Palouse and Nezperce Prairies Soil Quality Card Guide

Accompanies the Palouse and Nezperce Prairies Soil Quality Indicator Card

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Contents

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Additional Copies:
Additional copies of The Palouse and Nezperce Prairies Soil Quality Indicator Card and Guide can be obtained from the Nez Perce Soil and Water Conservation District at 1630 23rd Ave., Suite #501, Lewiston, Idaho 83501.

The Palouse and Nezperce Prairies

Soil Quality Card Guide

Agricultural producers, conservationists, and other land managers need reliable methods to assess soil quality to make management decisions that maintain long-term soil productivity. A group of North Idaho and Eastern Washington growers identified 10 soil quality indicators for the Palouse and Nez Perce Prairies, which will assist in assessing the impacts of agricultural activities on soil management.

This guide is designed to supplement the *Palouse and Nezperce Prairies Soil Quality Card* by providing information on the role of management, explaining why the soil quality indicators are important, and giving detailed methods for evaluating them.

Each field and soil that is assessed will start from a unique baseline or reference point, and the changes in indicators from year to year will show how management is affecting soil quality. An important point to remember is that soil characteristics, such as clay content, are not affected by management.

Soil-quality indicators are highly interrelated. For example, conditions of soil structure such as aggregate stability, compaction, and pore size influence and are influenced by, the activities of earthworms and other soil organisms. Water infiltration and availability, which are controlled by surface and subsurface soil structure, affect plant root growth and plant root health. Organic residue and root biomass from crop plants feed soil organisms and contribute to soil organic matter, which in turn enhances soil structure. These interrelationships begin to show the complexity of soil systems.

Using this Guide

For each indicator, this Guide contains:

- A description of the indicator
- An explanation of why the indicator is important for judging soil quality
- A discussion of how management affects the indicator
- Suggestions for when to assess the indicator
- Instructions for performing an accurate assessment

The assessment calendar on Page 4 shows the times of the year that are best suited for assessment of each soil indicator. Times vary according to the crop grown, but it is important to maintain as much consistency as possible from year to year in the assessment of each field. Assessment of some or all of the indicators more than once a year also provide a clearer picture of potential changes in soil quality.

Several indicators include instructions for performing both a basic and a more rigorous assessment. The rigorous assessments give more precide information, but require more time and equipment than the basic assessments.

Regardless of method used, accuracy increases if the same test or observation is done in several representative locations within a field to get an average rating for the indicator. Assessments performed consistently and carefully each year yield the most reliable information on soil quality.

Assessment Calendar					
Indicator	**Before planting Early spring**	**Active crop growth**		**Late Fall**	**Winter**
		Spring	**Summer/Fall**		
1. Infiltration	✓	✓	✓	✓	✓
2. Compaction	✓	✓	✓	✓	✓
3. Tilth and Structure	✓	✓	✓	✓	
4. Organic Matter	✓	✓		✓	
5. Plant Residue	✓	✓	✓	✓	✓
6. Worms	✓	✓		✓	✓
7. Erosion	✓	✓	✓		
8. Seedling Emergence		✓	✓		
9. Plant Growth		✓	✓		
10. Rooting Systems		✓	✓		

Management, crop and climatic factors determine the optimum time of soil quality assessment. The assessment times in this calendar are appropriate for the Palouse and Nezperce Prairies in Northern Idaho and Eastern Washington.

1 Infiltration

What is water infiltration?

Infiltration is the process of water entering the soil. When the soil is in good health or good condition, it has stable structure and continuous pores to the surface. Soil porosity is very important to infiltration. The number, length and size of pores determines water movement and retention. Large pores (1/16th to 1/4th inch in diameter) are responsible for the majority of water flowing through a soil.

Water infiltration is also affected by other soil factors such as texture, slope, compaction, soil aggregation and structure. Sandy soils generally have higher infiltration rates than silty or clayey soils. Water tends to drain more quickly from positions higher on the landscape.

Soil structure can control water infiltration. Unstable soil aggregates disintegrate when wet, and release small clay particles that clog pores. Compacted soils restrict water movement into deeper subsoil layers where water is stored for plant use.

Why is water infiltration important?

- Soil with good infiltration has little surface runoff and resists erosion. Good infiltration means the soil dries out and warms up quickly after heavy rains.
- When there is good infiltration of water into the soil due to proper management, the soil can capture as much as allowed by the specific soil type. This will, in turn, increase the water holding capacity of the soil, which allows for adequate moisture for plant use longer into and during the growing season.
- Increased surface runoff can carry soil particles, surface applied fertilizers and pesticides off the field.

How does land management affect this indicator?

Management that promotes topsoil with a loose granular or crumb structure composed of aggregates that maintain their integrity when wet, will be conducive to good water infiltration.

Tillage operations that preserve soil structure promote good water infiltration. The addition of organic matter from organic residues will greatly improve the soil aggregate stability and hence, increase water infiltration.

Decreasing the formation of crust by maintaining plant cover or by practicing residue management will decrease the impact of raindrops on the soil to improve infiltration.

Infiltration is best assessed after a heavy rainfall when you know the soil is completely saturated. Observe and record the duration of any ponding on the soil surface.

How is the indicator assessed?

If you use the open cylinder method (shown at right) to determine water infiltration, you can perform the test at any time of year. This assessment method is more quantitative and may be performed at more than one location in the same field

Basic Test

Materials needed:

Palouse and Nezperce Prairies Soil Quality Indicator Card

What to do:

To assess this indicator, observe the field after a saturating rain or irrigation, and record how long water stands in the field

Cylinder Test

Materials needed:

- Notebook
- Open metal cylinder about 6” in diameter & about 6” long, that is sturdy enough to be driven into the soil.
- Container with several gallons of water

What to do:

1. Push the cylinder into the soil so that about 3 inches extend above the top of the soil to allow water to be “ponded” there.
2. Place a cloth, burlap bag or plastic wrap on the soil surface to absorb the energy of the water as it is poured.
3. Gently fill the top of the cylinder with water and keep it full by adding water as it percolates down. Note that pouring water too vigorously on the soil surface may disrupt infiltration. Continue adding water and refilling the cylinder for about one-half hour or until you are sure the soil within the cylinder is completely saturated.
4. Observe the amount of time a known amount of water (e.g., 1 gallon, 1 quart, etc.) remains on the surface within the cylinder after the soil within the cylinder is saturated.
5. It is important to note whether the cylinder has been placed in a tractor wheel track, because these areas usually allow slower infiltration than non-track areas.

Rating the indicator		
Least desirable=1	**Moderate=5**	**Preferred=10**
Water ponds or runs off field following most rains. Long wait to get on the field following rain; Soil surface is crusted.	Water drains slowly with some ponding. Soil surface may be partially crusted.	Soil drains well after rain; Little or no ponding or runoff following rain. Can move equipment into field immediately following a rain event.

2 Compaction

What is compacted soil?

Soil compaction occurs when soil particles are pressed together, reducing the pore space between them. Compaction occurs when farm machinery repeatedly passes over the same area of soil. The weight of the equipment, the number of trips across the field, and the type of soil determine the degree of compaction.

Why is compaction important?

- Compaction restricts rooting depth, decreases pore size, and affects the activity of soil organisms by decreasing the rate of decomposition of soil organic matter and subsequent release of nutrients.
- Soil compaction greatly decreases infiltration and thus increases runoff and the hazard of water erosion.
- The reduced pore space that results from compaction limits the ability of earthworms and other organisms to live in the soil.

How does management impact compaction?

The more intensely a soil is tilled, the more likely it is to be compacted. Fewer trips across the field can reduce compaction. Machinery that has axle loads of more than 10 tons may cause compaction below 12 inches.

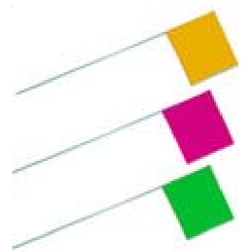
Compaction can be prevented or reduced by not working the soils when they are saturated. Often, compacted soils are found just below the till zone. This depth is the downward limit of stirring and loosening action performed by implements. Physically breaking through a deep compacted layer with subsoiling equipment when the soil is dry can counteract deep compaction.

Increasing organic matter in soils by addition of cover crops and organic residues will contribute to biological activity and aggregate stability. This will greatly enhance the soil's ability to resist compaction.

How is the indicator assessed?

Assess soil compaction both before spring tillage and during the crop growing season.

Soil moisture content greatly affects penetration into the soil. Perform this assessment when there is adequate moisture in the soil for crop growth.



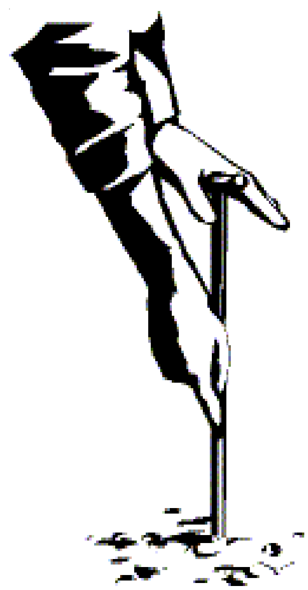
Basic Test

Materials needed:

Wire flag or metal rod about 1/8 inch in diameter

What to do:

Hold the wire flag or rod and push it vertically into the soil at several different locations in the field. Record the depth at which it bends due to resistance in the soil.



Rating the indicator		
Least desirable=1	**Moderate=5**	**Preferred=10**
High resistance to penetrations by soil probe, shovel, wire flag, tillage implement, etc. Tillage pan present. The flag bends readily. Plant roots that turn horizontally indicate a hardpan.	Some resistance to penetration by soil probe, wire flag, tillage implement, etc. Some restrictions to a penetrating wire flag, some root growth restrictions.	Little resistance to penetration by soil probe, shovel, wire flag, tillage implement, etc. No tillage pan present. The wire flag can penetrate all the way into the topsoil beyond the tillage layer and into the subsoil without bending.

3 Tilth and Structure

What is soil structure and tilth?

Soil structure is the way the solid particles in a soil are held together. It is the naturally occurring arrangement of soil particles into secondary units or peds. Soil porosity is maintained, in part, by soils having a good granular or crumb structure. Granular and/or crumb structure allows the free movement of air, water, plant roots, and organisms throughout the soil. Soils that lack this kind of structure often lack good porosity.

If the individual soil crumbs break into powder easily, the soil is said to have poor aggregate stability. If the crumbs do not break apart, they are too hard, or cemented. The formation of stable soil aggregates results from the grinding action of humus and other soil organic matter components, the activities of soil organisms and the growth of plant roots. When the soil has good granular structure, infiltration of water into the soil is increased and erosion reduced.

Good soil tilth means the soil works easily. Individual crumbs retain their shape under the stresses of tillage, yet the soil is still friable. Also related to tilth is bulk density, which is the weight per unit volume of dry soil. A lower bulk density means a higher soil porposity and better soil tilth.

Why is soil structure important?

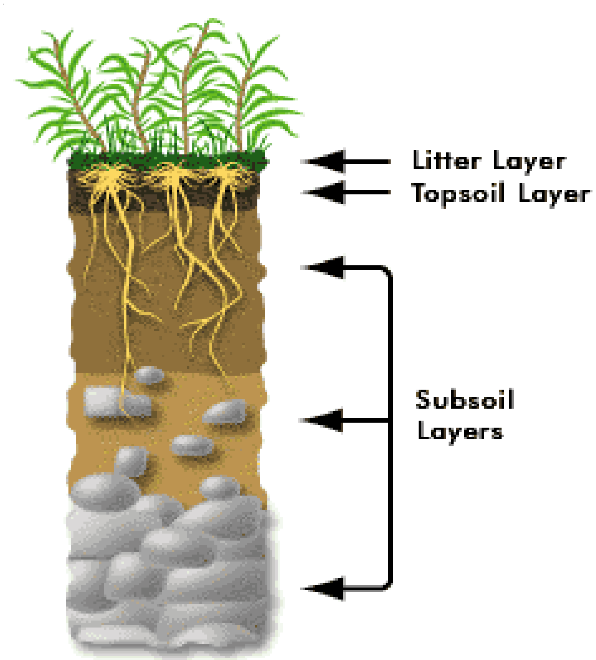
- Soils with ample pore space and an even distribution of large and small pores are well aerated, have good water-holding capacity and infiltration rates, and are easy for roots to grow through.
- Stable crumb aggregates preserve pore space in soils by preventing the clogging of pores with loose particles.

How does management impact soil structure and tilth?

Soil management directly affects soil structure and tilth. A seasonal or yearly assessment of this indicator may show whether current management practices are helping or hindering the free movement of air and water through the soil.

Management of plant residue that encourages biological activity and residue decomposition creates soil organic matter and improves structure.

Operations that allow erosion and compaction of the soil, such as leaving a field bare over winter or working a soil high in clay when it is too wet, result in poor soil structure.



How is the indicator assessed?

Assess soil structure and tilth when the soil is not extremely wet or dry. Do not assess frozen soils. When you make these assessments, be sure to note how much time has passed since the last tillage operation.

Basic Test

Materials needed:

- Shovel
- Squirt bottle with water

What to do:

1. In one or more respective areas of the field, dig out a section of soil 6-10 inches deep.
2. Take an intact portion of soil about the size and volume of a 15-ounce soup can from the shovel.
3. With your finger, lightly break apart this piece of soil. Look for individual granular crumbs. If crumbs are present, squeeze a few of them between your thumb and forefinger and note the amount of pressure required to collapse them.
4. Use the squirt bottle to gently wet some of the remaining intact crumbs. Now see how much pressure is needed to break them, comparing this effort to the pressure used when the crumbs were not wetted. Note the resistance difference between the wetted and unwetted crumb aggregates.

Kitchen Scale Test

Materials Needed

- Shovel
- Squirt bottle with water
- Small kitchen scale

What to do:

Complete steps 1-2 of the basic test. Then substitute the following for steps 3 & 4.

1. Place a soil crumb that is about 1 cubic inch in volume on the tray of the scale (1 inch by 1 inch by 1 inch). Press down with your forefinger on the top of the crumb until it breaks. Record the weight at the time when the crumb broke apart.
2. Repeat this procedure using the moistened soil crumb.
3. Record how many pounds of pressure are needed to break the crumb.
4. Compare the two resistance differences between the crumbs before and after wetting

Note: Aggregates that cannot be broken with pressure between the thumb and forefinger when either wet or dry and that maintain their shape under at least 15 lbs. of force or greater, are considered too hard and should be rated as least desirable.

Rating the indicator		
Least desirable=1	**Moderate=5**	**Preferred=10**
Soil has a cloddy, powdery, massive, or flaky structure with no visible crumbs.	Soil has some crumb structure. Individual crumbs break under only slight pressure and are much more fragile after wetting.	Soil is crumbly with a definite crumb structure. Aggregates maintain shape with pressure.

4 Organic Matter

What is organic matter?

Organic matter impacts water infiltration, tilth and nutrient cycling. Presence of a variety of types of residue from the previous season indicates that the soil is alive. For example, partially decomposed residue suggests that organic matter has been returned to the soil and nutrients recycled, while larger intact pieces are valued for their ability to provide structure and tilth to the soil.

Organic matter is formed when plant residue from a previous crop or added organic materials, such as manure or straw, decomposes over time. When decomposition is active, soil organic matter will be in all stages of breakdown, from recognizable plant parts, to individual plant fibers, to dark staining humus. Soil organisms decompose plant residue and recycle it into many different forms that benefit the soil. Most of the decomposition that takes place in soils is due to microbial activity. As larger soil organisms consume organic residue, they break it down into smaller pieces which allow bacteria and fungi to work more efficiently. Active decomposition of plant residues is a good indicator that the biological community is thriving in the soil. No visible residue suggests that insufficient organisms are available to decompose the materials.

Residues in various stages of decomposition are most favorable since the larger pieces help provide tilth and structure to the soil, while small pieces are used as food for soil microorganisms.

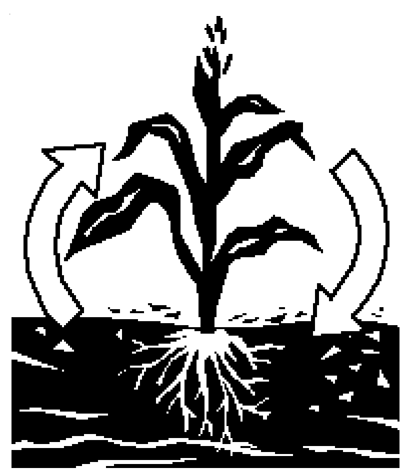
Why is organic matter important?

- Increases the soil cation exchange capacity (its ability to hold essential plant nutrients)
- Provides decomposition products which glue soil particles into aggregates improving soil structure, water infiltration and tilth
- Provides a food source for a diverse population of soil organisms that promote nutrient recycling, aeration and water movement within the soil
- Represents the principle sources of N and S (and much of the P) for crops.

How does management impact organic matter?

Management systems that include cover crops and the addition of organic residues to fields, supply the raw materials for organic matter formation.

Management that allows plant residue to be distributed within the topsoil helps create soil organic matter in all stages of decomposition.



How is the indicator assessed?

Organic matter content can be evaluated by the way the soil smells and by its color. For example, soils that are darker in color generally indicate a higher organic matter content. A darker surface color than that of the subsoil color indicates a higher organic matter content in the surface layer.

Advanced Test

Obtain a recent copy of a soil test and determine if the organic matter content is low, medium or high for your soil type.

Basic Test

Materials needed:
Shovel

What to do:

1. Collect a surface soil sample.
2. Collect a sample from 4-6 inches deep.
3. Compare the soil color from the two depths. (Note: samples need to be compared when they are at the same moisture level.)
4. Note the color differences. Is the surface color similar to the subsoil color?
5. Smell the soil sample. A sweet, earthy smell indicates a soil high in organic matter.

Rating the indicator		
Least desirable=1	**Moderate=5**	**Preferred=10**
Light colored surface soil. Surface soil is similar to subsoil color. No visible organic material in soil. No smell. Soil test shows low organic matter.	Surface color closer to subsoil color. Soil test shows medium organic matter levels.	Dark colored soil surface. Visible organic material. Earthy smell. Soil test shows high organic matter. Topsoil is defined and is definitely darker than subsoil.

5 Plant Residue

What is plant residue?

Plant residues protect the soil surface from erosion as well as providing organic materials to the soil. Plant residues located at the soil surface break up the energy of raindrops and prevent the washing of surface soil particles. Plant residue from a previous crop, or added organic material such as manure or straw, decomposes over time and becomes soil organic matter.

Soil organisms break down plant residue and recycle it into many different forms that benefit the soil. Most of the decomposition that takes place in soils is due to microbial activity. As larger soil organisms consume organic residue, they reduce it to smaller pieces, thus allowing bacteria and fungi to work more efficiently.

When the soil has enough air, decomposition occurs at an ideal rate and the soil has a fresh, earthy smell. Poorly aerated soil decomposes its organic matter more slowly and has a sour or pungent smell.

Why is plant residue important?

- Residue decomposition must take place for the soil to maintain its organic matter content. Organic matter is important to soil quality because it increases the soil's ability to supply essential plant nutrients.
- Soil organic matter helps maintain good soil structure. The activities of soil organisms create air and water passage ways that improve soil structure.
- Rapid organic residue decomposition shows that a thriving biological community lives in the soil.
- When organic residue is present, it increases infiltration and water storage. In this way, the potential for erosion by water runoff is reduced.

How does management impact plant residues?

Management systems that include a majority of high residue producing crops provide the largest amount of available plant residues.

Residue management systems that are considered no-till or direct seed systems leave the most plant residues on the soil surface. Minimum tillage, inversion tillage, and conventional tillage systems leave the least amounts of plant residues on the soil surface.

How is the indicator assessed?

A good time to assess plant residue decomposition is during the growing season or in the fall, perhaps at the same time that soil structure is assessed.

Wait at least one month after incorporating a cover crop or other residue before assessing this indicator.

Be sure to do this assessment at the same state of soil moisture and temperature each time because these conditions affect the smell of the soil.

Basic Test

Materials needed:
- Shovel
- Squirt bottle with water

What to do:
1. Dig down at least 6 inches and examine the soil for organic residue by breaking the soil apart with your finger. Look for evidence of organic residue in various stages of decomposition.
2. Smell the soil particle after breaking it apart and note the smell.
3. Lightly moisten some soil with a squirt bottle. Rub this soil between your fingers and see if it leaves a dark stain that is difficult to remove.

Rating the indicator		
Least desirable=1	**Moderate=5**	**Preferred=10**
No visible residue on soil surface. Residue does not decompose.	Some plant residue visible on soil surface. Residue is slowly decomposing.	Noticeable residue on soil surface. Residue is in all stages of decomposition and has an earthy, sweet smell.

6 Earthworms

What are earthworms?

There are thousands of species of earthworms in the world. The two major behavioral classes of earthworms that dwell in agricultural soils are the shallow soil species and the deep burrowing species.

The shallow soil dwelling species are about 3 to 5 inches long. These species dwell in the top 12 inches of the soil, and burrow randomly through the soil, consuming plant residues and mineral soil. This worm species is more active in the spring and fall.

The deep burrowing earthworm species are about 4-8 inches long. These species construct large vertical permanent burrows that can be up to 6 feet deep. Deep burrowing earthworms pull plant residues from the soil surface down into their burrows. This residue is digested as it becomes softer and more decomposed. These earthworms are only found in fields where permanent surface residue exists.

Why are earthworms important?

- Earthworms have long been recognized as an important part of good agricultural soils. Burrowing types ingest large amounts of organic materials and mineral soil and excrete them as casts at the soil surface. Earthworm casts contain more enzymes, bacteria, organic matter, and available plant nutrients than the surrounding soil.
- Earthworms mix the soil and break up raw plant material. Some bring organic residue from the surface down into their burrows and, in turn, deposit minerals from deep soil layers at the surface with their casts.
- The movement of earthworms through the soil creates passageways that increase aeration and water infiltration. Their lubricating secretions bind soil particles together and increase aggregate stability.

How does management impact earthworms?

Management can directly affect earthworm populations. Addition of organic residues and cover crops provides food sources and can increase the diversity and abundance of earthworms.

Management practices that leave permanent surface cover, such as direct seeding or minimum tillage, support a larger more diversified earthworm population. This type of management supplies a larger food source and mulch protection.

How is the indicator assessed?

This indicator is assessed by digging into the soil at about 12 inches and counting how many earthworms are present, along with the size of each worm.

- Earthworms are very sensitive to soil moisture and temperature. If the topsoil is too dry or saturated, or if the soil temperature is too hot or too cold, you won't see them.
- Assess earthworm abundance in the late spring and late fall when the soil is moist, but not saturated, and relatively warm.
- Time of day and weather should be consistent among assessments since these factors also affect earthworm activities.

Basic Test

Materials needed:
Shovel

What to do:
1. Excavate a 12"x12"x12" hole, using the shovel.
2. Count the number of earthworms found in the excavated soil.
3. Note any earthworm castings or holes.

Rating the indicator		
Least desirable=1	**Moderate=5**	**Preferred=10**
0-1 worms in shovelful of top foot of soil. No worm casts or holes. Few insects or fungi.	2-10 worms in shovelful. Few casts, holes or worms. Some insects and fungi.	10+ worms in top foot of soil. Lots of casts and holes in tilled clods. Birds behind tillage. Many insects and fungi.

7 Erosion

What is soil erosion?

Soil erosion is the physical wearing of the earth's surface caused by wind, water or gravity. Soil erosion is a serious form of soil degradation.

Soil erosion may be a slow process that continues relatively unnoticed, or it may occur at an alarming rate causing serious loss of topsoil.

Why is soil erosion important?

- Soil erosion is important because erosion removes the topsoil, the most productive layer in the soil profile. Soil erosion also reduces levels of soil organic matter and contributes to the breakdown of soil structure.
- Erosion removes the surface soil or topsoil, which often has the highest biological activity and the greatest amount of soil organic matter. This causes a loss of nutrients and often creates a less favorable environment for plant growth and biological activity.
- Nutrients removed by erosion are no longer available to support plant growth onsite, but can accumulate in water where such problems as algae blooms and eutrophication may occur.
- Deposition of eroded material can obstruct roadways and fill drainage channels. Sediment can damage fish habitat and degrade water quality in streams, rivers and lakes.
- Wind erosion can affect human health and create public safety hazards.

What does management have to do with soil erosion?

Soil erosion can be prevented by reducing the amount of tillage on a field. Reduced tillage results in more soil organic matter and plant residues which aid in restricting the impact of rain drops and prevent soil erosion.

No till and direct seed systems greatly reduce erosion by leaving residue on the soil surface and by not inverting the soil.

The physical characteristics of a field can contribute to soil erosion. Factors such as slope gradient and length of field can affect the speed of water flowing over the field. Splitting a field into different sections, such as in strip cropping, can reduce the soil erosion.

How is the indicator assessed?

Soil erosion is assessed in the spring of the year, after snow melts and more runoff occurs.

An advanced method (shown at right) may be used for a quantitative measurement.

Basic Test

Materials Needed:

Ruler or tape measure

What to do:

1. Walk the field and observe the soil surface for rill or gully erosion.
2. Measure the rill or gully depth.
3. Select appropriate rating on indicator card.

Advanced Test

The Alutin Rill Erosion Method was developed by USDA/NRCS. Losses greater than 100 tons per acre are considered ephemeral or concentrated flow erosion and should not be measured using this method.

Materials Needed:

Rule and tape measure

Notebook for data recording

What to do:

1. Using a tape measure , measure a lineal distance of 37.5 or 75 feet across a slope.
2. Using a ruler, measure (in inches) the width (W) and depth (D) of each rill along the chosen distance. Record in the notebook.
3. Multiply each width and depth reading to obtain a product in square inches (W x D = square inches).
4. Add all products of readings along the chosen distance (sum of square inches calculations).
5. Divide this sum by 3 if a 37.5 foot distance was selected, or divide by 6 if the 75 foot distance was chosen. The result is ton(s) of soil loss per acre from rill erosion.

Rating the indicator

Least desirable=1	Moderate=5	Preferred=10
Large gullies over 2" deep, joined to others. Thin or no topsoil, rapid runoff with dark colored water.	Few rills or gullies; gullies up to 2" deep. Some swift runoff, light brown colored water.	No gullies or rills. Clear water or no runoff from soil surface.

8 Seedling Emergence

What is seedling emergence?

Seedling emergence is the emergence of the seed through the soil surface. Efficient management is key for good crop emergence. This is the critical stage for achieving even crop stands for good quality and yields. In the Palouse and Nezperce Prairies, this typically occurs during the fall and spring of the year.

Why is seedling emergence important?

- This is the critical stage for good crop stand development. Better seedling emergence creates a higher yielding crop.

What does management have to do with seedling emergence?

Using Direct Seed technologies under adequate growing conditions, planted seed can readily absorb more water and emerge healthier due to more nutrients from increased organic matter concentrations and more stored water.

Managing for the seedling emergence stage of crop development can be economically efficient with management of crop residues. Crop residues increase storage of moisture in the soil, decrease soil erosion and protect the seed beds for emerging seeds.

Erosion is not as frequent compared to fields where excess tillage was used for preparing seed beds. Surface crusting is also decreased with management of crop residues, making seedling emergence easier.

Using multiple crop rotations is important for isuring each crop has successful seedling emergence. Planting winter wheat, followed by spring wheat or barley, peas, lentils or chickpeas, subsequently followed again by winter wheat in the higher precipitation areas, can be beneficial to building soil health to produce better seedling emergence. Alternating crop rotations can also break disease and weed cycles and improve nutrient availability over time.

Consistent seed drilling depths are important for successful seedling emergence. Using depth bands for the desired depths is recommended. Types of drills used with seedlings are also important. This should be determined depending on moisture zone and soil texture.

How is the indicator assessed?

Always observe at same interval after seeding, generally 7-10 days, depending on the crop planted.

Determine whether the planted rows can be readily observed.

Use a ruler or tape measure to observe the height of seedlings and the approximate number of seedlings that have emerged per foot. Emergence is uniform if all seedlings are approximately the same height and occur in the same numbers per unit measured.

Basic Test

Materials needed:

Ruler or tape measure

What to do:

1. Measure several 100' sections of seeded rows.
2. Count the number of plants emerging in the 100' section.
3. Randomly measure the height of several plants within the row. Plants with the same height indicate even emergence.

Rating the indicator		
Least desirable=1	**Moderate=5**	**Preferred=10**
Slow and uneven emergence.	Some variability in emergence.	Rapid and even emergence.

9 Plant Growth and Vigor

What is plant vigor?

Plant vigor is indicated by the health of individual plants in the field. Uniform growth of all crop plants in a field is also a factor in plant vigor. Crop plants within a field that reach maturity at the same time are also another sign of good plant vigor.

Plant vigor is, in some ways, difficult to judge because plants respond to fertilizer inputs, pest problems and other factors not directly related to soil quality.

The growth of all plants growing in the field, including weeds, can be used to assess this indicator.

Why is plant vigor important?

- Good plant growth requires a soil with good structure, water regulation, nutrient cycling ability, and a diversity of soil organisms. Good plant vigor is an indication that these conditions are present.

What does management have to do with plant vigor?

With this indicator, it is especially important to determine whether the crop was under optimal management. If management was less than optimal (e.g., late planting, insufficient irrigation or rainfall, etc.), then plant vigor may not be a good soil-quality indicator.

Examine the crop for pest or disease damage. It is important to determine whether the disease problem is related to soil quality. For example, root-borne diseases may be caused, in part, by compacted soil that remains saturated with water for long periods.

How is the indicator assessed?

Assess plant vigor during the active growth phase of the plant, before flowering.

The light conditions during the assessment must be the same each time; for example, a shade of green looks different in full sunlight at midday than it would under a cloudy sky or later in the day.

Basic Test:

Materials needed:
None

What to do:

1. Walk a section of the field.
2. Note color of plants, height of plants, number of plants, and evidence of plant stress.

By David Warren/ courtesy USDA

Rating the indicator		
Least desirable=1	**Moderate=5**	**Preferred=10**
Uneven color, variable height and population, poor growth, visible evidence of plant stress.	Some variation in color, height, and population; moderate growth; mild stress.	Uniform deep-green color, rapid growth, even stand (height and population), no visible signs of stress.

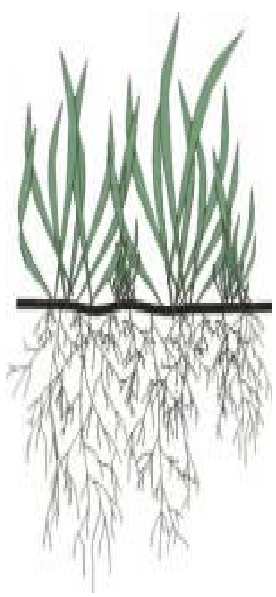
10 Rooting Systems

What is healthy root growth?

Root growth often is as extensive as above-ground plant growth. Soil with good structure encourages a strong root system that sends out many fine roots to explore as much of the soil as possible.

Why is root growth important?

- Roots are in direct contact with soil constituents such as air, water, organisms, and soil aggregates. If these factors are suboptimal, then plant roots show less than ideal characteristics.
- Plant roots supply the rest of the plant with nutrients and water. A strong root system anchors the plant and supports its upright growth.
- Good root growth may indicate a diverse population of soil organisms supported by abundant organic matter that inhibits the spread of certain root diseases caused by detrimental fungi, bacteria or nematodes.



How does management impact root growth?

Root growth can be restricted by coompacted layers in the soil and by soil that is saturated with water for days at a time. Poor root growth can be an indication of these conditions.

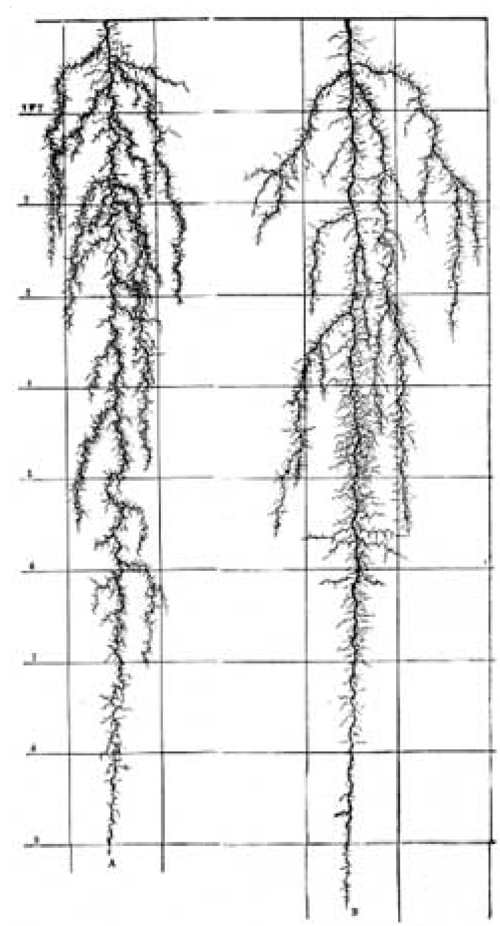
Management that encourages good soil structure also promotes root growth. Cultivation and compaction can inhibit root growth.

Factors that contribute to good plant vigor are reflected in healthy roots as well.

How is the indicator assessed?

Assess root growth at the same time that plant vigor is assessed -- during the growing season of the plant.

Moisture conditions in the soil should be similar for each assessment because the wetness of the soil may change the ease with which finer roots can be observed.



Basic Test

Materials needed:
- Shovel
- Hand Trowel

What to do:
1. Dig around a crop plant as extensively as possible to get an idea of how deep the roots extend into the soil.
2. Examine the root system by separating the soil from the roots.
3. Look for:
   - Extent of root system development
   - Number of fine roots
   - Color of new roots

Note: Weeds or annual crop plants can be removed completely from the soil for assessment. Examine perennial crop root systems in place by digging soil away from beside the plant and removing soil from around the roots with a trowel.

Rating the indicator		
Least desirable=1	**Moderate=5**	**Preferred=10**
Few or no roots present; roots short, coarse, not uniformly distributed; roots growing sideways; obvious restrictions.	Roots present in profile; some misshaped roots; some restriction to root growth.	Robust, large, deep, well-dispersed root system; no obvious restriction to root growth; many fine roots.