

Indicator 4.19.

Area and Percent of Forest Land With Significant Soil Degradation

What is the indicator and why is it important?

Underlying soil conditions directly control forest productivity and health. Soil conditions, as described by various physical and chemical properties, determine overall soil quality. Changes in soil conditions, as a result of disturbances or land use activities, may adversely affect forest productivity and health. The goal of this indicator is to quantify changes in soil quality resulting from climate changes, disturbances, or land use activities. The Forest Inventory and Analysis (FIA) Soil Quality Indicator was developed to assess the condition and trend of soil quality on all U.S. forest lands and therefore directly meets this indicator goal.

What does the indicator show?

Estimates of bare soil on FIA plots provide an indirect or surrogate measure of soil erosion potential, which is also related to precipitation amounts and distribution, slope steepness and length, soil texture, and types of disturbances (Elliot et al. 2000). Estimates of plot area showing evidences of soil compaction indicate the areal extent of disturbances that may change the physical properties of soils. This indicator estimates only the areal extent of visual evidences of compaction and does not measure compaction intensity. The affect of soil compaction on forest productivity is complex and depends on numerous factors, including soil texture, moisture content, and vegetation (Powers et al. 2005).

Most FIA plots have at least some bare soil, but only a very small percentage of plots (0.4 to 5.5 percent) have bare soil covering more than one-half the plot area (table 19-1). These plots are at highest risk of accelerated soil erosion, but cover only a very small fraction of all forested lands. Only 0.3 to 4.7 percent of all plots show evidences of compaction on more than one-half the plot area (table 19-1). Thus, soil compaction is not a widespread problem on forested lands and is largely confined to trails and forest harvest operations.

Soils develop in response to several interacting factors: parent material, topography (landscape position), organisms, climate, and time. In general, more highly weathered soils have lower levels of organic matter and nutrients and develop in warmer areas with ample precipitation. Over time, forests adapt to these local soil conditions, but forests developed on low productivity soils may have a higher risk of soil-related forest health decline when subjected to additional environmental stressors and may be more prone to accelerated soil degradation if forest cover is lost.

Nutrient-poor and acid forest soil conditions are found throughout the United States, but acidic soils with low Ca and high Al levels are concentrated in the Northeast and South, primarily in the Appalachian regions (table 19-2). The most serious soil-related emerging forest health threat is increasing soil acidity and associated decreasing soil Ca reserves along with increasing potentially toxic levels of exchangeable Al. This soil condition is strongly related to atmospheric acid deposition (Driscoll et al. 2001).

Table 19-1. Percent of Forest Inventory and Analysis P3 plots assessed from 1999 through 2005 with bare soil on more than 50 percent of plot area and showing evidences of compaction on more than 50 percent of plot area.

	Northeast ^a	North Central	South	Interior West	Pacific West	United States
Total plots (N)	1,716	1,424	857	1,461	543	6,001
Soil condition	Percent of plots					
Bare soil greater than 50% of plot area	0.4	1.6	1.6	5.5	1.8	2.2
Compaction greater than 50% of plot area	1.3	4.7	1.9	0.3	1.8	2.0

^a Northeast: CT, DE, MA, MD, ME, NH, NY, NY, OH, PA, RI, VT, WV; North Central: IA, IL, IN, KS, MI, MN, MO, ND, NE, SD, WI; South: AL, AR, FL, GA, KY, LA, MS, NC, OK, SC, TN, TX, VA; Interior West: AZ, CO, ID, MT, NM, NV, UT, WY; Pacific West: AK, CA, HI, OR, WA; States in which the FIA Soil Quality Indicator is not yet implemented: MS, OK, NM, AK, HI.

Table 19-2. Percent of Forest Inventory and Analysis P3 plots (2000–2005) by region and soil depth with selected suboptimal soil conditions and with increased risk of soils-related forest health decline.

Soil condition	Northeast ^c		North Central		South		Interior West		Pacific West	
	0–10 cm	10–20 cm	0–10 cm	10–20 cm	0–10 cm	10–20 cm	0–10 cm	10–20 cm	0–10 cm	10–20 cm
	Percent of plots									
Organic C less than 1%	1.4	15.0	4.3	33.9	15.3	62.4	19.4	34.6	8.0	18.0
Total N less than 0.1%	6.3	29.7	14.1	50.1	47.0	82.8	31.0	52.2	22.7	41.9
Water pH less than 4.0	25.7	8.6	3.0	1.2	5.9	2.5	0.1	0.0	1.6	1.0
Exch ^a K less than 100 mg/kg	73.6	90.4	55.4	76.3	73.4	85.4	11.1	23.0	20.7	28.3
Exch Mg less than 50 mg/kg	58.3	73.2	19.9	35.3	45.9	61.6	6.3	10.0	17.9	28.3
Exch Ca less than 100 mg/kg	38.0	57.1	7.0	18.2	27.2	48.7	0.6	1.7	3.7	9.2
Exch Al greater than 100 mg/kg	73.7	73.0	23.2	27.1	30.9	35.2	6.8	7.6	20.0	21.6
Bray 1 P less than 15 mg/kg	81.7	83.8	63.8	67.7	83.8	89.2	39.3	53.4	31.3	41.5
Olsen P less than 10 mg/kg	34.8	60.0	24.9	52.8	87.9	92.6	47.9	63.5	29.2	45.4
SQI^b less than 50%	33.2	52.5	10.3	31.4	39.7	69.7	6.5	14.4	5.4	14.3

^a Exch = 1 M NH₄Cl exchangeable.

^b SQI = soil quality index (less than 50 percent indicates increased risk of soil-related forest health decline).

^c Regions same as defined in table 1 previously.

What has changed since 2003?

Because of changes to the Soil Quality Indicator and the more limited data set collected in 2003, direct comparisons between then and now are, for the most part, not possible. The 2003 report was based on only 2 years of FIA data. In the 2003 report, 1.6 percent of the plots (1999 to 2000) had evidence of compaction on more than one-half of the plot area. With 6,001 plots assessed from 1999 through 2005, that percentage has increased to just 2 percent of all plots. This increase is probably attributable to the assessment of a much wider geographic area of the United States.

Are there important regional differences?

The interior West tends to have more bare soil in forested areas than other regions, and is likely the result of more open tree canopies and less forest floor accumulation of organic matter

during the sustained drought of recent years. The extent of bare soil can fluctuate during a growing season and depends on physiographic location and plant communities and their condition. The North Central Region tends to have more areas with evidence of soil compaction. The South has more highly weathered soils with lower organic matter and nutrients than other regions and the South and Northeast have a large percentage of strongly acidic soils with low Ca and high Al levels. The data in table 19-2 indicate a developing soils-related forest health threat. Continued loss of Ca and increases in Al throughout the northern and southern Appalachian Mountains puts Ca-sensitive tree species at risk of decline and mortality. Although southern forests are adapted to soil conditions in that region, the already low organic matter and nutrient status of these soils indicates that these forests may be more susceptible to influences from additional stressors (e.g., industrial inputs, drought, insects, and disease).