# Assessment of soil composition and vegetation survey of Old Field, Forest 1, and Savanna 2 areas of the Asylum Lake Property, Kalamazoo, Michigan

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**Keywords:** Asylum Lake, Old Field, Core sampling, Vegetation Survey, Soil Analysis

**Abstract**

Understanding how environments recover after years of being impacted by human activity is essential in the design of management strategies for creating urban nature preserves. At the Asylum Lake property in Kalamazoo Michigan, all but one of the impacted habitats have undergone some recovery except for the Old Field habitat, which has resisted in-growth of trees from the adjoining forests and savannas. Thus, core sampling was done in order to determine soil nutrient levels and also to analyze soil particle composition of Old Field compared to the surrounding Forest 1, and Savanna 2 areas. A vegetation survey was done using a quadrat method in order to quantitatively analyze vegetation surrounding the sampled points.

Zn levels for Old field were significantly lower than surrounding Forest 1 and Savanna South. Sand levels for Old Field and Savanna North were significantly higher than Savanna South. Forest 1 had significantly higher Fe than Old Field and Savanna North. Forest 1 had significantly higher Phosphorus values than Old Field, while Old Field had significantly higher Mg values than Forest 1.

With regards to vegetation, Old Field had a significantly higher numbers of Bromus inermus (Smooth Brome) than Forest 1. Old Field had significantly fewer Agropyron repens (Quack Grass), Dactylis Glomerata (Orchard Grass), Rumex acetosella (Sheep Sorrell), and Achillea millefolium (Yarrow) than Savanna North. Savanna South had more Solidago canadensis (Canada Goldenrod) than Old Field, while Forest 1 had significantly more Parthenocissus quinquefolia (Virginia Creeper) than Old Field.

These data indicate that the sandy, low nutrient composition of Old Field support larger numbers of vegetation types such as forbs and grasses compared to adjacent Forest 1. Interestingly the Savanna South area bordering Old field supported the most vegetation with only a non-significant trend of higher Phosphorus setting it apart from Old Field. These data can be used in the design of remedial activities to help speed reforestation in the Old Field area.

**Introduction**

The Asylum Lake preserve, owned by Western Michigan University (WMU), is a 274 acre area located in Kalamazoo Michigan (WMU Environmental Institute 2008). The parcel, until 1969, was the site of The Michigan Asylum for the Insane, which later became Kalamazoo State Hospital, and is no longer in existence; the structures were demolished in 1977 and the tunnels were demolished in 1978 (WMU Environmental Institute 2008). Currently, it seems as if the property in undergoing what is called secondary succession, since it was once inhabited and used to suit residence needs. Secondary succession occurs when once inhabited land undergoes the process of reverting back to its natural state; this process could take a number of days or hundreds of years (Offwell 2004).

The land is now used for passive recreational purposes and research under agreement with the City of Kalamazoo (WMU Environmental Institute 2008). Asylum Lake is currently overseen by The Asylum Lake Policy and Management Council to ensure that the research and/or activities taking place on the preserve are in the best interest of the preservation and ecology of the land (WMU Environmental Institute 2008). Asylum Lake is divided geographically into various sections. The three sections this research is concerned with are Old Field B and the immediate Forest 1 area surrounding it, and Savanna 2 (see figure 1).

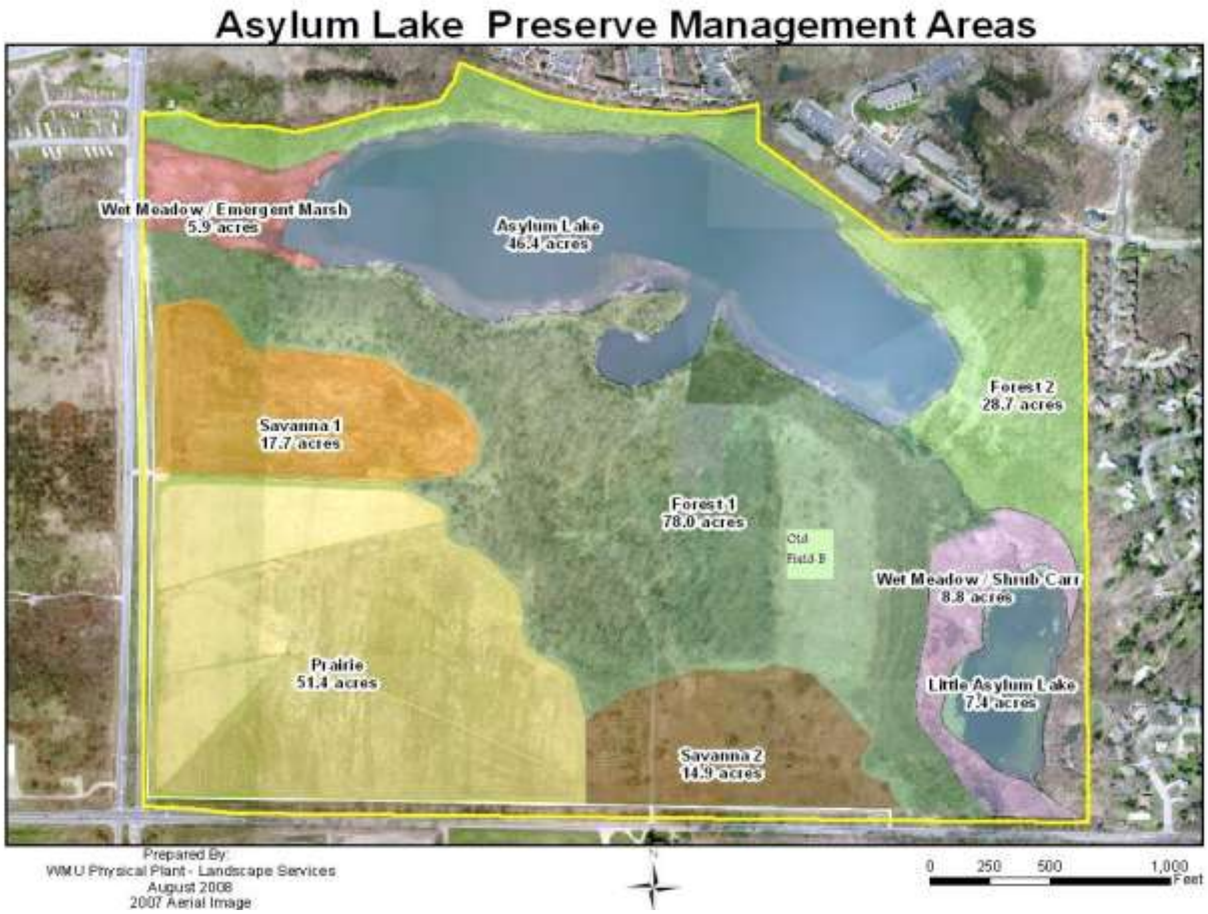


Fig. 1: Preserve Management Areas map; areas of interest (Old Field B, Forest 1, & Savanna 2).

Currently, Asylum Lake is being managed by WMU's Physical Plant, which is the university's landscape and grounds management department, under the supervision of Cari DeLong (Asylum Lake Coordinator & Facilities Manager of the WMU Environmental Institute). Physical Plant is considering plans to increase the forest areas in the preserve which includes succession of trees from Forest 1 and/or movement of trees from Savanna areas into Old Field B. Old field is an area that has been devoid of anything but low growing, low quality vegetation for as long as has been on record. The reasons that Old Field and Savanna warranted clearing of trees originally are not known. What types of chemicals and/or nutrients Old Field has been subjected to be also information that is not on record.

For the purpose of this report, soil surveys were conducted to help determine the feasibility of increasing forest succession on the Asylum Lake property. Soil is a mixture of various amounts of organic matter from decomposition and particles of minerals (Starr, Taggart 2006). Weathered rock also plays a role, when broken down, forming “coarse grained gravel, then sand, silt, and finely grained clay;” air and water fill in the spaces between the particles (Starr, Taggart 2006). Soil can be obtained by various sampling methods; core sampling was implemented in this study. Core sampling utilizes a soil probe that is pushed into the ground to obtain a sample. When the probe is removed from the ground, it brings with it a soil sample that gives a periscopic view of the composition of the underlying soil (Seattle Public Utilities 2001) (see figure 2).

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Fig. 2: Core sampling

Assessing what types plants grow around the points surveyed was also important in understanding the feasibility of long term forest planning. Vegetation can be surveyed using various methods. A quadrat method, which was used in this particular study, is an ecological tool used to survey and quantitatively measure the amount of vegetation in a particular area (Joanna Philippoff et. al. 2009).

**Materials and methods**

**Survey points**

With the help of Cari Delong (Physical Plant), a grid was created at the scale of 100 $m^2$ as an overlay for quadrants to be used to plot points on a 2007 satellite image map of the Asylum Lake preserve using an ESRI ArcGIS ground imaging system (GIS) (see figure 3). Fifty four points were then plotted fifty meters apart within the areas of Old Field, surrounding Forest 1, and bordering Savanna 2 (see figure 4). These points were entered into the GIS and uploaded into a Trimble GeoXH 2005 series GPS system. Of the fifty four points, 20 were chosen for sampling and located via GPS at the site.


Fig. 3: 2007 Asylum Lake aerial image map with 100×100 meter grid overlay.

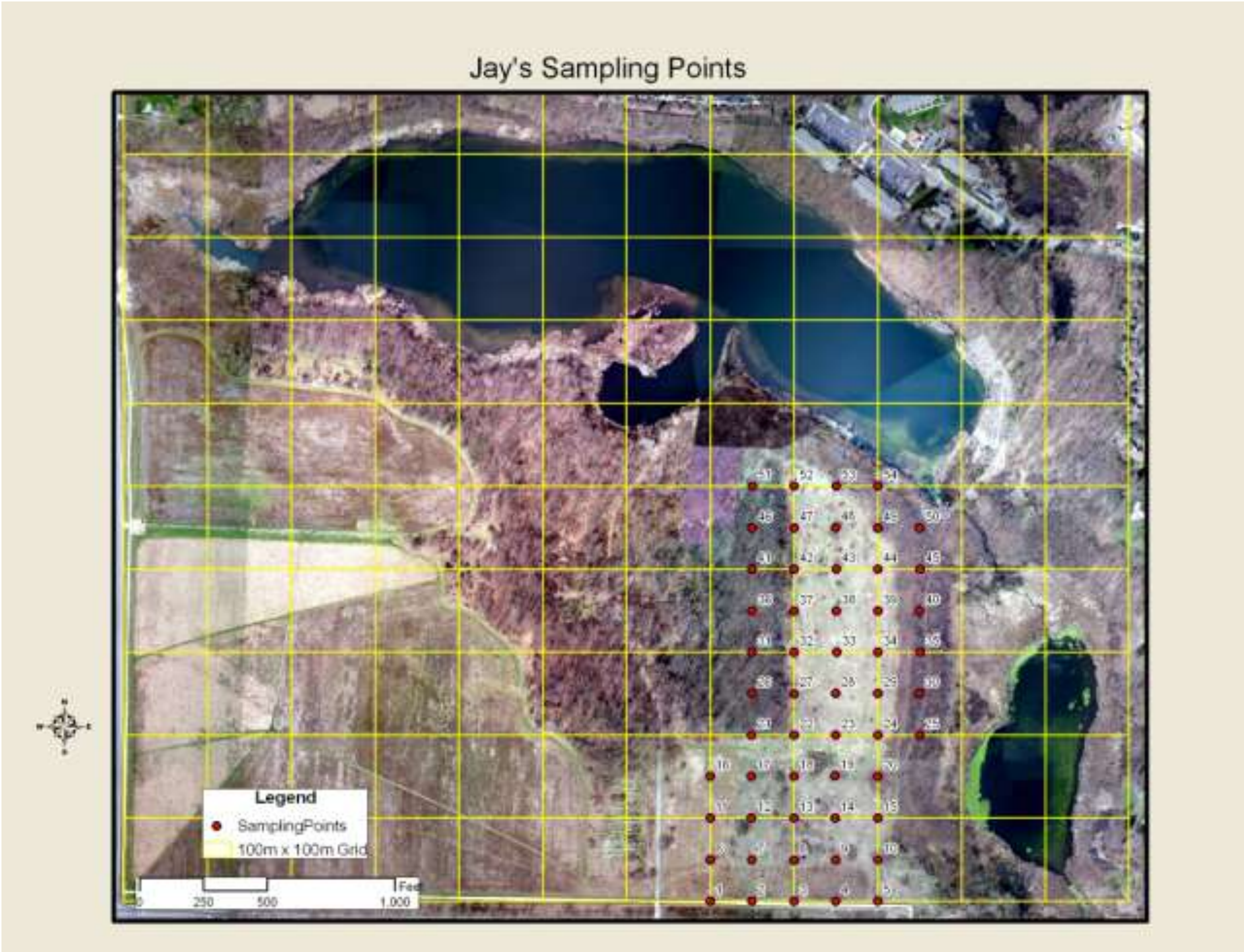


Fig. 4: GIS map of 54 points within the areas of Old Field, surrounding Forest 1, and Savanna North and South.

### Soil Sampling

Once the points were located, an 18” Oakfield Apparatus Company soil probe was used to obtain core samples – one inch in diameter and one foot in depth – at each of the 20 points chosen. Each point was flagged to better facilitate returning to these locations for later vegetation surveys. A total of three cups of soil were extracted from each sampling point to be sent out for analysis.

Each core was placed in a one gallon Ziploc bag. Each bag was marked with the coordinate point number and the coinciding cores were packed in a 15”×14”× 9” Rubbermaid cooler (no ice or heat) for transport. The samples were crushed – one by one – by hand within the bag, then removed and dried for 24 hours (Kalamazoo County 2009) on white printer paper. The samples were then re-bagged in new Ziploc bags and marked with their corresponding coordinate points.

**Soil Analysis**

The samples were repacked into the cooler and transported to the Michigan State University Extension Service in Kalamazoo County (Kalamazoo County 2009) to be sent to Lansing, MI for testing. The analysis included pH, which was tested using a 1:1 soil:water pH method and a Phosphorus (P) test using a Bray P 1 Extractant. Potassium (K), Magnesium (Mg), Calcium (Ca), micronutrient testing (which included Zinc (Zn), Manganese (Mn), Copper (Cu), and Iron (Fe)), and Nitrate-Nitrogen (N) tests were done using a 1N Ammonium Acetate Extractant.

A particle size analysis was also conducted which included sand, silt, and clay content of the soil.

**Quantitative soil analysis**

The 20 points chosen were grouped into categories according to the areas the soil samples were extracted from (Forest 1, Old Field, Savanna North, and Savanna South). In order for analysis to be clear, nutrient data from the soil samples extracted from the ecological edges were taken out of the statistical analysis leaving four points from each area to analyze because ecological edges are a transitional boundary between ecosystems that often blend nutrients from dissimilar areas (Turner et. al. 2003). Therefore, Old Field was defined by averaging data from points 43, 44, 28, and 29. Forest 1 data averaged for analysis were from points 41, 26, 45, and 30. Savanna North was averaged for analysis by using data from points 16, 17, 18, and 19, and Savanna South was averaged by using data from points 1, 2, 3, and 4. Statistical analysis was run to compare data from each of the four areas. (see figure 5)


Fig. 5: Sampling points used for quantitative analysis; Forest 1 (41, 26, 45, & 30), Old Field (43, 44, 28, & 29), Savanna North (16, 17, 18, & 19), Savanna South (1, 2, 3, & 4).

## Vegetation Survey

A one meter × one meter quadrat was constructed with yard sticks. The yard sticks were extended to measure one meter and four were joined together in a square formation to create a one square meter quadrat. Holes were drilled at ten centimeter increments along each side; string was run through each hole and attached to the opposite side in order to create a grid within the meter square quadrat that consisted of 100, 10×10 cm sections (see figure 6).

The quadrat was taken to each flagged point, set over the sampled area, and photographed (see figure 6). The point location, count of each species surveyed, date and time of survey, and camera memory card number for photograph reference were all recorded.

Any vegetation that was not identified on site was given a unique identifier and counted. A sample was taken of the unidentified species, placed in a Ziploc bag, labeled with the identifier and corresponding location, and later identified.

Fig. 6: Meter×meter quadrat at sample point.

## Results

## Soil Composition

Soil nutrient data from sampled points in Old Field, Savanna North, Savanna South, and Forest 1 were subjected to statistical analysis (ANOVA).

Soil composition maps were created using ESRI ArcMap software by Cari DeLong (Physical Plant). The sampling points were entered into ArcMap and the Arc Toolbox application was used to interpolate the sampling points with Inverse Distance Weighing.

Significant differences were shown between Forest 1 and Old Field areas as well as between Forest 1 and Savanna North areas for nutrient content.

Zn values proved significantly higher in Forest 1 than in Savanna North ($P > .0387$) and Old Field ($P > .0317$) (see figure 7). Forest 1 soil contained more Fe than Old Field ($P > .0396$) and also more Fe than Savanna North ($P > .0276$) (see figure 8).

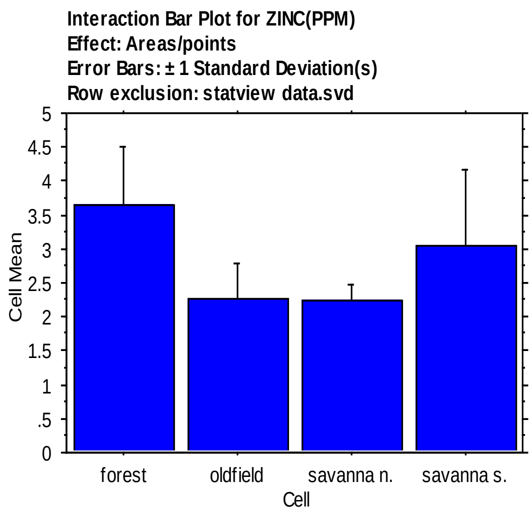


Fig. 7: Forest 1: significantly higher Zn levels than Old Field and Savanna North.

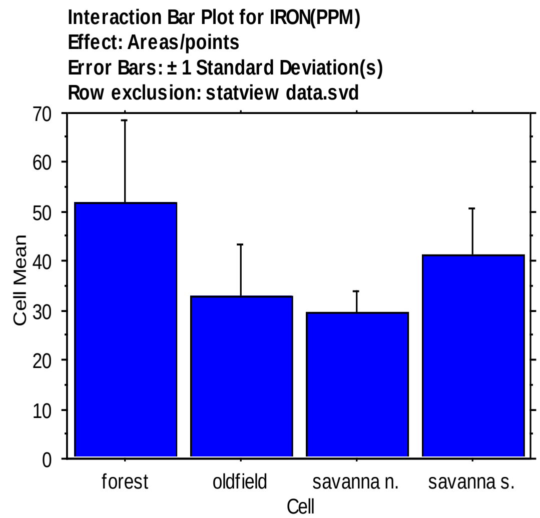


Fig. 8: Forest 1: significantly higher Fe levels than Old Field and Savanna North.

Savanna South showed significantly higher K levels than Forest 1 (P > .0254); there was no significant difference shown for Forest 1 VS. Old Field in respect to K levels (see figure 9).

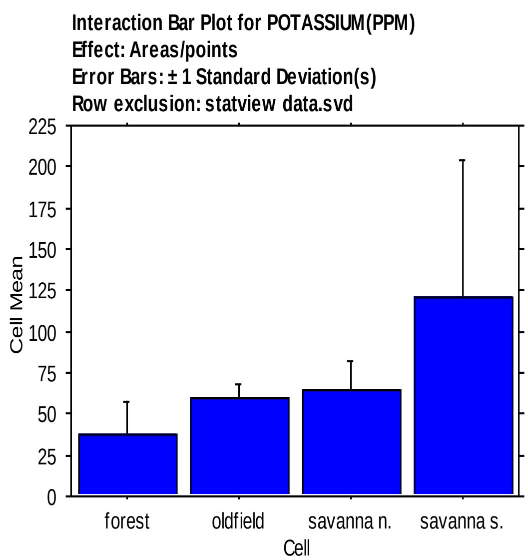


Fig. 9: Savanna South; significantly higher K than Forest 1.

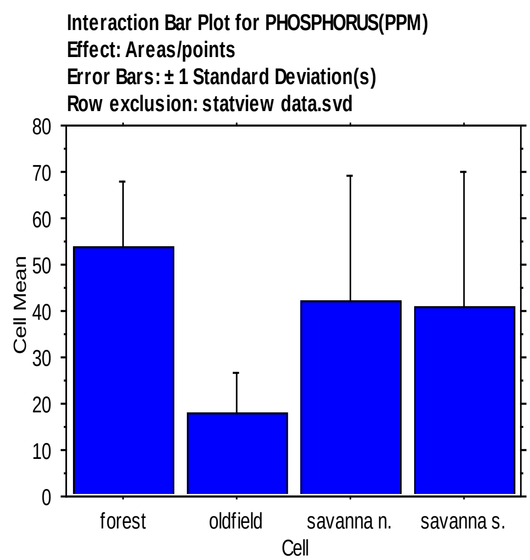


Fig. 10: Forest 1: significantly higher P levels than Old Field.

Results for P were low for Old Field in respect to Forest 1 (P > .0338) (see figure 10). Mg values were significantly lower for Forest 1 than Old Field (P > .0106) and Forest 1 also had significantly lower Mg values than Savanna South (P > .0067) (see figure 11).

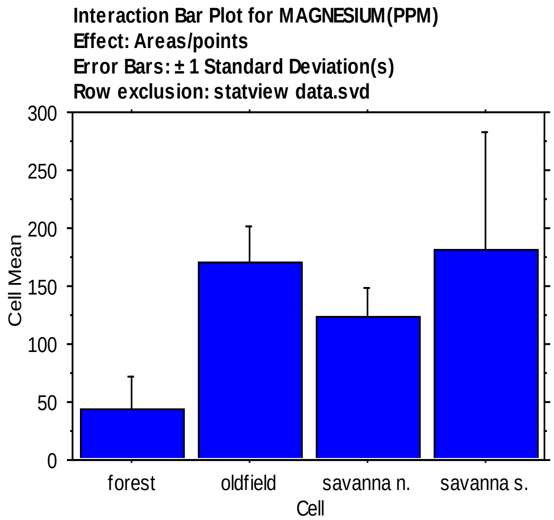


Fig. 11: Forest Mg levels; significantly lower than

Old Field and Savanna South.

With regards to soil particle analysis, Forest 1 was significantly lower in clay content than Savanna South (P > .0012). Forest 1 also had significantly lower clay content than Old Field (P > .0291). Savanna North proved to have a significantly lower clay content than Savanna South (P > .0027) (see figure 12).

Old Field had significantly higher sand content than in Savanna South (P > .0385) and Savanna North also had significantly higher sand content than Savanna South (P > .0340) (see figure 13).

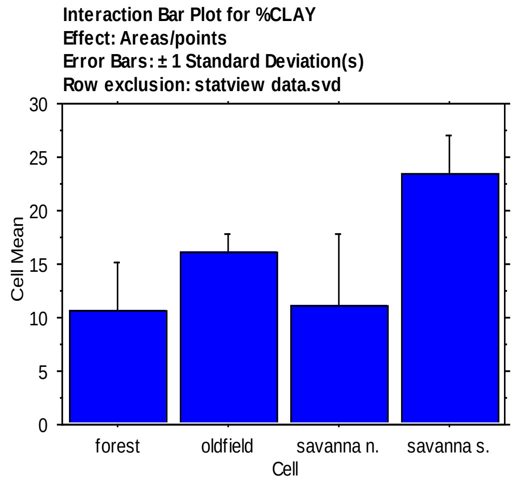


Fig. 12: Forest 1: significantly lower clay value than Old Field and Savanna South.

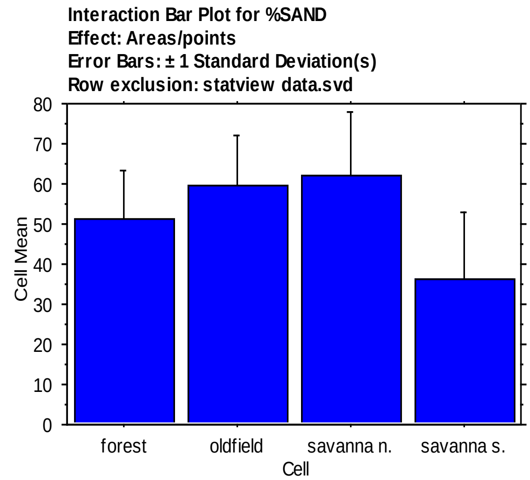


Fig. 13: Savanna South: significantly lower sand values than Old field and Savanna North.

## Vegetation Analysis

Thirty plant species were identified and counted for the vegetation survey. They were then assigned to groups depending on which areas they were surveyed in. Therefore, groups were identified as Old Field, Forest 1, Savanna North, and Savanna South. Plant count data were subjected to statistical analysis (ANOVA) tests to define significant differences among the surveyed areas.

Savanna North had significantly higher numbers of Agropyron repens (Quack Grass) than Old Field ($P > .0192$), Forest 1 ($P > .0192$), and Savanna South ($P > .0192$). Savanna North also had significantly higher numbers of Dactylis glomerata (Orchard Grass) than Old Field ($P > .0042$), Forest 1 ($P > .0010$), and Savanna South ($P > .0010$). For Rumex acetosella (Sheep Sorrell), Savanna North had significantly higher numbers than Old Field ($P > .0047$), Forest 1 ($P > .0047$), and Savanna South ($P > .0047$). Savanna North also had significantly higher numbers than Old Field ($P > .0363$), Forest 1 ($P > .0363$), and Savanna South ($P > .0363$) in respect to Achillea millefolium (Yarrow).

Savanna South had significantly higher numbers of Solidago canadensis (Canada Goldenrod) than Forest 1 ($P > .0002$), Savanna North ($P > .0003$), and Old Field ($P > .0078$), and had significantly higher numbers of Potentilla recta (Rough Fruited Cinquefoil) than Forest 1 ($P > .0410$).

Old Field had significantly higher numbers of Bromus inermis (Smooth Brome) than Forest 1 (P > .0267) and Savanna North (P > .0347) and significantly higher numbers of Solidago canadensis (Canada Goldenrod) than Forest 1 (P > .0373).

Forest 1 had significantly higher numbers of Parthenocissus quinquefolia (Virginia Creeper) than Savanna South (P > .0402) and Old Field (P > .0402).

**Discussion-Conclusions**

It was expected that the soil results would differ per area; this assumption was supported by the data. In areas where sand content was highest, such as in Savanna North and Old Field, Fe and Zn content was lowest (see figures 14, 15, & 16).

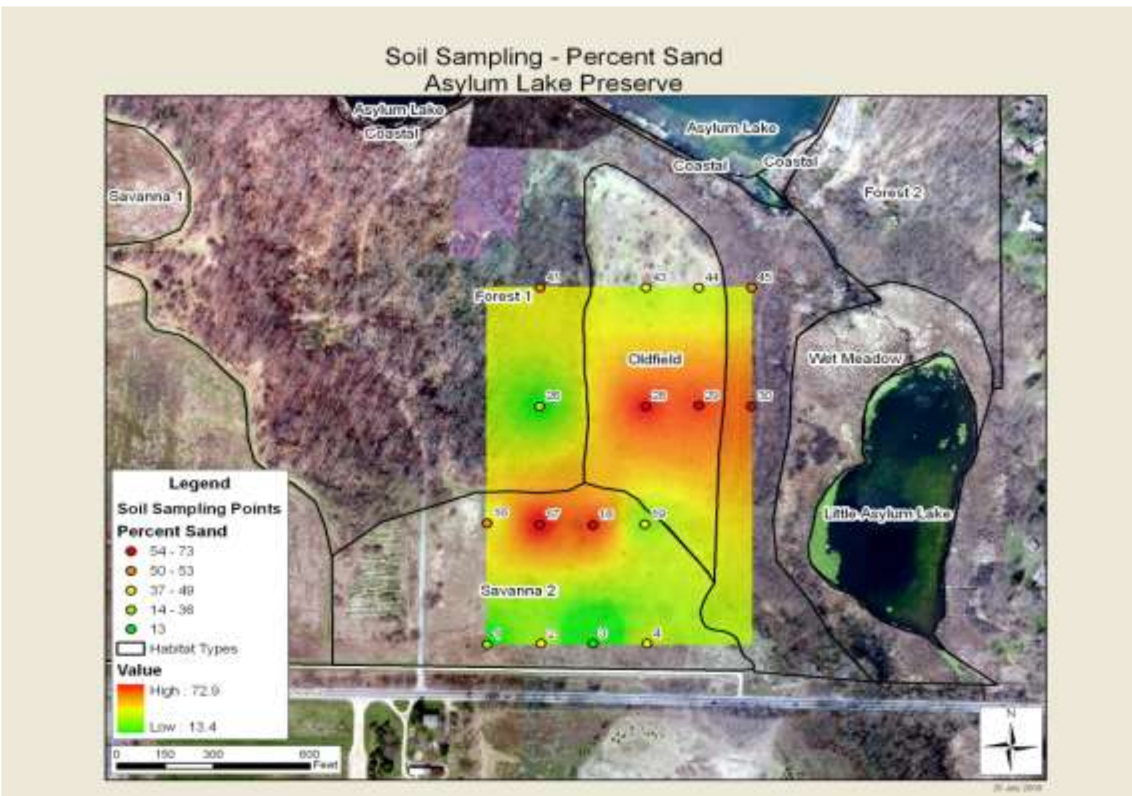


Fig. 14

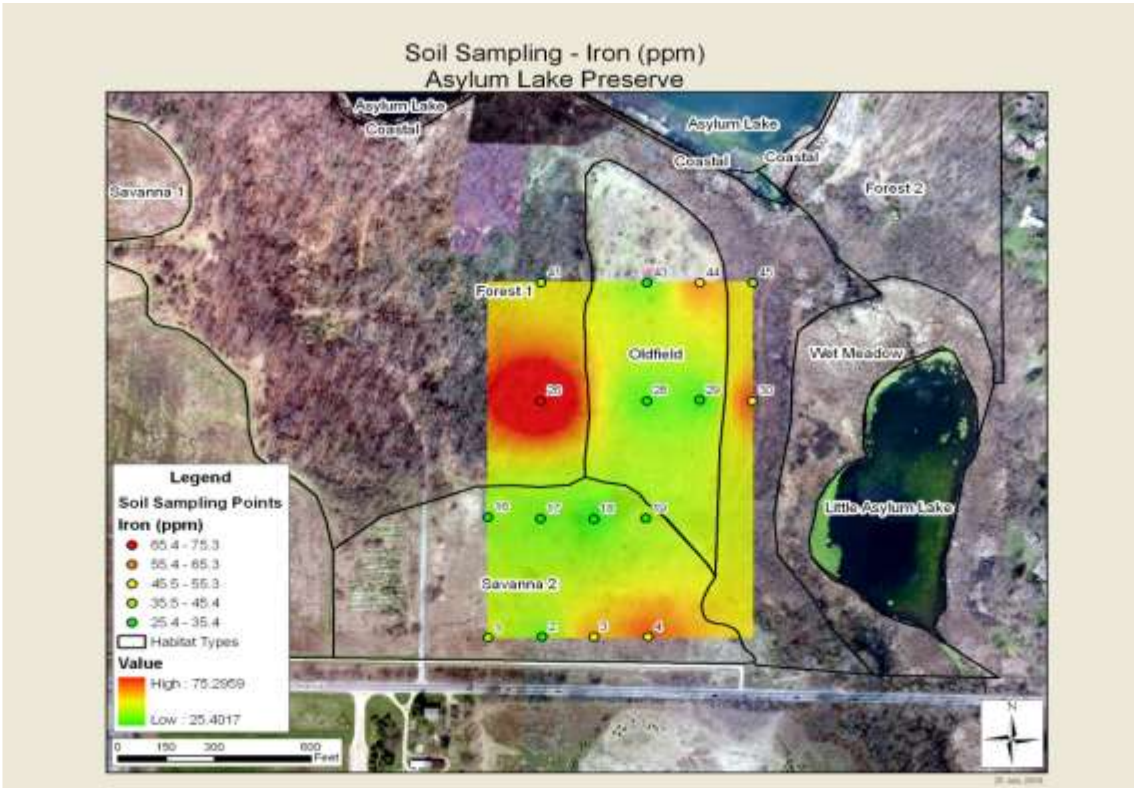
Soil Sampling - Iron (ppm)
Asylum Lake Preserve
Asylum Lake
Coastal
Savanna 1
Forest 2
Forest 1
Oldfield
Wet Meadow
Little Asylum Lake
Savanna 2
Legend
Soil Sampling Points
Iron (ppm)
65.4 - 75.3
55.4 - 65.3
45.5 - 55.3
35.5 - 45.4
25.4 - 35.4
Habitat Types
Value
High : 75.2959
Low : 25.4017
0 150 300 600 Feet

Fig 15

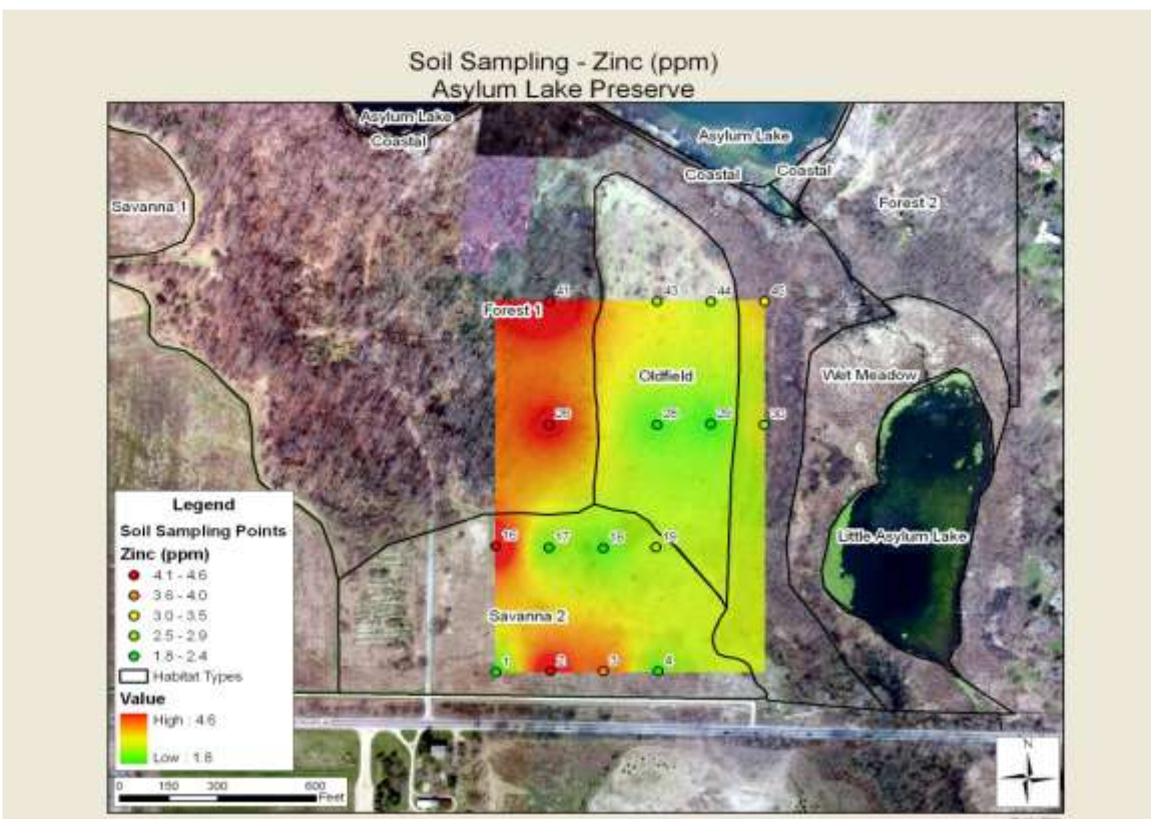
Soil Sampling - Zinc (ppm)
Asylum Lake Preserve
Asylum Lake
Coastal
Savanna 1
Forest 2
Forest 1
Oldfield
Wet Meadow
Little Asylum Lake
Savanna 2
Legend
Soil Sampling Points
Zinc (ppm)
4.1 - 4.6
3.6 - 4.0
3.0 - 3.5
2.5 - 2.9
1.8 - 2.4
Habitat Types
Value
High : 4.6
Low : 1.8
0 150 300 600 Feet

Fig. 16

Sandy soils, because of their heightened porosity and composition, may allow for migration of nutrients from the sandy surface to subsurface soils and/or allow for faster breakdown of nutrients. This would partially explain the heightened levels of P found in Forest 1 in the given example. When compared, it is evident that Old Field has lower P levels and significantly greater sand content that Forest 1 (see figures 14 & 17).

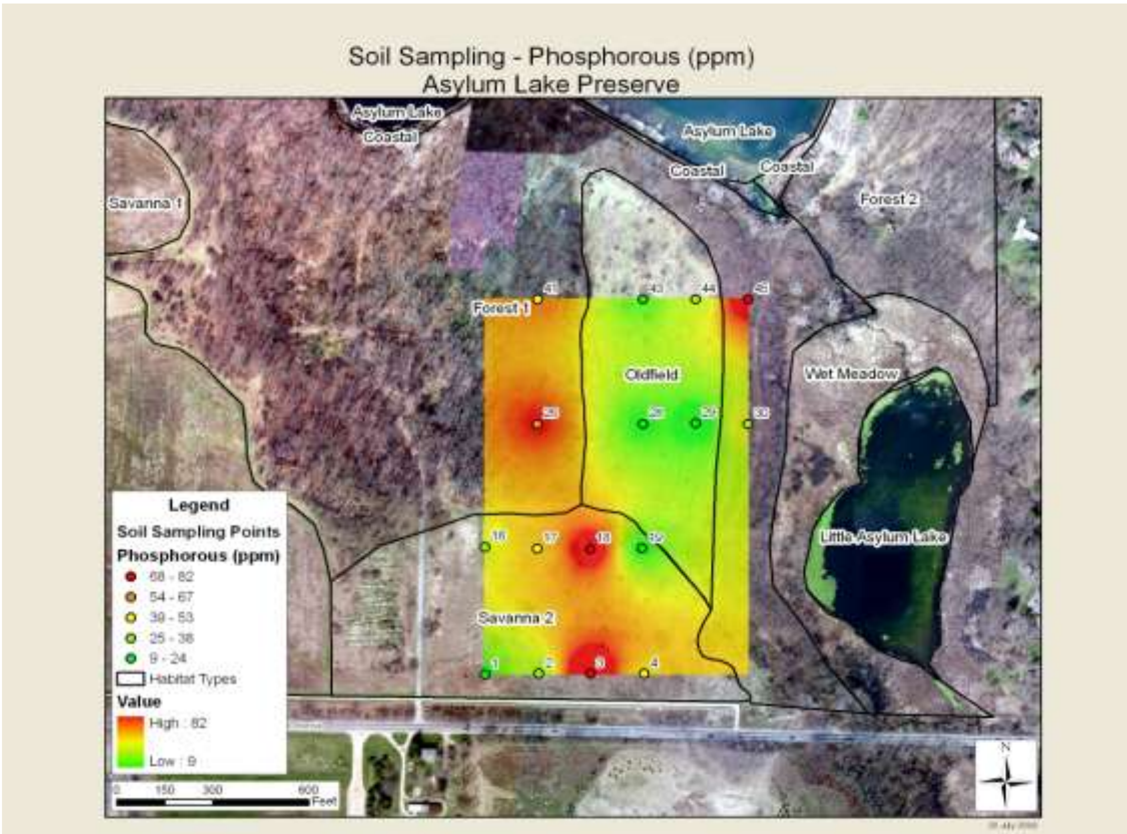


Fig. 17

There is also the possibility that the high P levels are due to leaf litter decomposition from mixed species of trees; tree litter decomposes and delivers inorganically bound P to the surface of forest floors causing the surface soils to receive organic P from sub-surface soils (Talkner et. al.). Forest 1, and Savanna South, with their trees, contain more leaf litter than the other areas; however, no litter count was quantitatively analyzed in this study.

Another possibility is that past land use practices in Forest 1 lead to the higher P levels (Dupouey et. al.). A recent land use study shows that in areas where human habitation and agricultural practices take place (fires used for heat, structures built and demolished, and fertilizers used), P levels in the leaves of surrounding trees and P levels in surrounding soils were greater than the levels of P found in less utilized areas (Dupouey et. al.). Forest 1 may show higher P levels, perhaps, because of methods used to produce heat and power for the residences formerly within the area. There were also structures built and demolished in Forest 1. There is no record of land use for Old Field.

High K and Mg levels in Savanna South soils (figures 18 & 19) may be specifically due to Oak tree litter. Debris accumulates under oak canopies increasing biodiversity by creating a more conducive habitat for living organisms and increases nutrient cycling for base cations such as K and Mg (Dahlgren et. al. 2003).

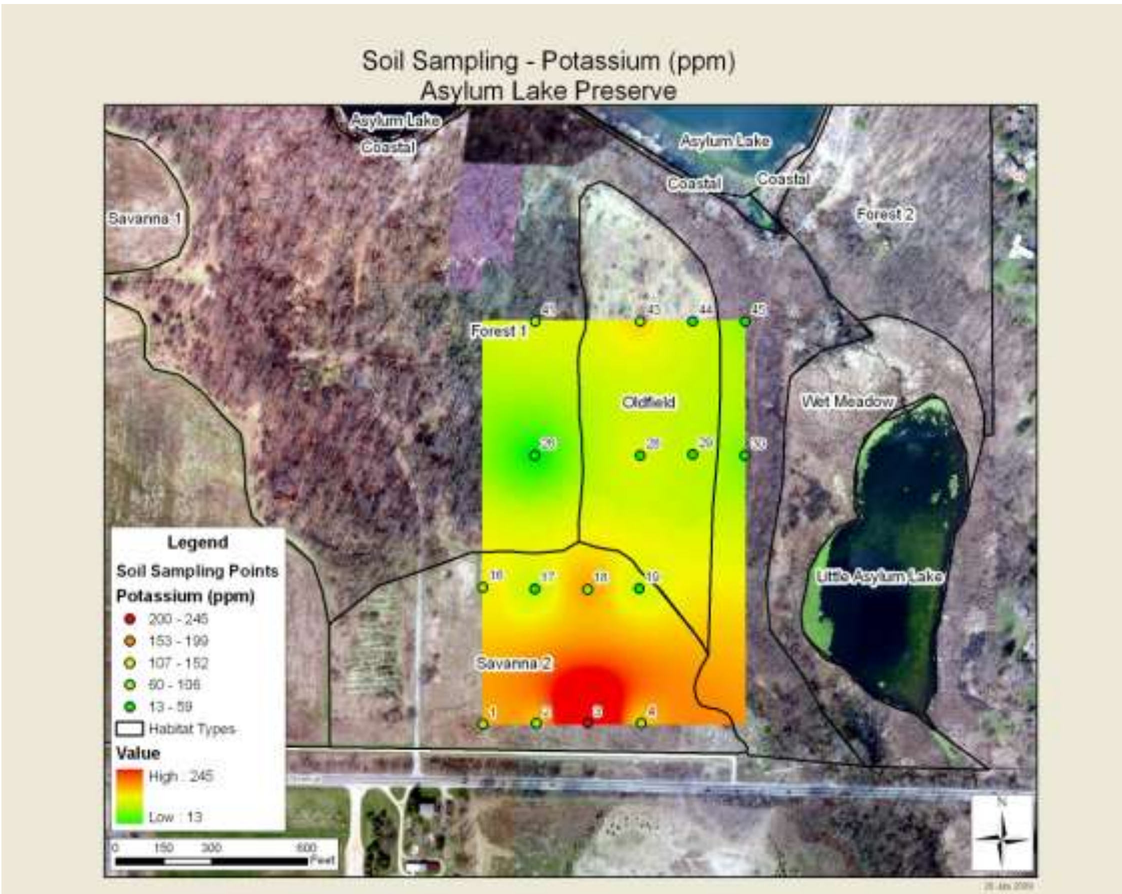


Fig. 18

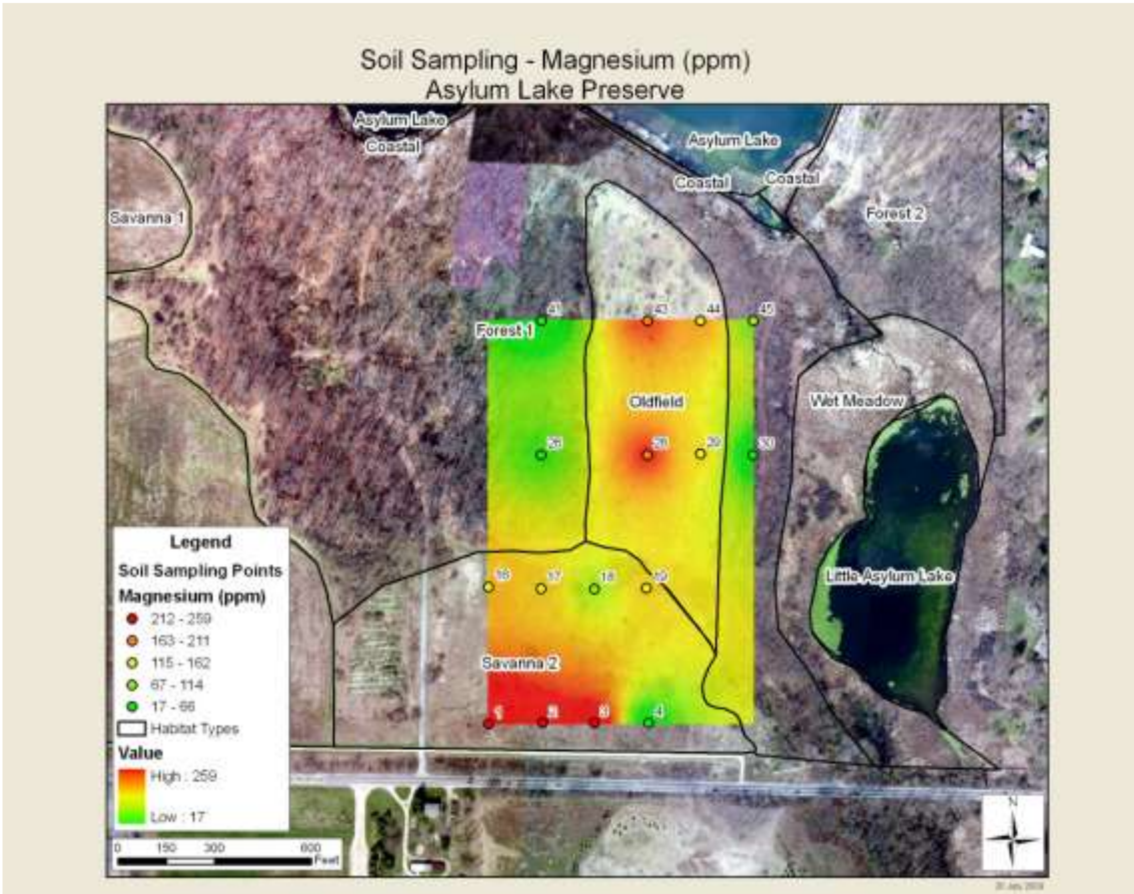


Fig. 19

There appears to be some relationship between sandier, more nutrient deficient areas and the plants found in those areas via the survey. Savanna North showed the most significant levels of plant presence/ including grasses, trees, and forbs/ out of all of the areas surveyed. Old Field also proved to support higher amounts of grasses and forbs than Forest 1; and, Savanna South contained a significant number of forbs according to the survey.

The Forest 1 floor showed only one species, through survey and analysis, to be dominant: Parthenocissus quinquefolia (Virginia Creeper, a vine). There may be a relationship between nutrient levels and plant material data for Forest 1, however, for future research, larger transects should be used in order for the vegetation data to be more representative of the area. Future research should also include plant to soil composition relationships.

There seems to be evidence confirming the notion that it is not just the soil that is influencing the vegetation in the areas of Old Field, Forest 1, and Savanna, implying that, the vegetation influences the soil as well. The presence of tree litter may be the determining factor in regards to soil nutrient levels. Additional studies assessing microbial activity would be useful. It is also important to note that no toxicity analysis was done during this study. It is not known if past use of pesticides influences current vegetation patterns on the Asylum Lake property. Also, invasive plant species within the areas surveyed and their possible effect on tree germination was not determined.

In theory, if forest succession is to happen in Old Field as it is happening in the Savanna; perhaps it may be a slower process because of current soil quality. As succession happens, more tree litter will be introduced to the soil surface creating a more nutrient rich soil layer that may allow for forest in-growth in the future. On the other hand, this study indicates that the addition of top soil and/or nutrients to Old Field may help speed up natural forest succession or aid forced forest succession.

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