



Opportunities to Improve Forest Soil Health (with biochar)

Debbie Page-Dumroese

USDA Forest Service, Rocky Mountain Research Station



Outline



- What is soil health?
 - Forest residues and biochar
- How to increase soil carbon/organic matter in forest soils
- Biochar & forest soil examples
- Benefits

Preview



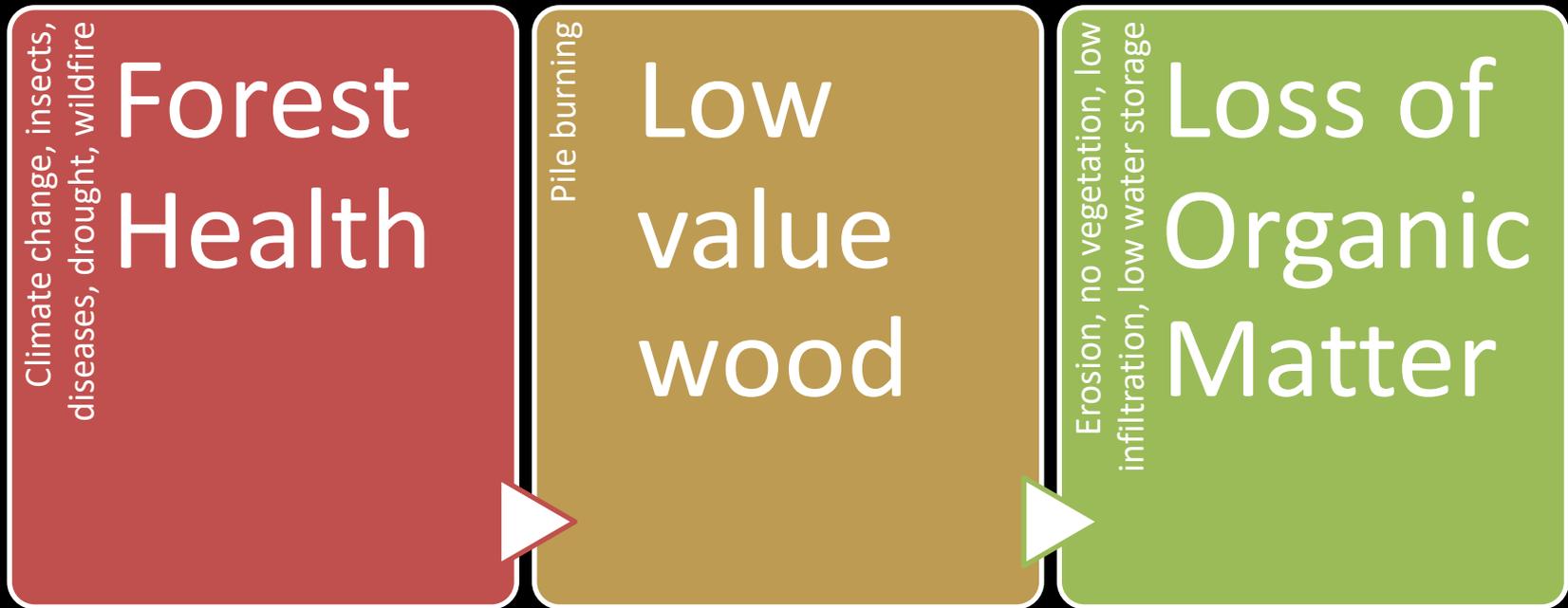
Highlights:



Biochar...ods Jan 2022



The triple threat to soil health



Threat 2: Low value wood (slash pile burning)



Low value wood in slash piles. Burned for disposal

- Legacy of burn scars
- Loss of OM
- Nutrient volatilization
- Few trees or shrubs
- Often non-native species

Threat 3: Loss of Organic Matter



- Invasive species
- Compaction
- Low infiltration
- Erosion

What is soil health?

- 42 attributes identified (e.g., carbon, pH, water holding, nitrogen, infiltration, fungi, etc.)
- Chemical, physical, and biological, and environmental flux properties

Soil organic matter content is key across all health measures



Forests and biochar



Forest soils

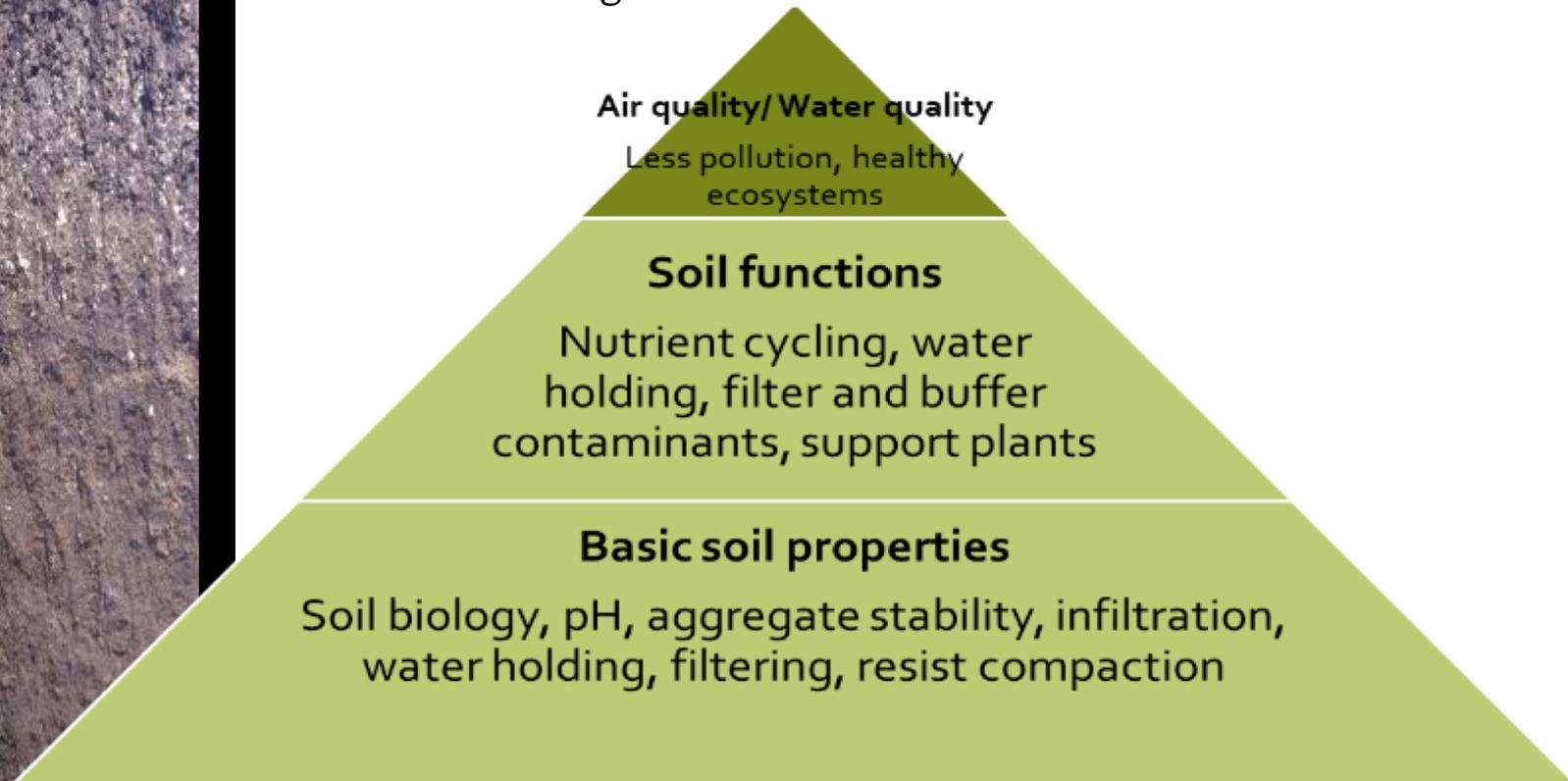
- Slower rate of change
- Climate smart forest operations
 - Harvest operations maintain or increase soil C and organic matter
- Healthy wildland soils:
 - Grow healthy forage
 - Raise healthy animals
 - Provide healthy forests and ranges
 - Resilient to climate change

What does it take to change soil health?



Add organic matter

- Composts
- Manure
- Cover crops
- Biochar, wood chips, biosolids
- Intact organic horizons



Forest residue retention

- Harvest residues reduce erosion
- Increase carbon and nutrients
- Large logs (>7 cm diameter) for biodiversity
- Burn smaller slash piles (create charcoal)



Forest harvest residues



- Too much biomass
- Often burned in slash piles
 - Smoke and particulate emissions
 - Soil impacts
- Difficult to handle
- Not uniform shape and size
- Low bulk density
- High transportation costs

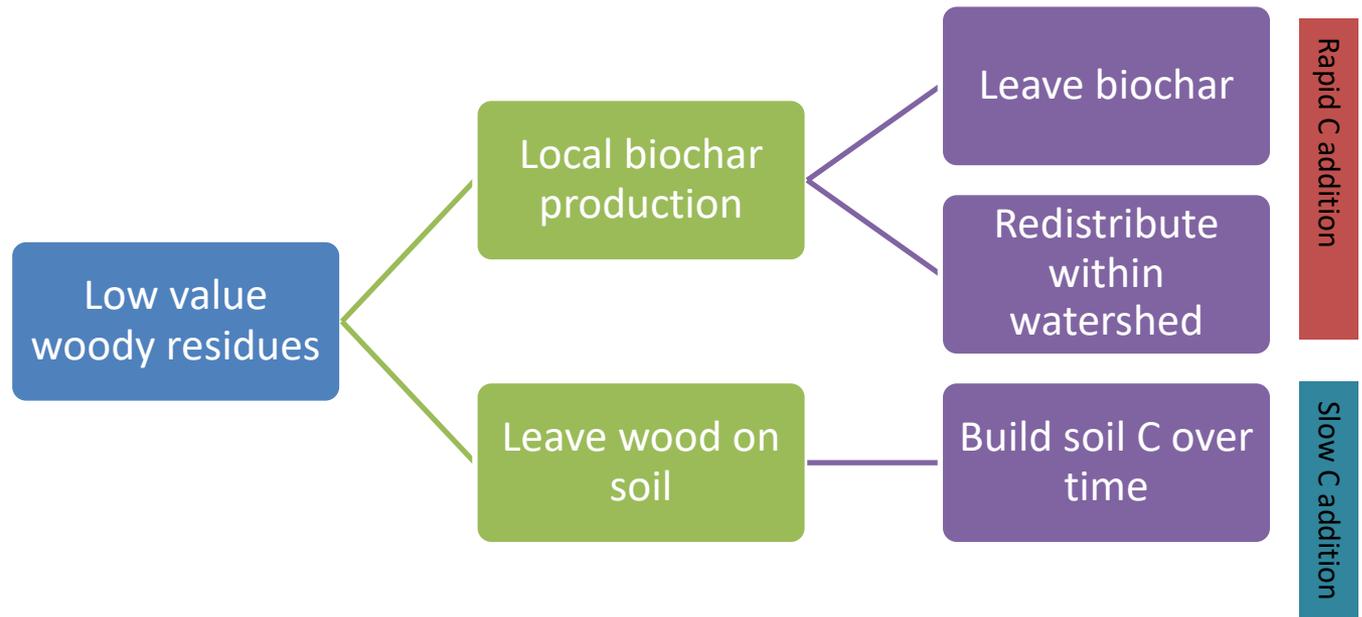


Organic matter or biochar? Two ways to soil health



Fuels management to reduce wildfire

- Thinning reduces stand biomass
- Residual trees grow faster



Healthy soils from 'waste wood' to biochar



- Made on-site
- High carbon
- Lasts for decades to centuries
- Improves degraded
 - Physical
 - Chemical
 - Biological

Biochar and soil physical properties



- Alters pore size distribution and total porosity
- Decreases bulk density
- Refugia for beneficial microbes
- Increase water holding capacity

Water (building a soil sponge)



- Decrease overland flow
- Increase infiltration

Biochar increased available water:

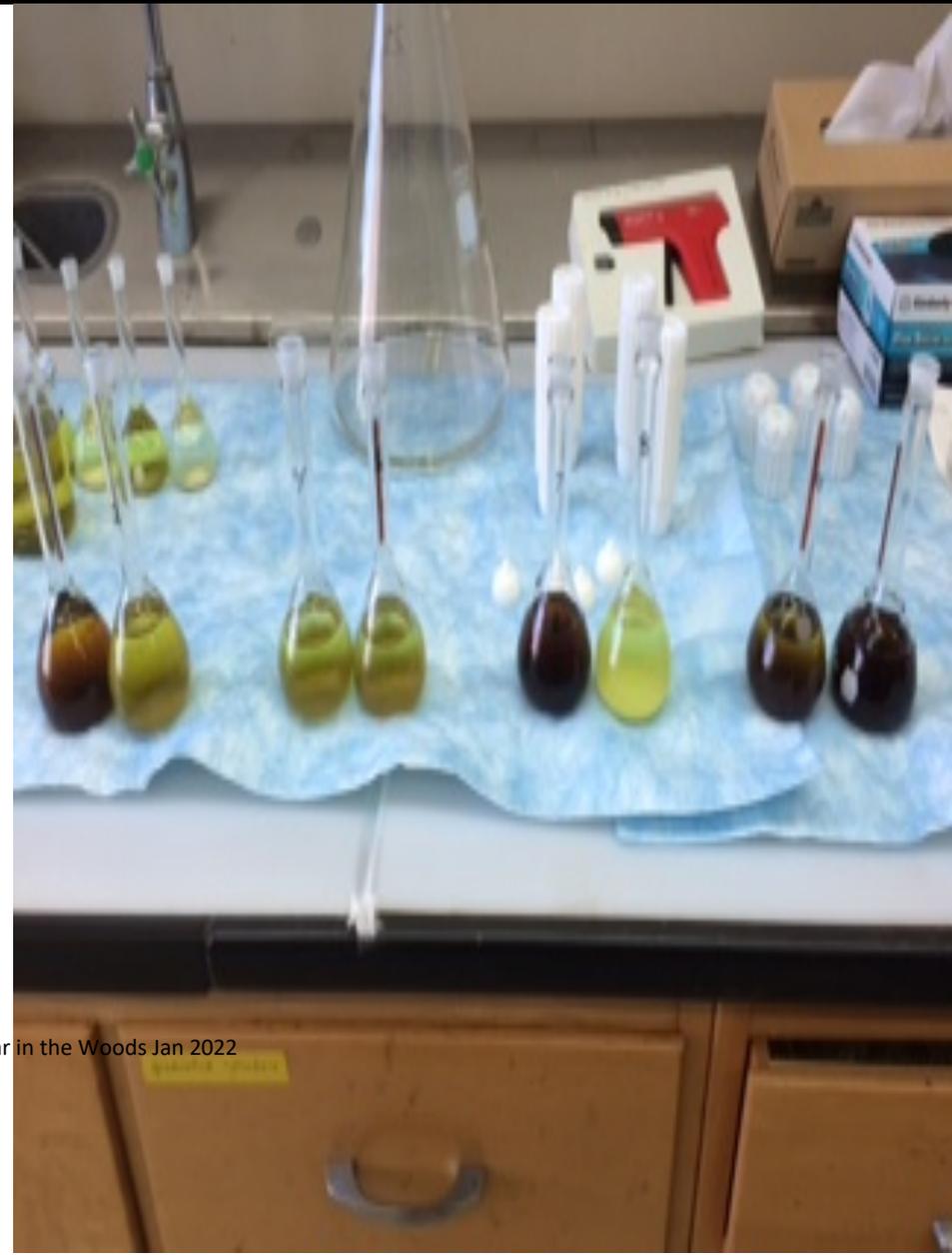
- 38%: coarse-textured soil
- 19%: medium-textured soil
- 16%: fine-textured soil



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

Biochar and soil chemical properties

- Increase capacity for retention of nutrients = reduced leaching
- Can increase total N, C, P, K, Mg, and Ca
- Increased retention should mean increased uptake by roots
- Increase soil pH; reduce liming costs



Biochar and soil biological properties

- Alter biological community structure and activity
- Reduce greenhouse gas emissions
- Soil respiration
- Increase soil N availability
- Increase nodulation of N-fixers
- Decomposition



Biochar in the Woods Jan 2022

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

Summary of Forest Soil Changes

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

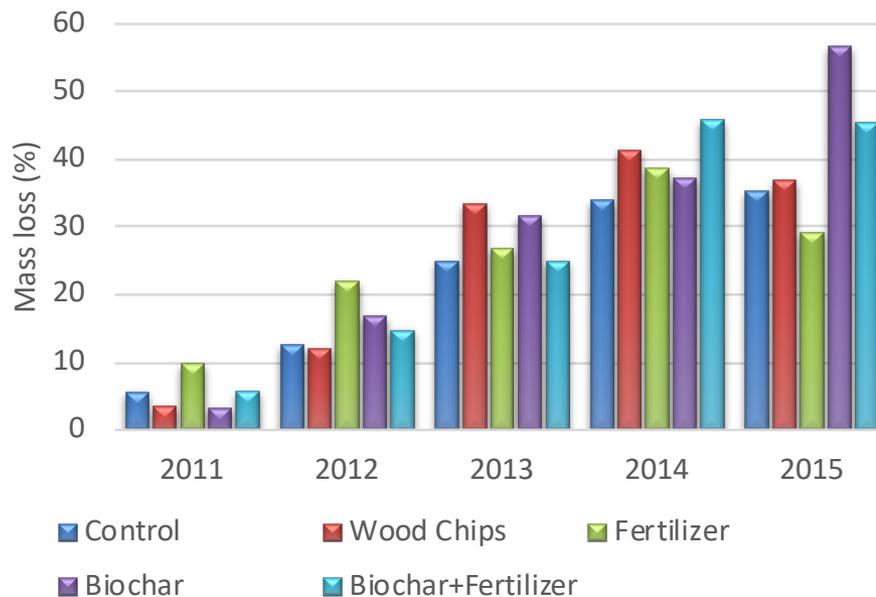
A photograph of a forest floor covered in pine needles and dark soil. Several blue plastic markers are placed on the ground, likely for forest management or research. The text is overlaid on the lower half of the image.

An example: Bitterroot National Forest

Forest thinning

Bitterroot National Forest: Long-term forest site biochar results

Aspen wood mass loss Mineral soil 0-30 cm



Wood chips: 50 tons/acre; Biochar: 10 tons/acre; Fertilizer: 200# N using NKSB formulation

Biochar in the Woods Jan 2022

- Soil moisture increases continue
- Understory stays green longer
- Tree growth is not impacted
- Forest soil responses can be slow
- More work:
 - Insects
 - Diseases
 - Tree health

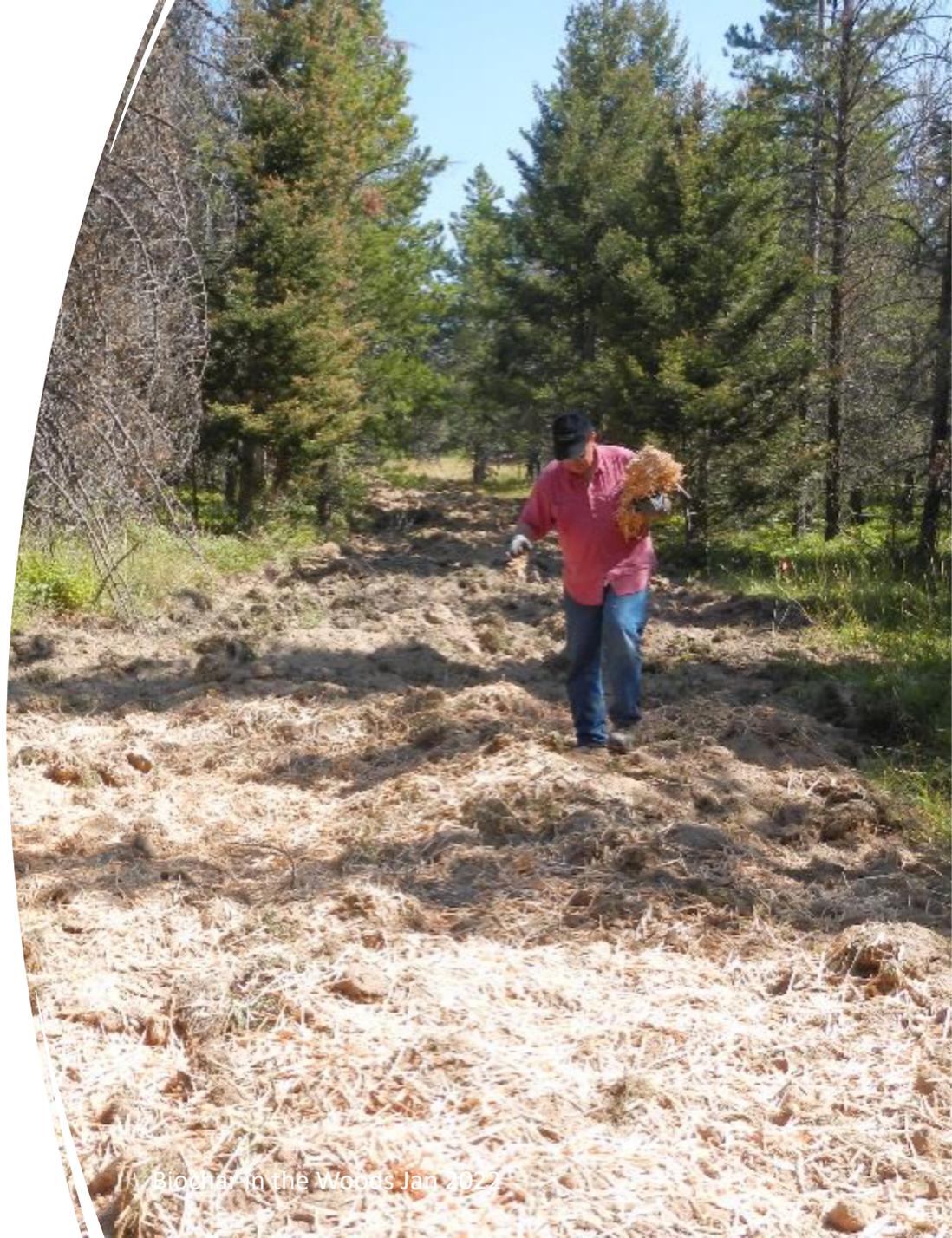
A photograph of a forest floor. The ground is covered with a mix of green grass, brown pine needles, and small plants. A path of dirt and grass runs through the center. The background shows more trees and foliage, with some shadows cast on the ground.

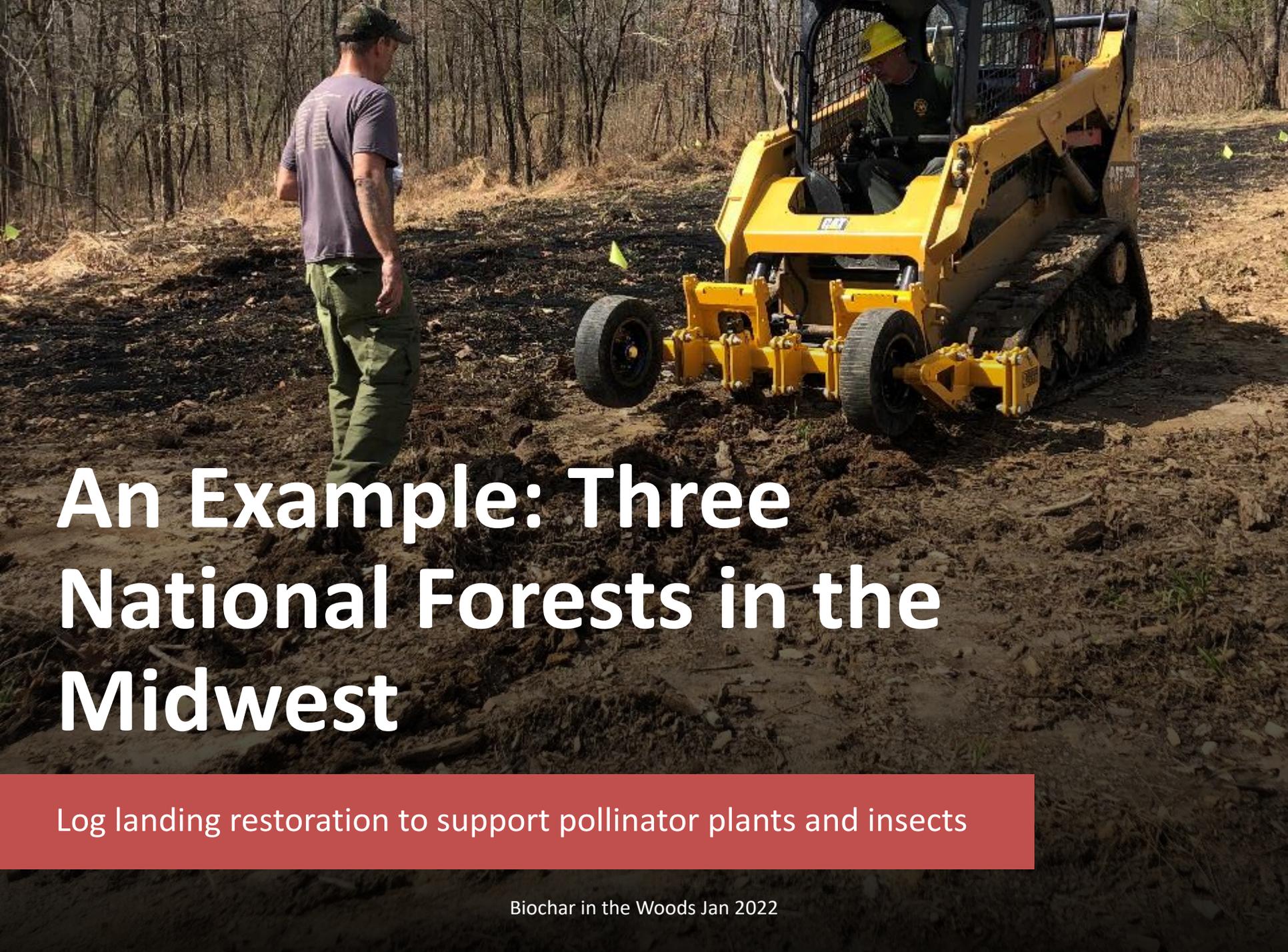
An example: Helena National Forest

Road obliteration

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





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



A photograph of a herd of elk grazing in a grassy clearing within a dense forest. The elk are scattered across the middle ground, some facing left and some right. The background is filled with tall, green coniferous trees. The foreground is slightly out of focus, showing more of the grassy area. The overall scene is peaceful and natural.

Example: Umpqua National Forest

Establishing vegetation to reduce erosion

Establishing vegetation

- Biochar alone or mixed with composts or biosolids
- Provide OM to establish vegetation
- Seeding local species is key





An example: Stanislaus National Forest

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





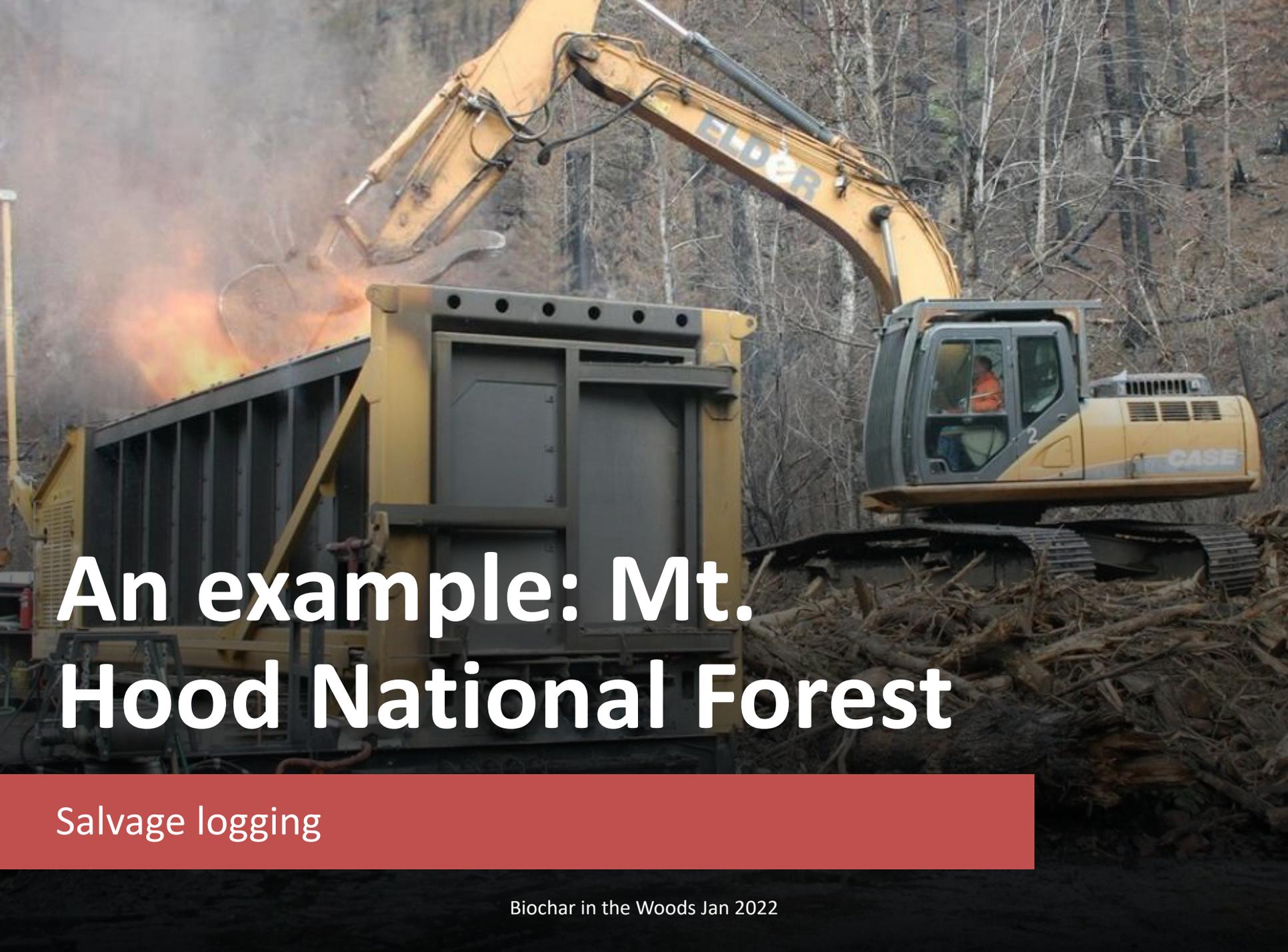
An example: Caribou-Targhee National Forest

Restoring vegetation



Caribou-Targhee National Forest: vegetation restoration

- New installation
- Goals:
 - Improve water quality to nearby spring
 - Improve vegetation cover
 - Seeded



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....

A person wearing a yellow hard hat, a blue long-sleeved shirt, and a safety vest is working in a forest. The trees are charred and black, indicating a wildfire. The person is holding a white bucket and appears to be collecting samples or working with the ground. The forest floor is covered in ash and charred debris. The background shows more charred trees and a glimpse of a blue sky.

Example: Beaverhead- Deerlodge National Forest

Restoring vegetation after wildfire

06/24/2021

Restoring vegetation after wildfire

- Goal: reduce soil erosion on severely burned areas
- Determine which native species perform best
- Determine if surface application or raking is best



Forest soil benefits



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

Biochar in a changing environment



USDA IS AN EQUAL OPPORTUNITY PROVIDER AND EMPLOYER.

Healthy
SOIL SECRETS

unlock the
SECRETS
IN THE
SOIL

HALF OF A HEALTHY SOIL'S COMPOSITION SHOULD BE PORE SPACE THAT
CONTAINS **AIR AND WATER.**

AN IDEAL SOIL COMPOSITION BY VOLUME SHOULD BE APPROXIMATELY
25 PERCENT WATER, **25** PERCENT AIR, **45** PERCENT MINERAL
AND **5** PERCENT ORGANIC MATTER.

WANT MORE?
SOIL SECRETS?

CHECK OUT
WWW.NRCS.USDA.GOV

- Forest soil responses are slow
- Increase water storage
- Carbon sequestration
- Increase ecosystem resilience

Thank you for your attention

Debbie Page-Dumroese
Debbie.Dumroese@usda.gov

