Learning Soils in Homer

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Homer Garden Club

[ASSOCIATED SLIDES ARE IN ALL CAPS]

Though we aren't experts, we both have taught people about soils. We offer some basic insights about how to learn and work with soils in the Homer area.

TONY AT SOIL PIT [2 slides]
The best way to learn soils is describing profiles of real soils. Even if you make mistakes as you attempt to describe a soil, you will learn from the process. Each profile is another portal into an unknown dimension of your landscape.

We present the basic concepts offered to our students to get them ready to describe their first soil profile.

<u>Why learn soils?</u>
GENIUS LOCI (WITH LARES)
The concept of *Genius loci* derives from the Roman idea of a local spirit who protected a place, often with the aid of *Lares* spirits who guarded boundaries (Wikipedia 2014a). The term evolved to mean a location's unique sense of place, which became a goal of creative landscape design. It may mean an evocative garden design that connects a person with the natural vitality of a place, or the imposition of a formal ideal upon a place, maximizing a sense of control and productive utility.

The labyrinth of living soil can be regarded as the core of a *Genius loci*.
Soil is the hinge connecting the geological and ecological processes that shape the sense of place.

SOIL PEDON WITH KEY CONCEPTS
<u>Key concepts</u>
There are 4 key concepts to get you started.
3 basic soil-forming processes develop soils from geological and organic material.

eluviation - (from Latin *e* or *ex* = out + *lavare* = to wash: literally 'wash-out')
Eluviation occurs when water percolating down through the soil leaches substances out of the upper layers. For example, sandy soils beneath wet boreal spruce forests are heavily leached by water that becomes acidified as it seeps through tannin-rich humus. The acidic water dissolves most minerals, except quartz, and carries them deeper into the soil, resulting in a pale, depleted, albic horizon.

illuviation - (from Latin *il* = in + *lavare* = to wash: literally 'wash-in') Illuviation occurs as water percolating down through the soil carries materials from upper layers into deeper layers. An illuvial soil horizon has accumulated clays, minerals, or organic substances transferred by water flow from overlying soil. Thus an illuvial soil horizon receives stuff that has been eluviated from the soil layers above it, and over time this process changes a uniformly mixed sediment deposit into a mature soil with distinct strata, which are oriented parallel with the land surface.

Eluviation and illuviation eventually produce a layered structure with zones, or horizons, composed of contrasting materials.

Weathering is the process of physical and chemical changes in rocks, which are caused by atmospheric agents such as water, oxygen, and carbon dioxide. Weathering takes place at or near the earth's surface (where weather occurs). Weathering may involve the disintegration of rocks into smaller particles, or the decomposition of rocks into different minerals. Long-term weathering often forms various kinds of clays. Previously weathering was thought to be mostly a physical process; however evidence is revealing that microbes are ultimately responsible for many weathering processes.

SOIL FOOD WEB

Soil is alive and wild.

This is the fourth key concept to understand soils.
Soil has a very complex living community with its own metabolism, respiration, growth, and evolution. It is a labyrinth of metamorphosis, changing a substance from one form to another though interacting cycles of life and death. Healthy soils are self-organizing ecosystems with considerable resilience. Thus they are essentially 'wild', in the sense that the soil community continuously self-organizes and evolves in response to whatever opportunities and limitations it experiences. As with all living things, it as a memory and is constrained by its history. The only was the take wildness out of the soil is to sterilize it and isolate it from recolonization.

The soil community can perform these functions:

- dead organic materials become plant nutrients,
- potentially toxic accumulations become harmless or even useful,
- water is filtered and purified (air, too, if it passes through healthy soil),
- carbon accumulates as humus, which often improves soil tilth.

As you learn to read the soil, you understand more about the history and constraints imposed upon the land. Thus the ability to interpret a soil profile is a critical aspect of place-based education.

CLORPT

Soil forming factors - ‘CLORPT’

- Climate
- Organisms
- Relief - topographic position
- Parent Material - bedrock, beach sand, peat, etc.
- Time - the longer weathering, eluviation, illuviation, and soil community development proceed, the stronger the contrasts among horizons.

CLORPT IN A LANDSCAPE SECTION

Different topographic situations within a landscape produce different soils. Often there is a repeating pattern of the same sequences of soils along similar topographic gradients within a watershed. This consistent pattern of different soils connected within landscape is called a *catena*.

PEDON IMAGE WITH LABELED HORIZONS

A three-dimensional unit of soil is called a *pedon*. The the two-dimensional face of a pedon is a *profile*.

MASTER SOIL HORIZONS

Soil Horizons

Diverse types of soil layers have been grouped into 6 categories of master horizons, based on how their composition and how it has been influenced by eluviation or illuviation. Each master horizon category is designated by a letter: O, A, E, B, C, and R. Though there are many intermediate types and variations within each category, you only have to learn 6 major horizon types to understand basic soil profile description.

Master and Transitional Horizons

organic matter ↓	O	**organic**	forms above the mineral soil profile, dominated by fresh or partly decomposed organic material
↓	A	**mineral + organic**	organic-enriched mineral horizon; may be characterized by eluviation of Fe, Al, and/or clay; often darker, coarser-grained
	AE or AB		dominant A with some E or B (not easily separated); often thin
	A / E or A / B		discrete, intermingled bodies of (predominant) A and (subordinate) E or B
	EA		dominant E with some A (not easily separated)
	E / A		discrete, intermingled bodies of (predominant) E and (subordinate) A
clays oxides carbonates ↓	E	**mineral**	intensely weathered horizon just below A; eluviation of organic matter, clay, Fe, Al; resistant silicates remain; often lighter than A/B; common in forests, rarer in grasslands
	EB		dominant E with some B (not easily separated)
	E / B		discrete, intermingled bodies of (predominant) E and (subordinate) B
	BA or BE		dominant B with some A or E (not easily separated)
	B / A or B / E		discrete, intermingled bodies of (predominant) B and (subordinate) A or E
salts (in wetter climates) ↓	B	**mineral**	forms below O/A/E. Characteristics: subsurface soil structure; illuviated clay, Fe, Al, silicate, $CaCO_3$, $CaSO_4$, in-place weathering, and/or $CaCO_3$ loss
	BC		dominant B with some C (not easily separated)
	B / C		discrete, intermingled bodies of (predominant) B and (subordinate) C
	CA or CB		dominant C with some A or B (not easily separated)
	C / A or C / E		discrete, intermingled bodies of (predominant) C and (subordinate) A or B
	C	**mineral**	least weathered (lacks A/B properties); excludes bedrock but may retain some features (or may not originate from bedrock); alteration usually from biochemical weathering (roots and/or microorganisms)
	R	**mineral**	unaltered, often consolidated, bedrock

MAJOR SOIL FACTORS IN HOMER

<u>Major factors forming Homer soils</u>

Cold - water is frozen, unavailable to life for months every year.

More rainfall than evaporation - the land is often saturated,and water tables are often close to the soil surface, which restricts available oxygen in the soil, slowing decomposition.

Nutrients are leached away by snowmelt and rainfall. As water passes though the soil profile, soluble nutrients are carried into groundwater and streams. Soil nutrients may be replaced gradually from these sources:

- weathering rocks
- decaying leaves and stems on the soil surface and decaying roots within the soil
- dust particles and raindrops
- alders and some lichens partner with microbes to fix nitrogen from the air
- spawning salmon deliver scarce nutrients to headwaters.

Spruce forest produces acidic *mor* humus.

mor humus - from acid, low-nitrogen plant litter, such as conifer needles, which microbes decompose slowly. A thicker layer of poorly decomposed litter accumulates (10-20 cm), forming an organic horizon (O) well colonized by fungal hyphae and plant roots. There is an abrupt boundary between organic and mineral horizons, evident by a distinct color difference, the thin, black organic layer (O) contrasting with the pale, leached mineral soil (E) beneath. Mor humus is usually formed under coniferous forest (Lukac & Godbold 2011, 114).

Bluejoint (*Calamagrostis canadensis*) grassland produces *mull* humus.

mull humus - derived from easily decomposed litter, which forms a thin (0-5 cm) layer over a dark mineral (A) horizon that shows signs of intensive soil organism activity, especially earthworms. In grasslands decaying fine roots throughout the topsoil are a significant source of organic material. Soil pH is higher than mor-topped soils. The A horizon is relatively deep (20-50 cm) and gradually transitions into the less organic horizon beneath. Mull humus is more nitrogen-rich than mor humus, with C/N ratios of 10-15. Mull is usually formed under deciduous forest and grassland (Lukac & Godbold 2011, 114).

Organic acids from spruce and other plants leach through the soil and accumulate in wetlands. These acids make some nutrients unavailable and inhibit decomposition, contributing to the accumulation of thick peat deposits.

Volcanic ash, deposited from eruptions on the west side of Cook Inlet, is an important component of parent materials for many soils on the Kenai Peninsula (Ping et al. 1989).

Many soils in the Homer Bench are derived from successive mudslides and debris flows off the ridge. Frequent erosion and deposition events create surfaces that are too unstable for long-term soil formation to occur.

HOMER SOIL TYPES

Table 1. Major soil orders of the Homer-Ninilchik soil survey area (271,700 acres). Percentage cover is from (Hinton 1971). Current classifications are from official NRCS descriptions (SSS 2014a).

Soil Order	% area	Major Features & Concept
Entisol	6.4	undeveloped horizons
Inceptisol	5.5	poorly developed horizons
Spodosol	37.0	pale, leached horizon over darker horizon; formed under spruce forest; Mor humus
Histosol	20.3	very thick surface layer of organic material
Andisol	24.4	thick, organic-retaining surface horizon; Mull humus; derived from volcanic ash

These are soil orders, major categories of soils distinguished by features that indicate which processes dominated their formation. Knowing which major soil orders are in the landscape and how to recognize them gives you a lot of insight into the patterns of vegetation, and which plants can grow where.

A particular soils that share similar profile characteristics are grouped in Series. These are the basic units of soil classification. Similar Series are grouped into a Family; similar Families are put into a Great Group; similar Great Groups are gathered into an Order, such as Spodosols. A Soil Series is usually named for the place where it was first described.

SPODOSOL PROFILE IMAGE
Spodosols often form under boreal spruce forests that produce mor-type humus. The soil order name was derived from Greek *spodos*, wood ash, which relates to the older name, *Podzols* (Wikipedia “Podzol”), derived from Russian *pod* (beneath) and *zol* (ashy), referring to the pale horizon beneath the darker surface layer (Moorberg 2012). In Spodosols water carries acids from spruce needles and other plant litter down through the soil, leaching minerals and humus away from the upper soil. The eluviated soil becomes a pale, bleached, *albic* (E) horizon. The leached iron and organic matter accumulate below in a dark, illuviated *spodic* horizon.

If a soil profile shows an abrupt change from the surface organic material to a pale mineral soil, and there is a darker layer below the pale soil, it’s probably a spodosol. Mutnala, Tokositna, and Spenard Series soils are common spodosols in our area.

When you see a spodosol profile, assume the soil drains well.

Spruce forest and spodosol go together. If you want to grow something other than a spruce forest on these soils, add nutrients as compost and buffer the acidity with ground limestone. This will promote the conversion of mor-type humus to mull-type humus.

HISTOSOL IMAGE
Histosols can be recognized by a thick layer of organic material on the surface, often derived from *Sphagnum* moss. The organic layer is often fibrous - full of partly decomposed plant remains, with very little mineral soil. These are peatland soils, where decomposition has been slowed by cold, wet conditions. Most of the world’s peatlands are between 50° and 70° north latitude (Bridgham et al. 2001). Homer, at 59°, is in the middle of this zone.

The factors that slow decomposition and promote peat accumulation are low oxygen, cold temperatures, and organic acid accumulation. Drainage to promote fluid flow through the soil can make these soils productive for conventional gardening, but there may be temporary severe nutrient deficiencies as the microbial community shifts from anaerobic to aerobic decomposers. Histosols may collapse after draining as the aerobic decomposers convert part of the peat into carbon dioxide. Starichkof, Doroshin, and Salamatof Series are some of the Histosols found in the Homer area.

DARK ANDISOL IMAGE

The Andisol Order name was derived from *ando*, Japanese *an* (dark) *do* (soil) (Takahashi & Shoji 2002), referring to volcanic soils with dark horizons containing high amounts of organic carbon. Unlike the Histosols, the organic carbon in Andisols is mostly well decomposed humus, very small particles complexed with the unique minerals found in Andisols. Rapid weathering of volcanic ash creates minerals that retain organic matter and water. In temperate and tropical climates these soils support productive agriculture and relatively dense human populations. The most extensive Andisols in the Homer-Ninilchik area have been mapped as Kachemak Series. These soil are often covered by grassland or alders. The organic surface material transitions to a dark topsoil at least 5 inches thick. There is no pale albic horizon in these soils.

If you see an Andisol profile, consider this a good source of fertile topsoil.

LAYERED ANDISOL

Volcanic materials are deposited in discrete eruptive episodes. Consequently Andisol profiles often have horizons showing a sequence of deposition events and soil development, with older soils buried by subsequent volcanic deposits of new parent material.

GLEYED ENTISOL - GLEYED PROFILE IMAGE

Beluga Series soils are common around Homer. They are in the Entisols Order, more precisely are considered Cryaquents - Entisols formed under the influence of high water tables and cold temperatures. The concept of Entisols groups soils that show relatively little alteration of the parent materials – not much eluviation, illuviation, or weathering – either because there has been too little time for soil to form, or the soil-forming processes have been retarded. Beluga soils appear immature, having shallow topsoil (about 6 inches thick) over gray, gleyed horizons.

The gleyed layers indicate frequent oxygen deprivation due to prolonged water saturation relatively close to the soil surface. When oxygen flow into the soil is restricted by a high water table, microbes decomposing the organic material use up available oxygen close to the soil surface. The hungry microbes below have to switch to anaerobic fermentation to consume organic matter, switching from oxygen to iron as a terminal electron acceptor. The iron in the soil is changed from the warm rusty colors of oxidized Ferric iron into the bluish-gray of reduced Ferrous iron (Craft 2001). Whenever oxygen is introduced into gleyed soils, whether though root channels or temporary lowering of the water table, the reduced iron gets oxidized, which creates a mottles color pattern of reduced gleyed gray and oxidized orange rust.

Beluga soils are associated with Discharge Slope Wetlands (Gracz 2011), which are a unique complex of footslope seep habitats on the alluvial fans downhill from Skyline Drive. These Discharge Slope Wetlands are the upper part of the “Wetland Heart of Homer” (HSWCD 2013). Most soil formation occurs through the downward percolation of water through the soil profile, which eluviates material, forming distinct horizons. Gleyed horizons indicate that water moves so slowly through the soil that it becomes depleted in oxygen, hence soil-forming processes are substantially retarded due to slower vertical percolation.

<u>Concept application with soil profiles</u>

SPODOSOL profile: Is this soil likely to have a drainage problem?

HISTOSOL profile: What are the dominant factors influencing this soil?

ANDISOL profile: Is this soil likely to grow healthy vegetables?

GLEYED soil profile: What happened to this soil?

<u>This is the background information to get you started. How can you understand the soil in your neighborhood?</u>

A recent soil survey of the Western Kenai Peninsula is available online (Van Patten 2005). Or if you want to focus on your own place, create and download a soil report using the Web Soil Survey (SSS 2014b).
WEB SOIL SURVEY HOME SCREEN: push the green button to start.

- AOI SCREEN: locate your site and define your area of interest (AOI).
- AOI DEFINED
- MAP SCREEN: You will get a map with a customized report of the soil mapping units.
- BELUGA SILT LOAM MAP UNIT DESCRIPTION: Each map unit is described in terms of its component soils and there functional interpretations.

Remember that the mapping is not detailed, and will not show recent changes due to construction activity. It simply narrows the possibilities for you to consider when trying to find out what kinds of soils you have.

You still need to describe a soil profile to understand which soil you are dealing with. Dig a hole and look at the soil. If you see trenches or ditches nearby, check them out. Look for pale, leached layers, organic-enriched layers, oxygen-deprived layers, and contact with the underlying, unaltered geological material.

SOIL PROFILE BEFORE CLEANING

- CLEANING THE PROFILE - Use a spade and trowel to expose a fresh face.
- CLEANED PROFILE
- BOUNDARY DETAIL
- PEGS MARK BOUNDARIES - Stick nails or twigs in to mark horizon boundaries. As you check colors and textures of each horizon, you may want to reposition your boundary markers.
- GLEYED LOWEST C HORIZON
- USING MUNSELL BOOK FOR COLOR DESCRIPTION

SOIL TEXTURE TRIANGLE
Estimate the textures of each horizon to determine its texture class. This allows you to compare your soil with official descriptions which specify the texture class of each horizon in a representative profile. Soil texture has a major influence on how well water and oxygen percolate and how well nutrients are retained.

JAR METHOD
Soil texture can be estimated by shaking a sample in a jar with water, then measuring the thickness of settled materials at different times, as the larger particles settle out first and the fine particles stay suspended. For example sand particles settle out within 40 seconds after shaking stops. Using a dispersant such as Calgon helps break up the clay clumps so you get a more accurate indication of the clay content. The method is described online by Ted Sammis (1996).

HAND METHOD FLOW CHART
The hand method is useful when you are onsite describing the soil profile. You may not be accurate in your estimation; however getting a feel for each horizon reveals which are coarser and finer, thus allowing you to diagnose master horizons. The flow chart is available online from NRCS (2014).

YIN-YANG
<u>Working with soil</u>
Soil is a complex, living ecosystem. It seethes with life, death, and transformation. It is the foundation of *Genius loci*, the attributes unique to a particular place. How do you deal with a 'wild' thing that is sometimes hard to understand and predict? Based on what we understand about Homer soils, what practices could enhance the soil system to improve plant health?

If you want the most control, remove the native soil and replace it with a rich, weed-free topsoil, then add appropriate amendments as indicated by soil testing. Brenda Adams (2013) uses this method to deliver a predictable garden bed that conforms with her original designs. More control requires more investment of money and/or energy.

Living soil is 'wild' – its communities self-organize to adapt to whatever constraints they experience. If you choose to negotiate a garden out of native soil, try to understand the natural soils before you start to cultivate, so that your inputs will be skillfully efficient in adapting plants, soils, and your expectations in an evolving possibility rooted in place.

Most people want the most fertile soil to grow the most plants – understandable, yet excessive fertility can have adverse consequences when nutrients wash into streams and groundwater.

When water moves easily though soil, it can carry substances, and as it drains, oxygen can penetrate into the vacant pore spaces. When fluids flow well, life thrives. Soil that has more available oxygen also has more biological activity. Make raised beds if your site is saturated for long periods, to keep fluid moving through the soil.

Feed the soil well. Create mull-type humus by adding compost and using cover crops. Local sources for nutritious compost include fish processing waste and seaweed.

Hügelkultur SLIDE
Dead wood and its associated soil organisms form the basis of *Hügelkultur* (Wheaton 2014). This practice mimics the colonization of fallen logs by soil-forming organisms, which create a place where seedlings can establish. You can observe this natural process along the Calvin & Coyle Trail northeast of Beluga Lake.

> Here, in the redwoods, dead trees and dead tree parts are treated like treasured resources, considered an essential, useful and interesting element of this landscape. Most are left to lie where they fell, but some smaller and more easily moved dead trees are used to lessen potential erosion problems from road cuts and construction damage. Some are arranged parallel to the slope. Others, with complex branching structures still intact, are set into the hillsides with trunks perpendicular to the slope, a technique called *vegetative riprap*. Major limbs hug the hillside, providing small niches where soil can accumulate and plants begin to grow. Branches and whole trees are placed with their base snugged into the base of the slope, smaller branches and twigs heading upward. The niches formed by these numerous crotches accumulate soil and make good nurseries for seed and transplants. Compared to other methods used to stabilize minor road cuts and stream banks, such as cement sacks, cement blocks, or imported rock, vegetative riprap can be an unobtrusive, natural-looking way to hold slopes until plants become established.
>
> The gardeners at these sites are enlightened practitioners of the restoration arts, including in their yards a place for coarse woody debris. The presence of coarse woody debris is a crucial element in old-growth forest. In old-growth Douglas fir forests, 25 percent of the total biomass consists of coarse woody debris, standing or downed logs in one or another of what biologists have separated into the five stages of decay before final incorporation into the forest floor. The complex and varied accumulation of different kinds of woody debris in the forest is the keystone of its biodiversity. (Lowry 2007, 115-116)

POLE BASKET TO RAISE SOIL
Dead wood is a major food source for many local soil communities. Use macrowoody debris to create raised beds.
TONY’S RAISED BED WITH TREE TRUNKS

ELAINE INGHAM
Dr. Elaine Ingham has led a growing awareness of the husbandry of soil organisms. People are being trained in ecological soil testing using microscopes to assess relative abundance of bacteria, fungi, protozoa, nematodes, etc. Her website, soilfoodweb.com, is a source of useful insights.

SOIL BIOLOGY REPORT
This is a soil biology report I requested for a soil sample taken from a healthy-appearing tallgrass prairie, which seemed to be an appropriate model for an urban prairie restoration project in Fort Worth. This information about relative amounts of bacteria, fungi, and protozoans, along with the types of nematodes, provided a baseline for comparing with the urban prairie soil, to indicate how successful our restoration was.

COMPOST TEA MAKERS
In tandem, there is widespread experimentation with diverse kinds of compost teas to add microbial communities with bacteria/fungus ratios tailored to specific soils and plant communities. The intent is to improve nutrient availability and reduce the risk of plant diseases by creating a healthier soil.

FINAL POINTS
The more you observe and experiment with soils, the better you understand the foundation for plant health. This knowledge helps you read the landscape and create a richer sense of place. A culture that sustains a healthy relationship with the soils that support it gains resilience and perspective essential for long-term survival, as it shifts from plundering to co-evolving.

How would you create a healthier relationship with soils?

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