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Forest Applications of Biochar
Stanislaus Demonstration Site

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Making and using biochar 2023

Collaborators

Research team:

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

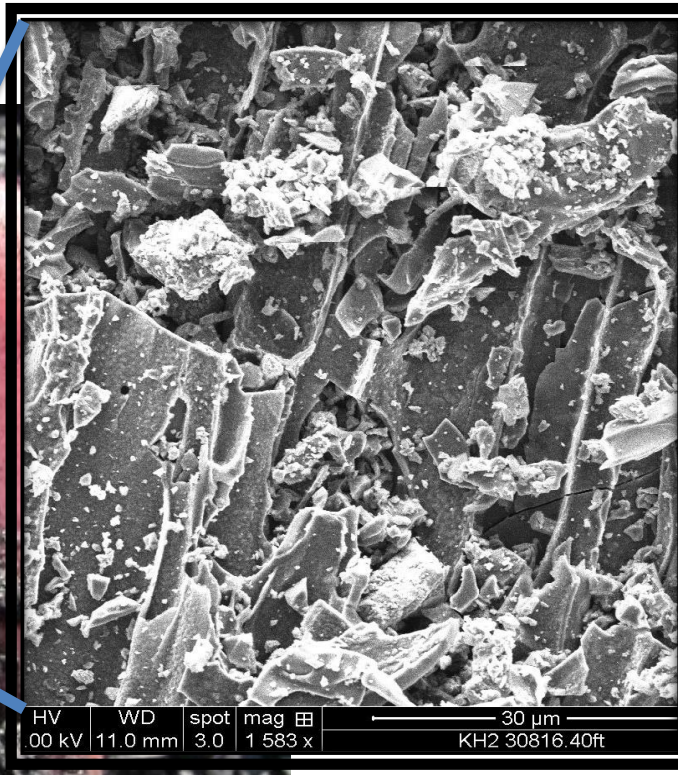
Local Contributors:

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

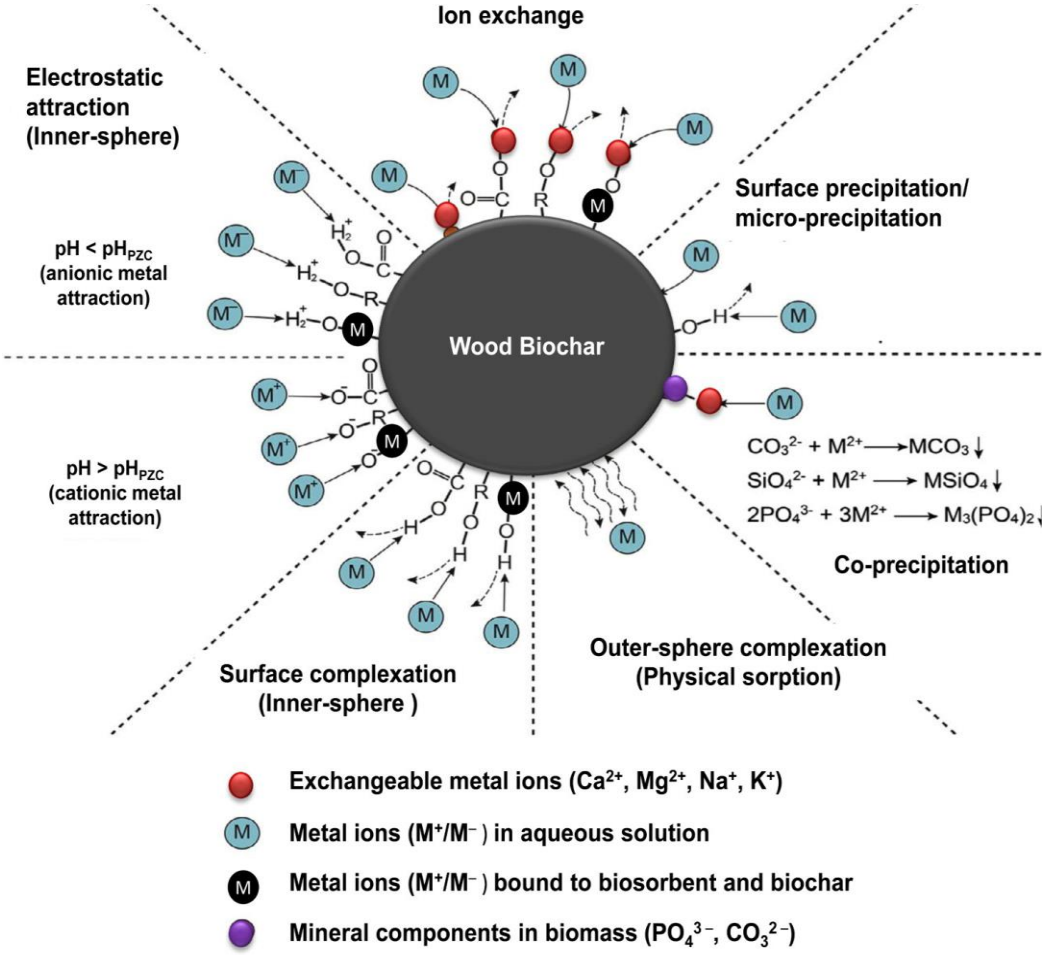
Outline

- 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!?

From Shaheen et al. 2019. International Materials Review. 54: 216-247

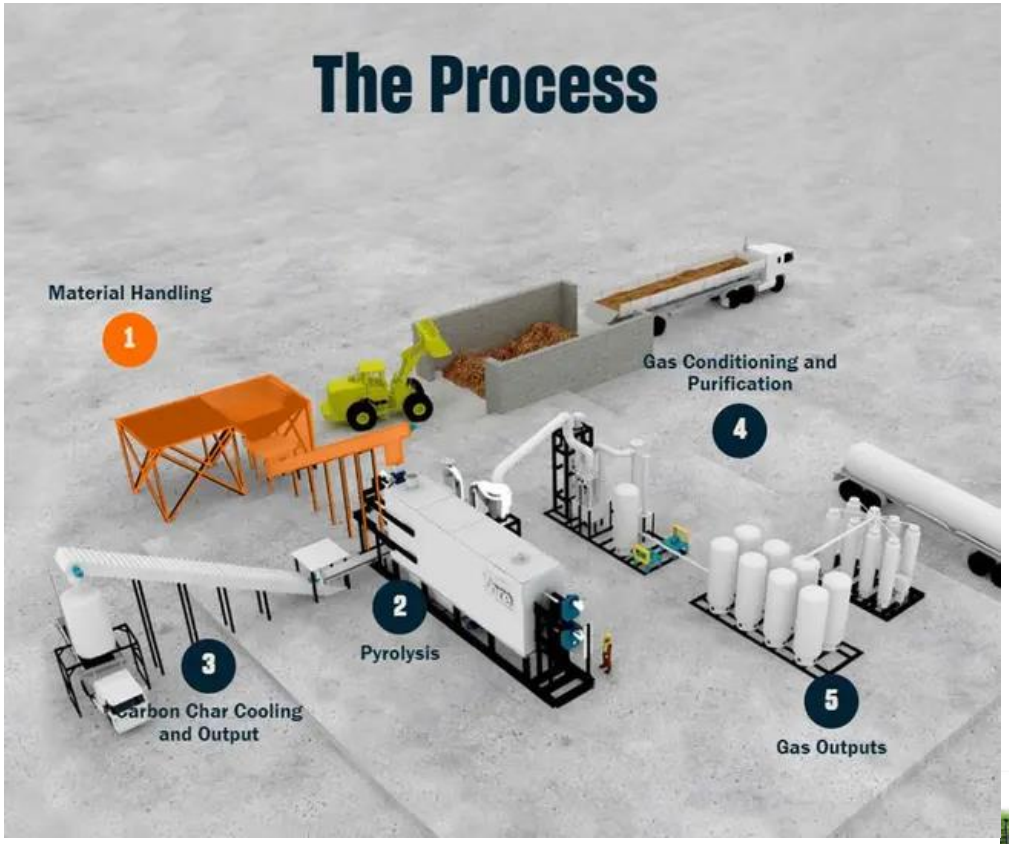
In-woods biochar production

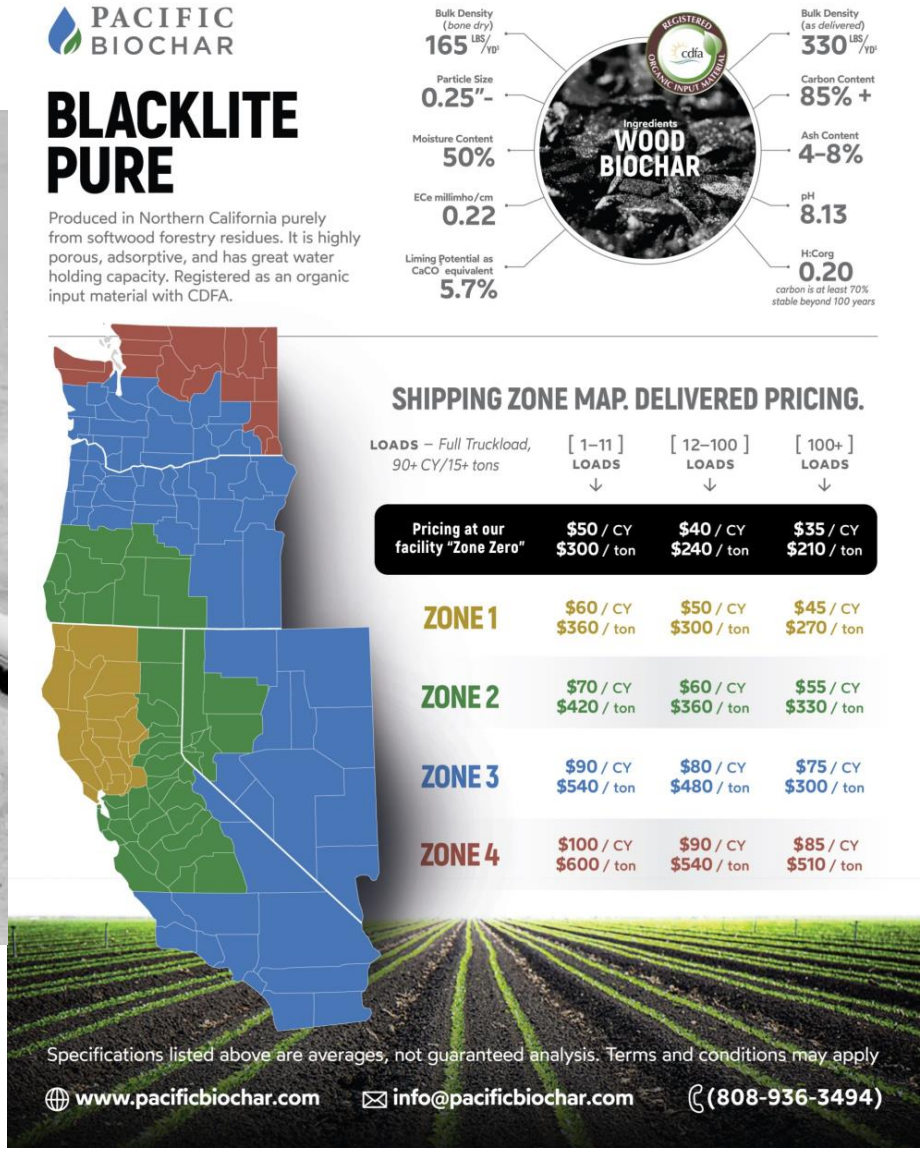
Burn Piles

Kilns

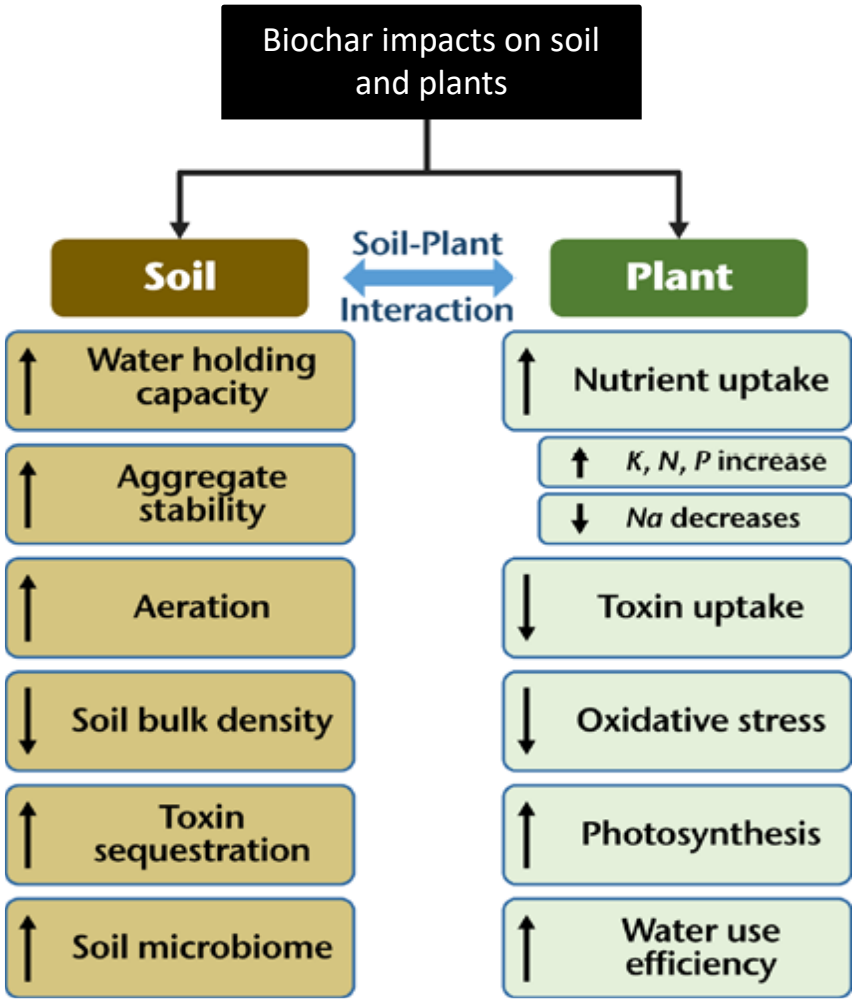
Air burner or pyrolizer (not pictured)

Industrial biochar production





Biochar impacts - soil and plants



From: Biomass to Biochar: Maximizing the carbon value - https://csanr.wsu.edu/biomass2biochar/

Water (building a soil sponge)

- Decrease overland flow
- Increase infiltration

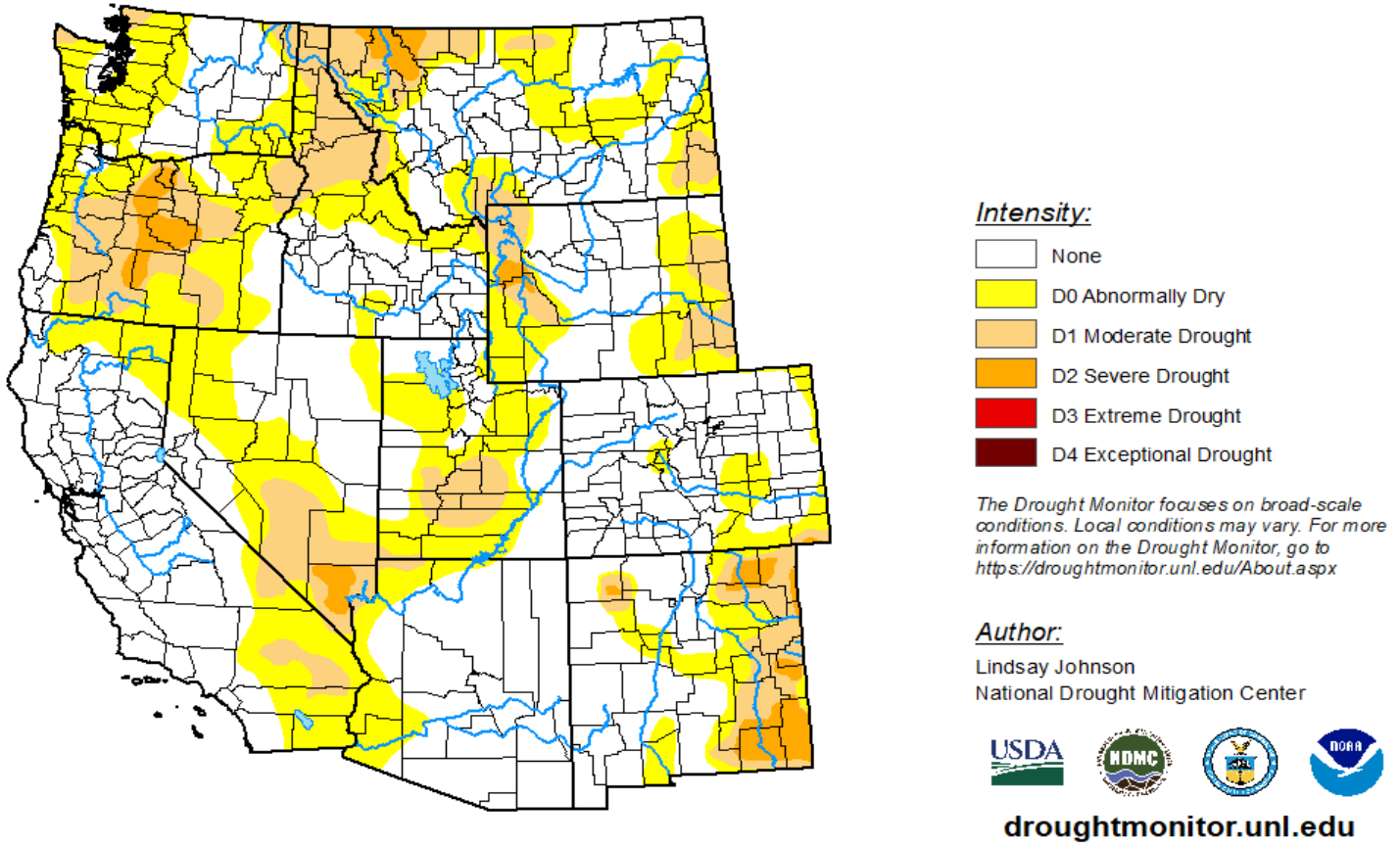
Biochar increased available water:

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

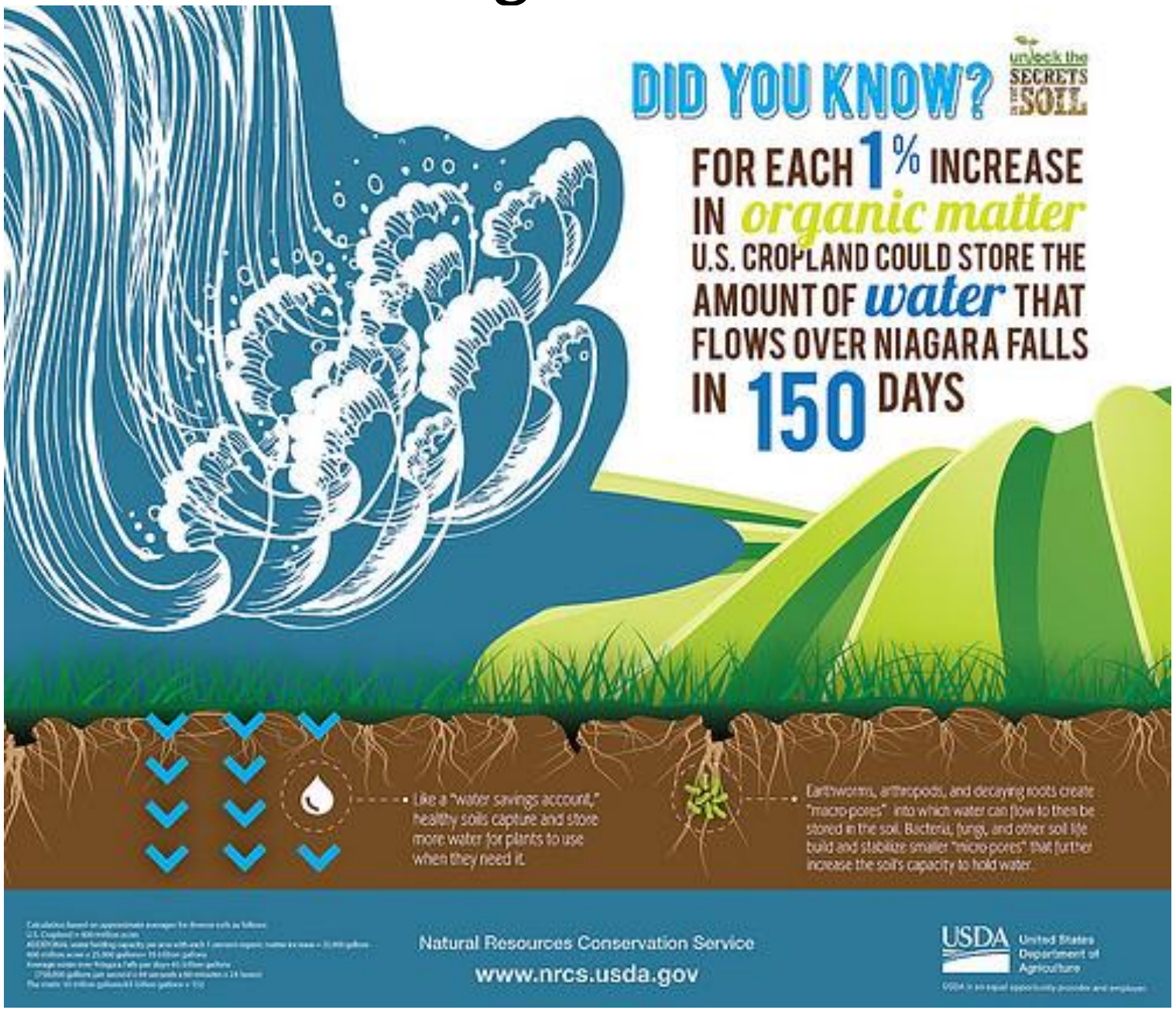
Data from: Blanco-Canqui, 2017; Edeh et al., 2020; Razzaghi et al. 2020

Why Biochar? - Forest and soil health

Why Biochar? - Water in forest ecosystems



Why Biochar? - Add organic matter

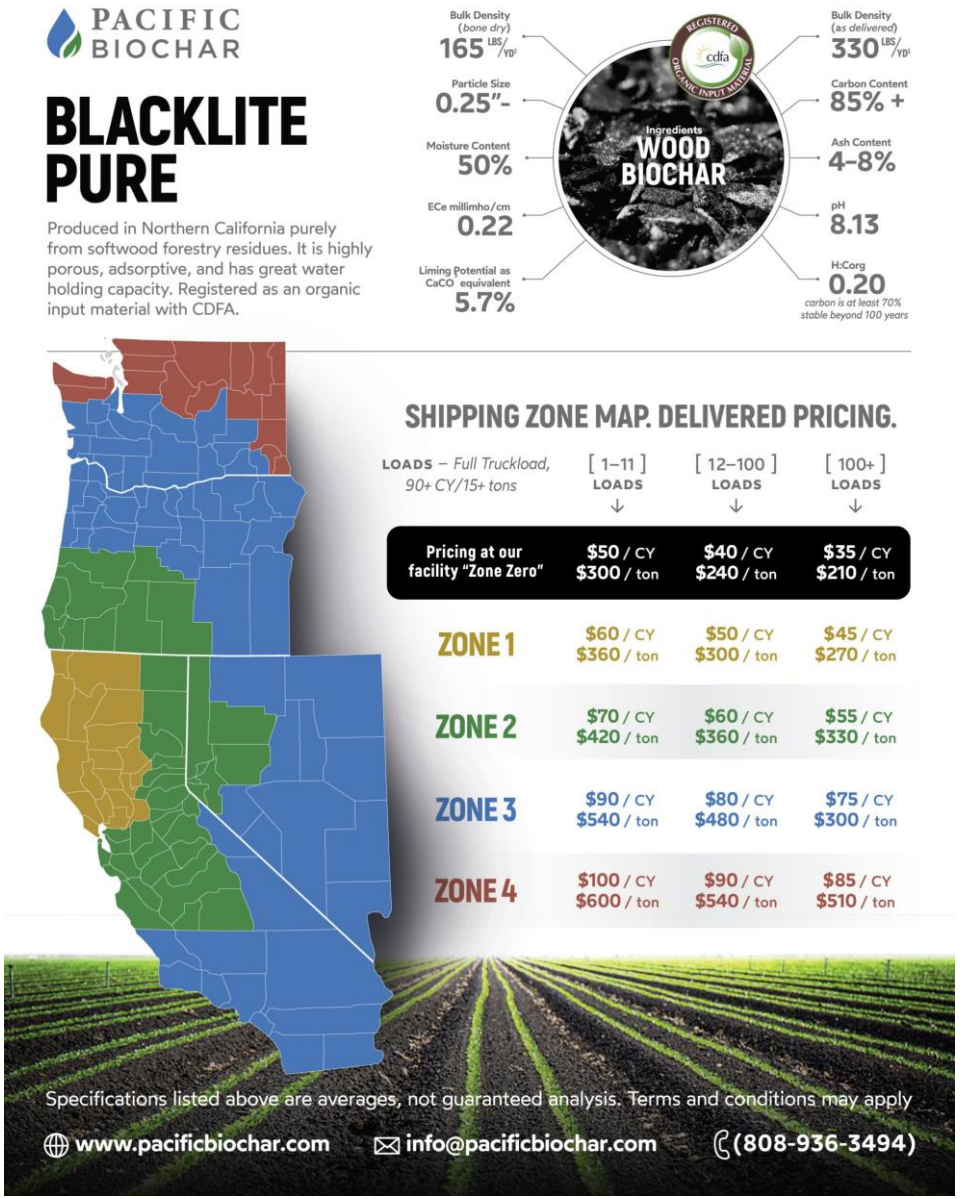


Potential Uses

- 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



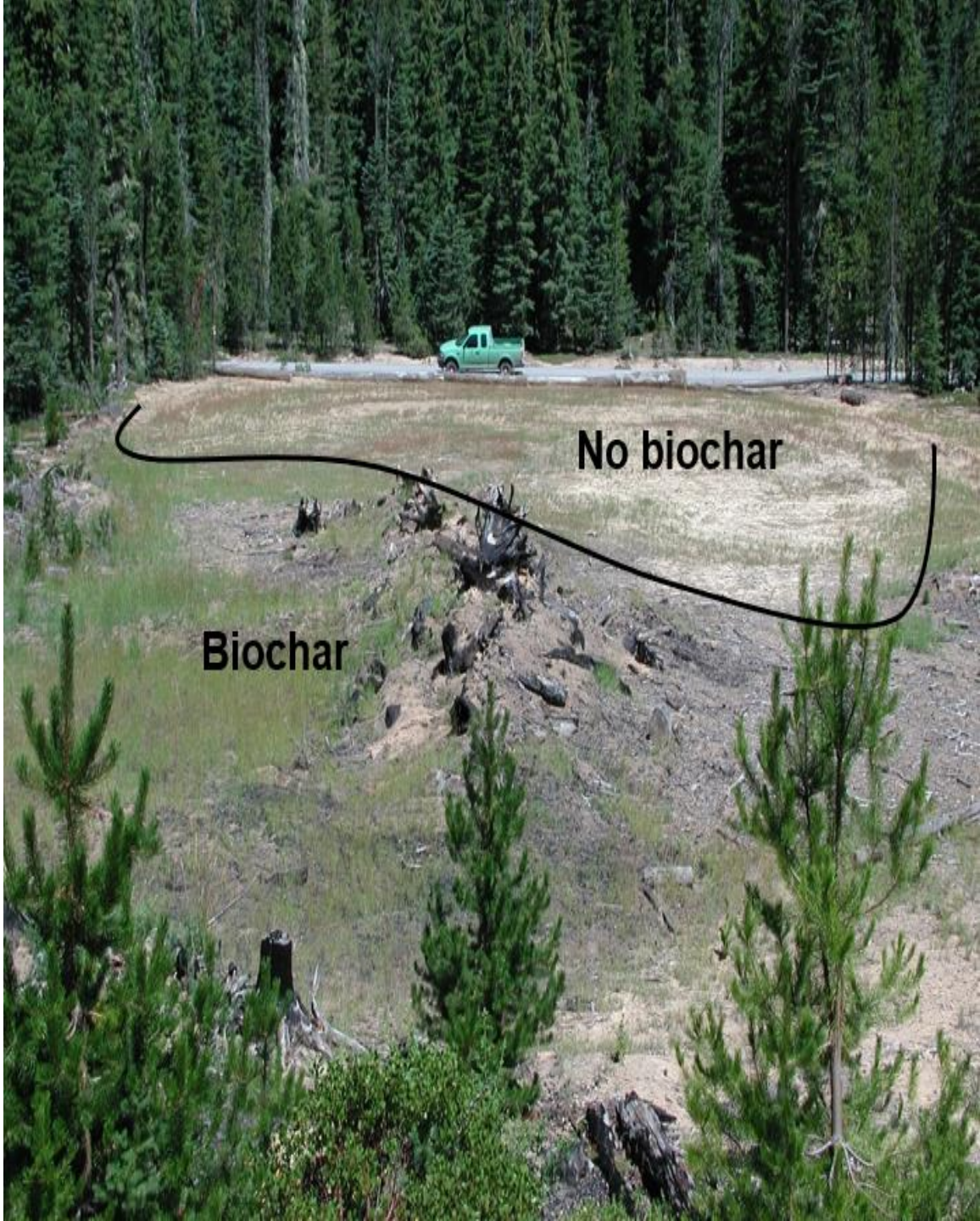
Agricultural applications

- 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

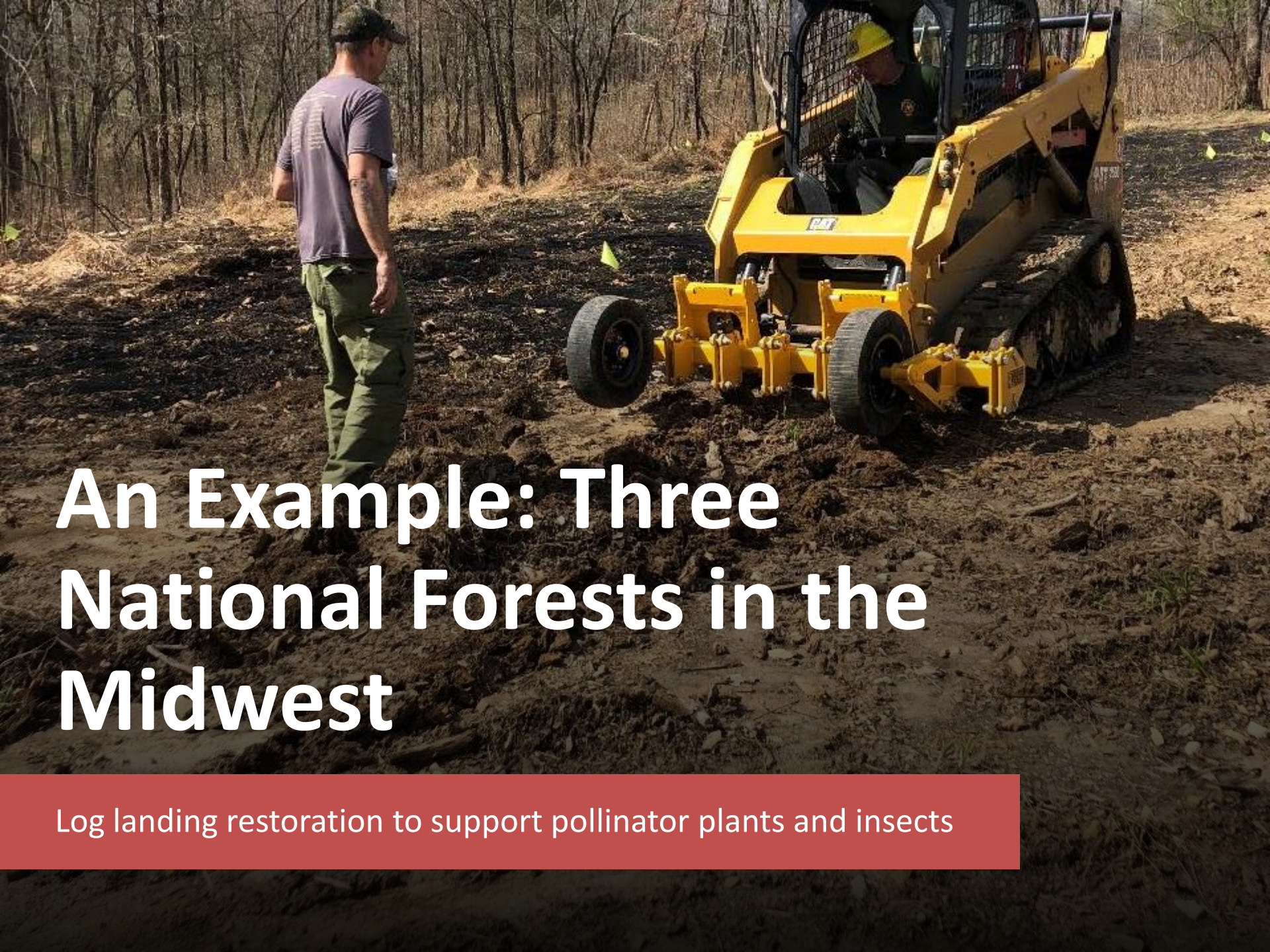
Umpqua NF, Oregon



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



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

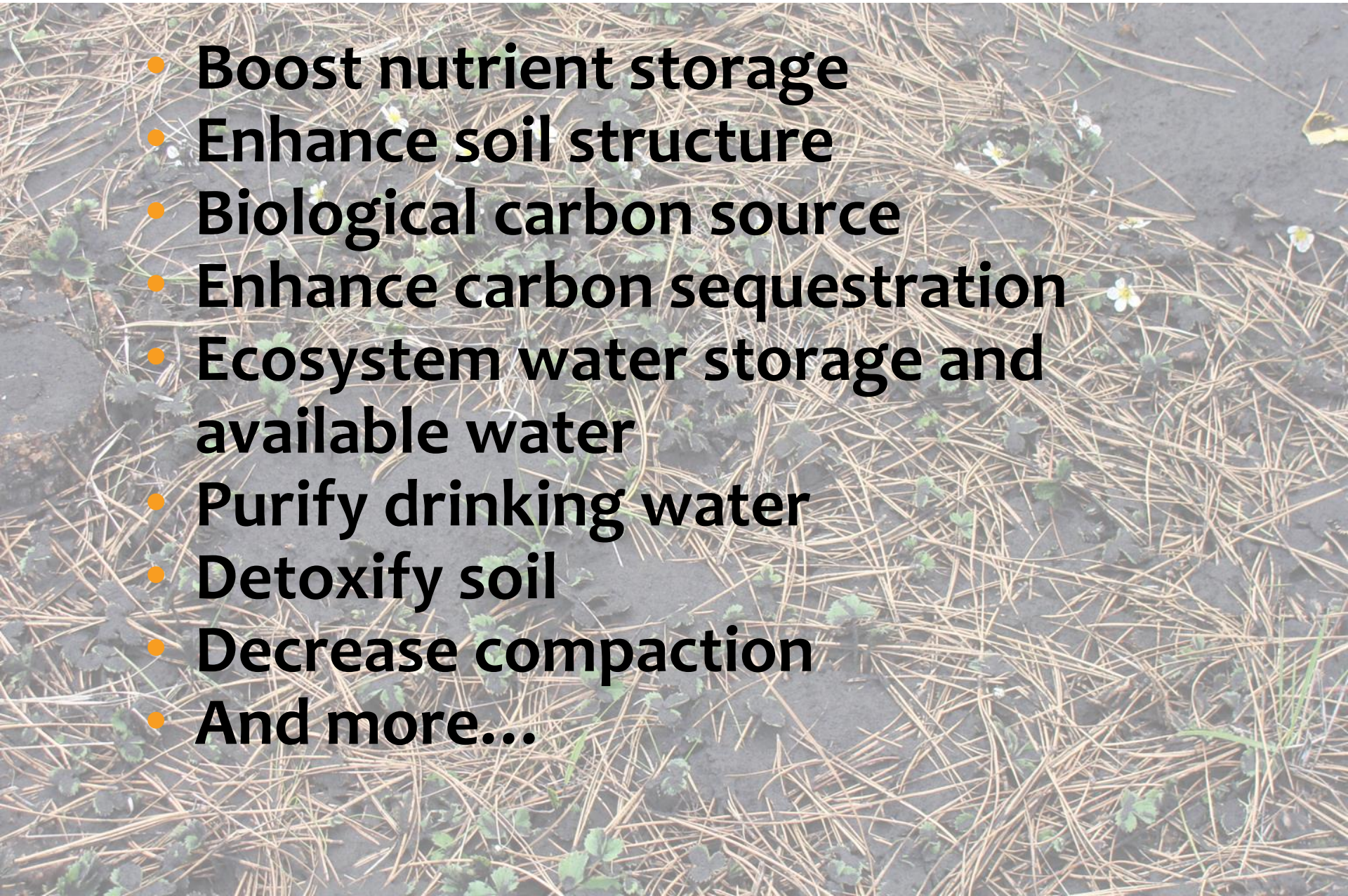
- An opportunity to create biochar from dead trees
- Tons of feedstock
- Used for agriculture, mine site restoration, viticulture, feedlots, compost….

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



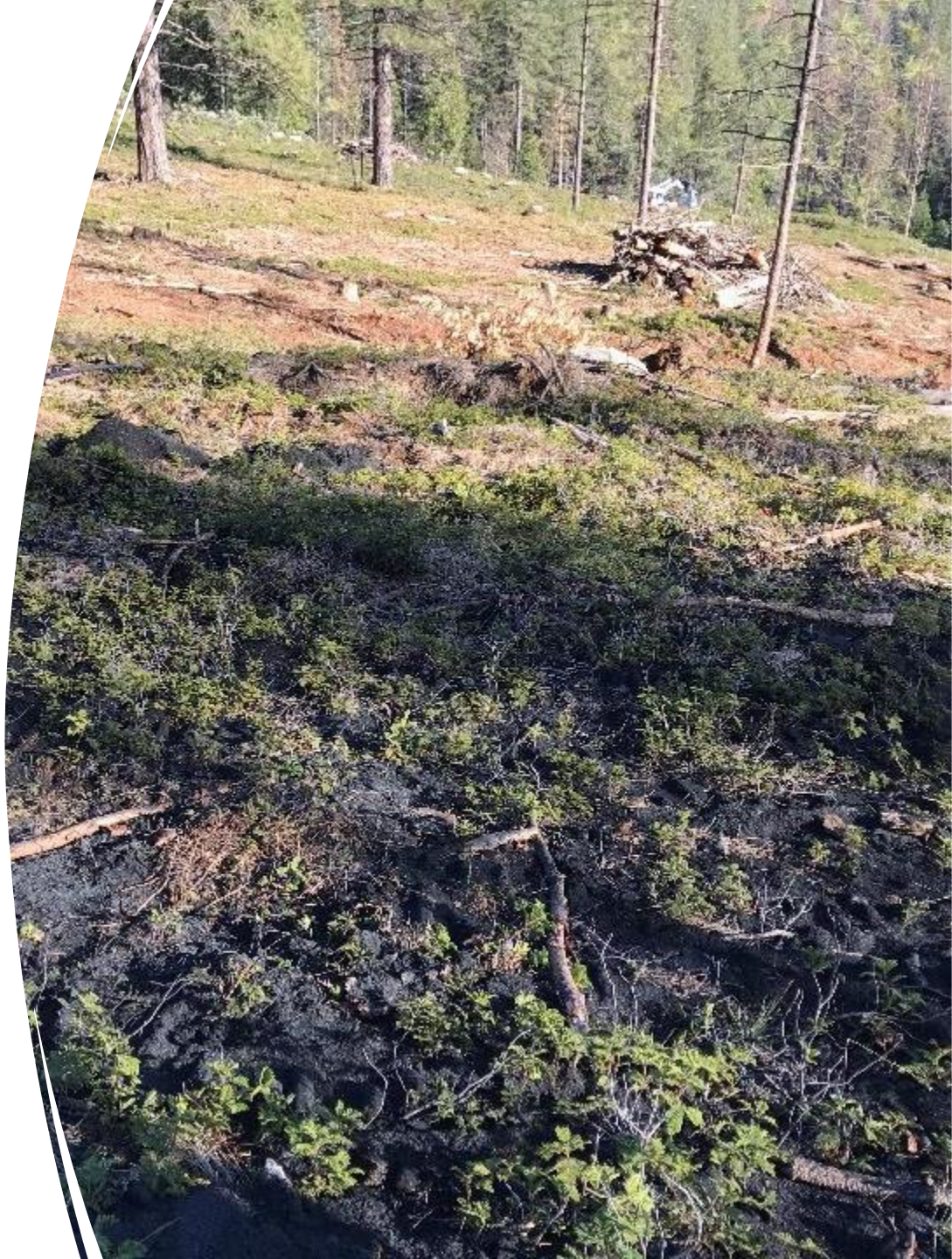
- Boost nutrient storage
- Enhance soil structure
- Biological carbon source
- Enhance carbon sequestration
- Ecosystem water storage and available water
- Purify drinking water
- Detoxify soil
- Decrease compaction
- And more…

Stanislaus National Forest Study Site

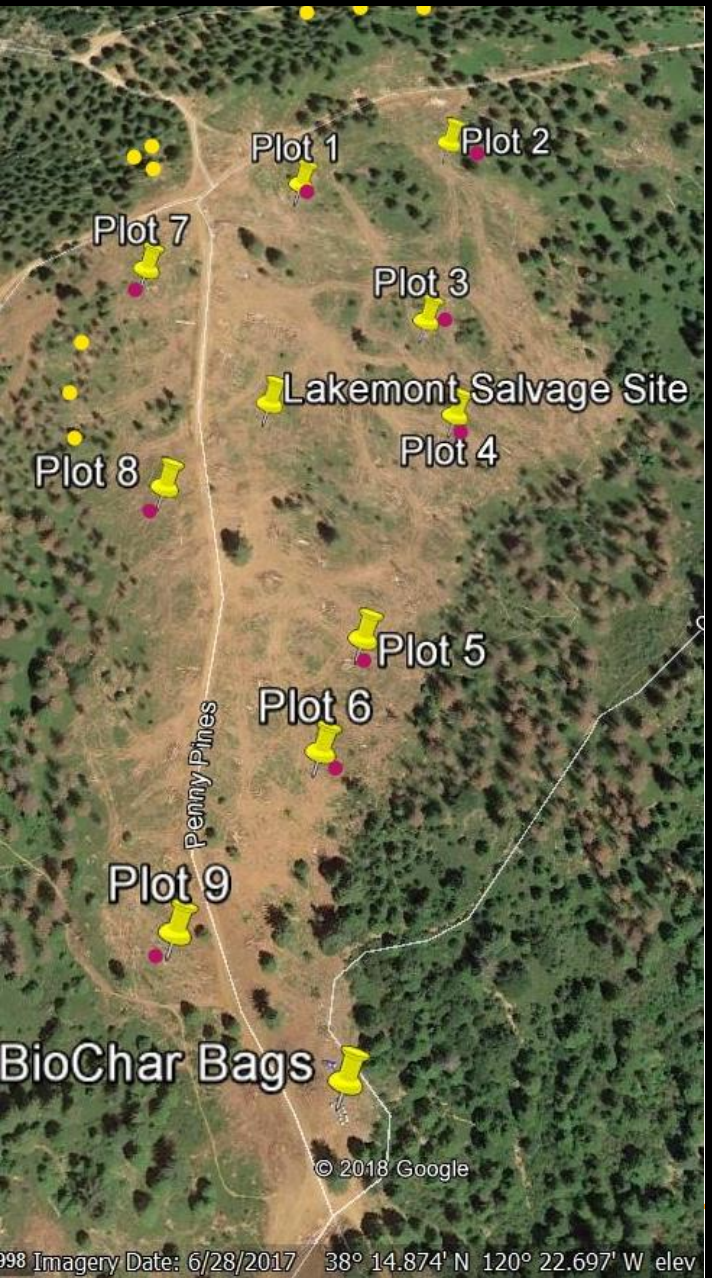
Salvage logging

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

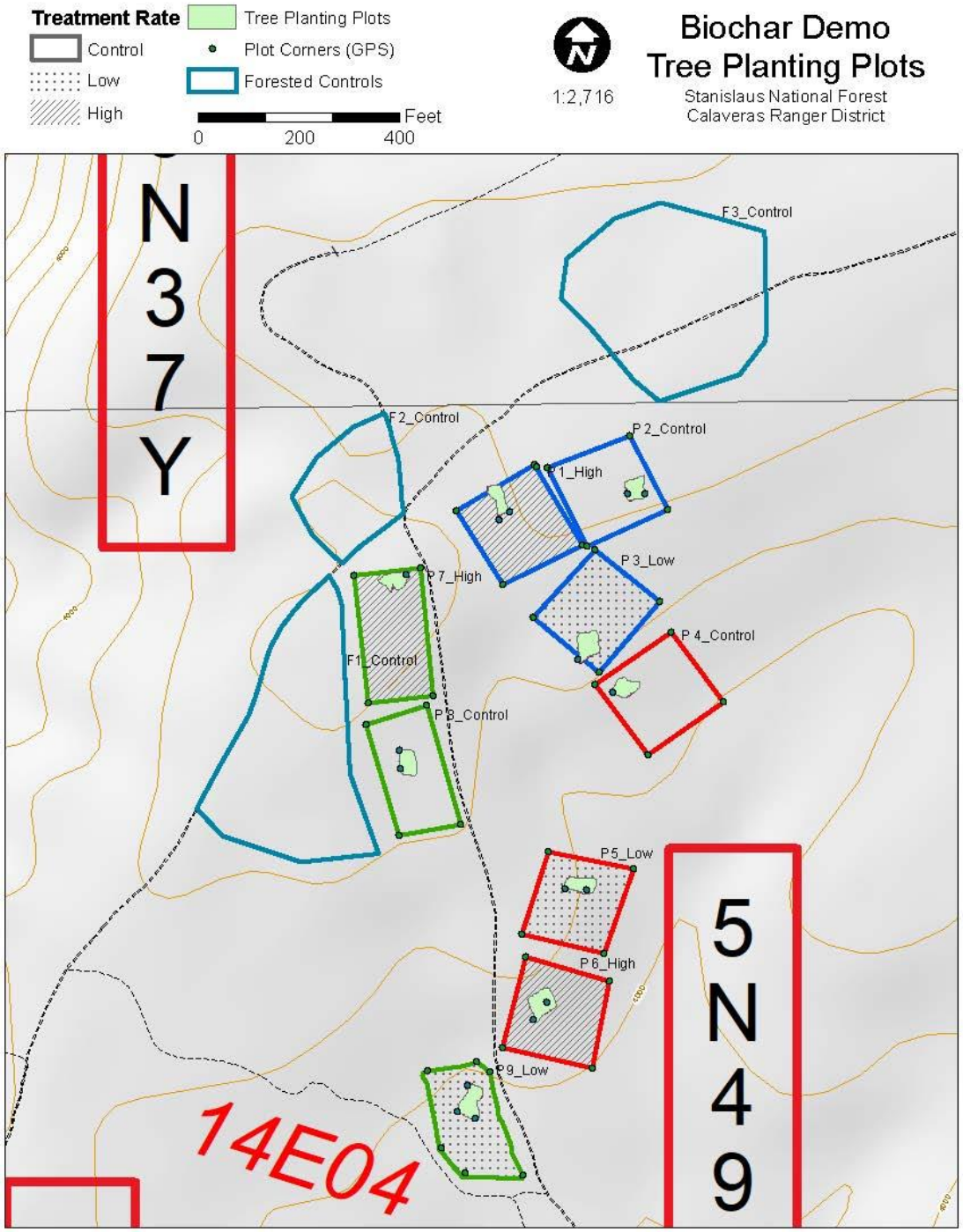


- 2016-2017 Beetle Kill
- Salvage Logged, biomass piles
- (some) Piles converted to biochar & applied to soil

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



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

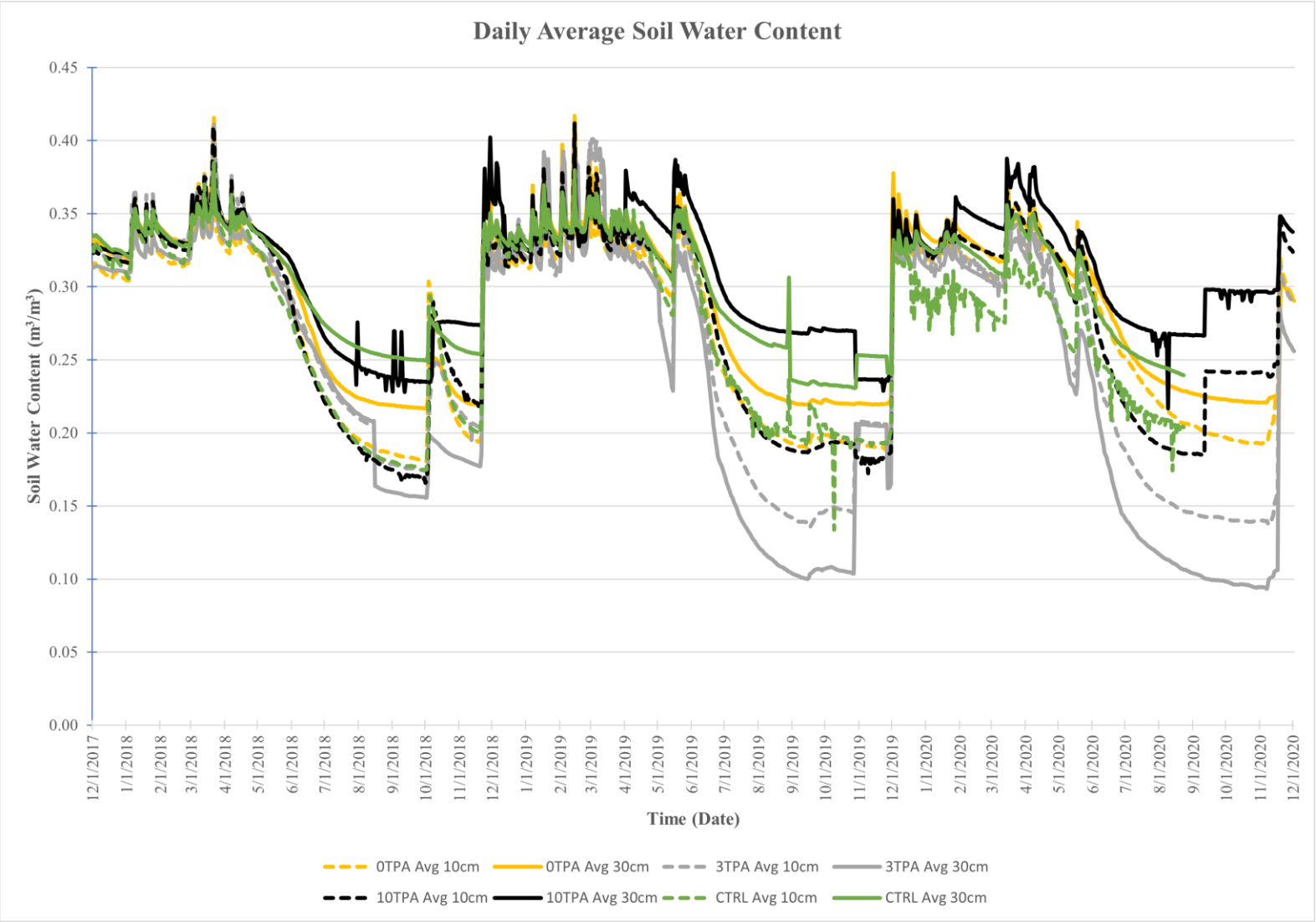
- Wood Stakes at Each Plot
  - Aspen & Pine
  - Buried Below Ground
  - At soil surface

- Sampling
  - Every Year Dig up 1 from each row
  - Weigh in field “wet”
  - Take to lab & oven dry
  - Compare “dry” weight to original mass.

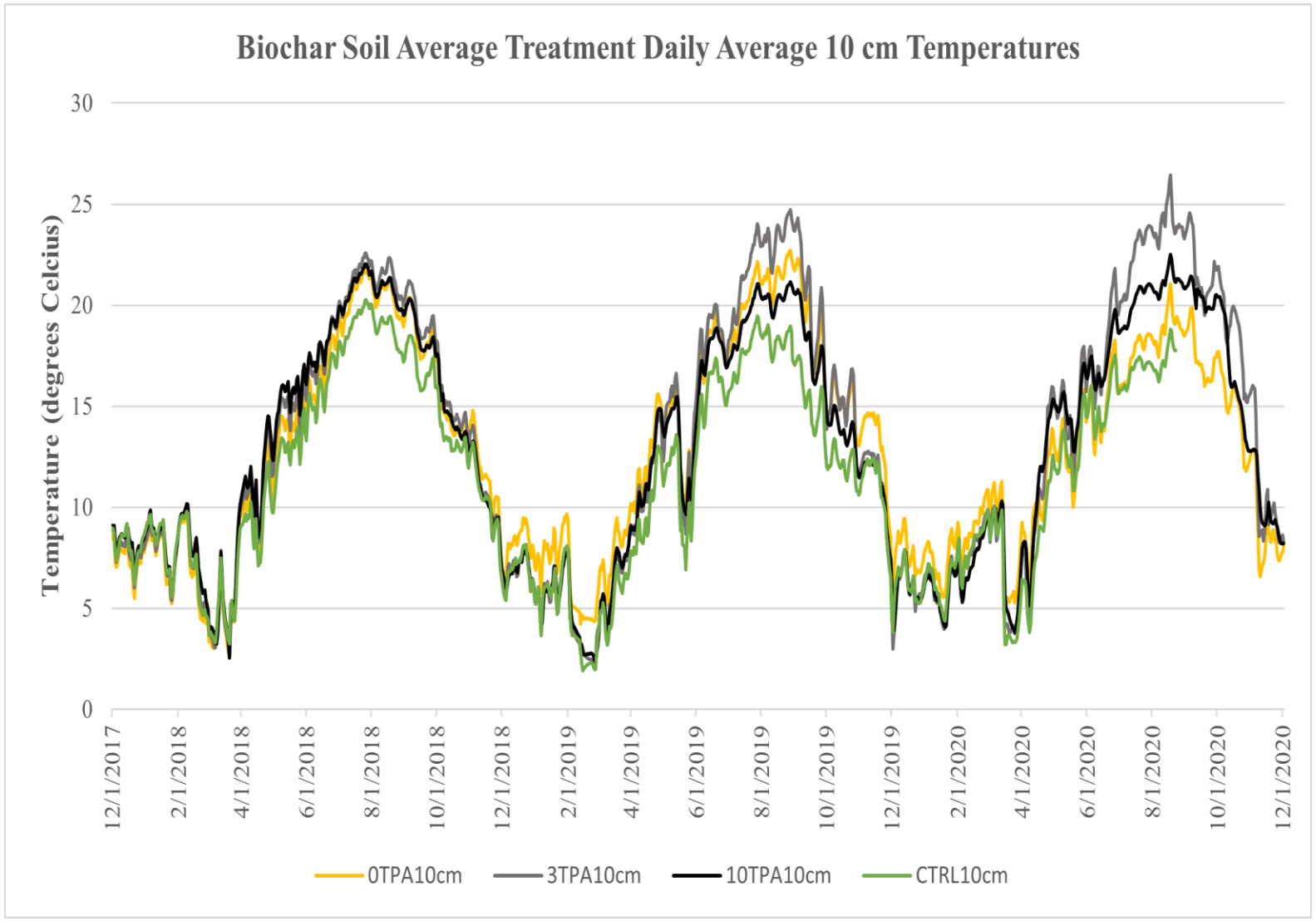
Soil Climate

- 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

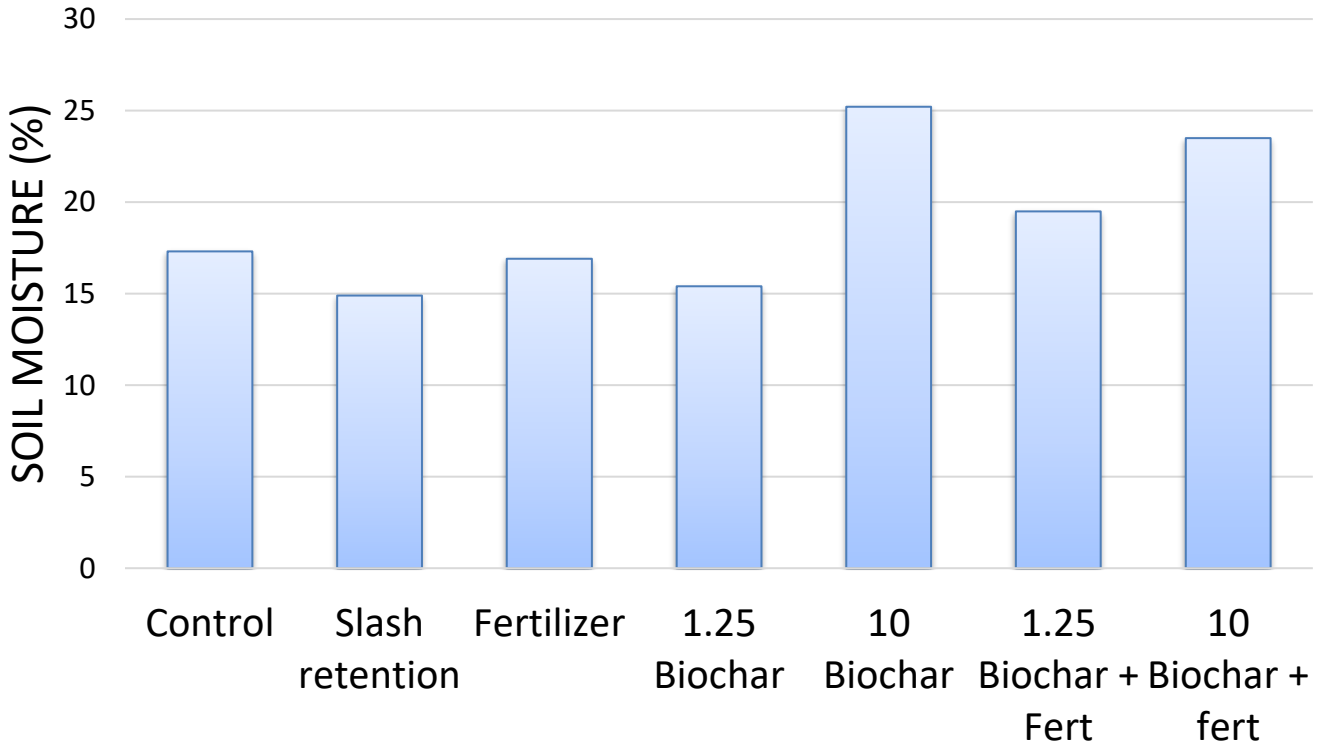
Soil Climate – Soil Moisture Content



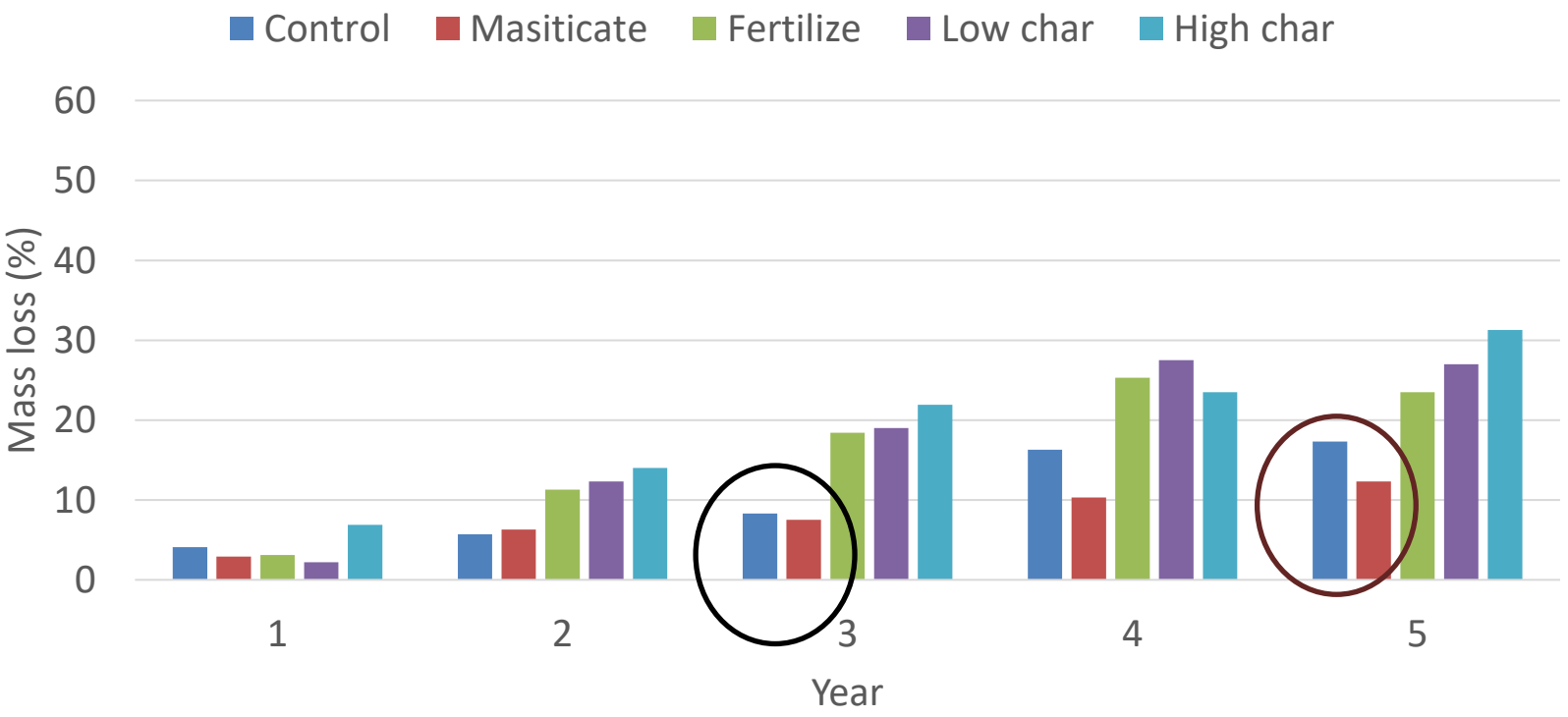
Soil Climate – Soil Temperature



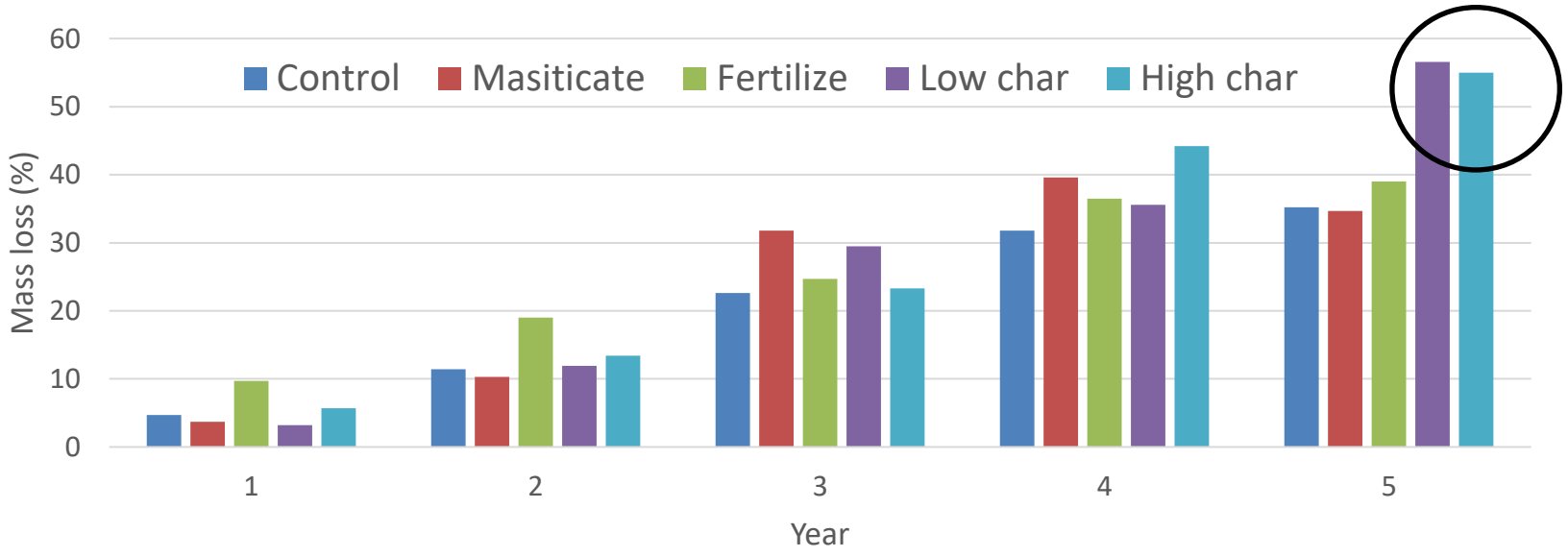
Change in soil water holding capacity – Bitterroot National Forest



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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USFS National Soils Program

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

Aurell et al. 2017. Atmospheric Environment 150: 395-406

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

1. Elevated pile

2. Quench fire when flames go out

3. Rake biochar around area

4. Grass green longer in biochar treated soil

- 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