Carbon Dynamics Workshop September 9-12, 2019

Recollections of connecting partners, pooling knowledge and building momentum towards shared goals

Carbon Dynamics Workshop September 9-12, 2019

Workshop Event Team:

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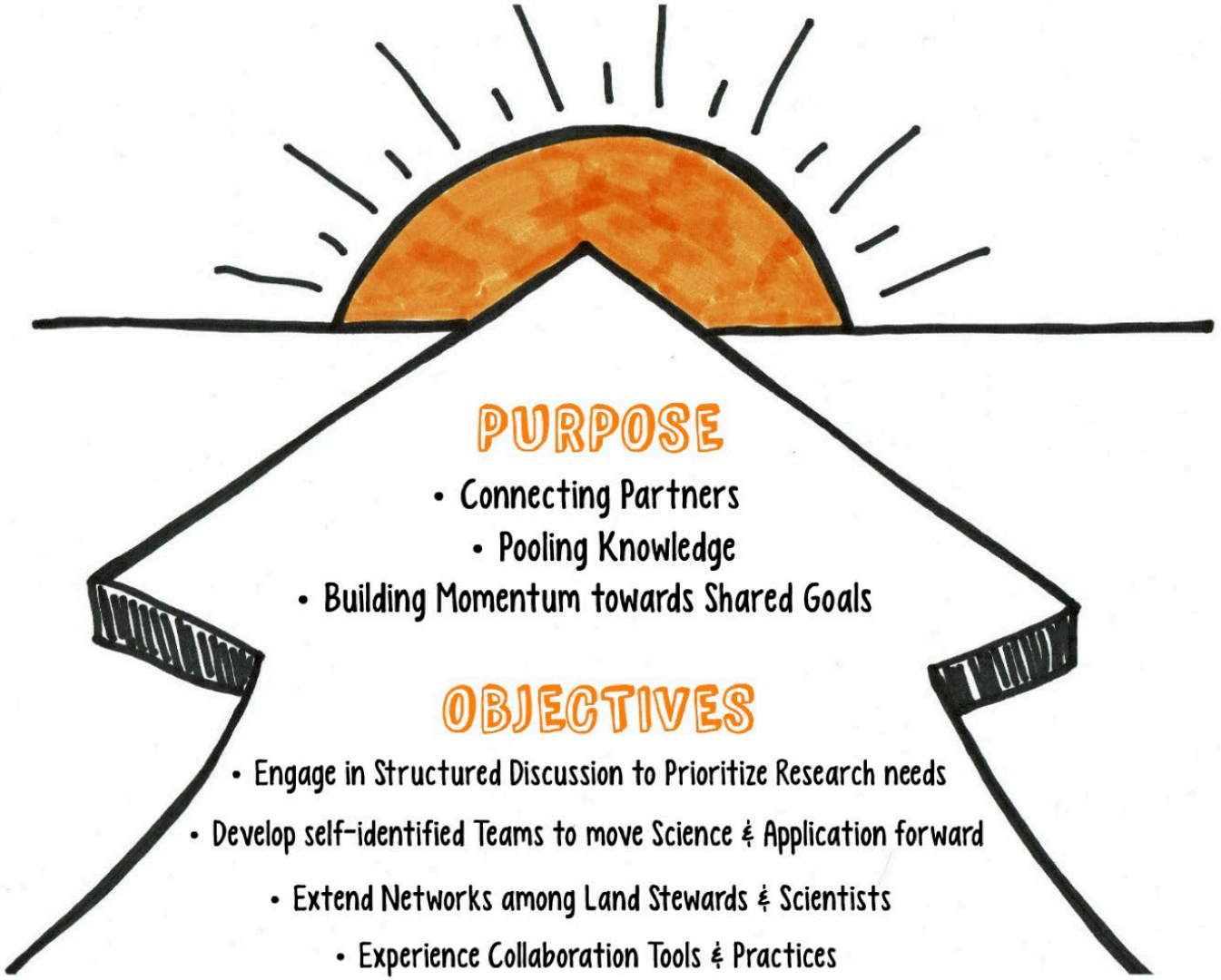
Workshop recollections prepared by Jane Terzibashian and Rachel White

* Presentations are available on this event website. Reference materials from the workshop as well notes and images are available to attendees by invite. If you would like access please contact jane.terzibashian@usda.gov

USDA Forest Service, Pacific Northwest Research Station has launched a **research initiative** to enhance and organize policy-relevant understanding of carbon flux and carbon accounting, and to fill knowledge gaps about forest carbon dynamics.

This workshop supported PNW's research initiative by bringing together scientists and land stewards for collaborative and productive discussions on improving the relevance of carbon science.

Carbon Dynamics Workshop



PURPOSE

- Connecting Partners
- Pooling Knowledge
- Building Momentum towards Shared Goals

OBJECTIVES

- Engage in Structured Discussion to Prioritize Research needs
- Develop self-identified Teams to move Science & Application forward
- Extend Networks among Land Stewards & Scientists
- Experience Collaboration Tools & Practices

Unconventional convening techniques were employed in this workshop to change how scientists and land stewards communicate.

Use of these novel models of working together helped us harness the expertise and experience of participants and better understand the complex challenges facing carbon science.

<u>Ultimately this resulted in actions that will move the research initiative forward</u>

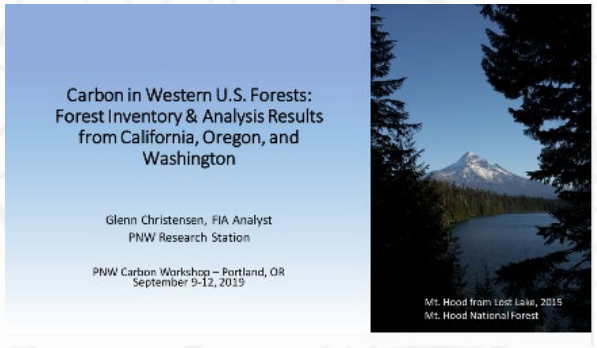
By the end of the workshop three self-identified teams formed to further explore these research questions:

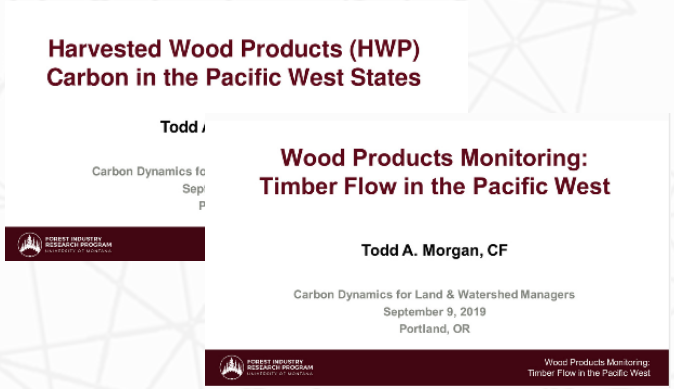
- How do we identify and improve the most appropriate carbon models of the forest sector and all lands?
- What is the state of the current knowledge for Green Carbon in Pacific States?
- What are the carbon fluxes and social implications of different forest management strategies?

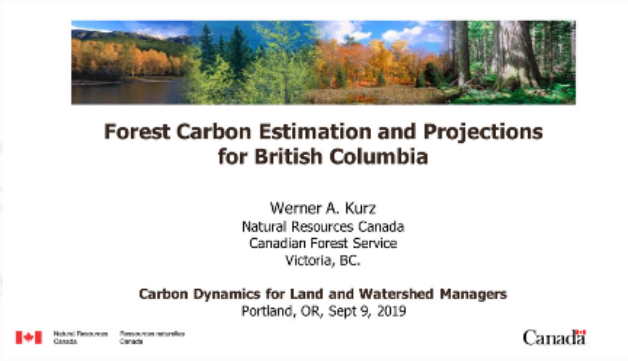
The following collection of notes, images, and records serve to remind attendees *how* we convened around these research questions and to re-inspire forward momentum. They may also aid as a reference to share the experience with others as we continue the journey of co-production of carbon research.

Day 1: Defining information needs from inventory

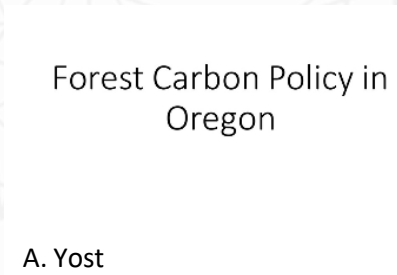
An audience representing a wide variety of stakeholders were in attendance on day one to hear speakers present current results from Forest Carbon Inventories in Washington, Oregon, California and British Colombia.







Partners shared current forest carbon policy objectives and strategies from their respective state/province.

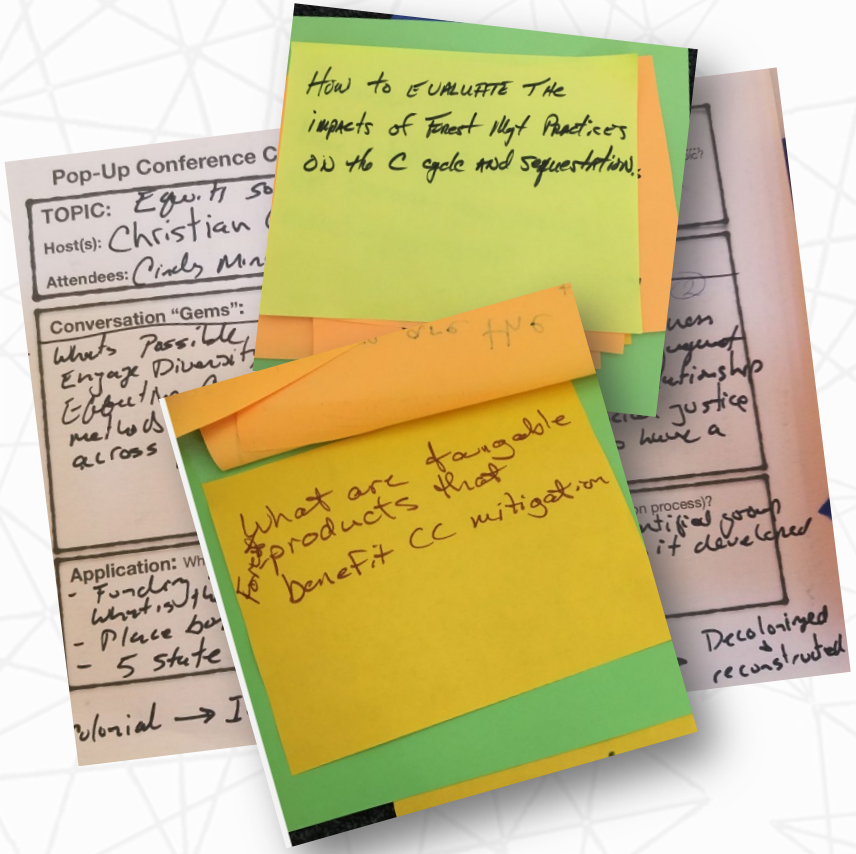


Facilitated discussions, panel Q&A's, and brainstorming exercises during this session examined how carbon estimates are currently being calculated, what is missing, and what is undiscussed. A comparison of the US and Canadian approach to estimating carbon was presented further fueling the discussion.

Throughout the day participants emphasized the goal of consistency in reporting, the value of including harvested wood products, importance of projection/scenario modeling in the reporting, and acknowledgement of information gaps around below-ground carbon. Displacement factors/substitution benefits of harvested wood products generated some interesting discussion as did the role of nonscientists and the reality facing various landowners and managers as it pertains to carbon mitigation.

Day 2-4: Connecting Partners, Pooling Knowledge, Building Momentum towards Shared Goals

Many of the ideas and knowledge shared in activities throughout the workshop were captured in notes and illustrations.



Facilitators challenged us to periodically review individual input in dynamic ways.

As a collective, we worked to find patterns and meaning in what we were **ALL** saying.

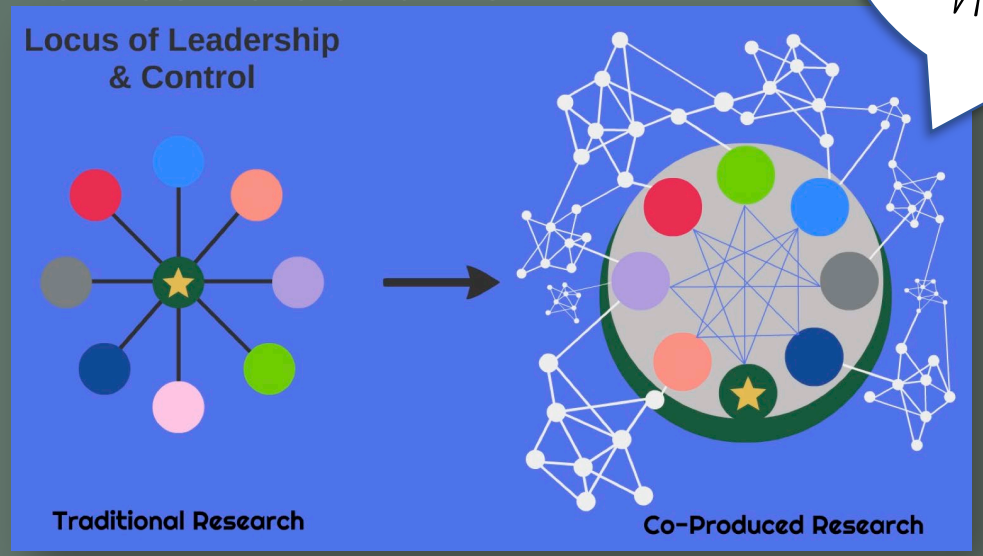
Core principals for convening and collaborating

Distilling complex issues down into a few actionable items TOGETHER

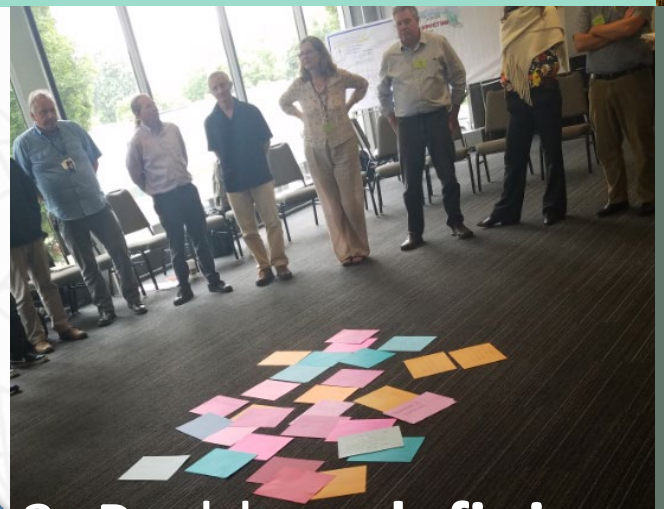
1. Inquiry over advocacy

Being inclusive requires humility

2. Power sharing is at the heart of collaboration

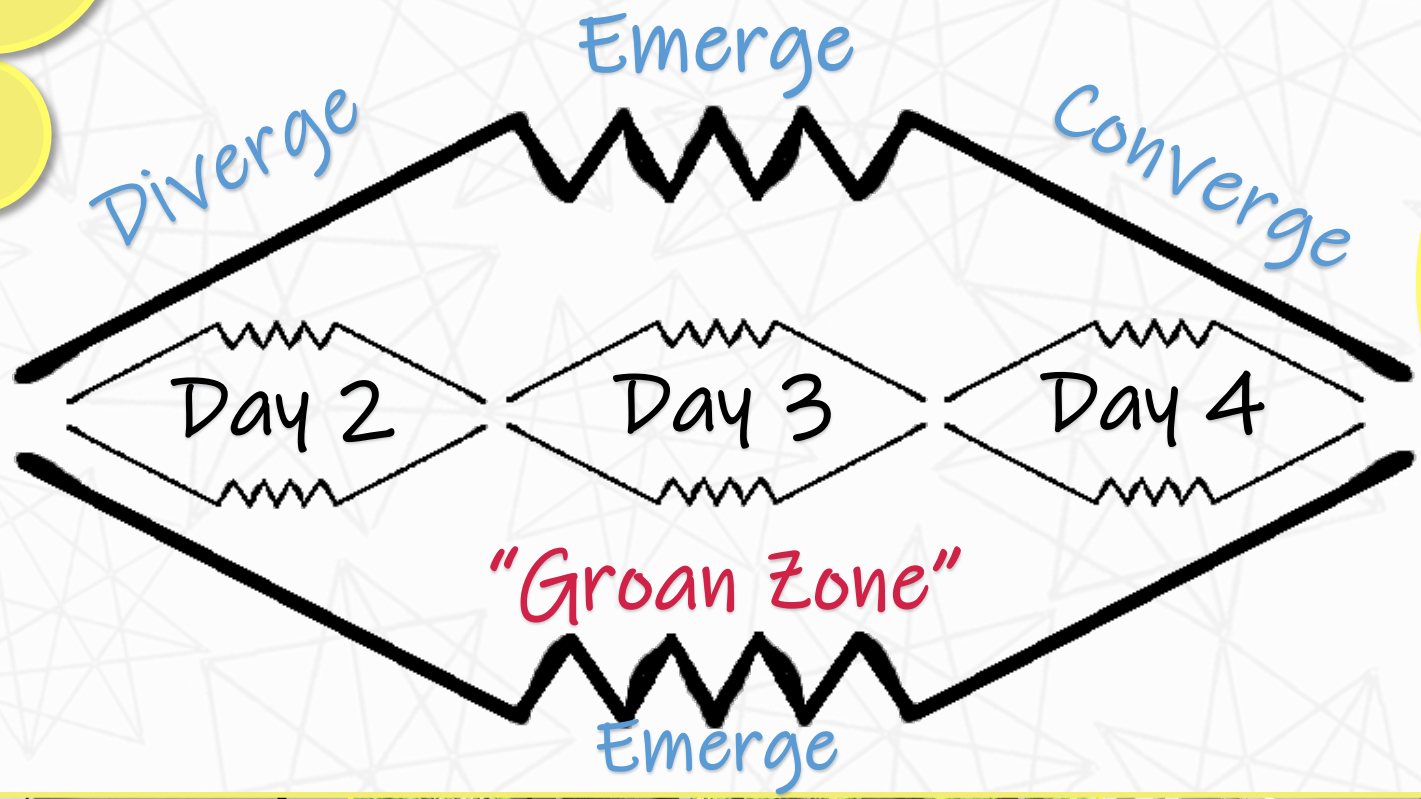


What's the cost of continuing doing what we are already doing?



3. Problem **defining** before problem **solving**

Non-linear problem defining phase really challenged participants!



Our group eventually converged around 3 research questions and a commitment to form a communication strategy.

Diverge

Converge

an ongoing collaborative process for including diverse voices to motivate questions, methods, and implementation of research

a collaborative process on a set of services to achieve an agreed upon outcome

collaborators who represent different points on a spectrum from producer to consumer working together to define and answer questions.

multiple stakeholders being interested in the process/ research throughout the process from inception to products /deliverables

collaboration on a project with mutual agreement on the deliverables

a process that encompasses interests of multiple stakeholders toward a common purpose.

collaborative ID of problem area, need, approaches, data, management and synthesis into useful information with the responsibility for production being a mutually decided upon, and ranging from heavy leadership by research by stakeholders or "in-between"

...proactively incorporates multiple stakeholders and partners in a research process where questions are identified and answered.

...the process of improving research outcomes through collaboration between scientists and stakeholders

...a diverse group of people defining a problem and working through the necessary research to find a solution

co-generation – a process that engages stakeholders/ end users to define needs and produce useful information

collaboration concepts applied through the entire cycle of research

a series of interactions to identify questions, design approach... ending in science delivery

creating a project with someone with different skills and interests

...working in a diverse group toward a shared objective

What is co-production?

Co-production means working hand in hand with partners through all phases of research, from defining problem statements, to outlining study plans, to delivering and integrating research findings and tools.

Only by bringing researchers and land managers together across geographic and institutional boundaries can we fully understand the decision making context of our partners and grasp their most critical information needs.

Co-production

What are the RISKS?

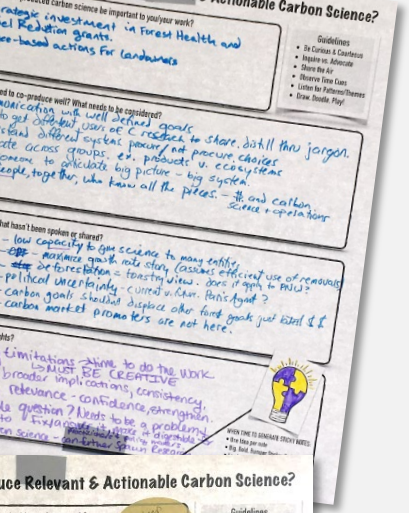
- time commitment
- unfunded mandates
- potential loss of control
- shifting priorities
- everyone has a full plate
- collaborative work not rewarded

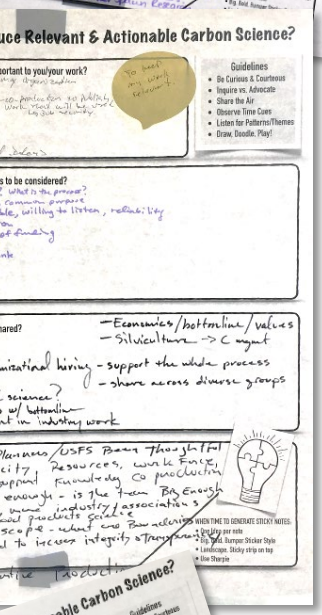
What are the REWARDS?

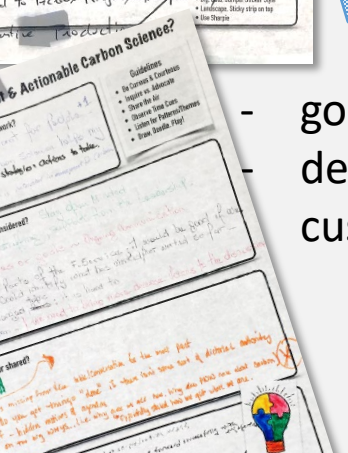
- better focus/visibility for PNW Research Station
- informing Carbon legislation in positive ways
- greater relevance
- long term efficiencies
- higher impact of research
- enhanced adaptation of work
- new applications for land managers
- make a bigger pie

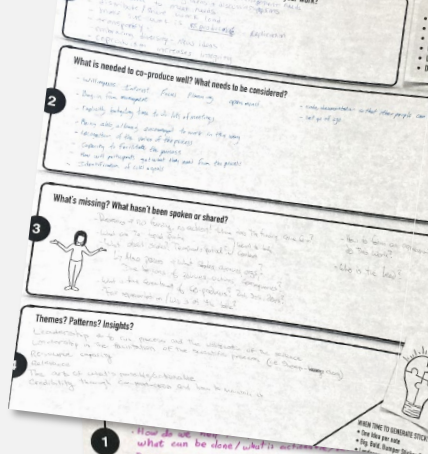
What mindset/skillset might be required?

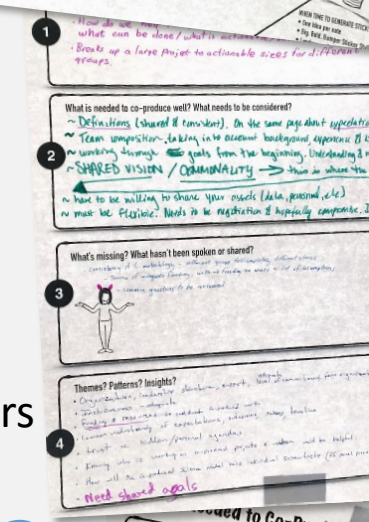
- good communication, story telling skills
- developing a collective perspective
- customer service mindset
- emotional intelligence
- meeting facilitators
- project manager
- synthesis
- boundary spanners
- see who needs to be involved reaching and including all with a stake

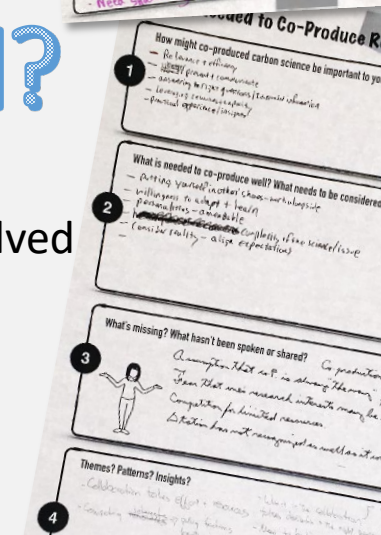












two rounds of “pop-up conferences” allowed for deeper discussions around carbon

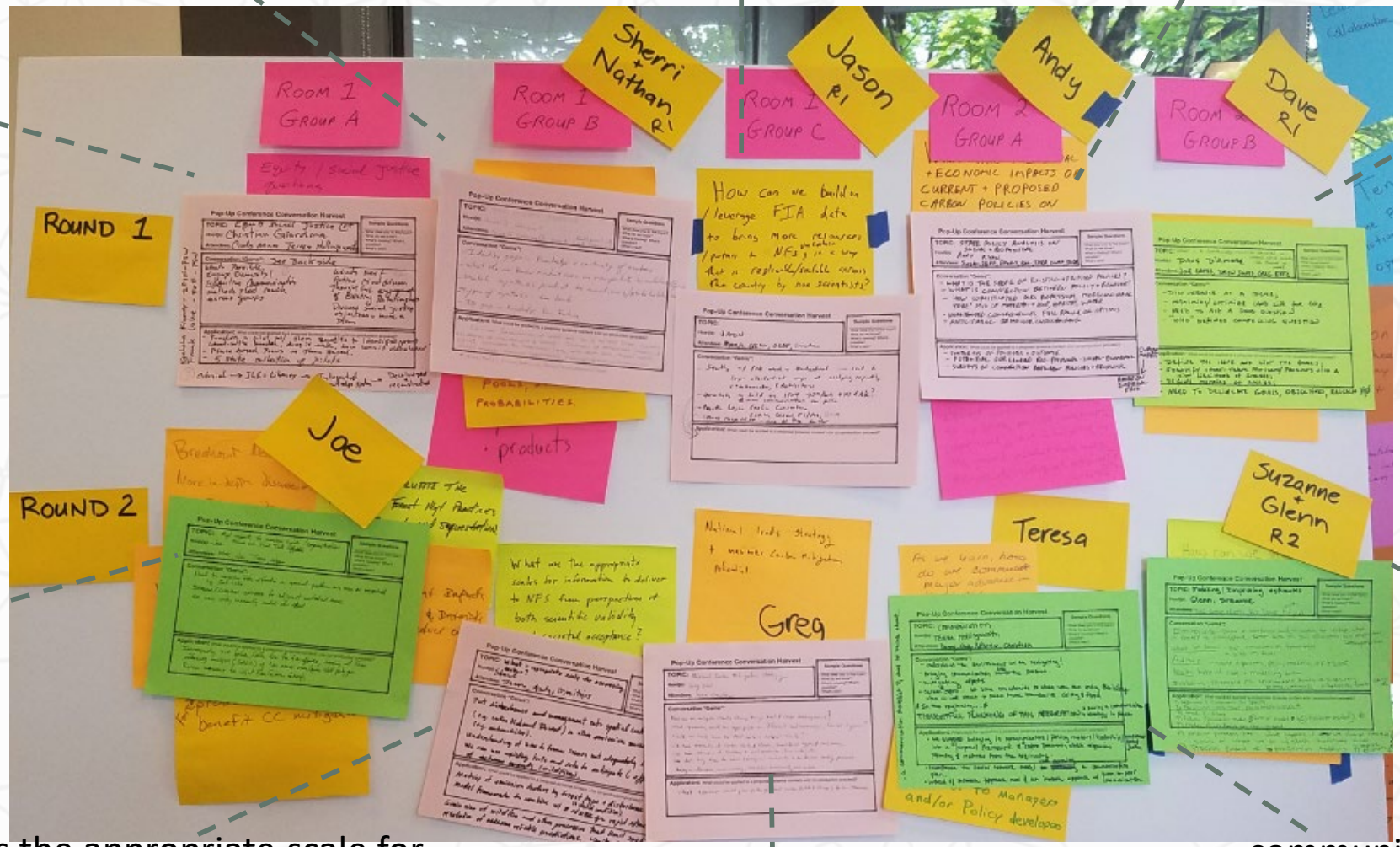
key science products (synthesis and gaps)

FIA pacific region carbon reporting

state policy analysis on social and biophysical

equality, social justice and carbon

what is a compelling scientific question on carbon cycle science - one project or many?



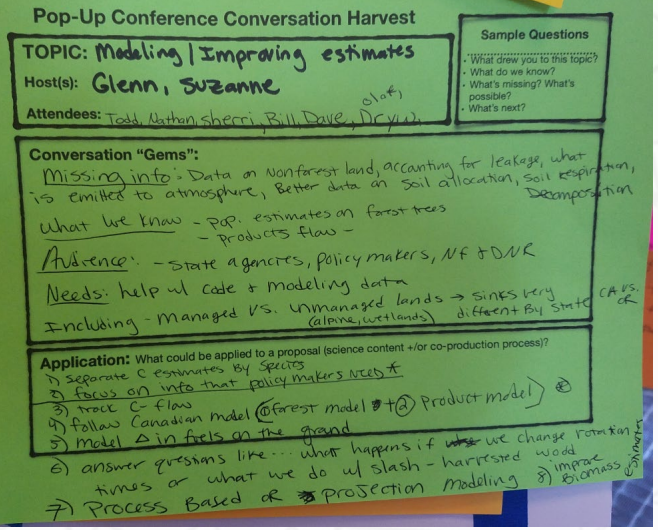
management impacts to carbon cycle/ sequestration - focus on fuel treatment efforts

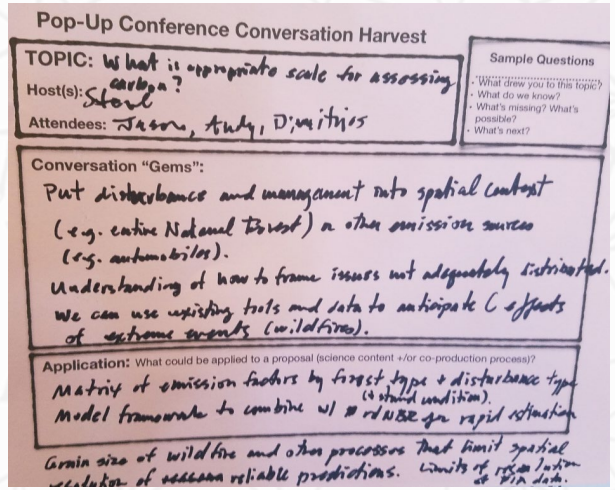
modeling/ improving estimates

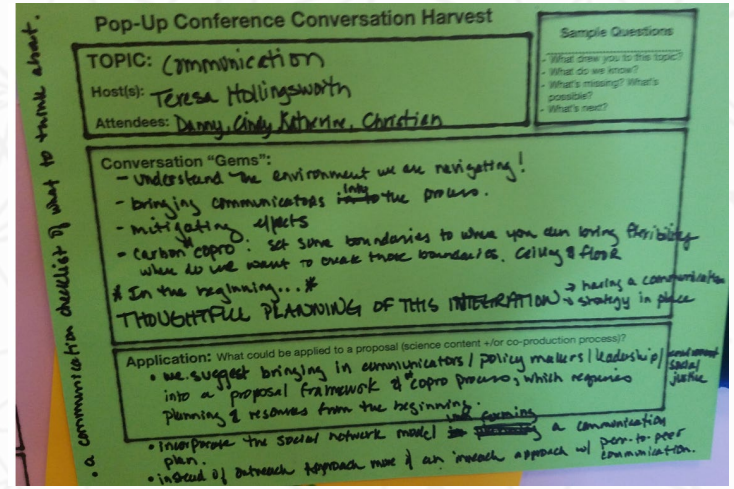
what is the appropriate scale for assessing carbon?

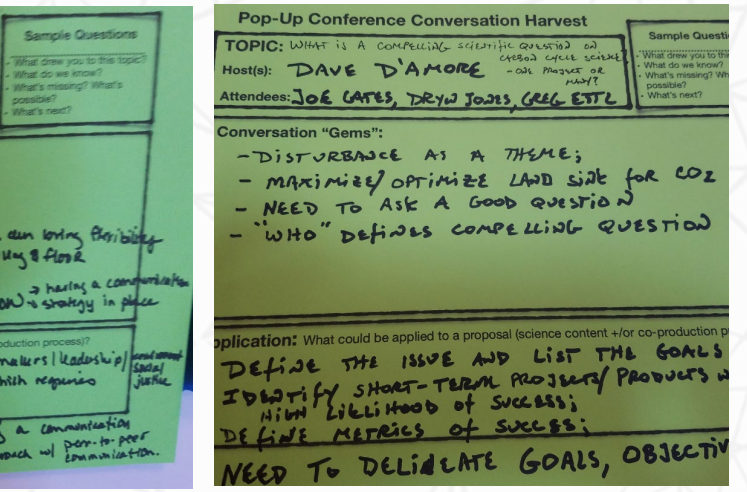
national carbon mitigation strategy

communication

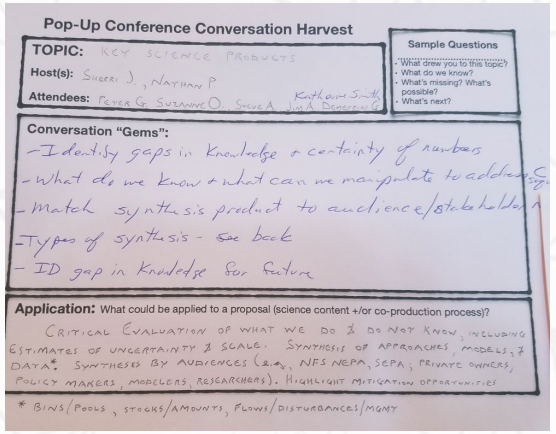


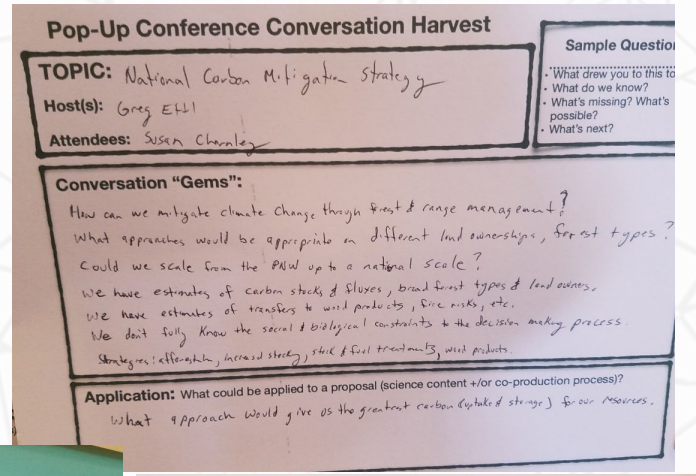


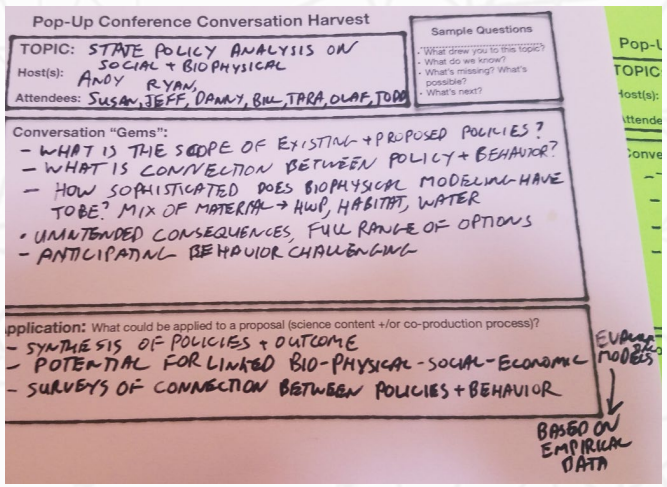


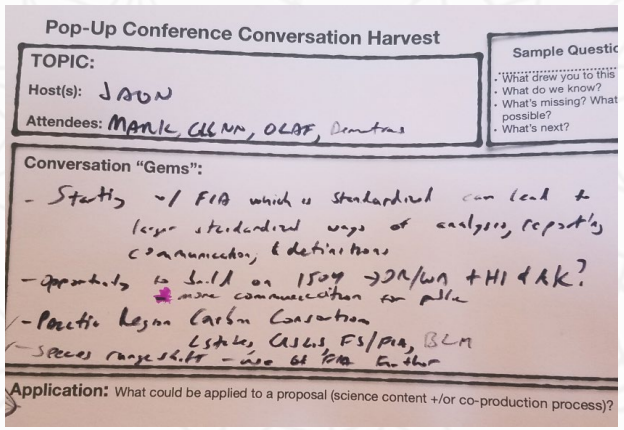


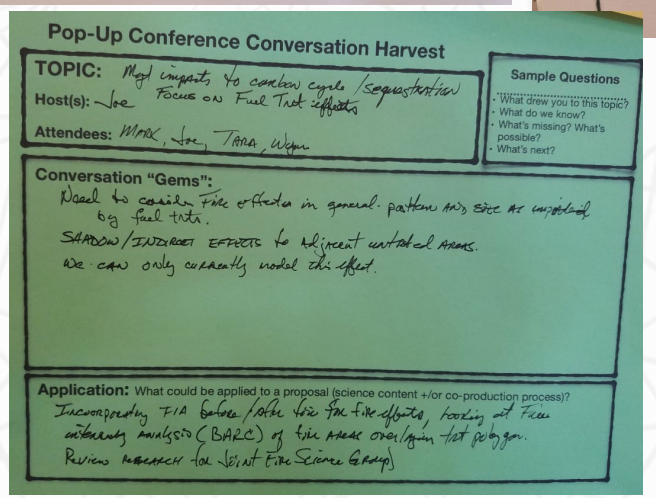
Pop-up conference note templates provided a great opportunity to flesh out ideas. These references have been transcribed and are available to meeting attendees.

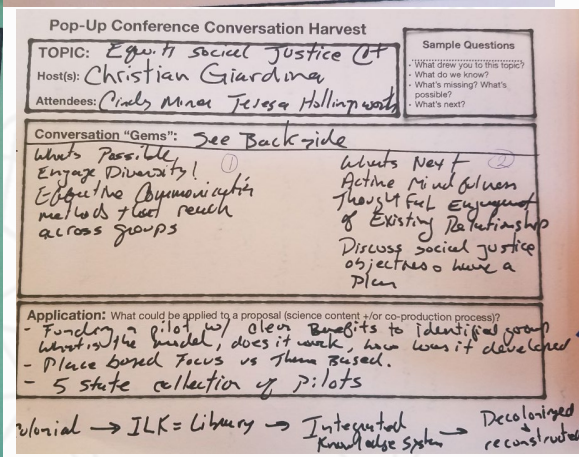






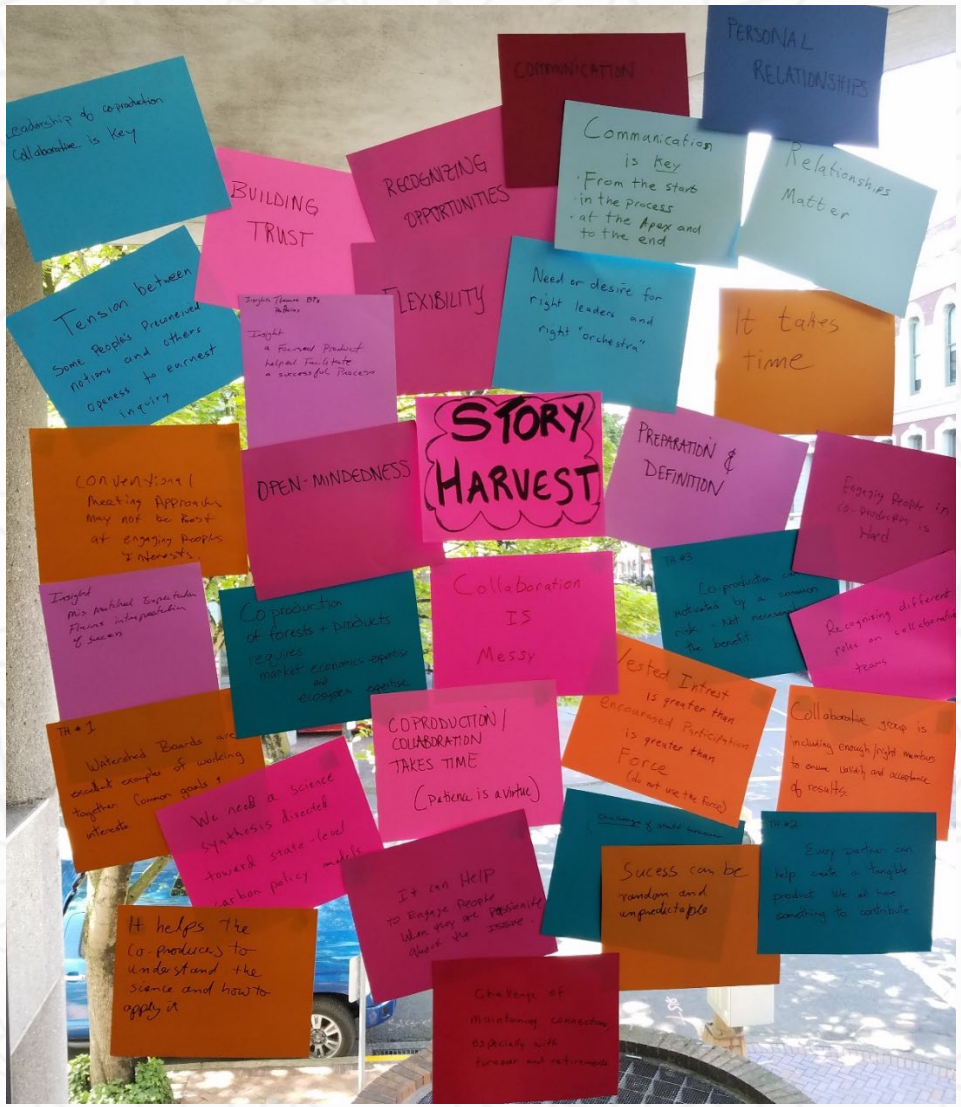






story sharing meta themes

relationships & trust matter ● coping with turnover ● patience with the process ● leadership roles practice together ● scientists moving institutions ● interests – reasons for being there ●

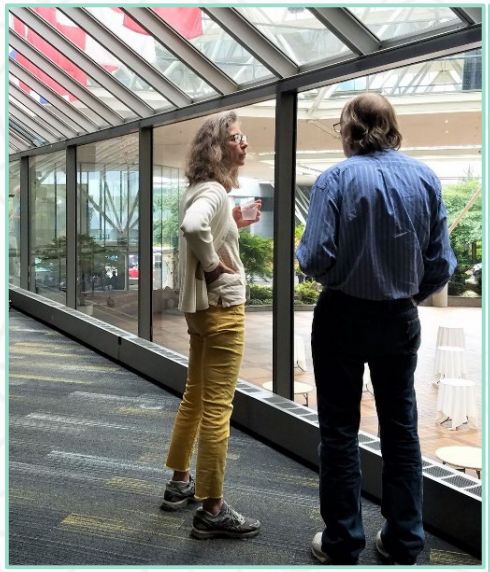


open mindedness/flexibility ● communication ● inclusion ● time & energy

how we converge

● honoring unique contributions ● Making knowledge accessible ● connecting people & ideas

● encouraging each person to share



● listening together for PATTERNS, insights and deeper meaning.

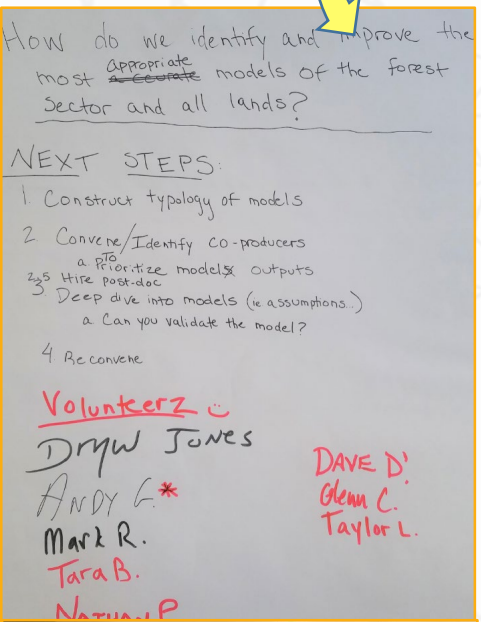
Participants generated ideas, clustered them around themes, and searched for patterns. Three research questions emerged as well as a group to continue coordination of carbon co-production.

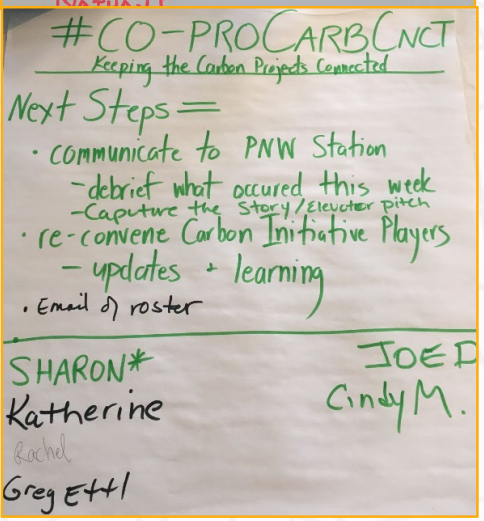
Additionally, recurring areas of concern that touch **all work** were identified. These essential items were seen as a **common thread** among research topics deserving of energy and integration:

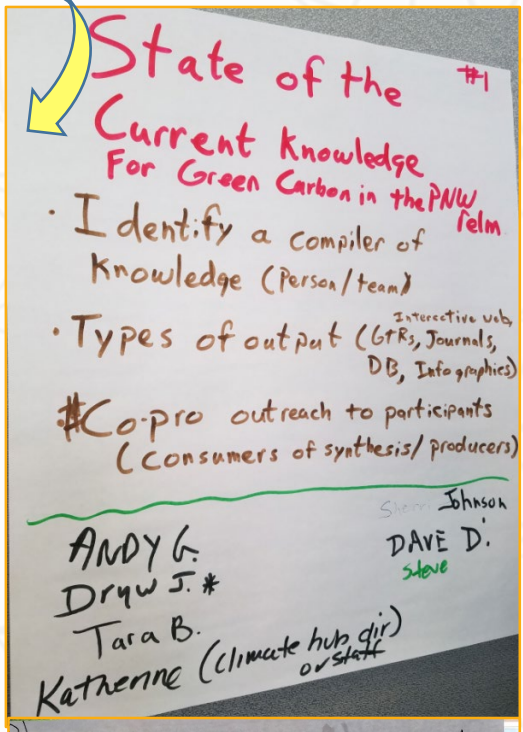
- ★ communication
- ★ maintaining a cultural frame
- ★ scale (spatial and temporal)
- ★ effort to bring in all voices
- ★ consideration of all lands (rural and urban)

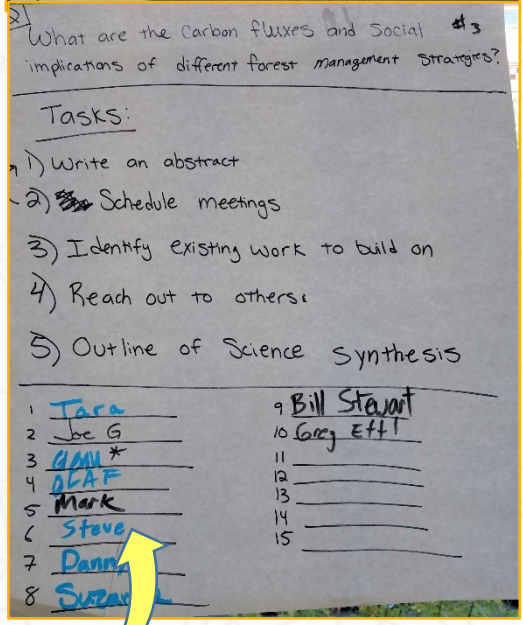
#3 How do we identify and improve the most appropriate models of the forest sector and all lands?

#1 State of the current knowledge for green carbon in the PNW realm









#4 #Co-ProCarbCnct keeping the carbon projects connected

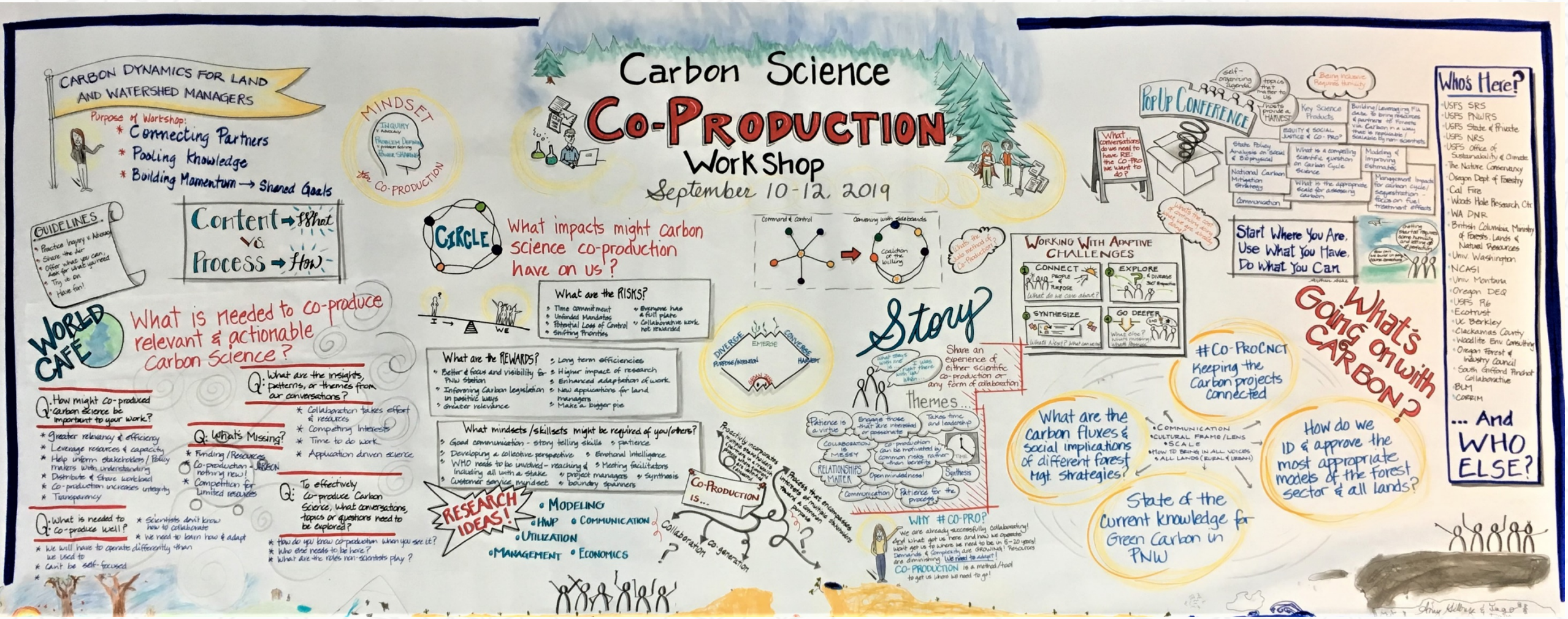
#2 What are the carbon fluxes and social implications of different forest management strategies?

Working groups formed and elected a leader for the first “convening-of-the-group”. These groups were tasked to get together via conference call or webinar to further define their goals, refine the research question(s), and work with the research station to start funding the work.

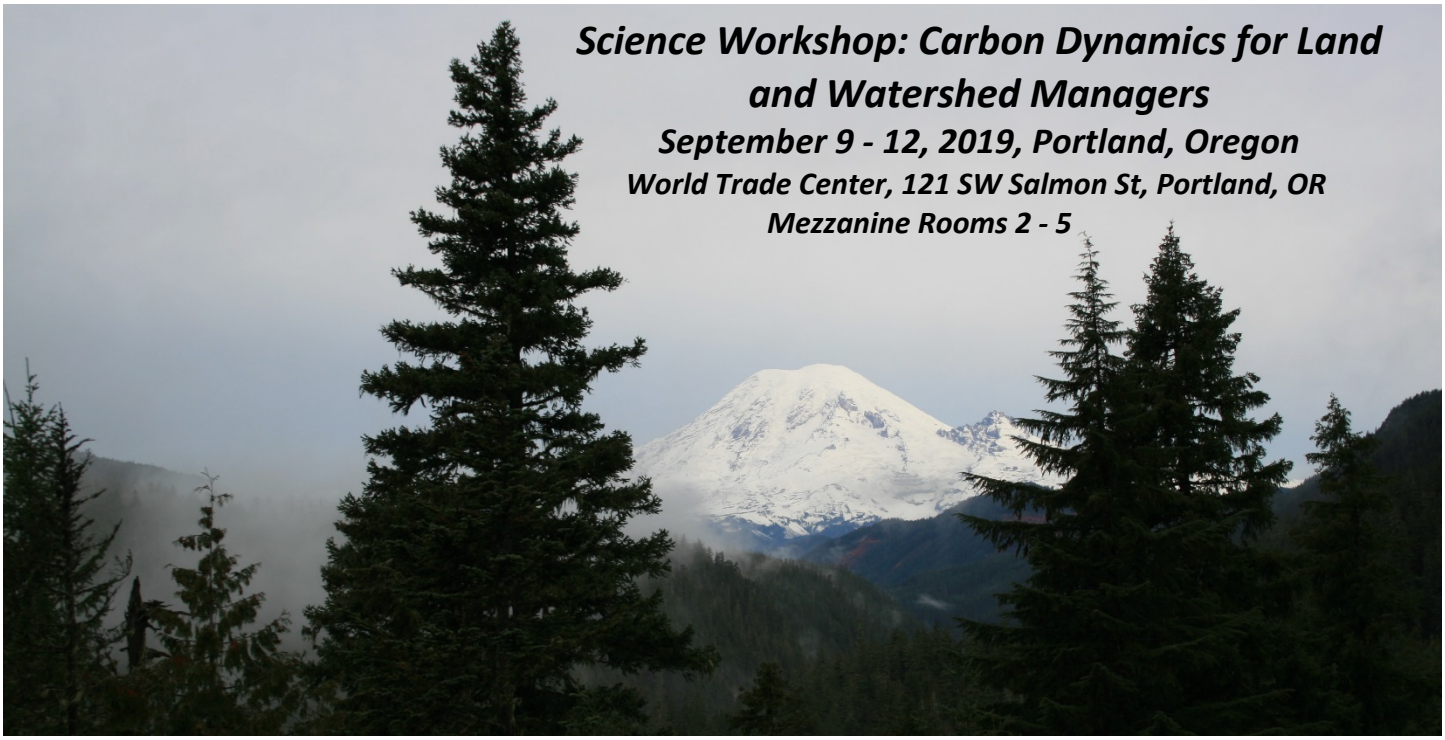
The groups are open to additional members – this is essential to the success of the co-production model. Please contact Sharon Stanton/Joe Donnegan for more information on how to get involved!

- How do we identify and improve the most appropriate carbon models of the forest sector and all lands?
- What is the state of the current knowledge for Green Carbon in Pacific States?
- What are the carbon fluxes and social implications of different forest management strategies?
- Carbon co-production facilitation. Keeping the carbon projects connected.

We realize scientists and land stewards must create new ways of working together, and new networks to co-producing carbon science – this workshop was a step in that direction.



The Carbon Workshop event team would like to acknowledge Paul Anderson, PNW Research Station Director, and Katherine Smith, Assistant Station Director for their leadership in Forest Service Research & Development in shaping a model of shared stewardship by providing a co-production of research method to meet partner and stakeholder needs with science.



Workshop Objectives: Convene a carbon workshop where land stewards and scientists discuss the most pressing management needs that can be informed by carbon science through the synthesis of existing work, extension via new research, and improved assistance in application. This workshop seeks to adapt the communication behaviors of scientists and land stewards toward new models of working together to uncover issues and avenues that better enable solutions. The workshop is designed to be a conversation toward improved shared stewardship among scientists, land managers, and decision makers.

Engage participants in discussions that prioritize research needs in carbon science, and develop teams to move science and application forward jointly. Develop and extend networks among land stewards and scientists.

Day 1: 9:00 – 5:00 – Defining Information Needs from Inventory: Coastal Forest Monitoring Network
States and provinces discuss needs and explore opportunities for transparent carbon measurement, monitoring, and reporting systems toward the management of carbon flux.

Participants:

- State, province, USFS forest and carbon analysts and policy advisors.
- Agency staff, leadership, Researchers
- Key stakeholders and interests
- Board members from agency oversight groups

Objectives for Day 1

- Share current forest carbon policy objectives and strategies
- Share results from Forest Carbon Inventories in California, Oregon, Washington, and British Columbia, Canada. (Includes forest ecosystem and harvested wood products inventories and BC's use of projection modeling.)
- Compare methods, results, and lessons learned.

- Suggest opportunities to improve carbon inventory.
- Explore implications of inventory results and possible next steps.

Day 1, Agenda Outline

- Introduction - *Paul Anderson/Katherine Smith, USDA Forest Service, PNW Research Station* **9:00 – 9:20**
  - Purpose & goals of workshop, history

- Western U.S. Overview: **9:20 – 10:10**
  California, Oregon, and Washington - *Methods, results, lessons learned*
  Glenn Christensen, USDA Forest Service; Todd Morgan, University of Montana

- **Break** **10:10 – 10:25**

- British Columbia Overview – Methods, results, lessons learned **10:25 – 11:30**
  Thomas White, Provincial Government of British Columbia; Werner Kurz, Canadian Forest Service

- Comparing & contrasting U.S. and Canadian approaches to forest carbon inventory/monitoring strategies - *Richard Birdsey, Woods Hole Research Center.* **11:30 – 12:00**

- **Lunch** **12:00 – 1:00**

- How do estimates from current forest carbon analyses inform the strategies: **1:00 – 2:30**
  Moderator: Mark Rosenberg, California Department of Forestry and Fire Protection
  Panel members: Chris Keithley, California Department of Forestry and Fire Protection; Andrew Yost, Oregon Department of Forestry; Dan Siemann, Washington Department of Natural Resources; Thomas White, Provincial Government of British Columbia.
  - Climate & policy goals, and forest sector contributions to meet them.
  - How are the inventory results being used to inform climate strategies?
  - Uncertainty around specific forest carbon pools:
    - What are the acceptable levels of uncertainty relative to policy?
    - What opportunities exist to strengthen the precision and efficiency of the inventory?

- **Break** **2:30 – 2:45**

- Toward a regional approach to forest monitoring in support of climate mitigation: **2:45 – 3:45**
  Chris Keithley, California Department of Forestry and Fire Protection; Todd Morgan, University of Montana
  - Implications of the inventory/projection results and opportunities for common reporting across states or a wider regional level?
  - Regional impacts on forests and timber flow resulting from state/province driven climate objectives?

- Panel discussion: Research needs and next steps in carbon assessment: **3:45 – 4:45**
  Panel members: Richard Birdsey, Werner Kurz, Grant Domke, Andy Gray…
  - Major research questions: e.g., opportunities to improve assessments, disturbance effects, projections, and applications
  - What are the most important forest carbon, health, or risk indicator opportunities for research or new application efforts?

- Summary & future workshops, closeout: *Joseph Donnegan, USDA Forest Service* **4:45 – 5:00**

Days 2, 3 & 4 – September 10 – 12
Carbon Workshop: Connecting Partners, Pooling Knowledge, Building Momentum towards Shared Goals

Participants:
Alaska, California, Oregon, Hawaii, Washington, USFS Region 5, 6, and 10 resource managers, PNW & PSW scientists interested in the Carbon Initiative. Tribes, NGOs, BLM, NPS, NRCS, industry, and other resource managers. Group size limited to 40-50 for conversations that are manageable as smaller groups.

Day 2 Objectives:

- Define the value and rationale for scientific co-production; identify knowledge gaps, assumptions, shared and competing commitments that may impact co-production efforts.
- Collectively identify & explore elements (behaviors, agreements, etc.) needed to effectively develop and implement co-produced scientific research.
- Determine and clarify sideboards like operational constraints, timelines, decision-making criteria, etc.
- Identify scientific areas for experimentation with co-production approach and who has interest in what subtopics.
- Build and strengthen relationships among participants to enable the collaborative work ahead.

Day 2: 9:00-5:00 – Agenda: will include morning and afternoon breaks, Lunch from 12:00-1:00

1. **Welcome and introductions**

2. **Orientation – How we will be working together: purpose, outcomes & process**

3. **World Café style conversation about: What is needed to co-produce relevant and actionable science?**
    - **Purpose & Outcomes:**
        - Connect people to each other and the purpose of this endeavor
        - Clarify at a collective level what scientific co-production will entail, including naming the challenges and opportunities that exist
        - Identify the various elements that need attention/ clarification
        - Build and strengthen relationships to enable actual collaboration (versus positional competition)
        - Create a synthesis of what needs to be attended to or clarified for science co-production to happen, e.g. knowledge gaps, communication, sideboards

4. **Deeper Dive into Priority Topics surfaced from morning conversation**
    - **Purpose & Outcomes:**
        - Further develop and refine key topics from morning conversations
        - Develop clarity on what elements need to be considered and addressed in working group proposals developed on days 3 and 4

Day 3 Objectives:

- Facilitation team will refine day's agenda to build off outcomes from Day 2
- Deepen knowledge and understanding of what will make this larger effort successful.
- Clarify priority working group topics, e.g. relevant questions that can be answered by research co-production

- Breakout into working groups based on topic interest in order to develop research proposals
- Share working group progress and get feedback from larger group.

Day 3: 9:00-5:00 – Agenda: will include morning and afternoon breaks, Lunch from 12-1

1. **Framing of the Day**

2. **Small Group Activity**
    - **Purpose & Outcomes:**
        - Learn more about each other's experience with collaborative science
        - Illuminate best practices, successes, and "flopportunities".

3. **Identify and develop proposals for co-production experimentation**:
    - **Purpose & Outcomes:**
        - Breakout work on identified topic areas
        - Begin proposal development
        - Share progress and refine with group input

Day 4 Objectives:

- Facilitation team will refine day's agenda to build off outcomes from Day 3
- Cull relevant learning about experience working together in this workshop and consider application for project teams going forward
- Finalize proposal work and present to whole group and refine as needed
- Assess participant interest in supporting ongoing work
- Clarify next steps, who/what/when, including any follow up from PNW, R&D, land stewards and facilitation team

Day 4: 9:00-4:00 – Agenda: will include morning and afternoon breaks, Lunch from 12-1

1. **Framing of the Day**

2. **Collaborative process debrief**
    - **Purpose & Outcomes:**
        - Assess and reflect on the processes experienced in this workshop
        - Consider application to project team work

3. **Finalize Proposals on each topic area**
    - **Purpose & Outcomes:**
        - Identify next steps
        - Assess participant interest in ongoing support roles on project teams
        - Final presentation to whole group for any needed refinement

4. **Clarify next steps:**
    - **Purpose & Outcomes:**
        - Who will do what by when for each project team
        - Clarify PNW, R&D, land steward's and facilitation team follow up commitments, including communication out about workshop and outcomes

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Expected Participants:

FirstName	Last Name	Affiliation	Title
Steve	Acker	USDA Forest Service R6	USFS Northwest Oregon Ecology Group
Paul	Andersen	USDA Forest Service PNW	Station Director
Jim	Archuleta	USDA Forest Service S&PF R6	Regional Wood Innovations Coordinator
Tara	Barrett	USDA Forest Service PNW	Scientist, TMC Team Leader
Dave	Bell	USDA Forest Service PNW	Scientist
Richard	Birdsey	Woods Hole Research Center	Scientist
Emily	Bruns	WA State Dept. of Ecology	Senior Env. Tech. Spec.
Mike	Buffo	WA-DNR	Assist. Division Manager - Forest Informatics
Neil	Caudill	WA-DNR	Department of Ecology, Air Quality Program
Susan	Charnley	USDA Forest Service PNW	Scientist
Glenn	Christensen	USDA Forest Service PNW	FIA Carbon Analyst
Dave	D'Amore	USDA Forest Service PNW	Scientist
Bob	Deal	USDA Forest Service PNW	Research Forester
Dominick	DellaSala	Geos Institute	President
Grant	Domke	USDA Forest Service NRS	Scientist
Joe	Donnegan	USDA Forest Service PNW	RMA DPM
Jackson	Dougan	OR Dept. Env. Quality	Climate Change Specialist
Alexa	Dugan	USDA Forest Service WO	GIS Data Specialist
Greg	Ettl	Univ. WA	Assoc. Dir. School of Env. and Forest Sci.
Peter	Gould	WA-DNR	
Andy	Gray	USDA Forest Service PNW	FIA Scientist
Ryan	Haugo	The Nature Conservancy	Oregon Conservation Science Director
Teresa	Hollingsworth	USDA Forest Service PNW	Scientist
Sherri	Johnson	USDA Forest Service PNW	Scientist
Dryw	Jones	USDA Forest Service PNW	Scientist
Chris	Keithley	CalFire	Chief
John	Kim	USDA Forest Service PNW	Scientist
Brian	Kittler	Sustainable Northwest	Forest Program Director
Jeff	Kline	USDA Forest Service PNW	Scientist
Jason	Ko	USDA Forest Service S&PF R5	Ecosystem Services Program Manager
Werner	Kurz	Natural Resources Canada	Senior Research Scientist
Duncan	McKinley	USDA Forest Service WO	Program Specialist, WO
Cindy	Miner	USDA Forest Service PNW	AD
Todd	Morgan	Univ. MT	Scientist/Economist
James	Mulligan	World Resources Institute	
John	Nickerson	CA Air Resources Board	Vice President, Forestry
Danny	Norlander	Oregon Dept. of Forestry	Forest Carbon and Health Policy Analyst
Russ	Plaeger	USDA Forest Service Retired	
Nathan	Poage	USDA Forest Service R6	Ecologist, NE Oregon Ecology Program
Steve	Prisley	NCASI	Principal Research Scientist
Maureen	Puettmann	WoodLife Environmental Consultants, LLC	
Mark	Rosenberg	CalFire	Research Data Specialist
Gail	Sandlin	WA State Dept. of Ecology	Air Quality Program, Climate Policy Section
Dan	Siemann	WA-DNR	
Katherine	Smith	USDA Forest Service PNW	AD

Sharon	Stanton	USDA Forest Service PNW	RMA PM
Bill	Stewart	Univ. CA, Berkeley	Co-Director, Berkeley Forests
Thomas	White	Natural Resources Canada	
Samantha	Wolf	Clackamas Cty. Ag & Forest Econ. Dev.	GIS & Special Projects Coordinator
Andrew	Yost	Oregon Dept. of Forestry	
Lenny	Young	WA-DNR	

Recommended Carbon Reading – An Overview

Ryan, M. G., M. E. Harmon, R. A. Birdsey, C. P. Giardina, L. S. Heath, R. A. Houghton, R. B. Jackson, D. C. McKinley, J. F. Morrison, B. C. Murray, D. E. Pataki, and K. E. Skog. 2010. A Synthesis of the Science on Forests and Carbon for U.S. Forests. Issues in Ecology 13:16. https://www.fs.usda.gov/treesearch/pubs/35006

Duncan C. Mckinley, Michael G. Ryan, Richard A. Birdsey, Christian P. Giardina, Mark E. Harmon, Linda S. Heath, Richard A. Houghton, Robert B. Jackson, James F. Morrison, Brian C. Murray, Diane E. Pataki, And Kenneth E. Skog. 2011. A synthesis of current knowledge on forests and carbon storage in the United States. Ecological Applications, 21(6), 2011, pp. 1902–1924.
https://www.nrs.fs.fed.us/pubs/jrnl/2011/nrs_2011_mckinley_001.pdf

Fischer, A. Paige; Charnley, Susan. 2010. Social and cultural influences on management for carbon sequestration on US family forestlands: a literature synthesis. International Journal of Forestry Research. Article ID 960912. 14 p. https://www.fs.fed.us/pnw/pubs/journals/pnw_2010_fischer001.pdf

Gray, Andrew N.; Whittier, Thomas R.; Harmon, Mark E. 2016. Carbon stocks and accumulation rates in Pacific Northwest forests: role of stand age, plant community, and productivity. Ecosphere 7(1): e01224.
https://www.fs.fed.us/pnw/pubs/journals/pnw_2016_gray001.pdf

Birdsey, R; Dugan, A; Healey, S; Dante-Wood, K; Zhang, F; Chen, J; Hernandez, A; Raymond, C; McCarter, J. In press. Assessment of the influence of disturbance, management activities, and environmental factors on carbon stocks of United States National Forests. Fort Collins, Colorado: Gen. Tech. Report RM-xxx.Xxx pages plus online appendices.

Turner, David P.; Ritts, William D.; Kennedy, Robert E.; Gray, Andrew N.; Yang, Zhiqiang. 2016. Regional carbon cycle responses to 25 years of variation in climate and disturbance in the US Pacific Northwest. Regional Environmental Change. 16(8): 2345-2355.
https://www.fs.fed.us/pnw/pubs/journals/pnw_2016_turner001.pdf

Alexa J. Dugan, Richard Birdsey, Vanessa S. Mascorro, Michael Magnan, Carolyn E. Smyth, Marcela Olguin & Werner A. Kurz. 2018. A systems approach to assess climate change mitigation options in landscapes of the United States forest sector. Carbon Balance and Management, volume 13, Article number: 13 (2018).
https://cbmjournal.biomedcentral.com/articles/10.1186/s13021-018-0100-x

C. E. Smyth, B. P. Smiley, M. Magnan, R. Birdsey, A. J. Dugan, M. Olguin, V. S. Mascorro & W. A. Kurz. 2018. Climate change mitigation in Canada's forest sector: a spatially explicit case study for two regions. Carbon Balance and Management, volume 13, Article number: 11 (2018).
https://cbmjournal.biomedcentral.com/articles/10.1186/s13021-018-0099-z

S. P. Sohi,, E. Krull, E. Lopez-Capel, and R. Bol. 2010. A Review of Biochar and Its Use and Function in Soil.

Advances in Agronomy, Volume 105, 47-82.

Barrett, T.M. 2014. Storage and flux of carbon in live trees, snags, and logs in the Chugach and Tongass National Forests. General Technical Report PNW-GTR-889. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 44 p. http://www.fs.usda.gov/treesearch/pubs/45431

Aufdenkampe, A. K., E. Mayorga, P. A. Raymond, J. M. Melack, S. C. Doney, S. R. Alin, R. E. Aalto, and K. Yoo. 2011. Riverine coupling of biogeochemical cycles between land, oceans, and atmosphere. Frontiers in Ecology and the Environment 9:53-60. https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1890/100014

Watts, Andrea;. Steve Wondzell, Sherri Johnson, and Alba Argerich. 2018. Counting carbon: Calculating how headwater streams contribute to the carbon cycle. Science Findings 212. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 5 p. https://www.fs.usda.gov/treesearch/pubs/57407

D'Amore, D. V., R. T. Edwards, P. A. Herendeen, E. Hood, and J. B. Fellman. 2015. Dissolved Organic Carbon Fluxes from Hydropedologic Units in Alaskan Coastal Temperate Rainforest Watersheds. Soil Science Society of America Journal 79:378-388. https://www.fs.usda.gov/treesearch/pubs/49542