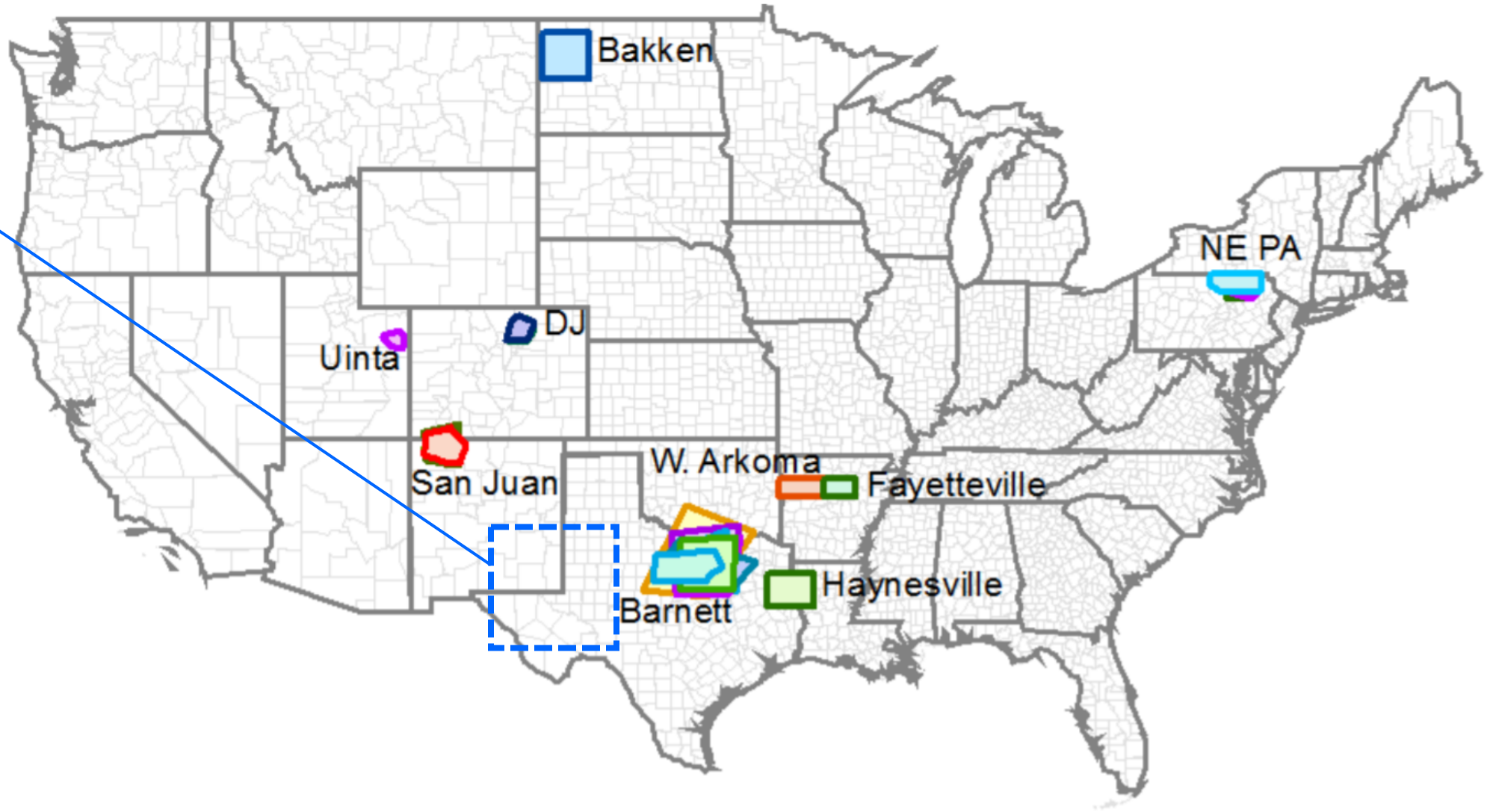


Maasakkers, J.D., Jacob, D.J., Sulprizio, M.P., Turner, A.J., Weitz, M., Wirth, T., Hight, C., DeFigueiredo, M., Desai, M., Schmeltz, R. and Hockstad, L., Gridded national inventory of US methane emissions, *ES&T (2016).*

EDF-led US O&G emissions Synthesis study

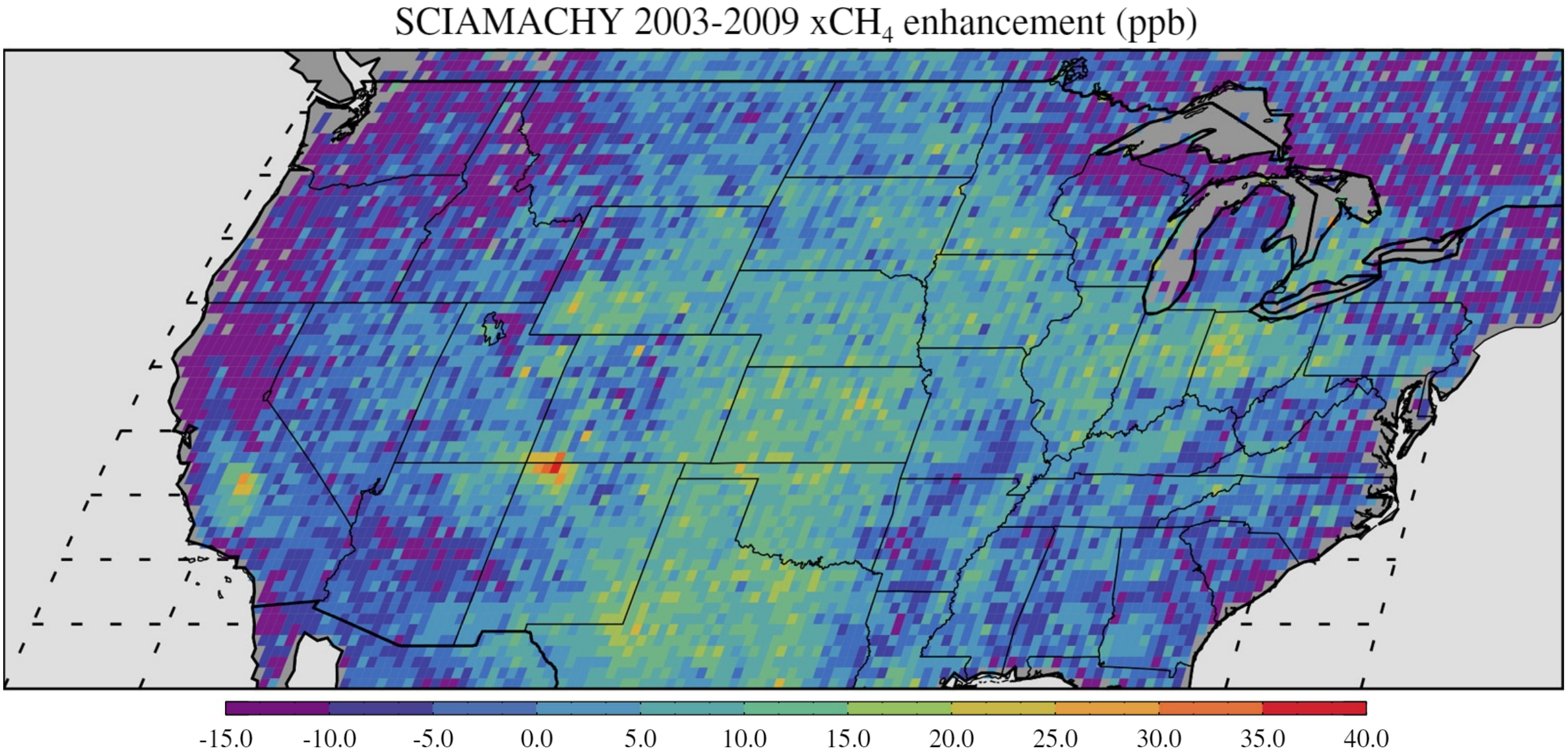
When scaled up nationally, the Synthesis study indicates US natural gas supply chain emissions to be 13 ± 2 Tg/y (for year 2015), equivalent to 2.3% of gross U.S. gas production (Alvarez et al. 2018).

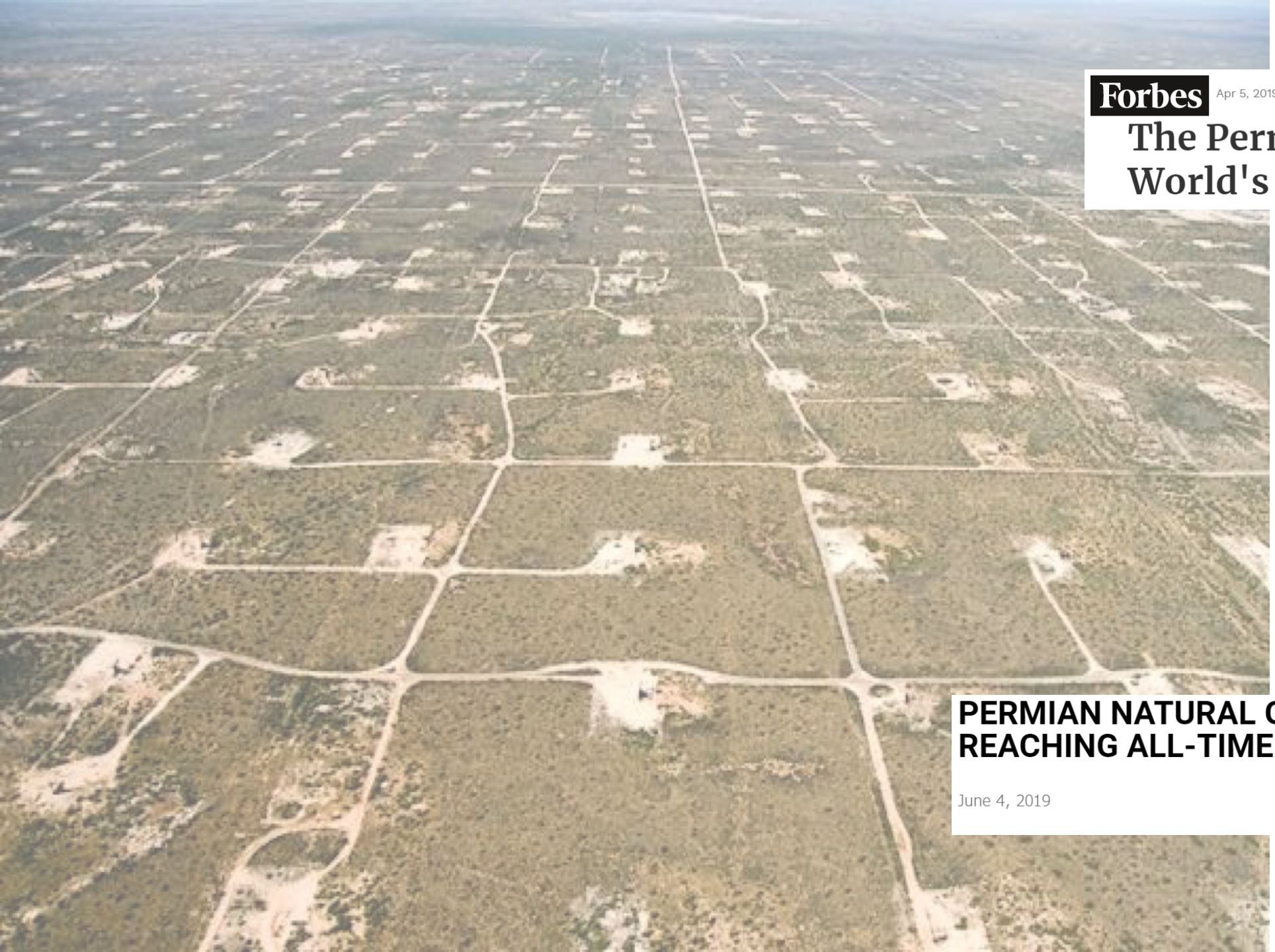
Permian Basin (*not* part of the 9-basin Synthesis study) is located across the states of Texas and New Mexico, and covers an area of 400 km x 400 km.



Permian Basin associated with weak methane enhancement in the previous decade

Map below shows anomalous U.S. methane emissions (or how much the emissions differ from average background concentrations) for **2003 to 2009**, as measured by the European Space Agency's **SCIAMACHY** instrument (Kort et al. 2014).





Forbes Apr 5, 2019,

The Permian Basin Is Now The World's Top Oil Producer

The Permian Oilfield is among the most prolific oil producing basins in the world (largest in the US).

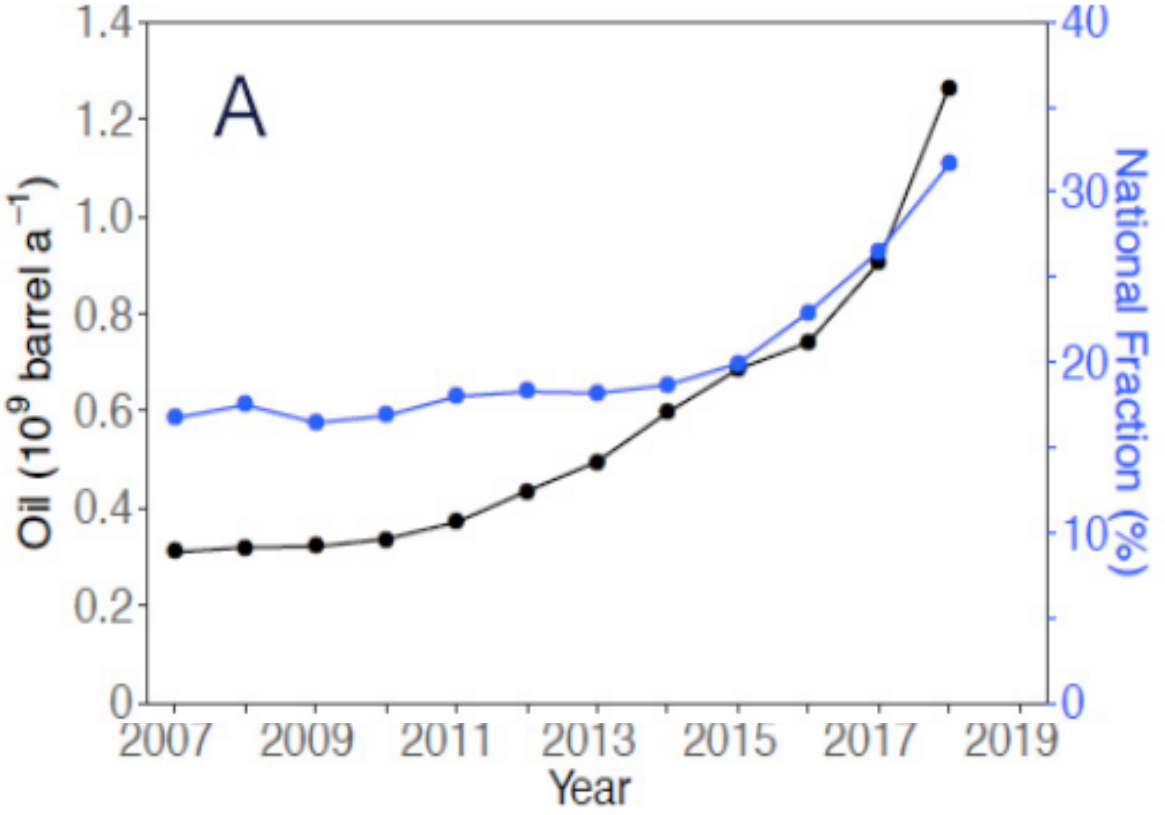
Contributes to >30% of total US oil production.

PERMIAN NATURAL GAS FLARING AND VENTING REACHING ALL-TIME HIGH

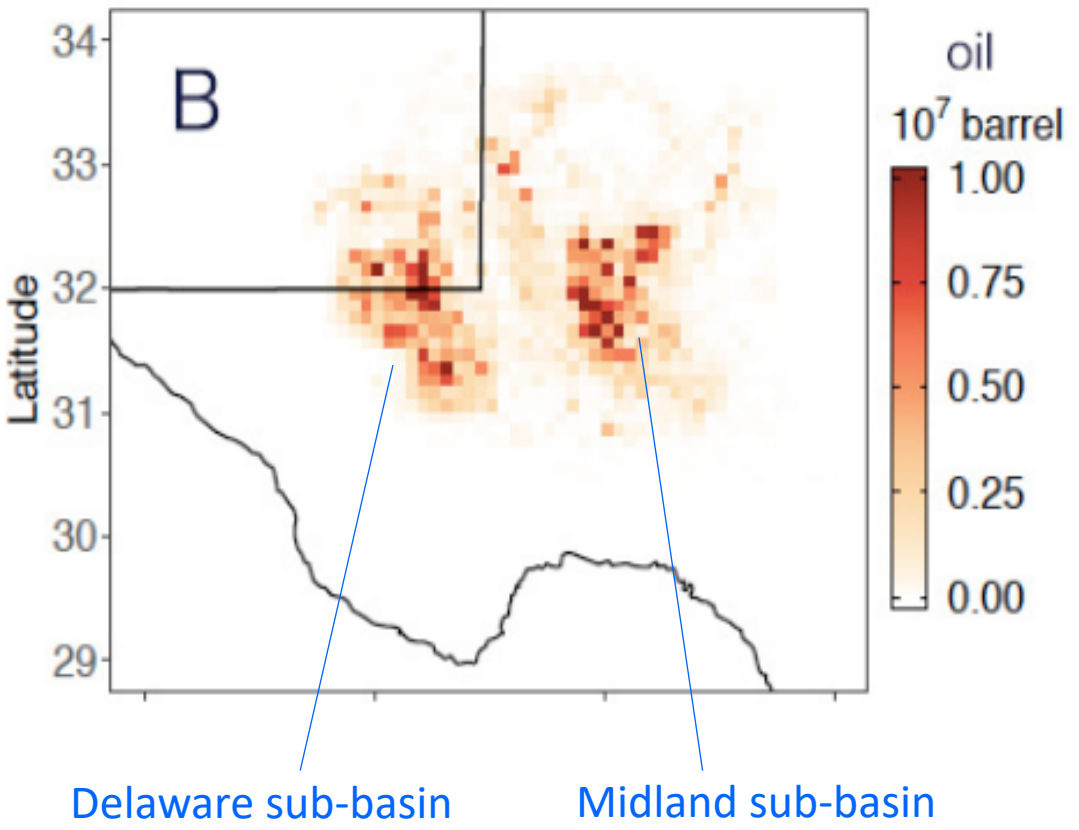
June 4, 2019

RYSTAD ENERGY

Oil & Gas production has been on significant rise in the Permian Basin during the past decade, especially the last five years.



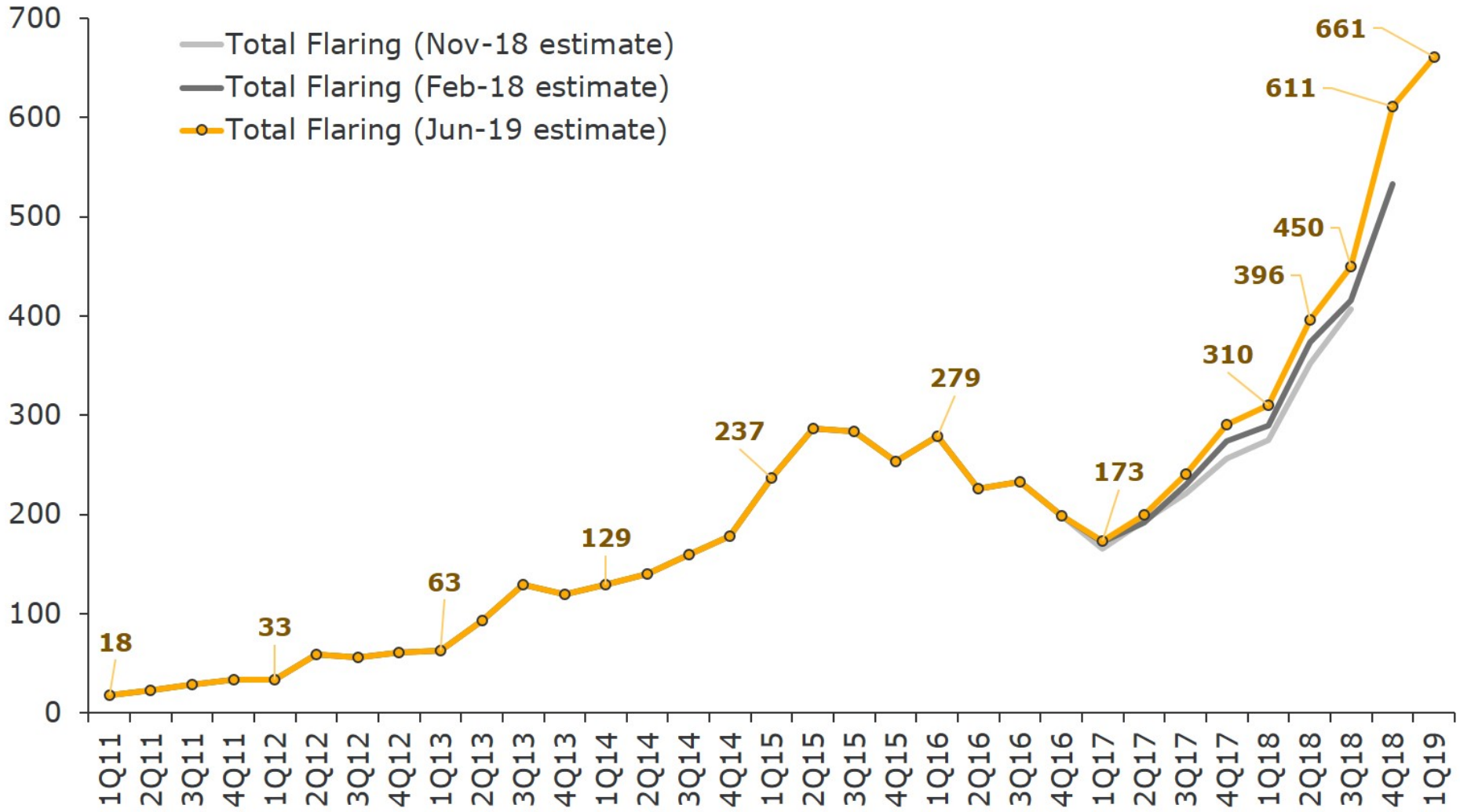
Permian Basin



Zhang et al. (under review)

Natural gas flaring and venting in the Permian Basin by quarter

Million cubic feet per day



Source: Rystad Energy research and analysis, Rystad Energy ShaleWellCube

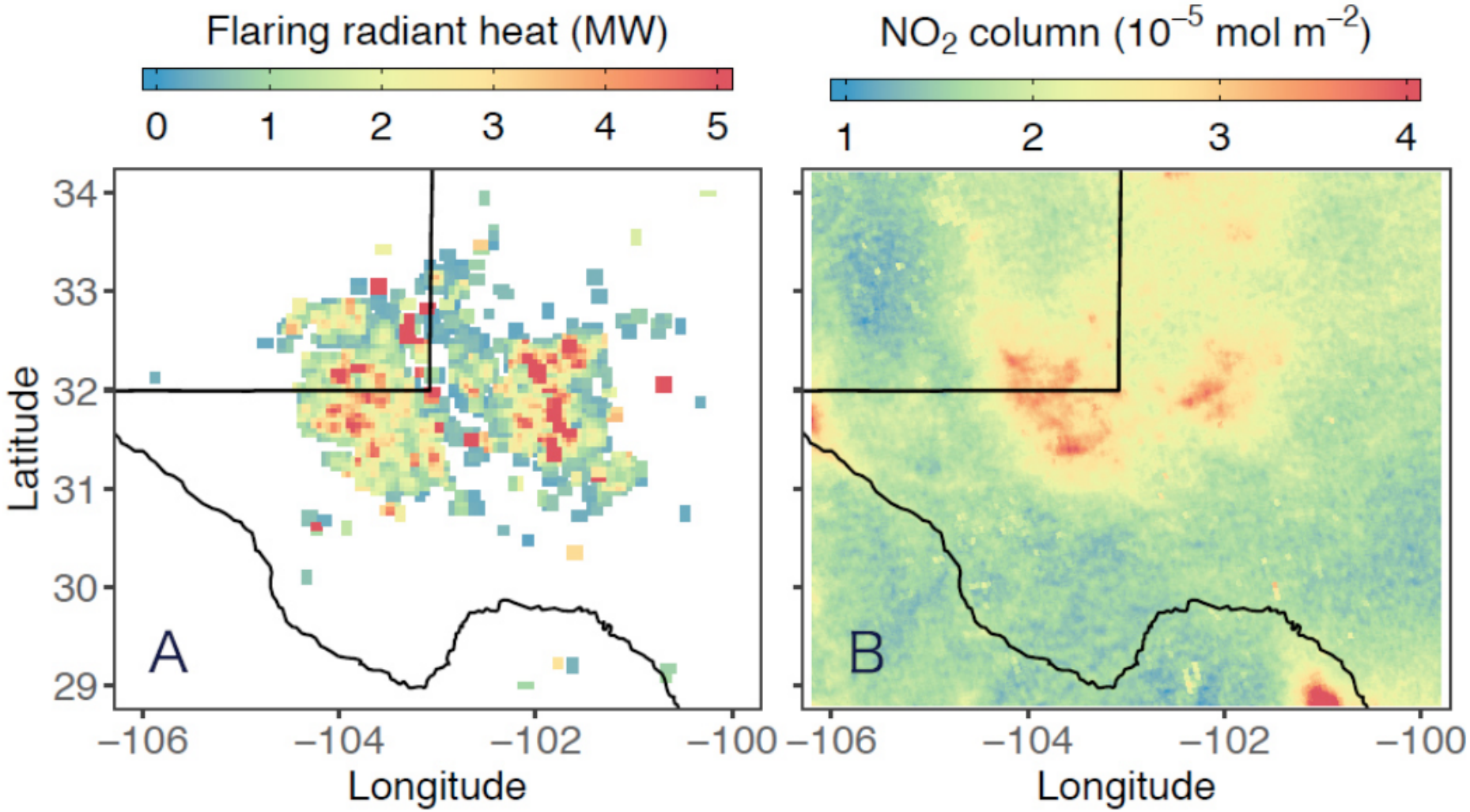
RYSTAD ENERGY

The central question(s) we set out to address-

- ***What is the magnitude of Permian methane emissions and how it compares to emissions from other oil/gas basins in the US?***

- ***And whether satellite data can be used to detect & quantify methane emissions from Permian Basin?***

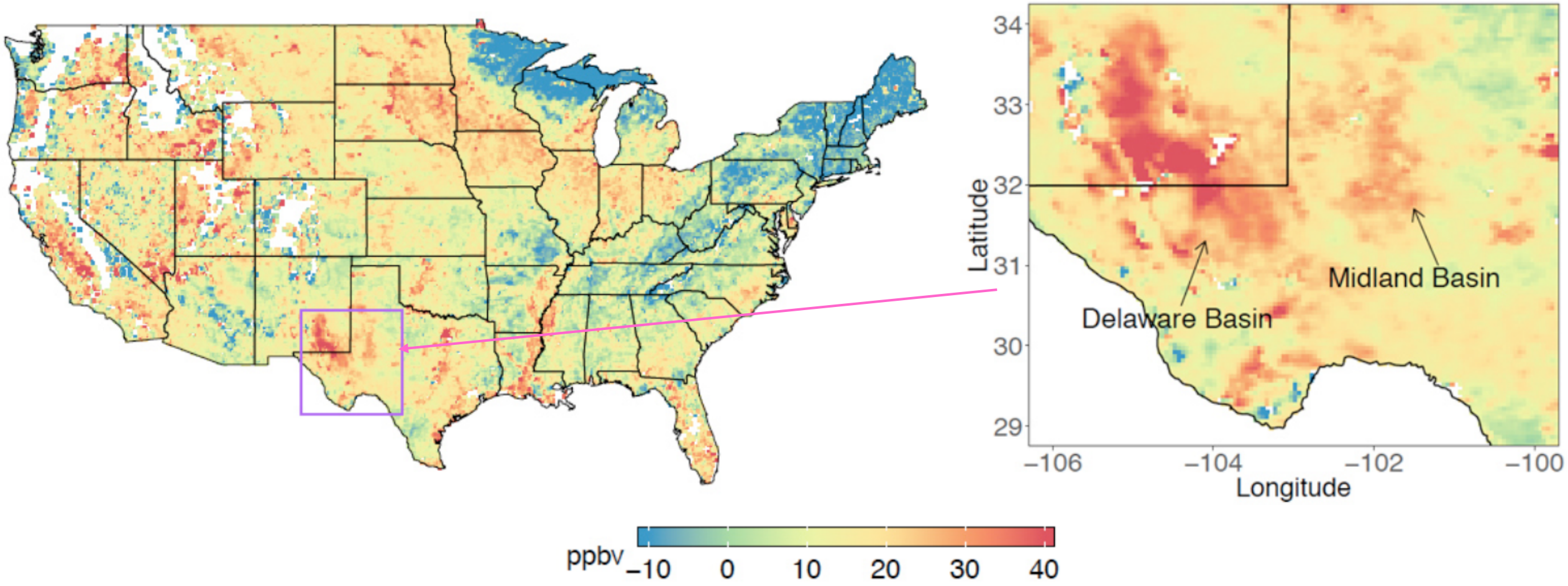
Satellite observations of gas flaring radiant heat (VIIRS data on left) and NO_2 tropospheric column density (TROPOMI data on right) over the Permian Basin



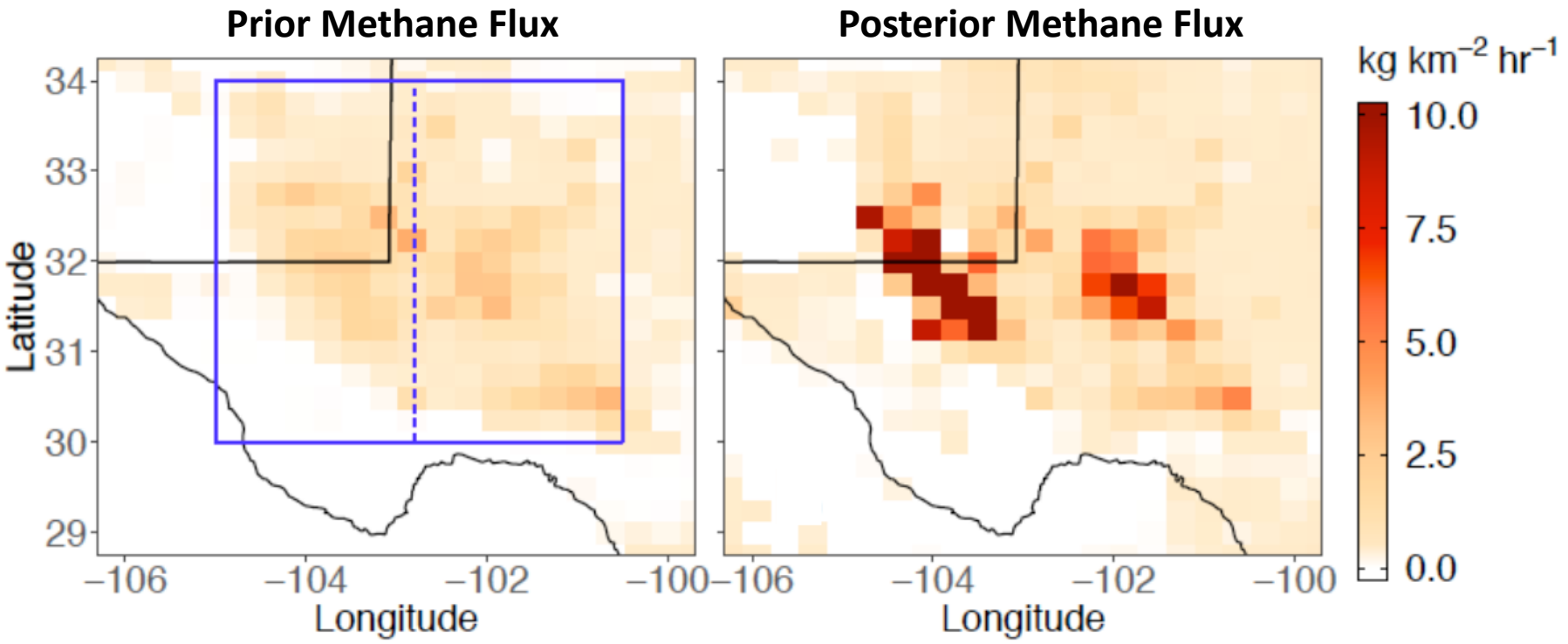
Zhang et al. (under review)

Permian methane anomaly

(10 months of TROPOMI XCH_4 data averaged during May 2018 – March 2019)



Zhang et al. (under review)



Zhang et al. (under review)

- Permian methane emissions derived from TROPOMI data, using full inverse analysis and mass balance, represent the largest methane flux relative to previously-reported U.S. oil & gas producing basins.

- This estimate is >2 times larger than emissions extrapolated from recent EPA GHGI data.

EI $_{prior1}$ – Emissions inventory extrapolated from recent EPA GHGI data (Maasakkers et al.)
EI $_{prior2}$ – Emissions derived from recent EDF/U. Wyoming data (Mark Omara et al.)
Atmospheric Inversion using TROPOMI data – Yuzhong Zhang et al.
Mass Balance estimate using TROPOMI data– Pankaj Sadavarte et al. (SRON)
Alvarez et al. 2018 – EDF synthesis of US oil/gas methane emissions

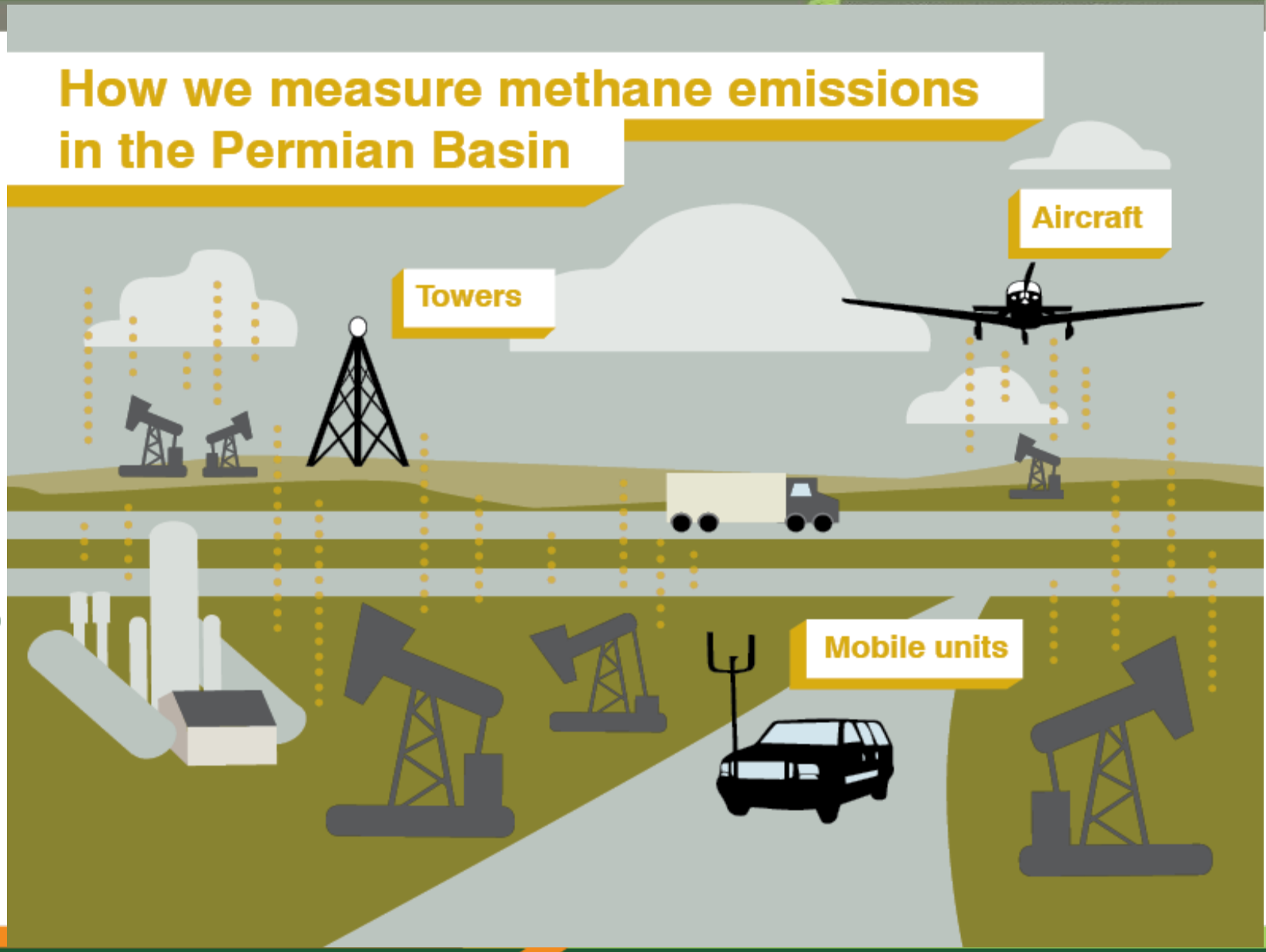
Permian Basin Methane Campaign

Lead Organization – EDF
(David Lyon et al.)

Partners-
Penn State Univ. (Ken Davis et al.)

Scientific Aviation (Steve Conley et al.)

Univ. Wyoming (Shane Murphy et al.)



Permian Basin Campaign (Oct. 2019 – Sep. 2020)

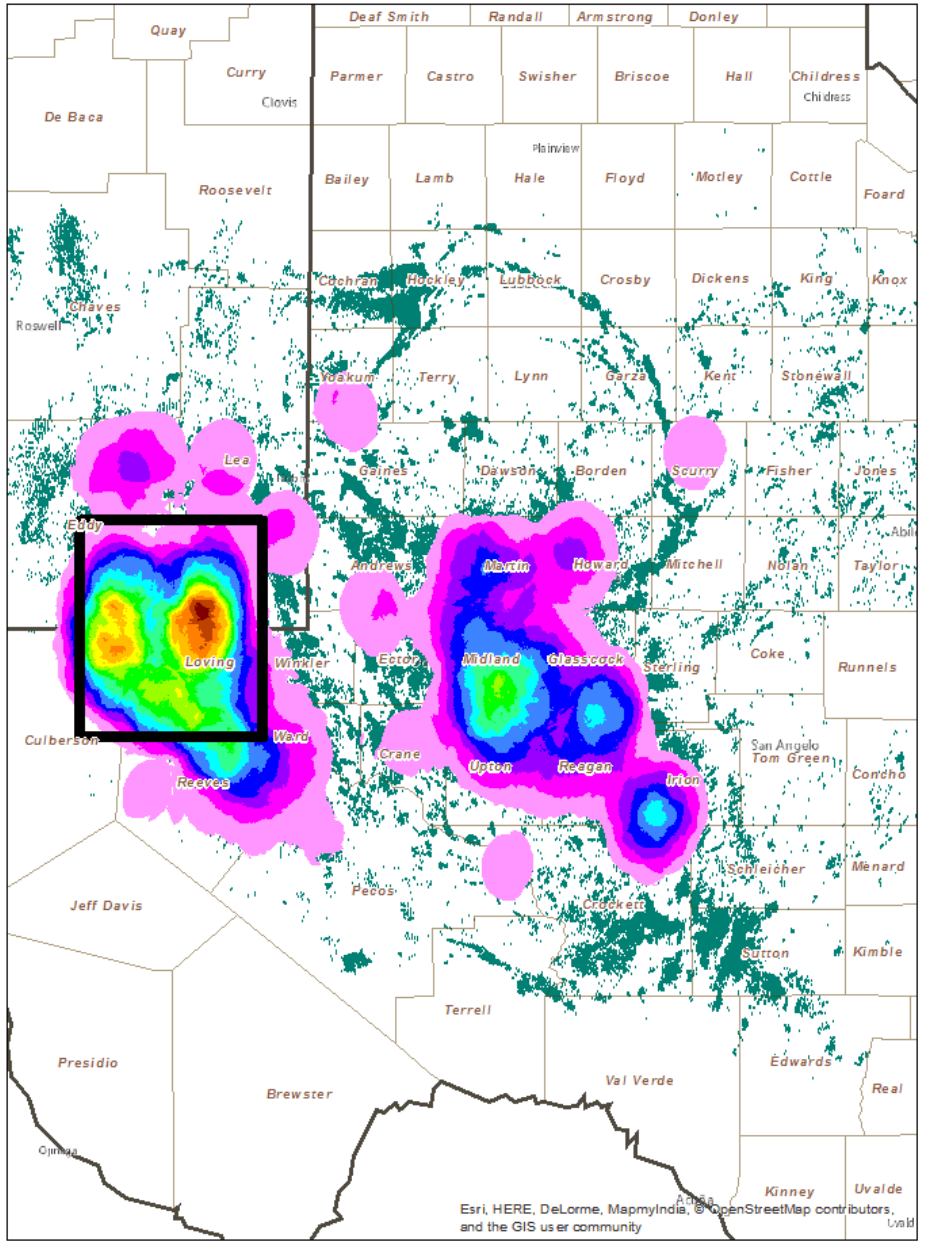
- Twelve month campaign with science and advocacy goals
- Uses multiple methods to detect and quantify methane emissions
  - How do total and site-level emissions change over time?
  - What is the statistical and spatial distribution of site-level emissions?
- Emissions data will be published frequently on a public website (prior to submitting for peer-review).

Target Area:

10,000 km^2 area of Permian Basin
(Delaware sub-basin in Texas and New Mexico)

Area of highest production and recent development

Permian gas production -heatmap



Number of sites in box = 7,900 (or 5.5% of Permian sites)
Gas production in box = 3.7 bcfd (or 37% of Permian gas prod.)
Oil production in box = 880 kb/day (or 28% of Permian oil prod.)

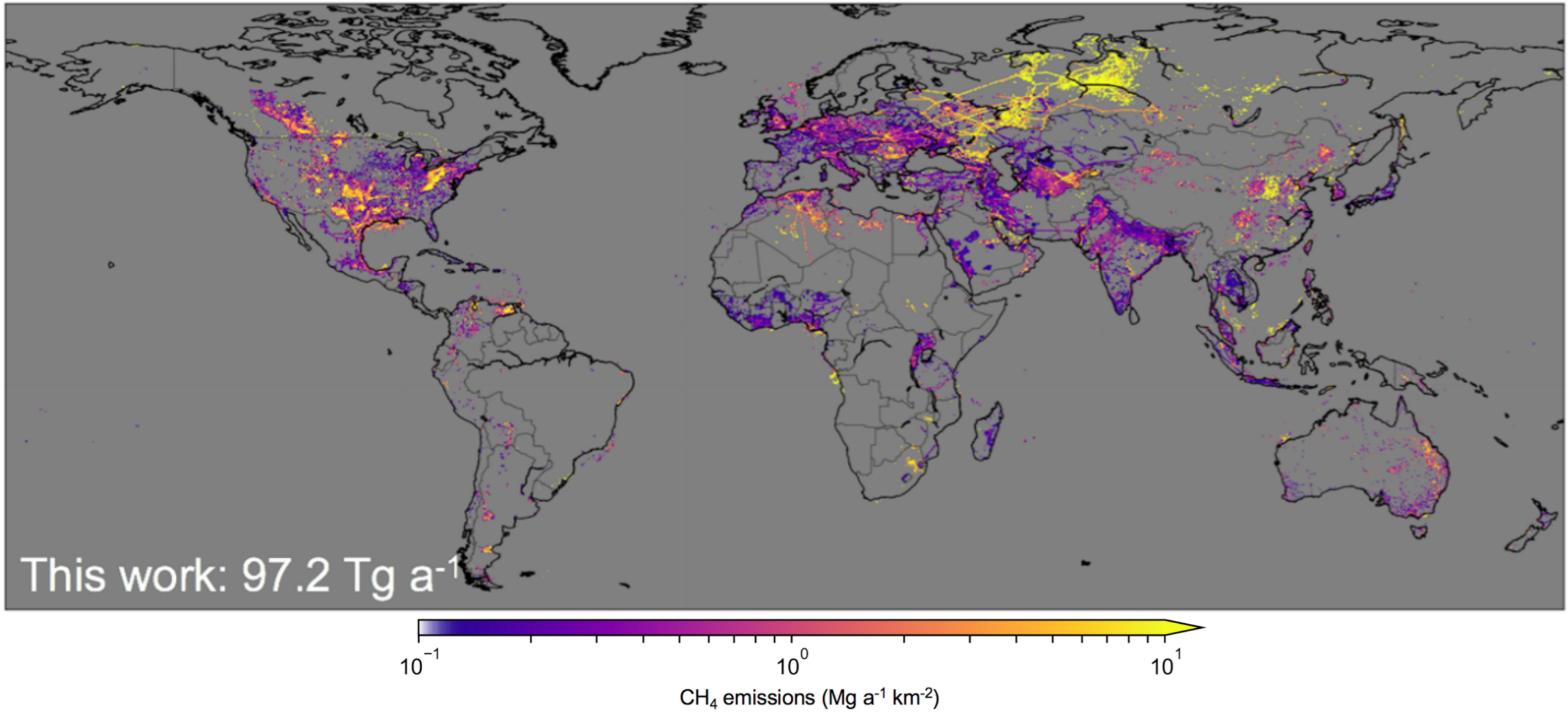
0 10 20 40 60 80 Miles

Development of Well Pad detection/classification and Storage Tanks database in Permian Basin derived using high-res satellite imagery

- *EDF working with Descartes Labs to build a publicly-available database of well pad locations and their classification (simple vs. complex sites) and number of storage tanks.*
- *This effort uses from machine learning applications to high-resolution satellite imagery (1 – 10 m satellite imagery).*
- *First version of the database expected to complete by Nov-end, and will soon after be made publicly available.*
- *Additional updates to the database made available on a quarterly basis throughout 2020.*

A global gridded (0.1° x 0.1°) inventory of methane emissions from oil, gas, and coal exploitation based on national reports to the UNFCCC (*Scarpelli, Jacob et al. 2019*)

- Uses the GOGI database for oil & gas infrastructure information globally



Closing thoughts

- EDF has been increasingly using data products and knowledge gained from CMS projects (PI- Daniel Jacob) focusing on characterizing oil & gas related methane emissions (US and internationally).
- Specifically, CMS products including gridded methane emissions inventories for US, Mexico, updated Permian inventory - AND - the analytical inversion method for quantifying total emissions and generating spatial distribution of methane flux follows the method developed at Harvard through CMS – *have all been highly useful in quantifying methane emissions at regional-to-national scales*.
- Within the US, Permian Basin is a priority area of methane science and policy efforts.
- One of the questions we are presently trying to address globally relates to characterizing methane emissions linked to gas flaring. Permian Basin could serve as a testbed to better understand flaring related emissions. *Are there existing or planned CMS datasets that help in quantifying flaring related emissions?*
- We are also highly interested in building an oil & gas infrastructure database, in support of MethaneSAT. *Are there existing or planned CMS products that EDF could access or partner to incorporate into our plans for developing a temporally dynamic, spatially complete and granular oil & gas infrastructure database?*

Acknowledgements/EDF methane science team-

Developing a carbon monitoring system in Mexican ecosystems: challenges and opportunities relaying on NASA CMS

Eghon A. Yépez

INSTITUTO TECNOLÓGICO DE SONORA
Educar para Trascender

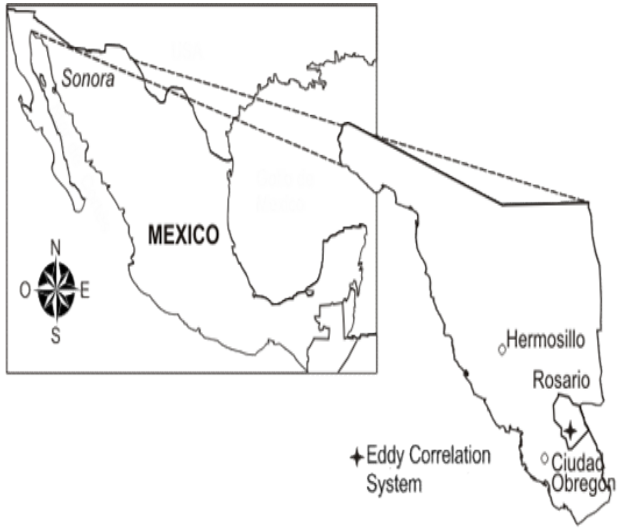
yepezglz@

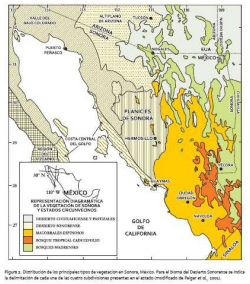
.

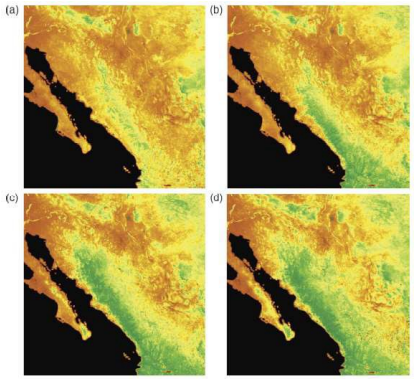
Semiarid Mexican Northwest

Tropical Dry Forest

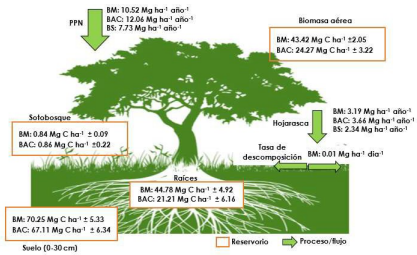
Sonora





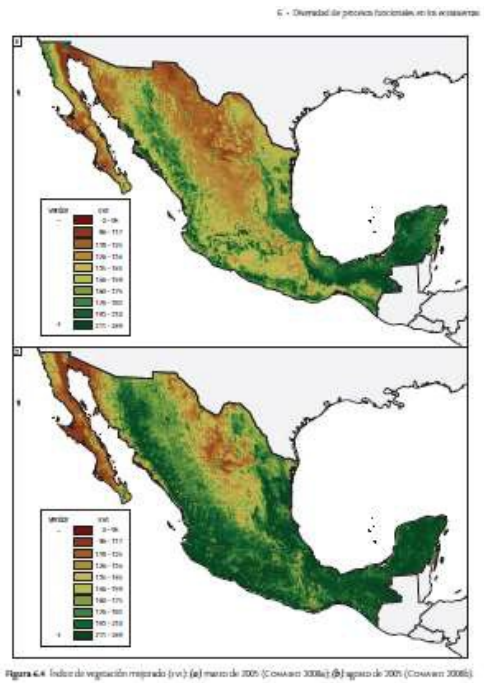


CO_2 AND WATER FLUX MEASUREMENTS



Mexico

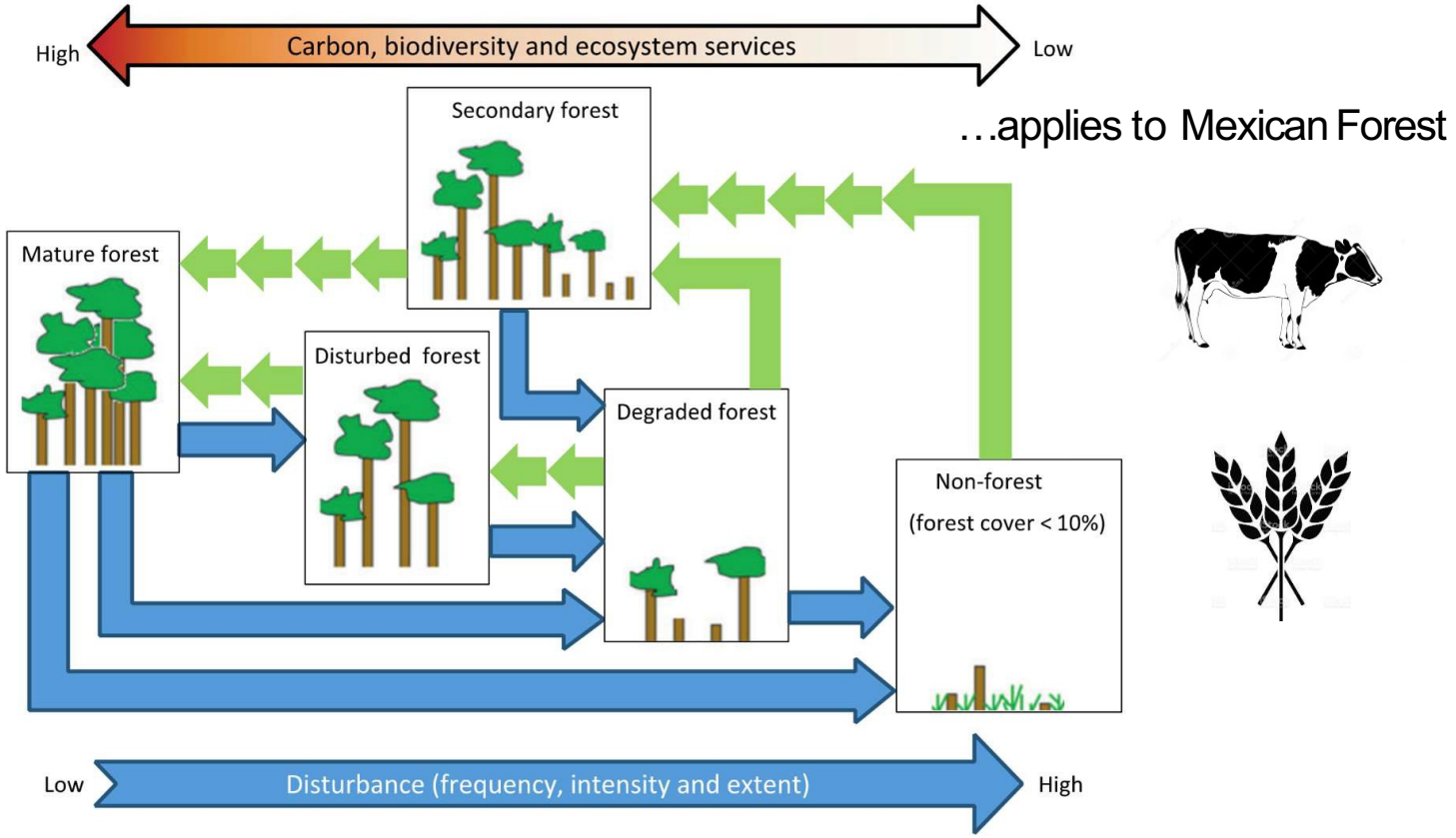
Challenges to monitor Cstocks and fluxes across tropical and subtropical Mexican ecosystems



- Area ~2000 km^2
- Population ~130 M
- Magadiverse (beta diversity)
- Strong seasonality
- High coastal area
- Complex orography
- The northern-most limit of key ecosystems (i.e. TDF and magrove) ocurr here

51 Vegetation clases INEGI
24 Ecoregions CONABIO

Challenges to monitor Cstocks and fluxes across tropical and subtropical ecosystems.



…applies to Mexican Forest

…poor information of activity data…

Bustamante et al GCB2016

Stakeholders

SEMARNAT

SECRETARÍA DE MEDIO AMBIENTE Y RECURSOS NATURALES

INECC

INSTITUTO NACIONAL DE ECOLOGÍA Y CAMBIO CLIMÁTICO

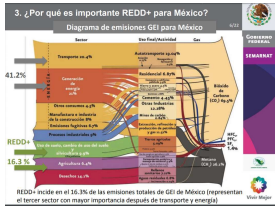
CONAFOR

COMISIÓN NACIONAL FORESTAL

Formally reports national emissions to UNFCCC

6th Communication

Manages the forestry sector
Carries the *National Inventory of Forest and Soils (INFYS)*
Formally reports to REDD



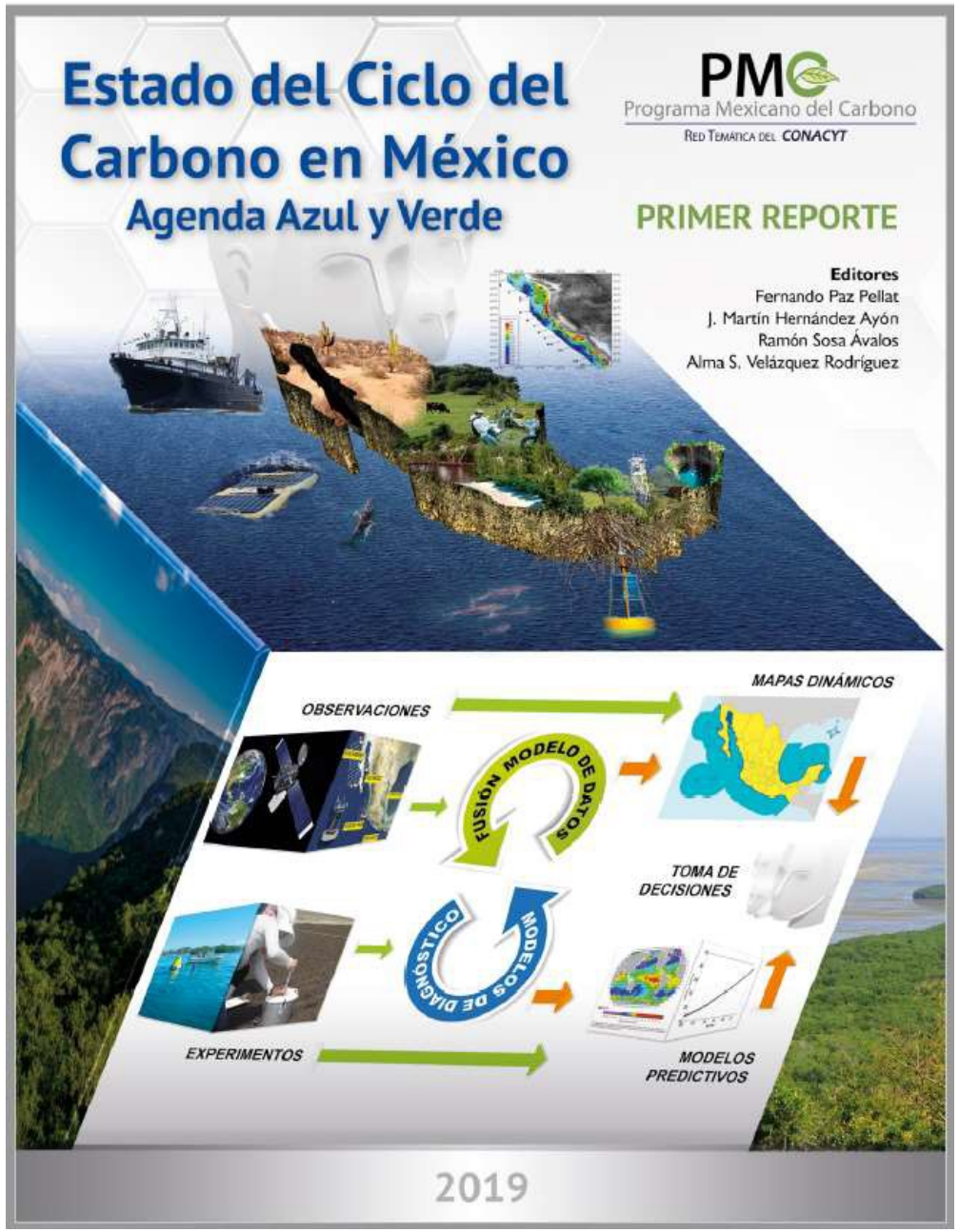
REDD+ incides in 16.3 %of total GHGemissions (3rd sector)

Stakeholders

PMC
Programa Mexicano del Carbono

La Figura C2.1. muestra en forma esquemática los elementos del Plan Científico del Programa Mexicano del Carbono, en donde la generación de escenarios (modelos predictivos) es un factor crítico para los tomadores de decisiones, en la evaluación del impacto de las políticas públicas.

Figura C2.1. Elementos del Plan Científico del Programa Mexicano del Carbono. Fuente: adaptado de PMC (2008).



First state of the Carbon cycle report in Mexico: blue and green agendas

Country wide assessment based on field observations

PMC
Programa Mexicano del Carbono

Carbon distribution ABB and BGB, including live and death

<u>Opportunity for NASA CMS</u>

Uncertainty assessment through modeling and satellite platforms

i.e. For tropical dry forest
Total biomass = 52.18 +/- 50.4 (Mg Cha^{-1})

Relaying on CONAFOR INFYS and other data sources.

Carbon Stocks

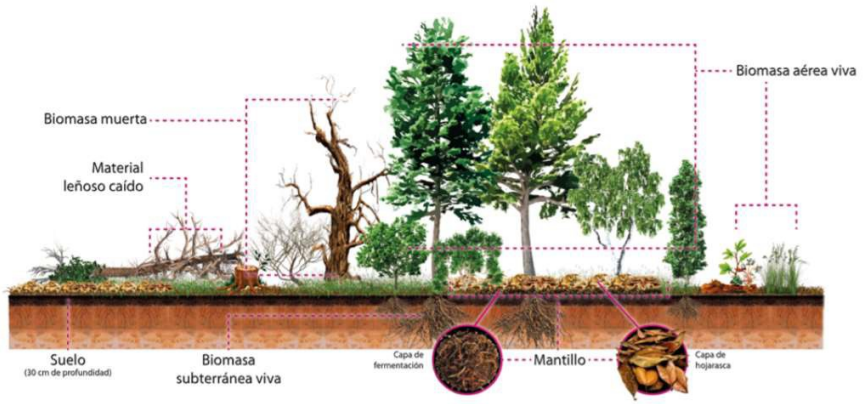
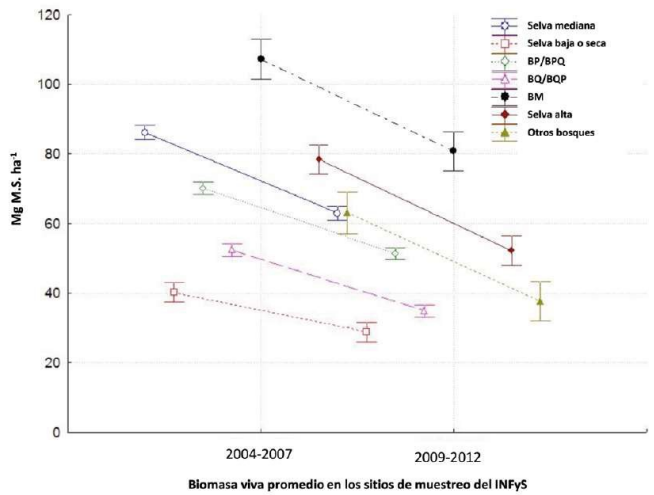


Figura 1. Almacenes de carbono en los bosques. Fuente: Casiano *et al.* (2018).

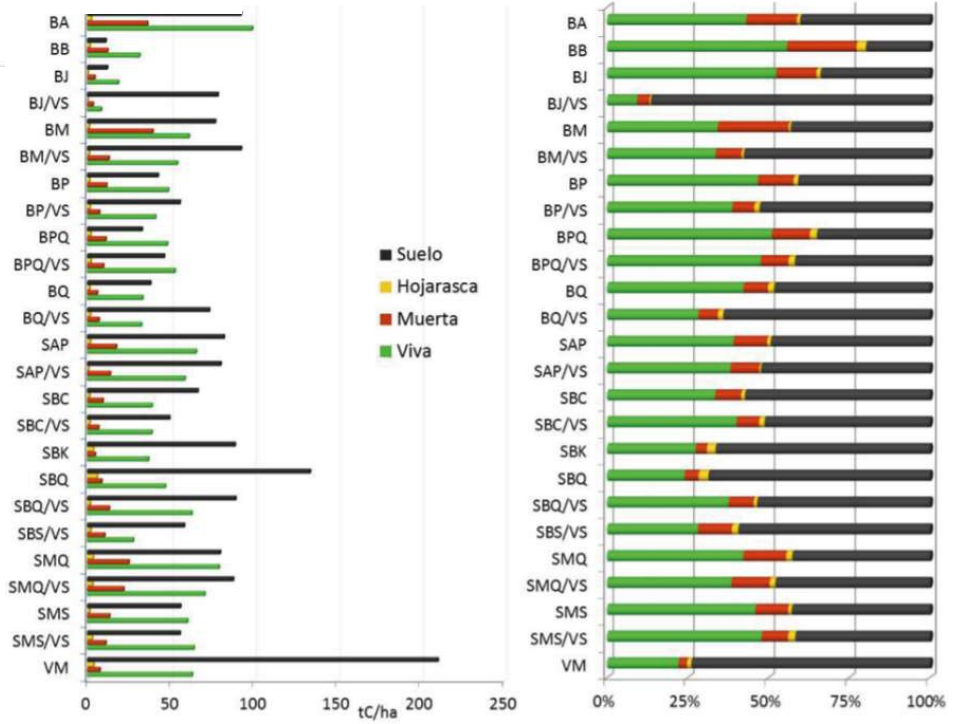
Opportunity for NASACMS

Improved protocols for Carbon Stocks quantification in key ecosystems to support INFYS-CONAFOR.
Development of tools for assessment of activity and reponses to climate.



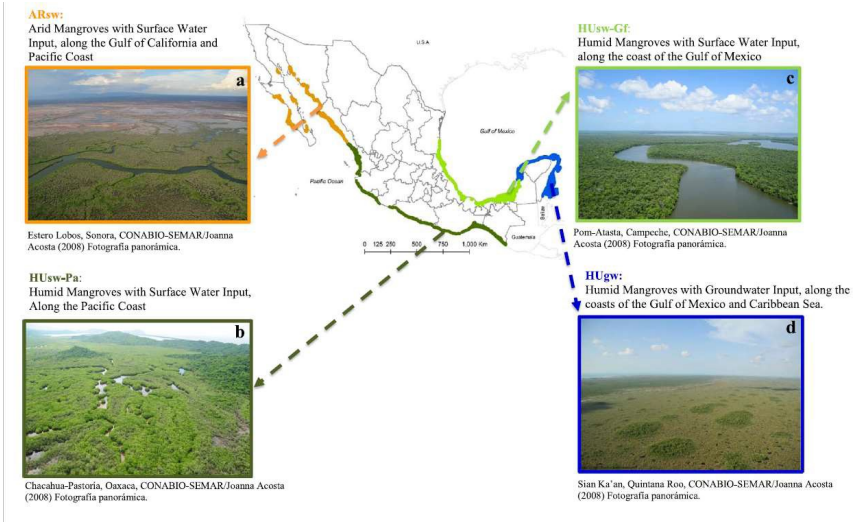
Biomasa viva promedio en los sitios de muestreo del INFyS

Figura 17. Almacenes de la biomasa aérea entre los dos ciclos del INFyS para los bosques y selvas del país.



NASACMS Product

Greenness trends and carbon stocks of mangroves across Mexico



NDVI from 2001 to 2015 at 1 km of spatial resolution of the MOD13A3

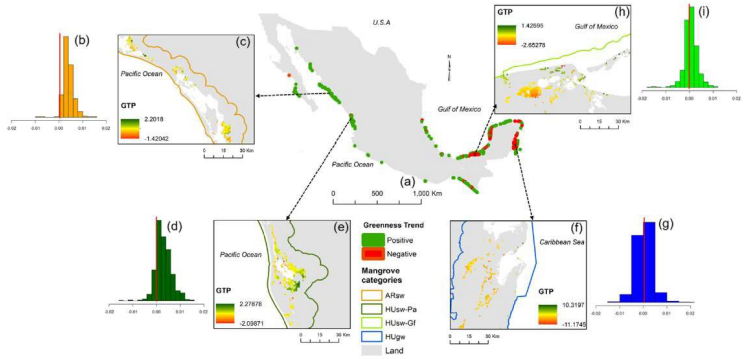


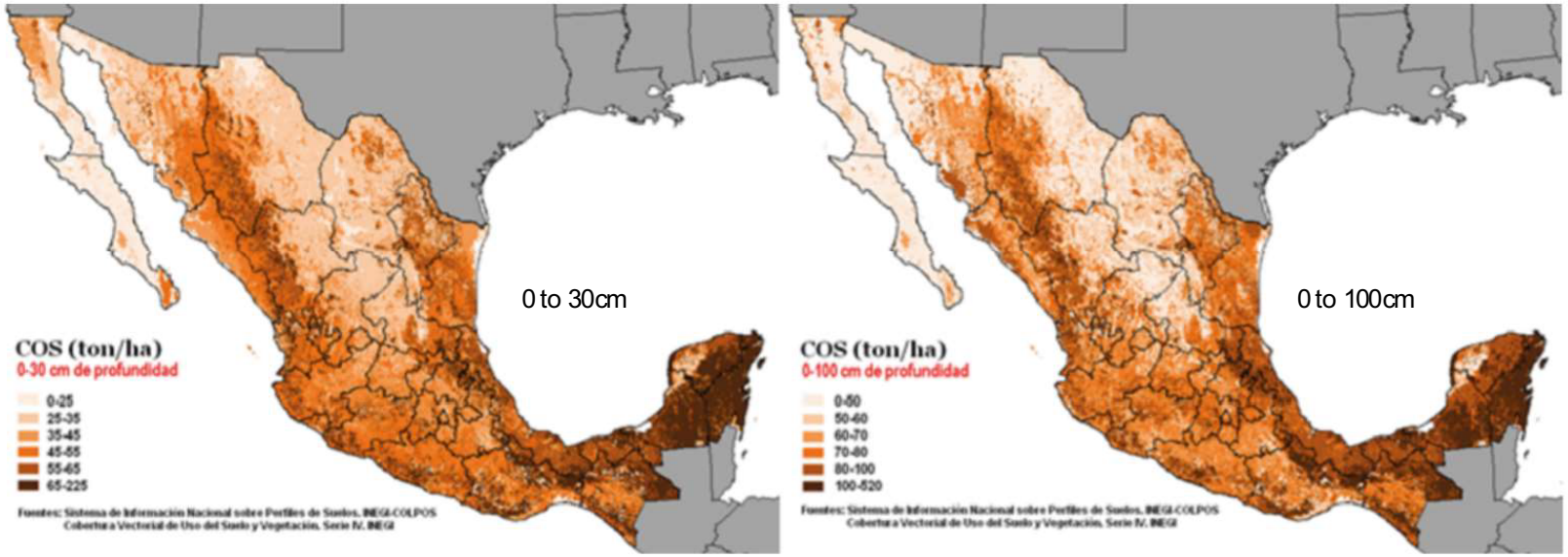
Figure 5. Spatial variability of greenness trends across mangroves of Mexico. The central figure showed significant greenness trends ($p < 0.05$), red spots are negative greenness trend and green spots are positive greenness trend. Histograms showed the statistical distribution of the spatial variability of greenness trends for every mangrove category. Four representative mangrove areas are enhanced to show the percentage of greenness trend in every category.

"We propose that the combination of environmental factors such as quantity/quality of freshwater input, storms, anthropogenic influence, and site-specific characteristics could have more influence on greenness trends than climate variability alone"

Alma Vázquez-Lule *et al* 2019 *Environ. Res. Lett.*

PMC
Programa Mexicano del Carbono

Soil Organic Carbon



Relaying on CONAFOR INFYS and other data sources

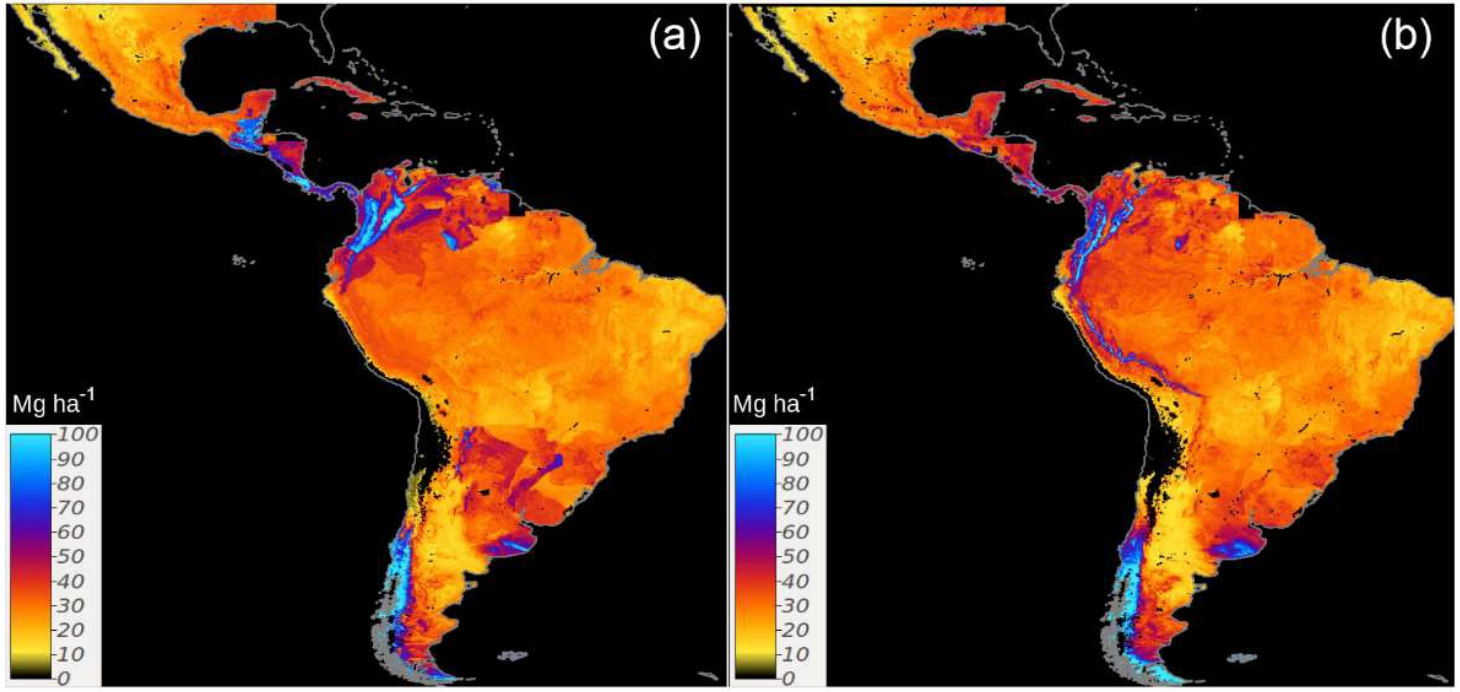
Challenge

Association of SOC estimates with vegetation cover types and activity (both perturbations and succesional recovery)

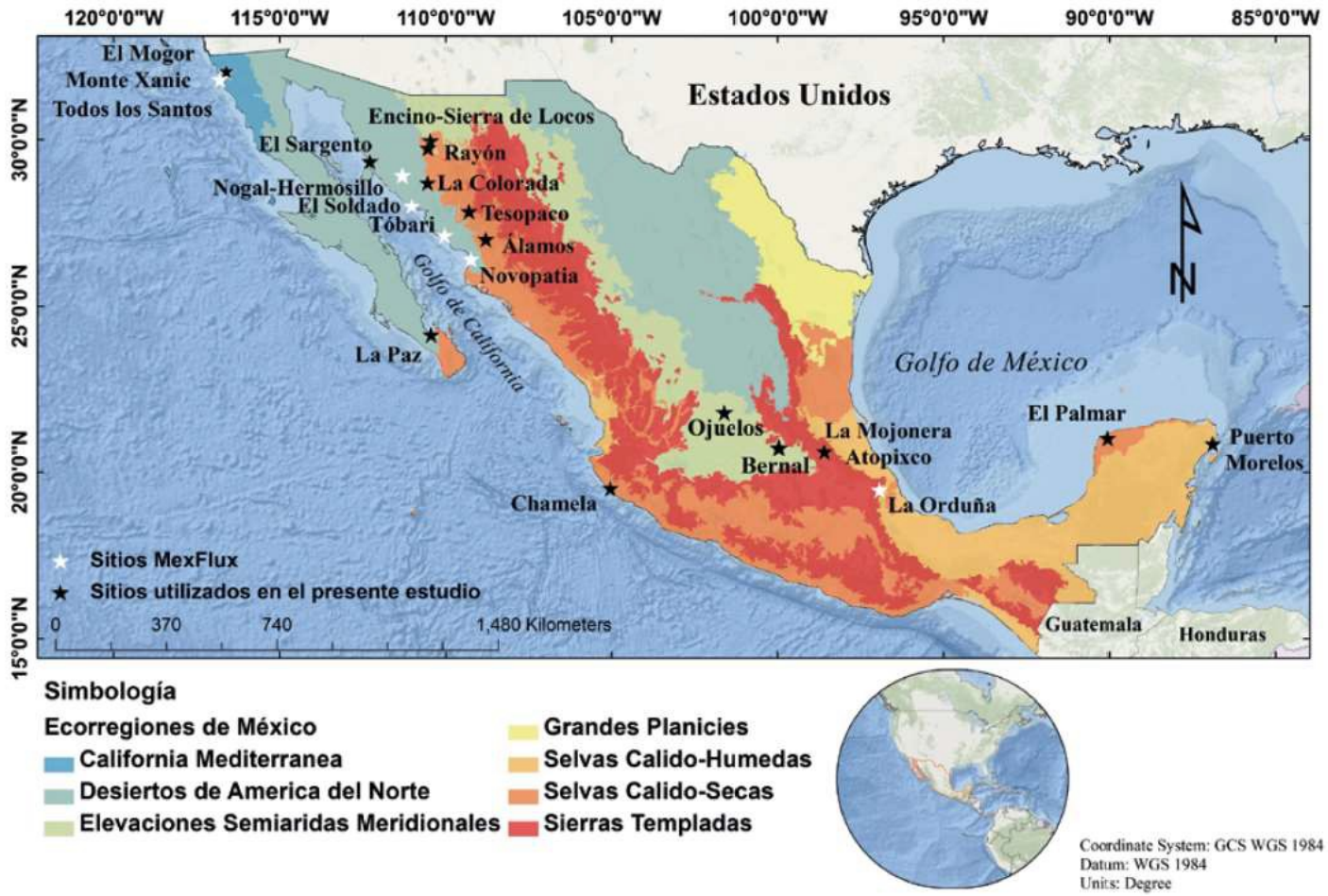
Silver bullet for national/continental scale SOC assessments?

Product from NASA CMS

Attempts for uncertainty assessment through modeling and satellite platforms



Guevara et al., 2019 soil systems


120°0'0"W
115°0'0"W
110°0'0"W
105°0'0"W
100°0'0"W
95°0'0"W
90°0'0"W
85°0'0"W
30°0'0"N
25°0'0"N
20°0'0"N
15°0'0"N
El Mogor
Monte Xanic
Todos los Santos
Encino-Sierra de Locos
El Sargento
Rayón
La Colorada
Nogal-Hermosillo
El Soldado
Tesopaco
Tóbari
Álamos
Novopatia
Golfo de California
La Paz
Estados Unidos
Golfo de México
Ojuelos
La Mojonera
Atopixco
Bernal
El Palmar
Puerto Morelos
Chamela
La Orduña
Guatemala
Honduras
Sitios MexFlux
Sitios utilizados en el presente estudio
0
370
740
1,480 Kilometers
Simbología
Ecorregiones de México
California Mediterranea
Desiertos de America del Norte
Elevaciones Semiaridas Meridionales
Grandes Planicies
Selvas Calido-Humedas
Selvas Calido-Secas
Sierras Templadas
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree

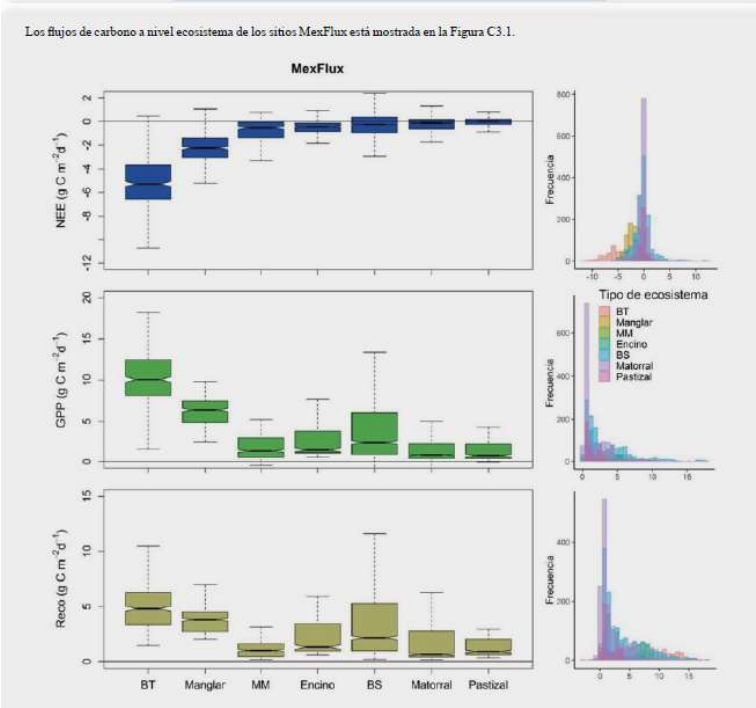
MexFlux Database

14 sites
54 site years compiled

Cuadro 2. Descripción de sitios y periodos con disponibilidad de datos.

Sitio	Tipo de ecosistema	Periodo	Años	Altitud (m)	PMA (mm)	TMA (°C)
La Paz	Matorral sarcocaule	2002 - 2008	7	21	182	23.6
El Mogor	Matorral mediterráneo	2008 - 2012	3	409	281	17.0
Rayón	Matorral subtropical	2008 - 2012	5	632	524	21.4
Ojuelos	Pastizal semiárido	2011 - 2017	7	2228	424	18.0
La Colorada	Sabana /Pastizal inducido	2011 - 2013	3	398	343.8	22.7
Álamos	Selva caducifolia	2015 - 2017	3	368	673.18	23.4
Tesopaco	Selva caducifolia	2005 - 2008	4	426	647	24.3
El Palmar	Selva caducifolia	2017 - 2018	2	8	650	25.5
Chamela	Selva caducifolia	2007 - 2013	7	73	844	25.8
Atopixco	Bosque templado	2017 - 2018	1	2064	1534	13.5
Bernal	Matorral xerófilo	2017 - 2018	2	2050	550	16.7
Sierra de Locos	Bosque de encino	2010 - 2014	5	1314	496	18.9
El Sargento	Manglar	2014 - 2016	3	0	125	24.2
Puerto Morelos	Manglar	2017 - 2018	1	0	1105	27.0
Total (años/sitio)			53			

PMA = Precipitación media anual, TMA = Temperatura media anual.

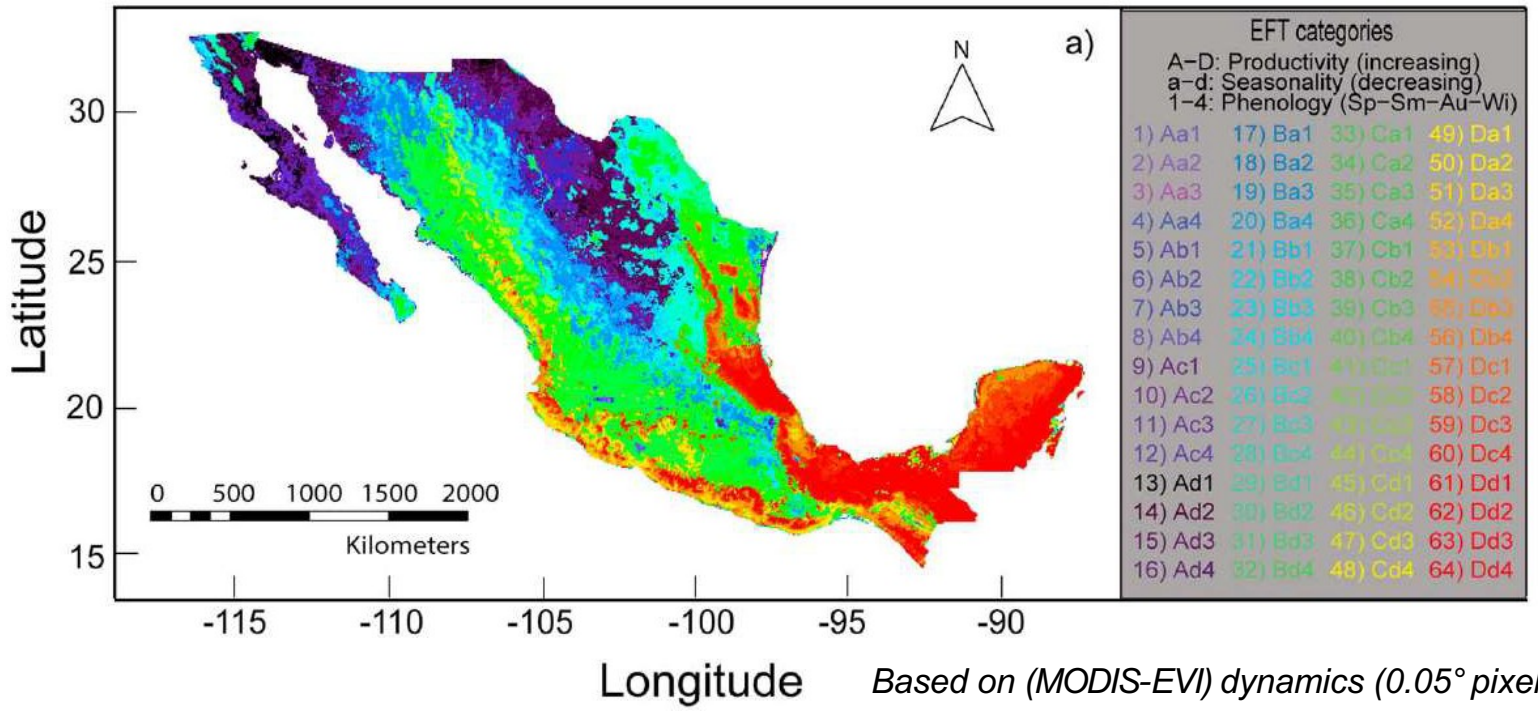


…in the processes of being analyzed for seasonality, phenology and productivity.

Delgado-Balbuena et al., 2019 PMC

Nasa CMS Product

Spatial distribution of carbón uptake patterns as expressed by ecosystem functional types EFTs



Based on (MODIS-EVI) dynamics (0.05° pixel)

Product from NASACMS

Attempts for uncertainty assessment through modeling and satellite platforms

Villareal et al., 2019 JGRBiogeosciences

Nasa CMS Product

Spatial distribution of the seven general ecological similar areas (ESAs)

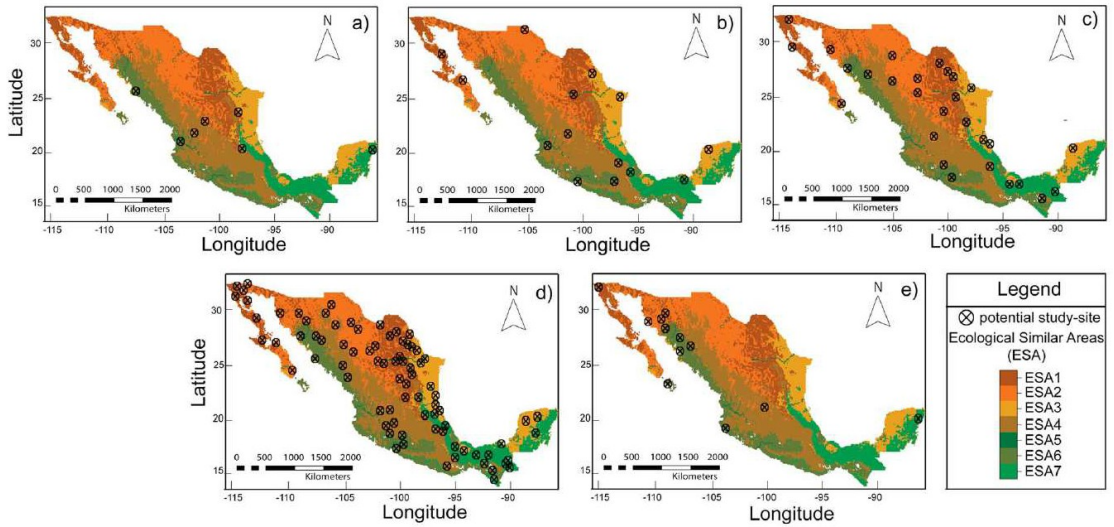


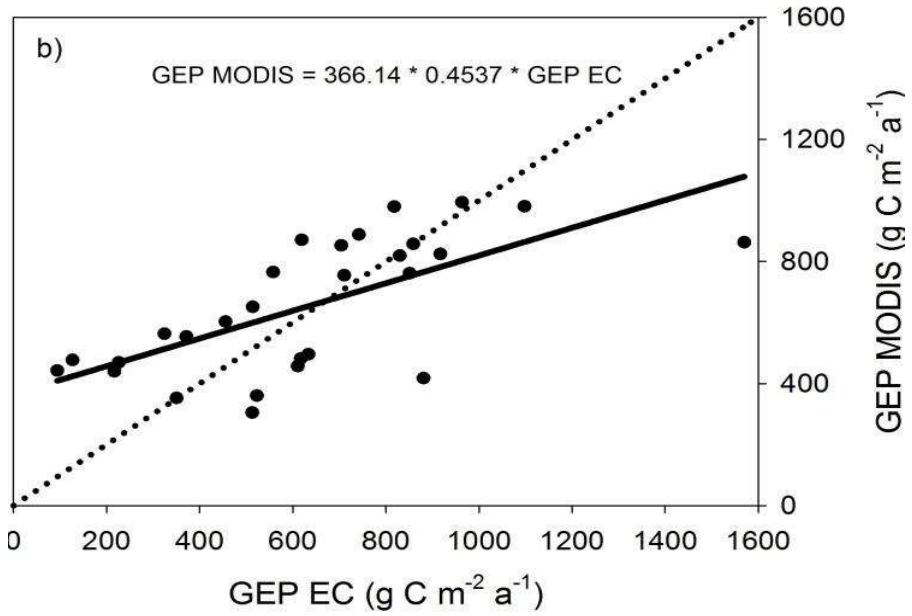
Table 3

Spatial Representativeness of Gross Primary Productivity (GPP), Evapotranspiration (ET), and Ecosystem Functional Types (EFT) for All Scenarios: 7, 14, 28, and 84 Potential Study Sites, and the 14 Current MexFlux sites

Environmental variable	7 Sites	14 Sites	28 Sites	84 Sites	MexFlux sites (14 sites)
GPP	4% (0.14%)	8% (0.42%)	29% (0.63%)	45% (0.50%)	3% (1.14%)
ET	4% (0.24%)	8% (0.40%)	19% (0.47%)	49% (0.42%)	5% (1.19%)
EFT	7/64= (35%)	13/64=(47%)	16/64=(61%)	31/64=(91%)	8/64=(32%)

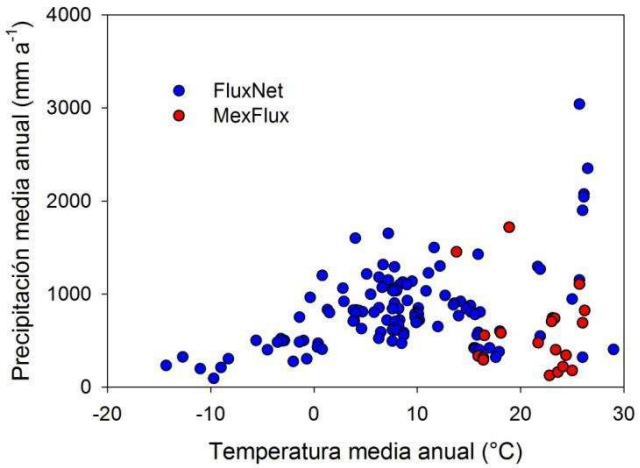
Note. Percentages refer to the area of Mexico where GPP and ET would be represented by the corresponding number and configuration of sites. The percentages in parentheses indicate the standard deviation associated to the spatial representativeness. EFT representativeness is reported as the number of categories represented divided by the total number of possible categories (i.e., 64) and by the surface covered by the categories monitored expressed as percentage.

Villareal et al., 2019 JGR Biogeosciences



Opportunity for NASACMS

Development and validation of new algoritmts based on satellite platforms with not previously considered ecosystems



Delgado Balbuena et al, 2019

CONCLUSION

To advance the CMS in Mexico some key needs are:

-Improve and implement uncertainty assessment
-Development of data acquisition, management and integration strategies
-Adapt strategies for multi-scale coordinated efforts

Tools to reduce uncertainty

-Better field protocols (i.e. Intensive monitoring sites for Cstoks and fluxes
-Better tools for data acquisition, management and integration

Tools to assess activity and relate to static variables (i.e. SOC)

Tools for scaling

Bulding capacities for students, scientist and agency personnel for modeling, data management and integration

Consequently, there is a need to develop reference frameworks for long-term monitoring projects of carbon stocks in Mexico and implementation of REDD+ initiatives

Thanks !

- Ángeles-Pérez Gregorio
- Arredondo Tulio
- Ayala-Niño Fernando
- Bullock Stephen H.
- Castellanos Alejandro E.
- Cueva Alejandro
- Figueroa-Espinoza Bernardo
- Garatuza-Payán Jaime
- Hinojo-Hinojo César
- Maya-Delgado Yolanda
- Méndez-Barroso Luis
- Madrigal Jose
- Oechel Walter
- Paz-Pellat Fernando
- Perez-Ruiz Eli R.
- Rodríguez Julio C.
- Rojas-Robles Nidia E
- Sanchez-Mejia Zulia M.
- Uuh-Sonda Jorge
- Vargas Rodrigo
- Vivoni Enrique R.
- Watts Christopher

National Aeronautics and Space Administration

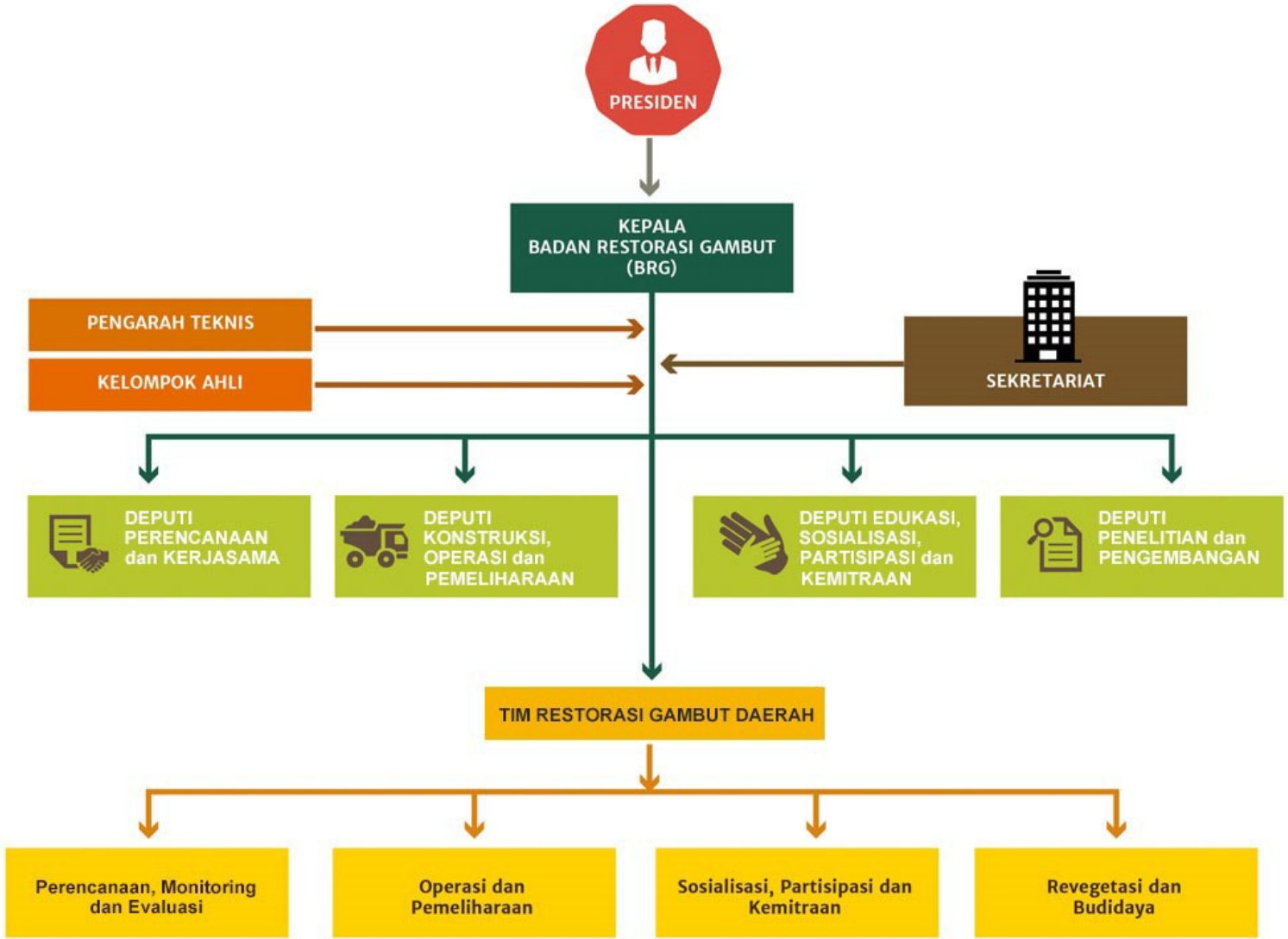
NASA Carbon Monitoring System

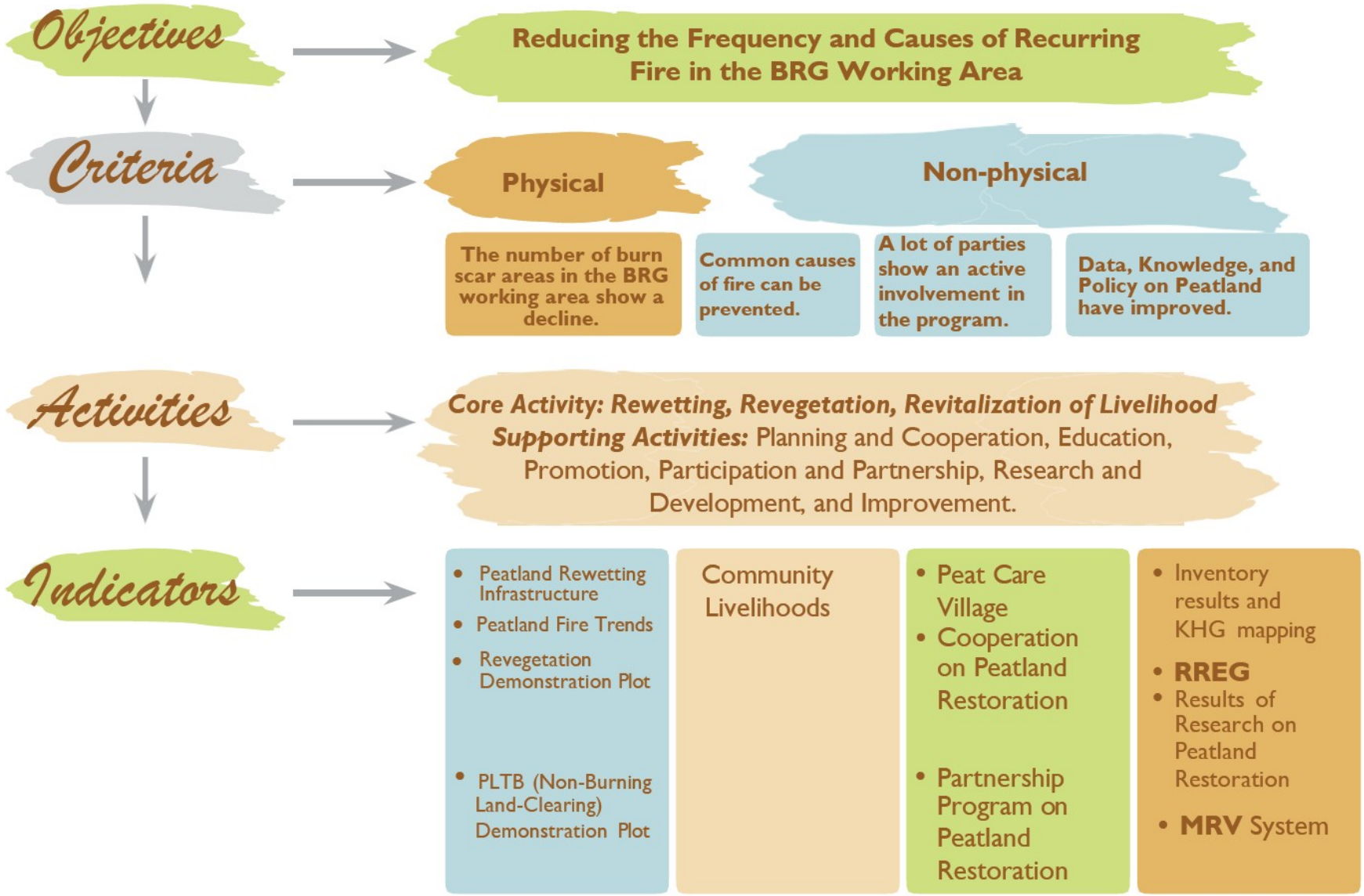
BRG-PEATLAND RESTORATION AGENCY AGRICULTURE FACULTY OF JAMBI UNIVERSITY PUI-PT LAND RECLAMATION









PRESIDEN
KEPALA BADAN RESTORASI GAMBUT (BRG)
PENGARAH TEKNIS
KELOMPOK AHLI
SEKRETARIAT
DEPUTI PERENCANAAN dan KERJASAMA
DEPUTI KONSTRUKSI, OPERASI dan PEMELIHARAAN
DEPUTI EDUKASI, SOSIALISASI, PARTISIPASI dan KEMITRAAN
DEPUTI PENELITIAN dan PENGEMBANGAN
TIM RESTORASI GAMBUT DAERAH
Perencanaan, Monitoring dan Evaluasi
Operasi dan Pemeliharaan
Sosialisasi, Partisipasi dan Kemitraan
Revegetasi dan Budidaya



Performance Criteria and Indicators Peatland Restoration

National Aeronautics and Space Administration

NASA Carbon Monitoring System

Badan Restorasi Gambut

THE IMPLEMENTATION OF PEATLAND RESTORATION IN INDONESIA

2,492,510* ha

*By virtue of the Decision Letter of the Chief of BRG, SK.05/BRG/KPTS/2016

Conservation Area

332,766 ha

Assignment to Regional Stakeholders (National Park Agency, and the others, can establish a partnership with NGOs)

Concession Area

1,410,926 ha

Concessionaire (BRG's supervision)

Other Areas, including Production Forest, Protected Forest, and other APL without permit.

748,818 ha

Assistance Task addressed to Regional Government and Partnership with NGOs.

NOTES

Assistance Task

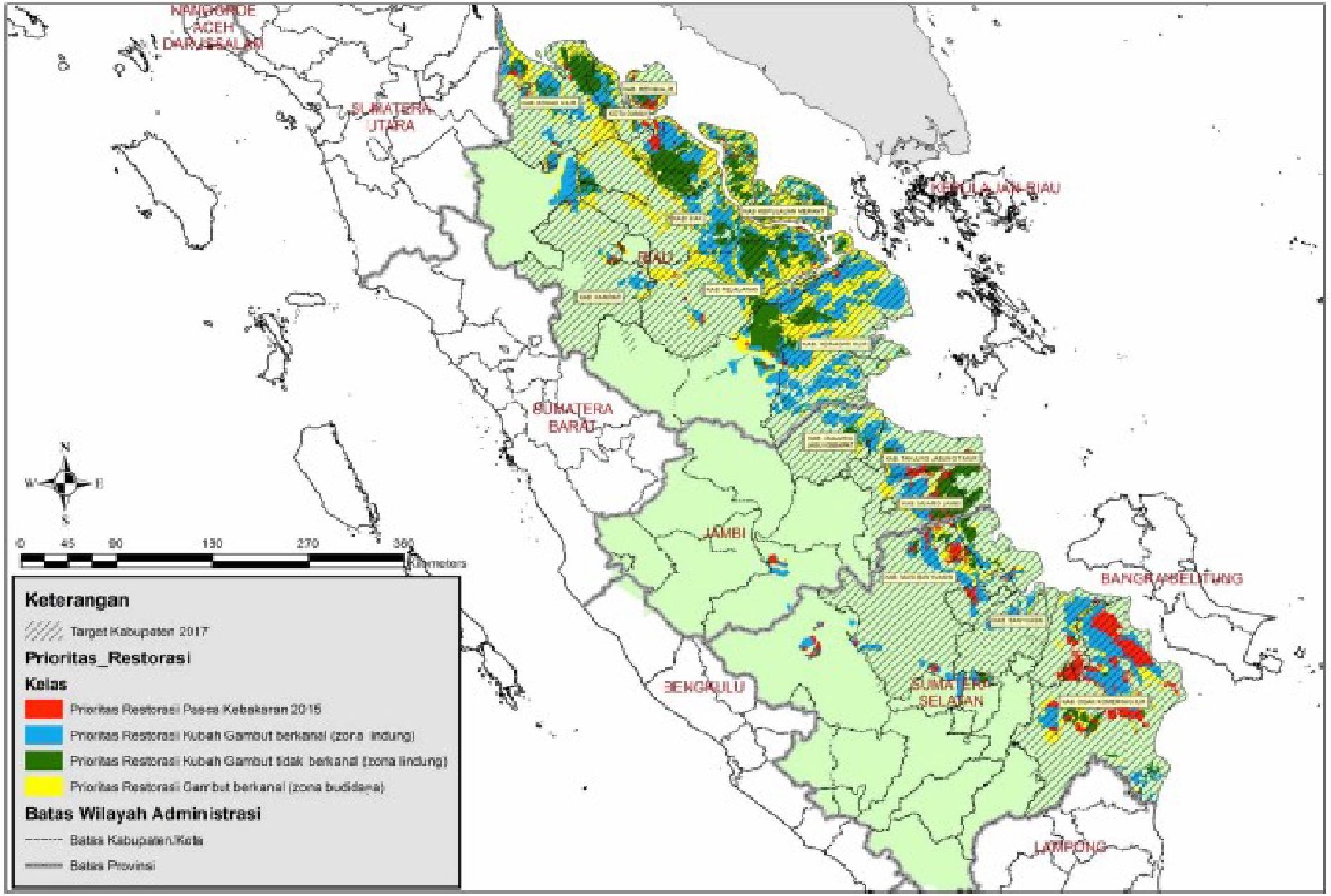
is an order issued by the Government to the regional government for implementing a certain task with the obligation to report and account for the implementation to the commissioning agency.

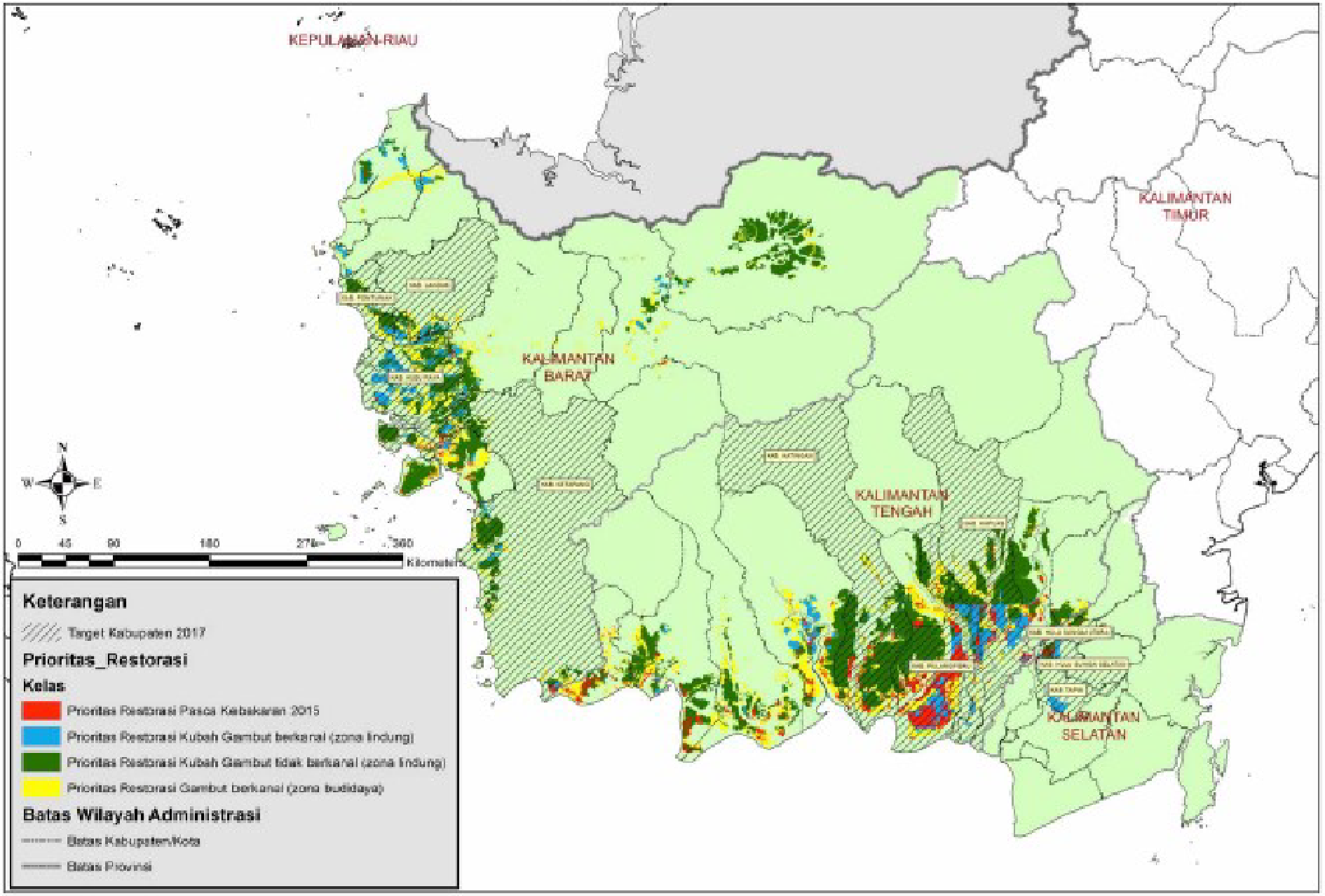
Concessionaire

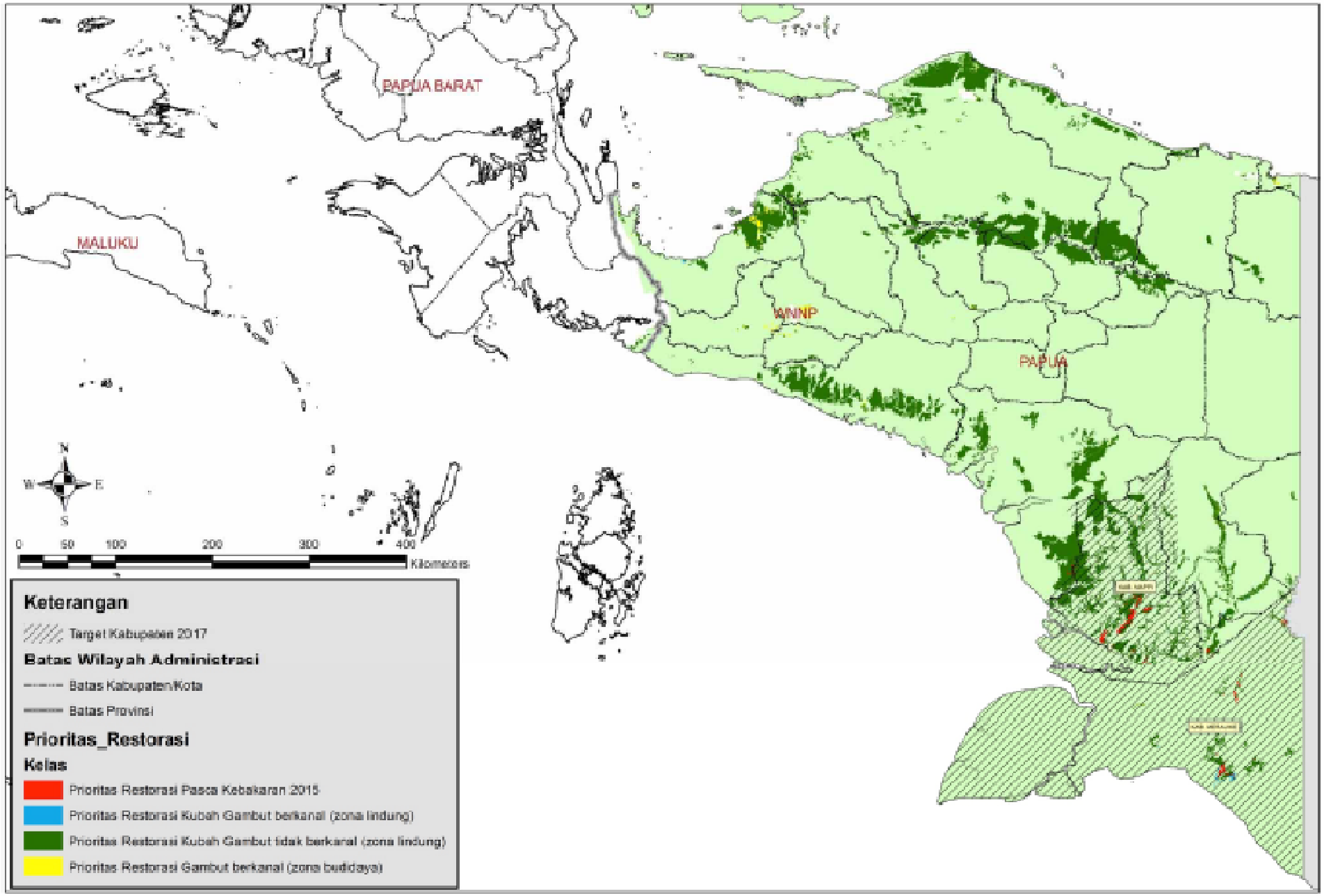
or the person in charge of the business is the holder of the permit or right over the business areas which are located within the boundaries of the target restoration area as sworn in the peatland restoration indicative map.

National Aeronautics and Space Administration

NASA Carbon Monitoring System

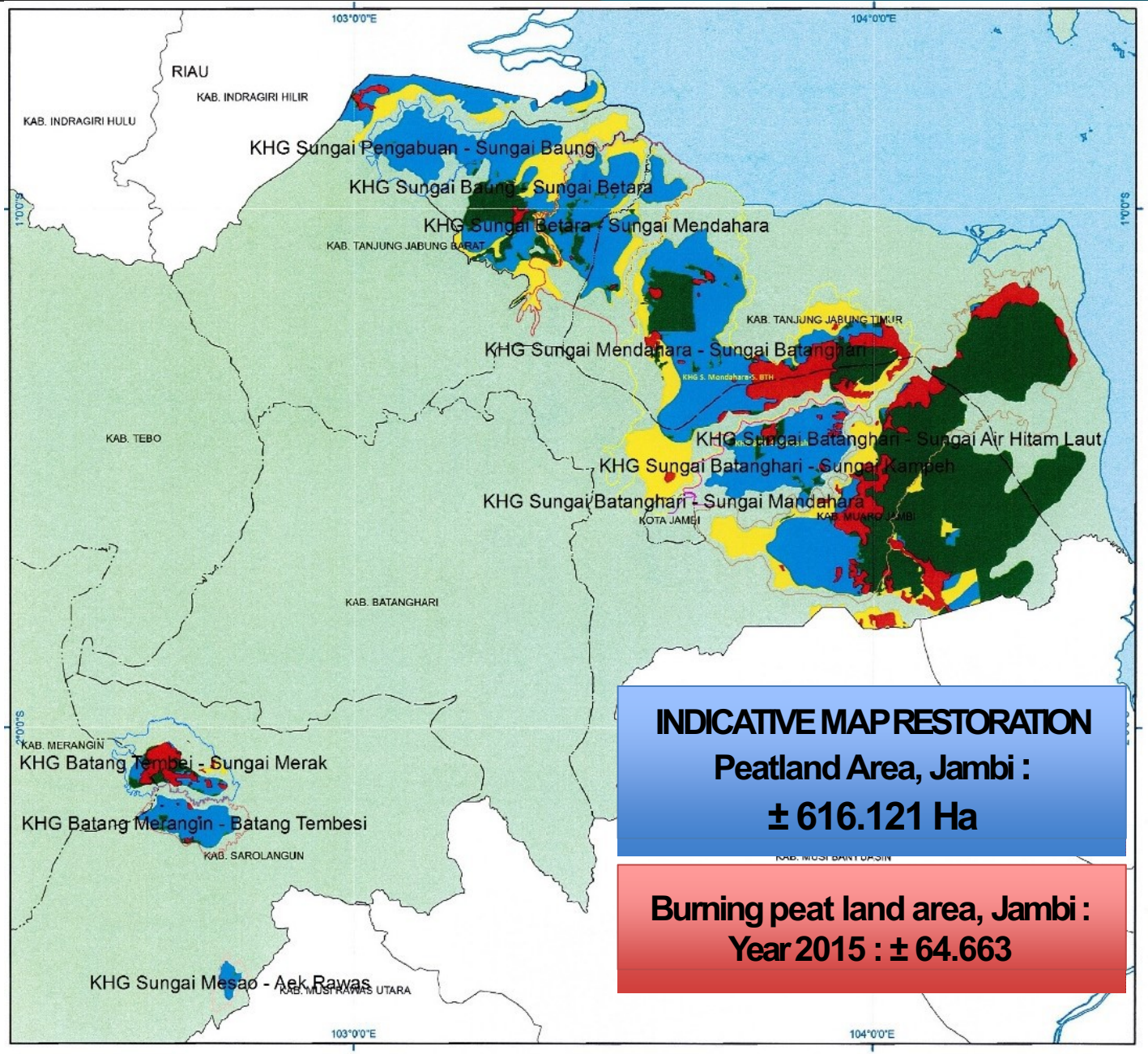



KEPULAUAN RIAU
KALIMANTAN BARAT
KALIMANTAN TENGAH
KALIMANTAN TIMUR
KALIMANTAN SELATAN
N
W
E
S
0
45
90
180
270
360
Keterangan
Target Kabupaten 2017
Prioritas_Restorasi
Kelas
Prioritas Restorasi Pasca Kebakaran 2015
Prioritas Restorasi Kubah Gambut berkanal (zona lindung)
Prioritas Restorasi Kubah Gambut tidak berkanal (zona lindung)
Prioritas Restorasi Gambut berkanal (zona budidaya)
Batas Wilayah Administrasi
Batas Kabupaten/Kota
Batas Provinsi


PAPUA BARAT
MALUKU
WNNP
PAPUA
N
W
E
S
0 50 100 200 300 400
Kilometers
Keterangan
Target Kabupaten 2017
Batas Wilayah Administrasi
Batas Kabupaten/Kota
Batas Provinsi
Prioritas_Restorasi
Kelas
Prioritas Restorasi Pasca Kebakaran 2015
Prioritas Restorasi Kubah Gambut berkanal (zona lindung)
Prioritas Restorasi Kubah Gambut tidak berkanal (zona lindung)
Prioritas Restorasi Gambut berkanal (zona budidaya)

National Aeronautics and Space Administration

NASA Carbon Monitoring System



INDICATIVE MAP RESTORATION
Peatland Area, Jambi :
± 616.121 Ha

Burning peat land area, Jambi :
Year 2015 : ± 64.663

PETA INDIKATIF PRIORITAS RESTORASI PROVINSI JAMBI

U

0 4 8 16 24 32 Km

DIAGRAM LOKASI

LEGENDA

Kabupaten/Kota	Kelas Prioritas Restorasi (Ha)				Luas (Ha)
	1	2	3	4	
Kab. Merangin	534	964	609	2	2,109
Kab. Muaro Jambi	36,241	70,247	113,625	45,840	266,054
Kab. Sarolangun	5,432	17,707	2,736	708	26,583
Kab. Tanjung Jabung Barat	2,141	67,444	18,484	33,150	141,219
Kab. Tanjung Jabung Timur	20,374	66,956	72,660	21,226	181,237
Kota Jambi	-	-	-	380	380
Jambi	64,722	243,319	208,134	101,386	617,562

Keterangan :
1. Prioritas Restorasi Pasca Kebakaran 2015
2. Prioritas Restorasi Kubah Gambut berkanal (zona lindung)
3. Prioritas Restorasi Kubah Gambut tidak berkanal (zona lindung)
4. Prioritas Restorasi Gambut berkanal (zona budidaya)

Proyeksi : Mercartor
Sistem Grid : Grid Geografi
Datum Horizontal : WGS84

Sumber Data :
1. Batas Wilayah Administrasi Kabupaten/Kota Indikatif, PPBW Badan Informasi Geospasial, 2015
2. Gambut Skala 1:250.000, Balai Besar Litbang Sumberdaya Lahan Pertanian Kementerian Pertanian, 2015
3. Kebakaran Hutan dan Lahan 2015, Kementerian Lingkungan Hidup dan Kehutanan, 2015
4. Penutup Lahan 2015, Kementerian Lingkungan Hidup dan Kehutanan, 2015

Tanggal : 14/9/2016
Disahkan oleh :

Nazir Foead
Kepala Badan Restorasi Gambut

EDISI SEPTEMBER 2016

National Aeronautics and Space Administration

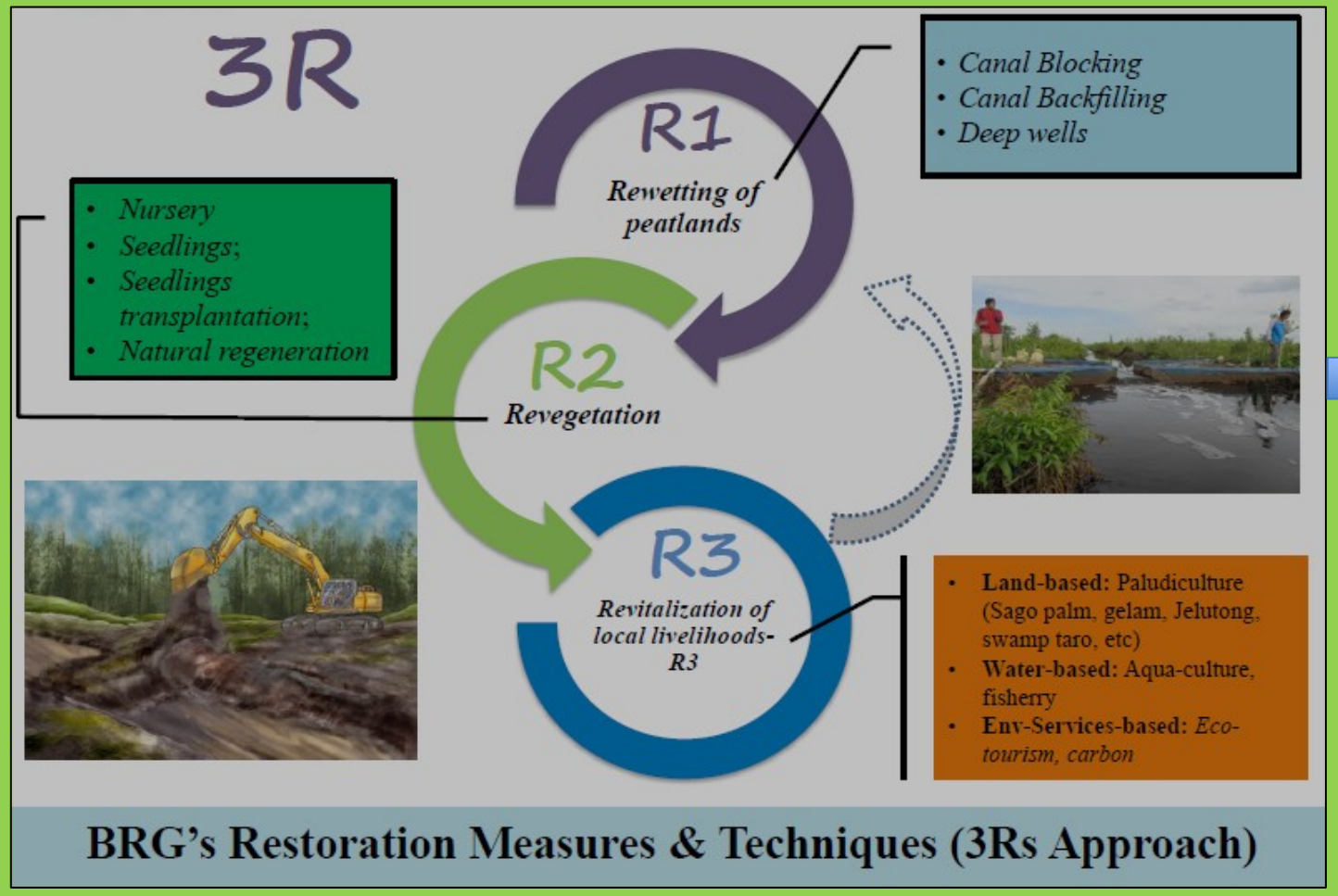
NASA Carbon Monitoring System

TANAH GAMBUT TROPIS DAN MUKA AIR TANAH JAUH DI BAWAH 145 CM MUSIM KEMARAU BULAN SEPTEMBER 2015

TANAH GAMBUT EROFADARI BAHAN SPHAGNUM

CORE IN PEATLAND PT JAW

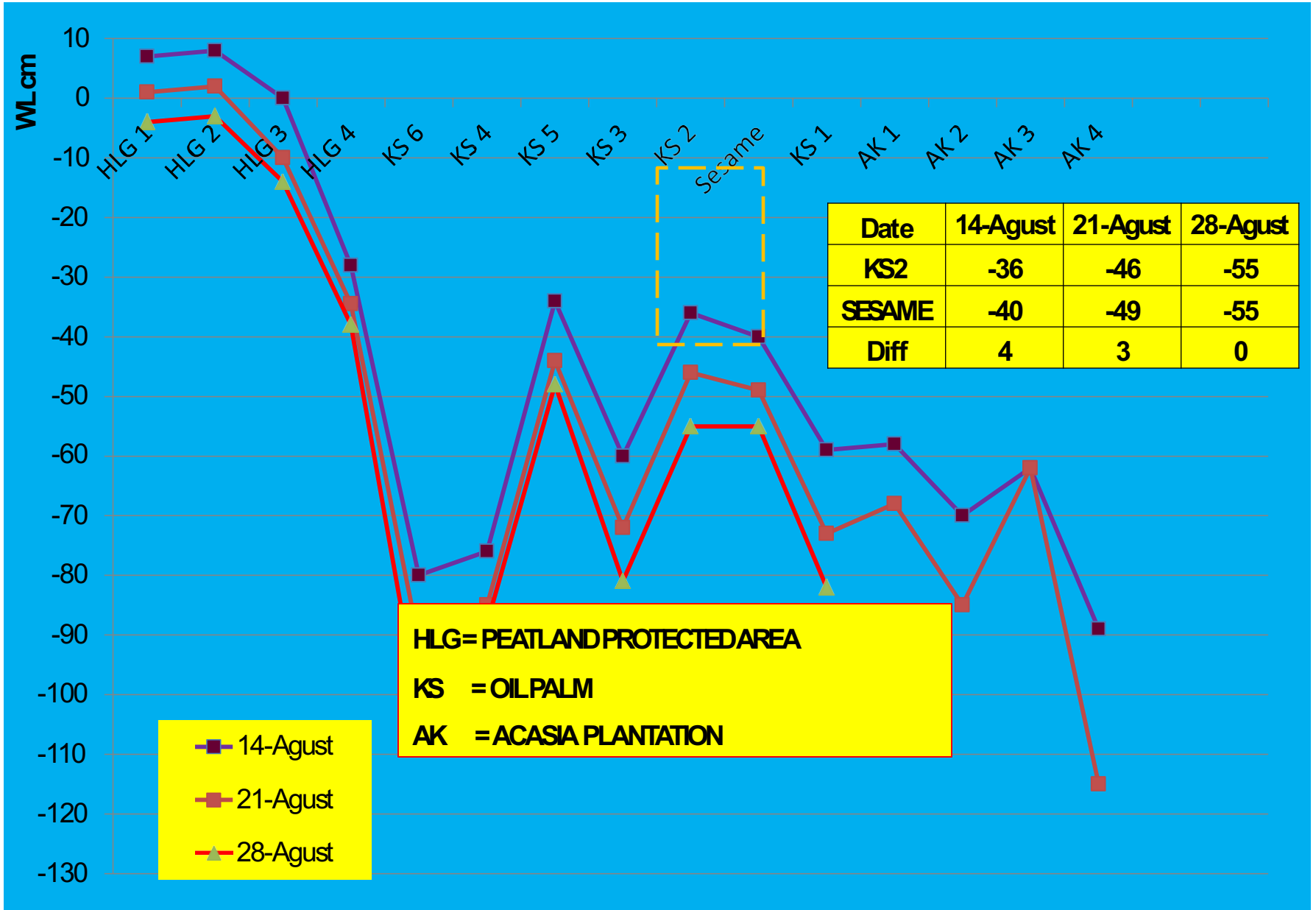
- PEATLAND RESTORATION AGENCY (BRG) WAS ESTABLISHED ON JANUARY 6, 2016 IN ORDER TO ACCELERATE THE RECOVERY OF HYDROLOGICAL & VEGETATION OF DEGRADED PEATLAND THAT CAUSED BY PEAT AND FOREST FIRES.
- GOVERNMENT REGULATION IN LIEU OF LAW NO. 1/2016



Restoration
Conservation
Concession &
Society

2015 REVETATION 2018 BURNING 2019

El Nino
Not Enought
Rain
No Canal
Blocking
Man Made
Fire

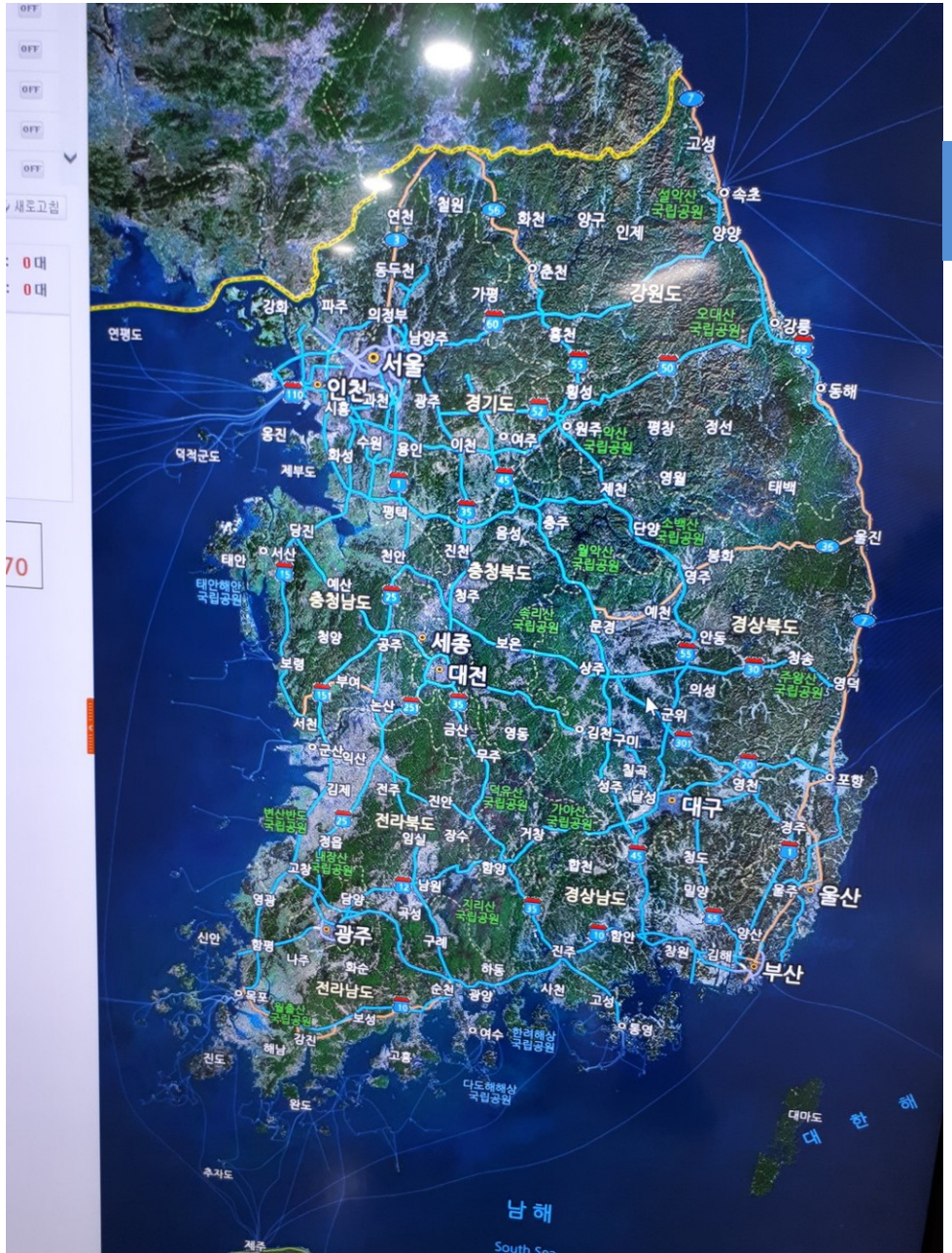

WLcm
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
HLG 1
HLG 2
HLG 3
HLG 4
KS 6
KS 4
KS 5
KS 3
KS 2
Sesame
KS 1
AK 1
AK 2
AK 3
AK 4
Date | 14-Agust | 21-Agust | 28-Agust
KS2 | -36 | -46 | -55
SESAME | -40 | -49 | -55
Diff | 4 | 3 | 0
HLG= PEATLAND PROTECTED AREA
KS = OIL PALM
AK = ACASIA PLANTATION
14-Agust
21-Agust
28-Agust

- FLOODED TO EXTINGUISH FIRES ON PEATLAND BURNING
- DEEP GROUND WATER LEVEL

No	Peat Dept (cm)	WATER TABLE (cm) Dry Season	WATER TABLE (cm) RAINY Season	WTAER TABLE CANAL (CM) RAINY	INFO
1	523	155	46	59	
2	602	140	48	69	
3	475	202	89	93	
4	604	214	92	70	
5	461	166	105	70	Burning
6	449	164	92	101	
7	401	169	92	92	Burning
8	577	141	71	97	Burning
9	574	173	69	68	
10	516	141	48		Burning
11	628	115	41	81	Burning
12	>751	95	69	61	
13	-	130	85	71	Burning
14			68	71	

National Aeronautics and Space Administration

NASA Carbon Monitoring System



Fire Monitoring In South Korea

Korea Plans To Conduct The Re-vegetation in Peat Burning In Jambi

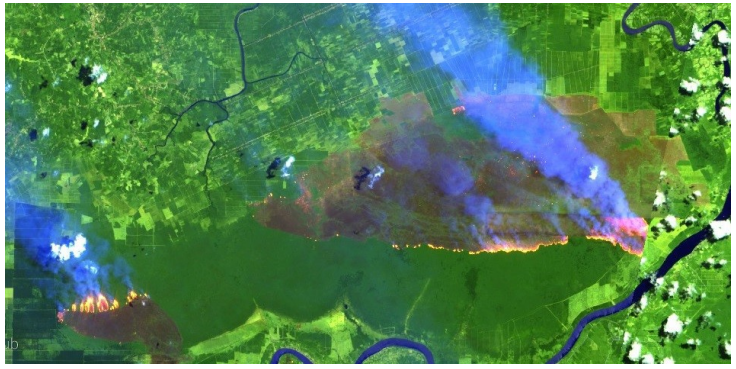
National Aeronautics and Space Administration

NASA Carbon Monitoring System

FIRE IN THE PALM OIL COMPANY DATE IMAGE 09-21-2019. NASA

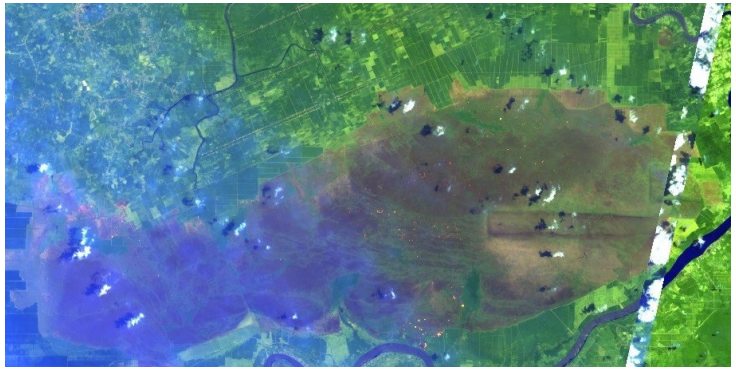
START BURNING , 08-31-2019

DEVELOPMENT OF FIRE AREA IN HLG LONDERANG JAMBI (KAB Muaro Jambi and TANJUNG JABUNG TIMUR Regency)



FIRE CONDITION , 09-08-2019

THERE ARE INDICATIONS OF FUNDS BURNED IN SOME LOCATIONS



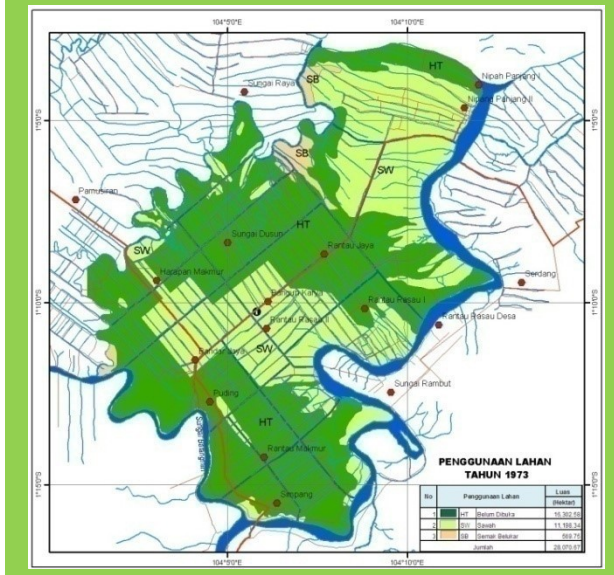
ALL BURNED , 09-18-2019

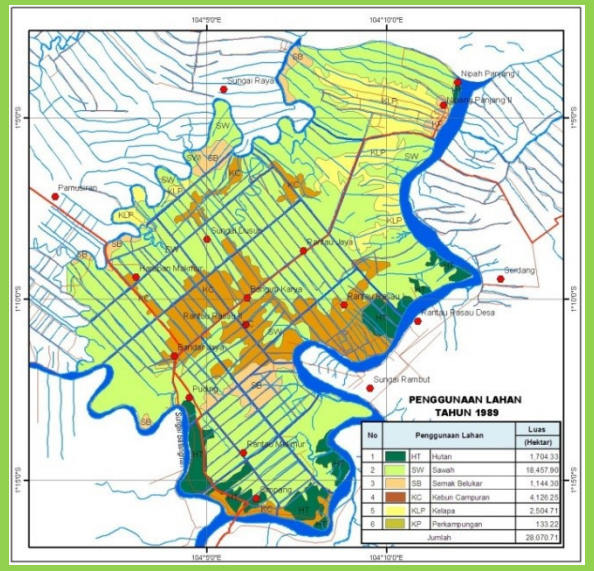
KEBAKARAN DI KEBUN KELAPA SAWIT
API YANG MASIH BERTAHAN
SELAMA 10 HARI DI LAHAN GAMBUT

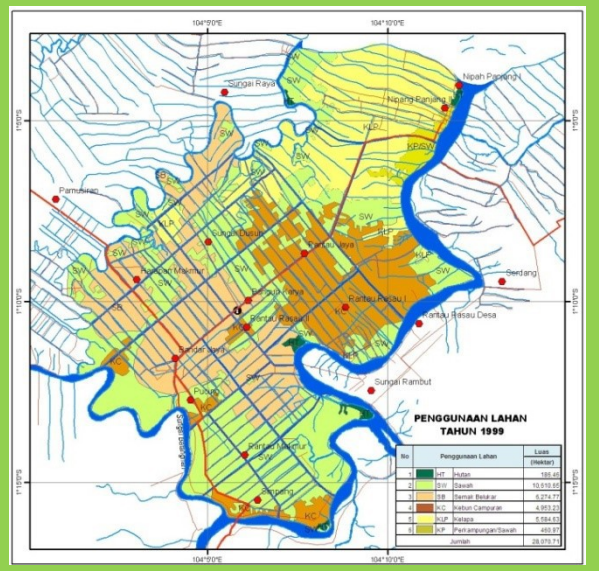
National Aeronautics and Space Administration

NASA Carbon Monitoring System

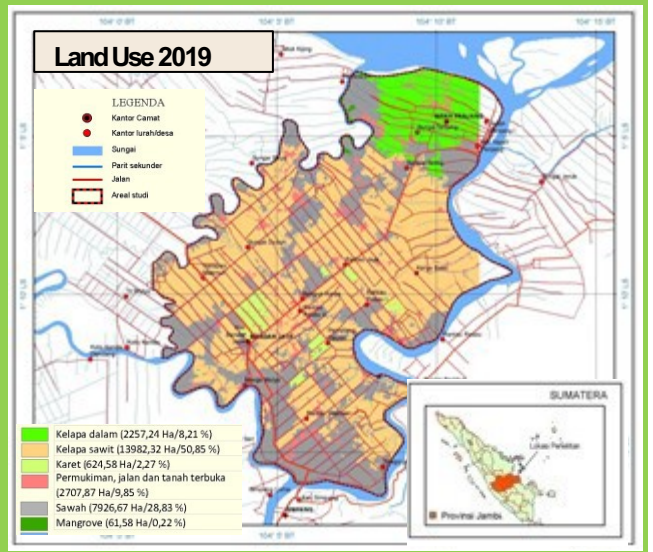
LAND USE CHANGE DUE TO PEAT FIRES AND THE EMERGENCE OF ACID SULPHATE SOILS, 1973-2019





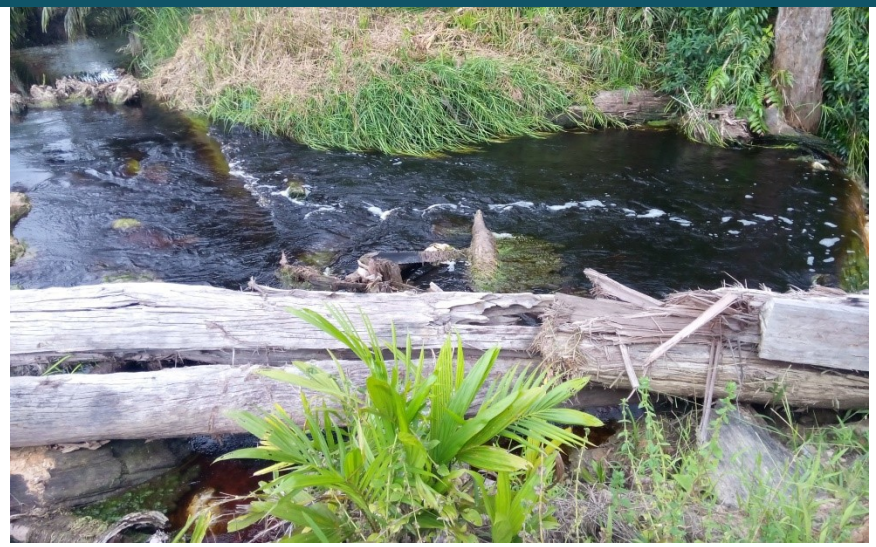


No	Land Use			Year			
				1973	1989	1998	2008
				Area (Ha)			
1		F	Forest	16,302.	1,704	186.46	166.66
2		RI	Rice Field	11,198	18,457	10,610	12,425
3		SH	shrubs	569	1,144	6,274	1,351
4		MG	Mixed Gardens		4,126	4,953	729
5		C	Coconat		2,504	5,584	9,526
6		V	Villages		133.22	460	198
7			Rubber Palntation				1,046
8			Oil Palm Plantation				2,625
Total				28,070	28,070	28,070	28,070



Canal Blocking :
To keep the water table height

Batanghari River
Canal Blocking I
Canal Blocking II
October , 2015



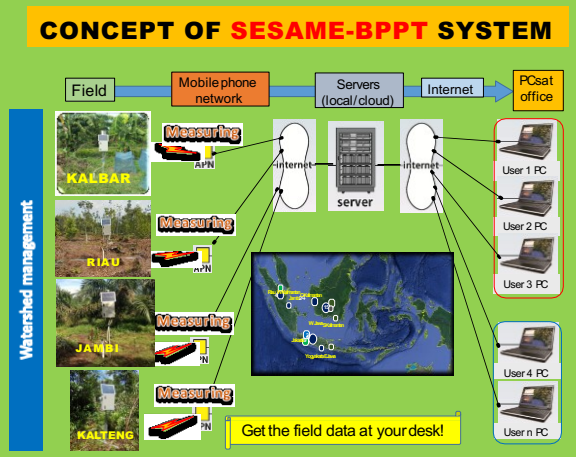
Canal Blocking I
Canal Blocking II
May13, 2017

Canal Blocking I
Canal Blocking II
September 06, 2019

FIRE TOWER MONITORING

SESAME-BPPT

MONITORING REAL TIME SYSTEM GROUND WATER LEVEL OF PEATLANDS



Access and see real time ground water level of plantations, forest, carbon sequestration, peat fire prevention in peatland ecosystems

National Aeronautics and Space Administration

NASA Carbon Monitoring System

Continue To Analyze Gas From Peat Fires On Different Land Uses and Some Water Level.
To Find Different kind of Gases

NEED FOR FUTURE

1. **Soil Water Table Monitoring Related to Soil Moisture Analysys By Satelite Data and Monitoring in the Field in Prevention Peat Fire.**

2. **Fire Scene Evaluation Imporivement to Measure Lost of Organic Matter While Peat Burning on Different Land Cover.**

3. **To Up Scale the Area Monitoring with different Land Use.**


KULI UMUM
"LECTURES ON TROPICAL PEAT FIRE BEHAVIOUR AND DYNAMICS"

THANK YOU

Oil Climate Index + Gas (OCI+):

Using CMS Data to Model Global Petroleum Sector GHGs and Develop Climate Mitigation Strategies

Deborah Gordon
Senior Fellow,
Watson Institute for International & Public Affairs
Brown University

NASA CMS Meeting, La Jolla
November 12, 2019

IPCC Oil & Gas Reductions to Meet 1.5°C Climate Target

Renewable share in electricity in 2030 (%)	60
↳ in 2050 (%)	77
Primary energy from coal in 2030 (% rel to 2010)	-78
↳ in 2050 (% rel to 2010)	-97
from oil in 2030 (% rel to 2010)	-37
↳ in 2050 (% rel to 2010)	-87
from gas in 2030 (% rel to 2010)	-25
↳ in 2050 (% rel to 2010)	-74

Heterogeneous Petroleum Resources & Climate Change

By assuming the lifecycle GHG footprints of petroleum resources are essentially the same, we miss a real opportunity to reduce oil & gas supply-side emissions

NOW

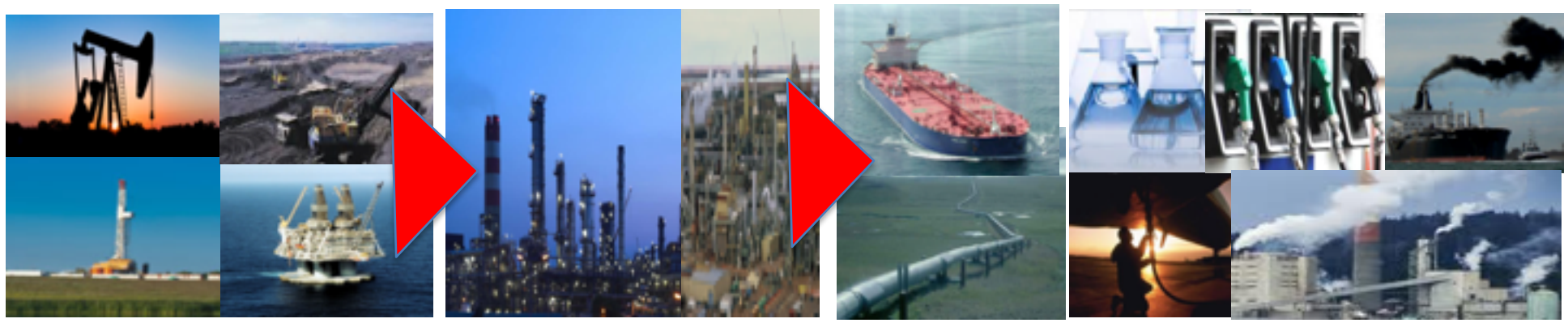
Background
Oil Climate Index + Gas (OCI+) Model

The OCI+ is a dynamic assessment tool that uses open source, peer-reviewed models to estimate and disaggregate lifecycle GHGs from the oil & gas value chain

OPGEE
Stanford

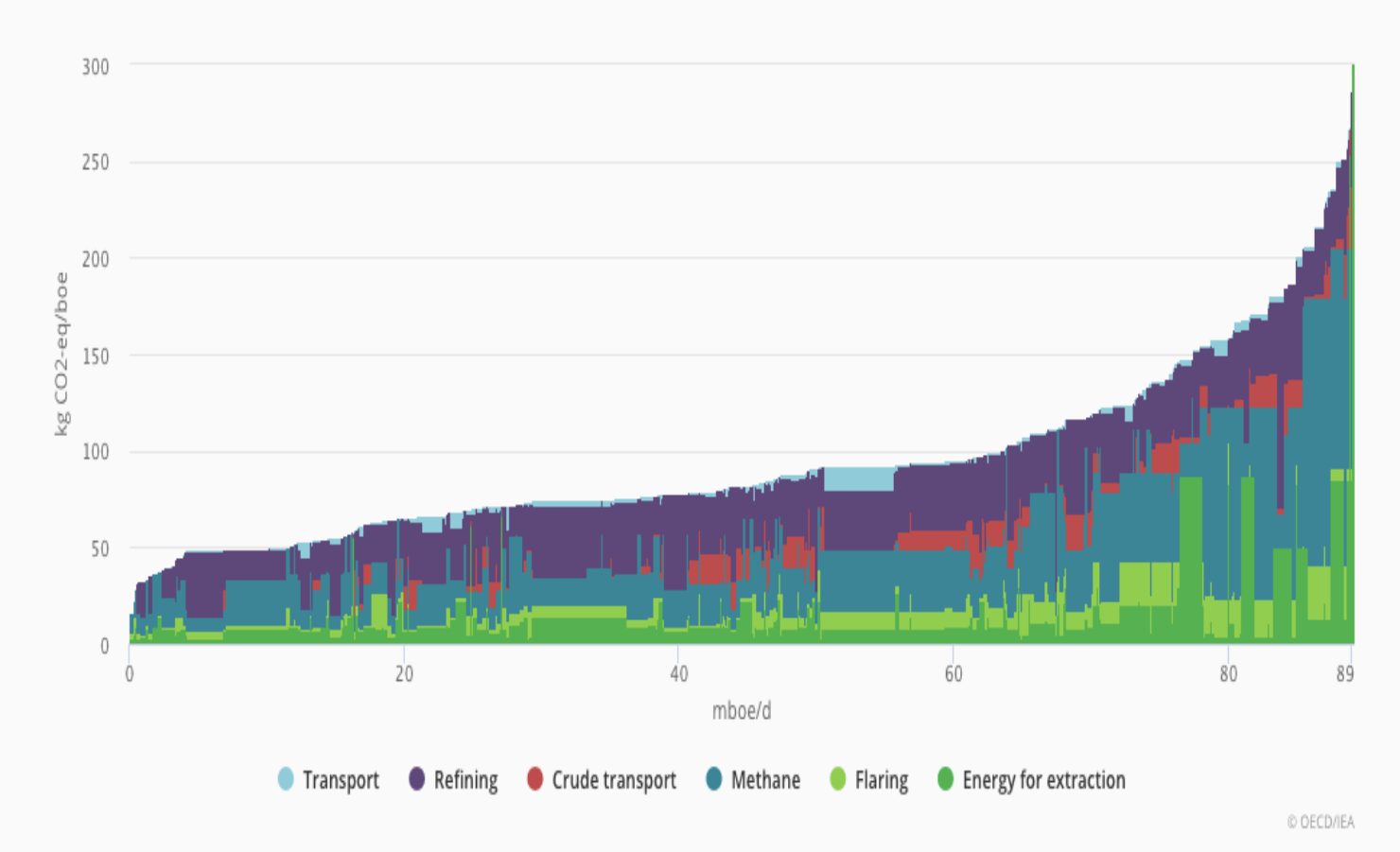
PRELIM
University Calgary

OPEM
Brown



production/processing → refining → shipping → end use consumption

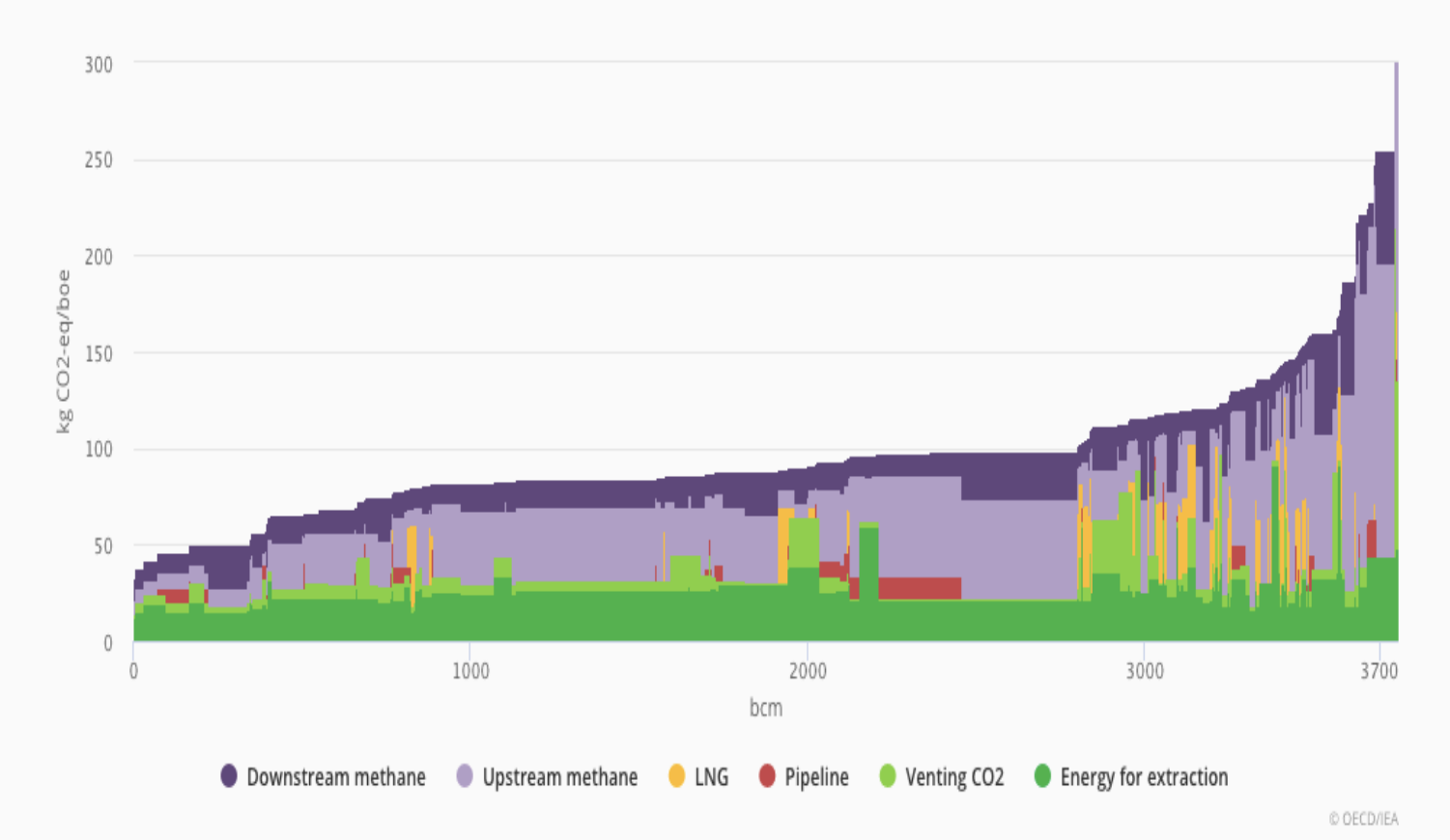
Climate Footprints Vary by Oil
(Industrial Portion of GHGs)



Source: IEA, World Energy Outlook 2018, using OCI model with methane GWP=30

Global Oil Industry's Direct GHGs Vary by ~30x at 20-year GWP=86

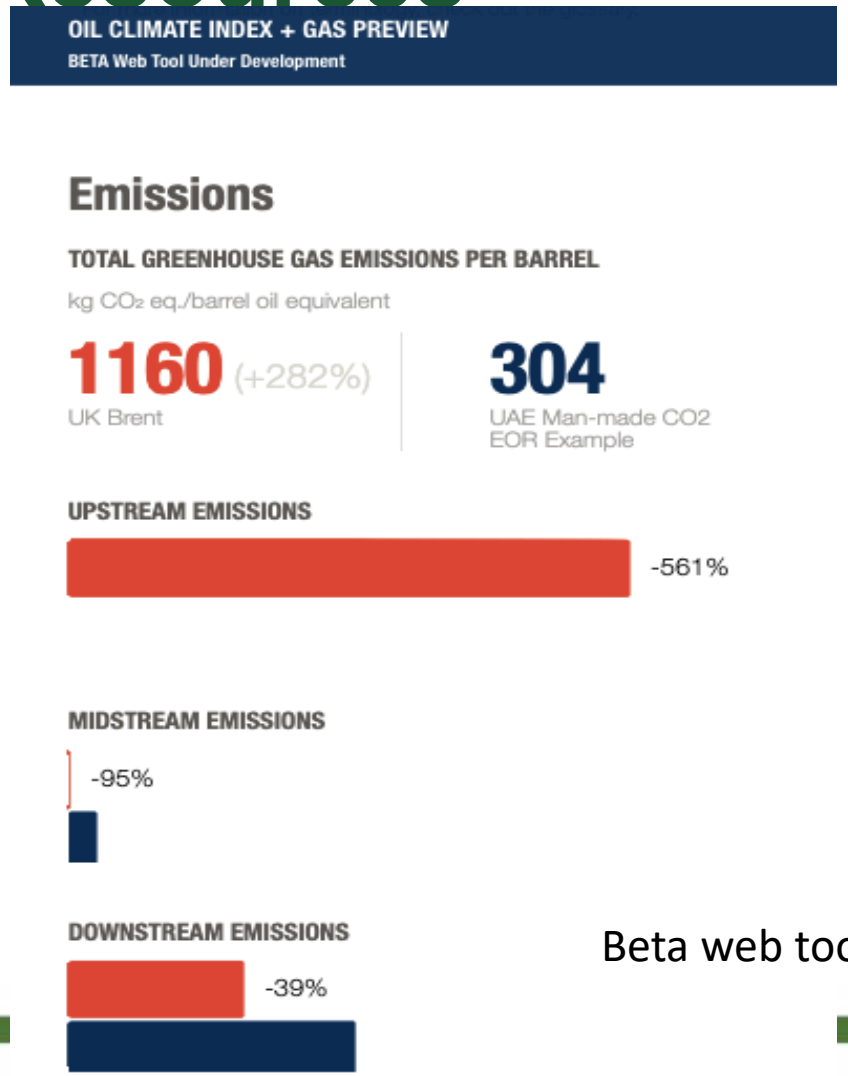
…And by Gas too
(Industrial Portion of GHGs)



Source: IEA, World Energy Outlook 2018, using OCI model with methane GWP=30

Global Gas Industry's Direct GHGs Vary by ~10x at 20-year GWP=86

OCI+ Preview Web Tool Modeling 29 Global Oil & Gas Resources



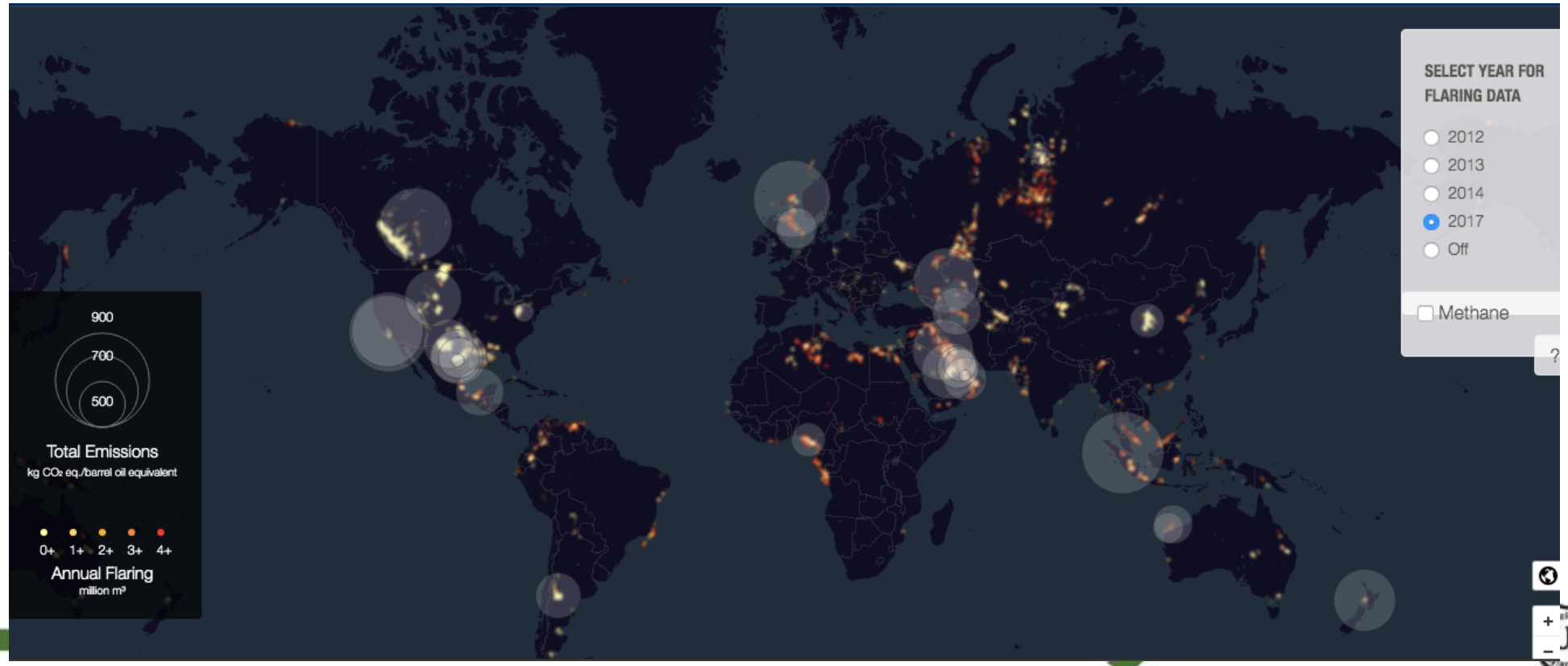
Global Oil & Gas Lifecycle GHGs (well to end use) estimated to vary by as much as **~4x**

Beta web tool URL: https://dxgordon.github.io/OCIPlus/

CMS Products Currently Used (and Planned) for the OCI+

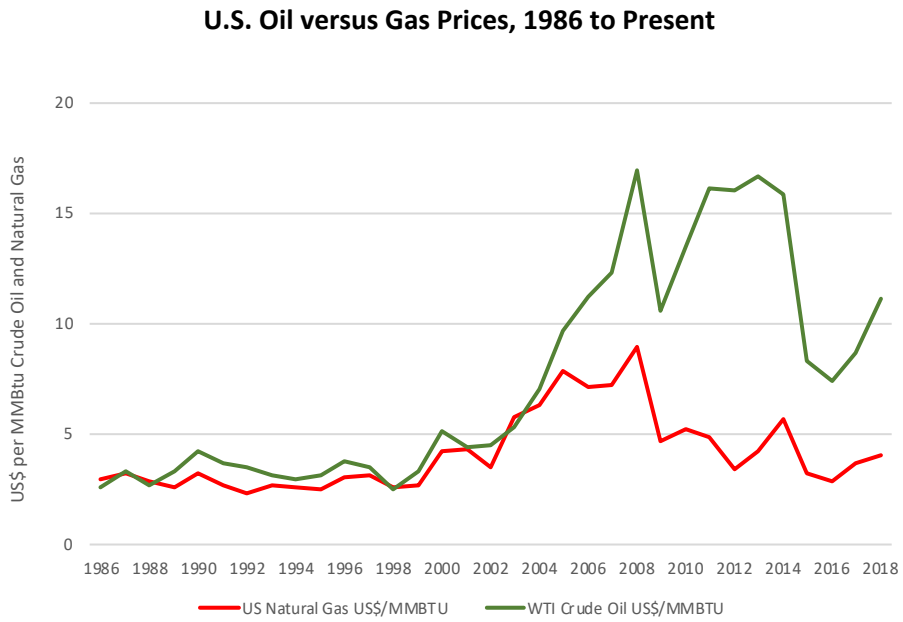
- **VIIRS Flaring**
- **GOSAT**
- **TROPOMI (forthcoming)**
- **Source Finder (forthcoming)**
- **John Worden Attribution Study (forthcoming)**
- *Other opportunities and suggestions?*

Oil & Gas Flaring
VIIRS Satellite, Chris Elvidge, NOAA/Mines



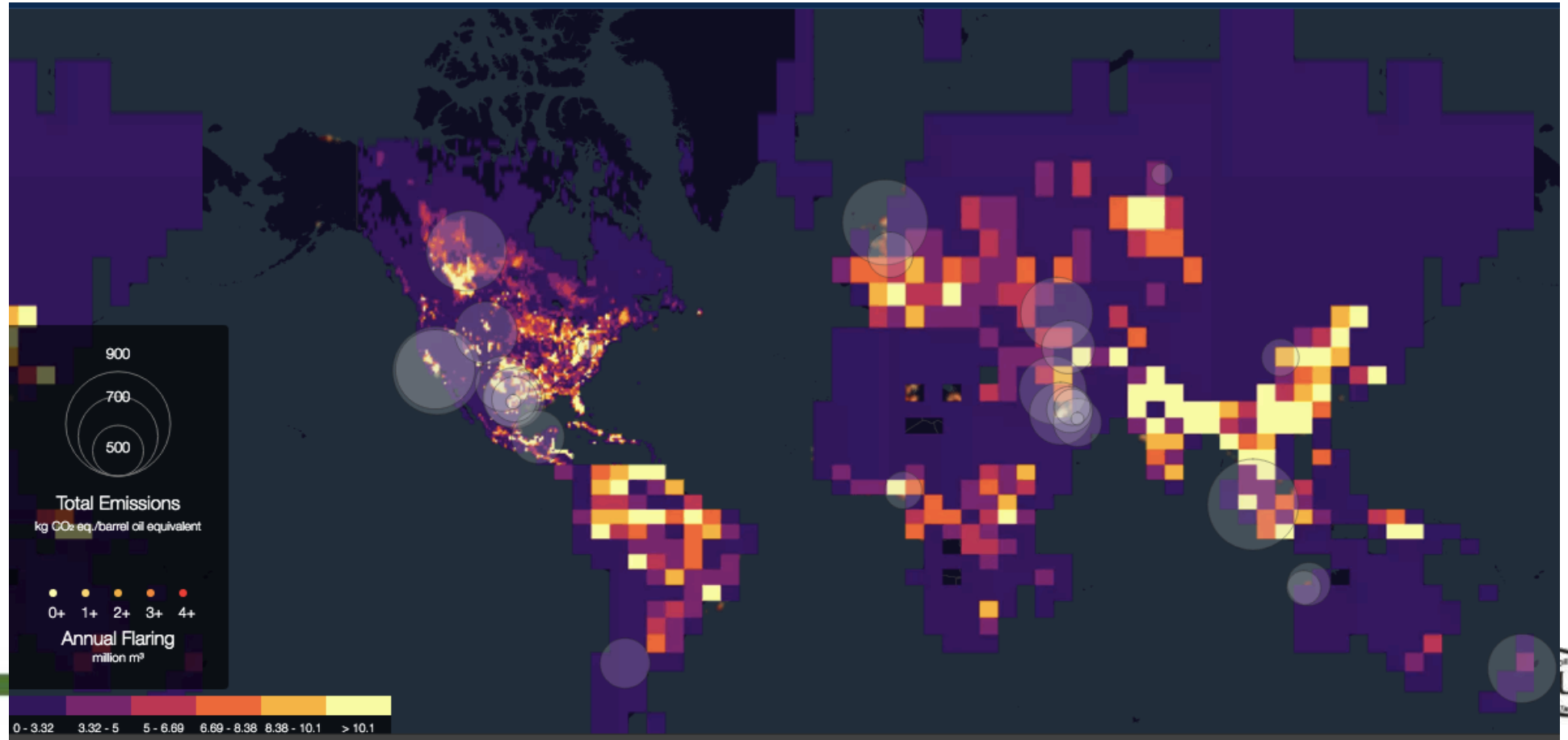
OCI+ Uses of VIIRS Satellite Data

- Gas flaring volumes incorporated into OCI+ upstream OPGEE model
- Flaring-to-oil ratios also used in OPGEE
- **Venting prevention:** Future assessment of inconsistent flaring signatures over time
- **Update PRELIM model:** Plan to incorporate VIIRS downstream refinery data



Source: Gordon and Reuland, *Mapping, Measuring, and Managing Methane,* Watson Institute for International and Public Affairs, November 2019

How Do Global Methane Hot Spots Align with Large Sources from Oil & Gas?
GOSAT 2015, Daniel Jacob, Harvard

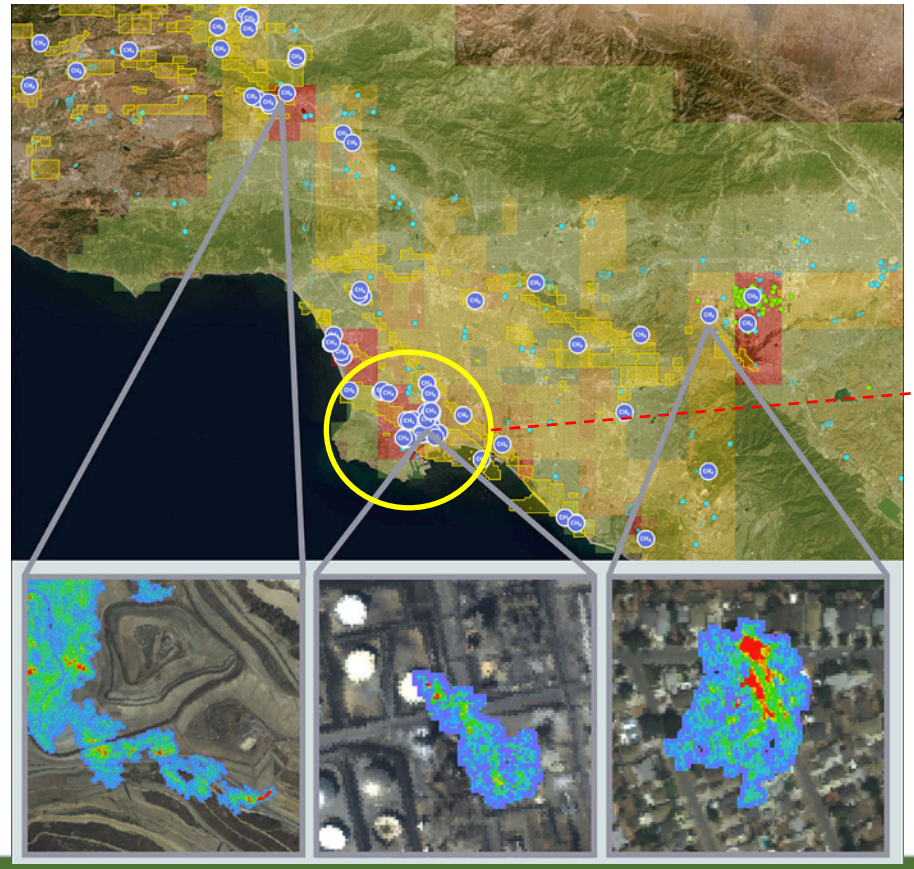


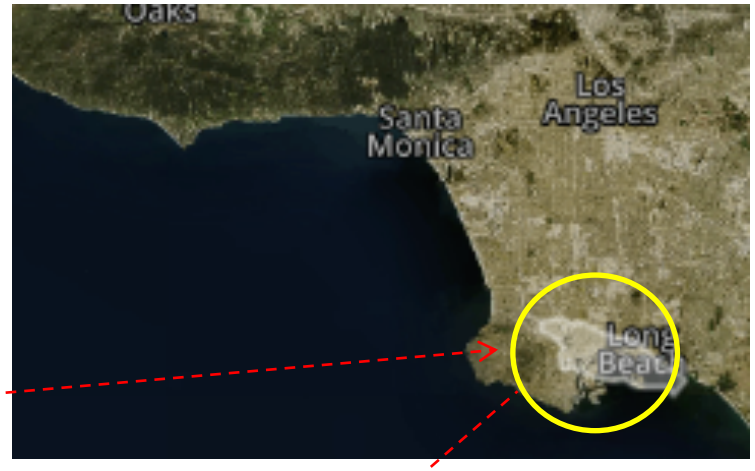
OCI+ Planned Uses of TROPOMI Data

- Mapping OCI+ results alongside methane satellite data for oil & gas sector attribution and mitigation targets
- Could provide check on OCI+ model algorithms for largest methane sources
- **In Search of 2019 TROPOMI data**

How Do Global Methane Hot Spots Align with Small Sources from Oil & Gas?

Riley Duren, JPL, Methane Source Finder





DEPLETED

U.S. California

Emissions Drivers

Refinery heat, Refin

Total

kg CO₂ eq./barrel c

Upstream

Midstream

Downstream

UPSTREAM EMIS

KG CO₂ EQ./BARREL CRUDE

Drilling	0.9
Production	30
Processing	0.7
Venting, Flaring, and Fugitive Emissions	17
Miscellaneous	3
Offsite emissions	5

Fugitive Methane (est. tonnes/day)

Wellhead – 7

Controllers – 5

Separator – 5

Misc Equipment - 5

OCI+ Planned Uses of Methane Source Finder

- Locating point sources of methane in oil & gas systems
- Knowing where to look: target remote sensing using OCI+
- Improving the OCI+ fugitive emissions module in the OPGEE model

OCI+ Timelines Related to CMS Data

- **Information, Transparency & Disclosure**
  - Updating OCI+ with global resources (2020-21)
  - California oil & gas data transparency (2020)
  - Oxford book contract-publication (2021)
- **Market Rules & Incentives**
  - Oil & gas methane certification program (2020-21)
- **Regulatory Action**
  - *California oil & gas regulations (2021-22)*
- **Innovation & Technology Transfer**
  - *Guiding methane management (ongoing)*

Policy Stakeholders Using the OCI+
(examples)

- Governments
  - U.S. Congress
  - California Air Resources Board
  - Government of Norway
  - India's Supreme Court
- NGOs
  - International Energy Agency
  - Rocky Mountain Institute
  - Natural Resources Defense Council
  - Transition Pathway Initiative
  - KAPSARC
- Academics
- Investors
- Oil and gas companies
- Philanthropies

Improving CMS Uptake

- Accessibility – Getting notifications (scientists' outreach) when new data available
- Time domain – Random detection; not on synchronized schedule (to reduce gaming)
- Spatial scale – Help matching different measurement regimes to oil & gas systems for full coverage of different types of methane releases
- Frequency of updates – More rapid turn-around; within months (or at least the same year) measurements are taken

Where CMS can help improve the OCI+

- Timely satellite reports and updates, including TROPOMI methane
- Finer-tuned methane estimates beyond North America
- Methane measurements **over water** (where a lot of oil and gas activity takes place)
- Clearer idea of detection limits as they relate to assets on the ground
- Better understanding of plumes, wind, and background methane concentrations for guidance on attribution to equipment
- Protocols for best practices applying CMS products
- Better understanding of GWP multipliers for methane and other SLCPs
- CMS products for black carbon (from the oil & gas lifecycle)

Looking Forward: CMS and OCI+

- **Positive aspects of CMS data for the OCI+**
  - CMS data can help attribute methane to oil & gas sources (John Worden project partner)
  - Remote sensing data used as model inputs
  - Overlaying CMS data with OCI+ GHGs provides useful visualization and serves as a powerful policy making tool
- **Next OCI+ Priorities**
  - Getting a better handle on methane venting
  - Modeling all major oil & gas assets worldwide
  - Adding black carbon to the OCI+
  - Continuing to develop oil & gas GHG mitigation strategies using OCI+ findings

SilvaCarbon

USAID
FROM THE AMERICAN PEOPLE

Potential use of NASA CMS products in National Forest Monitoring Systems for Carbon Emissions Reporting in the Tropics

Sylvia Wilson – U.S. Geological Survey

USGS
science for a changing world

NASA

CARBON MONITORING SYSTEM

SCIENCE TEAM MEETING & APPLICATIONS WORKSHOP

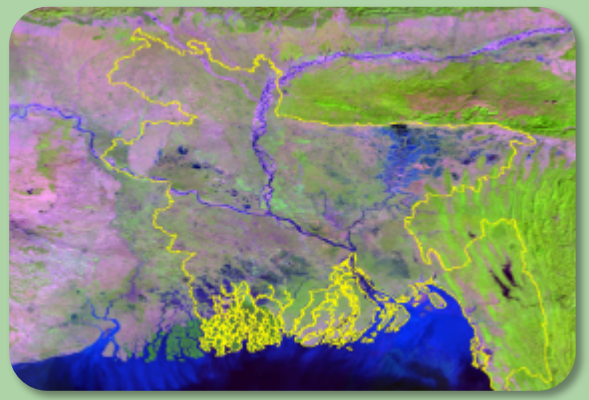
Scripps Seaside Forum, La Jolla, CA

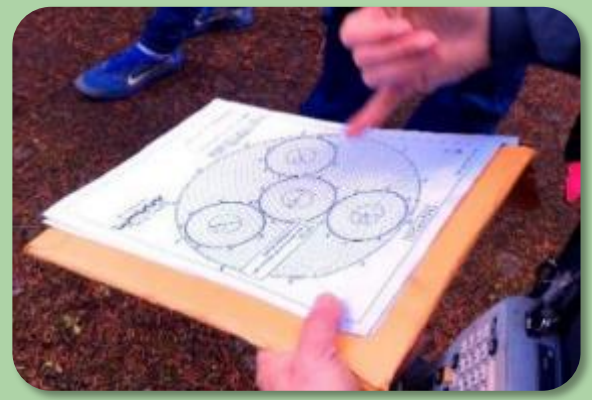
NOVEMBER 12-14, 2019

SILVACARBON PROGRAM GOALS

- Provide REDD+ countries with a **targeted package of support** to assist them build National Forest Monitoring Systems for reporting
- Ensure support is **targeted at country needs** to help accelerate progress towards reporting and action
- Foster a **network of experts** to help address challenges and bottlenecks to progress
- Facilitate **exchanges resources, comparative advantages**, **south-south collaboration** and enable learning between partners
- **Avoid overlaps and duplication** of effort by developing countries and US partners.

Background – Application Areas





Remote Sensing

Acquisition and analysis of spatial data on forest and landscape change

Forest Inventory

Design and implementation of ground-based forest surveys

GHG Inventory

Estimation and reporting of GHG emissions for the land sector

INTEGRATION

BACKGROUND - COUNTRY ENGAGEMENT

Americas
Costa Rica
Panama
Dominican Republic
Colombia
Ecuador
Peru
Paraguay

Africa
Cameroon
DR of Congo
R of Congo
Gabon
Ethiopia
Zambia

Asia
Bangladesh
Cambodia
Indonesia
Lao PDR
Nepal
Philippines
Thailand
Vietnam

Capacity building priorities

- Gaining more confidence/sovereignty in the use of cloud computing.
- Focus on the product instead of the tools. Capacity building should be targeting the generation of concrete products.
- Multi sensor operational systems / radar and optical data integration.

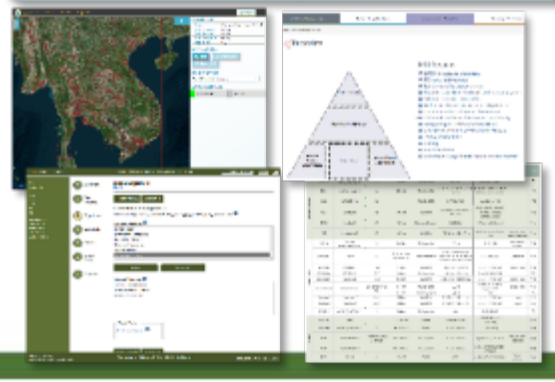
CAPACITY BUILDING STRATEGY

Direct Technical Assistance & Training

Focused Workshops

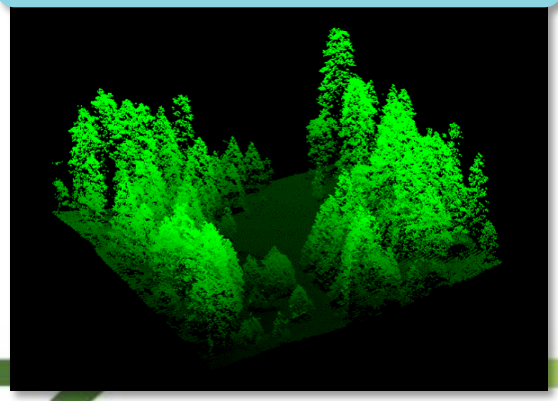
Study Tours

Tools & Guidance Development



South-South Collaboration

Applied Research



CMS DATA PRODUCTS

1. Accuracy assessment and Area Estimation tools – Pontus Olofsson, Boston University – currently being use

2. Use of Lidar and Radar data to develop carbon storage estimates – Lola Fatoyimbo, University of Maryland – currently being use

3. Pantropical degradation mapping using CODED – Pontus Olofsson, Boston University – currently being use

Plan on being use:

OBI-WAN (Online Biomass Inference using Waveforms And iNventory) – Sean Healey, U.S. Forest Service

- Applies GEDI assets to creating statistical biomass estimates for local, customizable areas
- A possible source of emissions factors for REDD+ and ISFL

GEDI
ECOSYSTEM LIDAR

TIMELINE FOR SILVACARBON (Policy and decision making)

SilvaCarbon aims to inform policy and mobilizing finance. There are several Climate financing opportunities - 2020:

1. Norway bilateral reimbursement – Alignment with commitments to NDCs

2. Forest Carbon Partnership Facility – World Bank

    - Readiness fund – $400 million
    - Carbon fund – $900 million

3. REM Early Movers Program – Germany

    - Support performance-based payments for verified emission reductions from deforestation prevention

Additional carbon data needs/gaps. How CMS can contribute to data

Wall to wall products that integrate radar and optical data – applicable in the tropics.

- Latin America Pacific coast (Colombia, Ecuador and Peru)

Emission Factors derived from Earth Observation

- Areas where access to NFI plots are not feasible. Terrain, or socio economical stressors
- Countries are not using pantropic or global biomass maps in their reporting. They are only using ancillary data.

Models that integrate Activity Data and Emission Factors

- Current models have many defaults and are not applicable for tropical countries

Monitoring of other Land covers besides Forest

- Regeneration, differentiate palm from forest

Challenges

Reporting timelines (2 years for GHGi, and yearly for REDD+)
Data (data volumes and storage, data integration)
Technical capacity
Lack of research, gap between governments and academia

Potential improvements in the short term, and contribution from CMS projects

Strengthen the link between Government and Academia in SilvaCarbon countries. Universities, research institutions and also NGOs are good vehicles for transferring capacity (training the trainers) – USAID Peer Program

Customization of global products to National levels and development of training materials

CAPACITY BUILDING SUMMITS

How do we check ourselves?

1. First Capacity Building Summit (Armenia – Colombia), September 2015
2. Second Capacity Building Summit (Kathmandu, Nepal), September 2017
3. Third Capacity Building Summit (Upcoming in Lusaka, Zambia), June, 2020

Objectives:
Get input from countries on how to coordinate capacity building efforts better
Share lessons, learn how others' approaches are evolving and promoting transparency
Introduce cutting edge methods with potential to become operational at a country level and replicable

More information available at

www.SilvaCarbon.org

➢ Sylvia Wilson, US Geological Survey
snwilson@usgs.gov

CMS Science Team Meeting & Applications Workshop
November 12-14, 2019 in la Jolla, CA
82 Participants

Edil Sepulveda Carlo (618), CMS Applications Coordinator, organized, moderated and presented during Day 1 of the meeting, the CMS Applications Workshop.

15 CMS Stakeholders presented on how they are using CMS data products, lessons learned and impact of the products for their organization, and further data needs, including:

California Air Resources Board, Illinois Farm Bureau, Maryland Department of Natural Resources, U.S. EPA, USDA Forest Service, Environmental Defense Fund, World Resources Institute, SilvaCarbon

Data Access Tutorial for CMS Stakeholders on Day 1, &

Data Submission Tutorial for CMS ST members on Day 2

Outcomes & Actions Moving Forward:

- Workshop Summary for CMS Quarterly Newsletter – Feb 2020
- CMS Applications Workshop Report/Proceedings – April 2020
- Agenda, Slides, Recording, and Report to be Published in CMS Website – Spring 2020
- CMS Stakeholder Fact Sheets with info about stakeholder organization, us impact, and data needs – Spring 2020
- Creation of CMS Stakeholder Working Group
- CMS Policy Speaker Series, Thematic Workshops, and Data Tutorials

CONTACT INFORMATION
Edil Sepulveda Carlo, CMS Applications Coordinator
301-614-6243
edil.sepulvedacarlo@nasa.gov