National Aeronautics and Space Administration

NASA Carbon Monitoring System

NASA Carbon Monitoring System Applications Workshop Welcome

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Science Team Meeting
November 16-18, 2015
Pasadena, CA

http://www.carbon.nasa.gov

Congressional Direction (Summary)

Congressional Direction in 2010:

Also included within the funds provided for other mission and data analysis, the conference agreement provides $6,000,000 for pre-phase A and pilot initiatives for the development of a carbon monitoring system. Any pilot developed shall replicate state and national carbon and biomass inventory processes that provide statistical precision and accuracy with geospatially explicit associated attribute data for aggregation at the project, county, state and federal level using a common dataset with complete market transparency, including extraction algorithms and correlation modeling.

Congressional Direction in 2011:

None

Congressional Direction in 2012:

The Committee recommends $10,000,000 from within available funds to continue the development of a carbon monitoring system initially funded in fiscal year 2010. The Committee expects no less than one-half of this amount shall be awarded externally.

Language in Senate Draft for 2013:

Of the funds provided within the earth science research and analysis activity, the Committee recommends $10,000,000 to continue efforts for the development of a carbon monitoring system initially funded in fiscal year 2010. The majority of the funds should be directed towards acquisition, field sampling, quantification and development of a prototype Monitoring Reporting and Verification [MRV] system which can provide transparent data products achieving levels of precision and accuracy required by current carbon trading protocols. The Committee recognizes that the current orbital and suborbital platforms are insufficient to meet these objectives. Therefore, the use of commercial off-the-shelf technologies is recommended as these products could provide robust calibration validation datasets for future NASA missions. Up to 20 percent of these funds should be made available to international Reducing Emissions from Deforestation and Forest Degradation [REDD] projects. Furthermore, the Committee is deeply disappointed with the lack of progress that NASA has made on this initiative thus far within the agency. Therefore, it directs that the above funds shall be competitively awarded within 120 days of enactment of this act.

Congressional Direction in 2014:

Carbon Monitoring- Of the funds provided within the Earth Science research and analysis activity, the Committee recommends $10,000,000 to continue efforts for the development of a carbon monitoring system. The majority of the funds should be directed toward acquisition, field sampling, quantification, and development of a prototype Monitoring Reporting and Verification [MRV] system which can provide transparent data products achieving levels of precision and accuracy required by current carbon trading protocols. The Committee is concerned that NASA has not established a program of record around the development of MRV system, and therefore expects a plan from NASA not later than 90 days after enactment of this act incorporating such a system into its operating plan and long-term budget projection. The Committee recognizes that the current orbital and suborbital platforms are insufficient to meet these objectives. Therefore, the use of commercial off-the-shelf technologies is recommended as these products could provide robust calibration validation datasets for future NASA missions.

…"pilot initiatives for the development of a carbon monitoring system…"
…"replicate state and national carbon and biomass inventory processes that provide statistical precision and accuracy with geospatially explicit associated attribute data…"
…"development of a prototype Monitoring Reporting and Verification (MRV) system which can provide transparent data products achieving levels of precision and accuracy required by current carbon trading protocols…."
…"[development of] a plan…incorporating such a [MRV] system into its operating plan and long-term budget projection…"

NASA-CMS Phase 1

Biomass Pilot. *The goals of the Biomass Pilot are to:*

- Utilize satellite and in situ data to produce quantitative estimates (and uncertainties) of aboveground terrestrial vegetation biomass on a national and local scale.
- Assess the ability of these results to meet the nations need for monitoring carbon storage/sequestration.

Flux Pilot. *The objectives of the Flux Pilot are to:*

- Combine satellite data with modeled atmospheric transport initiated by observationally-constrained terrestrial and oceanic models to tie the atmospheric observations to surface exchange processes.
- Estimate the atmosphere-biosphere CO_2 exchange.

Scoping Efforts. *The objectives of the Scoping Efforts are to:*

- Identify research, products, and analysis system evolutions required to support carbon policy and management as global observing capability increases.

NASA-CMS Phase 2

CMS Award year: # of projects (decision support - MRV)

2012: 20
2013: 17
2014: 15

Global Surface-Atmosphere Flux

2012: 2
2014: 3 (2)

Land-Atmosphere Flux

2012: 6 (5)
2013: 8 (6)
2014: 2 (2)

Ocean-Atmosphere Flux

2012: 1

Ocean Biomass

2012: 3

Land-Ocean Flux

2012: 1
2014: 1 (1)

Land Biomass

2012: 7 (5)
2013: 9 (9)
2014: 9 (7)

Participants By Type and By Country

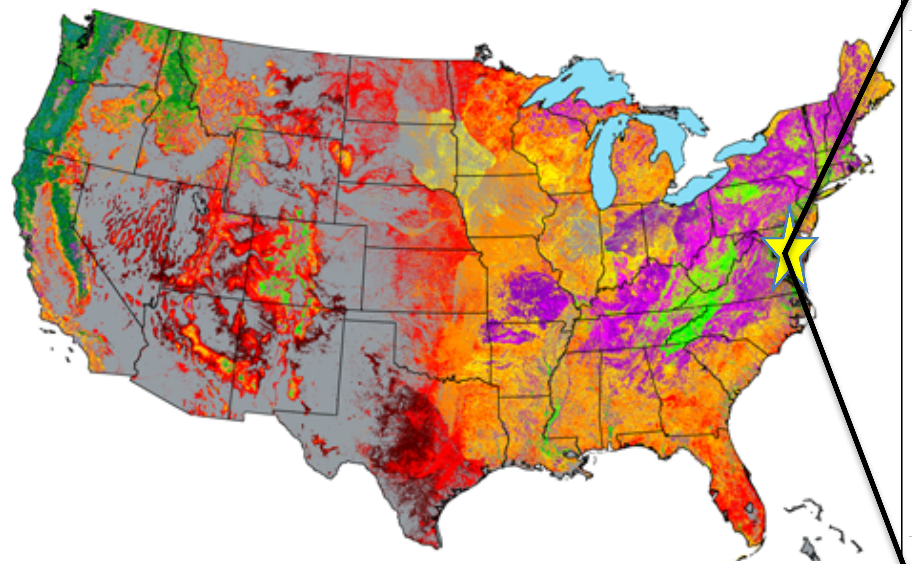
ORG TYPE (# unique)	US	MX	Brazil	UK	Total
University (35)	60	3	1	1	65
National Agencies/Labs (8)	62	1			63
State (1)	3				3
Private (12)	14				14
Research Center (2)	6	1			7
NGO (4)	4		1		5
Total	**149**	**5**	**2**	**1**	**157**

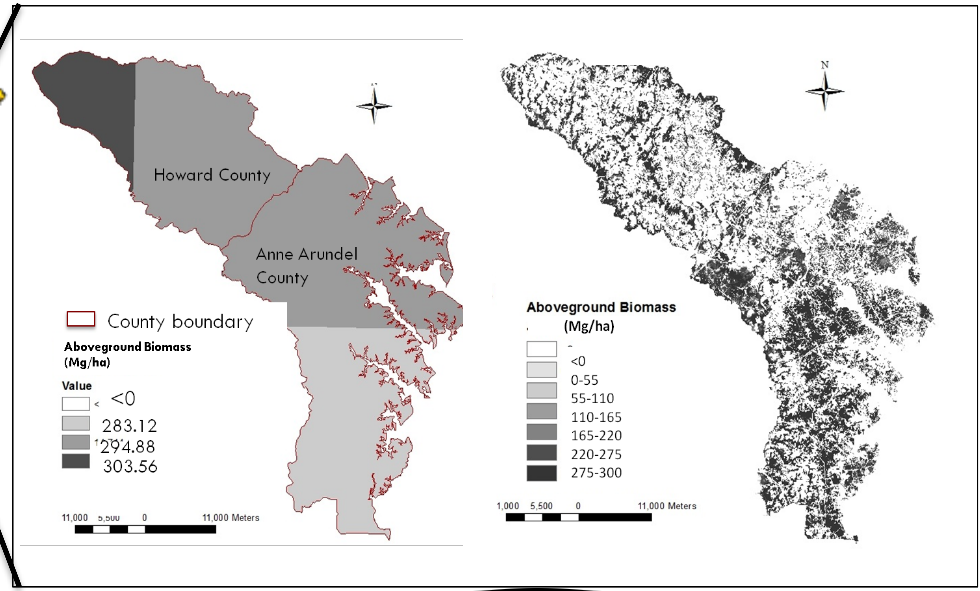
U.S. Agencies and Organizations

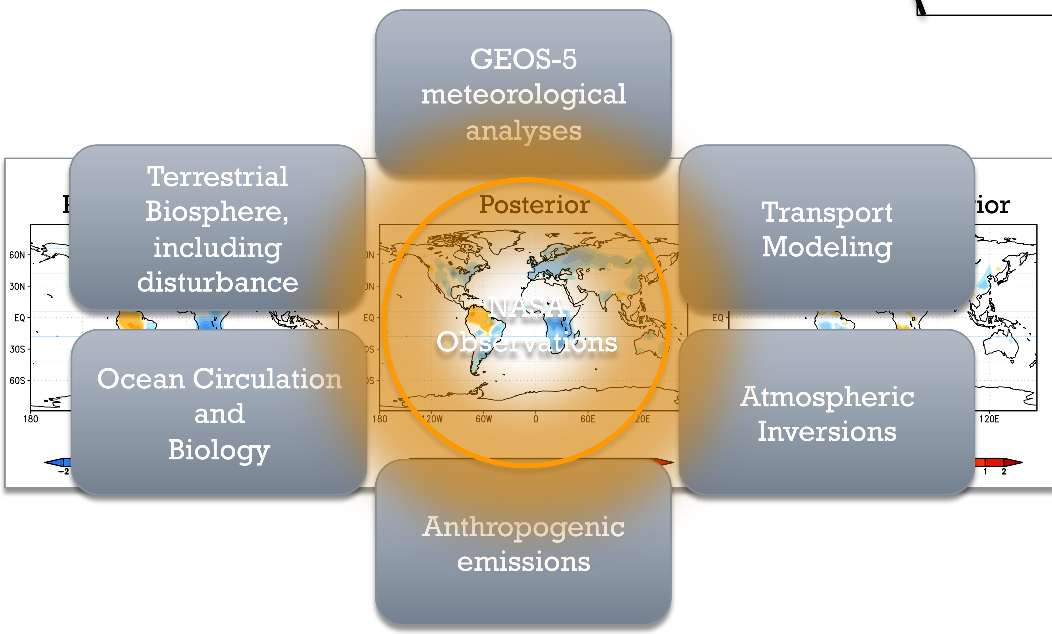
Federal	State	NGO	Private
NASA	CA Air Resources Board	Global Forest Watch	AER, Inc
NOAA		Resources for the Future	Applied Geosolutions
USDA FS	**US Research**	Winrock Intl.	Earth Networks
DOE	Woods Hole Research Center		Geodigital Intl Corp.
USGS			RHG
EPA			Neptune, Inc.
Dept. of State			Sigma Space Corp.
			Watershed Sciences Inc.
		I	4 Consultants

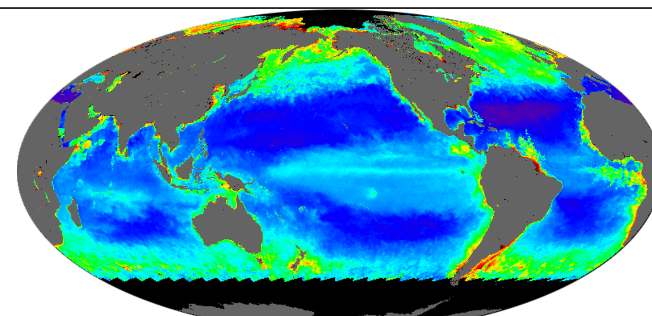
National Aeronautics and Space Administration

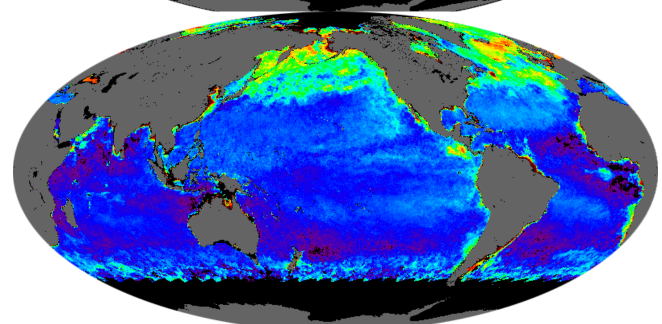
NASA Carbon Monitoring System







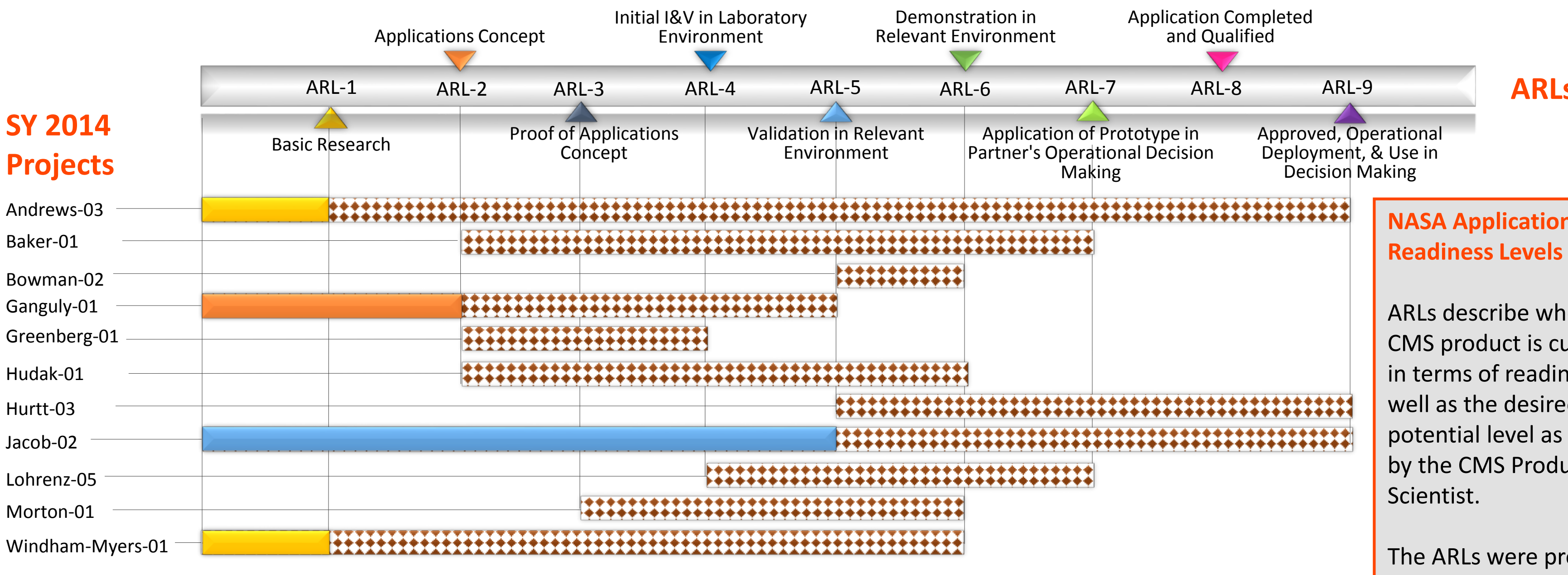




- 140 unique publications (papers, book chapters)
  - 7 publications in Nature, Science and PNAS including two currently on the NACP Citations Classics list with over 100 citations

- Baccini, A., S.J. Goetz, W.S. Walker, N.T. Laporte, M. Sun, D. Sulla-Menashe, J. Hackler, P.S.A. Beck, R. Dubayah, M.A. Friedl, S. Samanta, and R.A. Houghton. 2012. Estimated carbon dioxide emissions from tropical deforestation improved by carbon-density maps. Nature Climate Change (Houghton-02) NACP Citation Classic with 191 Citations
- Cai, W.-J., X. Hu, W.-J. Huang, M. C. Murrell, J. C. Lehrter, S. E. Lohrenz, W.-C. Chou, W. Zhai, J. T. Hollibaugh, Y. Wang, P. Zhao, X. Guo, K. Gundersen, M. Dai and G.-C. Gong (2011). 'Acidification of subsurface coastal waters enhanced by eutrophication.' Nature Geosci (*Lohrenz-03*) 116 citations (to be added to NACP classics)
- Erb, K.-H., T. Kastner, S. Luyssaert, R.A. Houghton, T. Kuemmerle, P. Olofsson, and H. Haberl. 2013. Bias in the attribution of forest carbon sinks. Nature Climate Change (*Houghton-02) commentary*
- Gately, C. K., L. R. Hutyra, and I. S. Wing, 2015: Cities, traffic, and CO2: A multidecadal assessment of trends, drivers, and scaling relationships. Proceed. National Academy Sci. (*Nehrkorn-01*)
- McKain, K., A. Down, S. M. Raciti, J. Budney, L. R. Hutyra, C. Floerchinger, S. C. Herndon, T. Nehrkorn, M. Zahniser, R. B. Jackson, N. Phillips, and S. C. Wofsy, 2015: Methane emissions from natural gas infrastructure and use in the urban region of Boston, Massachusetts. Proceed. National Academy Sci. (*Nehrkorn-01*
- Pan, Y., R.A. Birdsey, J. Fang, R. Houghton, P.E. Kauppi, W.A. Kurz, O.L. Phillips, A. Shvidenko, S.L. Lewis, J.G. Canadell, P. Ciais, R.B. Jackson, S.W. Pacala, A.D. McGuire, S. Piao, A. Rautiainen, S. Sitch, and D. Hayes. 2011. A large and persistent carbon sink in the world's forests. Science (*Houghton-02*) NACP Citation Classic with 766 citations
- Zeng, N., F. Zhao, G.J. Collatz, E. Kalnay, R.J. Salawitch, T.O. West and L. Guanter. 2014. Agricultural Green Revolution as a driver of increasing atmospheric CO2 seasonal amplitude. Nature (*West-03*)

CMS Application Readiness Levels (ARLs)



Fatoyinbo-01
Ott-01
Walker-W-01
Williams-C-01

Different ARLs are provided for the products in these projects. Refer to individual corresponding charts describing the product ARLs.

Project ID
PI-Project # (Andrews-02)-Each CMS Project is represented by its color and identified by the PI on the project

Solid color: each solid bar is indicative of where the PI feels their project is NOW in terms of application readiness.
Pattern fill: indicates the level each PI is striving for and the application readiness level they feel their project can ultimately satisfy.
Gradient fill: indicates current level has not been reached fully.

NASA Application Readiness Levels (ARLs)

ARLs describe where the CMS product is currently in terms of readiness, as well as the desired and potential level as defined by the CMS Product Scientist.

The ARLs were provided by the CMS Product Scientist and represent the most accurate representation of the state of each product.

Products can start at any level. It is not expected they will start at ARL1 and end at ARL9.

CMS Products and Policy Support Examples

CMS PI and Project	Organization	Policy of Interest
Cook-01 Forest biomass	USDA Forest Service	USFS Forest Inventory and Analysis (FIA), SilvaCarbon, USDA Forest Service Experimental Forests & Ranges system
Dubayah-03 Canopy height and forest/non-forest maps-For Maryland **Dubayah-04** Canopy height and forest/non-forest maps for Sonoma County	Maryland Department of Natural Resources and Sonoma County CA	(03): FIA, Federal Land Policy and Management Act (FLPMA), Maryland Greenhouse Gas Emissions Reduction Act Plan, Maryland Climate Action Plan, Chesapeake Bay TMDL, Maryland Forest Preservation Act, Maryland No Net Forest Loss Act. (04): REDD+, Sonoma County initiatives, California Assembly Bill 32: Global Warming Solutions Act (CA-AB32), CAP
Duren-01-Applications **Escobar-01**-Applications	IPCC, Doha/Kyoto, NGHGI, CAA, US-India Green Partnership EPA, MD, DE and PA DNRs, Chesapeake Restoration Program, RGGI, EPA, Sonoma County Agriculture Conservation	Low-resolution MRV technology for Safe Drinking Water Act's Underground Injection Control program Workshops and Reporting for MD GHG planning, Sonoma County AB32, EPA GHG Inventory Reports, USGS 3DEP Program
Jacob-01, Jacob 02, Estimates of methane emission fluxes and Anthropogenic and natural methane emissions estimates	EPA	Global Climate Change and Clean Air Initiative of the US State Department, Global Methane Initiative of the US EPA, CAA, NGHGI, President Obama's Climate Action Plan (CAP), NALS

CMS Products and Policy Support, Examples Con't

CMS PI and Project	Organization	Policy of Interest
Fatoyinbo-01 Mangrove forest biomass estimates	Brazil	REDD+, Le Gabon Emergent, Gabon Forest Carbon Assessment, Silvacarbon, GEO-FCT
French-04 Maps of emissions from wildland fires	US Forestry	Wildland Fire Emissions Information System (WFEIS), Global Fire Data (GFED), BlueSky, CAA, NGHGI, FLPMA
Keller-01 Maps of spatially explicit associated uncertainties in stock changes	Brazil Land Management	US-Brazil Memorandum of Understanding on Climate Change, Brazilian Forest Code, REDD+, NFMS, SilvaCarbon, Sustainable Landscapes Program Brazil
Morton-01 and Morton-02 Maps of annual deforestation, forest degradation, Maps of carbon stocks with pixel level uncertainties	Brazil	REDD+, SilvaCarbon, Science Without Borders, Global Carbon Project, GFED FIA, FLPMA
Saatchi-02 Disturbance layers (time since disturbance, recovery rate, disturbance severity)	US Forestry	NGHGI, CAP, IPCC Good Practice Guidance for Land, Use, Land-Use Change, and Forestry (IPCC GPG), FIA, NFMS
West-03 Carbon release by livestock and humans	EPA	IPCC GPG, NASA FPP, NASA Carnegie Ames Stanford Approach (CASA) model, DOE Integrated Assessment program, US Farm Bill, CAP

NASA's Approach to CM/MRV

- Recognizes that a sustained, observationally-driven carbon monitoring system using remote sensing data has the potential to significantly improve the relevant information base for the U.S. and world;
- Recognizes multiple users, multiple scales, multiple quantities, and multiple frameworks for MRV (e.g. International, national and subnational, markets);
- Regonizes the importance of user engagement to be responsive to stakeholder needs;

The goal for NASA's CMS project is to prototype the development of carbon monitoring capabilities needed to support U.S. needs for MRV.

*NASA-CMS (2014) Progress Report

Applications Workshop Summary (2014)

- Excellent interaction and input from stakeholders working with NASA-CMS projects, across a range of spatial/policy scales (subnational, national, international, and ocean).
- Stakeholders very pleased and encouraged by CMS activities, emerging capabilities, and future potential
- CMS should not just about data products, but also about addressing policy relevant science questions
- Importance of baseline, monitoring, and projection/prediction, and attribution
- Importance of uncertainty quantification, “accuracy willing to pay for”
- Importance of state of art capability, leadership in CMS capabilities
- Input is timely, with very aggressive policy timelines nationally/internationally
- Need to get ahead in understanding future policy needs and future capabilities
- Data Delivery? Don’t, make data available in std GIS format.

Key Questions Today and Beyond

- How can we continue to build and improve in stakeholder engagement and relevance of CMS science?
- What are stakeholder needs for CM/MRV, and to what extent are they being met?
- What are the emerging lessons of success, and failure, in working stakeholders and what are proposed solutions?
- What are the next priority topics, timelines, and opportunities for CMS?

End: George Hurtt
Next: Ken Jucks

HQ Welcome
CMS Applications Workshop

Ken Jucks

One of the CMS Program Scientist

NASA HQ

CMS and End Users

- CMS was implemented with “End Users” in mind. We were directed in appropriations language to design a prototype “System” for monitoring “Carbon”.
- Who ARE these “End Users”, at least in NASA’s mind?
  - People other than Earth Science researchers answering Earth Science “questions”.
  - That means 99.99999% of the US!
  - Needs and uses will vary MUCH more than that of researchers.

What's the future of CMS

- CMS activities are planned to remain in the NASA budget in the next 5 years.
  - That's as far out as we plan, budget-wise. Kind of like the USSR…
- The next CMS ROSES solicitation is being written now.
- As far as we know, there is no NEW guidance in appropriations bills for NASA regarding CMS.
- The satellite phase-space has changed since the last time we met.
  - OCO-2 has launched and has 1 year of data.
  - GEDI and ECOSTRESS were selected in EVI-2!
  - ACT-America, AToM were selected in EVS-2!
  - OCO-3 MAY get back in NASA's budget.

Who's who @ HQ **today**?

- Ken Jucks, Program Manager UARP and Program Scientist for Aura, OCO-2, OCO-3, CLARREO, ASCENDS, CMS, ATTREX, CARVE, ACT-America, GSFC-DISC…
- Hank Margolis, Program Manager Terrestrial Ecology, ABoVE, in process of taking over GEDI PS soon…, co-PS with Ken on CMS.
- Kathy Hibbard, IPA working with Hank, and doing alphabet soup stuff with Jack Kaye. Co-PS with Ken and Hank on CMS
- Paula Bontempi, Program Manager for Ocean Biology and Biogeochemistry, now Carbon Cycle & Ecosystems Focus Area Lead, PS for MODIS, PACE, and S-NPP.
- David Considine, Program Manager MAP, Program Scientist for CERES, CloudSat, CALIPSO
- Lawrence Friedl, now the Associate Director of Application Science. Brad Doorn has been engaged in Applied Science relative to CCMS.

AND…

- Make GOOD one page descriptions of science results from CMS!!!!
  - I need them!!!
  - My bosses need them!!!
  - The future budget of CMS needs them!!!
- Hence…
  - **YOU** need them!!!

End: Ken Jucks
Next: Vanessa Escobar

CMS Applications Activity and Stakeholder Engagement

Implementing CMS into policy and decision support

CMS Applications Workshop 2014

The breakout sessions were divided into sub-national, national, and international scales and oceans MRV. The questions that were asked during the session included:

- *What are the specific stakeholder needs that could potentially be addressed by current or future CMS data products?*
- *What actions can stakeholders take with NASA to evaluate and/or incorporate CMS data products into decision making?*
- *What are the main challenges to expressing uncertainty for each theme?*

Stakeholders Present Last Year

- ***Maryland Department of Natural Resources***, *Presenter: Rob Feldt "Current and Potential Uses for CMS Products in Maryland Forest Management and Policy"*
- ***California Air Resources Board***, *Presenter: Bart Croes "Data Needs for California's Air Quality and Climate Policies"*
- ***Sonoma County Agricultural Preservation and Open Space District***, *Presenters: Karen Gaffney and Tom Robinson "Climate and Conservation: Tools and data at the scale of land use decision-making*
- ***Asia-Pacific Program at USDA Forest Service***, *Presenter: Kent Elliott "The Carbon Stocks and the OneMap of Indonesian Peatlands"*
- ***Ocean Conservancy***, *Presenter: Sarah Cooley "Informing Decision Making about Ocean Acidification"*
- ***U.S. Environmental Protection Agency***, *Presenter: Leif Hockstad "Policy End Users and CMS Project Collaborations"*
- ***U.S. State Department***, *Presenter: Christine Dragisic "Linkages between U.S. Climate Policy and Carbon Science"*

Recommendations

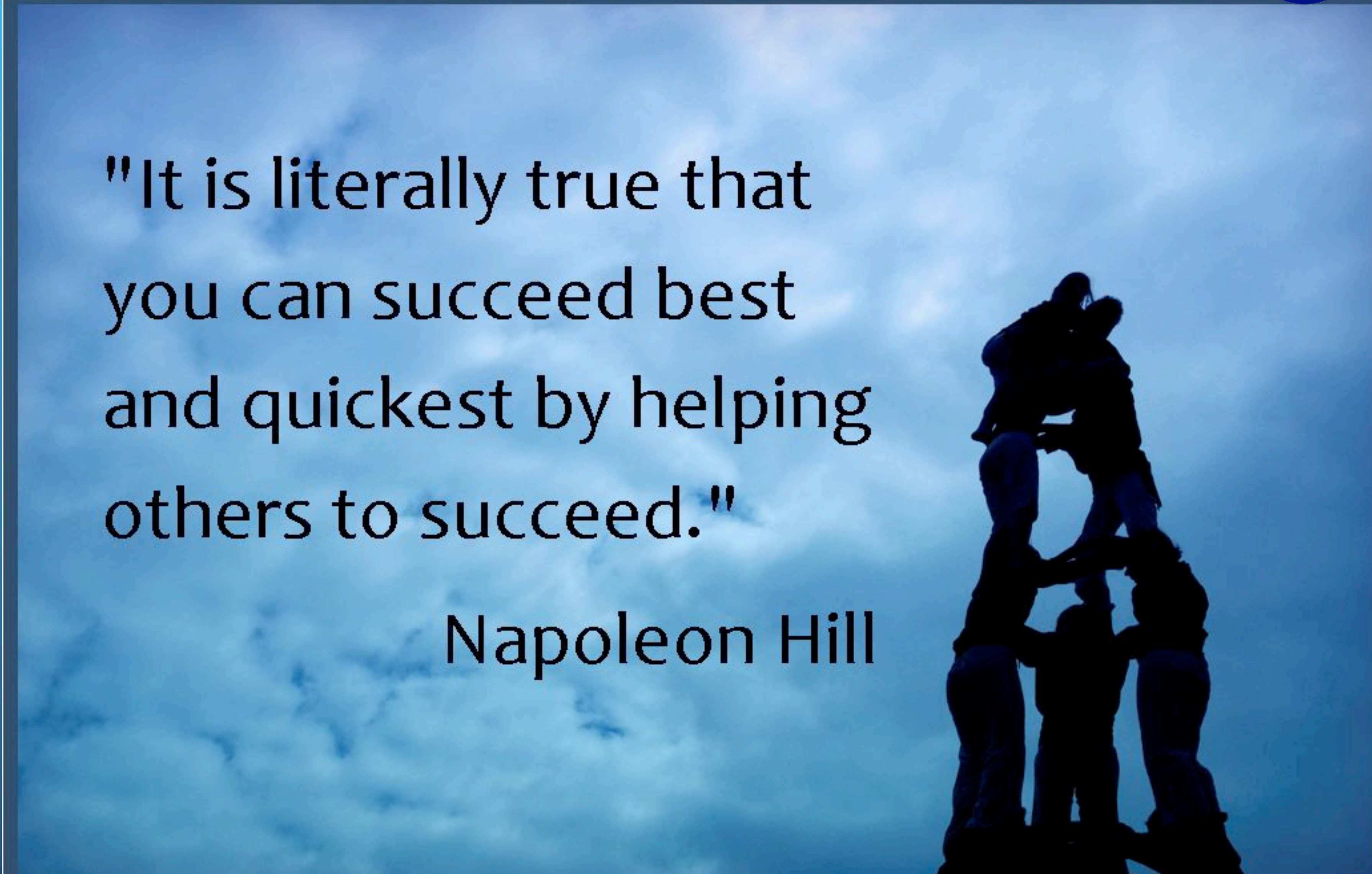
- Recommendations to Define an MRV for the CMS (emailed)
- Provide examples/context of where CMS product might be tied to stakeholder decisions and policies (emailed)
- Fit the products to the appropriate time line of policy and decisions. Need 6 month to 1 year lead time (action for today)
- Continue engagement and move beyond academia and federal government (your feedback needed!)

Actions Taken

- Updated Information: ARLs, Fact Sheets, policy time frames (documents in folder and on registration table, online)
- Reached out to more Stakeholders and presented products most relevant to them and their organization
- Used the Policy Series as a mode of communication and data gathering for the CMS (online)

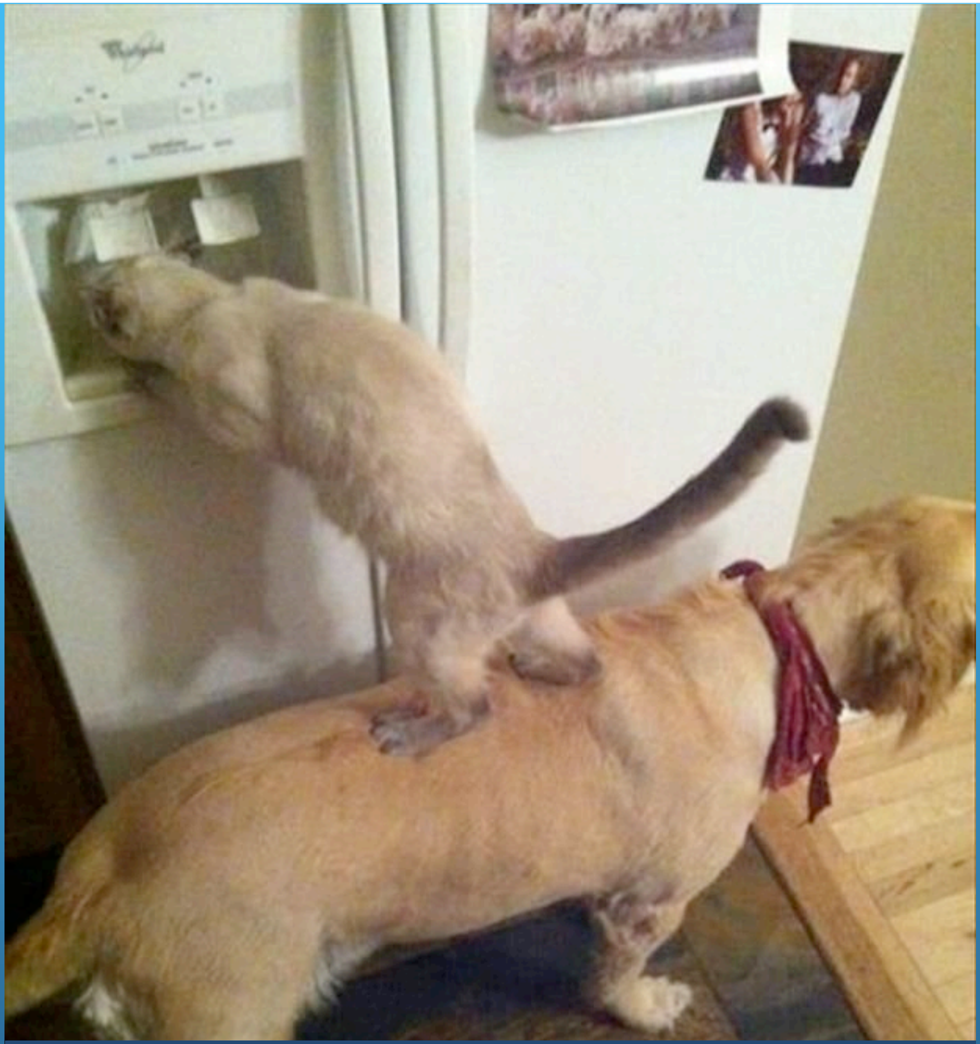
Current Engagement

- **EPA→** Informing Inventory reports through CMS projects and EPA/CMS advisory group (set up last month!)
- **USGS 3DEP→** Providing 3DEP a collection of all LiDAR products in support of the national program. http://nationalmap.gov/3DEP/
- **AB32** (California Global Warming Solutions Act of 2006)→facilitating the use of LiDAR through the Sonoma County Conservation. http://www.arb.ca.gov/cc/ab32/ab32.htm
- **Chesapeake Restoration Program→** merging information for the region and working with partners at the state level.
- **RGGI→** discussing membership with state departments


"It is literally true that you can succeed best and quickest by helping others to succeed."
Napoleon Hill

Today

- *Identify policies that need information*
- *Identify the time line for action*
- *Identify stakeholders and partners for the CMS*
- *Identify case studies for future CMS work-where can we demonstrate how CMS supports policy and decisions.*
    - *(RGGI, EPA, AB32, MD Forest Policies)*

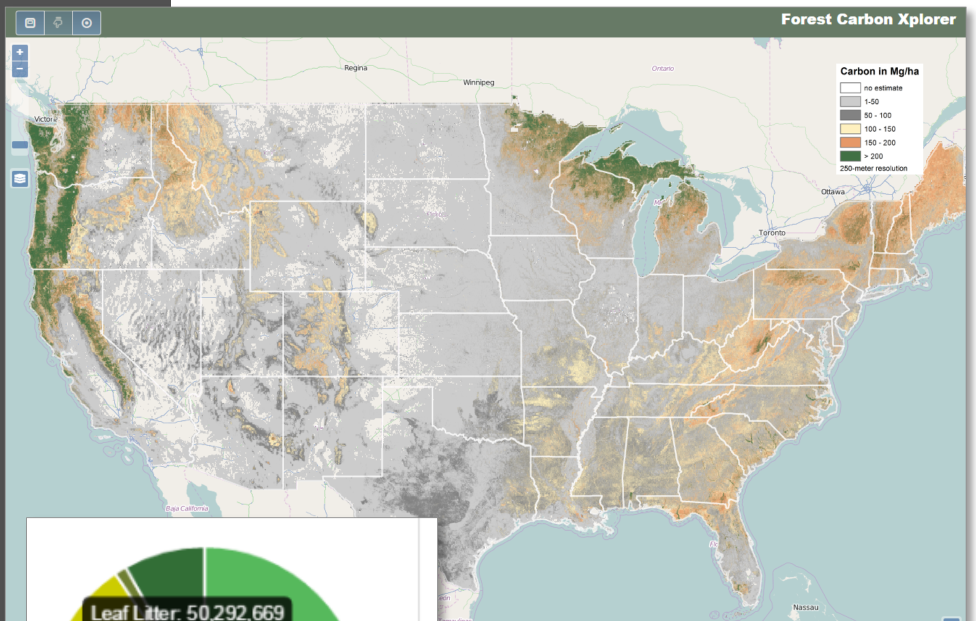


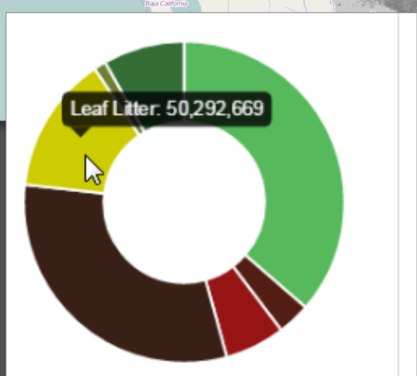
HAVE A GREAT MEETING!!

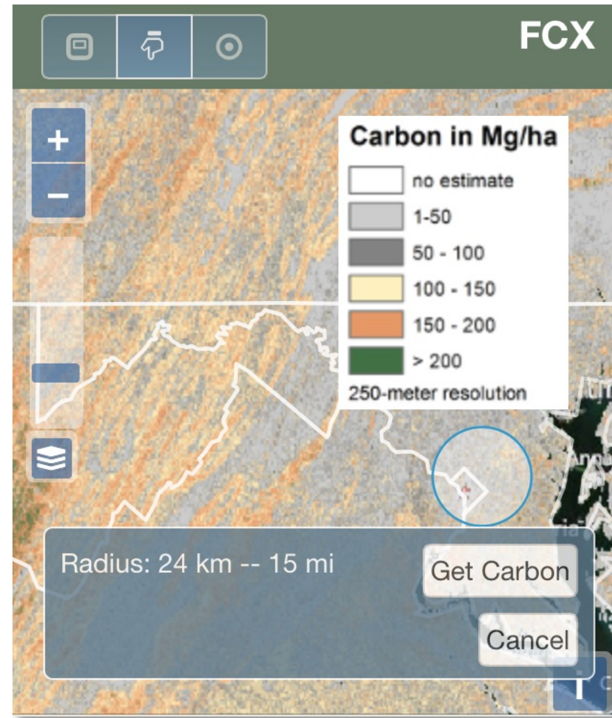
End: Vanessa Escobar
Next: Ian Hanou

FCX: *the Forest Carbon Xplorer App*

CMS Workshop: November 2015







http://forestcarbonx.umn.edu/

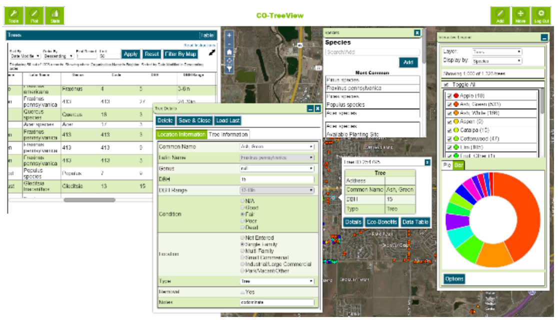
Presented by:

Ian Hanou, Owner/Principal, Plan-It Geo

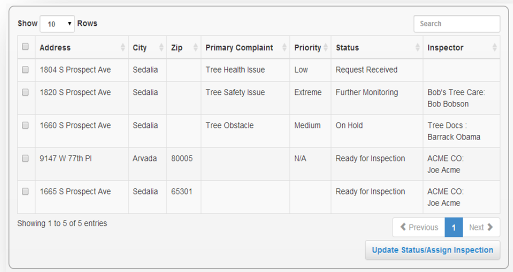
<u>During the talk</u>:
- What is your work? What are the decisions that you make in your work? ** Forest-related tools/techs; strategic tree planting for multiple goals/outcomes
- Are these internal/organizational decisions, or are they policies you are required to respond to? ** both
- What is the timeline for these decisions? ** N/A
- Which data do you already use to make decisions? ** FIA, land cover, i-Tree ecosystem services, census, GIS, LiDAR

Urban Forest Cloud Software

Tree Plotter®



Work Order Management®



Show 10 Rows

	Address	City	Zip	Primary Complaint	Priority	Status	Inspector
	1804 S Prospect Ave	Sedalia		Tree Health Issue	Low	Request Received	
	1820 S Prospect Ave	Sedalia		Tree Safety Issue	Extreme	Further Monitoring	Bob's Tree Care: Bob Bobson
	1660 S Prospect Ave	Sedalia		Tree Obstacle	Medium	On Hold	Tree Docs : Barrack Obama
	9147 W 77th Pl	Arvada	80005		N/A	Ready for Inspection	ACME CO: Joe Acme
	1665 S Prospect Ave	Sedalia	65301			Ready for Inspection	ACME CO: Joe Acme

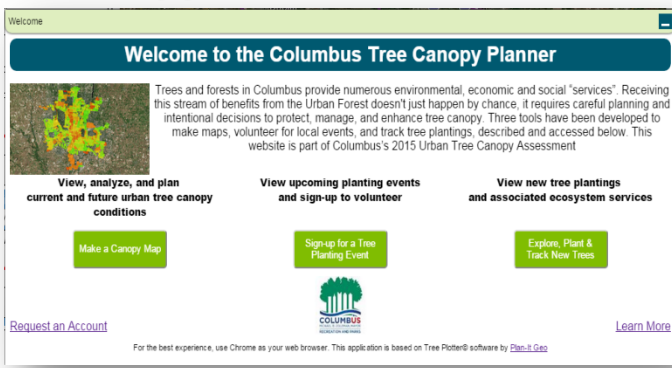
Showing 1 to 5 of 5 entries

Previous 1 Next

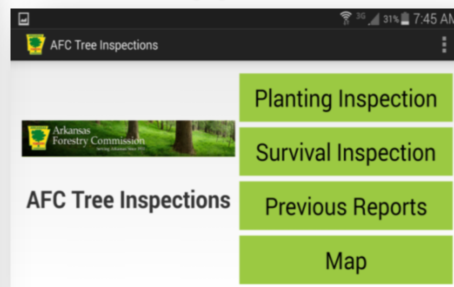
Update Status/Assign Inspection

Park Plotter®

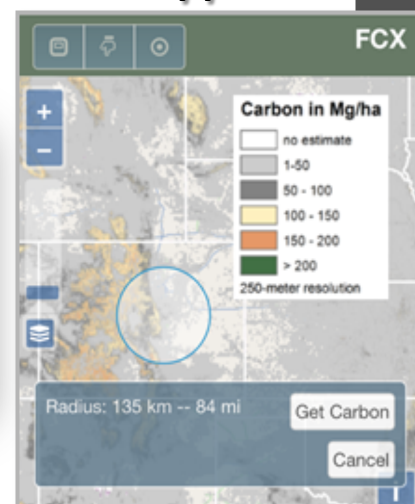
Canopy Planner®



Native Apps



Custom Apps



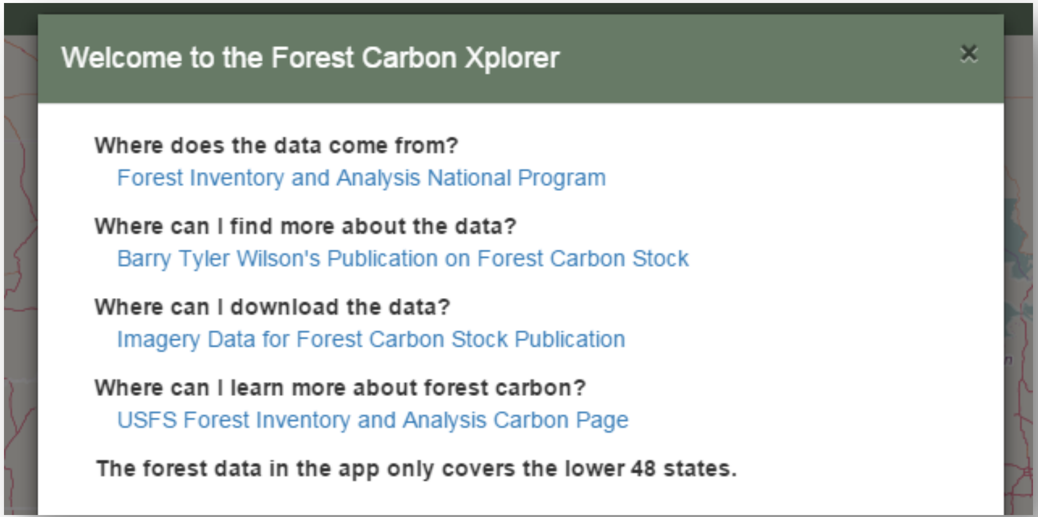
Project Background

- Funding from US Forest Service and University of Minnesota
- A simple app for smartphones, tablets, and desktop use to explore the extent and value of the nation's forest carbon
- <u>Methods</u>: by GPS location, by county (in map or in tables), and by radius (draw in map)
- <u>Outputs</u>: charts, graphs, tables of carbon (tonnes/$s)

Project Background

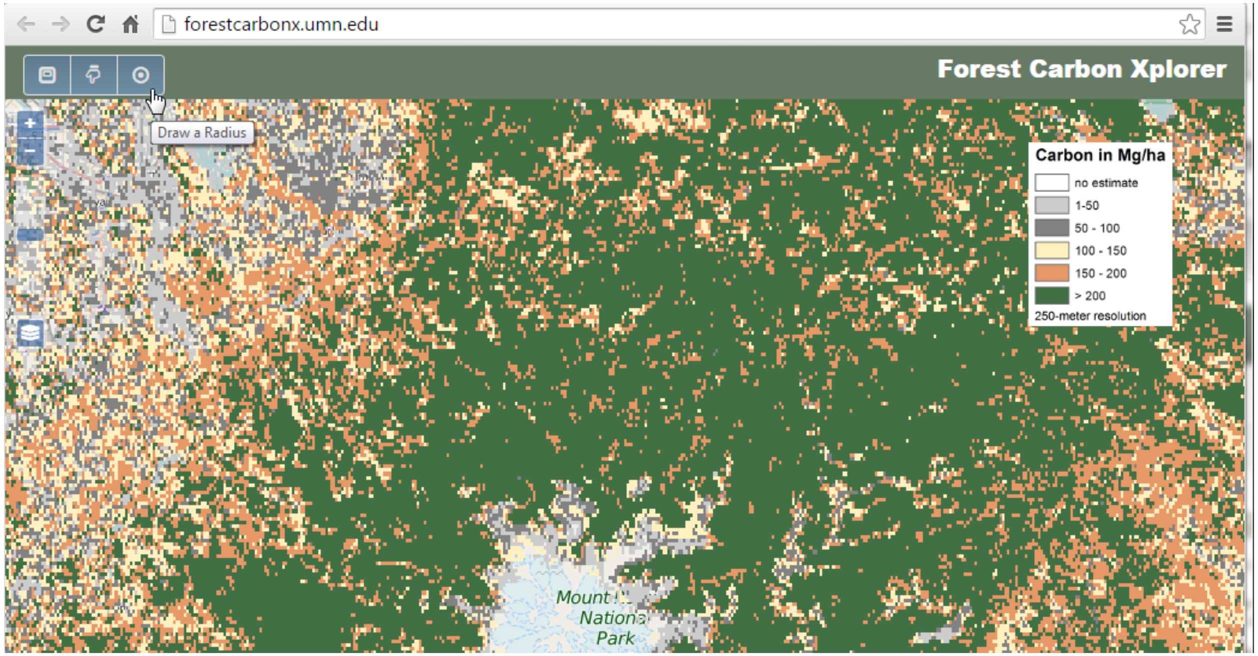
❖ <u>Resources</u>:

- ✓ <u>Forestry Research</u>: http://www.cbmjournal.com/content/8/1/1
- ✓ <u>Data</u>: http://www.fs.usda.gov/rds/archive/Product/RDS-2013-0004
- ✓ EPA GHG Equivalencies Calculator
- ✓ Interagency Working Group on Social Cost of Carbon (2013)
- ✓ State of CA Air Resources Board
- ✓ http://www.fia.fs.fed.us/



About the Data

- ❖ USFS Forest Inventory and Analysis (FIA): systematic inventory of forests for primary source of national statistics and supports informed forest management
- ❖ Data analyzed to provide wall-to-wall spatial GIS rasters of forest carbon estimates by pool (lower 48 states)



Introduction
Background
Technologies
Get Carbon
Reports & Values
What's Next?
Questions & Credits

About the Data

❖ 7 individual carbon "pools" and total (8 rasters), 250m res.

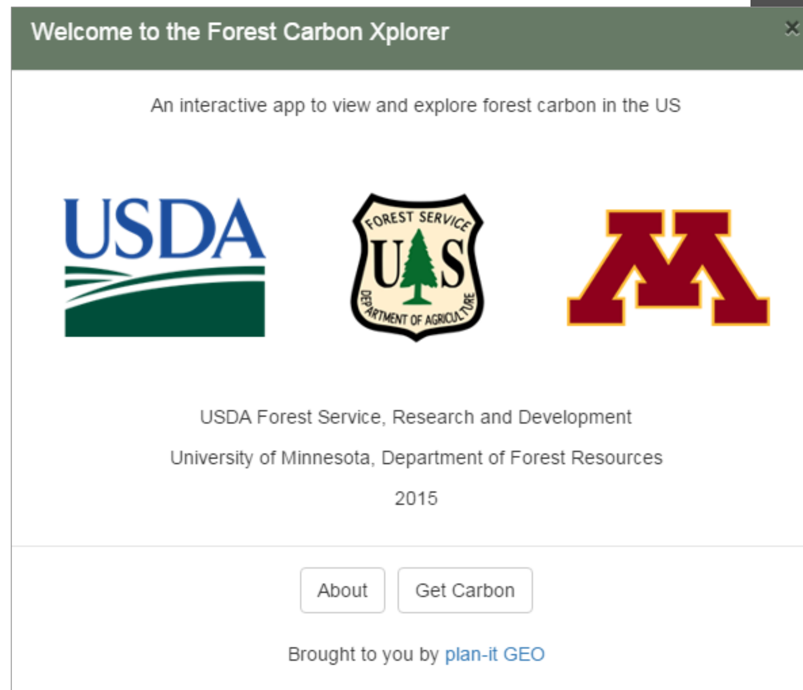
Definitions of Carbon Pools

Aboveground live tree	Live tree carbon that is above ground
Belowground live tree	Live tree carbon that is below ground
Understory vegetation	Carbon in the living vegetation that is not considered a tree, both above and below ground
Standing dead tree	Biomass in standing dead trees
Forest floor	Detritus on the forest floor including leaves, decaying material, and fine twigs
Downed dead wood	Dead wood that is lying on the ground such as logs
Soil organic carbon	Carbon in mineral soils

Technologies and Requirements

plan-it GEO

- Web browser-based
  - ✓ Web connection required
  - ✓ Some offline capability
  - ✓ No download/install
- Technologies:
  - ✓ Open Layers API
  - ✓ PostgreSQL / PostGIS
  - ✓ GeoServer
  - ✓ Responsive JS libraries
  - ✓ Red Hat Linux (UMN)
  - ✓ HTML5, CSS, etc.



“Get Carbon”

Introduction

Background

Technologies

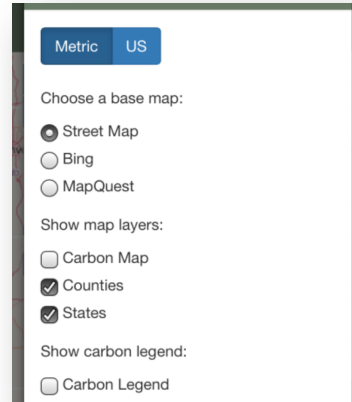
Get Carbon

Reports & Values

What’s Next?

Questions & Credits

-
- ✓ Wizard
- ✓ By GPS location
- ✓ By county (in map)
- ✓ By county (in tables)
- ✓ By radius (draw in map)



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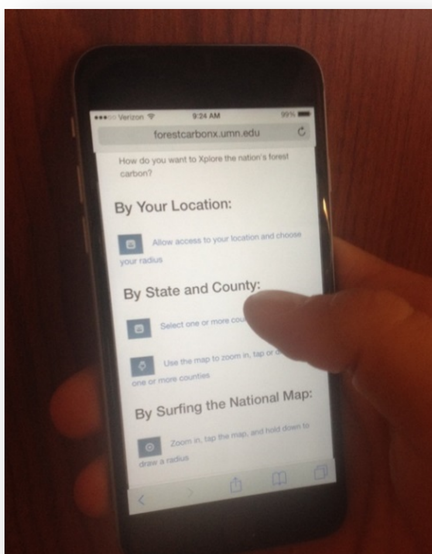
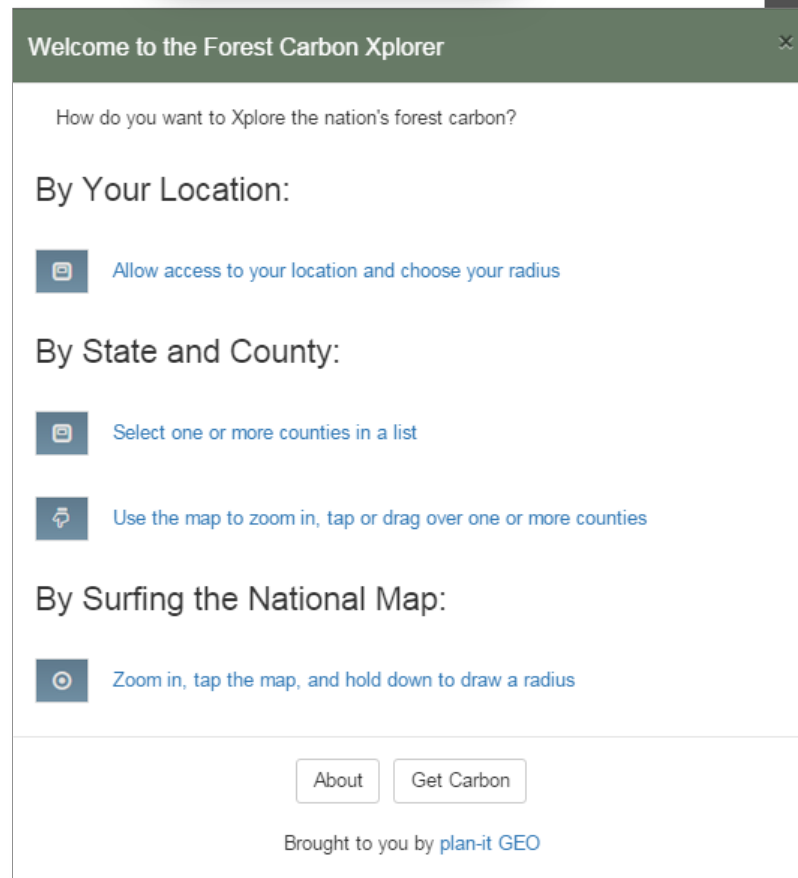
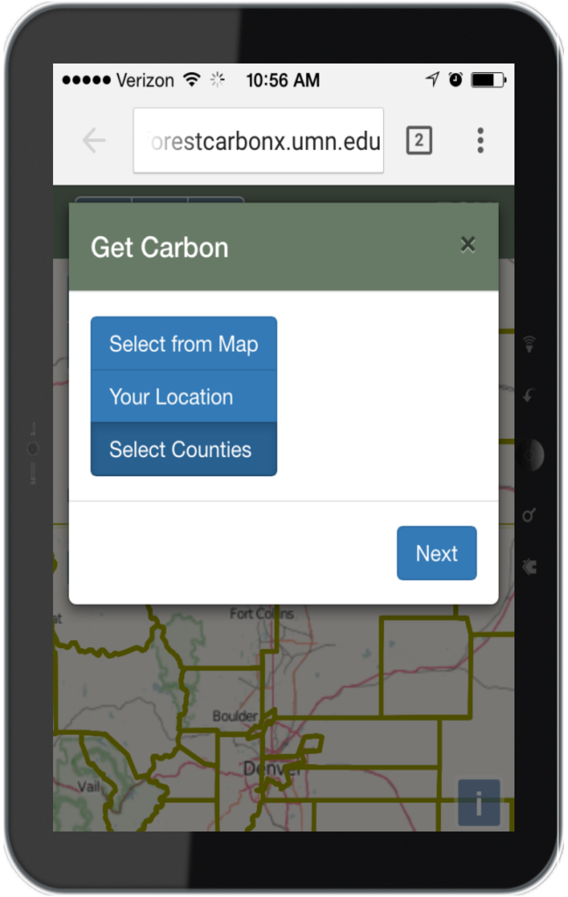
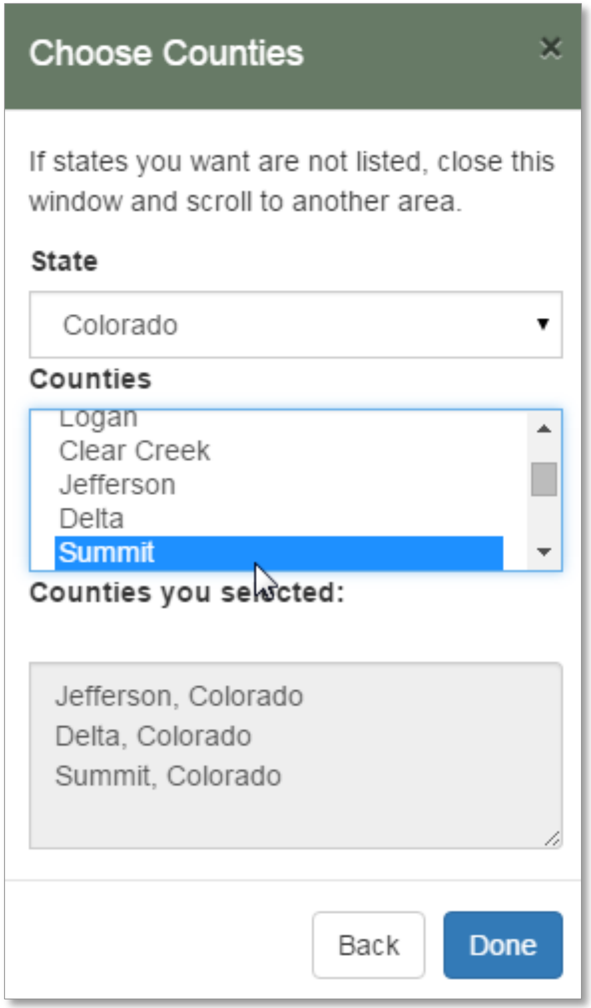


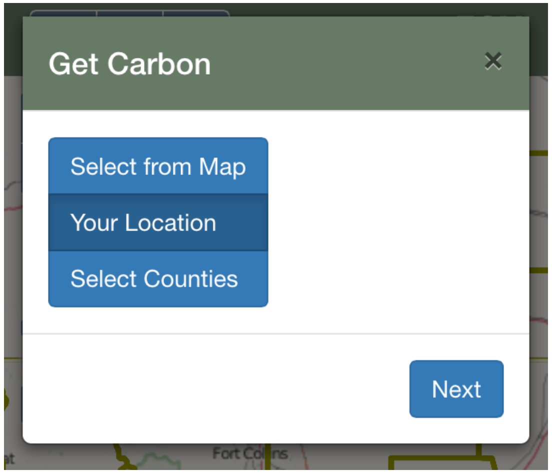


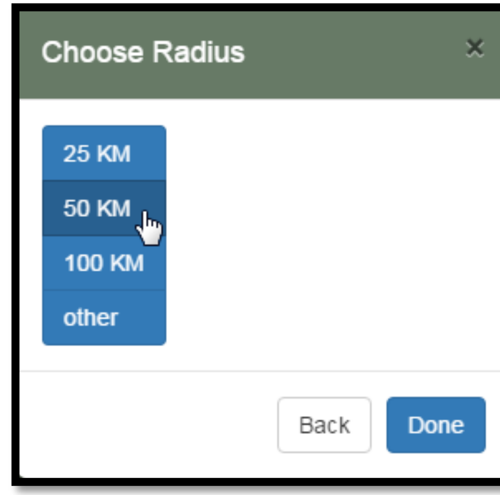
"Get Carbon" by County (via the Wizard)

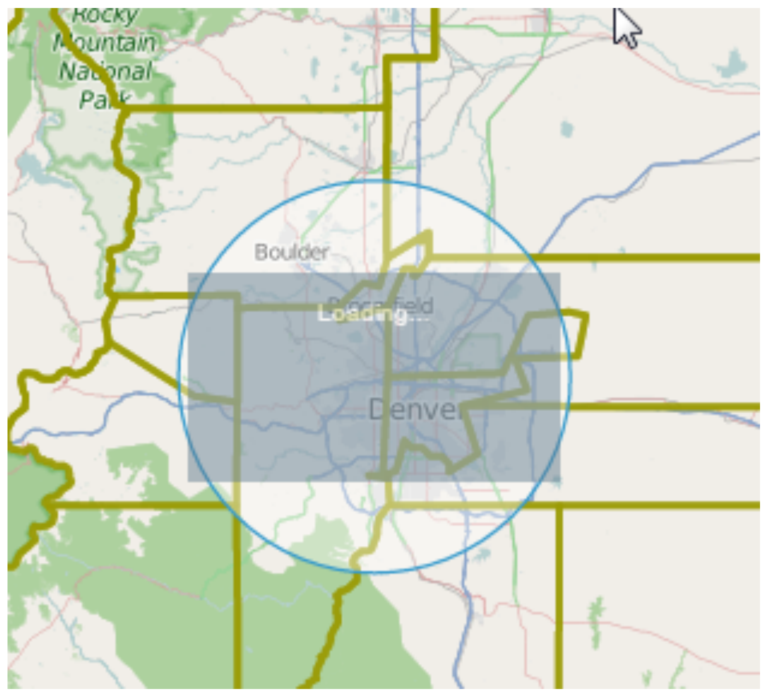




"Get Carbon" by Location (via the Wizard)







"Get Carbon" (by County in map)

plan-it GEO

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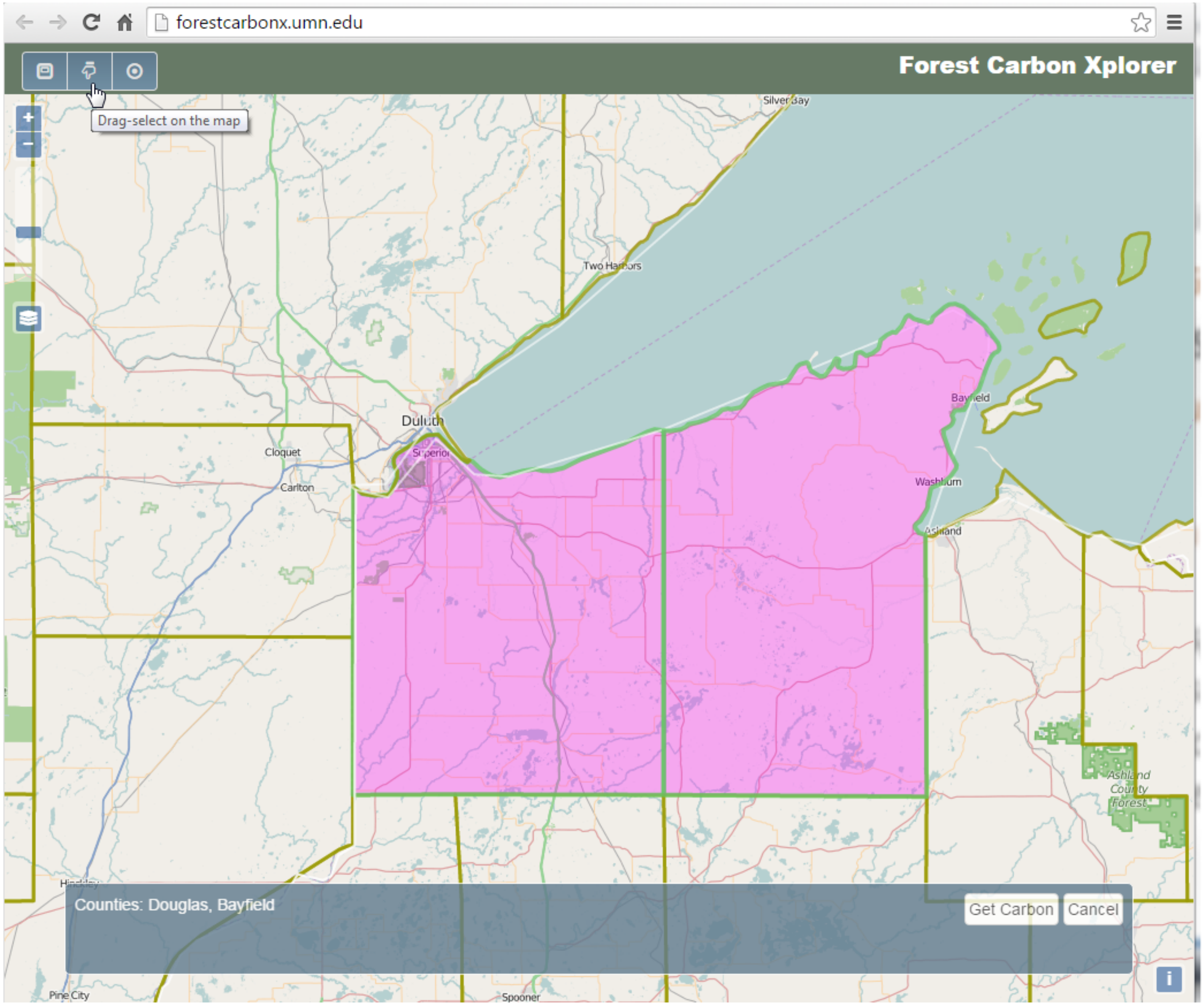
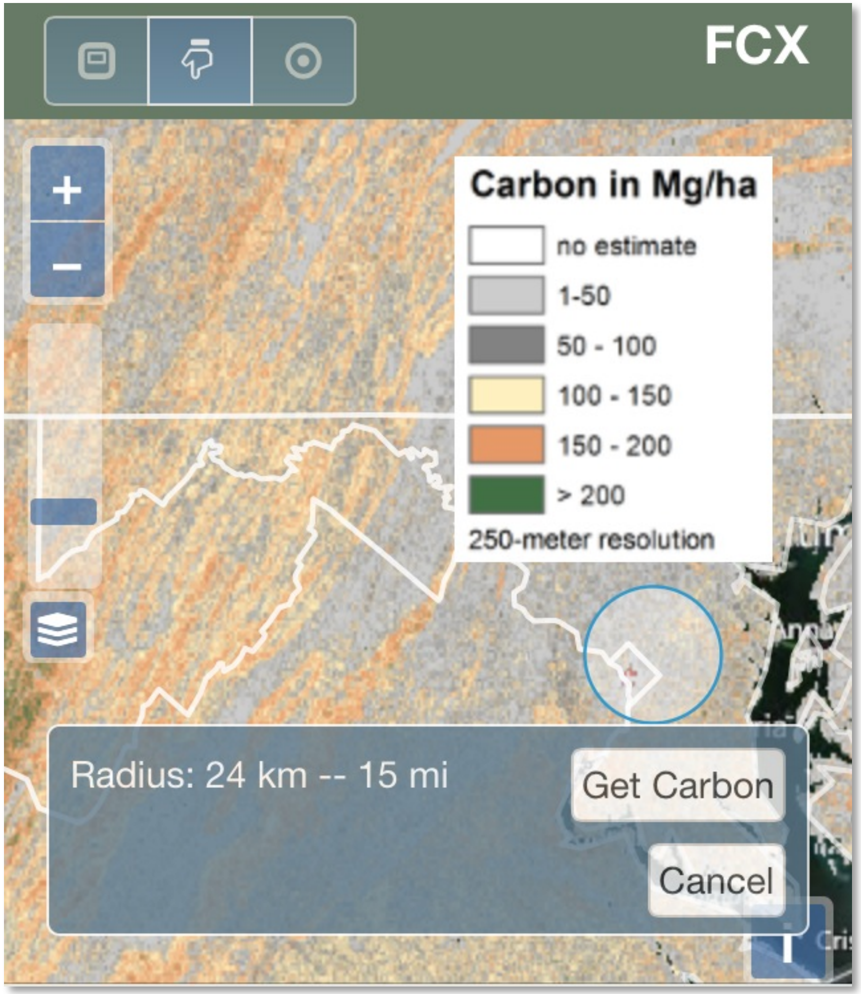
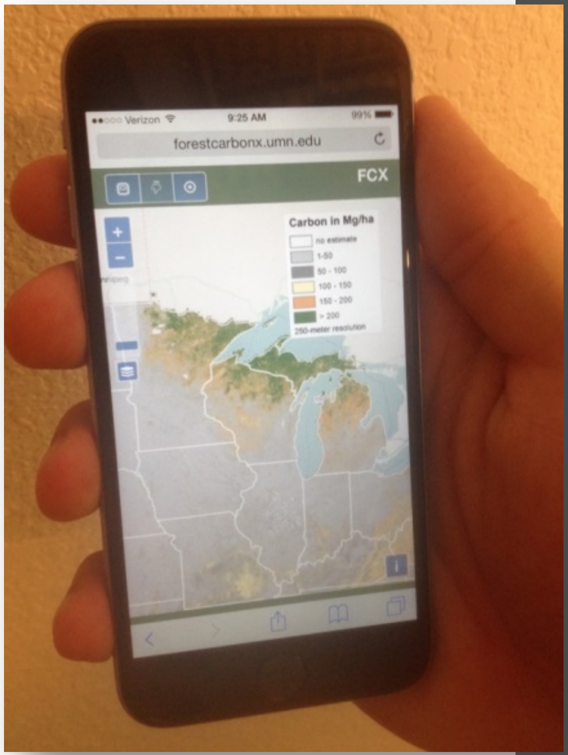
What's Next?

Questions & Credits



“Get Carbon” (draw radius in map)





Reported Carbon Values (tons)

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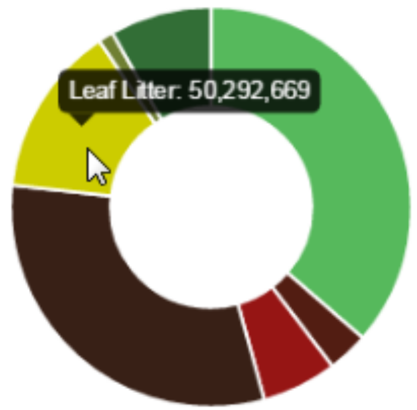
Carbon Summary

Amount | Value | Equal To

Total: 363,505,993 Tonnes (Metric) of carbon across 1,876,820 ha of land

Carbon Source	Density per hectare	Tonnes
Aboveground live tree:	70.3968	132,122,186
Downed dead wood:	11.7345	22,023,585
Standing dead tree:	6.4073	12,025,281
Soil organic carbon:	60.1075	112,810,901
Forest floor:	26.7967	50,292,669
Understory vegetation:	2.3575	4,424,637
Belowground live tree:	15.8814	29,806,544



Reported Carbon Values ($)

plan-it GEO

Carbon Summary

×

Amount | Value | Equal To

Carbon Value

$50,647,290,005

Social value of carbon: the economic damages associated with an increase in carbon dioxide (CO2) emissions in a given year.

$1,344,972,174

Market-based value of carbon: Economic value of forest carbon based on current market conditions.

How are these values arrived at?

Social value of carbon is based on information in a 2013 White House paper.

Market-based value of carbon is based on a California Air Resources Board auction in 2014.

Reported Carbon Values ("Equivalents")

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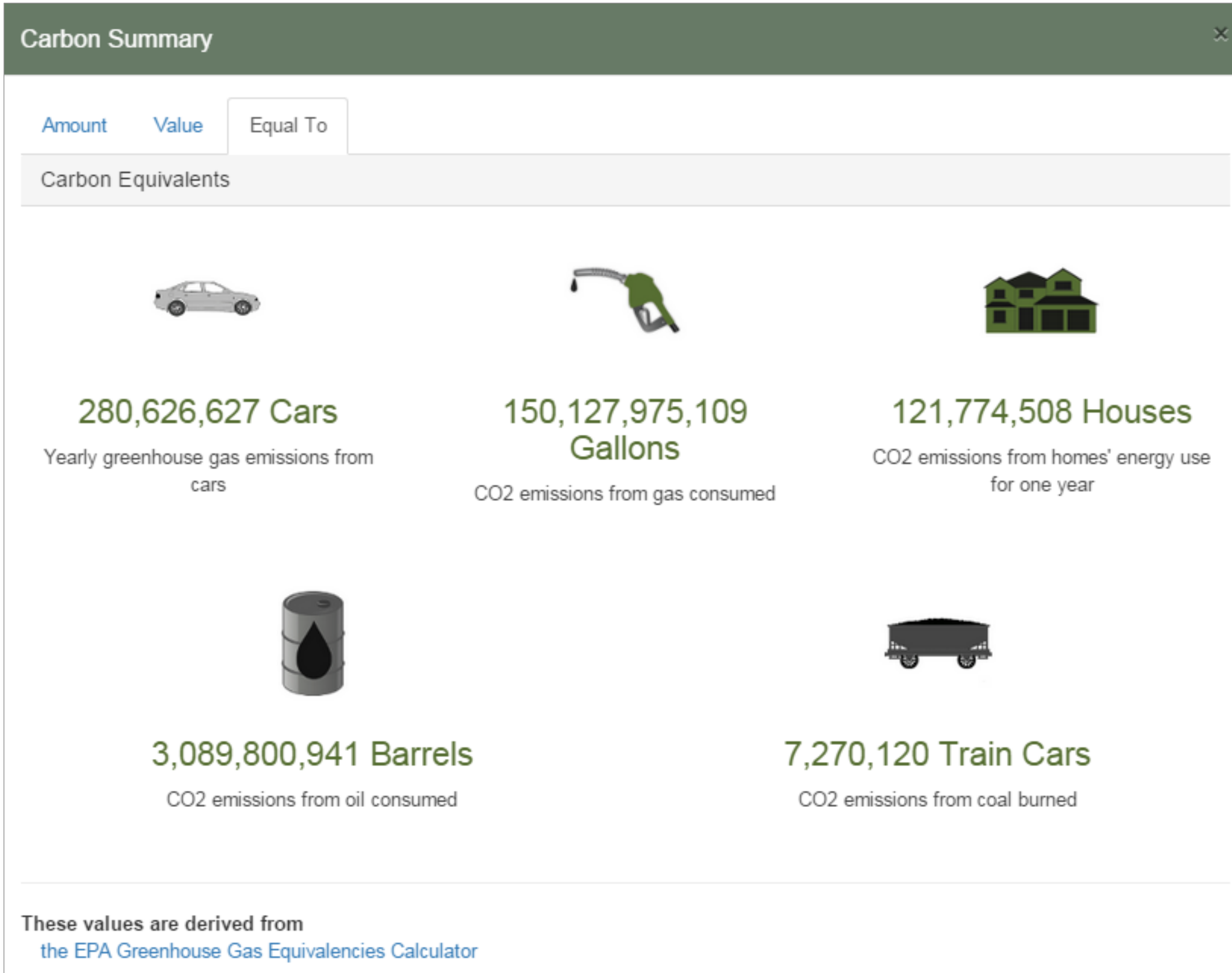

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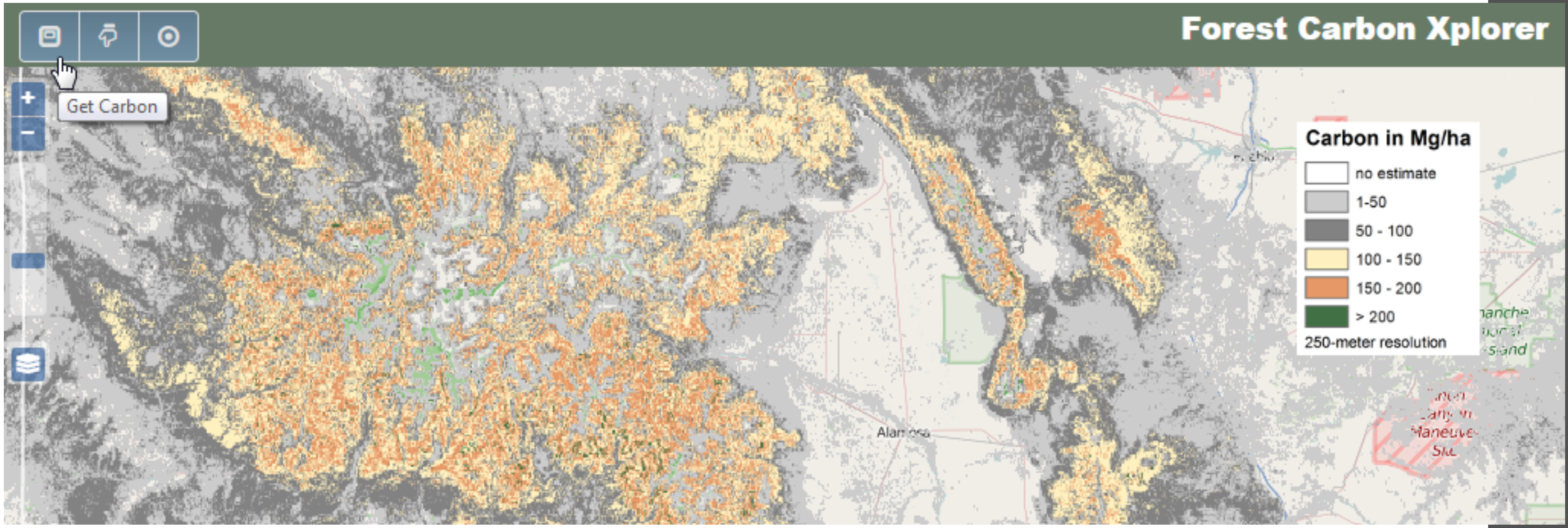
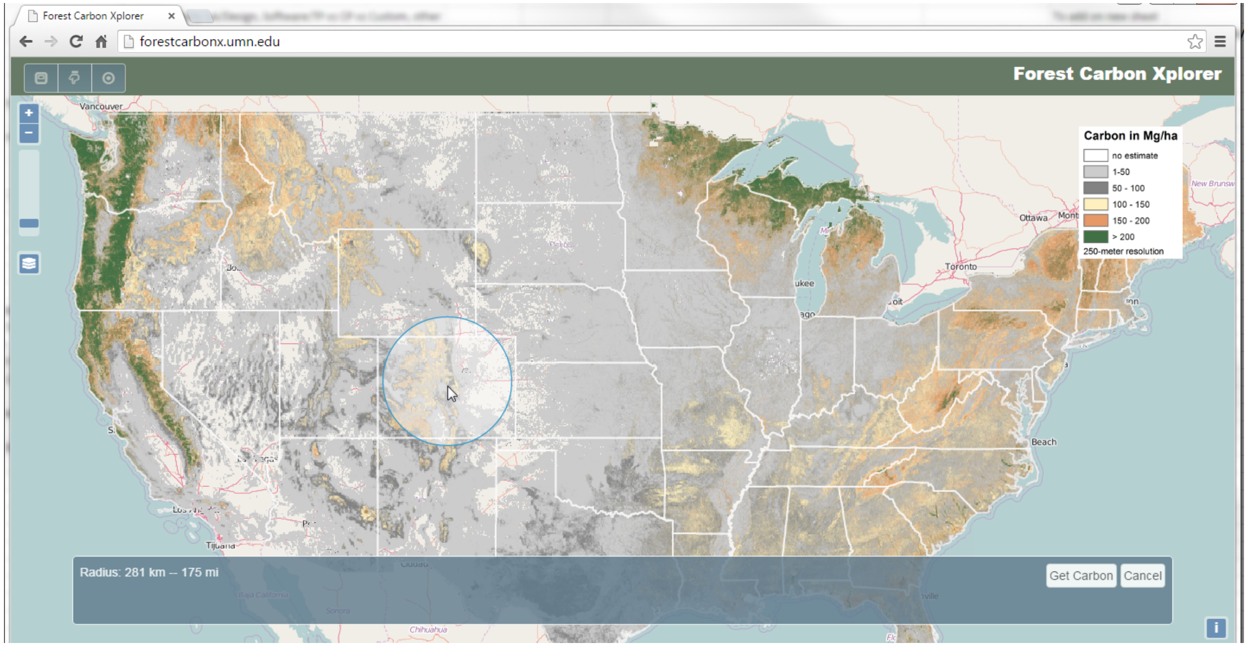
Where to Now?

- Export/save/print forest carbon reports
- Separate rasters for each carbon pool
- Show trends/changes based on fires, pests, etc.
- Other metrics displayed/summarized in 'focused' apps
- Xplore … ***Go "Get Carbon"!***



Parting Thoughts

- A baseline to compare your field estimates to
- Not supplant what we're measuring on the ground
- Research products, enable user access
- Expands on county tables and FIA "e-Validator tool" with spatial outputs
- New paradigm: phone → GPS location → forest attributes



<u>In Closing</u>:

- What C science info (e.g. biomass, canopy cover, flux estimates, ocean biomass, etc.) do you need/want for your org's decision framework? ** we're not making decisions but applying data in tools/models
- What timeframe, spatial scale, and frequency of data updates? ** depends on thee project or app/tool
- When/how should the C science info be delivered? ** diverse interactive ways for tech and non-tech users
- ***Are there any CMS products that you would like to learn more about?*** ** TBD/UNK

Acknowledgements

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What's Next?

Q's and Credits

Collaborators:

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Thank you | Questions?

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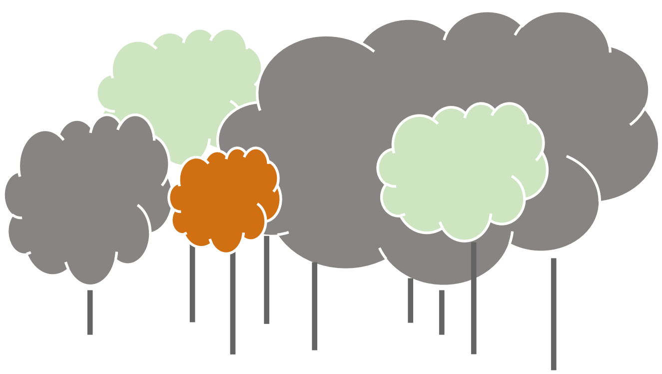

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End: Ian Hanou
Next: Mark Trice

Image: NASA MODIS

Local-Scaled Ocean Acidification Monitoring Efforts

Mark Trice
Program Manager

Water Quality Informatics
Maryland Department of Natural Resources

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Chesapeake Bay Watershed

Map from http://earthobservatory.nasa.gov/

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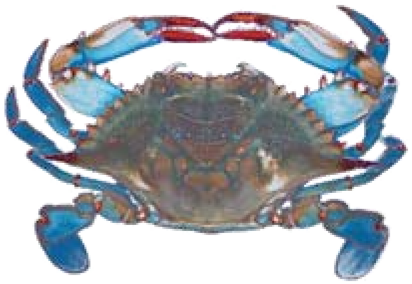
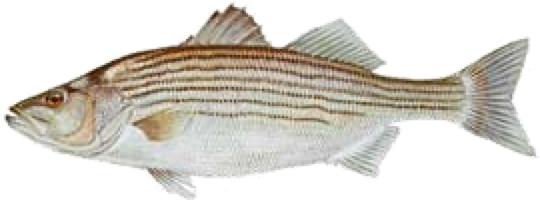
Maryland DNR's Tidal Water Quality Mission

- Monitor ambient water quality conditions to assess habitat for living resources in Maryland's Chesapeake and Coastal Bays


- Historically, efforts have focused on measuring sediments and nutrients (nitrogen & phosphorus) and their impacts on habitat (low dissolved oxygen (hypoxia), water clarity for aquatic grasses, and primary productivity (algal concentrations).

- Data informs research, modeling, restoration, management, event response, and public outreach

- Impacts of acidification are just starting to be considered and monitoring, other than pH, is sparse.

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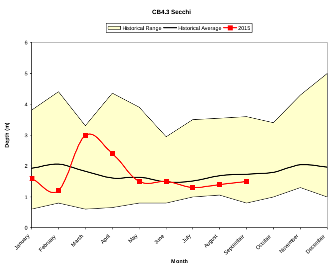
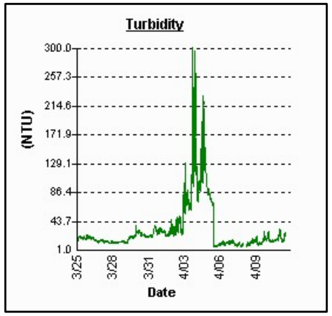
Maryland DNR Water Quality Monitoring Programs



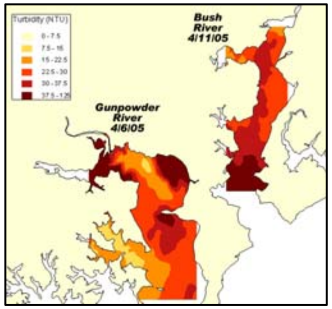
Long-Term Fixed Station Monitoring

- Monthly/Twice Monthly cruises year round
- Collected Since 1985
- 80+ Stations
- Full suite of parameters and depth profiles



Continuous *In Situ* Monitoring

- 30-50 monitors deployed annually
- Water quality monitoring at 5 NOAA buoys
- Vertical Profilers (1 DNR / 1 NOAA)
- Data collected every 15 minutes
- Parameters: D.O., Turbidity, Chlorophyll
  W.Temp, Salinity, pH, Depth
- Calibration Data Every 2 weeks



Water Quality Mapping

- Monthly cruises Apr.-Oct over large areas.
- Surface data collected every 4 seconds
- Parameters: D.O., Turbidity, Chlorophyll
  W.Temp, Salinity, pH, Water Depth
- Calibration Data at ~5 Sites each Cruise

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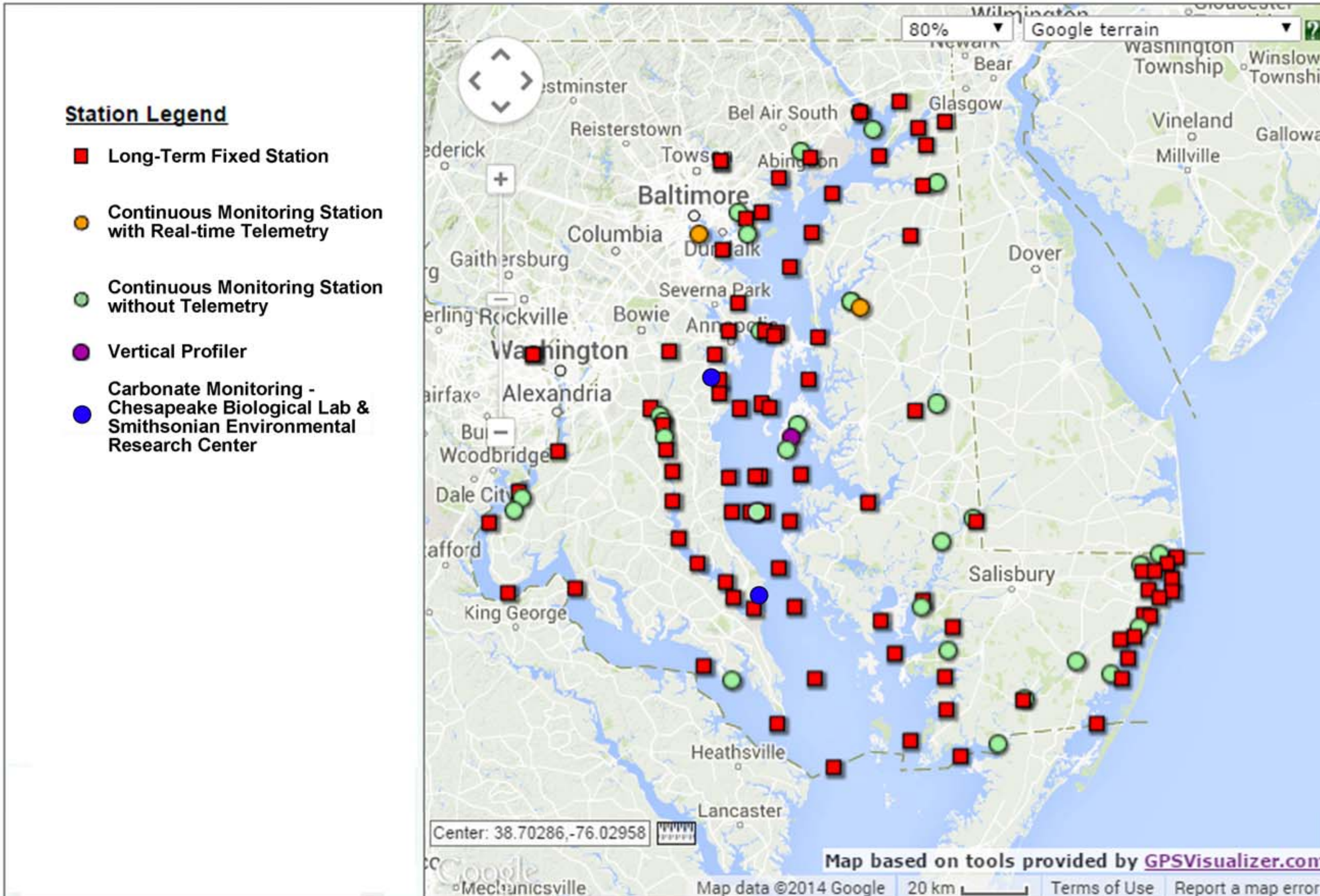
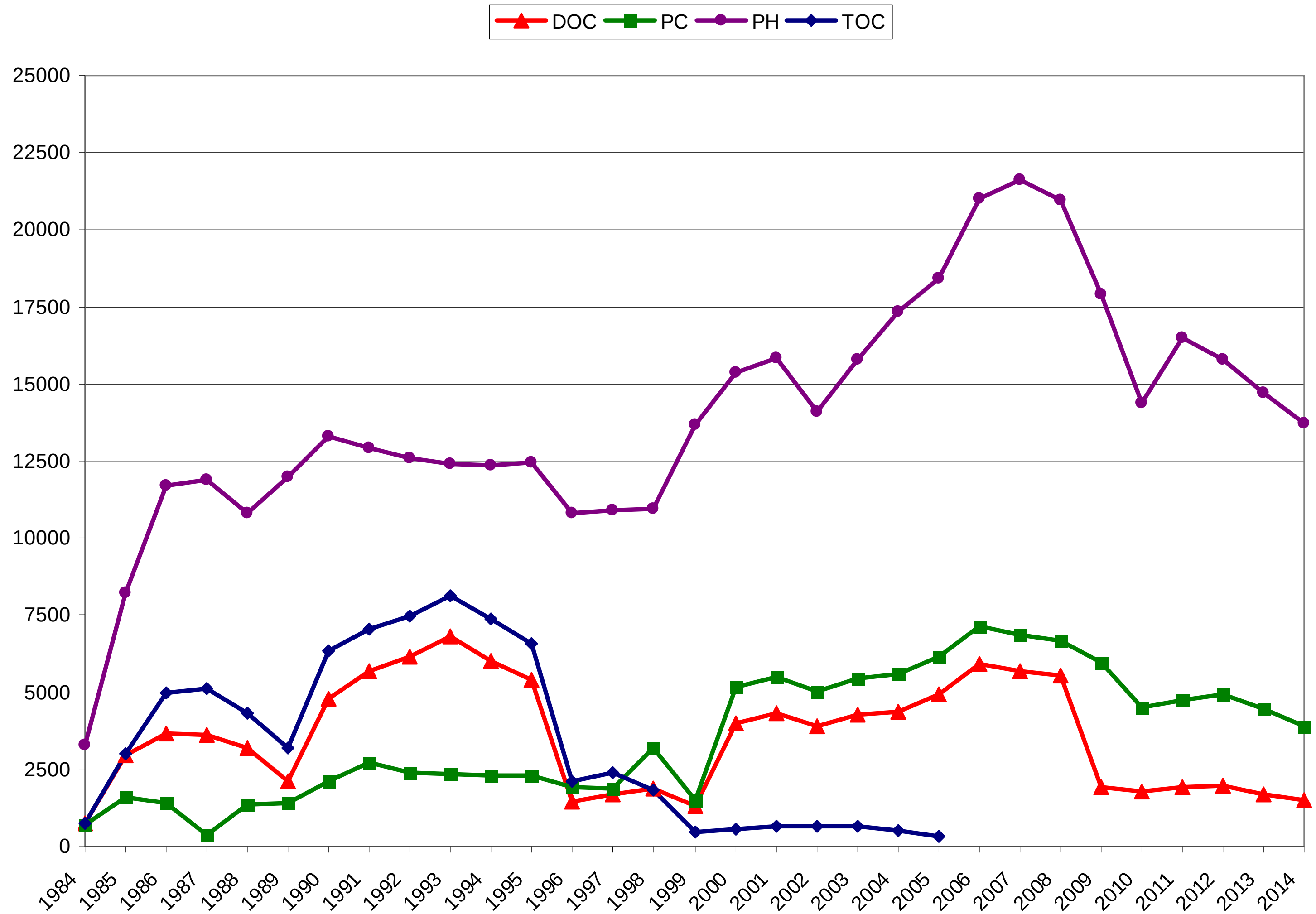
Maryland DNR Long-Term and Continuous Monitoring and CBL/SERC Carbonate Monitoring Sites



CBL = University of Maryland Center for Environmental Science – Chesapeake Biological Lab
SERC = Smithsonian Environmental Research Center

Annual Measurements of Select Parameters at In Situ Sites



Totals:

DOC: **111,306**
PC: **111,731**
pH: **433,738**
TALK: **39,292**
TOC: **74,553**

Continuous Sonde pH Measurements:
~11.5 Million

WQ Mapping pH Measurements:
~ 4.75 Million

DOC = Dissolved Organic Carbon
PC = Particulate Carbon
TOC = Total Organic Carbon

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Maryland Ocean Acidification Task Force

- Convened in 2014, with a final report in January 2015
  http://msa.maryland.gov/msa/mdmanual/26excom/defunct/html/27oceanacid.html

- Seven key findings were reported:
  1. Maryland needs to enhance monitoring to quantify OA scale, patterns, and trends
  2. Establish additional research priorities in estuarine and coastal waters
  3. Improve coordination with other states and federal resource managers
  4. Focus on impacts to key species and associated activities
  5. Provide direct support to affected industries
  6. Pursue legislative action
  7. Improve communications and outreach

- Possible impacts to key aquatic species was reviewed

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Impacts to Key Species

Oysters:

Alters metabolism, growth, survival and resistance to environmental stressors, such as low dissolved oxygen and disease. Can alter the rate of reef building and maintenance.

Blue Crabs:

Few studies on blue crabs, which have a varied life cycle in marine and estuarine waters. Greater bicarbonate (HCO_3^-) availability could increase calcification rates for crabs. Larvae would be more exposed to pCO_2 due to their life cycle

Striped Bass:

Acidification could impact larval survival and affect otoliths, which are vital structures for fish orientation and sensing.

Submerged underwater grasses (SAV):

Increased CO_2 could increase growth, but higher temperatures could negate or supercede any effects.

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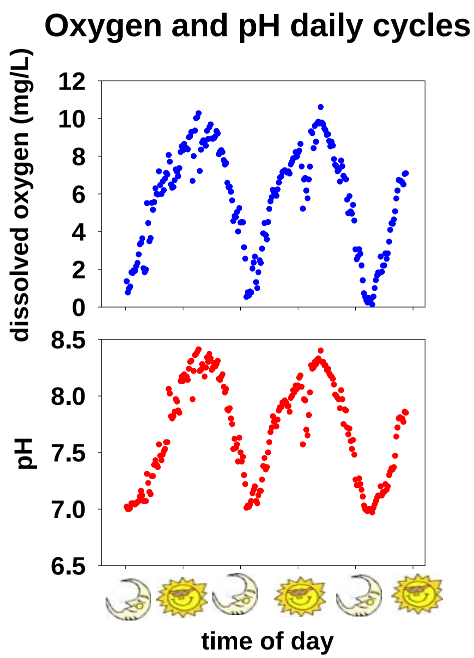
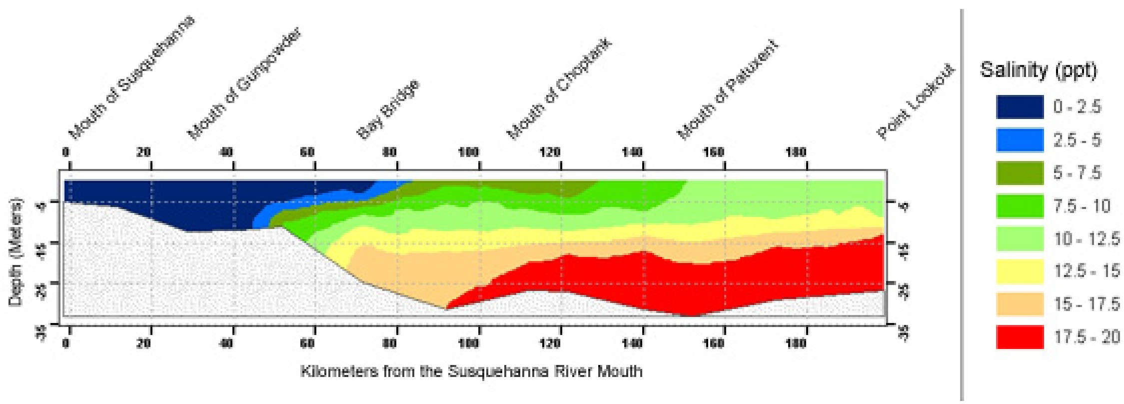
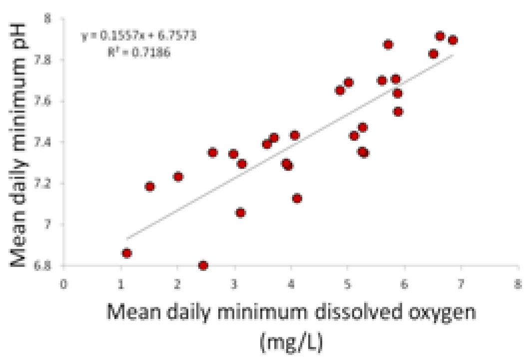
The Complexities of Monitoring Acidification in Coastal Waters

- Hypoxia is a large contributor of CO_2
- Large diurnal swings in pH
- Local management actions can regulate hypoxia
- Large and fluctuating salinty gradients with differing buffering capacities
- Landscape factors can influence carbon inputs and cycling
- Cost
- What is the tipping point for atmospheric CO_2 contributions?







Breitburg, et al. 2015. PLOS ONE

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How Would Data Be Used?

- Accelerate or increase management goals to alleviate hypoxia effects
- Guide oyster restoration site selection or scale
- Guide aquaculture and hatchery decisions
- Improve our understanding of the Bay(s) carbonate system which could lead to revised management actions
    - Best management practices on land
    - Fisheries management strategies

Maryland Department of Natural Resources

Monitoring on the Horizon

Recently funded NOAA Grant: Interactions between ocean acidification and eutrophication in estuaries: Modeling opportunities and limitations for shellfish restoration

Dr. Jeremy Testa (Principal Investigator; University of Maryland Center for Environmental Science (UMCES) Chesapeake Biological Laboratory), Dr. Wei-Jun Cai (University of Delaware), Dr. George Waldbusser (Oregon State University), Dr. Jeffrey Cornwell (UMCES Horn Point Laboratory), Dr. Ming Li (UMCES Horn Point Laboratory), Dr. Michael Kemp (UMCES Horn Point Laboratory)

Mid-Atlantic Ocean Acidification Network

Organized under MARACOOS and led by Dr. Grace Saba – Rutgers

Collaborative Monitoring

MD DNR – SERC (Dr. Whitman Miller)

Other Possible Grant Opportunities

MARYLAND DEPARTMENT OF NATURAL RESOURCES

UMCES- U of Delaware-Oregon State U. Sampling Plan

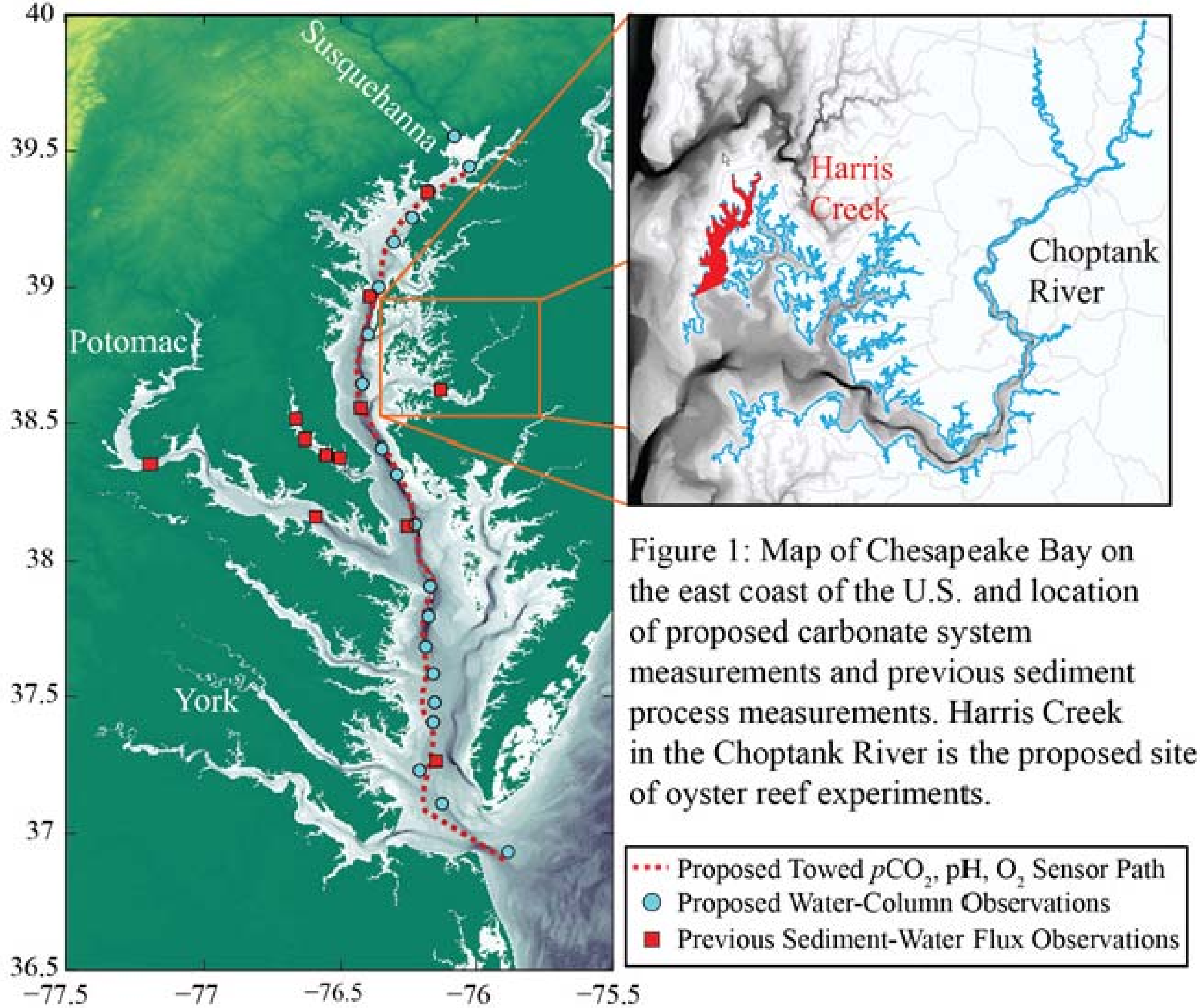

Figure 1: Map of Chesapeake Bay on the east coast of the U.S. and location of proposed carbonate system measurements and previous sediment process measurements. Harris Creek in the Choptank River is the proposed site of oyster reef experiments.

(1) 3-5 Day cruises in mainstm April, June, August, and October (above)
(2) Measurements of pCO2, pH and alkalinity in large rivers

Maryland Department of Natural Resources

The Mandatory Take Home Questions

What carbon science information do you need/want to support your organization's decision framework?

What are your needs in terms of timeframe, spatial scale, and frequency of data products and updates? More specifically, what information do you need for any decision support/policy/action this year, in 2 years and in 5 years?

When and how should the carbon science information be delivered?

Are there any CMS products that you would like to learn more about? Please review this list of 2012, 2013, and 2014 CMS products before attending the workshop.

Products desired by UMCES led project:
(1) Oceanic carbon (pCO2) fluxes (18 km resolution)
(2) Estimates/maps of ocean atmosphere fluxes of carbon dioxide
(3) Estimates/maps of land atmosphere fluxes of carbon dioxide (5 km resolution)
(4) Any and all phytoplankton biomass estimates

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U.S. Efforts Towards Incorporating Coastal Wetlands into National Greenhouse Gas Inventories

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Environmental Science Associates
Tiffany Troxler
Florida International University
Meredith Muth, Nate Herold,
Ariana Sutton-Grier, Amanda McCarty, Amber Moore
National Oceanic & Atmospheric Administration
Tom Wirth
U.S. Environmental Protection Agency
Steve Emmett-Mattox, Stefanie Simpson
Restore America's Estuaries
Blanca Bernal, James Holmquist & Pat Megonigal
Smithsonian Environmental Research Center

Jim Fourqurean

Lisa Windham-Myers

NASA Coastal Monitoring System Applications Workshop, Pasadena, California
November 16, 2015

Ecosystems in focus for climate change mitigation

Forest

Peatland

Mangroves

Tidal Marshes

Seagrass

Ecosystem services of Coastal Blue Carbon ecosystems: mangroves, seagrass and marshes

- Biological diversity
- Water quality
- Flood and storm protection
- Forest and non-timber forest products
- Aesthetic and ecotourism values
- Fish and Shellfish
- Carbon Sinks

White House on Coastal Blue Carbon

- **Climate and Natural Resources Working Group (CNRWG) of the U.S. Council on Climate Preparedness and Resilience** (2014). Priority Agenda: Enhancing the Climate Resilience of America's Natural Resources. https://www.whitehouse.gov/sites/default/files/docs/enhancing_climate_resilience_of_americas_natural_resources.pdf

- **Coastal Green Infrastructure and Ecosystem Services Task Force.** (2014). Ecosystem-Service Assessment: Research Needs for Coastal Green Infrastructure. Washington, DC: Office of Science and Technology Policy. https://www.whitehouse.gov/sites/default/files/microsites/ostp/cgies_research_agenda_final_082515.pdf

- ***Council on Environmental Quality***. *Incorporating Ecosystem Services into Federal Decision Making* [Memorandum for Executive Departments and Agencies]. 7 October, 2015. Washington, DC: Executive Office of the President of the United States. https://www.whitehouse.gov/sites/default/files/omb/memoranda/2016/m-16-01.pdf

Carbon Market – Coastal Wetlands

RESTORE AMERICA'S ESTUARIES

Tidal Wetland and Seagrass Restoration Methodology

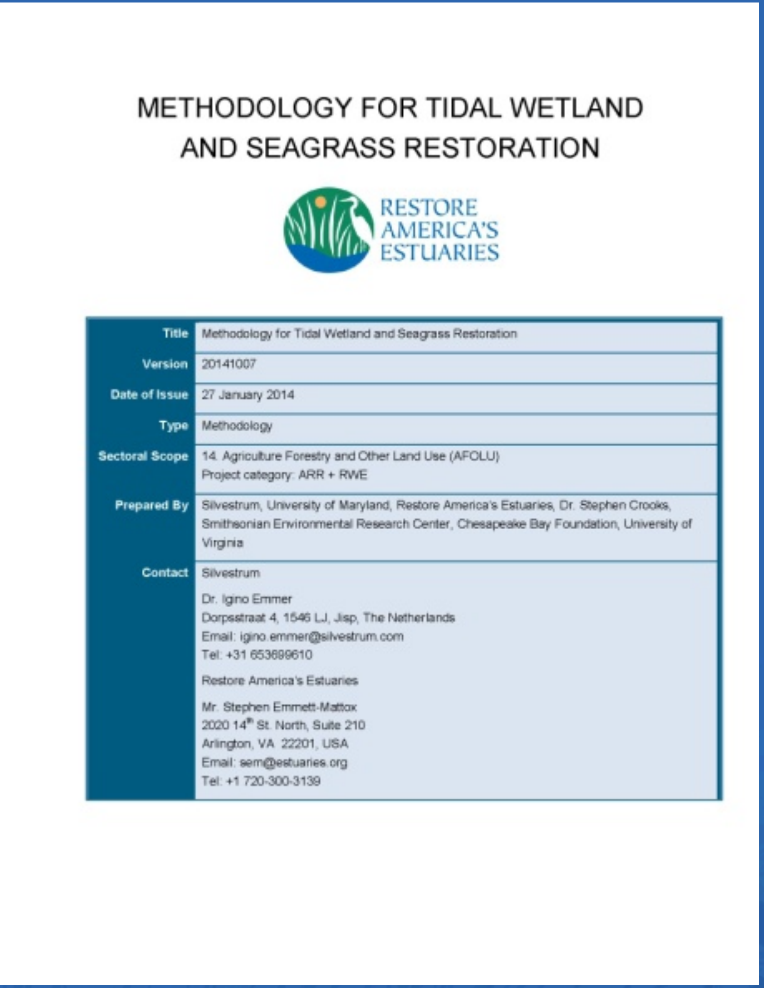
Habitats – all tidal wetlands and seagrasses, globally

- Marshes, all salinity ranges
- Mangroves
- Seagrasses
- Forested tidal wetlands

Eligible Activities

- Restoration via enhancing, creating and/or managing hydrological conditions, sediment supply, salinity characteristics, water quality and/or native plant communities.

All three GHGs: N_2O, CH_4, CO_2


METHODOLOGY FOR TIDAL WETLAND AND SEAGRASS RESTORATION

RESTORE AMERICA'S ESTUARIES

Title	Methodology for Tidal Wetland and Seagrass Restoration
Version	20141007
Date of Issue	27 January 2014
Type	Methodology
Sectoral Scope	14. Agriculture Forestry and Other Land Use (AFOLU) Project category: ARR + RWE
Prepared By	Silvestrum, University of Maryland, Restore America's Estuaries, Dr. Stephen Crooks, Smithsonian Environmental Research Center, Chesapeake Bay Foundation, University of Virginia
Contact	Silvestrum Dr. Igino Emmer Dorpsstraat 4, 1546 LJ, Jisp, The Netherlands Email: igino.emmer@silvestrum.com Tel: +31 653699610 Restore America's Estuaries Mr. Stephen Emmett-Mattox 2020 14th St. North, Suite 210 Arlington, VA 22201, USA Email: sem@estuaries.org Tel: +1 720-300-3139

OPEN ACCESS Freely available online

PLOS ONE

Estimating Global "Blue Carbon" Emissions from Conversion and Degradation of Vegetated Coastal Ecosystems

Linwood Pendleton[1], Daniel C. Donato[2*], Brian C. Murray[1], Stephen Crooks[3], W. Aaron Jenkins[1], Samantha Sifleet[4], Christopher Craft[5], James W. Fourqurean[6], J. Boone Kauffman[7], Núria Marbà[8], Patrick Megonigal[9], Emily Pidgeon[10], Dorothee Herr[11], David Gordon[1], Alexis Baldera[12]

Table 1. Estimates of carbon released by land-use change in coastal ecosystems globally and associated economic impact.

	Inputs			Results	
Ecosystem	**Global extent (Mha)**	**Current conversion rate (% yr^{-1})**	**Near-surface carbon susceptible (top meter sediment+biomass, Mg CO_2 ha^{-1})**	**Carbon emissions (Pg CO_2 yr^{-1})**	**Economic cost (Billion US\$ yr^{-1})**
Tidal Marsh	2.2–40 (5.1)	1.0–2.0 (1.5)	237–949 (593)	**0.02–0.24 (0.06)**	**0.64–9.7 (2.6)**
Mangroves	13.8–15.2 (14.5)	0.7–3.0 (1.9)	373–1492 (933)	**0.09–0.45 (0.24)**	**3.6–18.5 (9.8)**
Seagrass	17.7–60 (30)	0.4–2.6 (1.5)	131–522 (326)	**0.05–0.33 (0.15)**	**1.9–13.7 (6.1)**
Total	33.7–115.2 (48.9)			**0.15–1.02 (0.45)**	**6.1–41.9 (18.5)**

Compare to national emissions from all sources

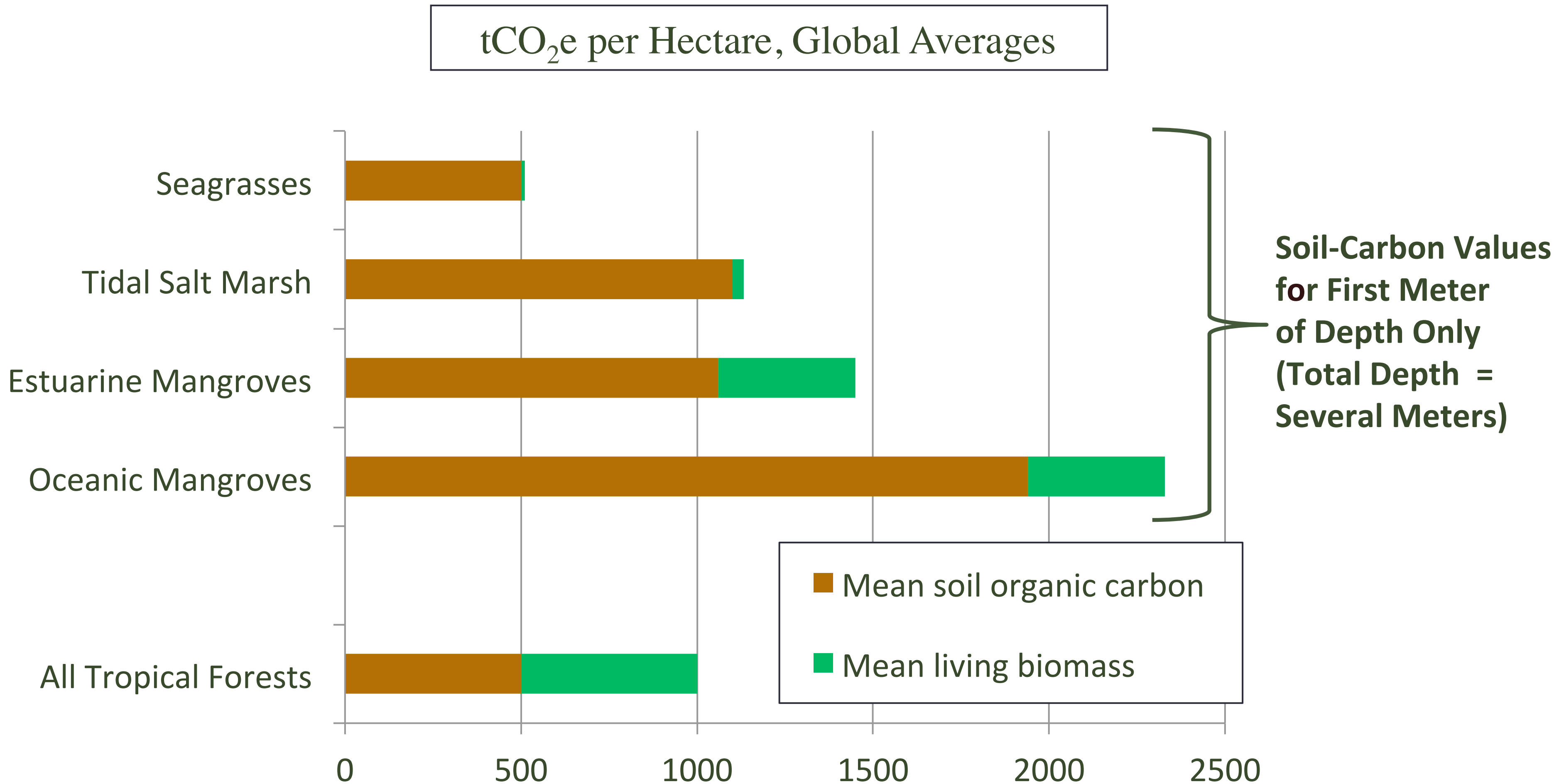
Poland

Japan

Long-term carbon sequestration and storage

Carbon from plants gather in soil and builds up over thousands of years

Distribution of carbon in coastal ecosystems

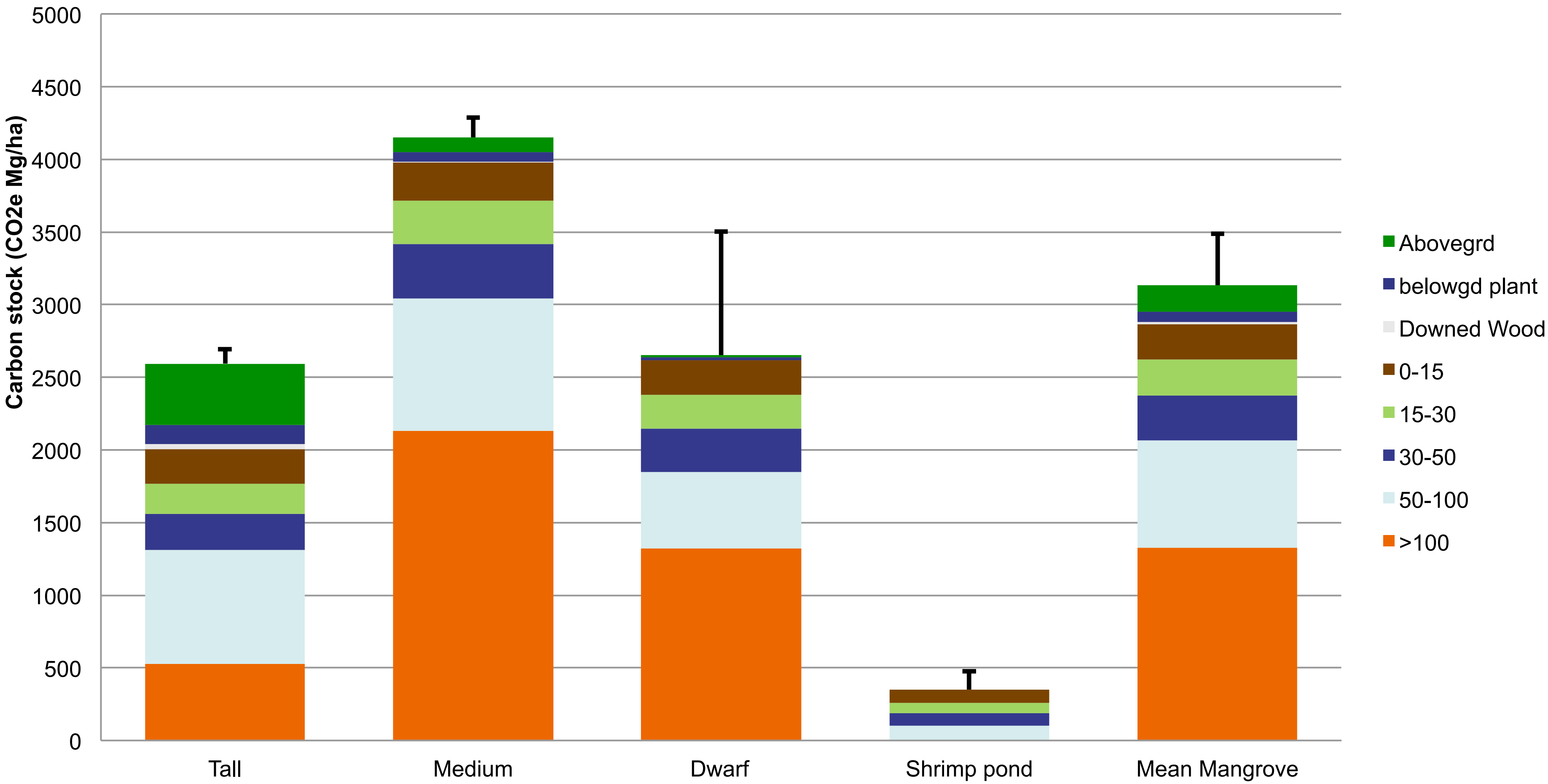


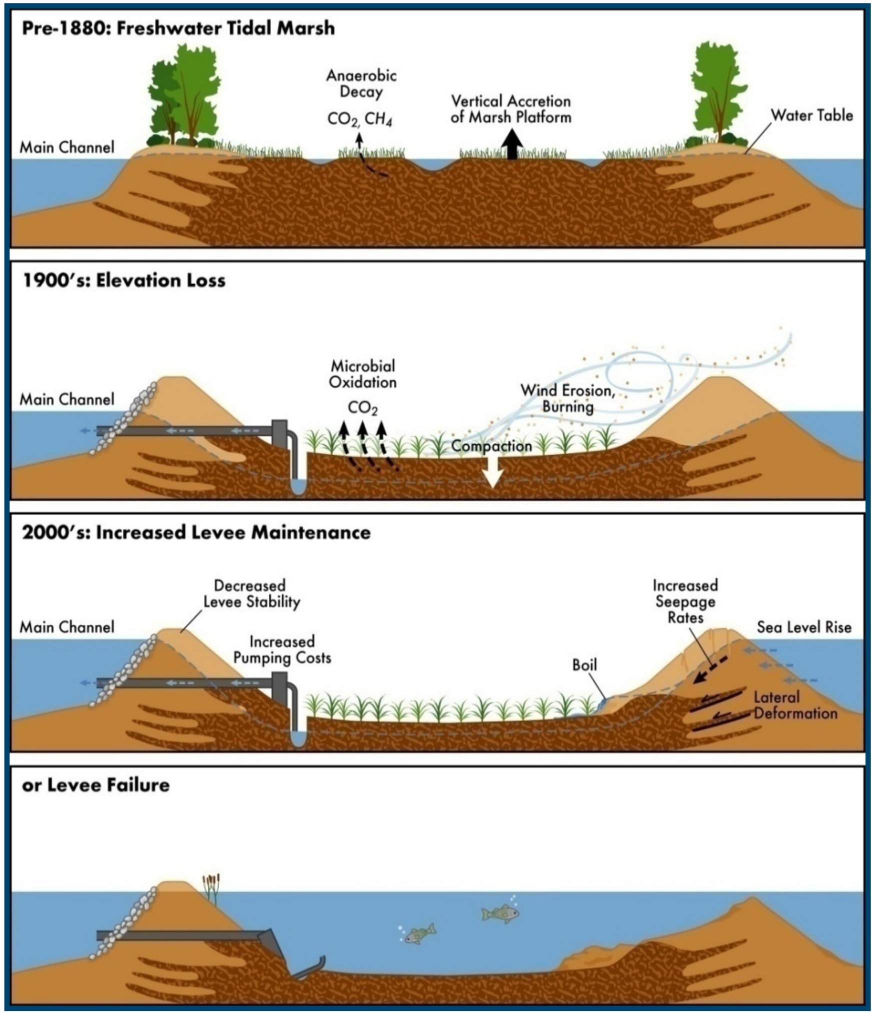
Data summarized in Crooks *et al*., 2011; Murray *et al*., 2011, Donato et al., 2011, Fourqurean et al 2013

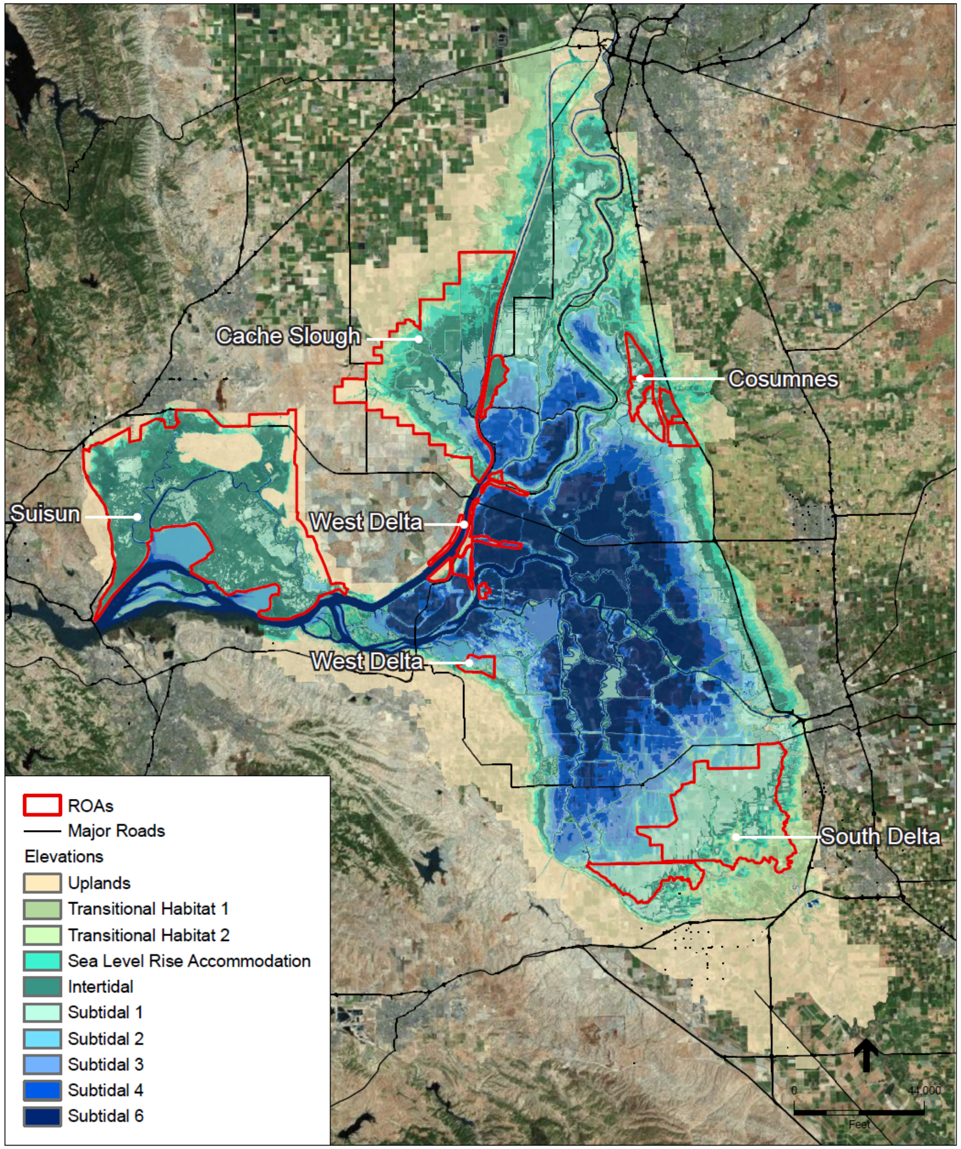
CARBON STOCKS OF NEOTROPICAL MANGROVES ARE AMONG THE LARGEST OF ALL TROPICAL FORESTS

Ecosystem C stocks in CO_2e, Republica Dominicana 2012

Kauffman et al. 2013)







SOURCE:

DWR 2007 LiDAR; ESA-PWA 2012

Bay Delta Science Conference.

Figure 1

Elevations and ROAs of Delta-Suisun Marsh Planning Area

Emissions from One Drained Wetland: Sacramento-San Joaquin Delta

Area under agriculture	**180,000 ha**
Rate of subsidence	2.5 cm / yr

1-3 million tCO_2/yr released from Delta

1 $GtCO_2$ release in c.150 years

4000 years of carbon emitted

Equiv. carbon held in 25% of California's forests

Accommodation space: 3 billion m^3

Carbon Capture Wetland Farm Bio-Sequestration

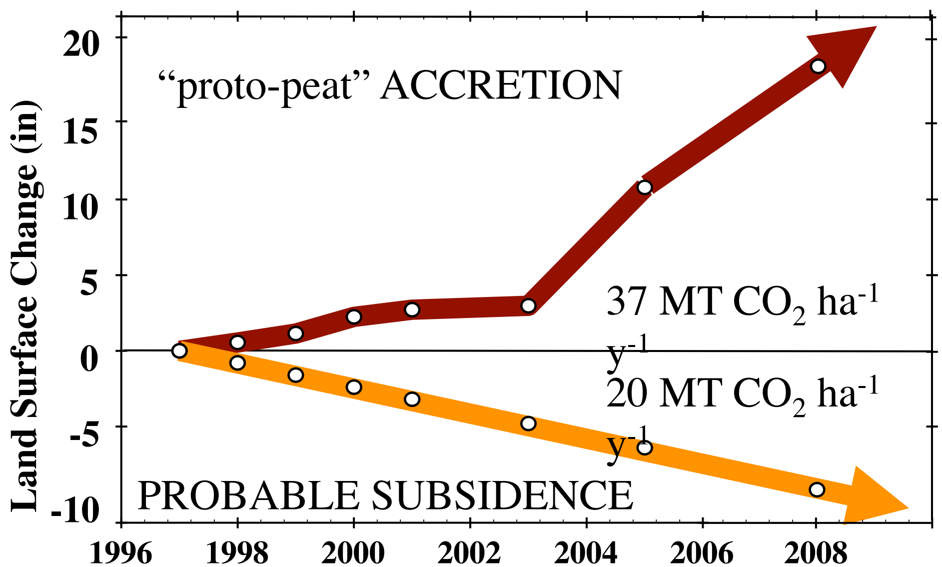
Stops peat oxidation and accretes "proto-peat" rapidly

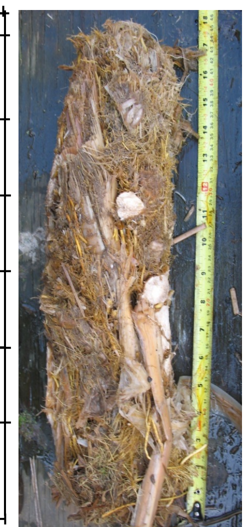
Continuously submerged about 1 ft

Low oxygen conditions

Balance between plant growth and reduced decomposition

Average annual soil sequestration: 1 kg C m^{-2} yr^{-1} in soil





USGS

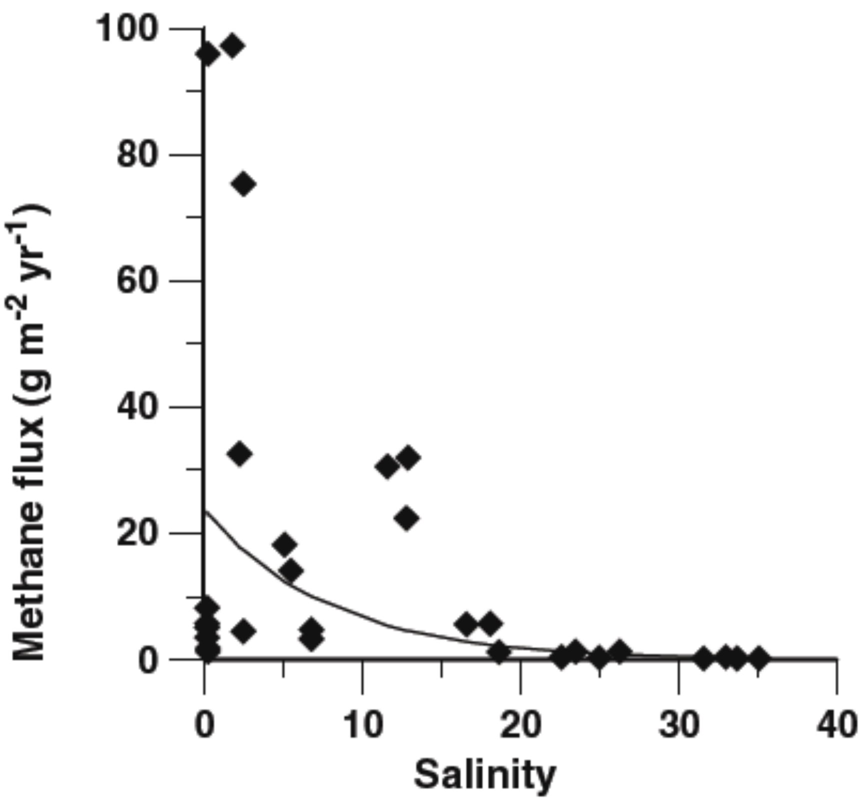
U.S. Department of the Interior
U.S. Geological Survey

Miller et al. 2008, SFEWS

Methane emissions impaired tidal drainage

Demonstration Project(s)

- Herring River Restoration, Cape Cod National Seashore – carbon project feasibility study



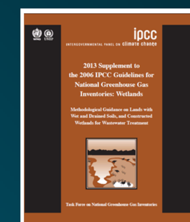
Poffenbarger, Needleman and Megonigal 2011

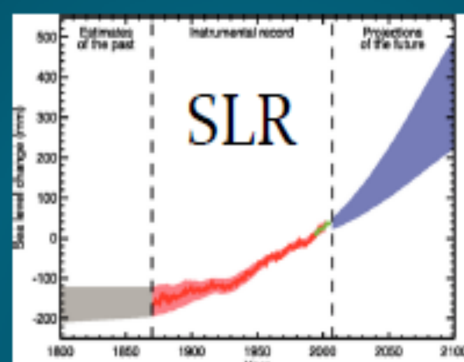
The state of blue carbon science:

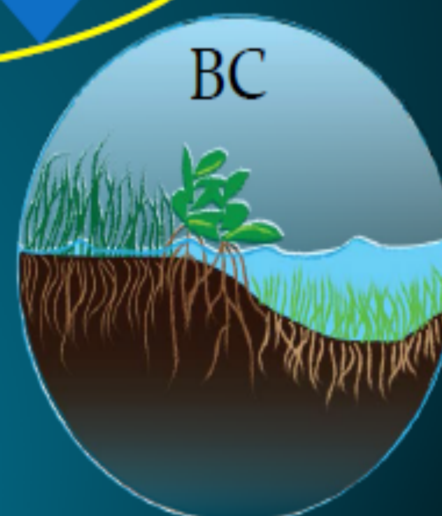
a short review of achievements and gaps

Chmura et al 2003

Duarte et al 2005







IPCC Guidelines for National Greenhouse Gas Inventories

- 1995 Guidelines
- 1996 Revised IPCC Guidelines
- 2000 Good Practice Guidance and Uncertainty Management
- 2003 Good Practice Guidance for Land Use, Land-Use Change and Forestry
- 2006 IPCC Guidelines
- 2013 IPCC Wetlands Supplement
- 2013 Revised Supplement to the Kyoto Protocol

IPCC Land Classification

Forest land

- All woody vegetation according to national definitions

Cropland

- Crops including rice and agro-forestry not included above

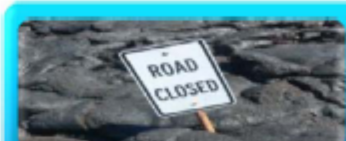
Grassland

- All rangelands and pastures not included above

Settlements

Wetlands

- Wetlands not included above (peat use and flooded lands)



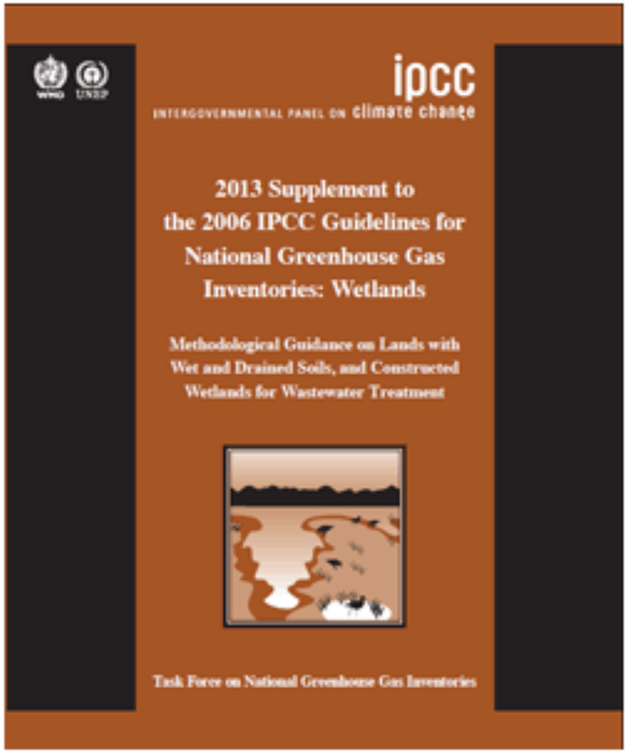
Other Lands

- Includes bare soil, rock, ice and lands not included above

2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands

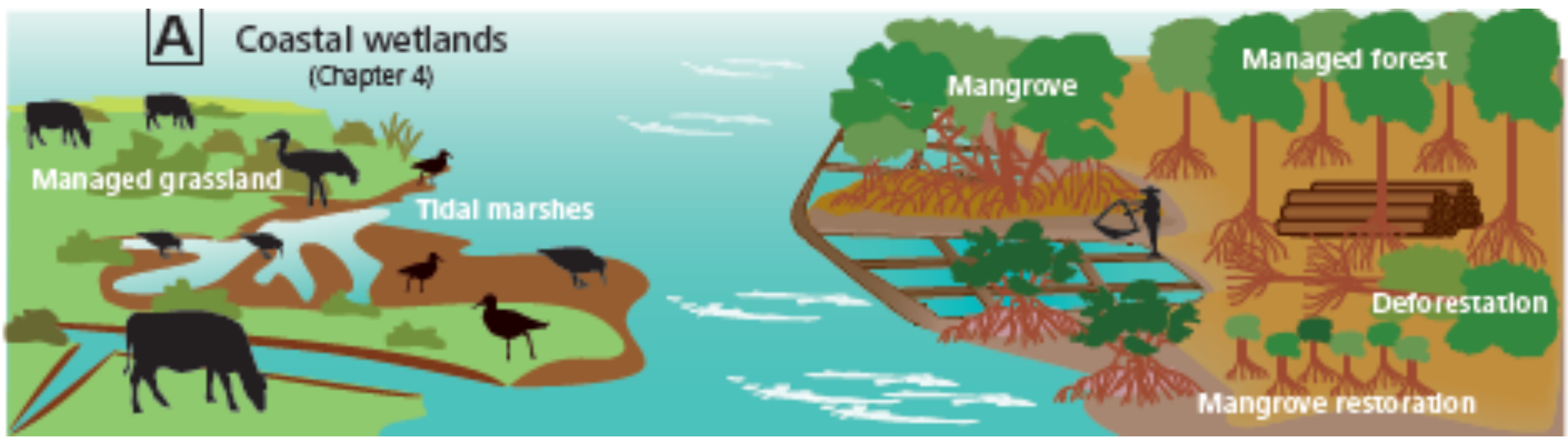
- Introduction
- Cross cutting guidance on organic soils
- Rewetting and restoration of organic soils
- Coastal wetlands
- Other freshwater wetlands
- Constructed wetlands
- Good practice and implications for reporting

- Adopted by IPCC Oct 2013, Published Feb 2014
- http://www.ipcc-nggip.iges.or.jp/



Chapter 4: Coastal Wetlands of the *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands*

- Updated default data for estimation of C stock changes in mangrove living biomass and dead wood pools
- New generic methodological guidance and data on:
  - CO_2 emissions and removals on coastal wetlands on organic and mineral soils for specific management activities
  - N_2O emissions during aquaculture use
  - CH_4 emissions from rewetted soils and creation of mangroves and tidal marshes



U.S. Coastal Wetland Carbon Working Group

U.S. National Oceanic and Atmospheric Administration (Coastal Management, Habitat Conservation, International), U.S. Environmental Protection Agency (Climate Change, Wetlands), U.S. Geological Survey, U.S Forestry Service, Environmental Science Associates, Florida International University, Smithsonian Environmental Research Center, Restore America's Estuaries, Colorado State University, Pennsylvania State University, Texas A & M.

U.S. Coastal Wetlands: Potential Emissions and Removal

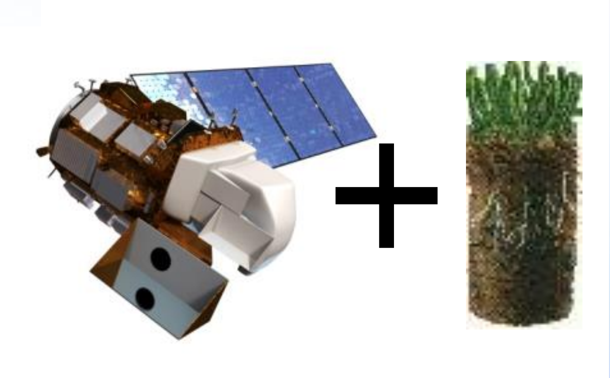
- **Drainage and excavation**
- **Human induced subsidence of wetlands (erosion)**
  - **(e.g. Mississippi Delta)**
- **Methane emissions from tidally disconnected /impounded waters**
- **Forestry activities on coastal wetlands.**
- **Aquaculture (operations)**
- **Restoration of coastal wetlands and seagrasses**

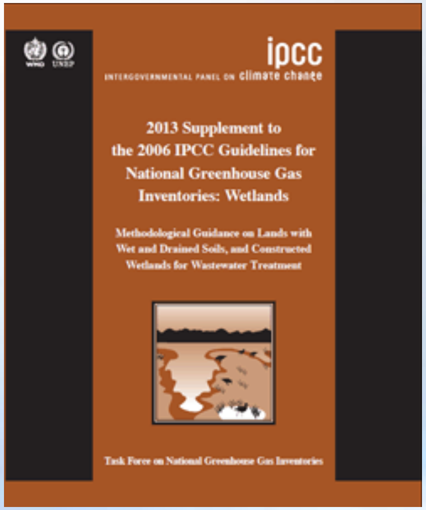
“Blue” Carbon Monitoring System

Linking soil and satellite data to reduce uncertainty in coastal wetland carbon burial: a policy-relevant, cross-disciplinary, national-scale approach

Lisamarie Windham-Myers (18 Science PIs; October 2014-17)

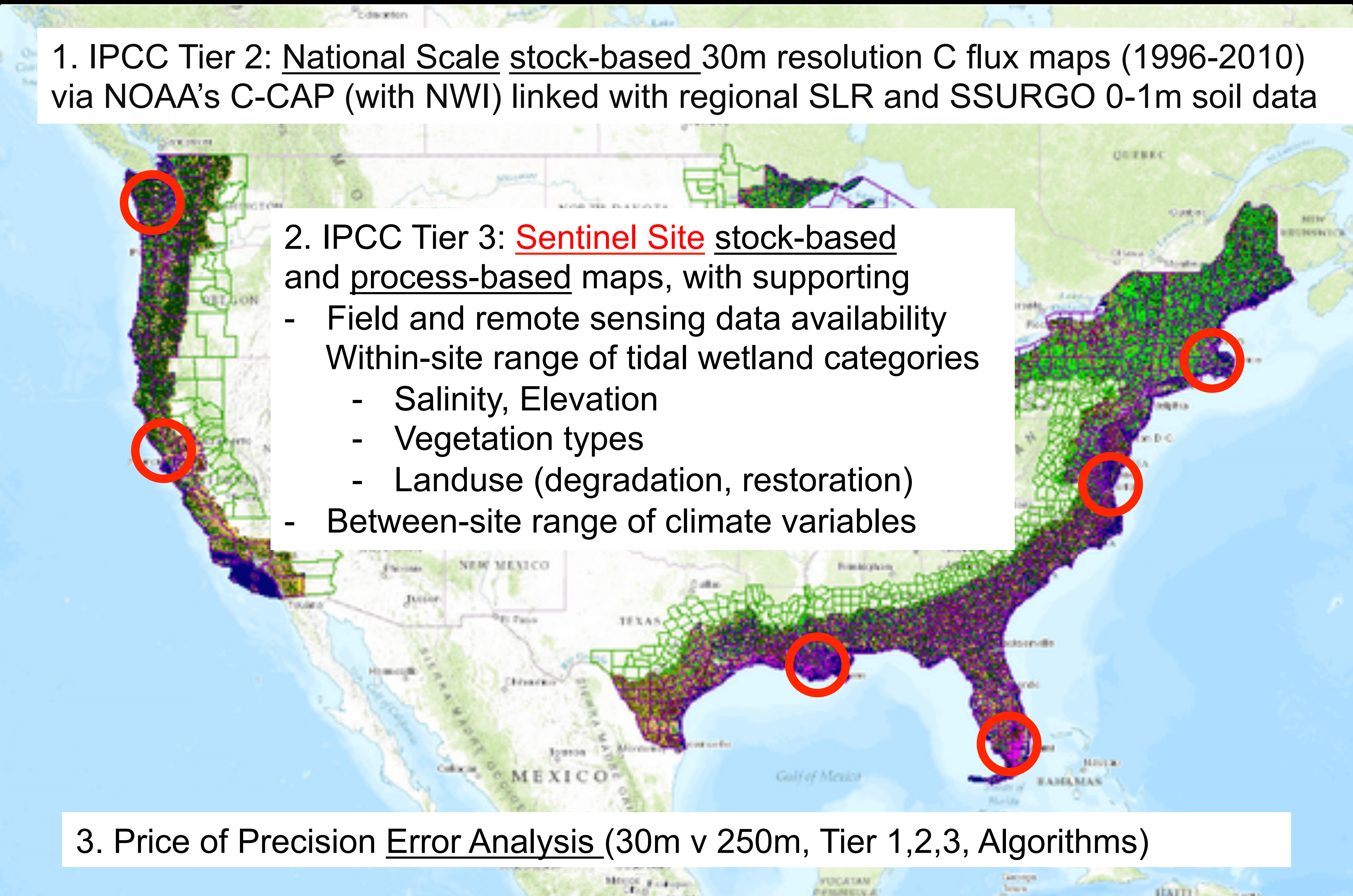
Federal		Non Federal	
USGS	Brian Bergamaschi	U. South Carolina	Jim Morris
	Kristin Byrd	U. Maryland/NOAA	Ariana Sutton-Grier
	Judith Drexler	U. San Francisco	John Callaway
	Kevin Kroeger	Florida Intl. U.	Tiffany Troxler
	John Takekawa	Texas A&M U.	Rusty Feagin
	Isa Woo	Independent	Stephen Crooks
Postdoc:	Meagan Gonneea		
NOAA-NERR	Matt Ferner		
Smithsonian	Pat Megonigal		
	Don Weller		
	Lisa Schile		
Postdoc:	James Holmquist		
NASA-JPL	Marc Simard		





“Blue” CMS – Product Goals

1. IPCC Tier 2: National Scale stock-based 30m resolution C flux maps (1996-2010) via NOAA’s C-CAP (with NWI) linked with regional SLR and SSURGO 0-1m soil data



2. IPCC Tier 3: Sentinel Site stock-based and process-based maps, with supporting

- Field and remote sensing data availability
  Within-site range of tidal wetland categories
    - Salinity, Elevation
    - Vegetation types
    - Landuse (degradation, restoration)
- Between-site range of climate variables

3. Price of Precision Error Analysis (30m v 250m, Tier 1,2,3, Algorithms)

Timeline

- Methodological procedures established, 2015
- White Paper & Peer-Review Paper, 2016
- Inclusion of Coastal Wetlands in Inventory, 2016
- Report to SBSTA March 2017
- Ongoing refinements (From Tier1-2 to Tier 2-3)

Support Request

Carbon Science Information:

National Inventory

Linking vegetation / geomorphology to CH_4 and CO_2 fluxes

CH_4 emissions coastal wetlands impounded waters

Fate of mobilized (eroded) carbon

Mapping of wetland distribution and change (seagrass?)

Markets and predictive tools

Nearshore suspended sediment concentrations

N_2O & CH_4 emissions coastal lowlands (agriculture etc)

Frequency:

Inventory emissions and removals reported annually.

Suspended sediment annualized in models

End: Steve Crooks
Next: Jeff Cole

Short and Long Term CMS Opportunities in Today's Forest Carbon Markets

NASA CMS Workshop
Pasadena, California
November 16, 2015

Blue Source

Overview

- About Blue Source
- Forest carbon offset markets & projects

- Forest carbon measurement needs, requirements, costs
    - Internal / External Decision Support
    - Decision Timeline
    - Current Decision Support Data

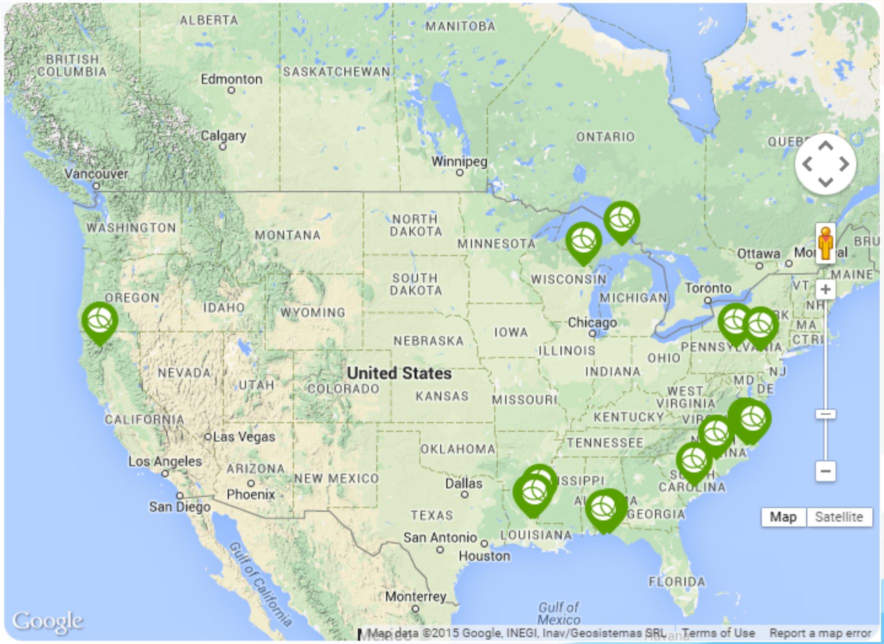
- Barriers to CMS adoption
- Speeding adoption

Who is Blue Source?

Founded in 2001, Blue Source is the oldest and largest offset project developer in North America

- **200+ Projects**
- **100,000,000 offsets created**
- **Offset projects in nearly all 50 states and most Canadian provinces**
- **Most forest offsets generated**

- **Emphasis**
  - Generating high quality, high volume GHG emission reductions
  - Motivating industry to action through leveraging carbon markets to provide financial incentives to reduce emissions
  - Simplifying carbon markets for those companies that wish to or are forced to address their carbon footprints



Blue Source

Global Carbon Offset Markets

A Carbon Offset is a reduction of greenhouse gases, measured in metric tonnes of CO_2 equivalent (mtC0_2e), meeting the following criteria, that is created by one entity, transferred to another, and ultimately retired.

- **Offset Criteria**

Real	Verifiable
Permanent	Surplus
Measurable	Additional

A carbon market is a group of companies and individuals looking for cost-effective means for reducing their environmental impacts, out of either internal motivations or regulatory requirements.

Voluntary, Compliance, Pre-Compliance Carbon Markets

- **North America**
  - Voluntary (VCS, ACR, CAR)
    - Internal Sustainability, CSR
    - Carbon Neutral Product or Supply Chain
  - Compliance
    - California, Quebec, Ontario
    - RGGI
    - Alberta
    - British Columbia
  - Pre-Compliance

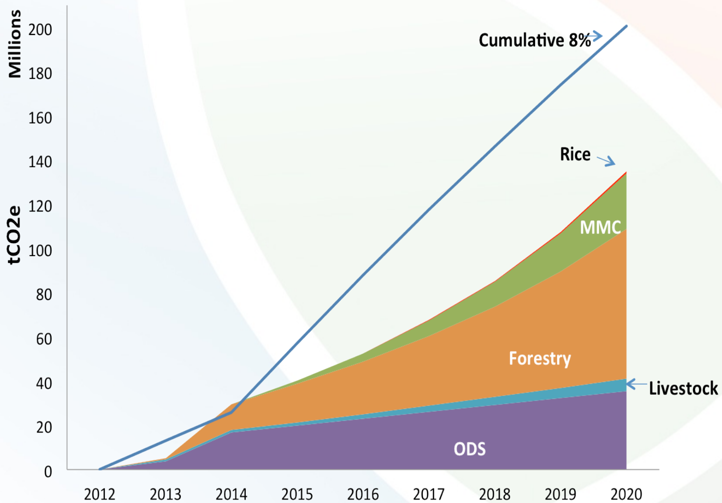
- **International**
  - Voluntary
  - Kyoto Protocol Driven (EUETS, CDM, JI)

Forestry's Role in Carbon Market

- **Voluntary Benefits**
  - Co-benefits
    - Biodiversity
    - Local water quality
    - Community
    - Community-economic

- **California Compliance Benefits**
  - High volume projects
  - Large potential reductions across industry
  - EHS Regulatory conformance

- **Disadvantages**
  - High cost of development
  - High degree of difficulty, long path to market
  - Complexity for buyers
  - 100-year landowner commitments
  - Monitoring Challenges



Source: *American Carbon Registry*

Blue Source

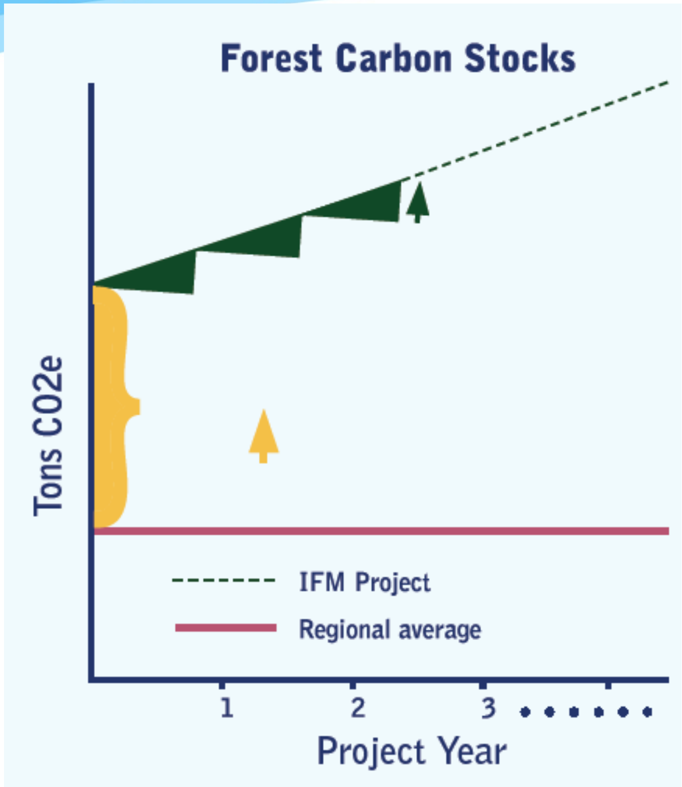
Forest Offset Project Requirements (California Cap and Trade)

- A/Reforestation (AR), Avoided Conversion (AC), Improved Forest Management (IFM)
- Lower 48 states and Alaska
- Natural forest management, sustainable harvesting (e.g. SFI, FSC, Tree Farm)
- Clear title/ownership of carbon credits, eased or un-eased
- ~100 year commitments: measurement, verification, reversals
  - Resample every 12 years, verify every 6 years, model and report annually
  - Compensate for intentional reversals (i.e. harvests)
  - Similar to a conservation easement with a termination option
    - Can subdivide and sell, but commitment transfers w/ownership
    - Can exit at any time if pay back all credits issued (+ 0-40% penalty)
  - Endowment may be set aside in first years to cover 100-year expenses
  - Also: 3-8 year invalidation risk (offset buyer is liable)
- See also VCS, ACR, CAR forest carbon project protocols

= Minimum Practical Size = 1,000 ac Avoided Conversion / 3,000 ac Improved Forest Mgt

Blue Source

Project Dynamics/Economics: Improved Forest Management (IFM)

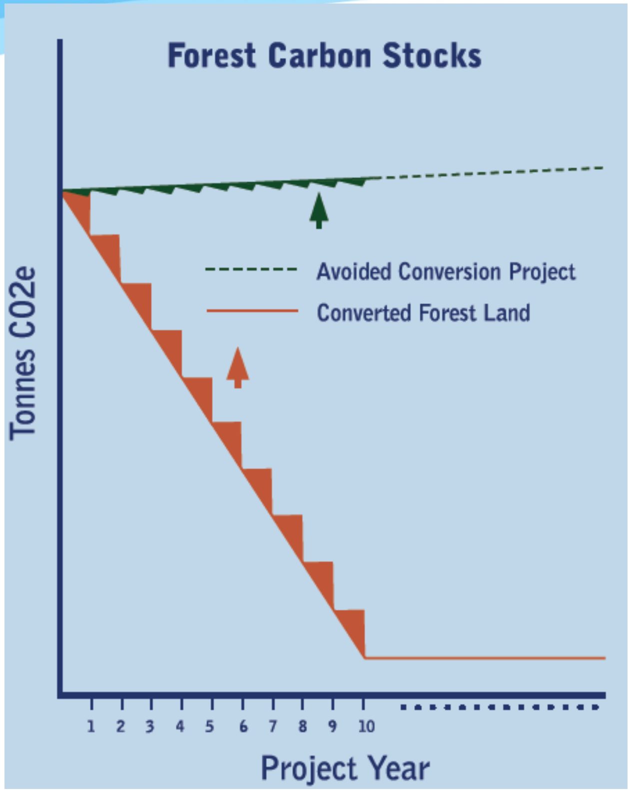


	Pacific Northwest Fir	Northern Mixed Hardwood	Southern Pine
Credits at project initiation	190,000	120,000	115,000
Revenue at project initiation	$1.9	$1.2	$1.2
Annual credit generation from continued CO2 stock accumulation	8,000	5,000	7,000
Gross revenue in first project decade	$2.7	$1.7	$1.9
Gross revenue per acre in first project decade	$270	$170	$185

Assumes
- 10,000 acres
- Carbon stocks 20% over average stock
- 50% annual growth harvested
- $10/ton carbon price
- 10 year crediting (25-100 year possible)

Blue Source

Project Dynamics/Economics: Avoided Conversion (AC)



	Pacific Northwest Fir	Northern Mixed Hardwood	Southern Pine
Annual Credits generated from conversion avoidance	28,000	18,000	16,000
Annual credit generation from continued CO2 stock accumulation	2,200	1,400	2,800
Gross revenue in first project decade ($ millions)	$3.0	$1.9	$1.9
Gross revenue per acre in first project decade	$1,208	$776	$752

Assumes:

- 2,500 acres
- 3 acre residential development avoided
- Carbon stocks 20% over average stock
- 50% annual growth harvested
- $10/ton carbon price
- 10 year crediting (25-100 year possible)

Blue Source

Carbon Measurement Requirements, Costs, Potential Savings

	Estimated Costs			
	Initial	Ongoing	Frequency	Potential Savings
1 Feasibility Assessment (eligibility, volume)	$5-$15k	$0	one time	**
Legal (AC Only)	$0-20k	$0	one time	
Appraisal (AC Only)	$5-30k	$0	one time	*
2 Forest Carbon Inventory				
Inventory Methodology and Design	Varies	Varies	~one time	*
Inventory Sampling / Field Work	$30-75k	$20-$100k	12 years (6?)	**
3 Calculation of Carbon Benefits				
Project Growth & Yield models	$15-$80k	$0-20k	6 years/harvests	*
Baseline Scenario Harvest Model (legal, economic)	$5-$50k	$0	one time	*
Conversion of “Gross” to “Net” Carbon Benefits (credits)	$5-20k	$0-10k	annual	
▪Inventory confidence				**
▪Leakage				*
▪Wood products				
▪Reversal risk, e.g. fire, wind				*
4 Project Design and Documentation	$10-100k	$0	one time	
5 Third-party Verification				
Full (Site) Verification	$30-75k	~80% Initial	6 years	**
Desk Verification	$0	$7-10k	when crediting	*
6 Registration	~$0.20/credit	~$0.20/credit	when crediting	
7 Marketing, Sales, Contracting	Varies	Varies	when crediting	
8 Annual Monitoring and Reporting	n.a.	$0-5k	annual	*
9 Project Finance	Varies	Varies	Varies	

- 12 month process
- Upfront Inventory, Verification Costs: $60-150k In Year 1
- 100 Year Monitoring, Verification, Inventory Costs: $100-200k Endowment

Blue Source

CMS Best Fit

Stage	Type	Timeframe	Current Data	Impact
Verification	External Requirement	Month 6-8 then ea. 6 yrs	Plot samples	****
Inventory	External/ Internal	Month 2-6 then ea. 12 yrs	Plot samples Aerial Imagery	***
Feasibility	Internal	Month 0	Timber cruise USFS FIA	**

Barriers to Adoption (CA Protocol)

- Strong support "as long as the science is there"
- Differing prospects for inventory, monitoring, verification; pre/post-crediting
- Specific protocol requirements would need modification
  - Plot sampling parameters including dbh, height for volumetric equations
  - Sampling Error <5%-20% of mean at 90% confidence
  - Required pools, verification protocols, modeling requirements

Table A.1. Requirements of carbon pool categories and determination of value for pool

Category	Carbon Pool	Improved Forest Management	Reforestation	Avoided Conversion	Determination of Value
Living biomass	Standing Live	Required	Required*	Required	Sampled in Project
	Shrubs and Herbaceous Understory	Excluded	Required	Excluded	Sampled in Project
Onsite dead biomass	Standing Dead	Required	Required	Required	Sampled in Project
Soil	Soil**	Required/ Excluded**	Required/ Excluded**	Required/ Excluded**	Sampled in project

* Pre-existing trees must be distinguished from planted trees. Since pre-existing and new trees are easy to distinguish for several decades after tree planting, pre-existing trees do not need to be inventoried until the offset project first seeks verification of GHG reductions and GHG removal enhancements.
** Soil carbon is not anticipated to change significantly as a result of most Forest Project activities. Soil carbon is excluded except when specified in Section 5.

a. Standard procedures for the collecting of field measurements. These procedures must be detailed enough so that any qualified forester would be able to accurately repeat the previous measurements. These procedures must include a description of the types of sample plots, location of plots, and frequency for updating or replacing sample plots as well as the forest carbon inventory as a whole;
b. Standard procedures for where and how to measure parameters used in biomass calculations such as dbh and height (including for irregular trees), how to classify dead wood, and for any other aspects of sampling where a consistent method needs to be documented; and

The following growth models have been approved:

- CACTOS: California Conifer Timber Output Simulator
- CRYPTOS: Cooperative Redwood Yield and Timber Output Simulator
- FVS: Forest Vegetation Simulator
- SPS: Stand Projection System
- FPS: Forest Projection System
- FREIGHTS: Forest Resource Inventory, Growth, and Harvest Tracking System
- CRYPTOS Emulator
- FORESEE

Table 10.1. Minimum number of sample plots in sequence, as a function of project size.

Test	Number of Strata Verified	Project Acres <100	100 - 500	501 - 5,000	5,000 - 10,000	> 10,000
Paired/Unpaired	3	2	3	4	5	6
	2	4	6	8	10	12
	1	8	12	16	20	24

CA Air Resources Board:
Compliance Offset Protocol U.S. Forest Projects
Section 10, Appendix A, Appendix B

Other Potential Barriers / Questions

- Single tree selection yields uniform ht/canopy, yet carbon varies w/basal area?
- 2-3 age classes - ability to penetrate the canopy/measure understory?
- Differentiate between e.g. hard maple and soft maple?
- Mixed old and second growth have similar ht/canopy, very different dbh/carbon?
- What's realistic expected reduction in plots (inv, verif)?
- Tradeoff in sampling uncertainty

Speeding Adoption

Verification

- Engage ARB to modify protocol; ACR/VCS/CAR to approve new protocol or module
  - Emphasize potential to reach small landowners, dramatically increase market potential
  - Post-crediting monitoring; use existing project data for ground truthing (Hurtt-03)

Inventory

- Start using to support inventory, demonstrate benefits (# plots, frequency)
  - Inventory likely easiest initial path; verification provides ground-truthing / safety-net
  - Some protocol changes required pre-full reilaince, non-paired t-test already approved

Feasibility

- Identify areas of (relative) high stocking and potential new projects
  - No barriers: use immediately: prove concept, provide data, generate revenues
  - Blue Source provides free eligibility assessments and revenue projection

Needs and Potential Timeline

Stage	Timeline	Data	Scale	Frequency
Verification	Next 3-5 yr	AGB (mt) Canopy cover Species?	Acre	~ea. 6 yrs
Inventory	Next 1-2 yr	AGB Species?	Acre	~ea. 12 yrs
Feasibility	Now	AGB Type	Stand	One-time

Research Projects of Interest

- Immediate Opportunity: U.S. Compliance Forestry Projects
  - Any models of biomass mt/acre, anywhere in U.S.
- Future Opportunities: Worldwide Voluntary and Compliance Projects
  - Grassland (vol. Avoided Conversion protocol approved)
  - Cropland (compliance rice protocol approved)
  - Blue Carbon (wetland protocol submitted)
  - Livestock emissions (free-range)

Working hard to bring projects to market…

Jeff Cole
Vice President
San Francisco
415.637.5333
jcole@bluesource.com
www.bluesource.com

End: Jeff Cole

Next: Bart Croes & Elizabeth Scheehle

California's GHG Research and Mitigation Programs

Bart Croes, Chief, Research Division
bart.croes@arb.ca.gov, 1-916-323-4519

Elizabeth Scheehle, Chief
Oil & Gas and GHG Mitigation Branch
elizath.scheehle@arb.ca.gov, 1-916-322-7630

California Environmental Protection Agency

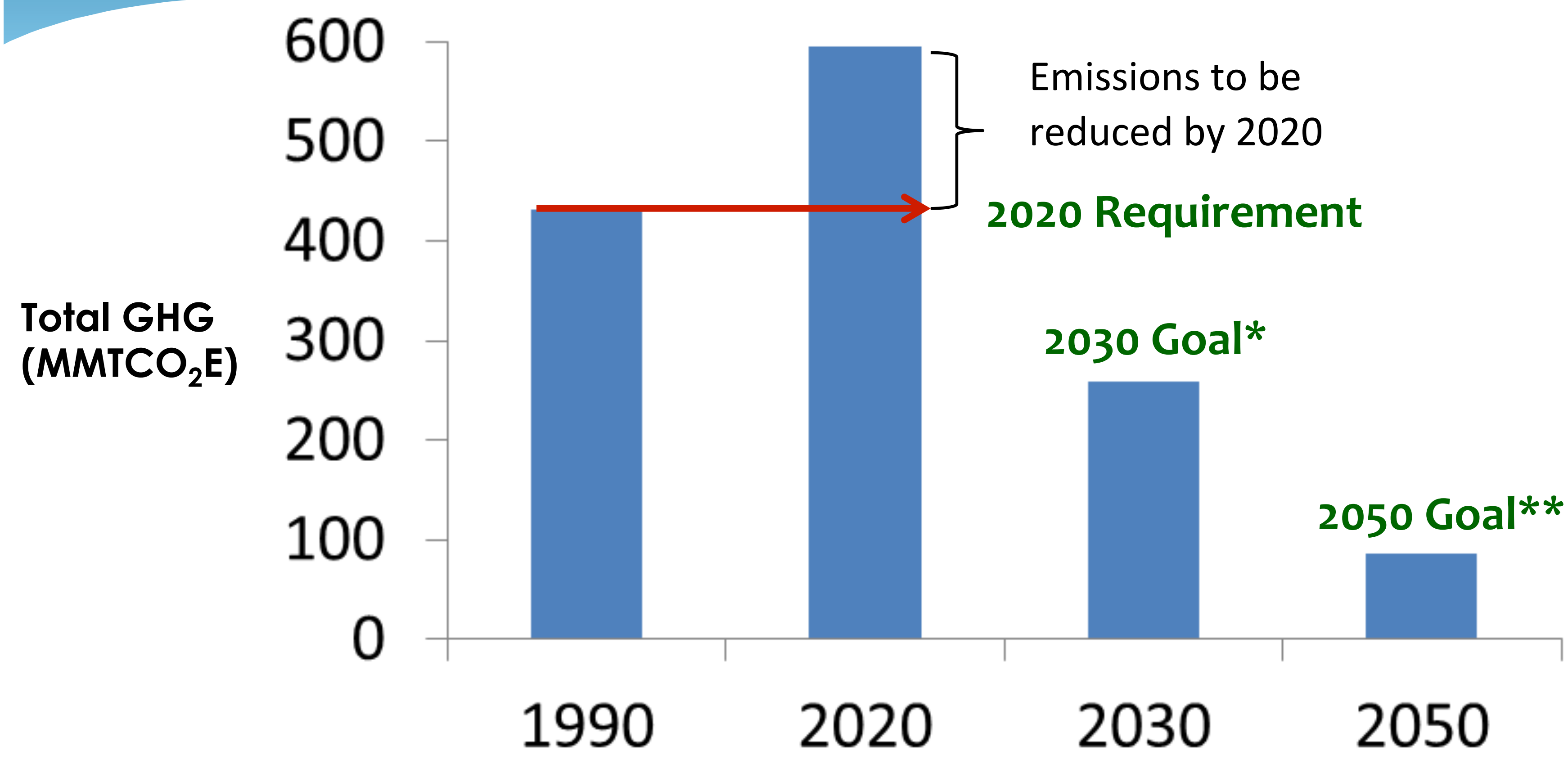
Air Resources Board

California Global Warming Solutions Act (Assembly Bill 32)

AB 32 charged Air Resources Board (ARB) to:

- Reduce 2020 GHG emissions to 1990 levels
- Monitor, report, and regulate sources of GHG emissions
- Rigorous and consistent inventory of emissions
- Monitor compliance with any rule, regulation, order, emission limitation, emissions reduction measure, or market-based compliance mechanism

GHG Emission Reduction Goals



* Executive Order B-30-15 and Senate Bill 350
** Executive Order S-3-05

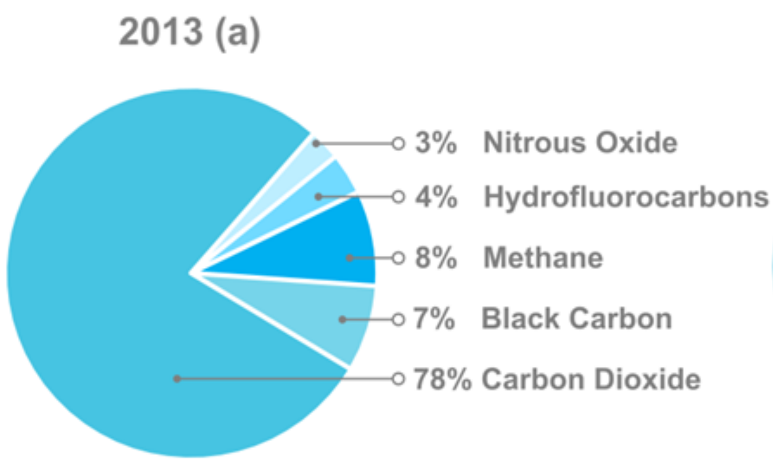
Existing Regulations and Policies

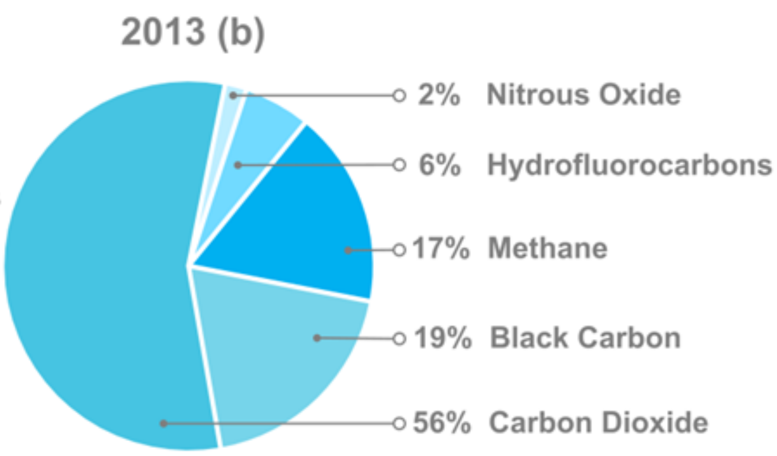
* Cap and trade program for all large sources (cap drops 2-3% per year)
  * Offset protocols for ODS, forestry, urban forestry, dairy digesters, mine methane
  * 25% of revenue goes to disadvantaged communities
* Transportation
  * 54.5 mpg fleet average by 2025
  * 1.5 million zero emission vehicles by 2025
  * 10% lower carbon intensity for fuels by 2020
  * ~7.6% per capita VMT reduction by 2020, ~12% by 2035 (SB 375)
* Electricity generation and energy efficiency
  * 33% renewable by 2020, energy efficiency audits
  * No imported coal power after 2025 (SB 1368)
  * 12,000 MW renewable self-generation by 2025
  * Appliance standards
  * $2.5B for school retrofits (Prop 39), retrofit existing buildings (AB 758)
  * Zero energy new residential buildings by 2020, commercial by 2030
* Short-lived climate pollutants
  * Six regulations covering all F-gases (CFC, HCFC, HFC, SF_6, PFC, NF_3)
  * Methane controls on landfills, oil and gas production (pending)
  * Diesel retrofit/repower requirements, local fireplace controls
* Water and waste
  * 20% per capita water consumption reduction by 2020
  * 75% waste diversion by 2020 (AB 341)

Short-Lived Climate Pollutant Plan

Senate Bill 605 – Develop SLCP strategy by 1/1/16

- Concept paper released 5/7/2015, draft strategy 9/30/15
- Board consideration in December 2015
- Final in spring 2016





(a) 100-year and (b) 20-Year Global Warming Potential values

SLCP Targets

From current (2013) levels:

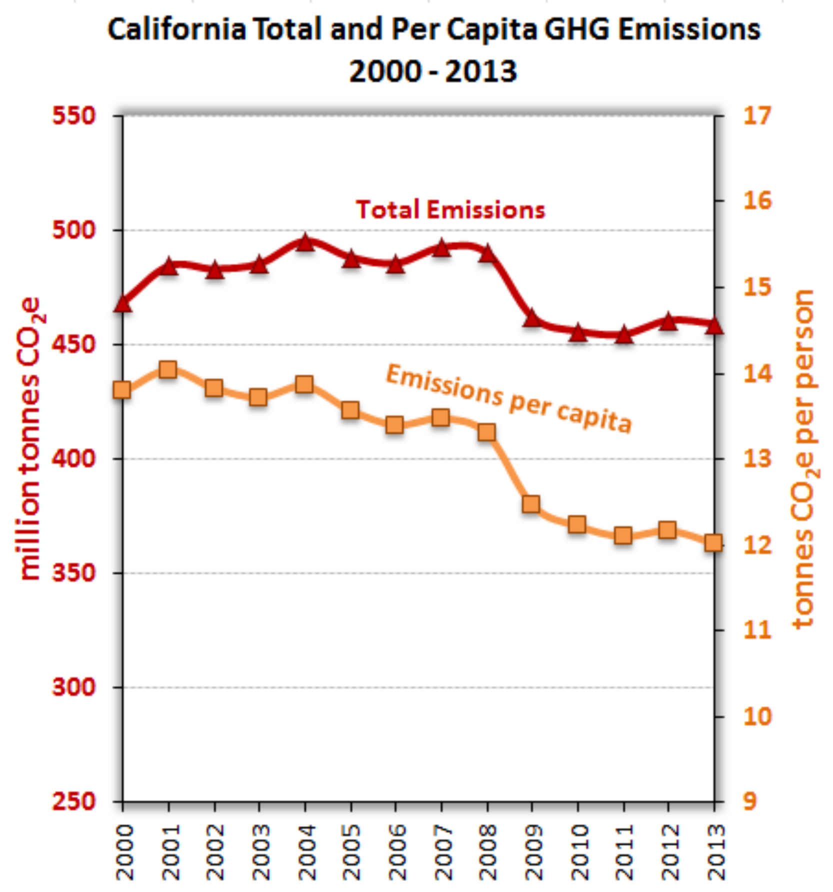
- Reduce black carbon emissions (non-forest) 50% by 2030
- Reduce methane emissions 40% by 2030
- Reduce F-gas emissions 40% by 2030

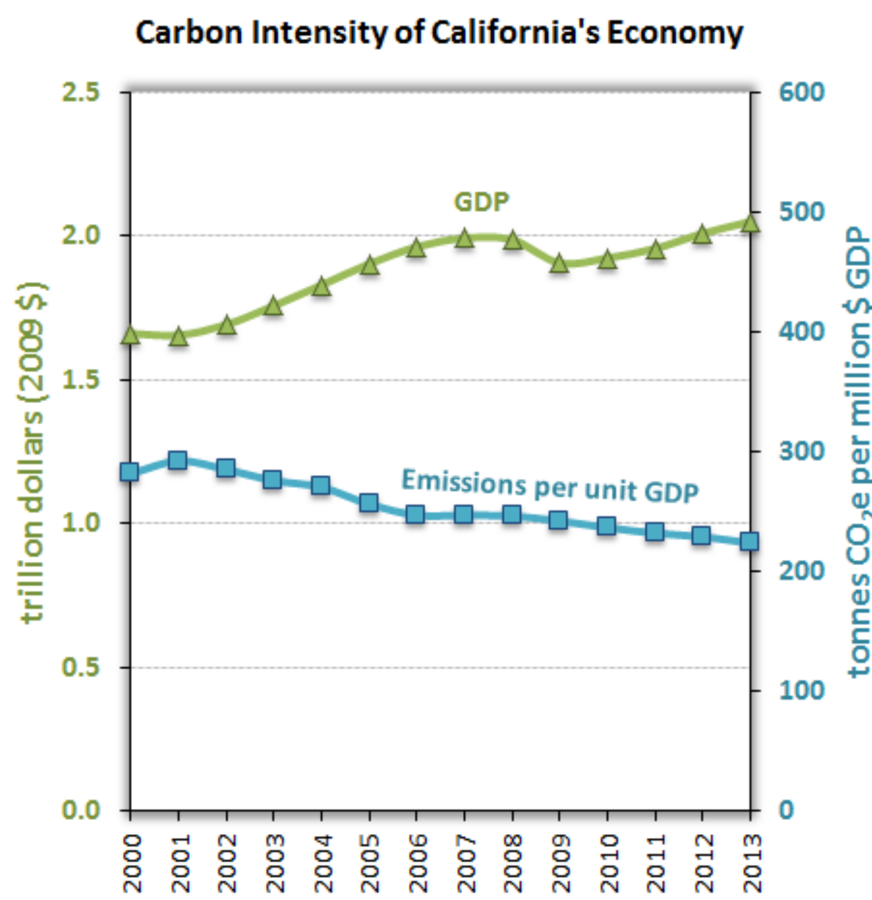
Governor Brown "5 Pillars"

- Set in 4th Term Inaugural Address – January 5, 2015
- By 2030:
  - Increase renewable electricity to 50%
  - Double energy efficiency of existing buildings and make heating fuels cleaner
  - Reduce petroleum use in cars and trucks by 50%
  - Reduce methane, black carbon, and other potent pollutants (short-lived climate pollutants)
  - Increase carbon sequestration in farms and rangelands, forests and wetlands

Assembly Bill 1496

* Measurements of high emission methane "hot spots" in California using aerial surveys and ground-based measurements
* Life-cycle greenhouse gas emissions analysis of natural gas produced and imported into California
* Review atmospheric reactivity of methane as a precursor to the formation of photochemical oxidant
* Update relevant policies and programs to incorporate the information

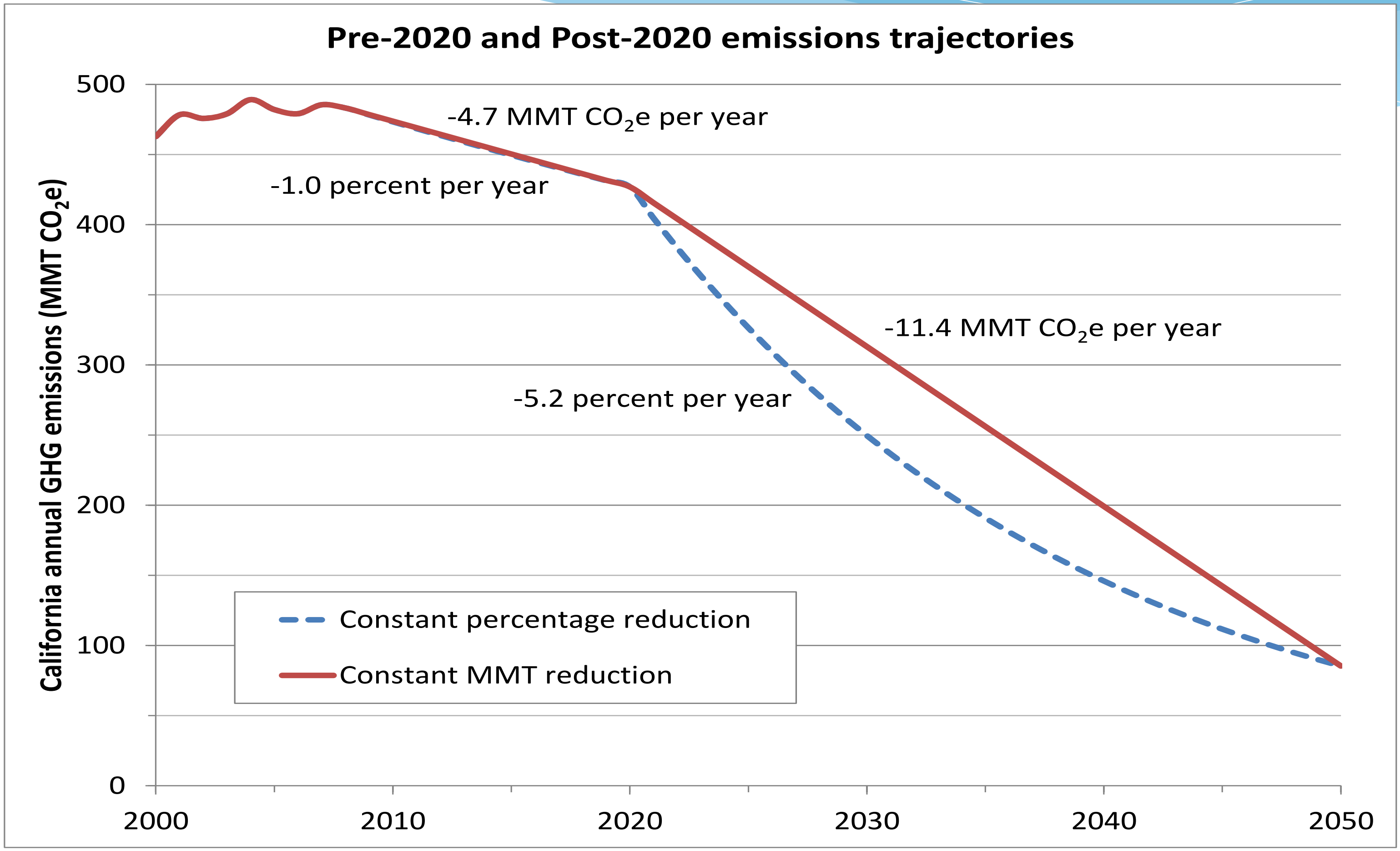




The total GHG emissions decreased by 0.3% while GHG emissions per capita decreased by 1%

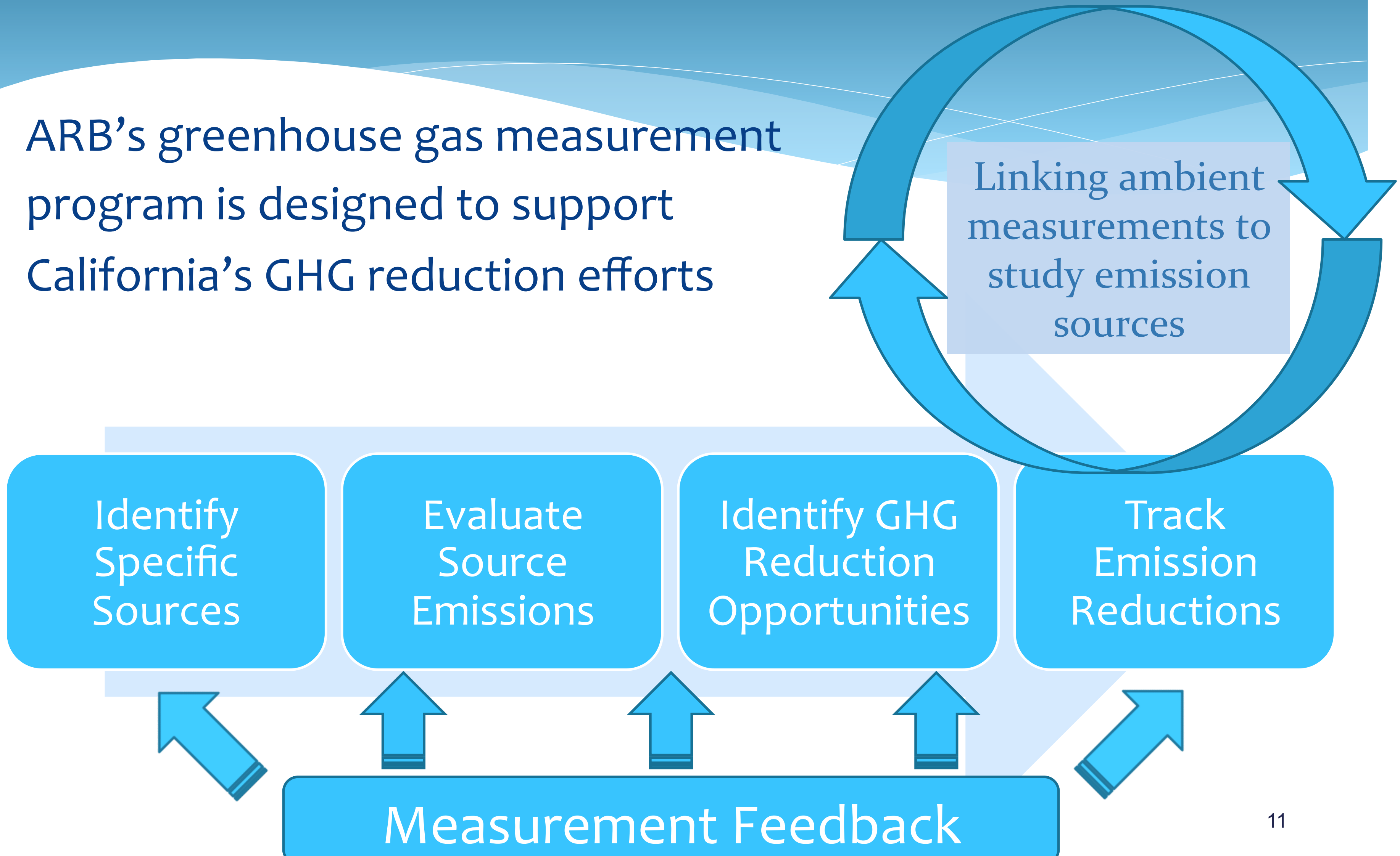
While California's economy and GDP continued to grow in 2013, the GHG carbon intensity of the economy (emissions per GDP $) continued to decline

Challenge of meeting 2050 target



ARB’s GHG Research Program

ARB’s greenhouse gas measurement program is designed to support California’s GHG reduction efforts



California Research Collaborators

Satellite Measurements (700 km)

NASA

Aerial Measurements (<1 km)

CIRPAS
JPL
NOAA

Ground-level Measurements

CEC

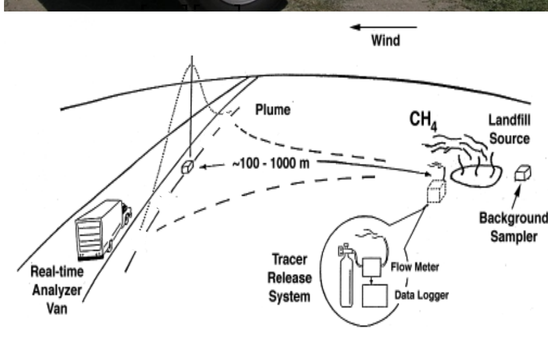
Towers	Mobile	Field Studies	Remote Sensing	Laboratory
ARB, Caltech	ARB	UC Berkeley	Caltech	Caltech
LBNL, LLNL	LBNL, Picarro	UC Davis	JPL	NOAA
Scripps	UC Irvine	Other UCs		UC Irvine

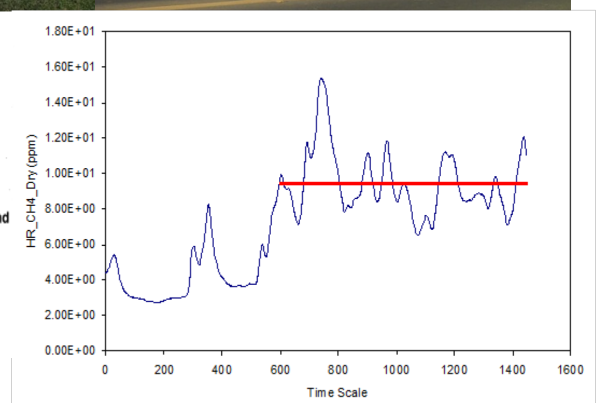
California's GHG Monitoring Network

Source-level Emissions Research

Measurement Tools

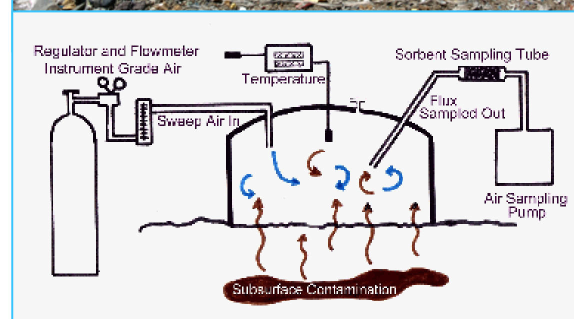
ARB Mobile Platforms





Jakober et al. (2015) Mobile measurements of climate forcing agents: Application to methane emissions from landfill and natural gas compression, *JAWMA*, 65:4, 404-412

Flux Chambers



Current Progress

- Identify Specific Sources
- Evaluate Source Emissions
- Identify GHG Reduction Opportunities
- Track Emission Reductions

Carbon Dioxide (CO_2)

SLCP

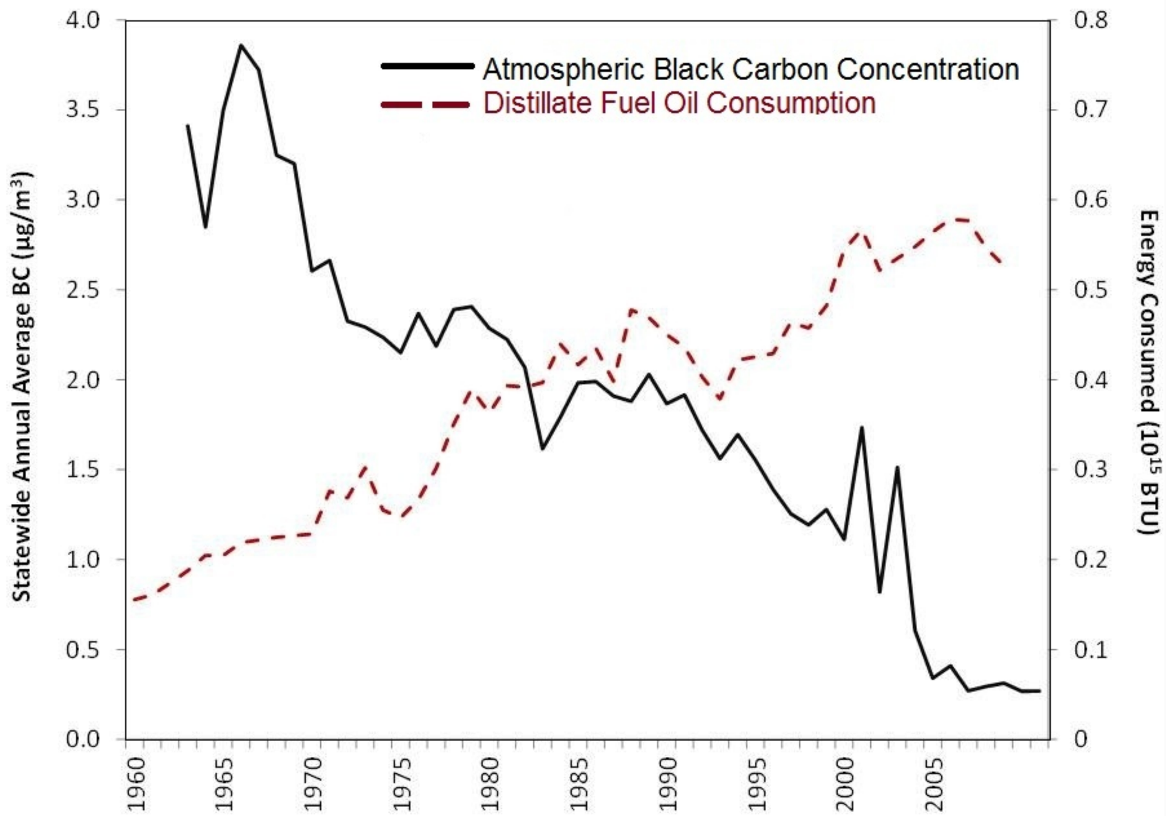
Black Carbon (BC)

Hydrofluorocarbons (HFC)

Methane (CH_4)

Nitrous Oxide (N_2O)

45 Years of Progress on Black Carbon

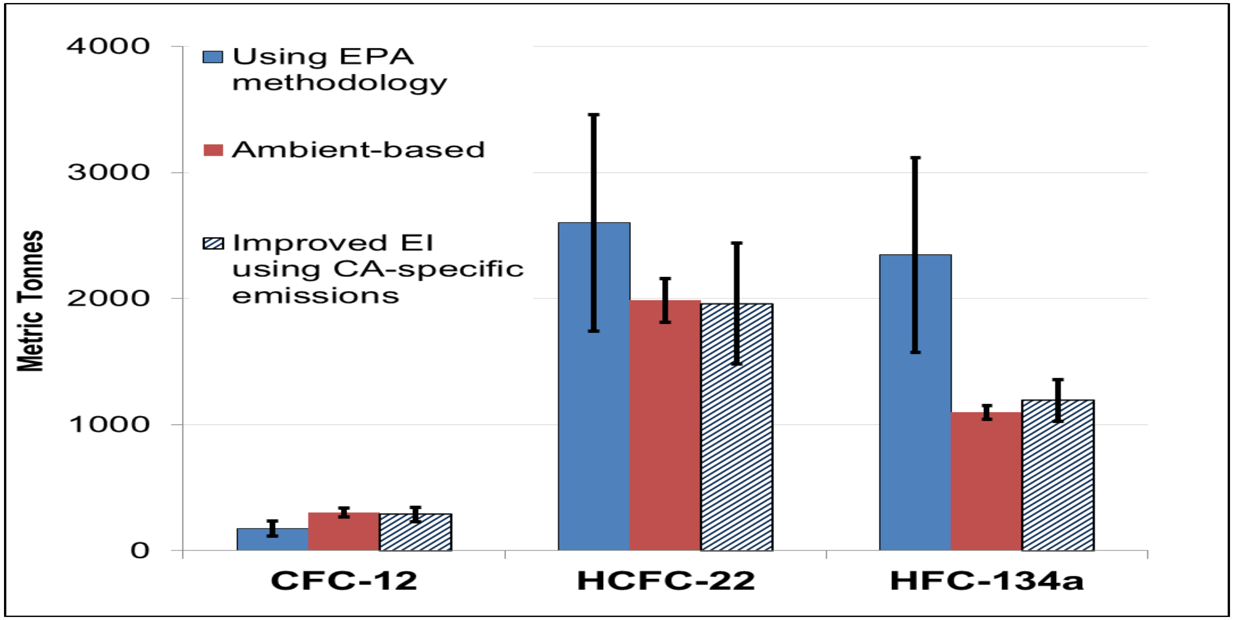


Reference: Ramanathan, Kirchstetter, et al. (2013) Black Carbon and the Regional Climate of California, CARB Contract No. 08-323

Hydrofluorocarbon Findings

Los Angeles Basin

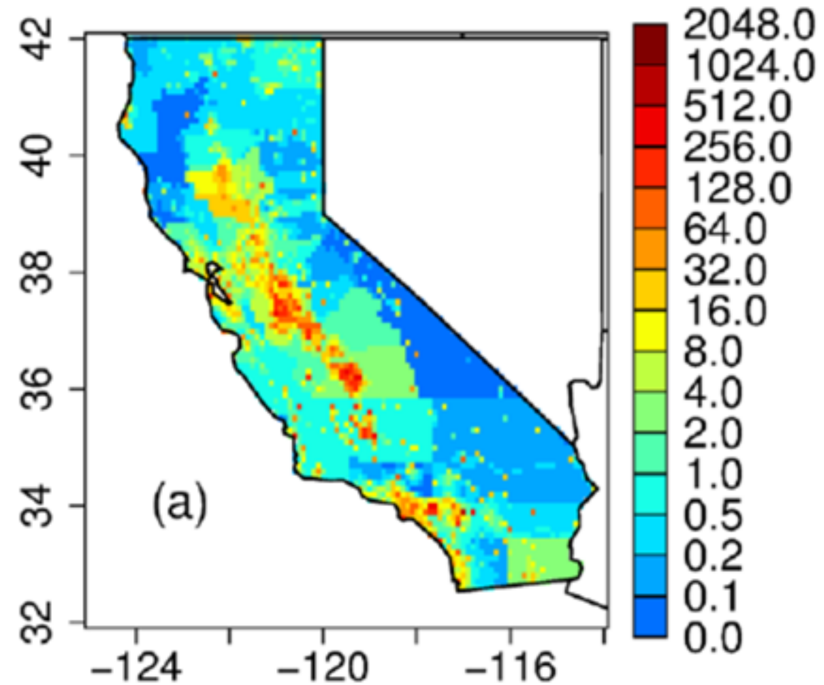
* Results from national EPA-based method differed significantly from 2007 Mt. Wilson measurements
* New California-specific emissions inventory consistent with measurements



Reference: Gallagher, et al. (2014) *Environmental Science & Technology*, pp. 1084-1093

Statewide Methane Findings

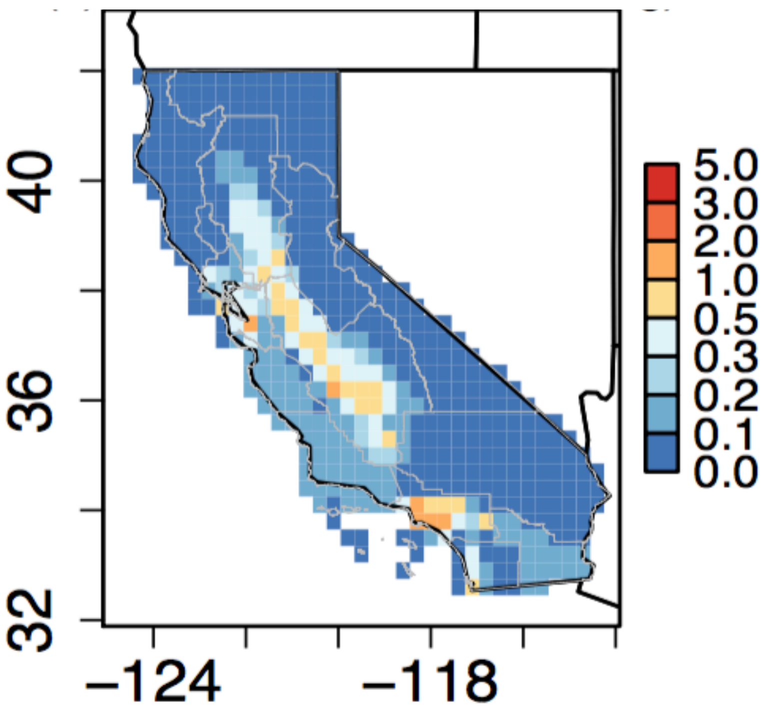
* Estimated methane emissions 1.3 - 1.6 times the ARB inventory
* AB 1496 requires investigation of methane hotspots/super-emitters to inform policies and programs



California-specific total CH_4 emissions (nmol m^{-2} s^{-1})

Fischer and Jeong (2012) Inverse Modeling to Verify California's Greenhouse Gas Emission Inventory, ARB Contract No. 09-348

Statewide Nitrous Oxide Findings



Estimated annual anthropogenic N_2O emissions (Gg N_2O/yr)

- Estimated N_2O emissions 1.7 - 2.2 times the ARB inventory
- Ongoing research to better characterize agricultural and mobile source emissions

Draft – Do not cite

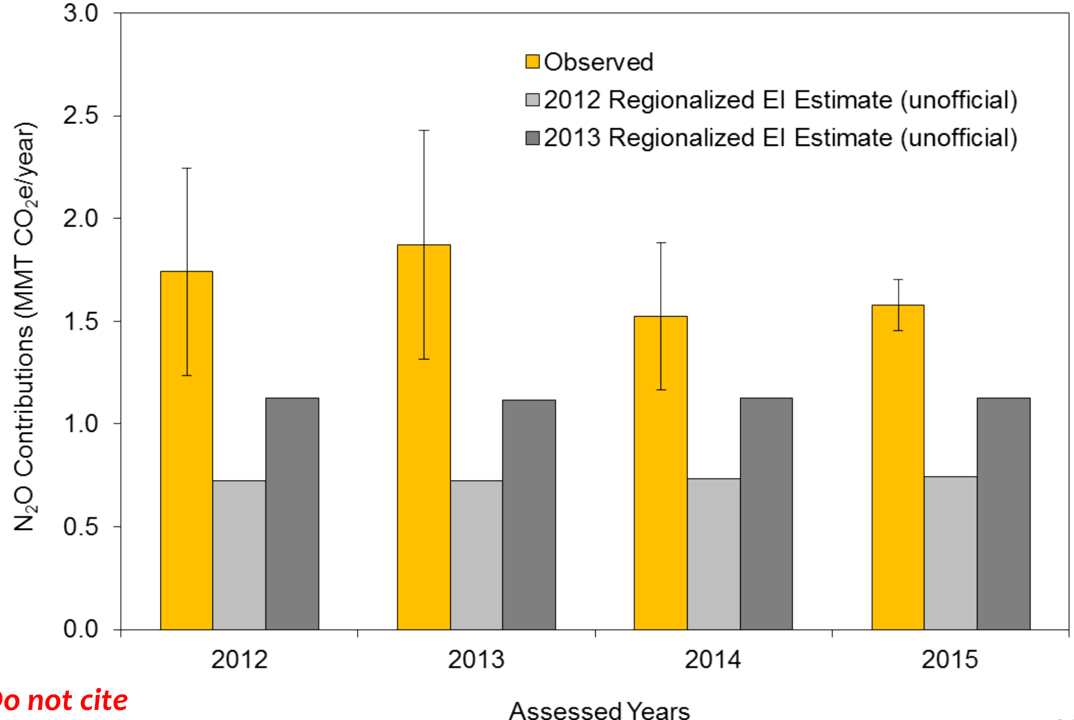
Fischer, et al. (2015) Draft ARB Research Contract Report (11-306)

Nitrous Oxide Findings

Los Angeles Basin

* Estimate based on Mt. Wilson N_2O:CO correlation 130±24% greater than earlier ARB emission inventory

* Recent ARB inventory update reduces discrepancy to 49±15%
* Annual emission trends (2012-2015) stable at 1.68±0.16 MMT CO_2e/year.



Draft – Do not cite

Kuwayama, et al. (in preparation)

California Data Needs

Meeting Air Quality Standards

* Role and source of ozone aloft (2016 field study)
* Role of stratospheric intrusions and transport from East Asia

Meeting Greenhouse Gas Targets

* Track Statewide and sector/source-specific GHG mitigation
* Track co-pollutant trends in disadvantaged communities
* Highly resolved CO and GHG inventories for inverse modeling
* Quantify CH_4 emissions from dairies, landfills, oil/gas sector
* Quantify N_2O emissions from fertilized fields/lawns, dairies, other sources
* Identify remaining sources of BC and BrC
* Land-use changes (urban, working, natural)

Forest Carbon Stock

* Statewide inventories of carbon stocks for forests and other lands
* Screening for carbon-depleted or high carbon-containing natural areas for priority management

Data Product Considerations

Spatial Resolution

* Geographic specificity to target reductions and convince stakeholders
* Role of super-emitters to design regulation/enforcement
* Proper accounting of natural sources (e.g., oil seeps)
* Ability to track individual facilities for compliance and upset conditions
* Landscape carbon accounting at the scale of offset projects

Timeliness

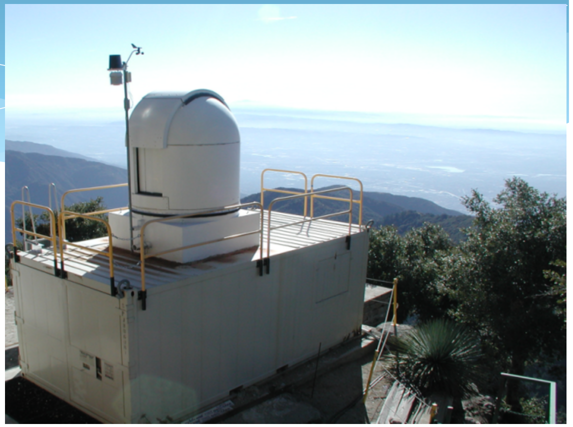
* Regulatory development phase takes 1-3 years
* Decisions on funding for working and natural lands year-to-year

Continuity

* Long-term commitment to measurements and analysis products
  * Inform mitigation program over next few years
  * Help track compliance and effectiveness to 2020, 2030, and beyond

Summary

* California GHG Research Program critical for success of AB 32 programs
  - Evaluate and inform ARB GHG inventory
  - Identify, implement, and validate effective emission mitigation strategies
  - Track GHG emission trends in the state
* Current efforts are helping improve emission inventories and source attribution
* Continued research collaborations invaluable to help California meet its short- and long-term climate goals



End: Bart Croes & Elizabeth Scheehle
Next: Walter Vergara and Fred Stolle

WORLD RESOURCES INSTITUTE

Initiative 20x20

A country-led effort to initiate restoration of 20 Mha in Latin America by 2020

WALTER VERGARA, WVERGARA@WRI.ORG

Context in Latin America

58% of annual GHG emissions in LAC from land use and land use change

50% of non large urban area employment in LAC tied to agriculture and forestry

13% of global food and fiber trade from LAC

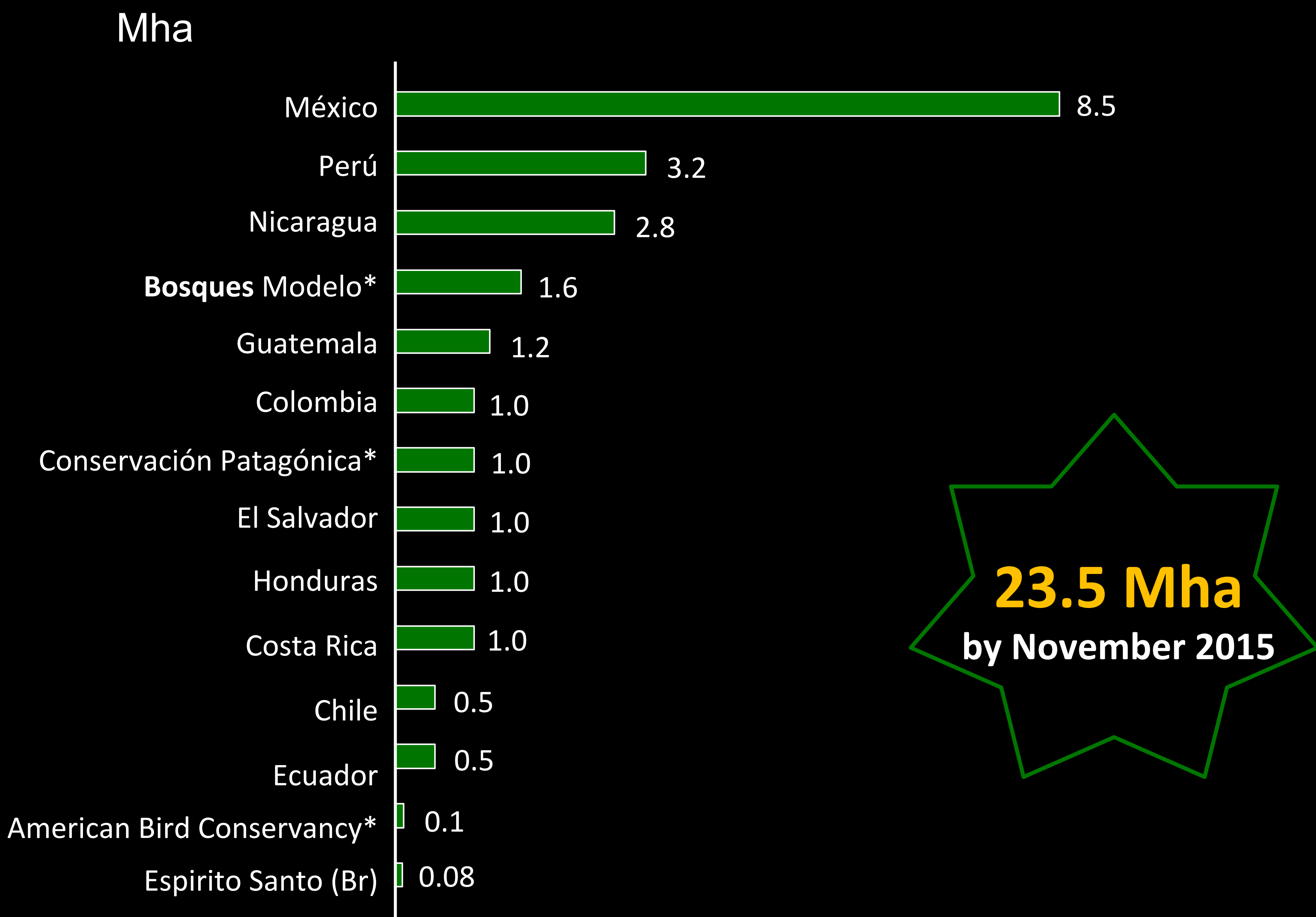
37 Mha of forests and grasslands converted to agriculture in LAC since 2000

350 Mha of lost or degraded forest landscapes (half the landmass of Australia

200 Mha with the potential to be restored into healthy landscapes

Sources: World Bank, FAOSTAT, GFW, Atlas of Forest and Landscape Restoration Opportunities, WRI

1. Initiative 20x20 ambitions to date



* Programas regionales

2. KEY THEMES FOR TECHNICAL ASSISTANCE

- Robust monitoring system
- Supportive incentive system
- Reliable long term supply of germ plasm
- Accessible information on restoration technologies
- Assessment of financial and economic returns
- Improved investment readiness

3. Secure financing

Private sector equity ($0.7 billion)

Debt finance (5X equity)

Partial Risk Guarantee ($115 million) and Capitalization Fund

Investment Readiness Fund ($10 million)

althelia ecosphere

ecoplanet bamboo

PERMIAN GLOBAL

Forestry and Climate Change Sub-Fund

rare

Terra GLOBAL CAPITAL

SLM Partners in Sustainable Land Management

IDB Inter-American Development Bank

CAF DEVELOPMENT BANK OF LATIN AMERICA

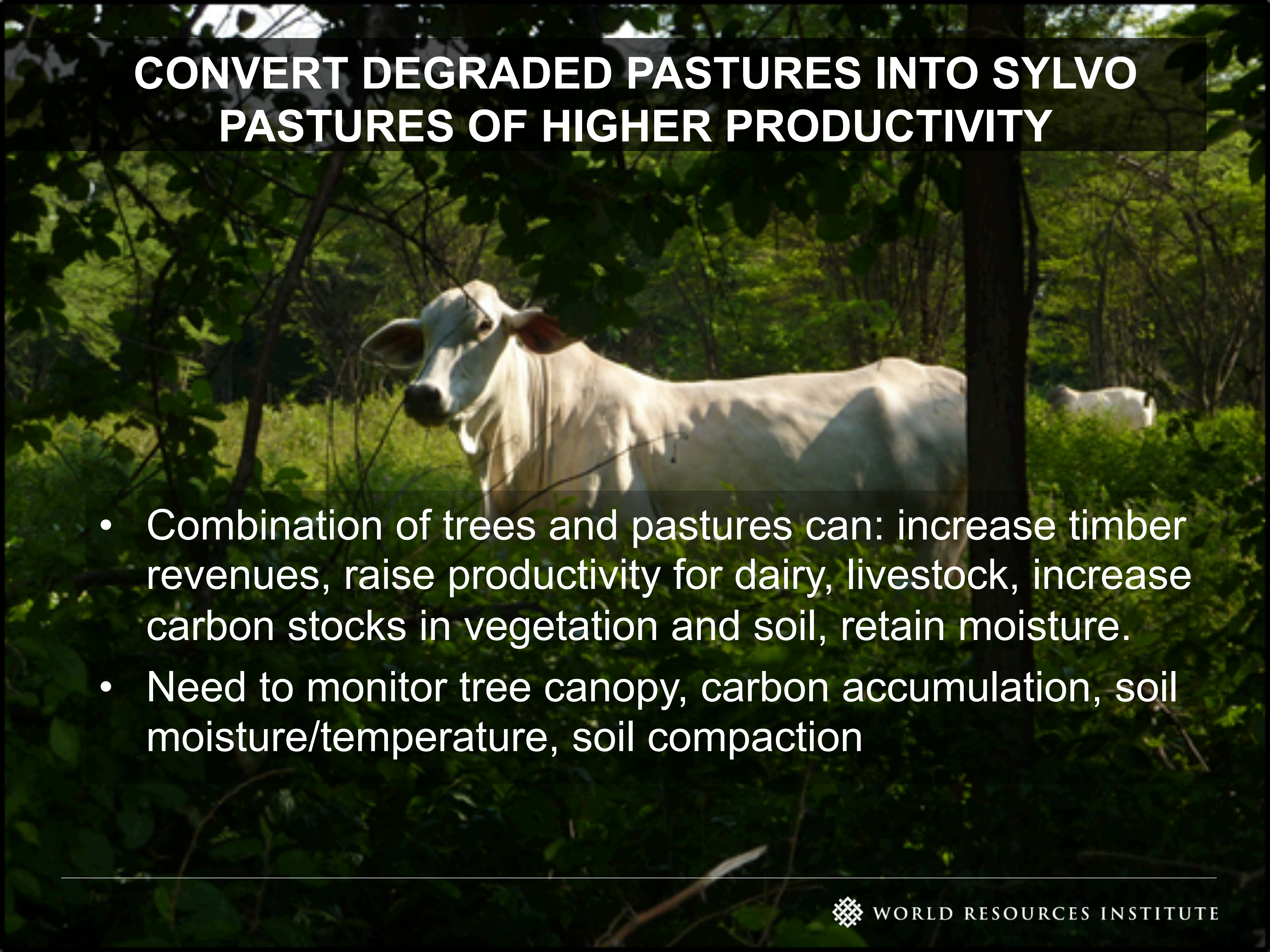
WORLD BANK GROUP

gef

GREEN CLIMATE FUND

SHIFT MONOCULTURE MARGINAL CROPLAND TO AGROFORESTRY

- Agroforestry can create timber revenues, raise productivity through higher yields and diversification. It can retain moisture, control temperatures, increase carbon stocks in vegetation and soil.
- Need to measure: gains in canopy, carbon accumulation, soil temperature and moisture



CONVERT DEGRADED PASTURES INTO SYLVO PASTURES OF HIGHER PRODUCTIVITY

- Combination of trees and pastures can: increase timber revenues, raise productivity for dairy, livestock, increase carbon stocks in vegetation and soil, retain moisture.
- Need to monitor tree canopy, carbon accumulation, soil moisture/temperature, soil compaction

REFOREST BARE LAND AND DEGRADED FORESTS

- Multi species reforestation can increase carbon stocks, support recovery of biodiversity, retain soil and recover lost hydrology.
- Need to monitor gains in canopy, carbon accumulation, soil temperature, and moisture; biodiversity

ENRICH SECONDARY FOREST AND PROMOTE ASSISTED NATURAL REFORESTATION

- Enrichment and assisted natural reforestation can promote ecological recovery at low cost.
- Need to monitor diverse canopy recovery, carbon stocks in vegetation and soil, soil temperature and moisture, biodiversity.

RECOVER STRIPPED-MINED AREAS

- Recovery is intended to return vegetation, manage toxicity, achieve some degree of ecological restoration.
- Need to monitor carbon stocks in vegetation and soil, accumulation and leachate of heavy metals

PROJECTS IN THE MAKING

- 100,000 ha grassland recovery project in Patagonia (Chile)
- 10,000 ha agroforestry project in Nicaragua
- 30,000 ha agroforestry project in amazon region in Peru
- 100,000 ha silvo pasture proposal in Colombia
- 1.4 million ha proposal for forestry recovery and avoided deforestation in Colombia
- 160,000 ha goal for protection and recovery of migratory birds habitat

CMS -- 20X20: CAN THIS BE A MATCH MADE IN HEAVEN ?

- Morton 01: projects in Peru and Brasil
  - Lidar biomass models
- Walker-01: projects in Mexico
  - Carbon density maps
- Kellndorfer 03: projects in Peru, Colombia and Mexico
  - Forest carbon fluxes
- Houghton 02: neo tropics
  - Net carbon fluxes

COULD WE USE CHLOROPHYLL FLUORESCENCE?

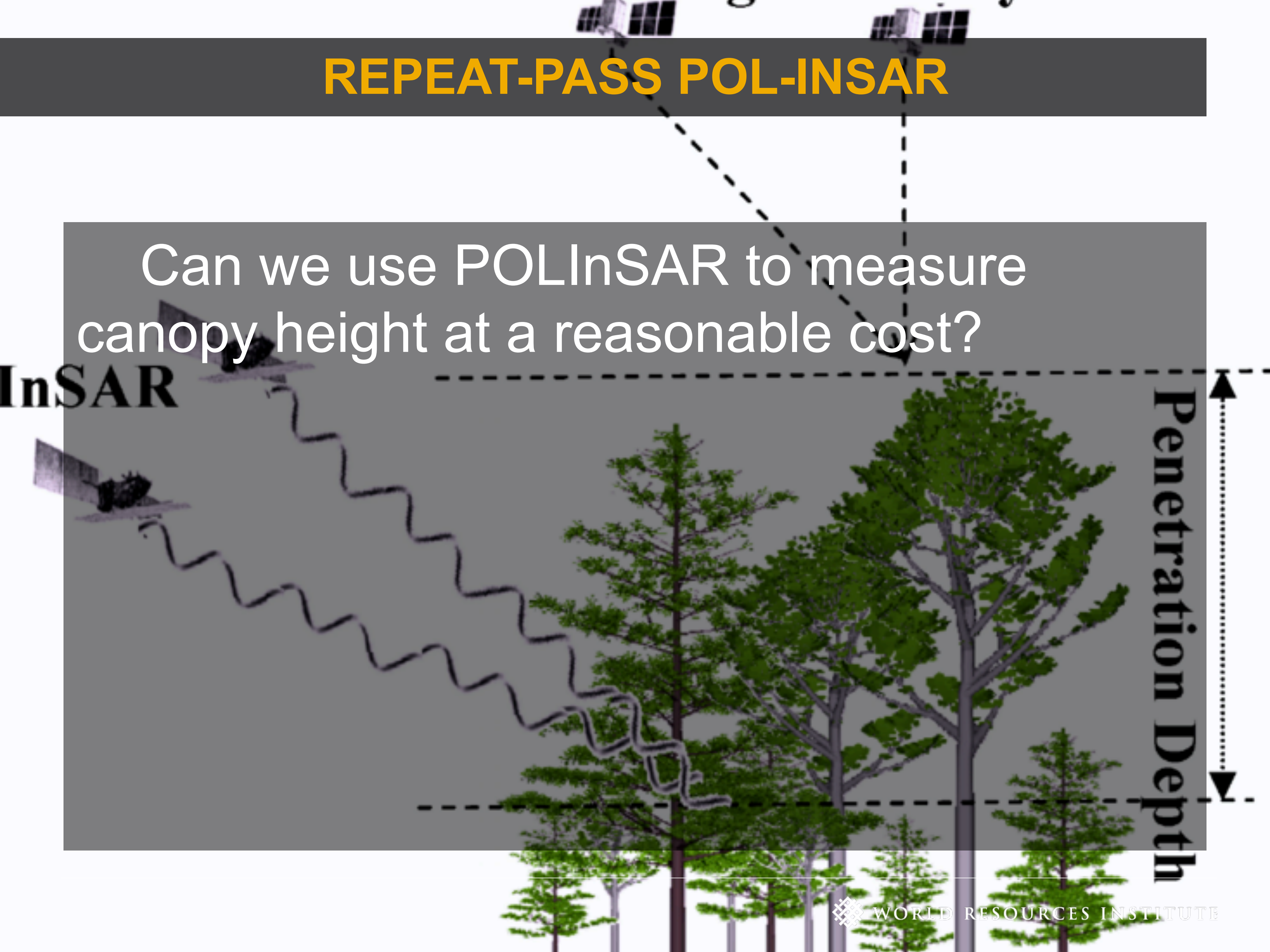
- Spectrometers aboard climate satellites can detect fluorescence coming from croplands and forest canopies
- Track the changes in plant growth in real time from space?.
- Can we expect improvements in resolution that would allow project-size application?

CAN WE USE UAVSAR TO MONITOR CHANGE IN VEGETATION COVER?

- Is 1 m resolution of vegetation cover possible for applications in agriculture and forestry?
- Could UAVSAR (POLSAR) be deployed for 10**3 Ha applications?

REPEAT-PASS POL-INSAR

Can we use POLInSAR to measure canopy height at a reasonable cost?



SUPPORT GLOBAL AMBITION

BONN CHALLENGE

New York Declaration on Forests

FOCUS SUPPORT

Initiative 20x20

MOBILIZE FINANCE

Argentina	Ecuador	Mexico
Chile	El Salvador	Nicaragua
Colombia	Guatemala	Peru
Costa Rica	Honduras	Espirito Santo – Brazil
		São Paulo - Brazil

ACHIEVE COUNTRY AMBITIONS

End: Walter Vergara and Fred Stolle
Next: Kate Larsen

The Post-Paris MRV Landscape

Where can CMS play?

Kate Larsen
Director
kmlarsen@rhg.com

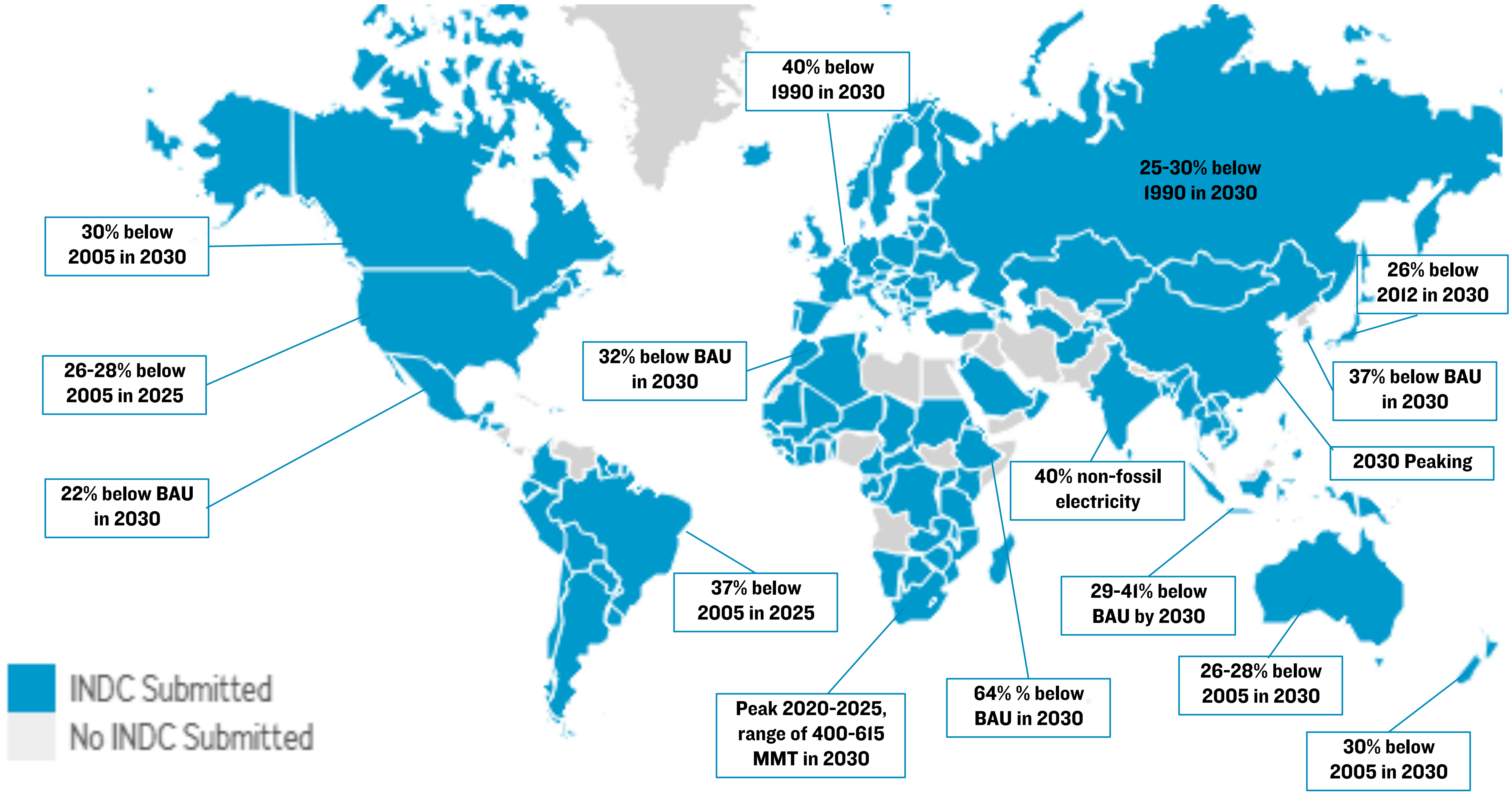
November 16, 2015

Overview

- MRV of new “Nationally Determined Contributions”
- MRV Landscape Pre/Post-Paris
  - International
  - National
- Opportunities for CMS products

Wide range of countries with INDCs to date

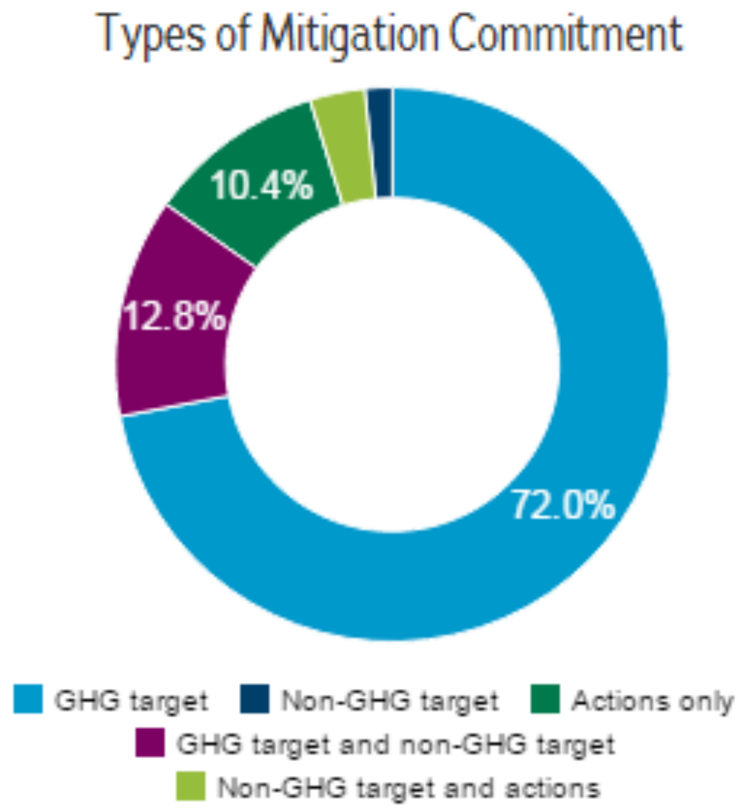
Primarily economy-wide GHG reduction or CO_2 intensity targets



Many INDCs include mitigation "actions" for the forest sector

MRV needs will vary by country

- **Chile:** restoration of 100k ha of native forest (sequestration of ~600k tCO_2e) and reforestation of 100k ha (capture of 900k-1.2m tCO_2e) per year by 2030
- **China**: increase the forest stock volume by around 4.5 bn m^3 above 2005 level.
- **Bhutan**: maintain minimum of 60% total land under forest cover with effort to maintain current levels (~70%)
- **Cambodia**: increase forest cover to 60% of national land area by 2030
- **Honduras**: afforestation/reforestation of 1m ha of forests by 2030.
- **India**: create additional carbon sink of 2.5-3 bn tCO_2 through additional forest cover by 2030
- **Vietnam**: increase forest cover to 45%



International MRV regime post-Paris

No significant changes in form or methods from current system

Purpose:

- Track annual GHG emissions
- Demonstrate progress toward and achievement of NDC

Measurement:

- GHG inventories (anthropogenic, 6 gases, covering IPCC sector categories)
- Submitted 2 years after year of emissions

Reporting:

- All self-reported by national government
- GHG inventories and qualitative information on actions

Verification:

- Technical review by experts
- Peer review by other countries (Q&A, public discussion session at UN)

Timeframe:

- Every ~2 years for most countries (annual inventories for developed countries)

National MRV driven primarily by UNFCCC requirements

No significant changes in form or methods from current system

Purpose:

- Track GHG emissions
- Identify emission reduction opportunities and potential by sector/gas
- Inform establishment of INDC and policies to achieve it
- Track and demonstrate progress toward/achievement of NDC to domestic/international audiences
- Improve understanding of GHG measurement uncertainty and improved methods

Measurement:

- GHG inventories (bi/annual)
- Industry self-reporting

Timeframe:

- Annual/biennial GHG inventories
- Projections out to 2025/2030 and beyond (done every 2-5 years)
- Periodic updates to GHG inventory methods (varies by country)

Where CMS products can help inform/improve MRV

1. Independent, go-to source for sub/supranational data:

- Provide estimates of global non/anthropogenic GHG emissions/removals for CO_2 and CH_4 by source (+ uncertainty) on annual basis

- Independent estimates of land-cover changes (for MRV of NDCs), and/or provider of data to countries for self-reporting

Where CMS products can help inform/improve MRV

2. Validation:

- Provide independent measurements for specific sectors/gases in countries using inaccurate GHG inventory methods
  - Ex: *Many countries oil & gas methane emission estimates are flawed*
  - Ex: "*Official data from China revealed country is burning up to 17% more coal annually than previously reported.*"
- Aim: improve GHG inventories, help identify mitigation opportunities
- Scope: within national borders, by sector/gas, annual timescale (or able to extrapolate to annual)
- Audience: stakeholders looking to identify/optimize mitigation efforts (NGOs, UN agencies

Where CMS products can help inform/improve MRV

3. Improve timeliness of GHG data:

- Provide more frequent/up-to-date estimates of GHG emissions
  - Ex: *many countries report only every 2-10 years, with a 2-4 year time lag*
- Aim: allow for independent assessment of recent (within 1 year) estimates of GHG emissions/removals
- Scope: within national borders, by sector/gas, annual timescale (or able to extrapolate to annual)
- Audience: could be used as backdrop for regular assessment of NDC progress, global emissions

End: Kate Larsen
Next: Sanden Totten

Getting the Public to Care About Carbon

Or Carbon Cycle II: This Time it's Personal….

What is a carbon cycle?

Carbon:
“sorta celebrity” status

Carbon: “sorta celebrity” status

Carbon:
"sorta celebrity" status

How to get the public to care

How to get the public to care

Step 1: Boost their Understanding

Step 1: Boost their Understanding

ALWAYS Recap The Basics

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- Start with the big picture

Step 1: Boost their Understanding

ALWAYS Recap The Basics

- Start with the big picture
- Drill down to specific issues and questions

Step 1: Boost their Understanding

ALWAYS Recap The Basics

- Start with the big picture
- Drill down to specific issues and questions
- Get to your area of research and its findings

Step 1: Boost their Understanding

ALWAYS Recap The Basics

- Start with the big picture
- Drill down to specific issues and questions
- Get to your area of research and its findings
- Have your elevator pitch ready!

Step 1: Boost their Understanding

Step 1: Boost their Understanding

ALWAYS Point Out Why This Matters

Step 1: Boost their Understanding

ALWAYS Point Out Why This Matters

- Start with the big picture problem and be specific

Step 1: Boost their Understanding

ALWAYS Point Out Why This Matters

- Start with the big picture problem and be specific
- Talk about how your research will help us solve a problem

Step 1: Boost their Understanding

ALWAYS Point Out Why This Matters

- Start with the big picture problem and be specific
- Talk about how your research will help us solve a problem
- What will we be able to do when research like yours is successful

Step 2: Make them Care

Step 2: Make them Care

Tell A Story

- Make it personal
- Make it specific

Step 2: Make them Care

Make It Personal To Them

Step 2: Make them Care

Make It Personal To Them

- What are the local effects?

Step 2: Make them Care

Make It Personal To Them

- What are the local effects?
- What changes might we actually feel?

Step 2: Make them Care

Make It Personal To Them

- What are the local effects?
- What changes might we actually feel?
- What changes will our kids feel?

Step 2: Make them Care

Make It Personal To You

Step 2: Make them Care

Make It Personal To You

- Why you got into this line of work

Step 2: Make them Care

Make It Personal To You

- Why you got into this line of work
- What person, place or species are you worried about?

Step 2: Make them Care

Make It Personal To You

- Why you got into this line of work
- What person, place or species are you worried about?
- Show your passion!

Step 2: Make them Care

Step 2: Make them Care

Don’t Leave Us Hanging

Step 2: Make them Care

Don’t Leave Us Hanging

- Is there hope and how do we get some?

Step 2: Make them Care

Don't Leave Us Hanging

- Is there hope and how do we get some?
- What can we do personally?

Step 2: Make them Care

Don't Leave Us Hanging

- Is there hope and how do we get some?
- What can we do personally?
- What work is being done to address this?

Step 2: Make them Care

Don’t Leave Us Hanging

- Is there hope and how do we get some?
- What can we do personally?
- What work is being done to address this?
- Be an advocate if you can!

Case Study:
The California Drought

Case Study: The California Drought

- Constant blitz, consistent messaging
- One specific step / issue at a time
- Outreach to various communities
- Gave people concrete things to do
- Used hash-tags and social media
- Having fun with it!

Get in touch!

Sanden Totten

stotten@scpr.org

Twitter: @sandentotten

Instagram: @sandentotten

Get in touch!

End: Sanden Totten
Next: Amy Holm

The Climate Registry

MRV Process and Water-Energy GHG Protocol Development

NASA CMS Applications Workshop

November 16, 2015

Amy Holm, Director of Programs & Operations
213.891.6922 (direct) www.theclimateregistry.org

The Climate Registry

Community of Members

CLIF BAR

DELTA

UNITED STATES POSTAL SERVICE

Ford

Virgin america

CISCO

Marriott HOTELS & RESORTS

SAFEWAY

HERSHEY'S

DIGITAL REALTY

City of Santa Monica

KAISER PERMANENTE

PG&E

Xcel Energy

BENTLEY

IRVINE RANCH WATER DISTRICT

CITY OF VENTURA

GILLS ONIONS QUALITY • CONVENIENCE

COUNTY OF SAN DIEGO
THE NOBLEST MOTIVE IS THE PUBLIC GOOD
MDCCCLI

Dean FOODS

THE UNIVERSITY OF CALIFORNIA IRVINE
LET THERE BE LIGHT

THE WESTIN MISSION HILLS RESORT & SPA PALM SPRINGS

COUNTY OF VENTURA CALIFORNIA

BROWN-FORMAN

WEST BASIN MUNICIPAL WATER DISTRICT

Shaw Where Great Floors Begin

KILROY REALTY CORPORATION

COUNTY OF LOS ANGELES CALIFORNIA

MASTERY UNDER GLASS HOUWELING'S TOMATOES

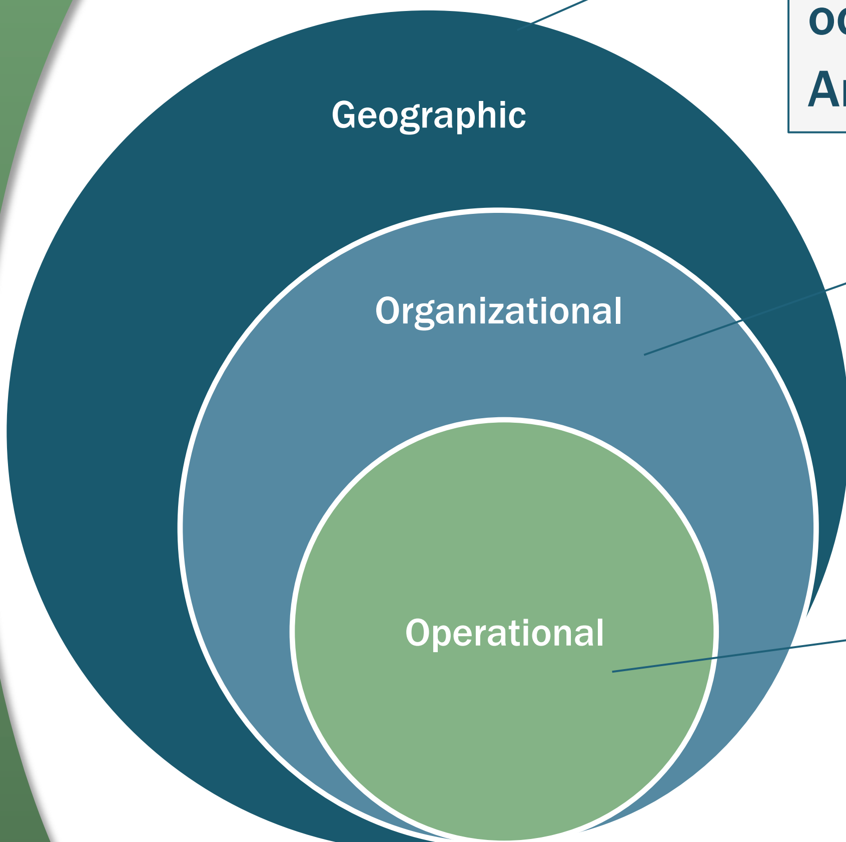
TORRANCE MEMORIAL MEDICAL CENTER

The Climate Registry's MRV Process

1. Identify your reporting boundaries
2. Select your facilities based on your boundaries
3. Organize and collect data on emission sources
4. Quantify and report emissions
5. Verify by independent third-party

The Climate Registry

Step 1: Identify your reporting boundaries



Where do your emissions occur spatially? North America? Globally?

Which emissions do you include in your inventory? Financial and/ or operational control?

Which greenhouse gases and scopes are included in your inventory?

Step 2: Determine specific facilities based on your boundaries

Stationary – warehouse, retail store, manufacturing plant, office building

Mobile – passenger cars, train fleet, tractors, marine vessels, aircraft, “special facilities” including oil and gas wells, pipelines, electricity transmission and distribution systems, and water conveyance systems

Step 3: Organize and collect data on emission sources

- **Scope 1 emissions**
  - ✓ mobile combustion from vehicles
  - ✓ fuel usage logs or annual mileage records
- **Scope 2 emissions**
  - ✓ purchased electricity and/or steam; heating or cooling
  - ✓ accounting records or obtain data from utility provider
- **Scope 3 emissions**
  - ✓ employee commuting or business travel
  - ✓ employee reimbursement forms and/or receipts

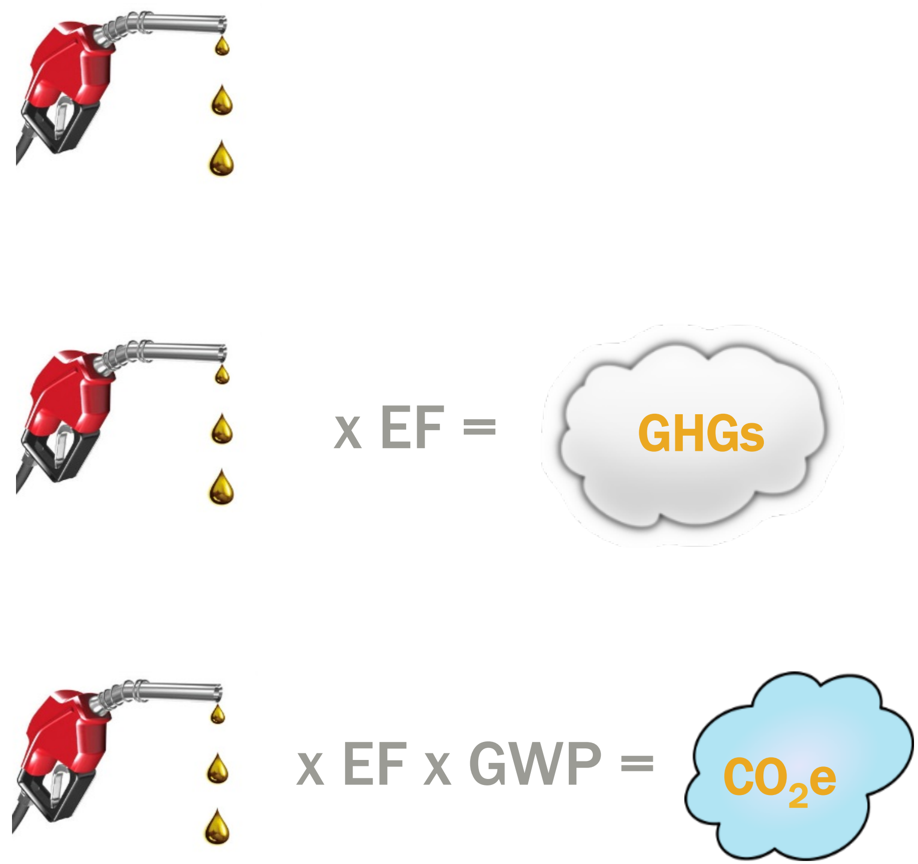
The Climate Registry

Step 4: Quantify and report emissions

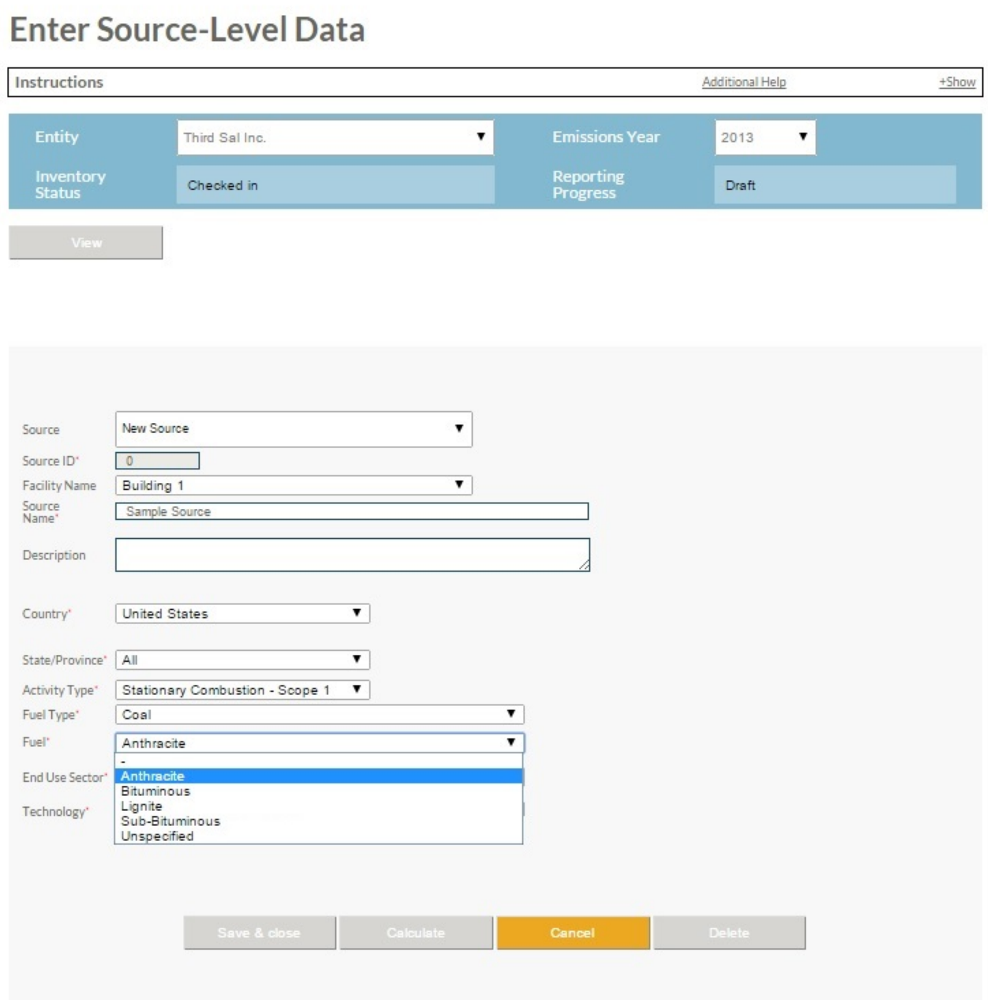
Activity Data: the amount of fuel or material that, when used, causes GHGs

Emission Factor (EF): converts activity data into GHGs

Global Warming Potential (GWP): converts non-CO_2 emissions into CO_2e



Step 4: Quantify and report emissions



The Climate Registry

Step 5: Verify by independent third party

- Optional, but highly encouraged
- Ensures conformance with:
  - Reporting requirements
  - Principles (completeness, transparency, and accuracy)
  - Minimum quality standard
- Places credible data in the public domain
- TCR's verification program is unique, robust, and requires verifiers to be accredited by ANSI (American National Standards Institute).

Water-Energy GHG Protocol

Source: http://words.usask.ca/sustainability/

The Climate Registry

Protocol Development Process

1. Research topic area & existing data
2. Relate to existing MRV best practices in GHG accounting
3. Propose MRV process for protocol
4. Open, consensus driven stakeholder process
5. Operationalize protocol in CRIS

Step 1: Research topic area & existing data

Source: http://www.iwawaterwiki.org/xwiki/bin/view/Articles/WaterSupplyNetwork

What unit of measurement?

What data is available?

How to account for water loss?

Step 2. Relate data to existing MRV best practices in GHG accounting

Organizational boundary?

Emission Factors?

Verification?

Source: Pacific Institute

Step 3. Propose MRV process for protocol

- ✓ Follow TCR's GRP to develop a GHG Inventory
- ✓ Collect additional data
- ✓ Calculate water-energy inventory (Scope 3 emissions relevant to water)
- ✓ Calculate intensity metrics
- ✓ Enter data into CRIS
- ✓ Verify GHG data

The Climate Registry

Step 4: Open, consensus driven stakeholder process

Step 5: Operationalize protocol in CRIS

Source: www.ridgehead.com & www.clipart.com

The Climate Registry

Conclusion

Information: carbon data related to water conveyance and use in North America

Timeframe: 2016-17, WEG protocol will be updated periodically as new data and policy emerges.

Collaborate: share potential of available data and participate in stakeholder process

End Presentations