



Forest Applications of Biochar Stanislaus Demonstration Site

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USDA Forest Service, Stanislaus National Forest



Collaborators

Research team:

- Debbie Page-Dumroese
 - Rocky Mountain Research Station (RMRS)
- Joanne Tirocke
 - RMRS
- Brad Kard
 - Oklahoma State University
- Steve Cook
 - University of Idaho
- Carol Shestak
 - PSW

Local Contributors:

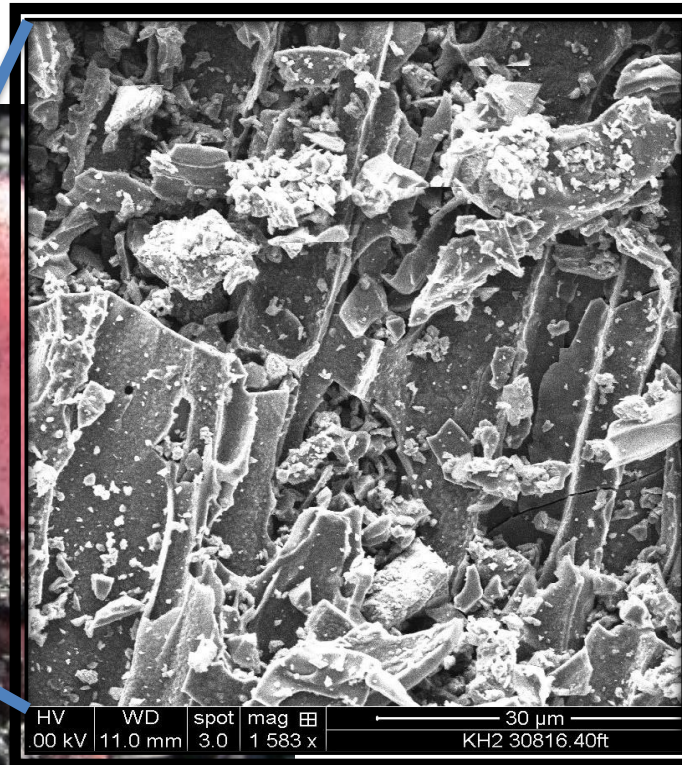
- Jim Archuleta (FS, retired)
- Dave Horak (FS, retired)
- Martin MacKenzie
- Calaveras Ranger District
- Phoenix Energy

Outline

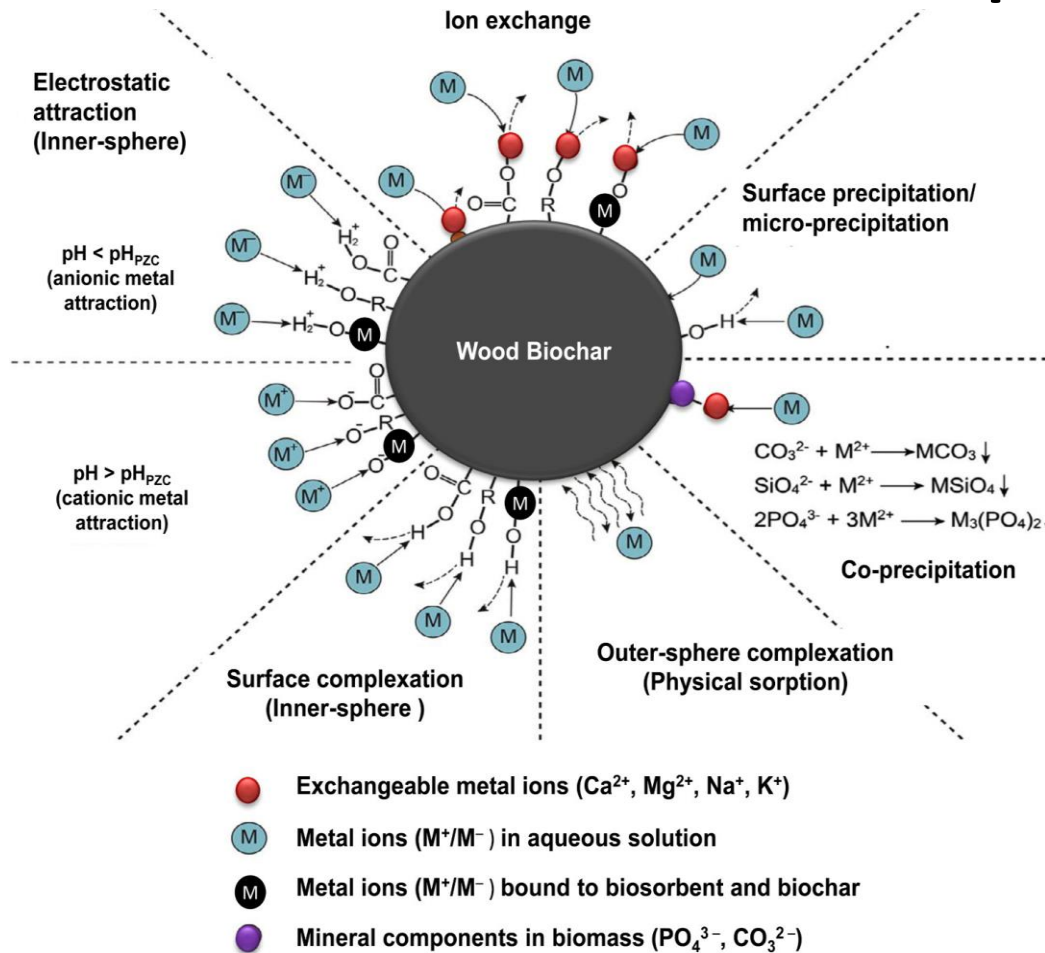


- What is biochar?
- How is biochar made?
- Benefits & tradeoffs
- Applications & examples of biochar use
- Lakemont / Arnold Study Site

What is biochar?

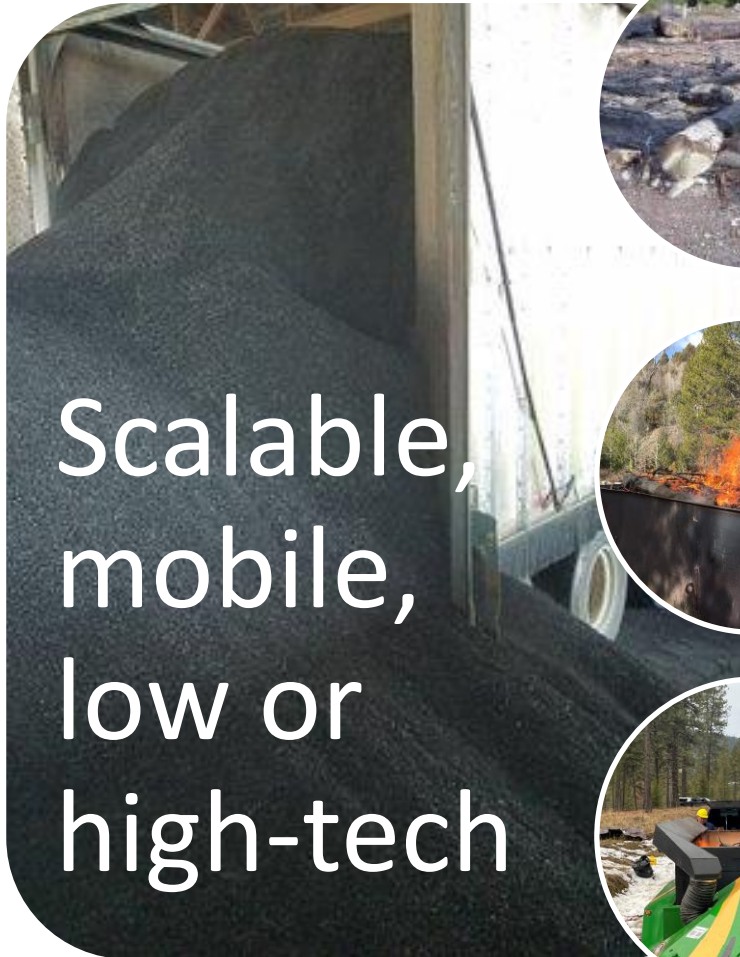


Biochar Properties



- Nutrient adsorption
- Heavy metal adsorption
- Water holding
- Pore space / physical attraction
- Other Chemistry!?

In-woods biochar production



Scalable,
mobile,
low or
high-tech



Burn Piles



Kilns



Air burner or
pyrolyzer (not
pictured)

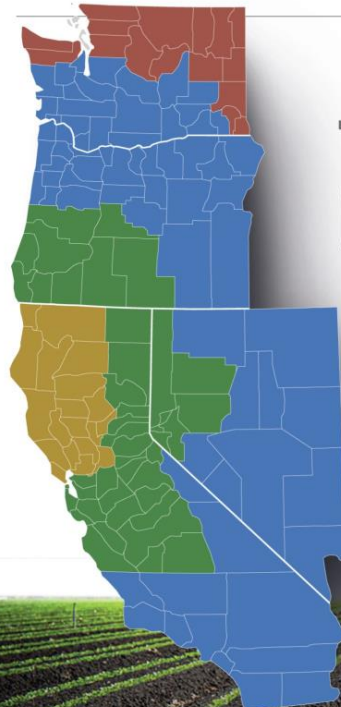
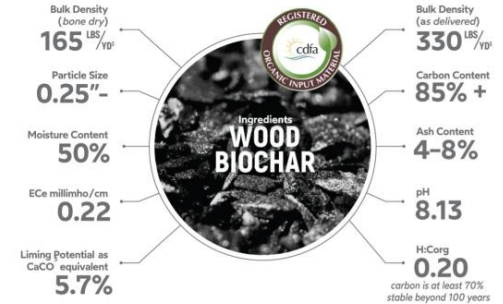
Industrial biochar production

The Process



BLACKLITE PURE

Produced in Northern California purely from softwood forestry residues. It is highly porous, adsorptive, and has great water holding capacity. Registered as an organic input material with CDFA.

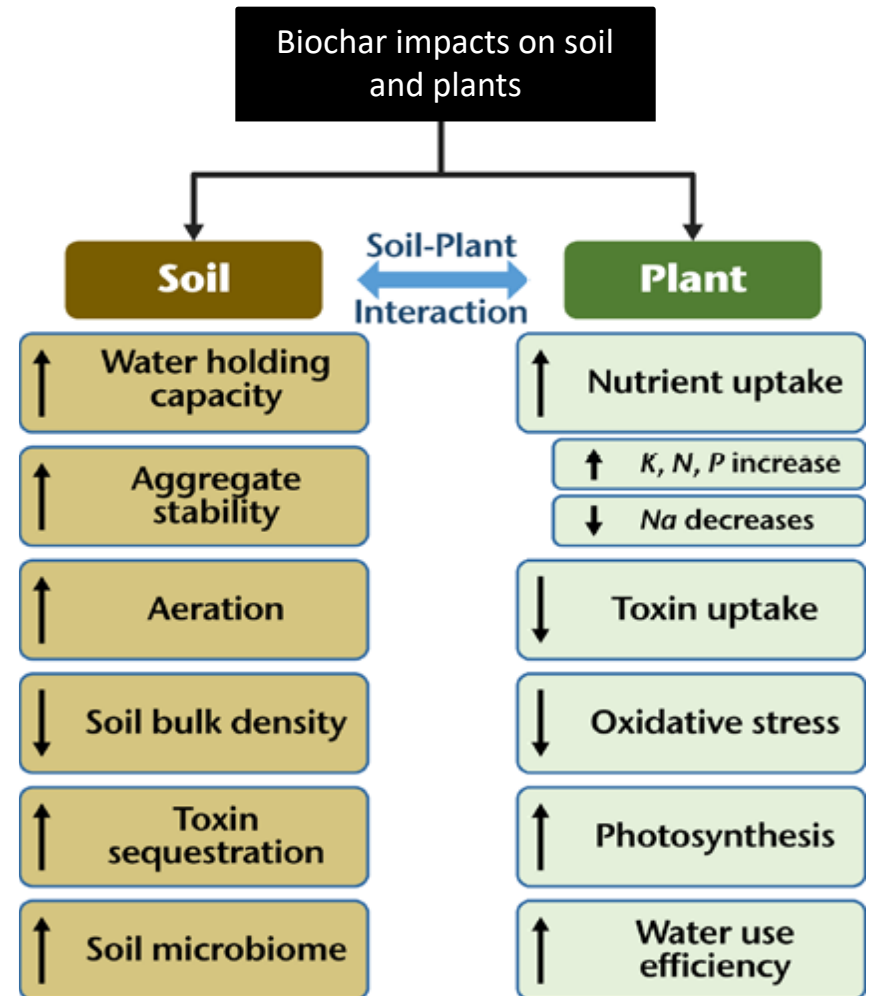


SHIPPING ZONE MAP. DELIVERED PRICING.

	LOADS – Full Truckload, 90+ CY/15+ tons	[1-11] LOADS	[12-100] LOADS	[100+] LOADS
Pricing at our facility "Zone Zero"	\$50 / CY \$300 / ton	\$40 / CY \$240 / ton	\$35 / CY \$210 / ton	
ZONE 1	\$60 / CY \$360 / ton	\$50 / CY \$300 / ton	\$45 / CY \$270 / ton	
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ZONE 3	\$90 / CY \$540 / ton	\$80 / CY \$480 / ton	\$75 / CY \$300 / ton	
ZONE 4	\$100 / CY \$600 / ton	\$90 / CY \$540 / ton	\$85 / CY \$510 / ton	

Specifications listed above are averages, not guaranteed analysis. Terms and conditions may apply

Biochar impacts - soil and plants



Water (building a soil sponge)

- Decrease overland flow
- Increase infiltration

Biochar increased available water:

- 38%: coarse-textured soil
- 19%: medium-textured soil
- 16%: fine-textured soil



Data from: Blanco-Canqui, 2017; Edeh et al., 2020; Razzaghi et al. 2020

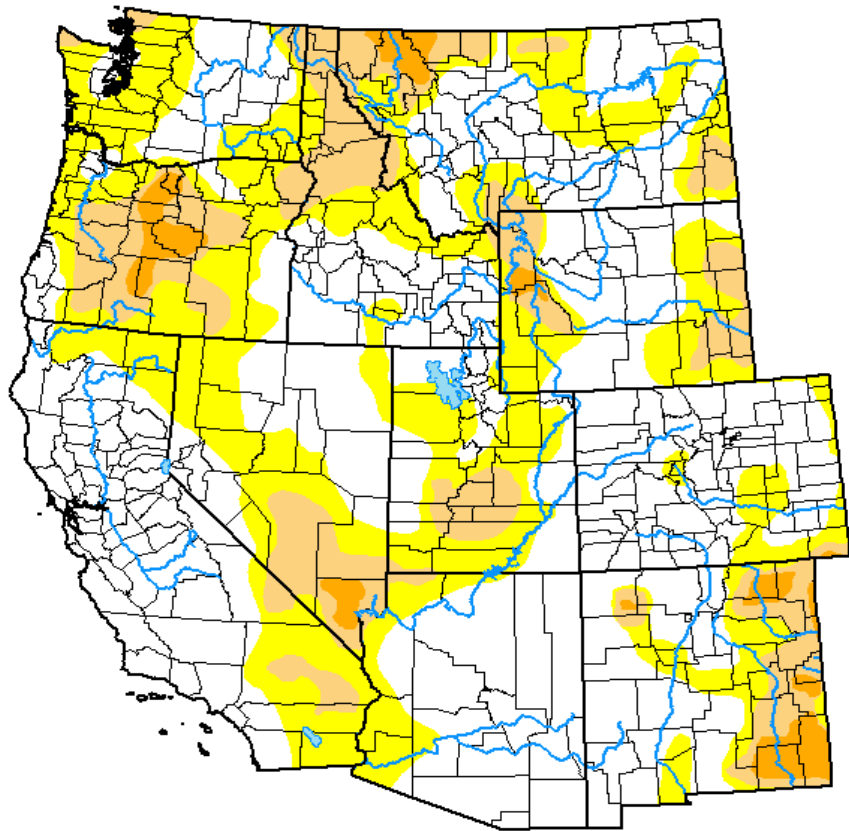
Why Biochar? - Forest and soil health









Why Biochar? - Water in forest ecosystems

U.S. Drought Monitor West

June 6, 2023
(Released Thursday, Jun. 8, 2023)
Valid 8 a.m. EDT



Intensity:

-  None
-  D0 Abnormally Dry
-  D1 Moderate Drought
-  D2 Severe Drought
-  D3 Extreme Drought
-  D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to <https://droughtmonitor.unl.edu/About.aspx>

Author:

Lindsay Johnson
National Drought Mitigation Center



droughtmonitor.unl.edu

Why Biochar? - Add organic matter

DID YOU KNOW? unlock the SECRETS OF SOIL

FOR EACH **1%** INCREASE IN *organic matter* U.S. CROPLAND COULD STORE THE AMOUNT OF *water* THAT FLOWS OVER NIAGARA FALLS IN **150** DAYS

Like a "water savings account," healthy soils capture and store more water for plants to use when they need it.

Earthworms, arthropods, and decaying roots create "macro-pores" into which water can flow to then be stored in the soil. Bacteria, fungi, and other soil life build and stabilize smaller "micro-pores" that further increase the soil's capacity to hold water.

Calculations based on approximate averages for forests such as follows:
U.S. Douglas fir 400 million acres
Average water holding capacity per acre with 40% forest organic matter = 10,000 gallons
400 million acres = 4,000 billion gallons
Average water flow Niagara Falls per day = 4.5 billion gallons
10,000 billion gallons organic matter = 100 million = 1% forest
The result: 10 million gallons = 100 million gallons = 1%

Natural Resources Conservation Service
www.nrcs.usda.gov

USDA United States Department of Agriculture
USDA is an equal opportunity provider and employer.

Potential Uses

- Avoid Pile burning
 - Less emissions & particulates
 - More Carbon storage / retention
 - Extended burn window with mobile units?
 - Less soil heat damage
 - Get a product from “waste” wood
- Other uses :
 - Log landing/skid trail restoration
 - Rehab abandoned mine lands
 - Keep understory green longer
 - Reduce fuels



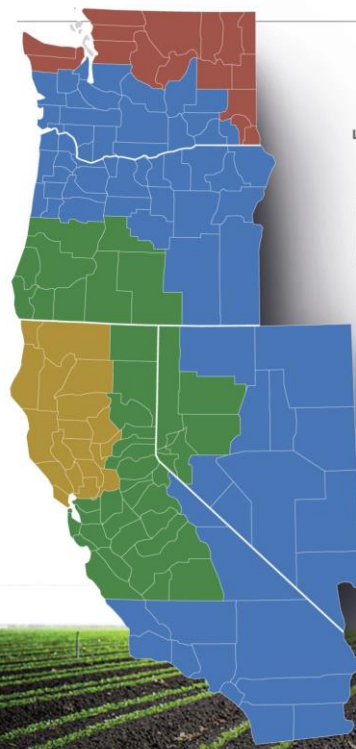
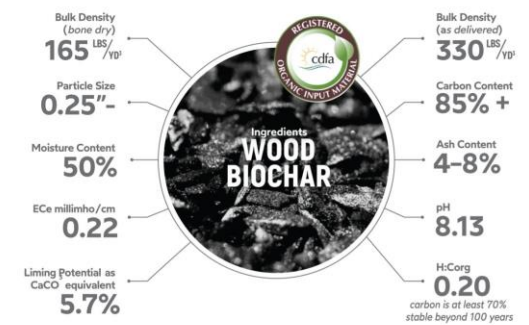
Potential Tradeoffs

- Tradeoffs
 - Expensive (commercial production)
 - Economy of Scale
 - Another piece of equipment (In woods production)
 - New methods / techniques
 - Soil Nutrient Tie-up
 - “Raw” biochar applied to low-nutrient soils can hold



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www.pacificbiochar.com
 info@pacificbiochar.com
 (808-936-3494)

Agricultural applications

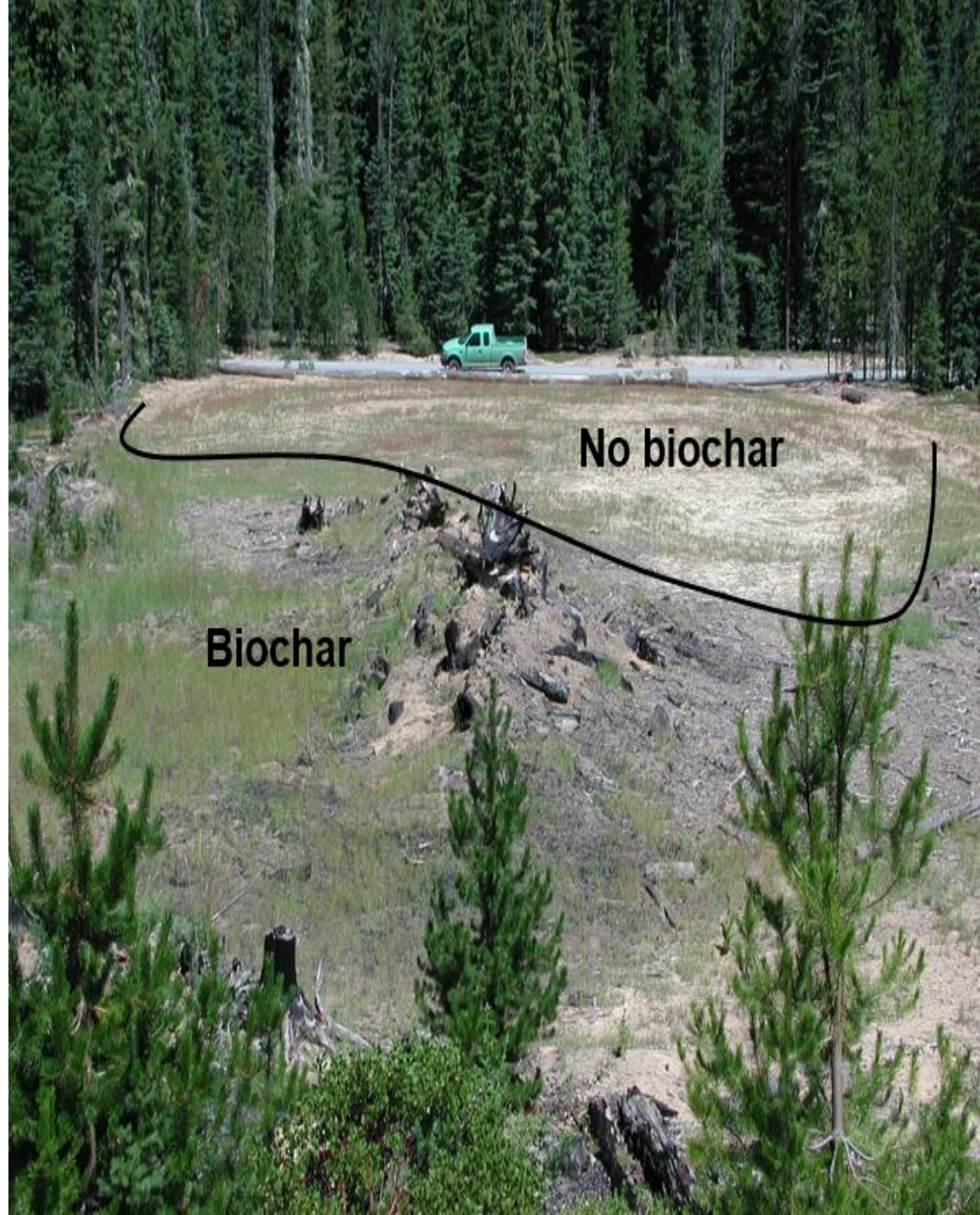
- Feedlots or pens
 - Prevent N leaching
- Degraded agricultural soil
- Water filtration
- Central Valley orchards – water conservation
 - Mixed in soil where new orchards planted



Examples: Establishing vegetation

- Using slash piles to create local biochar
- Provide OM to establish vegetation
- Keeps understory green
- Speed recovery of log landing

Umpqua NF, Oregon

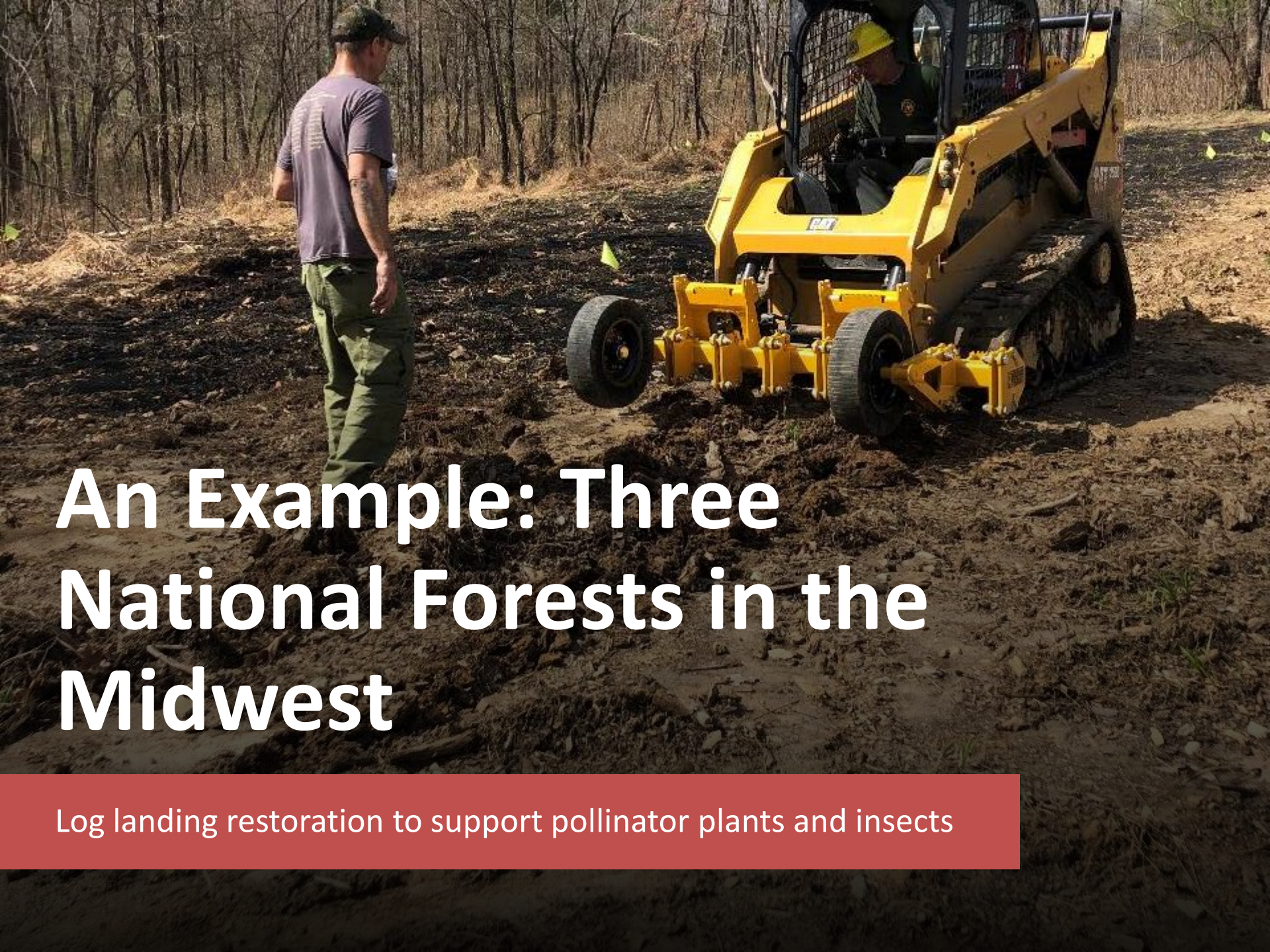


Examples: Helena National Forest Road obliteration

- Treatments:
 - Wood strands
 - Biochar (at 2 rates)
- Biochar plots:
 - Reduced bulk density in top 30"
 - Reduced (or delayed) invasive species
 - Long-term C input

Helena NF, Montana



A yellow CAT skid steer loader is shown in a forest clearing, with a worker operating it. Another worker stands nearby, observing the machine. The ground is dark and appears to be a log landing site. The background shows a dense forest of bare trees.

An Example: Three National Forests in the Midwest

Log landing restoration to support pollinator plants and insects

Three Forests with One Goal

- Reduce bulk density
- Biochar additions
- Seeding pollinator plants





An example: Mt. Hood National Forest

Salvage logging



Mt. Hood National Forest

- An opportunity to create biochar from dead trees
- Tons of feedstock
- Used for agriculture, mine site restoration, viticulture, feedlots, compost....



Biochar and mine site restoration


- 1000's of abandoned mine sites
- Contaminated or non-contaminated
- Biochar can alter soil properties
- Increase vegetation cover
- Reduce wind/water erosion
- Bring non-productive soil into production

Rodriguez-Franco, C. and Page-Dumroese, D. 2020. Woody biochar potential for abandoned mine land restoration in the U.S.: A review. doi: 10.1007/s42773-020-00074-y



Summary - Forest soil benefits

- Boost nutrient storage
- Enhance soil structure
- Biological carbon source
- Enhance carbon sequestration
- Ecosystem water storage and available water
- Purify drinking water
- Detoxify soil
- Decrease compaction
- And more...



Stanislaus National Forest Study Site

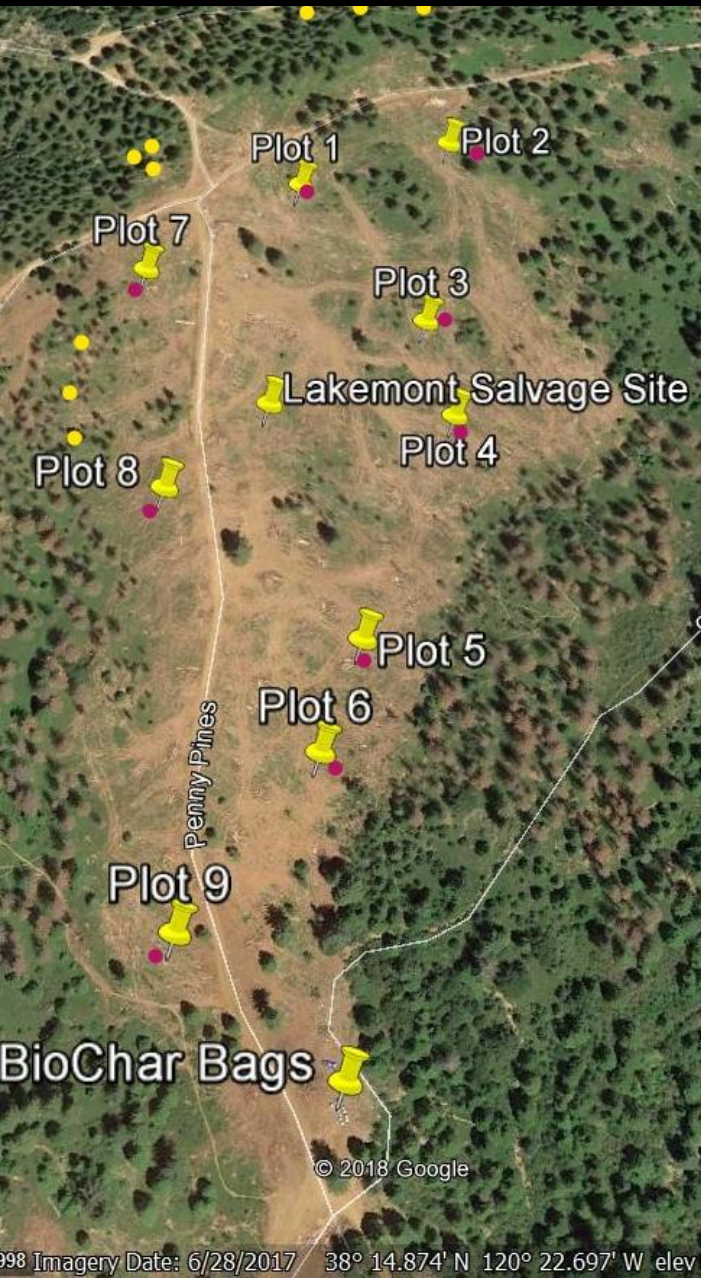
Salvage logging

Stanislaus National Forest: Improving soil organic matter/forest health

- Trees killed by drought and insects
- In Wildland-Urban Interface
- Examining changes in above- and belowground:
 - Insects
 - Vegetation
 - Microbial processes
 - Nutrients



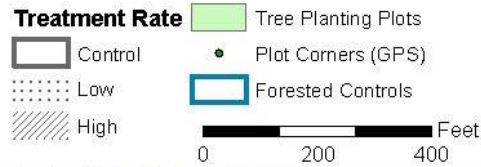
Stanislaus NF – Lakemont Study Site



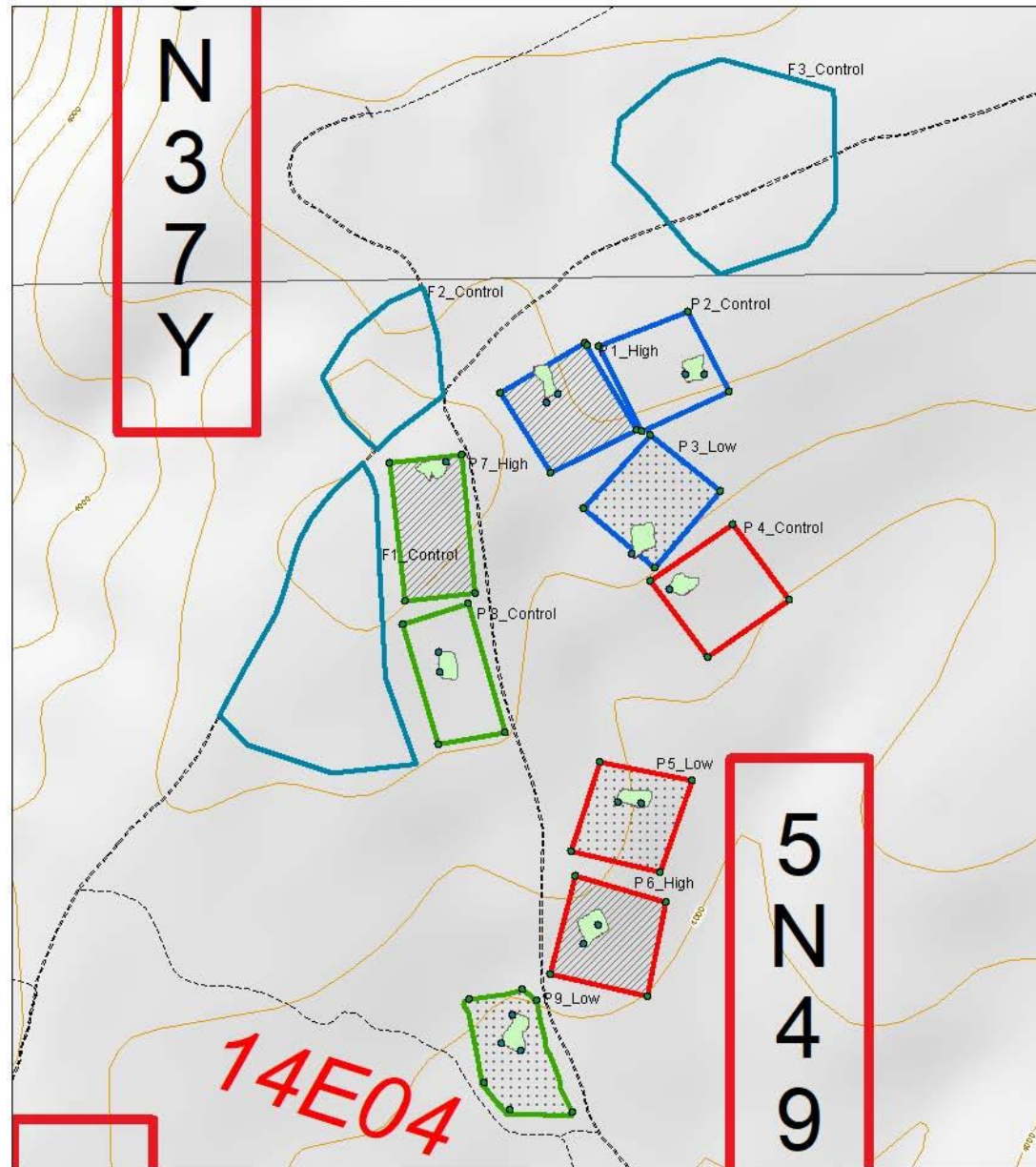
- 2016-2017 Beetle Kill
- Salvage Logged, biomass piles
- (some) Piles converted to biochar & applied to soil

Study Design

- Replicated Study
 - 10 tons/acre biochar
 - 3 tons/acre biochar
 - No biochar
 - Green tree / control site
- Variables Studying
 - Soil Climate (soil moisture & temperature)
 - Decomposition Rates
 - Insect Activity
 - Termites



Biochar Demo
Tree Planting Plots
Stanislaus National Forest
Calaveras Ranger District



Insects & Termites

- Insects (all)
 - Ground traps
 - Flying traps of varying styles & colors
 - Installed temporarily in early summer 2-3 times.
 - Not repeated long-term (too much data!)
- Termites
 - Multiple types of traps installed year-round
 - Checked for termite activity annually



Decomposition Rates

- Wood Stakes at Each Plot
 - Aspen & Pine
 - Buried Below Ground
 - At soil surface
- Sampling
 - Every Year Dig up 1 from each row
 - Weigh in field “wet”
 - Take to lab & oven dry
 - Compare “dry” weight to original mass.

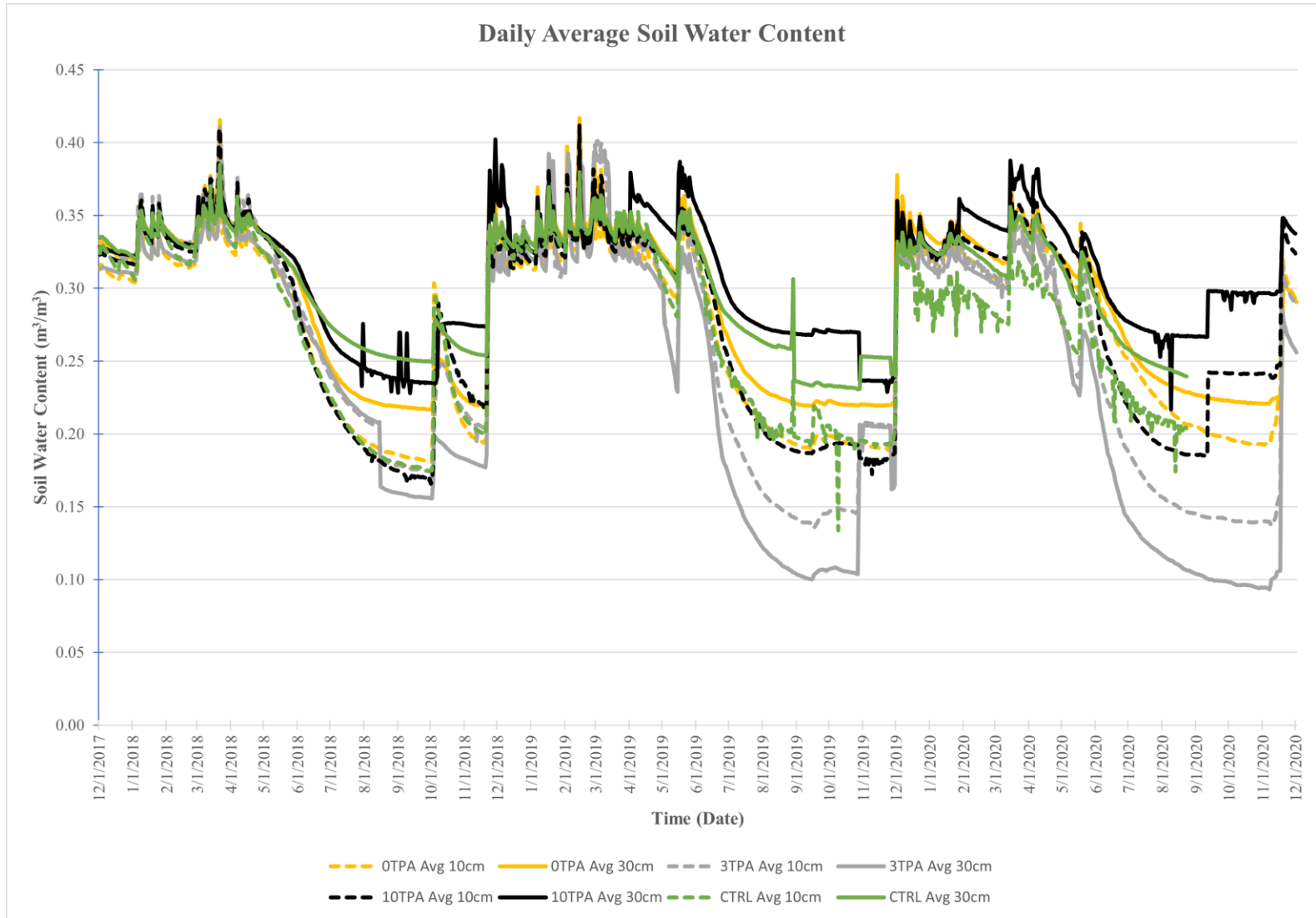


Soil Climate

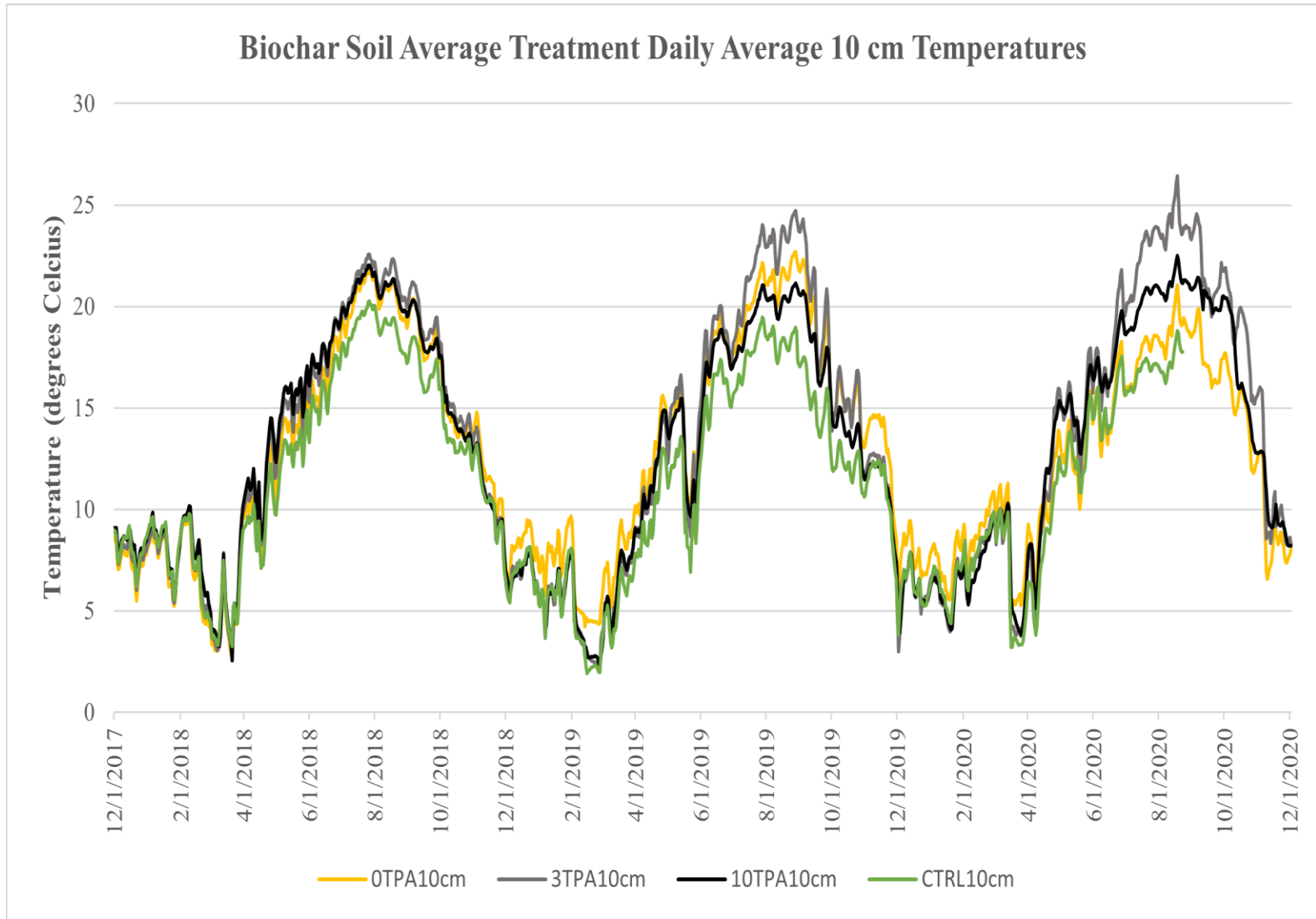
- Climate sensors in each plot
 - Air Temperature
 - Soil Moisture 10, and 30cm deep
 - Soil Temperature 0, 5, 10, and 30cm deep
- Sampling
 - Data recorded year round
 - Downloaded annually



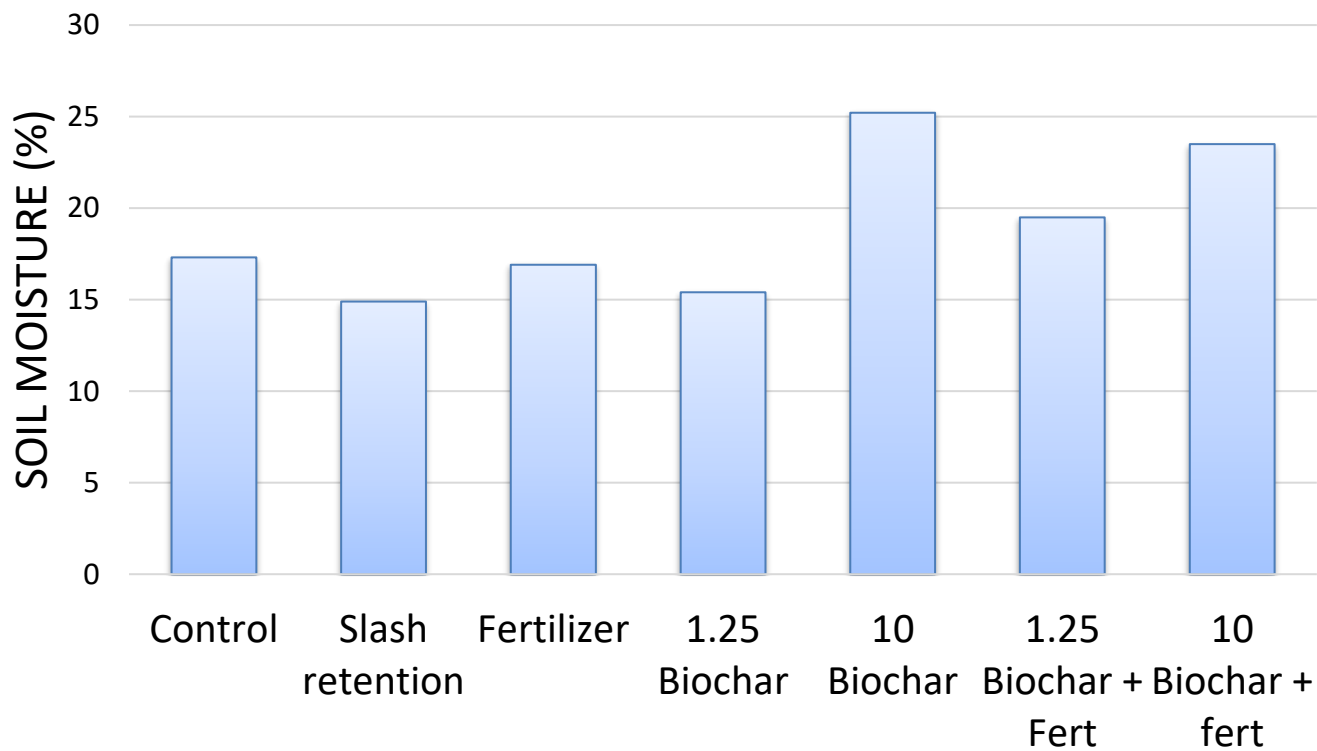
Soil Climate – Soil Moisture Content



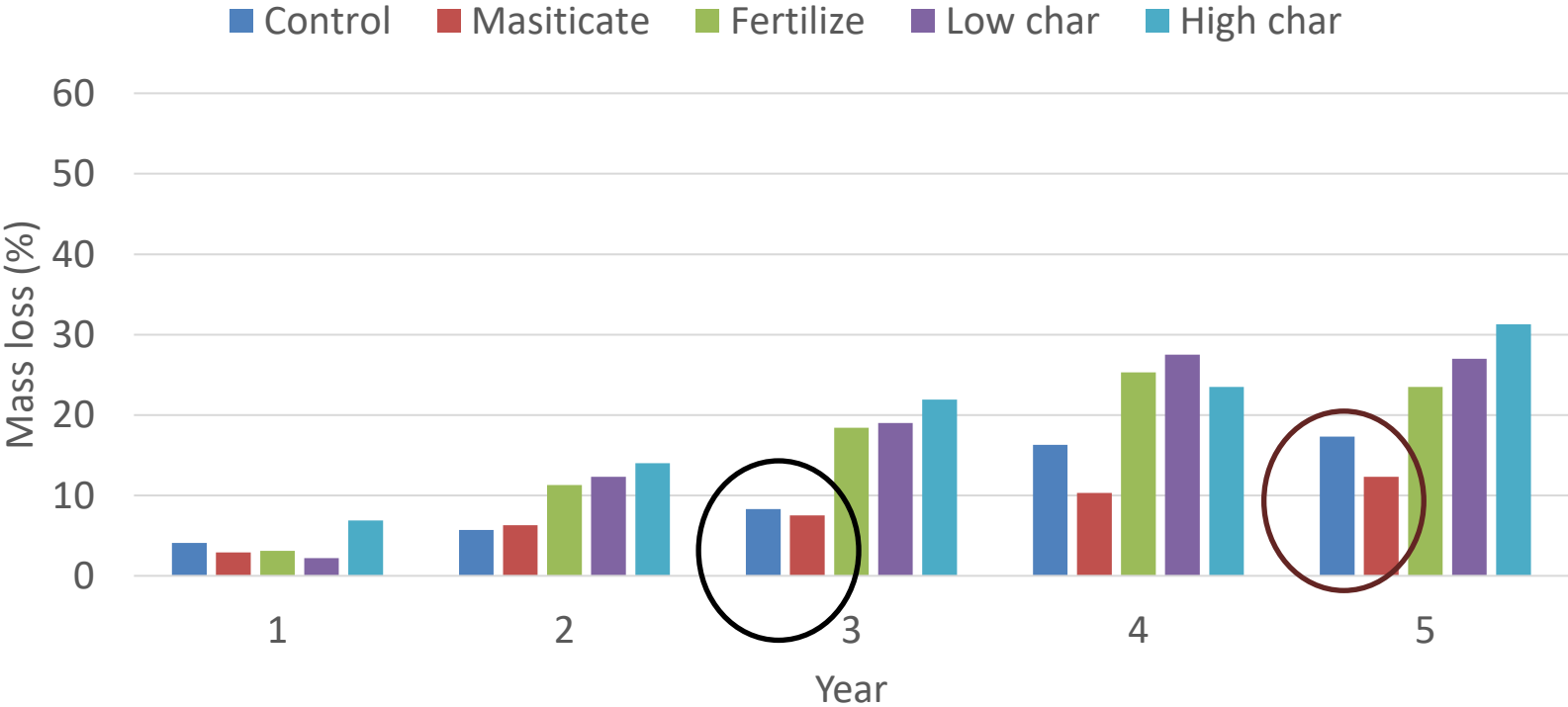
Soil Climate – Soil Temperature



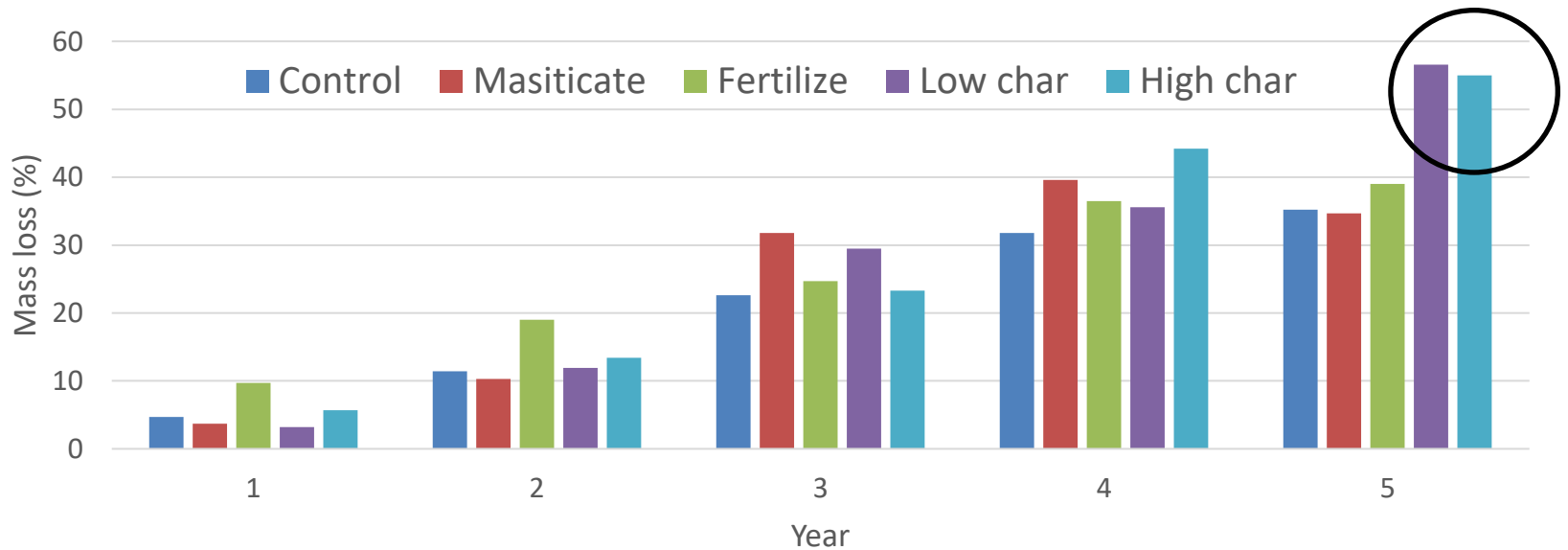
Change in soil water holding capacity – Bitterroot National Forest



Surface stake mass loss for each year and treatment



Mineral stake mass loss for each year and treatment














Thank you for your attention

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Summary of Forest Soil Changes

- Carbon sequestration 
- Available water 
- Greenhouse gas fluxes  
- Soil biology 
- Water erosion 
- Wind erosion 
- Nutrient leaching 
- Vegetation productivity  
- Invasive species 

Other benefits of kilns or air burners

- Burn near communities
- Extend the burn window
- Protect the soil
- Reduce smoke



'Typical' burning slash pile emissions

2.5 m high x 5 m diameter piles



Pollutant	Wet pile	Dry (uncovered) pile	Dry covered
	----- g/kg biomass consumed -----		
Carbon dioxide	1869	1785	1795
Carbon monoxide	82	29	46
Methane	5.7	1.1	2.0
PM _{2.5}	18	4.5	3.4

- Wet piles > dry piles
- Wet piles take longer to burn
- PM_{2.5} continue to be produced up to 4 days after ignition

Additional soil impacts from pile burning



- Burn scars can last for >5 decades
- Loss of nutrients
- Loss of productivity
- Increase in invasive species

Make biochar on site: slash piles



- Forest biochar can be made on-site and used as a soil amendment
- Heat is dissipated away from the soil
- Char increased soil cover and water holding capacity
- Partnered with National Forests

Biochar and invasive species



- Weeds challenge restoration efforts
- Alter soil properties and processes
- Biochar can:
 - Be used by heterotrophic microbes
 - Alter CEC, pH, water, nutrients to limit invasive species
 - Increase biomass of native grasses
- Consider combining biochar with compost
- Use invasive species (i.e., Russian olive) as biochar feedstock

Adams et al. 2013. The effect of biochar on native and invasive prairie plant species. *Invasive Plant Science and Management* 6: 197-207