

Soil pH trends in a sagebrush meadow and Ponderosa pine ecosystem

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Summary

1. The acidification effect of Ponderosa pine (*Pinus ponderosa*) needles on soil pH was tested by sampling and measuring pH of soil in areas with ponderosa pine needle litter and without.
2. A total of three depth classes for five samples in each category of pine needles present and absent were collected and analyzed.
3. Statistical analysis of pH data did not indicate statistically significant differences between depth classes and presence or absence of pine needles.
4. A comparison with other studies indicates that there are inconsistent trends in different ecosystems with pH and soil depth.
5. *Synthesis*. Multiple factors such as human influence, mineral composition, and decomposing litter can acidify soil while mineral balance and fire act as buffering agents. A comparison of the pH of soil at different depths with the presence and absence of ponderosa pine needle litter found no statistically significant differences. The study still recommends continuous monitoring of soil pH given the human factors and park management which may contribute to acidification of soil in Ponderosa State Park.

Key-words: mountain sagebrush, ponderosa pine, soil acidification, soil depth, soil pH trends

Introduction

The chemical and physical properties of soil are connected to the distribution of and ability of different plant species to grow in particular areas (Knight 1994). While soil properties such as texture and mineral content are highly influenced by parent material (Knight 1994), the species of trees present impact the soil nutrients and how they cycle (Anham 1998).

Investigations of conifer forests have sought to determine soil pH trends affected by the presence of conifers since the needles have a high ascorbic acid content (Taylor *et al.* 2012). Forest soil is generally acidic (Tamm & Hallbäcken 1988), but there is inconsistent evidence that the presence of conifers further acidifies soil (Alfredsson *et al.* 1998). Studies of pine mulch as a gardening aid to reduce weeds indicate that although pine needles decompose slowly, they significantly decrease the pH of soil (Duryea, English, & Hermansen 1999). Studies of conifer forests indicate that

mycorrhizal relationships may have a greater impact on soil acidification than the presence of decomposing needle litter (Alfredsson *et al.* 1998). Additionally, forest management and anthropogenic influences on the atmosphere have produced variable results in the trends of pH and soil depth (Jönsson *et al.* 2003, Tamm & Hallbäcken 1988). The unclear of trends and impacts of various leaf litter on soil pH prompted a specific study of soil pH and depth with the presence and absence of conifer needles.

This investigation focused on an ecosystem with areas of distinct presence and absence of conifer needle litter in a sagebrush meadow. I hypothesized that soil acidity would decrease (pH increase) with depth because the ascorbic acid present in needles is neutralized by heat over time and buffered by other parent materials incorporated in deeper soil. I also hypothesized that the presence of conifers would contribute to soil acidification. I tested these hypotheses on a local ecosystem level investigating the soil pH at different depths under ponderosa pine and mountain sagebrush. Finding a lower pH at more shallow soil depths and a lower pH overall under ponderosa pine could indicate that the ascorbic acid leaching from fallen needles impacts soil chemistry.

Materials and methods

STUDY SITE

This research was conducted in a mountain sagebrush (*A. tridentata*) and Ponderosa pine (*P. ponderosa*) dominated meadow of Ponderosa State Park in McCall, Idaho. The area is characterized by a dry climate averaging 22-24 in of precipitation annually and fine gravelly loamy coarse sand (Natural Resources Conservation Service Web Soil Survey, 2012).

EXPERIMENTAL DESIGN

Sampling focused on areas with mature ponderosa pine that had an obvious accumulation of needle litter under the canopy and mountain sagebrush areas without any visible needle accumulation. Sites were chosen by a random azimuth determined by a watch second hand.

SAMPLING

Soil samples were collected using a 30 cm long and 2.5 cm diameter auger. Soil cores varied in length obtainable in field tests so samples were limited to increments within 1-13 cm in depth. Before twisting the auger into the ground, litter and debris were brushed away to expose soil. The cores extracted were measured with a metric ruler and samples were collected in plastic bags from the following increments: 1-4 cm, 5-8 cm, and 9-12 cm.

pH ANALYSIS

Soil samples were made into slurries with a 1:2 ratio of soil to distilled water and agitated by hand in a sealed glass vial for 1 min. Samples were left to settle for 3 min and measured with a Vernier pH Sensor connected to a Vernier LabQuest (Vernier Software and Technology, Beaverton, OR, USA).

STATISTICAL ANALYSIS

An independent sample t-test was run on each permutation of depth class comparisons using R 2.15.2 software (R Development Core Team, 2012).

Results

A total of five areas were sampled for each soil category (ponderosa pine needle litter affected soil and mountain sagebrush leaf litter affected soil) with each sample divided into three depth classes. The soil pH values ranged from 5.6 to 8.03 overall (Table 1). The average pH of the ponderosa pine needle litter affected soil was 6.14, 6.67 and 6.56 for the 1-4, 5-8 and 9-12 cm depths respectively. The average pH of the mountain sagebrush leaf litter affected soil was 7.06, 7.04 and 6.65 for the 1-4, 5-8 and 9-12 cm depths, respectively (Fig.1). The statistical comparison of the difference between ponderosa pine needle litter affected soil and sagebrush litter affected soil overall yielded a p-value of 0.08.

Table 1 The soil pH measured from slurries of three depth classes in ponderosa pine (PIPO) and mountain sagebrush (SAGE) dominated areas.

PIPO (1-4 cm)	PIPO (5-8 cm)	PIPO (9-12 cm)	SAGE (1-4 cm)	SAGE (5-8 cm)	SAGE (9-12 cm)
5.54	7.66	7.3	7.45	7.7	6.36
7.1	6.82	6.5	7.3	6.71	6.77
6.05	6.56	6.4	7.8	8.03	7.85
6.09	6.42	6.29	6.8	6.94	6.68
5.94	5.9	6.32	5.96	5.8	5.6

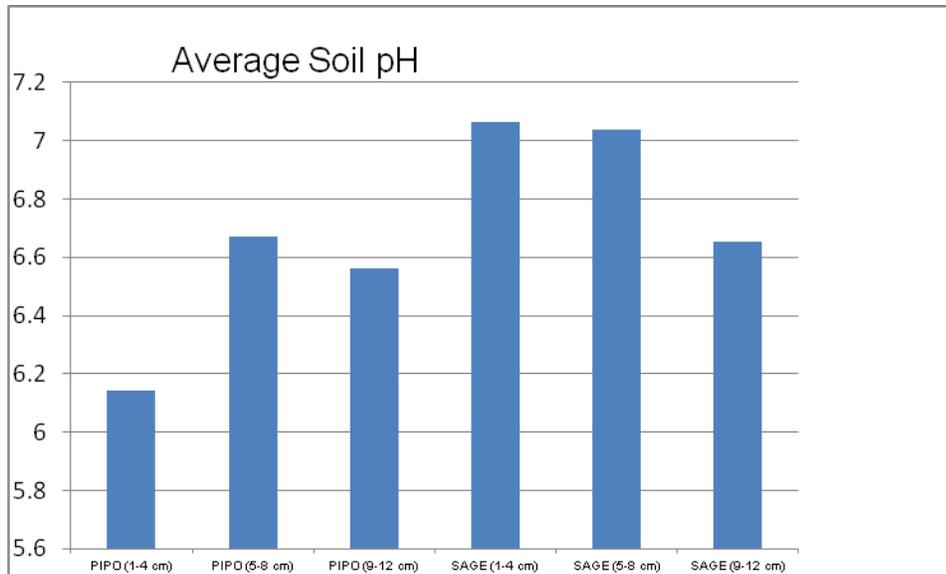


Fig. 1 The average soil pH of three depth classes in ponderosa pine needle litter affected soil and mountain sagebrush leaf litter affected soil.

Discussion

The results of this investigation did not yield a statistically significant difference ($p > 0.05$) in the soil pH of areas with ponderosa pine needle litter and without. All comparisons between soil pH of different depths within the ponderosa pine and mountain sagebrush categories as well as the overall comparison of the categories resulted in p-values above the threshold of 0.05 for statistically significant difference. These data do not support the hypothesis that ponderosa pine needle litter impacts the pH of soil in the sagebrush meadow because there was no consistent pattern found in pH value with depth of soil sampled.

The limitations of this study compared to other investigations were a less accurate measurement of pH and sampling depth accessible due to tools available. Future investigations could be improved by using a titration method of calculating pH in terms of hydrogen ion concentration to allow for more exact values to compare. This would determine both the buffering capacity of the soil and the acidification potential of the needles (Binkley *et al.* 1989). While other studies have also focused on the upper layers of soil, reaching greater depths to access additional soil horizons would provide a greater range of depth classes to sample (Alfredsson *et al.* 1998). These limitations coupled with the small sample size tested restricted the ability to thoroughly determine soil trends representative of the entire sagebrush meadow.

Research on anthropogenic impacts on forests through land use and management invite further study of soil pH trends in Ponderosa State Park. Sudden decreases in soil pH could serve as an indicator of the impact of development nearby and recreational

use of the park. Atmospheric contaminants from vehicles and industry are shown to acidify soil over time (Jönsson *et al.* 2003). Additionally, fire in its natural cycle aids to balance pH with ash acting as a buffer and removing nitrogen compounds (Grogan 2000). Ponderosa State Park is subject to both vehicle traffic and fire suppression. Further monitoring of soil pH could yield information about the impact of these activities on the ecosystem long term.

In sum, while this investigation did not allude to significant impacts on soil pH through pine needle acidification, there is potential for improvements in methodology to yield more results in future attempts. There may be significant findings with long term study of soil pH trends which would be important to monitor given the human impact on the park and how this influences both pine needle litter and other potential soil acidifiers.

Acknowledgements

Thank you to S. Anderegg, J. Casey, N. Davis, D. Harfmann, B. Kochevar, K. Martin and C. Shier for peer review of statistical analysis and J.U.H. Eitel for mentoring and project consultation. This research was funded by the pursuit of science and energy from the sun.

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