Tualatin Soil & Water Conservation District

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Conservation is for everyone.

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Under Our Feet

Exploring the soils of Washington County forests

by Dean Moberg
Tualatin Soil and Water Conservation District

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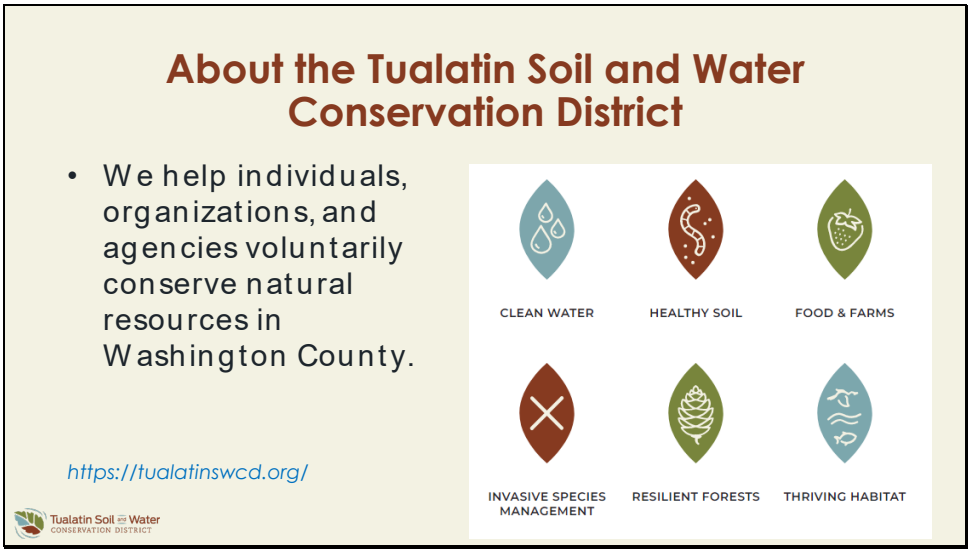
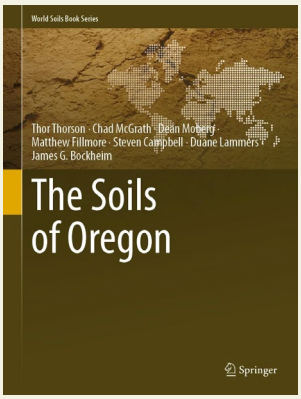


The Tualatin SWCD is not regulatory.
Priorities shown.

https://tualatinswcd.org/

About Dean

- USDA – 35 years (now volunteer)
- Tualatin Soil and Water Conservation District Director
- Co-author *The Soils of Oregon*
- Associate member SWA
- NOT a forester



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Overview

1. Soil classification
2. Web Soil Survey
3. Wash Co forest soils
4. Climate informed forestry
5. Forest soil health

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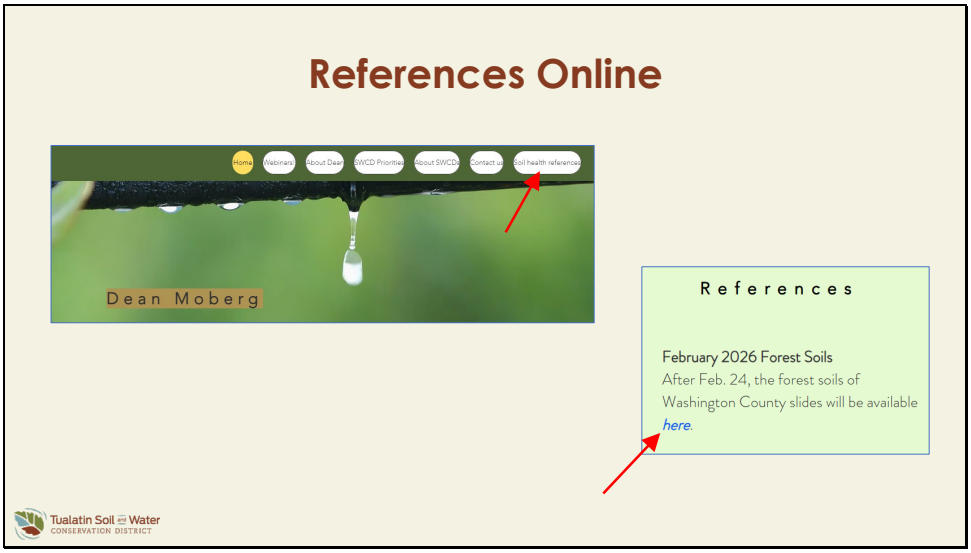
Photo is road cut west of Buxton, off Hwy 26 near the railroad trestle.



https://www.deanmoberg.com/

1. Soil classification

Van Gogh,
The Sower

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Order vs. series

- **Order**
  - Insects: lepidoptera
  - Soils: ultisols

- **Species and series**
  - Insects: monarch butterfly
  - Soils: Jory

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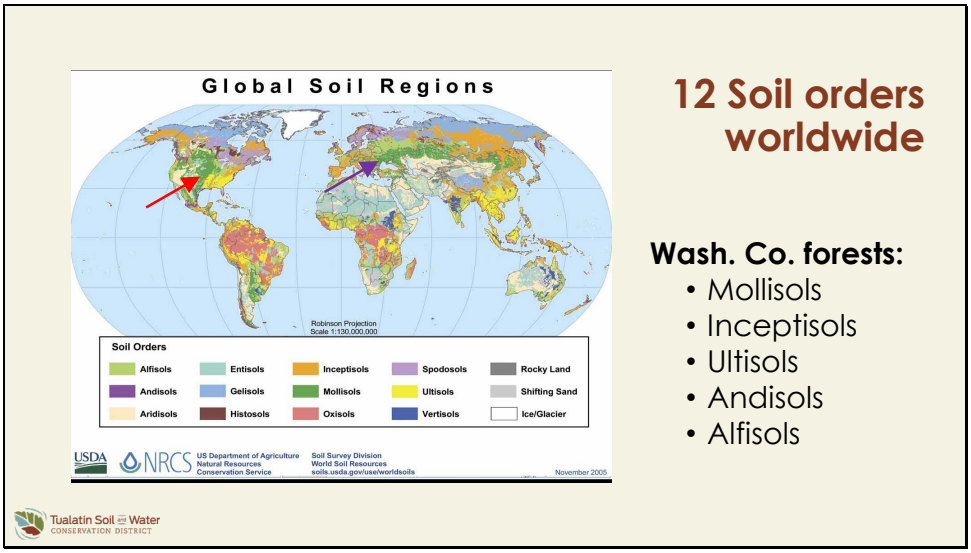
Monarch photo courtesy of US Fish and Wildlife Service.
Jory photo is from The Soils of Oregon, Thorson et al. (2022).



There are 12 soil orders around the world, 10 of which occur in Oregon: Gellisols (arctic) and oxisols (tropical) do not occur here.

Some Wash Co soils are mollisols. Soil scientist James Cassidy at Oregon State University has compared the abundance of mollisols in the US and Russia to their capacity as super powers. Note the dark green mollisols in the US "bread basket" and in Ukraine (just above the Black Sea).

Only six soil orders occur in Washington County, and of these only 5 are important for forestry:

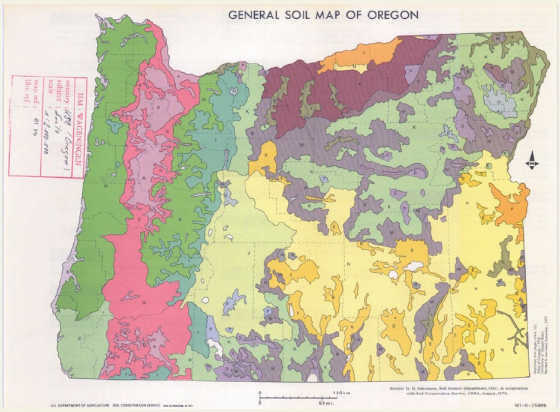
- Mollisols: "moll" is Latin for soft. Typically dark, fertile topsoil.
- Inceptisols: "inceptum" is Latin for "beginning." Less developed soil horizons.
- Ultisols: "ultimus" is Latin for "last" (old). Lower fertility, usually oxidized red color.
- Andisols: "andic" is a term that refers to volcanoes (like the Andes Mountains). Soil weathered from volcanic material.
- Alfisols: "alf" stands for alien life form, like the Muppet related puppet. But, joking aside, "alf" is not derived from any language. Somewhat like mollisols but topsoil is not so dark and is generally less fertile.

References:

https://www.uidaho.edu/cals/soil-orders

Factors of soil formation

- Climate
- Relief
- Parent Material
- Time
- Organisms



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If two sites have the exact same ClORPT, they will have the exact same soil.

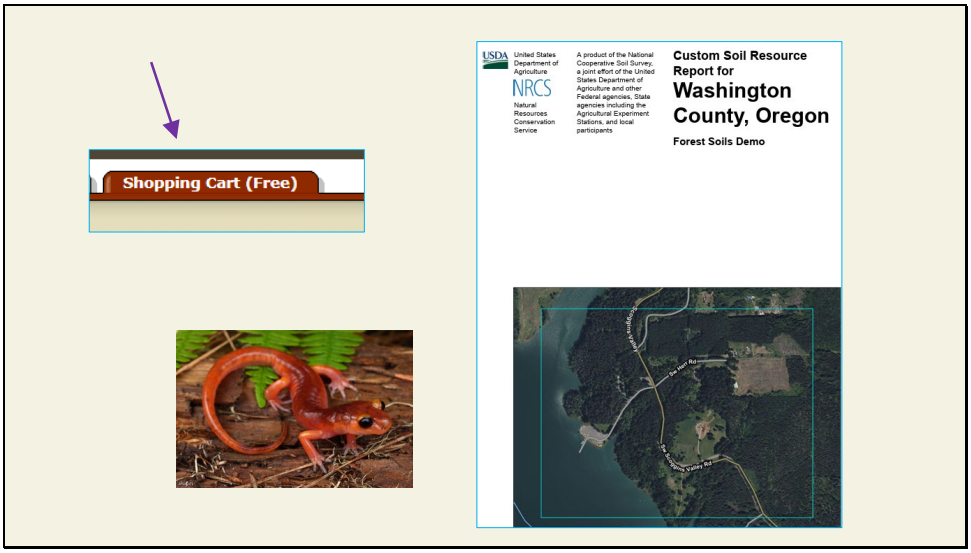
Quick examples:
Climate: coast (green) is wet and mild, different from SE OR (yellow), which is hot and dry.
Relief: east side of Cascades is different soil than west side
Parent material: lower elev Will Valley (light pink) formed in flood deposits; higher elev (dark pink) was not flooded

Time: Cascade soils have been forming for a long time after volcanoes erupted, sandy soils around Hermiston (orange) are much younger
Organisms: Climate determines organisms to a great extent, except for humans.

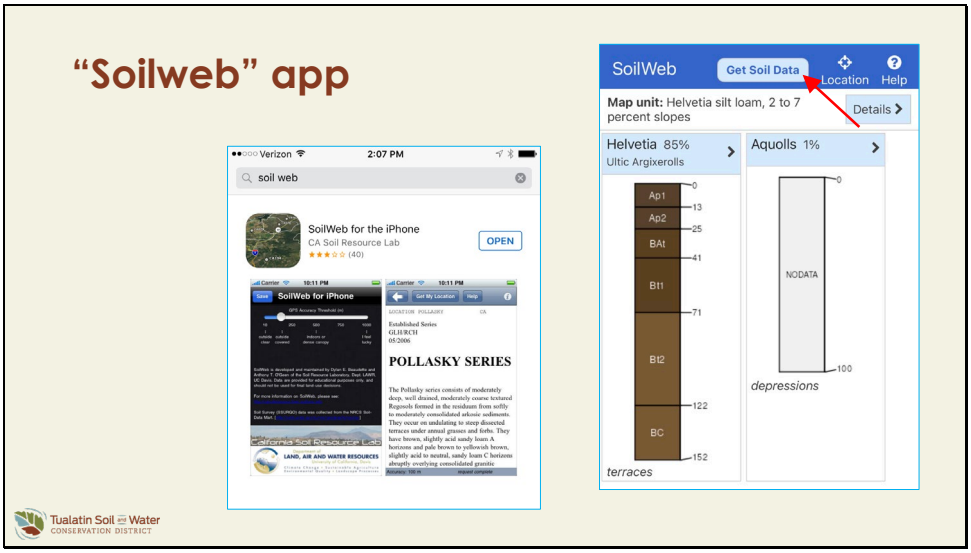
Soil map is from Oregon State University and The Soils of Oregon, Thorson et al. (2022).

Soil surveys were typically done county by county..
Then click the green button to start.

Reference:
https://websoilsurvey.nrcs.usda.gov/app/HomePage.htm?TARGET_APP=Web_Soil_Survey_application_lw4voo5icb2aq0hin25tpwiw



After generating all of the maps and tables you want, click “Shopping Cart (Free)” to download your report.



Free download for your phone. Search "SoilWeb" in your phone's app store.

Click "Get Soil Data" to see the soil on which you stand.

Reference:

University of California, Davis: https://casoilresource.lawr.ucdavis.edu/gmap/

3. Washington Co. forest soils

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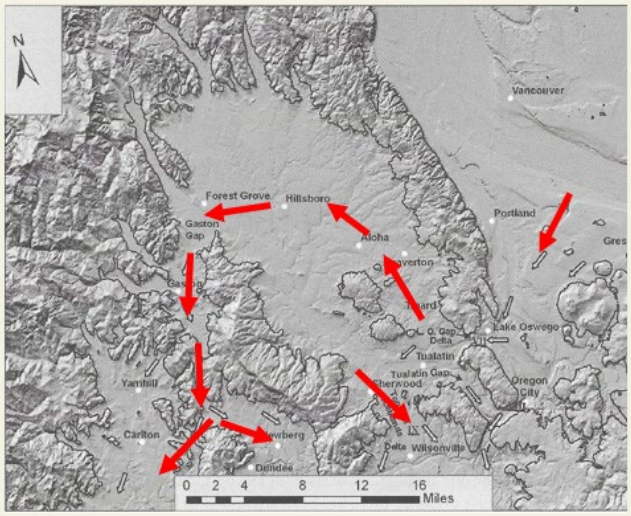
Photo credit: OFRI

Missoula floods



- 15,000-18,000 years ago
- Ice dam on Clark Fork River broke ~40 times
- Waves hundreds of feet high, 60 mph, 13x flow of Amazon River

Underlying geology is mainly old basalt flows.
But the most important geologic events pertaining to Washington County soils were the Missoula floods.

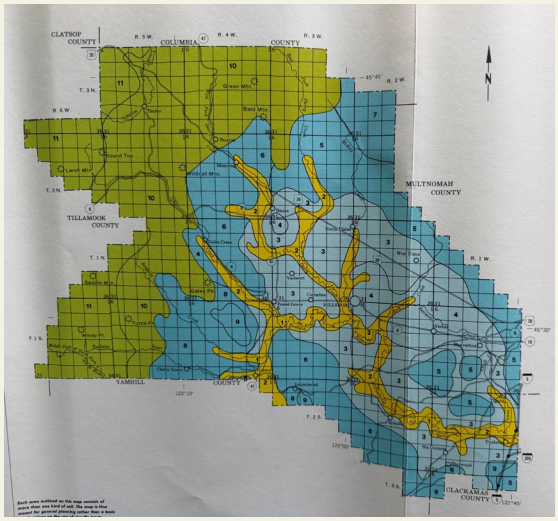
Read bullets.

-Water racing across what is now eastern Washington in a wave hundreds of feet high and travelling at estimates of 60 mph and a flow of up to 13 times the discharge of the Amazon River. There were multiple floods – maybe around 40 in total over thousands of years.
-The soupy flood was a mix of soils, rock, and ice that got deposited on the land.
-The flat gray area in this image is the highest extent of the floods, and the soils change drastically from those developed in flood sediments such as Woodburn silt loam, a mollisol with dark brown topsoil, vs the older soils higher up such as Jory silty clay loam, an ultisol with reddish topsoil.
- Much of the most productive forest soils in Washington County occur above the area that was flooded.

Reference:
Allen, J., Burns, M., and Burns, S. (2009). Cataclysms on the Columbia. Ooligan Press. Portland State University.

Soil associations

- Similar soil series lumped for simplified view of a large area.
- Xeric (Mediterranean)
- Udic (soils stay more moist into summer)



From lowest to highest:

-Yellow: floodplains – parent material = Missoula flood sediments modified by stream erosion and deposition
-Light blue: level to moderate terraces – parent material = Missoula floods and then developed pretty much in place
-Dark blue: steeper uplands – parent material is variable: some Missoula flood sediments, some basalt (colluvium, residuum), some loess
-Green: sloping to very steep mountainous areas of coast range – parent material is variable: basalt or sedimentary rock containing volcanic ash

Besides differences in parent material, these associations have different climates.
-Yellow and blue are xeric: Soil moisture regime common to mediterranean climates with cool moist winters and warm dry summers. Rainfall can be fairly high, but it doesn't happen at optimum periods for plant growth.
-Green area is udic: Rainfall is commonly well distributed throughout the year with stored moisture plus rainfall that is equal to, or exceeds, the amount of evapotranspiration.

For forestry purposes, we will focus mostly on the dark blue and the green, but I will include one soil from the light blue.

Note that definitions for many soil terms (e.g. xeric) can be found at:
https://www.soils.org/publications/soils-glossary?q=publications/soils-glossary/#

Xeric forest soils

Wash. Co.

Soil	Surface Texture	Site Class	Site Index	Median Elev. (ft)
Woodburn	silt loam	1	142	200
Melbourne	silty clay loam	2	122	550
Jory	silty clay loam	2	122	725
Saum	silt loam	3	110	725
Cascade	silt loam	2	117	825
Laurelwood	silt loam	3	112	850

Xeric soils occur at lower elevations (typically below 1000 feet in Wash. Co.):
Soils that commonly have:
- a soil moisture regime common to mediterranean climates that have cool moist winters and warm dry summers.
- a limited amount of water is present but does not occur at optimum periods for plant growth.

Site index is the average height in feet that dominant and codominant trees of Douglas-fir attain in 50 years.
The site index applies to fully stocked, even-aged, unmanaged stands.
The Wash. Co. soil survey site indices are based on research done by King in 1966:
Site classes were derived from site indices using an OSU publication (Woodard, 1997).

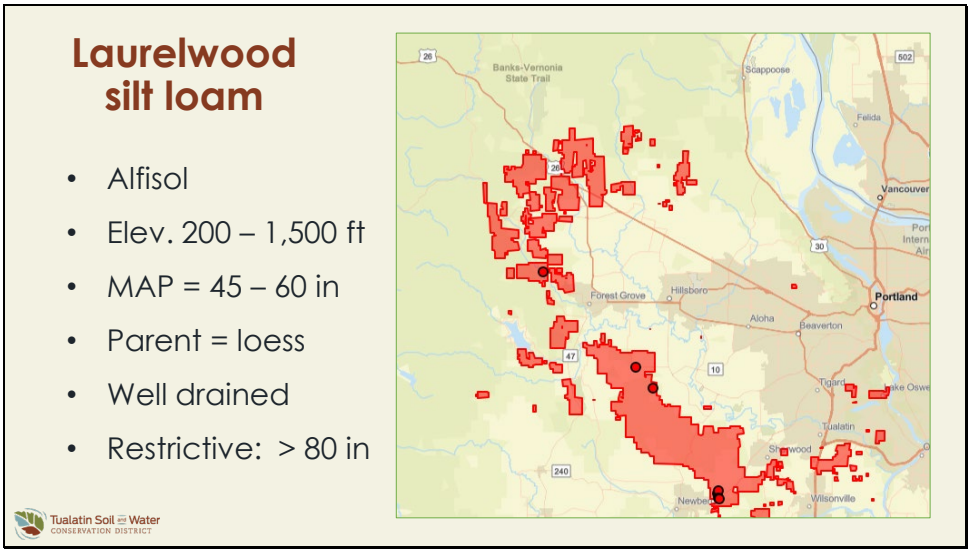
References:

https://directives.nrcs.usda.gov//sites/default/files2/1719427825/National%20Forestry%20Handbook.pdf

https://ir.library.oregonstate.edu/downloads/4q77fr444

King, J.E. (1966). Site index curves for Douglas-fir in the Pacific Northwest (Weyerhauser Forest Paper No. 8). Weyerhauser Forest Research Center.

Soil Science Society of America, Glossary of Soil Science Terms
https://www.soils.org/publications/soils-glossary?q=publications%2Fsoils-glossary%2F

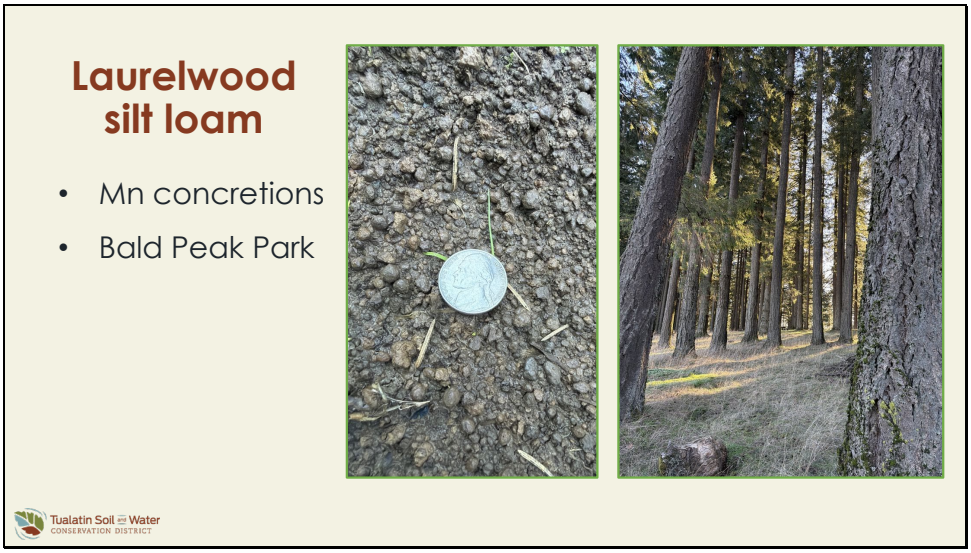


Laurelwood soil is located mainly in Washington and Yamhill Counties.
Alfisols are typically of a medium age and often develop in forested conditions.

Elev. = elevation
MAP = mean annual precipitation
MAAT = mean annual air temperature (degrees F)
Parent = parent material from which soil formed
Restrictive = the typical depth at which a soil layer significantly restricts root growth and the downward movement of water. Examples are fragipans (natural layers very low in organic matter and hard consistency) and bedrock. 80 inches is generally the limit of soil survey information. So, > 80 inches means no restrictive layer in the main root zone of trees.

References:
- Web Soil Survey: https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

Map generated from:
- Soil Series Extent Explorer: https://casoilresource.lawr.ucdavis.edu/see/#



It has 1 to 15 percent Fe/Mn 1-10mm rounded to well rounded concretions. Laurelwood soils form in silty loess overlying weathered Columbia River Basalt, which is naturally rich in manganese-bearing minerals like pyroxene and amphibole. As these minerals weather, manganese is released and becomes mobile under fluctuating moisture conditions.
During **wet periods**, manganese is reduced to soluble Mn^{2+} and moves downward with percolating water. When **conditions become oxidizing**, Mn^{2+} is oxidized by **microorganisms** (e.g., *Bacillus* and *Pseudomonas* species) or chemically precipitated as insoluble Mn^{4+} oxides (e.g., birnessite), forming the **distinct black manganese films** observed on ped faces and within pores in the Bt and BCt horizons. These coatings are especially prominent in zones with repeated wet-dry cycles, confirming microbial and redox-mediated pedogenesis as key drivers.
The presence of **dense, clay-rich subsoil layers** in Laurelwood soils restricts drainage, enhancing seasonal saturation and redox fluctuations that promote this manganese translocation and precipitation process.

Laurelwood silt loam

Y axis =
depth in cm

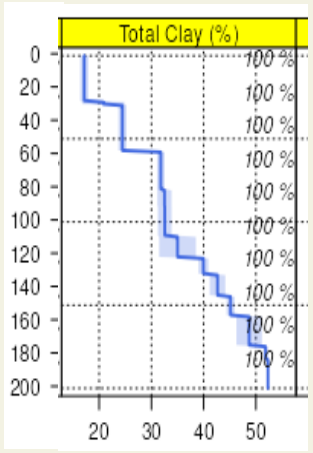


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Chart copied from:
- Soil Series Extent Explorer: https://casoilresource.lawr.ucdavis.edu/see/#

Jory silty clay loam

- Ultisol
- Elev. 250 – 1,200 ft
- MAP = 40 – 60 in
- Parent = clayey colluvium from igneous rock
- Well drained
- Restrictive: > 80 in

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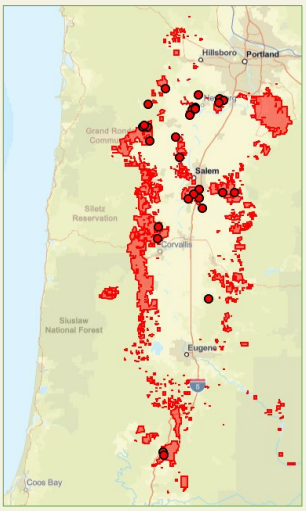

Note that Jory occurs in foothills on the west side of the Cascades and the east side of the Coast Range throughout Oregon.

Jory is an ultisol (older soil).

References:

- Web Soil Survey: https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

Map generated from:

- Soil Series Extent Explorer: https://casoilresource.lawr.ucdavis.edu/see/#

Jory silty clay loam

- State soil
- Prized for wine grapes

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It is old and highly weathered, with visible red color from iron oxides.

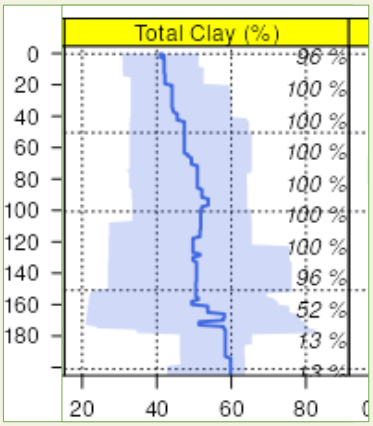
References:

Soil profile photo courtesy of The Soils of Oregon, Springer (2022).

https://link.springer.com/book/10.1007/978-3-030-90091-5

Jory silty clay loam

Y axis = depth in cm



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Percent clay is pretty constant throughout the profile because the soil formed from a clay parent material.

But soils mapped as Jory tend to be more diverse with respect to clay (light blue shading). Some Jory soils outside of Washington County are silt loams.

Chart is from:

- Soil Series Extent Explorer: https://casoilresource.lawr.ucdavis.edu/see/#

Udic forest soils

(Wash. Co.)

Soil	Surface Texture	Site Class	Site Index	Median Elev. (ft)
Pervina	silty clay loam	3	113	950
Goble	silt loam	2	124	1100
Olyic	silt loam	2	119	1250
Melby	silt loam	1	136	1250
Hembre	silt loam	2	127	1550
Tolke	silt loam	2	130	1650

Arranged by elevation.

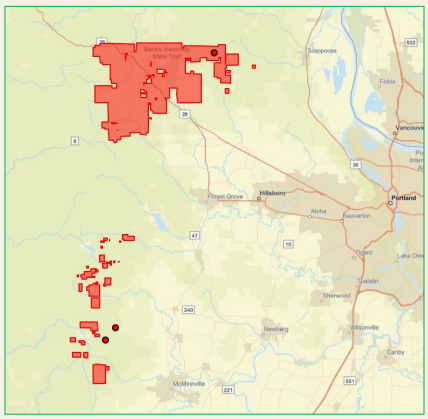
Udic soils occur at higher elevations (typically above 1000 feet in Wash. Co.):

Soils that commonly have:

- well distributed rainfall annually
- stored moisture plus rainfall that is equal to, or exceeds, the amount of evapotranspiration, or
- adequate winter rains to recharge the soils and cool, foggy summers (e.g., as in coastal areas).
- water moves downward through the soils at some time in normal years.

Melby silt loam

- Inceptisol
- Elev. 500 – 2,000 ft
- MAP = 60 – 70 in
- Parent = residuum and colluvium from sedimentary rock
- Well drained
- Restrictive: 41-61 in



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Melby mostly occurs in Washington and Yamhill Counties.

Inceptisols are typically younger and have not had as much time to develop very distinct horizons.

“Colluvium” = Unconsolidated, unsorted earth material being transported or deposited on sideslopes and/or at the base of slopes by mass movement (e.g., direct gravitational action) and by local, unconcentrated runoff. I.e. formed in material that moved down the slope (either gradually or in landslides).

Note the restrictive layer at 41-61 inches. This is silt stone bedrock.

References:

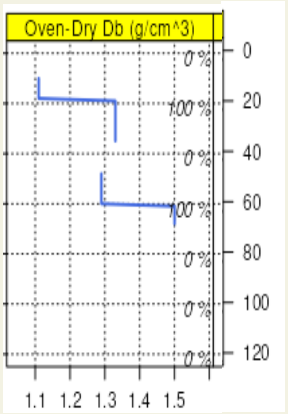
- Web Soil Survey: https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

Map generated from:

- Soil Series Extent Explorer: https://casoilresource.lawr.ucdavis.edu/see/#

Melby silt loam

Y axes =
depth in cm



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Notice increase in bulk density (Db) between 20 and 60 cm (8 and 24 inches).

Chart is from:

- Soil Series Extent Explorer: https://casoilresource.lawr.ucdavis.edu/see/#

Shiny object is a nickel for perspective.

Not a lot of horizon development.

Photos by Dean taken along Hwy 26 about 2 miles west of Buxton.

Tolke silt loam

- Andisol
- Elev. 800 – 2,500 ft
- MAP = 80 – 100 in
- Parent = colluvium from volcanic or tuffaceous sedimentary rock
- Well drained
- Restrictive: >80 in

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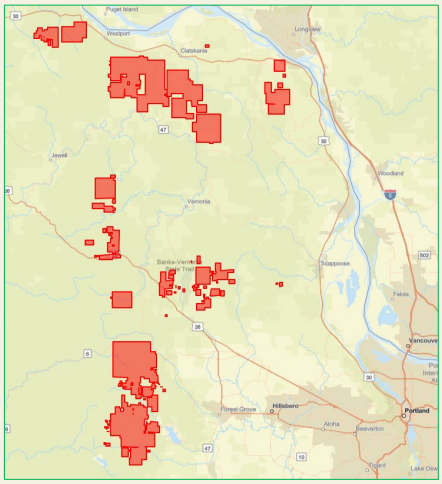

Tolke mostly occurs in higher elevations of Columbia, Washington, and Yamhill Counties.

Andisols commonly develop in volcanic ash, pumice, cinders, and lava.

Tuffaceous = rock that developed when volcanic ash consolidates.

NRCS does not have enough data to develop the charts shown for other soils.

References:

- Web Soil Survey: https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

Map generated from:

- Soil Series Extent Explorer: https://casoilresource.lawr.ucdavis.edu/see/#

Sample on left is upper 14 inches. Middle photo is the next 10 inches.

Shiny object is a nickel for perspective.

Thick duff layer.

Photos by Dean taken about 2 miles west of Timber.

4. Climate informed forestry

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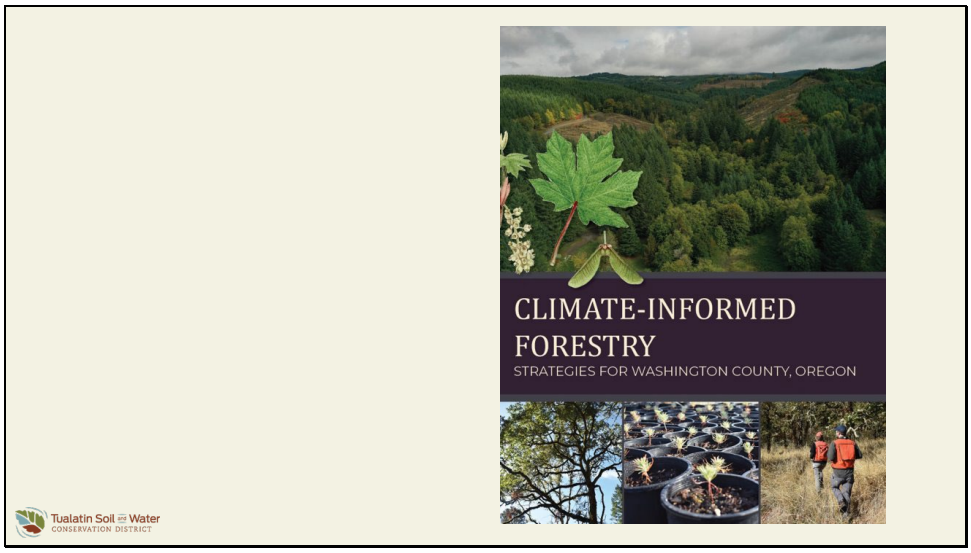
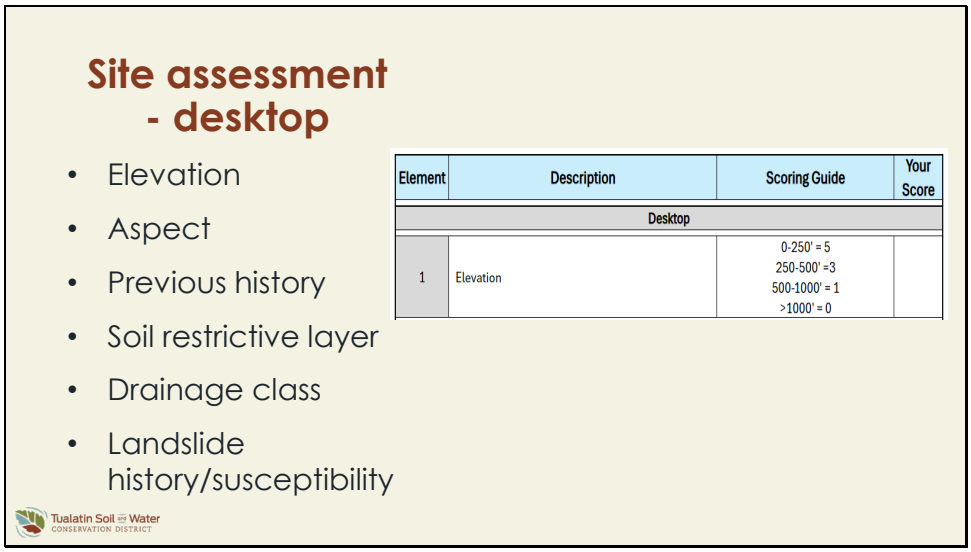
Photo credit: OSU, Dept. Forestry, 2021 heat dome.



Written by a team that includes forest owners, ODF, OSU, SWCD staff. Reviewed and edited by consultants, OSU, Tribal staff.

ODF has granted $249,000 to the Tualatin SWCD to implement ideas in this guide.



The guide has an assessment checklist to gauge how vulnerable a site is to a climate that will be warmer and drier.

The 7 desktop parameters can be determined in the office with online resources.

Each parameter receives a point value. E.g., elevations over 1,000 feet receive 0 points (low risk) while elevations < 250 feet receive 5 points (high risk).

The guide mostly focuses on risk for Douglas-fir on a site, but can also provide insight into other species.

Site assessment – in field

- Conifer vigor
- Vegetation community
- Aboveground roots
- Duff layer
- Rockiness

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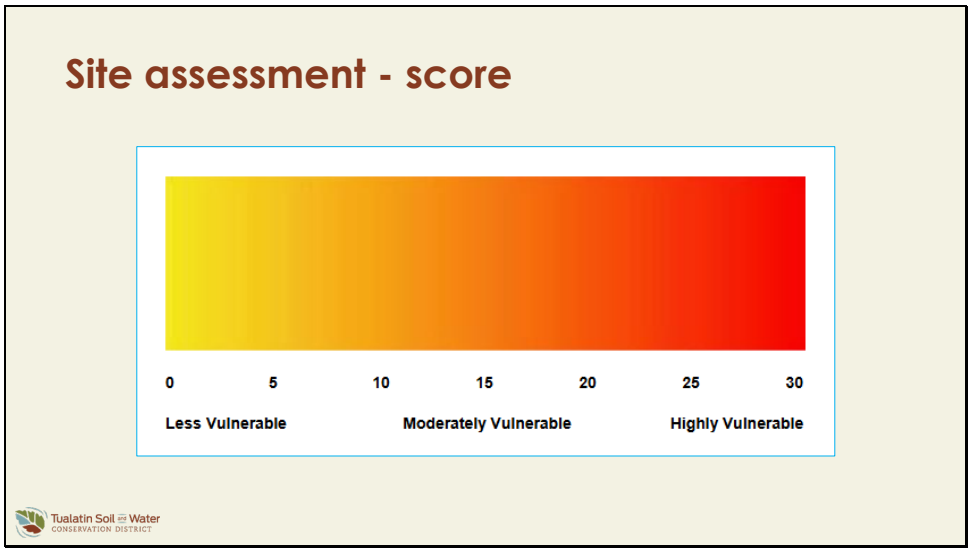
In-field parameters include:

- Conifer vigor (e.g., heavy cone crops on young trees, low leader growth on older trees).
- Vegetation community (madrone, poison oak, white oak indicate greater vulnerability).
- Are there many roots growing partially aboveground.
- How deep is the duff layer.
- Rockiness.



After completing the score sheet, you add up points. Higher points = greater vulnerability. But the assessment score is not meant to be highly precise – it's meant to provide information that you interpret based on your experience and judgement.

We will want feedback on how this assessment tool, and the guide in general works, and how we can improve it in future editions.
The first printing will be limited because we expect to update it based on feedback from local foresters.

5. Making soil healthier

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Schiros, *Roots*

Soil health definition (Dean's)

The ability of a soil to help us achieve reasonable goals without spending too much money or messing up the environment.

Photo by USDA-NRCS Oregon

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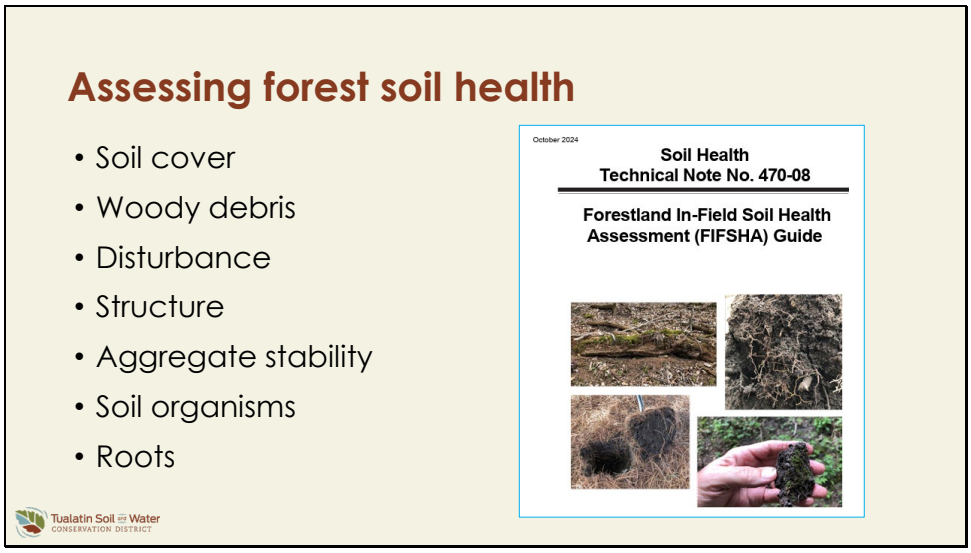
Reasonable: soil health practices won't help you grow Douglas-fir in a wetland.

Money: soil health does not require applying mulch around plantings to keep them alive.

Environment: soil health reduces the risk of pesticide runoff.



A new scorecard from USDA-NRCS.

Provides assessment of soil health and suggested practices.

Not surprisingly, some of the parameters to assess (like woody debris) are the same as in the Climate Informed Forestry site vulnerability assessment. Healthy soils are less vulnerable to a warmer, drier climate.

Available here:
https://directives.nrcs.usda.gov/sites/default/files2/1729877419/TN%20470-08%20FIFSHA%20Guide.pdf

6. More info

VanGogh, *Wheat Fields At Auvers*

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Interesting and informative series of discussion about soil biology. Accessible to all – you don't need a soils or biology degree.

Includes conversations with soil scientists in Europe and North America

https://rilliglab.org/podcast/

Thorson, T. (2022). The soils of Oregon. Springer, Cham, Switzerland. Available through Wash. Co. Comm. Library.

Simard, S. (2021). Finding the mother tree. Alfred A. Knopf, NY. Available in print and audio through Wash. Co. Comm. Library.

Nardi, J (2007). Life in the soil. University of Chicago Press, Chicago, IL. Available through Wash. Co. Comm. Library.

Questions

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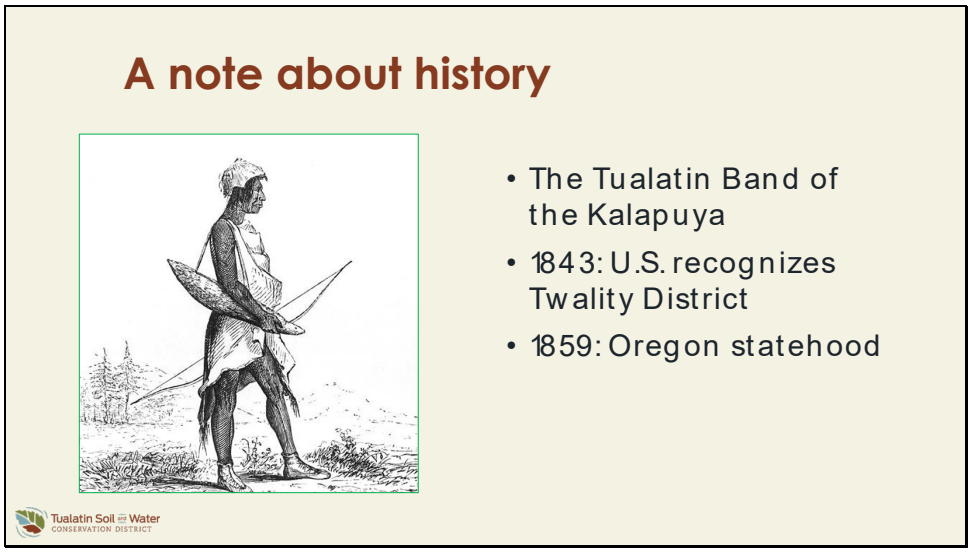
Slides on following pages were not included in the Feb. 2026 talk due to time constraints.

Tualatin Soil and Water Conservation District

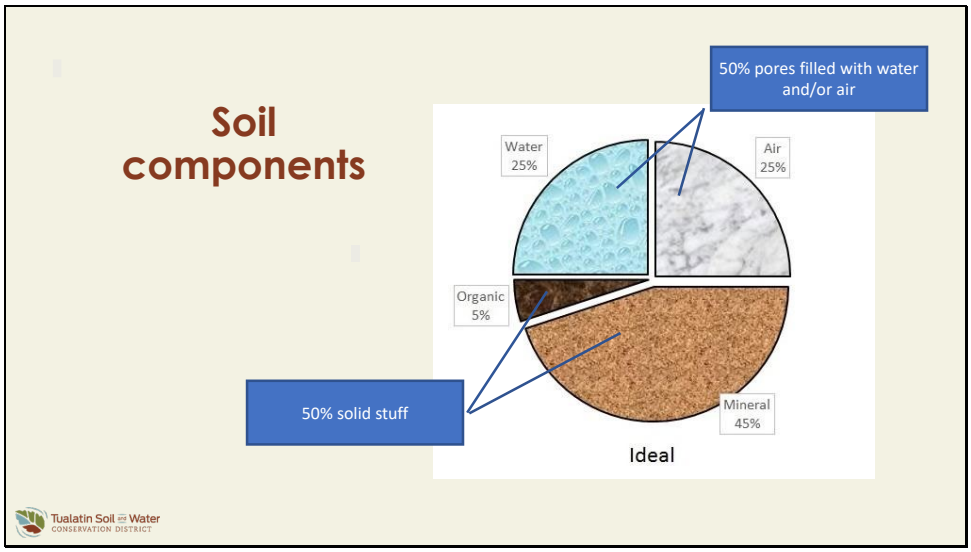


The Tualatin Band of the Kalapuya lived and prospered in what is now known as the Tualatin Basin since time immemorial.

They stewarded the natural resources of the basin for 10 – 15,000 years. Compare this to the roughly 200 years of English speaking people who settled in the basin. A forest owner we work with points out that if you stretch your arm out and think of it as representing the timeline of humans living in the basin, then the finger nail of your pinky finger is the time that English has been spoken here.

The Tualatin Band ceded their lands to the United States in 1855 and are now part of the Confederated Tribes of the Grande Ronde.

European settlement of the area began in mid 1800s, and the federal government recognized the area later to become Washington County as part of the "Twality District." Oregon became a state in 1859.



In general terms, soils have about 50% pore space.

Surprisingly, sandy soils tend to have less pore space (35-50%) than silt or clay soils (40-60%). We think of clay soils as “heavy” because their pores are small and hold water tightly, whereas sandy soils have large pores that drain more quickly. So the “heaviness” of clay soils is due to the water they hold, not a lower porosity.

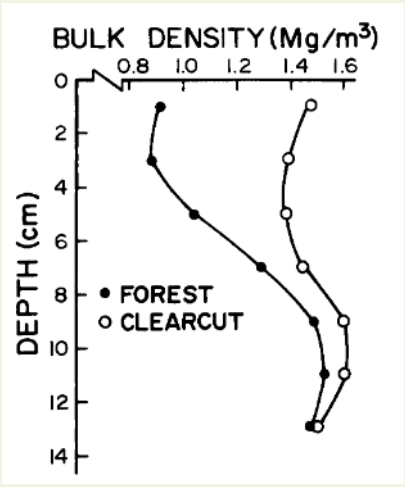
Because the solid stuff has a bulk density of about 2.67 g / cc, a healthy soil with at least 50% pore space has a bulk density of 1.33 g / cc or less.
1.33 g/cc is about 83 lb/ft3

References:

https://content.ces.ncsu.edu/extension-gardener-handbook/1-soils-and-plant-nutrients

Brady, N. (1990). The nature and properties of soil. MacMillan Publishing, NY.

Depth and management affect porosity and bulk density



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1. Surface soil ("topsoil") tends to have lower bulk density due to higher organic matter content than subsoil.

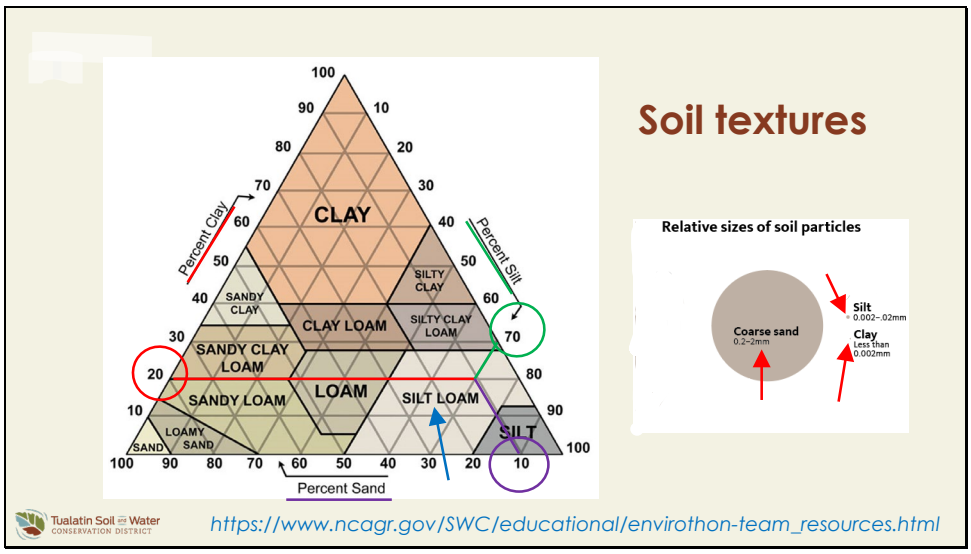
2. Management can affect organic matter content and compaction. Compaction is just the squeezing together of soil particles so that pores become smaller.

Lower bulk density and greater porosity allows better water infiltration, less erosion, and better root growth.

This chart is from research done in an Oklahoma forest with stony fine sandy loam and clay loam soil. The density of the clearcut soil was greater due to loss of organic matter by burning and decomposition and compaction, which was aggravated by grazing after timber harvest.

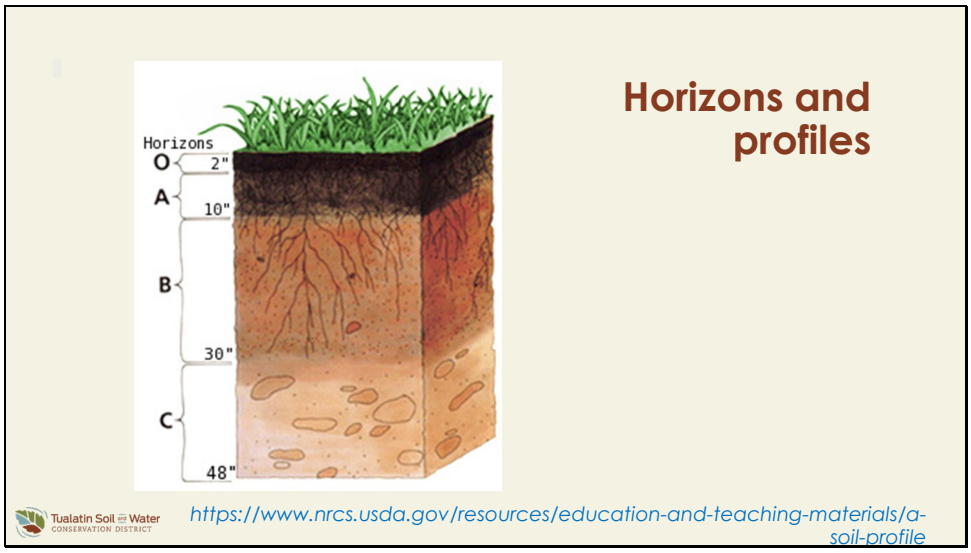
Reference:

McIntyre, S. C., Lance, J. C., Campbell, B. L., & Miller, R. L. (1987). Using cesium-137 to estimate soil erosion on a clearcut hillside. *Journal of Soil and Water Conservation*, *42*(2), 117–120. https://doi.org/10.1080/00224561.1987.12456054



The mineral part of soil is sand, silt, and clay.

Washington County forest soils are mostly silt loams and silty clay loams.



Organic matter slowly added to A horizon (“topsoil”).

Clay slowly moves downward to B horizon (“subsoil”).

“C” horizon is not changed much and is pretty much what the parent material looked like before the A and B horizons started to form.

Reduction and oxidation ("redox")

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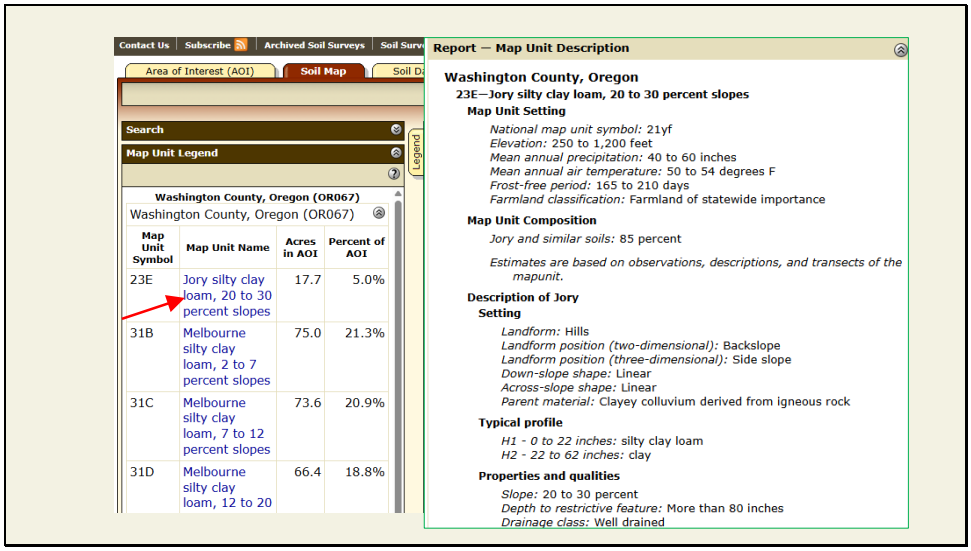
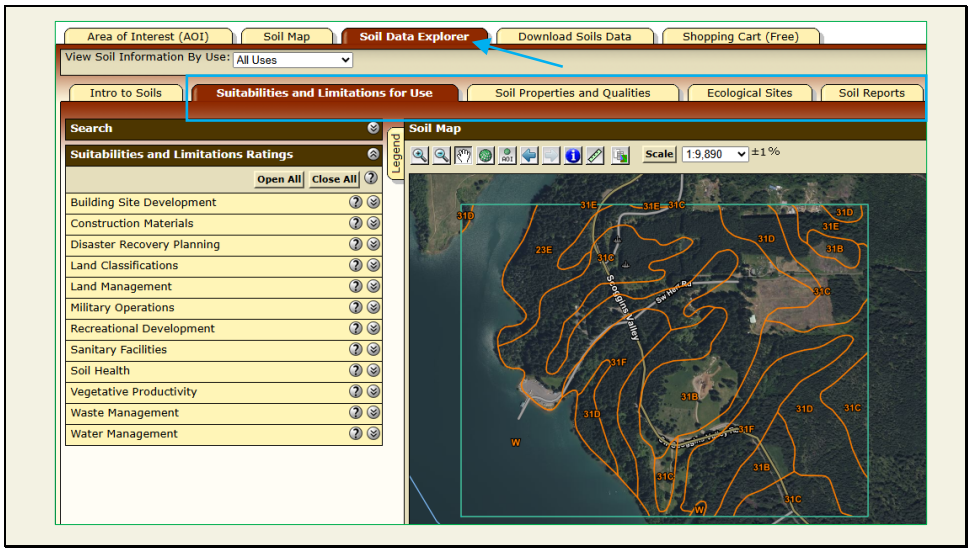
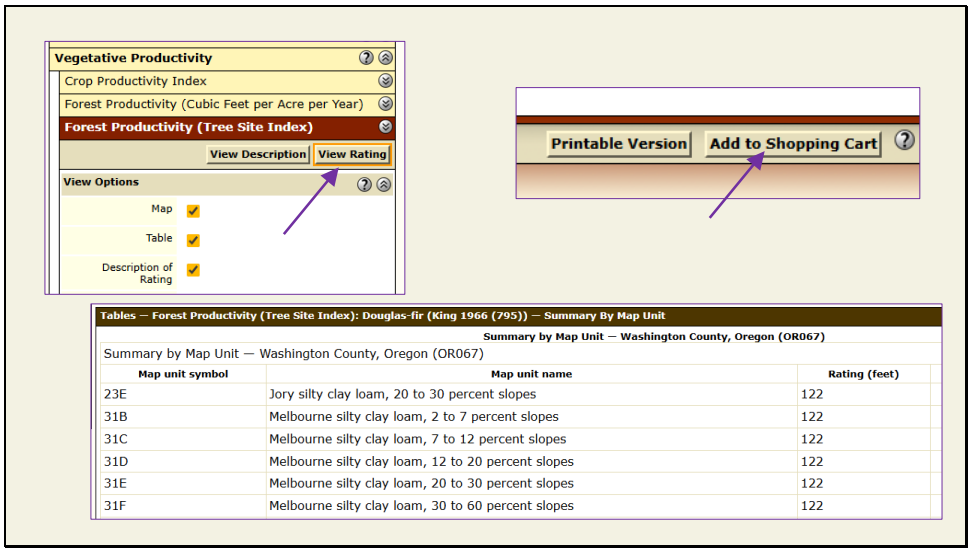
https://www.nrcs.usda.gov/resources/education-and-teaching-materials/a-soil-profile



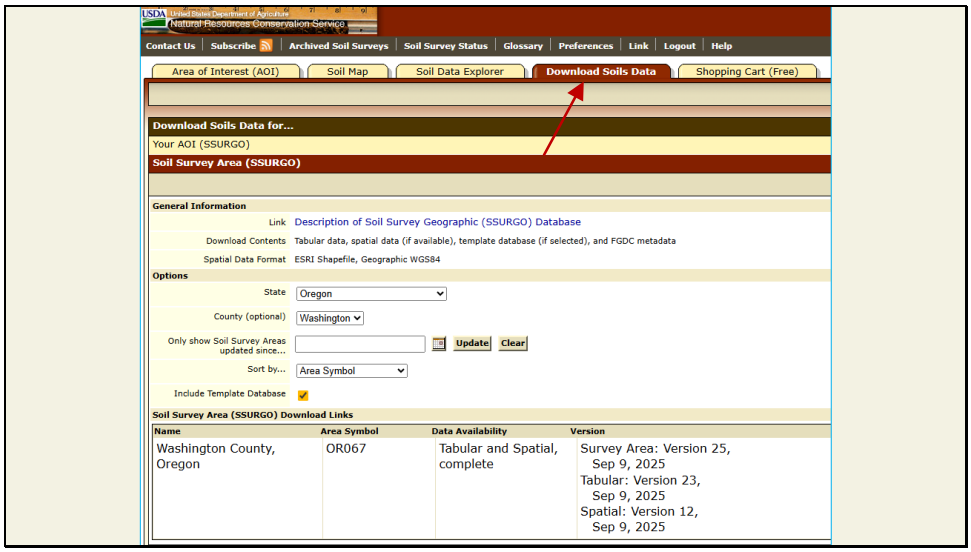
Click on the blue soil survey map unit name to get a nice summary of the soil, including info like elevation that's not available in any of the tables you can generate.



Click on Soil Data Explorer tab on the top to access data organized in the four tabs down below. You may need to hunt around for the info you want.

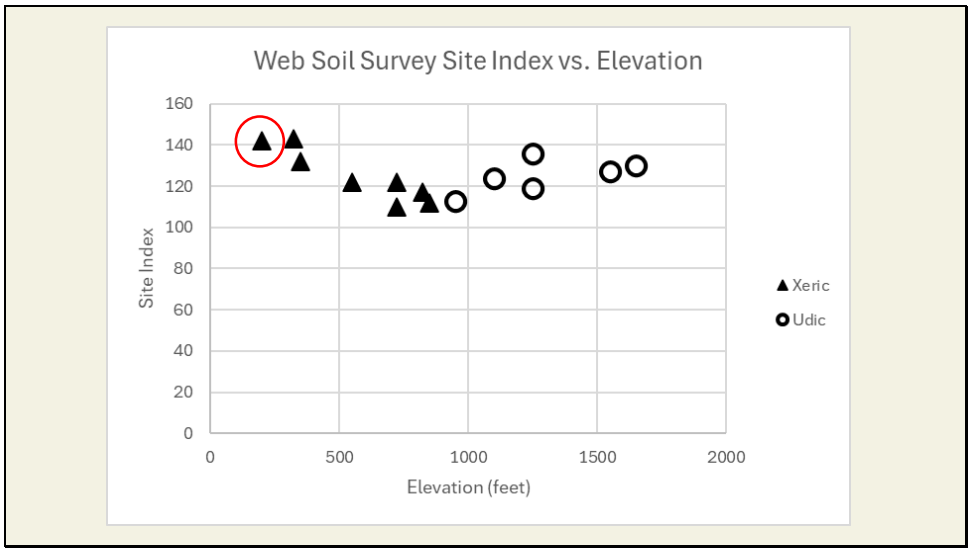


For example, selecting Vegetative Productivty – Forest Productivity produces a table with estimates of site index. If you want to generate a nice report for your forest, with maps and tables, click “Add to Shopping Cart.” Even tho it says “shopping,” it’s free.



Note to those who want to see information for lots of soils in a county: click on "Download Soils Data." The files here are large (>20 MB) and run in Microsoft Access database. If you do this and have trouble, call Dean for tips.

Using the whole database is probably most useful for consultants and agency folks, but not so useful for individual forest owners wanting information about the soils on their land.



These data are for the common forest soils in Washington Co. as shown in previous charts. You would think that udic soils are always more productive for trees, but obviously other factors are at play.

But low elevation soils like Woodburn (red circle), where heat stress in trees is common, often have high site index ratings provided in Web Soil Survey.

Note that these site indices were developed by King in 1966.

A paper by Gregory Latta et al., published in Forest Ecology and Management in 2010 supports the conclusion that old site index ratings may be inaccurate. On the other side of that coin, as the climate warms, it is possible that higher elevation soils may have improved growth for certain species that are currently limited by low temperatures.

Ref:

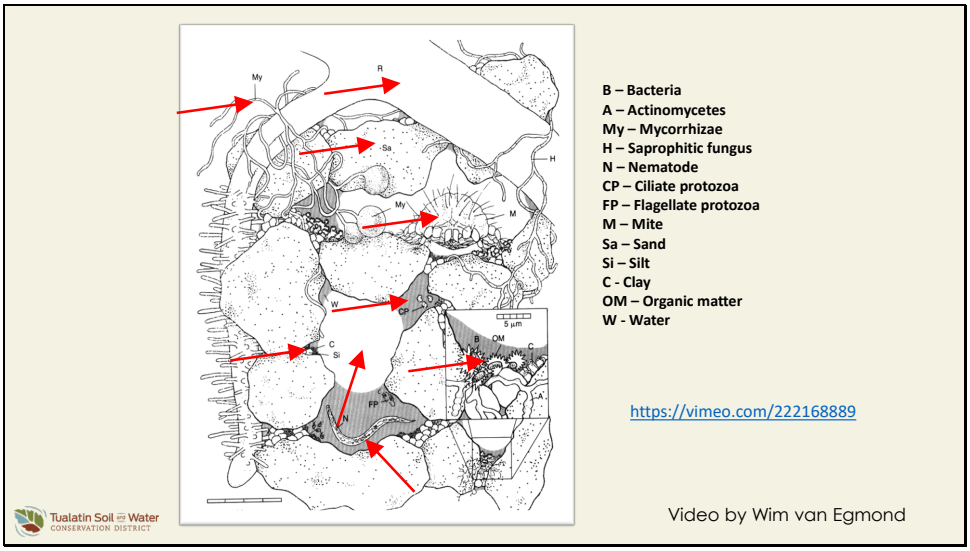
Latta, Gregory, Hailemariam Temesgen, Darius Adams, Tara Barrett (2010). Analysis ofpotential impacts of climate change on forests of the United States Pacific Northwest, ForestEcology and Management, Volume 259, Issue 4, pages 720-729, https://doi.org/10.1016/j.foreco.2009.09.003

Rx for soil health

- Minimize disturbance
- Keep soil covered
- Diverse plants
- Year-round live roots

Photo by USDA-NRCS Oregon

Tualatin Soil and Water Conservation District



- Disturbance destroys soil pores and many soil organisms. A diversity of organisms is needed to keep nutrients cycling, process dead leaves, etc., create pores for the flow of nutrients and water, and protect plants from diseases and pests.
- Note mycorrhizae. (Finding the Mother Tree).
- Link is for video of bioturbation. Earthworms, potworms, collembola, mites, isopods, over 15-week period.
- Soil ecosystems are as diverse and complex as tropical rainforests or coral reefs.