FOREST SERVICE AND CARBON

NFS, OFFICE OF SUSTAINABILITY AND CLIMATE
DUNCAN MCKINLEY, AURORA CUTLER, LAUREN ONOFRIO, BEN SODERQUIST, AND JACOB DEAL
R&D, ROCKY MOUNTAIN RESEARCH STATION
SEAN HEALEY
INTRODUCTORY REMARKS

Jamie Barbour  
Acting Director  
Office of Sustainability and Climate

Linda Heath  
Director  
Inventory, Monitoring & Assessment Research
OUTLINE

- What’s the interest in forest carbon?
- “Carbon System” and key concepts
- Rangeland carbon
- Forest Service experience and policy
- How carbon is estimated
- How the Forest Service influences carbon through vegetation management
- How we deliver science for decision making
- Energy development on NFS lands
- Sustainable operations – your role
- How we can help you
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WHY IS THE PUBLIC INTERESTED?

1. Concerned about carbon emissions and effects on climate

2. Interest in using management to sequester carbon (i.e. Mitigation) and reduce carbon loss where appropriate (i.e. Adaptation)

Further reading:


CARBON 101
HOW GREENHOUSE GASES ACT IN THE ATMOSPHERE

**Atmospheric CO₂ concentration**

Global average long-term atmospheric concentration of carbon dioxide (CO₂), measured in parts per million (ppm). Long-term trends in CO₂ concentrations can be measured at high-resolution using preserved air samples from ice cores.


OurWorldInData.co2-and-other-greenhouse-gas-emissions • CC BY

The Greenhouse Effect

Some sunlight that hits the earth is reflected. Some becomes heat.

CO₂ and other gases in the atmosphere trap heat, keeping the earth warm.
GLOBAL STOCKS AND FLOWS OF CARBON

ATMOSPHERE
816 (± 4.8 yr⁻¹)

PLANTS & SOIL
2,000

OCEANS
37,000

SEEDMENTS AND SEDIMENTARY ROCKS
66,000,000–100,000,000

COAL, OIL, & NATURAL GAS
10,000
U.S. FORESTS AND WOOD PRODUCTS CARBON SINKS ARE EQUIVALENT TO 12%–19% OF U.S. FOSSIL-FUEL EMISSIONS


From SOCCR Report: http://www.climatescience.gov
Sources and Storage | Carbon Dynamics

Carbon makes up about half of every tree.

Leaf litter

Microbe respiration

Dead wood

Carbon is stored in leaves, wood, and soil.

Root exudates

Old stable soil carbon

New labile soil carbon

Respiration

$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6H_2O$

Photosynthesis

Microbes
FORESTS AS A ‘NATURAL CLIMATE SOLUTION’

- Natural Climate solution, includes:
  - Restoration
  - Improved forest management
  - Conservation

Griscom et al. 2017 PNAS
FOREST MANAGEMENT CAN PRODUCE CARBON BENEFITS

But how?

TWO DIFFERENT WAYS...

1) Increase carbon stocks/sequestration in forest ecosystems

2) Increase carbon storage in harvested wood products and displace use of fossil fuels
CONSERVATION: AVOIDED DEFORESTATION

- Development, conversion to agricultural use. Important for U.S., not just tropics
- Large potential, low risk, but difficult to credit
- Many co-benefits

*156,000 million tonnes of C have been released globally due to land use change (1850-1998)

*Globally, deforestation releases 1,400-2,000 million tonnes of C per year
RESTORATION: REFORESTATION AND AFFORESTATION

- Moderate potential, low risk
- Benefits - Increased biodiversity and soil erosion control
- More water use, Loss of ag. production
- Uncertainties low when re-establishing forests
IMPROVED FOREST MANAGEMENT:
DECREASE OUTPUTS
(INCREASE ROTATION, DECREASE REMOVALS)

- Large potential in areas with active forest management, moderate risk
- Increase structural and biodiversity
- Increased risk of disturbance loss

![Graph showing the relationship between harvest interval and tree carbon storage for different removal levels.](Image)

- 20% Removal
- 100% Removal

Tree Carbon Storage (Mg/ha) vs. Harvest Interval (Years)
IMPROVED FOREST MANAGEMENT: INCREASE INPUTS (INCREASE GROWTH)

- Reforestation/regeneration, fertilization, genetics, silviculture, species selection
  - High potential, moderate risks:
    - full GHG accounting
    - potential maladaptation
  - Increased wood production, keeps forests as forests
  - Lower biodiversity, lower water yield and quality

*Combinations of fertilization, genetics, and vegetation control in operational plantations in the southern U.S. can increase wood growth by as much as 4X compared to unmanaged naturally regenerated secondary growth.*
HARVESTED WOOD PRODUCTS AND BIOMASS ENERGY SHOULD ALSO BE CONSIDERED
IMPROVED FOREST MANAGEMENT: FUEL TREATMENTS

- Thinning to reduce crown fire risk
- Low potential:
  - Landscape treatment, but C benefits only on site
- Co-Benefits:
  - Lower fire risk, potential for biofuels, potential for restoration, lower potential for forest conversion

*39-290 million metric tonnes of carbon per year is the range of emissions from wildfires in the conterminous U.S. since 1990 per year
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Differing perspectives on how to conceptualize the forest system is the greatest source of confusion.
Sometimes you make the wrong conclusions when you can’t see the whole…

G. Renee Guzlas, artist
Challenges: Competing views

Differing perspectives on how to conceptualize the forest system is the greatest source of confusion and conflict!
How most people view the forest system...

Deforestation and forest management activities (harvests, thinning, prescribed fires) release carbon to the atmosphere.

Growing forests and tree planting (afforestation/reforestation) take up and store carbon from the atmosphere.
But, we know there is A LOT more to the story...
The longevity of CARBON in the ATMOSPHERE

Emissions from fossil fuels are long-term "tenants" because there is no natural mechanism to re-absorb carbon in the atmosphere. The carbon cannot be "evicted," so they crowd and overheat the atmosphere.

Carbon Emissions

Emissions from forests and their products are short-term "tenants" because harvested forests regrow and re-absorb carbon in the atmosphere.

Carbon is released to the atmosphere through burning and decomposition.

Carbon is sequestered in forests and wood products.
The Natural Boom and Bust Cycle of Forest Carbon

Carbon uptake and storage (growth)

Carbon release (fire)

Carbon release (decomposition) and storage in dead trees

Carbon uptake and storage (regrowth)

Below-ground carbon storage (in roots & soil) is about 50% of forest carbon
The closed loop of FOREST CARBON in the ATMOSPHERE

CO₂

Growing forests remove carbon from the atmosphere.

Fires & decomposition following disturbance events release carbon into the atmosphere.

Bioenergy from forest biomass can substitute for fossil fuel energy.

Wood products can store carbon and can substitute for emission-intensive products such as concrete & steel.

CO₂

Fossil fuel use is an OPEN SYSTEM where CO₂ remains in the atmosphere.
The importance of KEEPING FORESTS as forests | Carbon & Land Use Changes

Even if a forest is disturbed or harvested, carbon is exchanged in a CLOSED SYSTEM as long as it remains forest.

Conversion of forests to non-forest land uses is an OPEN SYSTEM where CO₂ remains in the atmosphere.
Differing perspectives on how to conceptualize the forest system is the greatest source of confusion.
What’s happening in the Atmosphere? | A Systems Perspective

If the goal is minimize net emissions to the atmosphere, a systems perspective is needed.

Forest Sector
Consider net effects of growth and disturbances on ecosystem carbon stocks.

Adapted from IPCC 2007, AR4 WGIII, Forestry
What's happening in the Atmosphere? | A Systems Perspective

If the goal is to minimize net emissions to the atmosphere, a systems perspective is needed.

Forest Sector
Consider the net effects of growth and disturbances on ecosystem carbon stocks.

Services Used by Society
Consider the use and fate of wood once it leaves the forest, such as biomass for energy and storage in wood products.

Substitution Effects
Consider the reduction in fossil emissions when biomass energy is used in place of fossil fuel-intensive products and energy generation.

Adapted from IPCC 2007, AR4 WGI, Forestry
If the goal is to minimize net emissions to the atmosphere, a systems perspective is needed.

**Land Use Sector**
Consider loss or gain of forested land.

**Forest Sector**
Consider net effects of growth and disturbances on ecosystem carbon stocks.

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- **Land Use Sector**: Consider loss or gain of forested land.
- **Forest Sector**: Consider net effects of growth and disturbances on ecosystem carbon stocks.
- **Services Used by Society**: Consider the use and fate of wood once it leaves the forest, such as biomass for energy and storage in wood products.
- **Substitution Effects**: Consider reduction in fossil emissions when biomass energy is used in place of fossil fuel-intensive products and energy generation.

All emissions must be considered to understand the NET effects of activities on the atmosphere.

*Adapted from IPCC 2007, AR4 WGIII, Forestry*
The amount and timing of combined benefits depends on where you start.
SPEAKER

Duncan McKinley

Natural Resource Specialist
Office of Sustainability and Climate

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CONCEPTS THAT APPLY TO FORESTS APPLY TO GRASSLANDS AND RANGELANDS

Grasslands Carbon Storage | Non-forest Carbon

18th century  21st century

Soil carbon in grasslands is generally stable over time.

The majority of carbon storage in grasslands is below ground.
Soil carbon in grasslands is generally **STABLE** over time.

Carbon stocks **INCREASE** in some grasslands with conversion to shrublands and woodlands with the exclusion of fire.

Carbon stocks **DECREASE** if grasslands are converted to agricultural uses.

Carbon is lost in agricultural uses because of the loss of soil organic carbon (tilling breaks up soil aggregates and releases carbon).
FOREST SERVICE AND CARBON

VEGETATION MANAGEMENT
ENERGY DEVELOPMENT
SUSTAINABLE OPERATIONS
Carbon timeline – an evolving vision for federal forests

- **2005-2009: focus on “markets for ecosystem services”**
  - Voluntary carbon markets
  - Offset credits
  - Carbon reserves
  - Carbon insurance

- **2014-2018 USDA Strategic Plan (GHG 17% below 2005 level by 2020):**
  - *Help achieve Clean Power Plan*
  - “help maintain forests as a carbon sink”
    - Plant trees
    - Minimize deforestation
    - Land acquisitions
    - Conservation easements

- **2010 FS Climate Change Roadmap:**
  - managing carbon stocks
    - Reforestation after disturbance
    - Conserve working forests
    - Tech assistance to increase carbon thru afforestation, reforestation, and forest health
    - Retain greenspace and plant trees in cities
  - Demo projects for development of markets for carbon (private lands)

- **2015 USDA Building Blocks (GHG 26-28% below 2005 level by 2025):**
  - *Help achieve Paris Agreement*
  - “…Stewardship of federal forests Building Blocks are designed to recover, maintain, and enhance resilience of the carbon sink…through restoration/reforestation”
    - Reforest post-disturbance NFS lands Fuel treatments in WUI
    - Sustain or restore watershed function and resilience
CURRENT POLICY

2012 PLANNING RULE
(FSH 1909.12,4-4.2)

- Assessment of Carbon Stocks:
  - Role of forests in sequestering carbon
  - Effects of Disturbances & Management on carbon stocks
  - How carbon might be influenced by management
- Identifying Carbon Pools
- Assessing the Plan Area Influences on Carbon Stocks

Focused on carbon stocks

CEQ NEPA GUIDANCE AND CASE LAW

- Consider climate change effects:
  - Effects of projects on climate (carbon)
  - Effects of climate on projects

Focused on carbon emissions
CARBON PRINCIPLES

1. Emphasize ecosystem function and resilience
2. Recognize that carbon sequestration is one of many ecosystem services
3. Consider system dynamics and scale in decision making
4. Support a diversity of approaches
5. Use the best information and science
SPEAKER

Sean Healey
Research Ecologist
Rocky Mountain Research Station

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HOW ARE CARBON STOCKS MEASURED?

- Plot-level/ Stand:
  - Use mathematical approaches to calculate tree biomass from simple measurements, such as DBH
  - Belowground can be done through coring

- Landscape scale:
  - Remote sensing, such as radar and Lidar
  - Aerial images

- Forest Inventory and Analysis (FIA) uses field plots combined with remotely sense changes in forest age, cover types, and disturbances.
  - Regional gaps in inventory are often addressed using remotely sensed data combined with modeling
THE SCIENCE FOUNDATION: CARBON INFORMATION FOR EVERY NATIONAL FOREST!!!

Stocks/Stock Change

Baseline Estimates of Carbon Stocks in Forests and Harvested Wood Products for National Forest System Units

Northern Region

Climate Change Advisor’s Office
Office of the Chief

March 6, 2015

United States Department of Agriculture
Forest Service

Citation: USDA Forest Service. 2015. Baseline Estimates of Carbon Stocks in Forests and Harvested Wood Products for National Forest System Units; Northern Region. 43 pp. Whitepaper. http://www.fs.fed.us/climatechange/documents/NorthernRegionCarbonAssessment.pdf

Impact of Management and Disturbance

Assessment of the Influence of Disturbance, Management Activities, and Environmental Factors on Carbon Stocks of United States National Forests

Richard Birdsey, Alexa Dugan, Sean Healy, Karen Dante-Wood, Fangmin Zhang, Jing Chen, Alexander Hernandez, Crystal Raymond, James McCarter
Description of the primary forest carbon models used to conduct carbon assessments

**Carbon Calculation Tool (CCT)**

**Forest Carbon Management Framework (ForCaMF)**

**Integrated Terrestrial Ecosystem Carbon (InTEC) model**
HARVEST WOOD PRODUCTS IPCC PRODUCTION APPROACH
CARBON STORAGE AND EMISSIONS ESTIMATION TOOL

Applying cut sold data from each national forest

- historical product distributions ratios
- carbon conversion factors
- primary product half-lives
- disposition ratios
TOOLS IN THESE REPORTS CAN ANSWER RELEVANT QUESTIONS

How does the effect of management and disturbance compare with atmospheric and climatic changes?

How has management and disturbance affected total carbon?

How much total carbon on the landscape / in product pools?

InTEC

ForCaMF

Product C

FIA/CCT

Community of Monitoring Data
SPEAKER

Duncan McKinley
Natural Resource Specialist
Office of Sustainability and Climate

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SOME WAYS THE FOREST SERVICE INFLUENCES CARBON

On NFS lands:

“We manage the carbon in forests, not manage the forests for carbon”
KEEPING FORESTS AS FORESTS IS THE MAJOR CONCERN WITH RESPECT TO CARBON IN THE US
The Importance of Keeping Forests as Forests

Even if a forest is disturbed or harvested, carbon is exchanged in a closed system as long as it remains forest.

Some forests can convert to non-forested ecosystems, such as shrublands, after especially severe disturbances.

Conversion to non-forest systems can alter ecosystem carbon dynamics indefinitely, often leading to lower ecosystem carbon storage.

Reforestation, such as tree planting and fostering natural regeneration, can ensure forests remain as forests.
Reforestation efforts can accelerate the rates of trees growing back in areas where forests might not regenerate naturally for generations.
Carbon Benefits in the Broad View | How Carbon Stacks Up

In the NARROW VIEW of the forest system (shorter time scale, smaller geographic extent, narrow range of activities that influence carbon), there is a net INCREASE in CO₂ emissions.

In the BROAD VIEW of the forest system (longer time scale, broader geographical extent, broad range of activities that influence carbon), there is a net DECREASE in CO₂ emissions.
Salvage harvesting can result in more carbon storage than letting dead trees decompose in the forest.
**Fuel Treatments, Carbon, & Public Safety**

**Carbon Trade-offs**

Where the probability of severe wildfire is low for any stand in any year, fuel treatments are unlikely to provide a carbon benefit.

However, a lower carbon carrying capacity is a necessary trade-off in areas where public safety and asset protection are at risk.
Wildfires versus Fuels Treatments

Effects on Carbon Stocks & Emissions

Without Fuel Treatments

With high-severity wildfires, carbon stocks decrease but then gradually recover.

With Fuel Treatments

Fuel treatments decrease carbon stocks substantially and indefinitely, but might also reduce emissions during wildfire.

Without Fuel Treatments & No Regeneration

Sometimes forests do not regenerate, compounding carbon loss from wildfire and subsequent decomposition.

Carbon stocks in areas with fuels treatments will fluctuate frequently, assuming treatments are maintained.
SPEAKER

Lauren Onofrio
RAP Intern
Office of Sustainability and Climate

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OUR GOALS IN DELIVERING SCIENCE ACROSS OUR NATIONAL FORESTS...

- Develop information and approach that’s consistent and transferable among all National Forests
- Based on the best available science
- Ensure information “answers” to policy needs
- Reduces burden to individual National Forests while improving quality of information for decision makers and the public
THE TEMPLATE-BASED APPROACH

- OSC Staff
- Regional Staff
- EMC Staff
- Research & Development

Science Delivery
- Training and Communication
- OSC Staff Review

White Paper Template
- Unit-Level White Paper

Capacity
- Communication products
  - Carbon Literacy
  - Consistent Carbon Message
- NEPA
  - NEPA Templates
    - Project-Level NEPA
    - Plan-Level NEPA

Planning
- Forest Assessments
- Public Engagement
- 2012 Planning Rule Requirements

Monitoring
- Biannual Monitoring Reports
- Broad-scale Monitoring Strategy
NATIONAL APPROACH CAN PROVIDE RELEVANT CONTEXT
Carbon stocks in forests are always in flux due to variations in age, disturbance, and environmental factors. Detecting patterns and trends requires taking a broad view in both space and time.
DETECTING CHANGES IN CARBON STOCKS AFTER LARGE DISTURBANCES: “HAYMAN FIRE”

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

Approximate immediate impact of wildfire on carbon stocks
The Carbon Bathtub of National Forests

Carbon entering the tub through tree growth = 42 ounces.

Total carbon stocks in national forests = 10,240 ounces (an 80 gallon tub.)

Net gain of carbon (growth minus harvest & natural disturbances) = 31 ounces, equivalent to a large bottle of shampoo.

Carbon leaving the tub from harvesting = 3 ounces, equivalent to what a washcloth can absorb.

Carbon leaving the tub through natural disturbances = 8 ounces.

USDA United States Department of Agriculture

Forest Service Office of Sustainability and Climate February 2019
SPEAKER

Jacob Deal
ORISE Fellow
Office of Sustainability and Climate & R8

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GREENHOUSE GAS EMISSIONS FROM OIL, GAS, AND COAL DEVELOPMENT
In Context: Comparing Carbon Emissions from Coal Energy Use

- A 1000 Megawatt (MW) plant, servicing about 500k people, consumes 9,000 metric tonnes of coal per day
  - That’s 90 train cars – each carrying 100 metric tonnes
  - Assuming Anthracite coal is used – 1 train car every ~16 minutes
    - That’s 220 lbs of coal every second!
    - In terms of carbon, that’s about 100 lbs!
- There are about 308 coal power plants nationwide
- Results in about 260 Tg C annually

[https://www.eia.gov/tools/applications.php?subject=coal]
GLOBAL STOCKS AND FLOWS OF CARBON

ATMOSPHERE
816 (+ ~ 4.8 yr⁻¹)

PLANTS & SOIL
2,000

1.6

1.4

OCEANS
37,000

2.3

COAL, OIL, & NATURAL GAS
10,000

SEDIMENTS AND SEDIMENTARY ROCKS
66,000,000–100,000,000

McKinley et al. 2011
GHG EMISSIONS FROM FOREST SERVICE LEASES
BUT HOW DO OUR LEASE EMISSIONS COMPARE?
A HOLISTIC APPROACH

GREENHOUSE GAS EMISSIONS

Exploration & Production

Transportation

Refining & Processing

Combustion

Product Transportation
Example of analysis in template

- Exploration and production
- Raw material transport
- Refining and processing
- Product transport
- End-use

- Global anthropogenic (2016, all sources)
- Global anthropogenic (2020, fossil combustion)
- United States anthropogenic (2018, all sources)
- United States anthropogenic (2018, fossil combustion)
- Federal fossil fuel leases (2018)
- Texas (2018, fossil combustion)
- United States petroleum and natural gas systems (2018)
- Forest Service fossil fuel leases (2018)
- Project yearly emissions
EXPAND OUR ANALYSIS BOUNDARY?
ABANDONED INFRASTRUCTURE ON THE DANIEL BOONE NF

- Wells, pump jacks, tanks full of bottom sludge, powerlines with cables strewn across the forest floor, silt ponds, buildings and miles of pipeline

- Utilized drone technology and various sensors

- Prioritize areas for mitigation

- Work is relevant to recent “Climate Crisis” EO

Raw magnetometer data. Red (warmer) colors indicate wells and other metal hits. Credit: Shiloh Benton, Daniel Boone NF
What can I personally do to decrease my footprint?
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SUSTAINABILITY IS AT THE HEART OF THE FOREST SERVICE MISSION.

“...TO SUSTAIN THE HEALTH, DIVERSITY, AND PRODUCTIVITY OF THE NATION’S FORESTS AND GRASSLANDS TO MEET THE NEEDS OF PRESENT AND FUTURE GENERATIONS.”
SUSTAINABLE OPERATIONS IN THE FOREST SERVICE

- Sustainable Operations reduces the impact of operations on our ecological footprint
- The agency’s goal is to integrate sustainability into our operations, to reduce impacts in:
  - Energy and Water Consumption
  - Fleet & Transportation
  - Acquisition
  - Waste Prevention & Recycling
- Results:
  - Saves money, time, and resources
  - Results are tracked by USDA and Office of Management and Budget
  - Part of the individual Performance Plan of every supervisor in FS
HOW WE MEASURE OUR EMISSIONS

- **Scope 1 – All Direct Emissions** from the activities of the Agency or under their control. Includes fuel combustion on site such as gas boilers and fleet vehicles.

- **Scope 2 – Indirect Emissions** from electricity purchased and used by the Agency. Emissions are created during the production of the energy and eventually used by the Agency.

- **Scope 3 – All Other Indirect Emissions** from activities of the Agency, occurring from sources that they do not own or control. Includes employee commuting and business travel.

Source: Bhatia and Ranganathan, 2004,
SCOPES 1 & 2 GHG EMISSIONS (FEDERAL GOVERNMENT)
SCOPES 1 & 2 GHG EMISSIONS (FOREST SERVICE)
FY19 GHG EMISSIONS CATEGORIES (FOREST SERVICE)

- Employee Commuting, 28.5%
- Employee Business Ground Travel, 0.7%
- Employee Air Travel, 3.5%
- Building Energy Use, 29.9%
- Mobile (Fleet) Emissions, 34.8%
- Other, 2.6%
REDUCING OUR CARBON FOOTPRINT

It's all about our dedicated employees.

Forest Service savings from the Leadership in Sustainable Operations (LISO) Database (FY16-Current)

- **Estimated Savings Reported since 2016**
  - Electricity: 796,128 kWh
  - Water: 3,439,887 gallons
  - Fuel: 139,637 gallons
  - Money: $750,540!!
UNDERSTANDING THE SUBSTITUTION EFFECT

One woman’s quest to understand her emissions in heating her Colorado home. Wood or propane?
Resources (one stop shopping)
OSC Carbon Sharepoint:
https://usdagcc.sharepoint.com/sites/fs-nfs
osc/Pages/Carbon.aspx
Public facing website:
https://www.fs.fed.us/managing-land/sc/carbon (public)
SUMMARY

- Public interest in carbon is increasing as well as the need for information and capacity to respond effectively.
- The Forest Service does not manage to maximize carbon, but already does a lot of management activities that create carbon benefits.
- The carbon template-based approach for forest carbon and energy development is an effective and efficient means to deliver information to inform decision making.
- Sustainability starts with all of us....
- OSC is developing education and communication products to help build internal capacity and foster constructive public engagement.
CONTACT US

Duncan McKinley,
duncan.mckinley@usda.gov

Aurora Cutler,
aurora.cutler@usda.gov

Website,
https://www.fs.usda.gov/managing-land/sc/carbon