Forest Management for Small Landowners

Soils

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Soils

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Introduction

Forest land in western Washington is generally very productive, but has a wide range of site quality. If you are interested in purchasing forest land, then you should pay close attention to the quality of the soils in the tract you intend to purchase. The potential revenue you might earn can vary by 50% or more depending on the site quality. Even if you already own land, you should understand some basic soil information before discussing the growth potential of soil.

Rock Classification

Igneous rock

Igneous rock is formed from molten magma from beneath the earth's surface. Molten magma becomes lava when it erupts onto the earth's surface. It takes on many forms including ash, tuff, basalt, and batholiths. Large amounts of igneous rock can be found in western Washington, as a result of volcanic activity that has taken place for millions of years. Eastern Washington also has the Columbia River basalt flows that spread basalt hundreds of feet thick across thousands of square miles for 11 million years.

The favorite rock for road building is basalt, because when fractured (*crushed for road construction*) all edges are irregular, consequently the rocks will "lock up", creating a firm to solid road surface. If you have any topography on your tree farm (*slopes or hillsides*) and you need to build roads, try not to use crushed river rock. It is fine for County and State use when they compact it and overtop with blacktop or concrete. But on roads that remain gravel, it will not "lock up" and consequently each little rock will roll against each other, making it difficult to drive up hills.

Sedimentary rock

Sedimentary rocks are made of fragmental material and chemical precipitates that are produced and accumulated on land or beneath the sea. Over millions of years mountain ranges can be weathered down by wind, rain, and freezing conditions. Rock is broken down into small particles and blown or washed down to fill the surrounding areas with sediment deposits, some thousands of feet deep.

Most sedimentary rock is too soft to use in road building, however some sedimentary types can be hard enough. It will normally break down into fine soil particles that quickly become mud, resulting in no rock base to support heavy vehicles. But if you live in an area without basalt nearby, you may be forced to use it because you can't find anything else.

Metamorphic rock

Metamorphic rocks have been changed by heat and pressure but are the same basic chemical makeup of the parent rock. They have been buried deep enough to have been pressed into a new form, but not melted enough to change the chemical makeup of the parent material. This heat and pressure can come from depth of being buried or in some cases lying next to hot magma or batholithic intrusions (*molten rock that does not reach the surface until years later and then due to erosion*).

An example of metamorphic rock is marble, which is created from limestone that was buried by overtopping soils to a depth that received pressure and heat needed to change it from limestone to marble.

Formation of Soils

Soil is formed through the processes of physical and chemical weathering of deposited or accumulated geological material over time. The characteristics and properties of the soil at any given place are determined by the interaction of five factors:

- The physical and mineralogical composition of the parent material.
- The climate under which the soil material accumulated and existed since accumulation.
- The plants, vertebrates, invertebrates, and microbes in the soil and on the surface.
- The topography of the landscape.
- The length of time the forces of soil formation have acted on the parent material.

Most of the process of weathering and breakdown of parent rocks into soil developed over a long geological time period which is too long for humans to notice. In most cases the finer the soil particles, the richer the soil (*more productive*). An exception is clay particles which are very fine.

Soil Horizons

If you dig a hole in any forest soil, you will see different layers which are called horizons. These horizons are distinguished by differences in composition, color soil structure, and texture. In a typical forest soil, you are likely to see some or all of the master horizons O, A, B, C, and rock. (Figure 1)

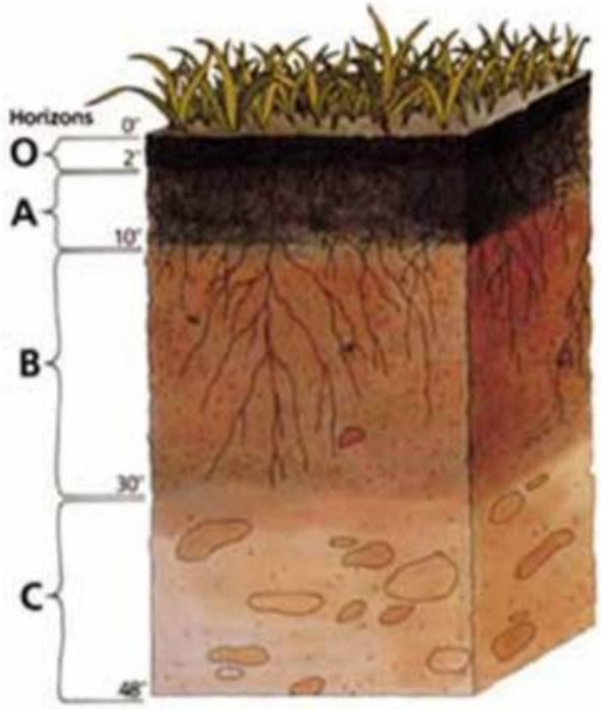


Figure 1. Soil profile diagram showing master horizons.

Image courtesy of USDA-NRCS.

"O" Horizon

The organic horizon or forest floor is composed mostly of leaves, needles, and other organic matter, usually above the other horizons.

"A" Horizon

The top layer of soil is generally called the "A" Horizon, and it has the most advanced breakdown of parent material that lies deeper under-ground. It is highly influenced by decomposed organic material like leaves, woody material, and the plants that lived on the forest floor from several to many thousands of years ago. It will be darker in color than horizons below because of the higher organic matter content.

"B" Horizon
The "B" Horizon is soil in the making that is somewhat broken-down parent material and may have been influenced by the rich organic layer of the "A" Horizon layer. It can be differentiated from the "A" and "C" Horizons by soil color and texture.

"C" Horizon
The "C" Horizon is the parent material with little to no rock decomposition. Roots will have penetrated this deep and begun breaking the rock up in smaller particulate material. However it lacks the properties of the above soil horizons.

Rock
Parent rock, relatively unchanged or with some signs of weathering

Soil Classification

Like plants and animals, soils worldwide are classified in six levels: Order, Suborder, Great Group, Subgroup, Family, and Series. For our purposes in a localized area, we are only concerned with the (*Soil*) Series. A series consists of soils that have similar horizons which are similar in:

- Color
- Texture
- Structure
- Reaction (*soil pH*)
- Consistence
- Mineral
- Chemical composition
- Arrangement in the profile

If you know the name of a soil series, you can obtain the full description at the Natural Resources Conservation Services Official Soil Series Descriptions, but it may include a lot more detail than the average tree farmer wants.

Soil Surveys

What is a soil survey?
A soil survey is a detailed report on the soils of a defined area. The soil survey includes maps with soil boundaries, photos, descriptions, and tables of soil properties and features. The Natural Resources Conservation Service (*NRCS*) is the federal agency charged with collecting soil information and building soil maps from that information.

How do I get a soil survey?
Previously soil surveys were printed and distributed by NRCS. These printed copies are no longer available, but downloadable copies of many of the soils in your counties may be available from an NRCS web site of Soil Surveys by State.

The current NRCS soil survey information is available at Web Soil Survey website. The instructions on the Web Soil Survey page direct you to first define your Area of Interest (*AOI*). Find your site by address, or choose state and county and zoom and drag until you find it. After you use the AOI button to outline the area, a photo overlaid with contours and small numbers will appear. If your land is very flat you may have only one soil series for your tree farm, but most land has varying topography and likely different types of soils. This will result in a soil map of your tree farm with several different soil series. *(Figure 2)* There are 4 soil series on this 160 acre tract shown in red.

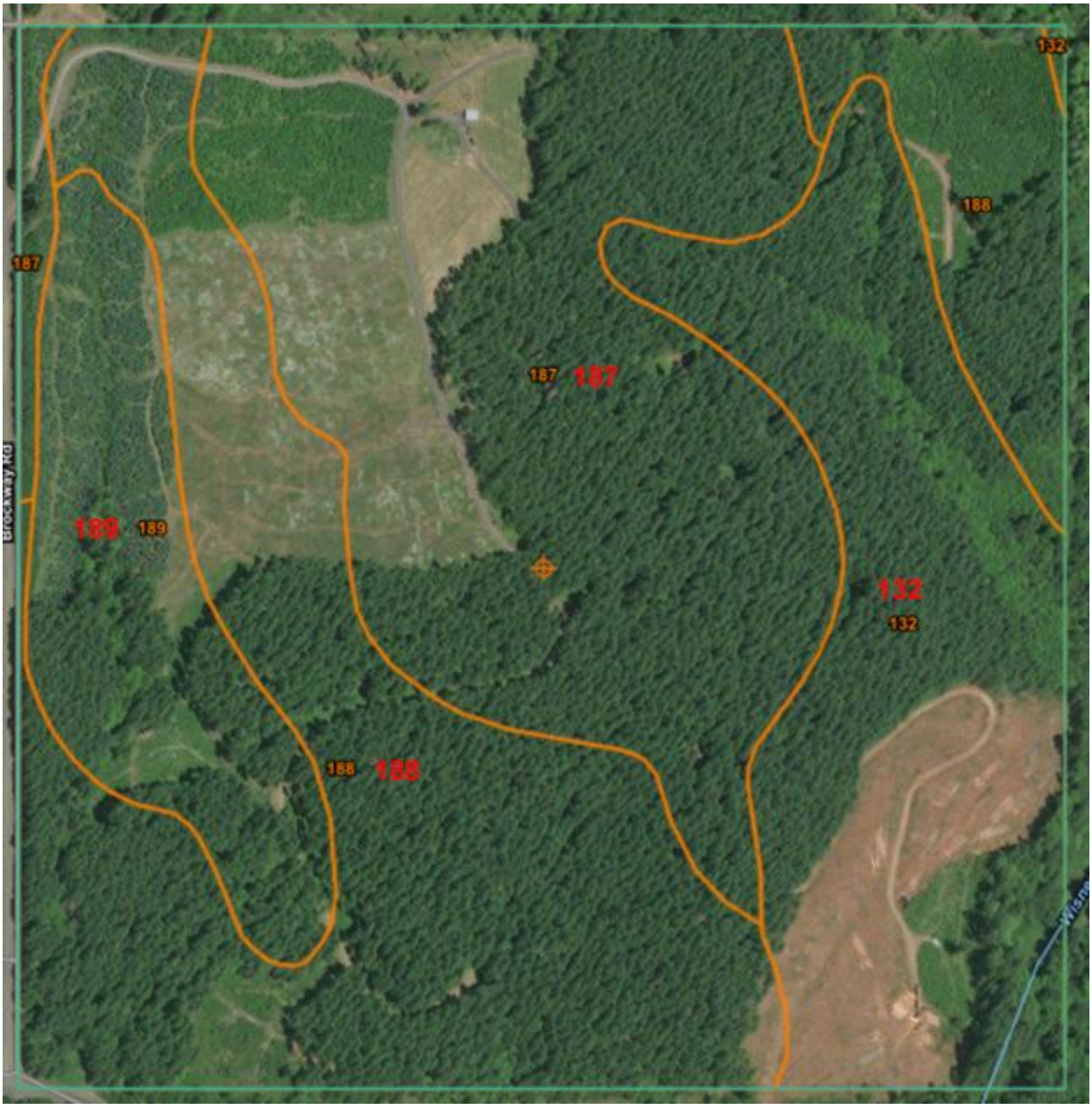


Figure 2: Soil survey for a 160 parcel in Lewis County

Custom report

You can obtain a custom report for the area you have defined, by printing or downloading, by following the instructions on the web site. The report will include a listing of the names and acreage of the soil series that are present, as well as a more detailed description of their properties. (*Figure 3*)

More detailed instructions for using the Web Soil Survey are in the WSU Extension publication Forest Soil Data for your Forest Stewardship Plan.

Map Unit Legend

Lewis County Area, Washington (WA641)

Lewis County Area, Washington (WA641)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
132	Melbourne loam, 15 to 30 percent slopes	34.2	21.8%
187	Salkum silty clay loam, 0 to 5 percent slopes	52.4	33.3%
188	Salkum silty clay loam, 5 to 15 percent slopes	54.1	34.4%
189	Salkum silty clay loam, 15 to 30 percent slopes	16.5	10.5%
Totals for Area of Interest		**157.3**	**100.0%**

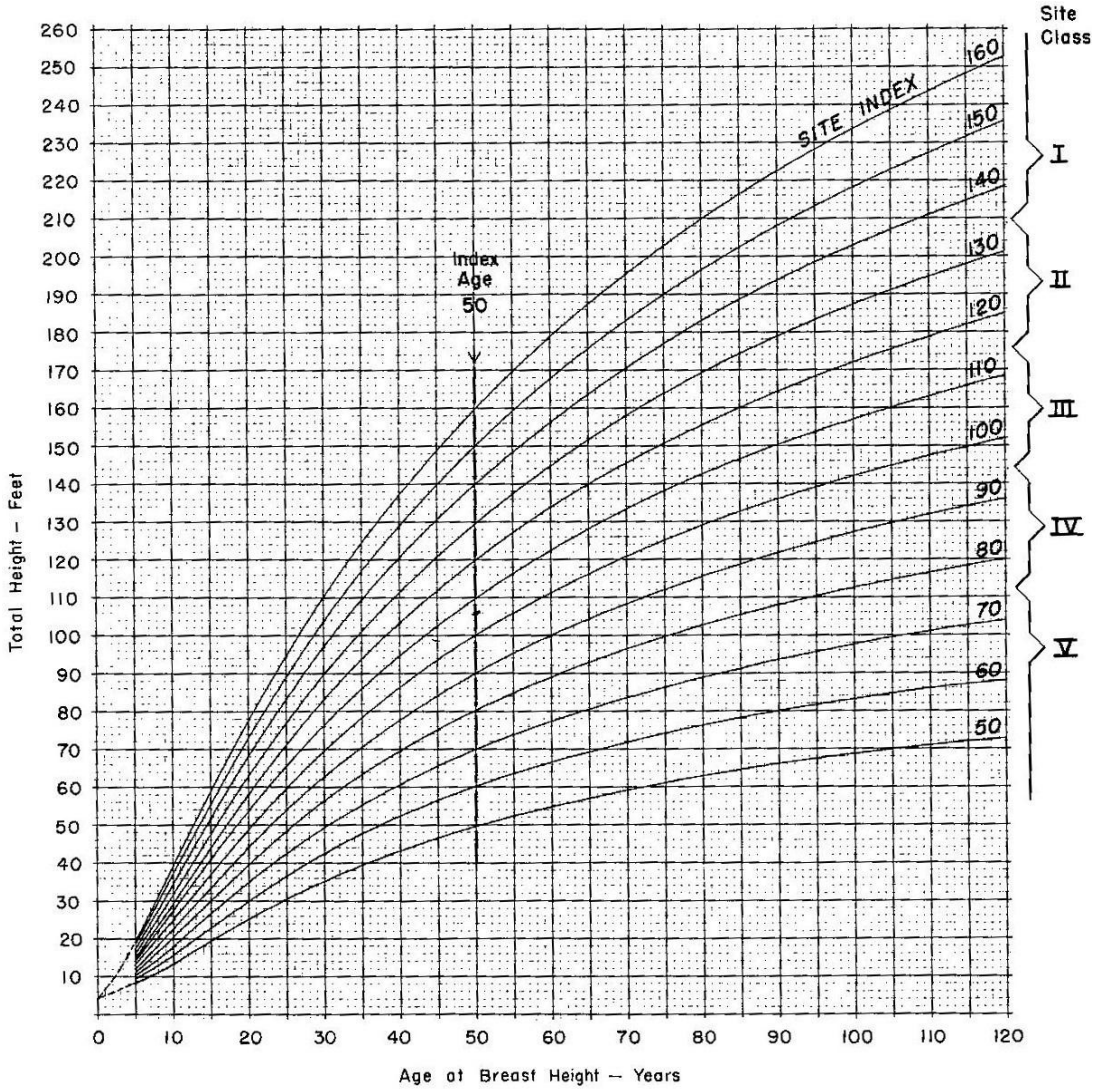
Figure 3: Soil series for the previous soil survey photo

Site Index

Site index is a species-specific measure of the quality of the site based on the height of dominant trees at a specific age. In the Pacific Northwest, most landowners use Douglas-fir 50 year site index based on site index curves. Many State and Federal agencies use 100 year site index tables.

Site Index Curves

Site index curves show the expected height growth pattern over time. Tree height is shown on the left axis and tree age on the bottom axis. The Douglas-fir site curves developed by Weyerhaeuser Company in the 1960s are still used. (*Figure 4*)



From: Site index curves for Douglas-fir in the Pacific Northwest, by James E. King. Weyerhaeuser Forestry Paper No. 8. 1966

Figure 4

Site Class

The term “site class” is a method of classifying the timber growing potential of the soil. It is divided into five levels, Site I-V, with Site I, II and III considered high, IV medium, and V low. Figure 5 (*on right*) summarizes the relationship of site class and site index for 50 year old Douglas-fir in western Washington (rounded from exact figures).

Site Class	Site Index (Tree Height)
I	140+ feet
II	130-120 feet
III	110-100 feet
IV	90-80 feet
V	70-60 feet

Figure 5

Obtaining Site Index and Site Class for your Property

To determine the exact site index of a parcel, use the NRCS Web Soil Survey. For a more “broad-brush” determination of site class for a specific area, use the Washington DNR maps. The most significant impact that site index and site class has on managing your property is its use in determining the width of the Riparian Management Zones (RMZs) if you have streams on your property. For that purpose, the DNR maps are used.

NRCS Web Soil Survey

It was easy to find the site index in the old printed soil surveys, but it is a bit more difficult to find in the NRCS Web Soil Survey. After you have defined your Area of Interest *(described above)*, you have to navigate through several levels.

Soil Data Explorer tab, → Vegetative Productivity, → Forest Productivity

The Rating shown in Figure 6 (*below*) is the site index for the various soils on the site pictured on page 6.

Figure 6: Site index from NRCS Web Soil Survey

The red arrow points to the site index height for the four soils in the previous soil survey in Figure 2 and custom report in Figure 3.

Washington Department of Natural Resources (DNR) Forest Practice Maps
The DNR website can be accessed at http://dnr.wa.gov. Click on the "**Forestry**" picture and choose "**Forest Practices Application**" to obtain an Activity Map and find your Site Class. The DNR has announced that a new, improved website will be ready in 2025, so soon everything will be different than it is now so no further details will be given here.

Forest Practices Rules and Site Class & Index
Forest activities in Washington are governed by the 1999 "Forest and Fish law", and the rules adopted by the Forest Practices Board in the intervening 20+ years. In the early years, the rules were published in a 3-ring binder over an inch thick. Now they have been expanded and updated many times, and are documented on the huge DNR web site. Unlike the methods of growing and managing a forest, the rules change frequently and cannot be explained in detail by a retired forester like myself, so for the most part I have not even tried in these articles.
One of the many changes over the years has been the way site class and site index is shown on official maps. The historical way was to express the site class by soil type, as mapped by the Natural Resources Conservation Service. But now the DNR has gone to a process that encompasses large areas with the same site class. Unfortunately there is nothing you or I can do about this. Even if you find you have an area that obviously is a different site than what the maps show, there is no process in place for you to petition for a change.

We have an area on our tree farm that received a huge amount of volcanic ash in the geological past. That ash is now a thick layer of clay, and the overburden soil is inches thick instead of feet. It is prone to windfall, shorter trees, and decreased wood production. In the hope of correcting my site index for a narrow riparian zone, I contacted DNR forester who had any knowledge of our tree farm, our regional office, the Olympia office, and the State Geologist. All sympathized but could not help us.

Soil Compaction

Soil compaction generally takes place when equipment is operated on the ground and there is excess soil moisture, often in conjunction with clay soils that commonly are found in the Pacific Northwest. The soil is much less likely to be compacted when dry, and some soils are more prone to compaction than others.

If a D-8 cat or logging shovel will leave compacted soil in the winter, then the small farm tractor you use will do the same thing. It just takes more passes over the soil! The soil that makes up your tree farm is like your bank account. If you treat it right and take appropriate action when needed, then it will grow a crop of trees that will meet your expectations.

There have been a lot of studies on soil compaction, and some of the conclusions have not always agreed with each other. I like to think that small forest landowners have a vested interest in doing what is right. It just does not make much sense to harm or destroy your soil investment!

While building an access road on the tree farm many years ago, we ran across a layer of thick clay. In layman's terms I would describe it as pottery-grade clay. I took a large chunk home to show my wife, and several months later when it was dry, I put it in a bucket and added water. It was like an Alka-Seltzer tablet dissolving in water. The water that had been in the clay had evaporated, leaving air in the microscopic holes, as the water displaced the air it acted like a pop bottle fizzing. I stuck my hand in the water and could feel very small particles in the bottom of the bucket. After a half an hour of flushing the water and clay particles I was left with about a thimbleful of small particles that under a hand lens turned out to be pumice. There was a lot of volcanic activity in the Cascade Mountains thousands or millions of years ago. It makes sense to me that thick layers of ash were carried by wind or water to depressions and collected into what is now layers of clay.

If you log during the winter months you will see varying levels of soil compaction where the logging shovel or other equipment made multiple passes over the land. If a logging shovel makes one pass over the land and is riding on a bed of branches, it will generally not cause any damage. But repeated passes during wet conditions will break through the branches and topsoil and begin to churn up the upper soil horizons. Especially when swinging the logs over the same route to the landing. The worst of this will be on and near the landing, where the logging shovel makes repeated passes. After the completion of logging, you can ask the shovel operator to use the grapples to pick out limbs and logs that were forced into the soil horizons or you can come back in the summer time when the soil has dried out, and have a dozer or excavator fluff up those soils.

Planting Compacted Soils

Planting in compacted soils can be very difficult.

- Just getting the planting shovel through the compacted soil can be very difficult as well as breaking out the ground around the shovel. *("Breaking out the ground" is a process to allow the planter to create a hole that a seedling is then planted in.*)
- Your tree planters will have additional problems when they hit buried limbs and other woody debris pushed into the soil by the equipment.
- Their frustration level may be high enough that they will just give up and plant an unacceptable shallow seedling.
- If the seedling is planted correctly, the adjacent compacted soil may not allow rain water to properly soak into the ground, causing puddling or a small pond. The standing water will seep into the planting hole, killing the seedling. Very few of the Pacific Northwest timber species like standing water. Some can survive it better than others but most will be damaged or killed.

Seedling mortality caused by excess water

Post-Planting

Over time (5-10 years) you will see the soil begin to recover. If you use a shovel to install land exam plots or other plots in the plantation, you will see how it becomes easier to get the shovel into the ground. However if you had compacted soil when you planted, you very likely have lost a percentage of your seedlings. If nothing was done to replant the mortality, then at harvest time you will very likely end up with a stand of timber that is not as well stocked as it could have been, and this means less revenue in your pocket.

Effects of Rain on Soil

- Before logging, the forest canopy intercepts the rain and instead of beating down directly on the mineral soil, the rain water drips on a bed of forest vegetation and litter. This breaks up the force of the rain on the soil and allows it to soak in.
- For 5-10 years after logging, while the former forest canopy is gone and there is little litter, the rain falls directly on the soil and often accumulates and runs off the harvest unit. You will be surprised to see water flowing in small draws where you never saw water flow in pre-logging days. This condition will last until the crowns are larger, some forest litter has accumulated, and any soil compaction has begun to be reduced.
- With this increased water flow, there also will be increased soil movement *(erosion)* off the new harvest unit.

As a young forester I was involved in a broadcast burn of a 60 acre unit in the district I later managed as the District Forester. A man who lived at the foot of a long hillside just below the burn had built a fish pond that was ½ acre in surface size. He contacted me following the first winter to complain about his pond filling up with sediments. I understood how water could move topsoil but I never imagined that it could move enough to fill his pond, especially since the stream flowing into the pond was not chock full of sediment. However I had seen the pond pre-burn, and we had a lot of rain that winter. It was years later that I realized just how much soil could be moved if it had no protective cover and measures were not taken to prevent erosion.

References

Best Management Practices for Maintaining Soil Productivity in the Douglas-fir Region. Sam D. Angima and Thomas A. Terry. Oregon State University Extension, EM 9023. 2011.

Keeping your forest soils healthy and productive. Helgerson, Ole T. and Richard Miller. Washington State University Extension EB2019. 2008.

Washington soil atlas. Hipple, Karl W. 121 p.
The soils included in this atlas were selected from several hundred different soils which have been identified and mapped in Washington State. Each of the soils have characteristics that make it a unique soil individual much like each person is a unique individual.

Links related to the Natural Resources Conservation Service Web Soil Survey

Web Soil Survey
Web Soil Survey (WSS) provides soil data and information produced by the National Cooperative Soil Survey. It is operated by the USDA Natural Resources Conservation Service (NRCS) and provides access to the largest natural resource information system in the world. NRCS has soil maps and data available online for more than 95% of the nation's counties and anticipates having 100 percent in the near future. The site is updated and maintained online as the single authoritative source of soil survey information.

Forest soil data for your Forest Stewardship Plan. Zobrist, Kevin. Washington State University Extension, EM064. Step by step instructions for using the Web Soil Survey.

Getting started with Web Soil Survey. A one page tutorial by NRCS.

Web soil survey gets update for forest management. Article published in Forest Stewardship Notes, February 2021.

Official Soil Series Descriptions.
If you know the name of a soil series, complete details can be obtained by entering the name on this site.

Soil Surveys by State
Printed soil survey reports were the main source of soils information from 1899 to 2005. Most of these reports are county-based, have been converted to PDF, and are available from links on this web site. USDA phased out the printing of reports after making Web Soil Survey the official source for information in 2005.

If you would like to dig a soil pit on your property to view the horizons, WSU Extension has a video which shows how to do it.