Introduction to Plant Indicators

Weeds, those pests in your fields, are going to become your most valuable tool for testing your soil.

Most fields have weeds. They are there day and night, rain or shine, experiencing the forces that shape plant growth. Weeds can be used as dynamic and sensitive indicators of growing conditions in a field.

For millennia, farmers and ranchers have been observing weeds and making decisions based on their observations. Acquiring this detailed information has been a long and arduous task.

This specific weed information has been stored in a computer database to enable everyone to make use of this skill. High-tech tools now give modern farmers, ranchers, and gardeners information that formerly took a lifetime to acquire. This is the basis for the reference section of **Reading Weeds**.

Let's consider the use of plant indicators in modern agriculture. A chemical soil test is a snapshot of what is happening at that moment in the soil. From this you can infer how the crop plant might react. This is an educated guess, based on the factors of a chemical reaction and comparison to similar situations, but still a guess.

In contrast a weed seedling has survived at least several weeks of the nearby conditions, and its development tells much about those conditions. The ability to translate its message is especially valuable because it measures directly the field's ability to grow plants. This, of course, is the soil quality you most want to know.

Chemical laboratory techniques and field assays are in no sense competitive, but closely complement one another. In addition to your other conventional methods of field evaluation, weed indicators give you different information. Also whenever you are in your field, you can make observations.

Surveys of weed seeds have shown ranges of 10,000 to 50,000 seeds per square foot of soil in a field. In most fields these don't all sprout at once. Since a seed waits to germinate until conditions are right, when you see a weed seedling you know that these requirements were met at least for a short time.

To germinate, seeds may require standing water, freezing, fire, fermentation, a lot of oxygen, or other factors. Knowing this helps you predict a crop's performance. After the plant is up, its growth shows that its growing conditions are also being met, giving you that much more information about the soil.

Clements said that "Every plant is a measure of the conditions under which it grows, an index of soil and climate, an indicator of the behavior of other plants and of animals in the same spot."

Three broad categories of plant properties are used as indicators. These are **floristic composition**, **morphology**, and **elemental composition**. Your choice of category will differ with the system you are studying.

Floristic Composition

A classic plant indicator is a single species whose presence or absence indicates the level of a soil quality. Some plants need a particular mineral to grow. For instance halogeton needs salt to grow (this is very rare), so its presence indicates a high level of salt in the soil.

Generally, though, it has been recognized that the entire plant community, or at least a large part of it, should be used as an indicator of conditions. The community gives repetitive, but more reliable, information about soil qualities.

Morphology

Morphology, or the study of form, is usually used to indicate plant vigor and can be used to indicate the level of soil qualities. In areas where high levels of toxic minerals occur, toxicity often results in changes in plant form and vigor. Levels of elements that are not toxic may also affect the vigor of plants whose requirements and tolerance differ widely from the levels found locally.

For instance salt can make plant leaves thick and fleshy, and high levels of nitrogen can make the distance between leaves longer.

Not only a specific quality, but the entire environmental complex may be assessed by the morphology of an indicator plant. For example, work in the western USA has shown that the growth and vigor of bracken fern (Pteridium aquilinum L.) may be a good indicator of the productivity of a site for forest trees.

Elemental Composition

Levels of a particular mineral within the plant tissue can often be used as an index of its levels in the soil. Plants vary in what minerals they concentrate, passively uptake and exclude. Some plants take up a nutrient to the extent it is available in the soil. These are valuable for assaying agricultural areas. Studies of grassland weeds show that the level of potassium in buckhorn plantain leaves is directly proportional to the potassium in the soil.

Other plants concentrate minute amounts of a mineral many fold in their structure. This is the basis of geobotanical surveying, the art of finding economic mineral deposits by plants growing on the site. In Canada alpine fir needles are found to be a very sensitive indicator of molybdenum in the soil. The fir concentrates molybdenum five fold in its needles where it is easily collected and analyzed.

Use of Plant Indicators - Factor, Process, Practice

There are three main types of uses for indicator plants: factors, processes, and practices. **Factors** include climate (both macro and micro), light, temperature, soil, nutrients, and toxins. **Processes** include fire, lumbering, cultivation, erosion, and so forth, and **practices** are agriculture, forestry, and grazing.

Factors in a Plant's Growth

Not all weeds are created equal. Some are more valuable indicators than others because they have more stringent needs. They are conservative and refined, and opt for quality sites. Others live frivolous, gregarious lives, growing just anywhere.

For example, pigweed only indicates a generally temperate climate, whereas sheep sorrel requires low lime, acid soil that has insufficient drainage, and a hard pan. Thus sheep sorrel is much more valuable as an indicator than pigweed. This illustrates the great difference in the amount of information you can get from one plant.

Eco-Geographic Range

A plant has a definite eco-geographic range. This means a fairly well-defined geographic area, altitude range, climate range, soil type, and moisture level. In the middle of this range the plant grows well in a variety of soils, but at the limits it becomes very selective. No longer does it tolerate just any old soil, but must have a special one. Thus a plant is a better indicator at the limits of its range.

Altitude

Altitude affects plant growth through temperature. Under normal conditions temperature generally decreases with increasing elevation: when you go up, the air gets colder. The rate of decrease is not uniform but varies with time of day, season, and location, generally averaging about 3.6 °F (2.0 °C) for each 1,000 ft. rise.

Plants use chemical reactions to grow. The speed or rate of chemical reactions slows by half with an 18 °F (10 °C.) drop in temperature. Thus, considering just altitude, plants will grow half as fast at 5,000 feet than at sea level,

Plant Form

The **form** a plant takes affects the way it absorbs water and nutrients. Different forms of roots pick up water from different depths of the soil. Fibrous roots spread out just under the surface to catch frequent rains or irrigation, while tap roots dive deep to bring up water when none has fallen for a while.

Water

Water is necessary for life, but too much excludes air, which is also needed. Ideally for crops an equal mix of soil particles, water, and air make up the soil. Water also mobilizes nutrients, or leaches them away from the root zone. Knowing how, when, and where a weed likes its water tells you useful information about a field's water budget.

Soil Texture

Soil texture can affect water drainage and water availability. This in turn favors one kind of root system over another and thus one plant over another.

The parent material of the soil, and its particle size and shape, determine what minerals are available and how easy it is to release them. Granitic, limestone, and alluvial soils have different balances of nutrients. The smaller the size of the grains, the more surface area is exposed to weathering or attack by plant roots.

Clays have plates of minerals. If worked moist, the plates are separated and the soil friable. But worked wet, clay becomes brick-like, and an unreceptive home for crop roots. However, some weeds (called colonizers) even thrive and flourish in this soil in stark contrast to the puny crop plants.

A simple test is used to determine if a clay soil is too wet to work. A handful of soil is squeezed in the palm of the hand and the hand opened. The resulting clump is flicked with the thumb. If the clump falls apart the soil is dry enough to work. If the clump sticks together the soil is too wet.

Puny crop plants and colonizer weeds indicate that the soil structure has been destroyed.

Organic Matter

Organic matter in the soil helps plants grow directly and indirectly. Plants mainly take up elements dissolved in the soil solution (or colloid). In many sterile soils, vital elements are chemically locked up and do not dissolve well in water. Decomposed organic matter or humates solubilize (chelate) these nutrients, keeping them available for roots to drink. After all, plants eat soup, not steak.

Organic matter, in various stages of decay, feeds microbes that mobilize minerals from the native rock. Microbes also hold precious nutrients on a water film on the soil particles. The amount one alga, fungus, or bacterium contributes is not impressive, but consider the nutrients contained by 5-25 tons of living organisms in an acre plow slice (top 8") of soil.

Some of these microbes also have symbiotic relationships with the plant roots, swapping minerals for sugars. Many common garden weeds need this lively community atmosphere, while others, like hermits, prefer rugged, sterile soils.

Limitations of Weeds as Indicators

Of course, reading weeds isn't foolproof. Some situations complicate using indicator plants. For instance, **anomalies** in the soil can permit a plant to take root. Then once rooted, the plant modifies its environment to please itself. The plant then correctly indicates the qualities of the micro-site, but not the general condition of the area.

Ecotypes confuse the picture further. An area may select a genetic extreme from a weed's gene pool. Where the average weed of that type may barely tolerate an acid soil, an ecotype that developed in an acidic area may live only in acid soils.

Considering a community of plants rather than a single individual keeps these cases from influencing your field evaluation. One plant that just doesn't fit in with the rest of the community you can give special consideration. It could indicate pockets of different soil or could just be an oddball plant. More thorough investigation may show a spot with special qualities or expose it as a fraud.

Weed communities have been extensively studied by ecologists, and in fact, are part of a special field of ecology called **plant sociology**. Plant sociology evaluates interactions and associations of plants (including weeds) to determine which develop in each area and in what order. Although this becomes extremely involved, some parts can be applied to everyday experiences.

What we notice is that one group of plants will colonize a particular type of soil. Then another group will gradually build up numbers crowding out the first group. This is refered to as succession. One group inherits a realm that has been civilized by the colonizers.

Weeds as Indicator Plants

The best way to start using indicator plants is to map the weeds in a particular field. Next, determine their indicator value and interpretation. Then overlay this map with other maps of the same field, comparing the new information to land features and soil variations.

Besides the weed's presence, the shape of its growth can indicate excess or deficient nutrients, heavy grazing, or compacted soil. For instance hawkbit and dandelion have only half the leaf length and plant diameter in heavily grazed pasture that they do in lightly grazed pasture. The percentage of English daisy leaves flat on the ground increases from lightly grazed, to heavily grazed, to mowed lawns.

Basic Factors

Now let us look at some factors important to the average grower.

Water has probably the most dramatic plant indicators. Chickweed and annual bluegrass show a good steady supply of water to the surface. Common horsetail shows a high water table, while swamp horsetail indicates that water stands in the spot for part of the year. Deep-rooted weeds like purslane suggest a lower water table.

Compaction by traffic promotes the growth of plants with low rosettes that can tolerate being trampled regularly, like plantains and hawkbit, or plants whose seeds need to be crushed to sprout, like pineapple weed. Layers of compaction, like plow pan, encourage docks, dandelion, and wild lettuce. Thoroughly compacted soil has primary colonizers (if anything), like lupines.

Small dips in the surface of the soil allow cooler air or frost to collect. The difference can be enough to stimulate the growth of a particular set of weeds and retard the growth of the common weeds. Thus patches of different weeds can indicate surface relief and its temperature-caused changes.

Air temperature is usually highest close to the ground and decreases with height, since most atmospheric heat is received directly from the surface of the land and only indirectly from the sun. In cold areas plants hug the soil surface or snuggle up to rocks. Darker colored soil absorbs more of the sun's heat and thus affects plant growth.

Macro nutrients (nitrogen, phosphorus, potassium, calcium, magnesium, sulfur) usually aren't considered to be reliably indicated by weeds. Despite this, some general guidelines can be useful. Legume weeds grow where nitrogen is low, and grasses where nitrogen is high. If redroot-pigweed and other weeds are reddish-purple and stunted, there is a low level of available phosphorus. The concentration of potassium in several grasses, especially sweet vernal grass, cocksfoot, and German velvet grass, responds directly to the amount in the soil.

Plants can't stand much salt, so it's important to know when and where salt may be increasing. Salt buildup in the soil can be inferred by the presence of halogeton, Russian thistle, or shepherds-purse - all plants that can stand salt or need it to survive.

Since the pH, or acid-base balance, determines what metal ions will move with the soil solution or stick to the soil particles, it dramatically influences weed growth. Some plants that like a low pH or acid soil are wild oat, smartweed, knotweed, curled dock, sorrel, corn spurry, buckhorn plantain, and English daisy. A high pH or alkaline soil favors orache, chickweed, columbine, shepherds-purse, hares-ear mustard, wormseed mustard, klamath weed, and broadleaf plantain.

One of the common current uses of plant indicators is to determine toxic substances in the soil. Cucumbers, oats, beans, and annual ryegrass are used to determine herbicide residue and evaluate drift. Plants have been used by prospectors to locate metal deposits. Some of these plants could be used in specialized situations, such as in serpentine (acid, high nickel, manganese) areas, to check for toxic heavy metals. There is a spiderwort (Tradescantia sp) variety that is used as a radiation monitor. This spiderwort is used by environmentalists to evaluate and document low level radiation leaks from nuclear power plants.

Scope of Book and Reference Section

The database covers the soil preferences of 500 common weeds, pasture plants, and native plants, focusing on the indicator value of the plants. To make this more generally useful I have included notes on non-chemical control, botany, climate, allelopathic interactions with crop plants, competition, value as groundcover or nurse plant, related microbes, food, fodder, and uses.

The plants selected are all of those listed in "Common Weeds of the United States" Dover reprint of a USDA publication, and "World's Worst Weeds" by Holm. A number of others were added from "Range Plant Handbook" by Phillips Petroleum and "Weeds" by Muencher based on occurrence and available information. Some plants were excluded because they grow solely in water. Some ground cover and crop plants were included because they are often found escaped from cultivation.

This should permit anyone in the continental United States to look around in their yard, garden or cultivated field, find several weeds listed in this book and interpret the condition of the soil. The written material should give one enough background to start reading weeds.

Value

Weeds are valuable, they can tell you what you are doing right or wrong. And just as a rowdy pet is both loved and irritating, weeds are viewed with ambivalence. **Reading Weeds** adds some more items to the positive side of the balance sheet.

The more you know about the plants growing in your area, the more you will enjoy working around them. So investigate the plants you see every day, learn their special indicator value, and begin reading the messages in the weeds.