The Effect of Prescribed Burns on Cation Exchange Capacity in an Oak Savanna

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Abstract

The Department of Natural Resources estimated that tallgrass savannas once covered approximately fifteen percent of Indiana. During the 1800's, settlers cleared these lands for their rich soils, which were well-suited for agricultural use. Fire was suppressed from the remaining savannas because of the threat to farmland. Today, fire is being reintroduced to the savanna ecosystem as a management tool. Prescribed burning reduces competition from non-native species, encourages community density, and promotes patch dynamics. Cation Exchange Capacity (CEC) is an important soil characteristic. With high CEC, soil fertility is increased and more nutrients become available for plant growth. This research will examine how fire affects CEC in pre and post fire soil samples. Thirty pre burn and sixty post burn samples (thirty at two different time intervals) will be collected in the spring from Hoosier Prairie Nature Preserve, Bill Barnes Nature Preserve, Conrad Savanna Nature Preserve, and Gibson Woods Nature Preserve. These samples will be taken using a 30.50 cm soil sampling tube with a 2 cm diameter at a depth from 1 to 5 cm. Samples will be processed for the identification and quantification of major individual cations, as well as, total CEC. I hypothesize that prescribed or naturally occurring fires will cause a short-term increase in CEC, which will gradually decline after the first week following the fire. Past research has shown a return to approximate preburn totals by the third or fourth week.

Introduction

The Indiana Department of Natural Resources (IDNR) estimated that tallgrass prairies once covered approximately fifteen percent (15%) of Indiana. The majority of these are found in the northwestern portion of the state along the Lake Michigan border. During the 1800's, settlers cleared these lands for their rich soils that were well suited for agricultural uses. The remaining prairies were protected from the naturally occurring fires, which posed a threat to such farm property.

When natural disturbances are removed from tallgrass prairies, species density decreases and shade tolerant species invade the understory (Wright, 1982). This secondary growth effectively destroys the natural ecosystem. Fire reduces competition from non-native species and promotes community density and patch dynamics in tallgrass prairies (Christensen, 1993).

Because of their deep-rooted meristems, grasses are able to protect themselves from natural or prescribed surface fires. In contrast, the shallow rooted woody species are consumed by the fire, allowing the grasses to maintain their competitive advantage (Collins, 1990). When grasses are dry, they burn rapidly and completely. Because grass fires burn so swiftly, the soil surface is exposed only briefly to the high temperatures created by the fire. Without fire, nutrients that are stored in organic matter are released slowly through decomposition, providing a gradual source of nourishment for the plant community. Fire helps to accelerate this process while removing any invasive plant species (Debano, 1998).

By providing much needed nutrients, naturally occurring fires or prescribed burns improve the health of the prairie community. Past research has shown that increased flowering, stem density, and enhanced growth occurred in the spring seasons following fires (Collins, 1990). Several perennial species have shown increases in both population and production after being exposed to fire. In some areas, nutrient cycling and production in the grass layer may increase as much as 30-50% (Menaut, 1993). Post fire soil analysis shows an increase in the production of nitrogen, phosphorus, trace minerals, and cations (Collins, 1990).

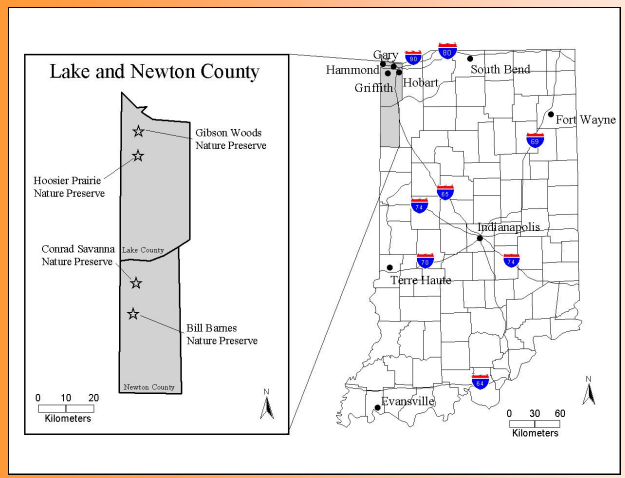


Figure 1: Location of the study areas

Site Descriptions

Hoosier Prairie Nature Preserve

Hoosier Prairie Nature Preserve (Figure 1) is located near the city of Griffith in Lake County, Indiana. The nature preserve is one of the largest unspoiled remnants of the sand prairies that used to be prevalent in Northwestern Indiana. The dominant vegetation types found at Hoosier Prairie are sedge meadows, black oak (*Quercus velutina*) savannas, wet prairies, and mesic sand prairies. The central portion of this 440-acre preserve will be subjected to prescribed burns during the course of the study (IDNR – NP, 1999).

Conrad Savanna Nature Preserve

Conrad Savanna Nature Preserve (Figure 1) is located near the town of Lake Village in Newton County, Indiana. The preserve is another remnant example of the sand prairie ecosystems. Oak savanna is the dominant plant community, which grows on dry, fine quartz sand. The major tallgrass species found in the preserve are Little Bluestem (*Schizachyrium scoparium*), Junegrass (*Koeleria macrantha*), and Porcupine Grass (*Miscanthus sinensis 'strictus'*). The prescribed burn will affect approximately 210 of the 313 acres during the course of the study (IDNR – NP, 1999).

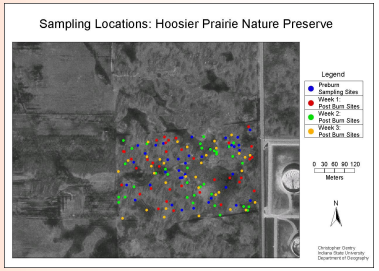
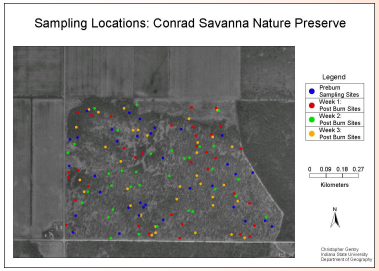


Figure 2



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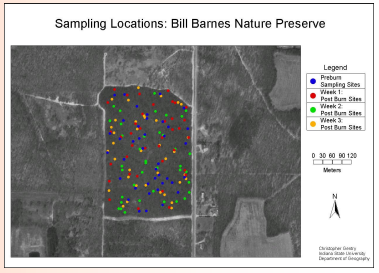

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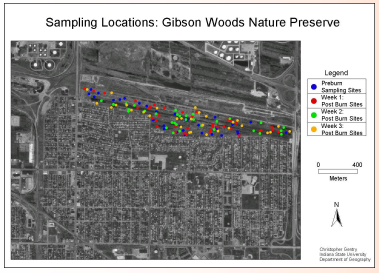

Figure 5

Bill Barnes Nature Preserve

Bill Barnes Nature Preserve (Figure 1) is located near the city of Morocco in Newton County, Indiana. Bill Barnes is a set of four prairies tracts, which occupy 249 acres of the Willow Slough Fish and Wildlife Area. The four separate prairie regions are designated as: Tract 1, Tract 2, Tract 3, and Tract 4. The nature preserve is a remnant of the past sand prairies of Northwestern Indiana. The preserve contains dry and dry-mesic sand prairies, black oak savannas, pin oak (*Quercus palustris*) flatwoods, and sedge meadows. During the course of the study Tracts 3 and 4 (Figure 4) will be subjected to prescribed burns and sampled for CEC comparison (IDNR –NP, 1999).

Gibson Woods Nature Preserve

Gibson Woods Nature Preserve (Figure 1) is located near the city of Hammond in Lake County, Indiana. The preserve is a one of the largest uninterrupted sand dune ridges outside of Indiana Dunes National Park. The dominant vegetation types found at Gibson Woods are dry mesic sand savanna, black oak savannas, bracken fern, mesic sand prairies, and wet-mesic pin oak and speckled alder (*Alnus rugosa*) forests. The principal tallgrass species is the Big Bluestem (*Andropogon gerardii*). Approximately 60 acres of Gibson Woods prairie lands will be affected by the spring burn season (IDNR – NP, 1999).

Methods

Sample Site Selection

Samples will be taken from Hoosier Prairie Nature Preserve (Figure 2), Conrad Savanna Nature Preserve (Figure 3), Bill Barnes Nature Preserve (Figure 4), and Gibson Woods Nature Preserve (Figure 5) during the spring burn season of 2003. Each of the afore mentioned preserves will have both a pre fire and post fire round of sampling. A combined total of 420 samples will be taken from the 4 sampling locations. Thirty of the samples will be extracted from the pre burn sampling locations and another two rounds of 30 from the post burn at one-week intervals. The remaining 60 samples will be taken from control plots (unburned sites) located at each of the sampling locations.

Aerial photographs were obtained from the Microsoft TerraServer Website. The datum and Universal Transverse Mercator (UTM) coordinates for the images were contained in the world file that accompanied the image. The aerial photographs were then imported into a geographic information system (GIS) in order to determine the bounding coordinates of the study areas. The northing and easting coordinates were then entered into spreadsheet software. A random number generation formula was then applied to determine the sampling locations. A database of locations was imported into GIS software and overlain on the aerial photographs to determine suitable sampling sites (Figure 6). A minimum of 40 random sites were generated in order to obtain a 30 suitable sampling locations. Because of the irregular shape of the study sites, coordinates were produced outside of the bounding rectangle for some study areas. Sampling sites that were generated outside of the study areas were eliminated.

Field Methods

A Garmin 12 GPS unit, with an accuracy of 5-15 meters (Rizos, 2002), will be utilized to locate the sampling sites in the field. The soil samples will be extracted using an Oakfield 12" soil sampling tube with a ¾" diameter at a depth of 5cm. The sampling probe will be washed prior to taking each sample in a non-phosphate detergent solution to assure no cross contamination occurs between samples. Each sample will then be placed in a plastic sample canister and stored in a cooler for transportation to the laboratory.

Laboratory Methods

The samples will be transported to the Indiana State University, Chemistry Laboratory for analysis. Under the supervision of Dr. Stephen F. Wolf, each sample will be processed for the identification and quantification of major individual cations, as well as, the sum CEC using a compulsive exchange method. Determination of CEC by Barium Chloride Dihydrate ($BaCl2\text{-}2H2O$) compulsive exchange (Gillman and Sumpter, 1986) is the method recommended by the Soil Science Society of America for its accuracy and repeatability.

After all samples have been analyzed, the quantification of major individual cations and the sum CEC will be recorded and statistical analyses will be preformed. An analysis of variance (ANOVA) will be used to determine if there is a significant change between pre and post burn samples. If change is shown to be significant, a Tukey's Post Hoc Test will be used to make multiple comparisons among all means while maintaining a Type I error rate at alpha (Howell, 1998).

Significance of the Research

The purpose of this research is to examine how fire affects the cation exchange capacity (CEC) in pre and post fire soil samples in soils of oak savanna ecosystems in northwestern Indiana. When CEC is used in conjunction with other soil fertility evaluation methods, an accurate assessment of soil quality can be determined (Ross, 1995). I hypothesize that the CEC of the soils will exhibit an increase after being subject to a prescribed burn and then gradually decrease after the first week. With this research, I wish to provide natural resource manager's insight into the effect of fire on soil productivity. Hopefully, it can also be used to educate the public on the beneficial effects of properly controlled fire.

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