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Applications of GIS to Natural Resource Management: GSU Field Station and Surrounding Thorn Creek Preserve

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Abstract. Geographic Information System is used to identify available natural resources and their management of Governors State University and surrounding Thorn Creek Preserve. Using ArcGIS 10.5.1, seven different map have been made categorized under, Governors State University campus map, land use types of the study area, available streams and ponds, major ground water resources in this area, human population dynamics, digital elevation model and soil type of the study area. The GPS points have been recorded using GPS unit. The available GIS data shape files have been collected from Illinois Natural Resource Geographical Data Clearinghouse. The Governors State University campus map identify locations of trails, sculpture park, field station and research sites, remnant prairie and tree species and sustainable garden. The land use types data map represents vegetation, agricultural land, wetlands, forest and developed land. This study area is covered by majority of deciduous forest and agricultural area. The ponds and stream data enable to see exact location of available ponds and streams of the study area. A shallow bedrock well is the most common ground water resource in this area. The population dynamics map suggest that human population is continue increasing around the study area which results in increasing pressure on natural resources. The digital elevation model shows that GSU campus is relatively flat, with a majority of area consisting of slope less than 4%. According to soil survey map, the campus and surrounding areas are comprised of alfisols and molisols.

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Chapter 1: Literature Review

Geographic Information System (GIS) is as an important decision-making tool for natural resource management. The demands for better management of natural resources require the organization, storage, and access of spatial data and information. GIS refer to the broad collection of information management techniques, which store and analyze such data, to contribute to the needs for planning and resource management. The use of GIS has produced remarkable changes in the way and rate at which georeferenced data are produced, updated, analyzed and disseminated, making production and analysis of spatial information very efficient. Furthermore, it is characterized by diversity of applications and can be effectively used in urban planning, natural resource management, selection of suitable species for reforestation, fire control management, monitoring fire decline, forest road designing, tourism development, and other land use fields (e.g. land resource mapping and land use changes). In the past three decades, this potential has led to rapid developments in both theory and technology resulting in increasing technical capabilities and decreasing hardware and software costs (Tripathi et al. 2004).

Land use and natural resources for future sustainable ecotourism sites has been evaluated using Geographic Information System in Surat, Thani district, Thailand (Bunruamkaew and Murayama 2012). Evaluation of sites was based on 2007 land use land cover data and ecotourism suitability data which were integrated with other GIS datasets to evaluate the land use and natural resources at a district level in this province. They classified that region in to four different categories: highly suitable, moderately suitable, marginally suitable, and non-suitable site for ecotourism. They concluded that marginally suitable areas can be developed as ecotourism sites with some infrastructure development. The highly suitable and moderately suitable areas can be used as attraction of ecotourism sites but under consideration of sustainable use of natural resources (Bunruamkaew and Murayama 2012).

A spatial model was developed, and geographic information system used for suitable locations to identify wetland mitigation sites (Van Lonkhuyzen et al. 2004). The model used six variables to characterize site conditions: hydrology, soils, historic condition, vegetation cover, adjacent vegetation, and land use. For each variable, a set of suitability scores was developed that indicated the wetland establishment potential for different variable states. Composite suitability scores for individual points on the landscape were determined from the weighted geometric mean of suitability scores for each variable at each point. These composite scores were grouped into five classes and mapped as a wetland mitigation suitability surface with a GIS. Sites with high suitability scores were further evaluated using information on the feasibility of site modification and project cost. This modeling approach could be adapted by planners for use in identifying the suitability of locations as wetland mitigation sites at any site or region (Van Lonkhuyzen et al. 2004).

The Florida Agroforestry Decision Support System (FADSS) utilized a GIS enabling the user to select a location of interest which is linked to spatial data on climate and soils characteristics for the state of Florida (Nair et al. 2000). The application also incorporates a database of over 500 trees and 50 tree attributes, forming a relational database. The application structure consists primarily of building database queries using Standard Query Language (SQL). SQL queries are constructed during run-time based on spatial parameters of a selected location, the type of agroforestry system desired, and production and management criteria provided by the user. Experts were interviewed to help develop queries used to select trees and other agroforestry species. Being a prototype, the application is built with a modular and flexible framework in which spatial data of different scales and/or regions as well as plant data may be easily incorporated. Among the major limitations encountered during the development of FADSS with implications on future agroforestry decision support systems was the current lack of tree information relevant to agroforestry and the lack of research involving the assessment of suitable trees and their characteristics (Nair et al. 2000).

Wetlands play a vital role in maintaining the overall cultural, economic, and ecological health of ecosystems, their fast pace of disappearance from the landscape is of great concern. Prasad et al. 2002, conducted study on status and distribution of wetlands and causes and consequences of wetland losses which provides an overview of the use of remote sensing and GIS tools in flood zonation mapping, monitoring irrigation and cropping patterns, water quality analysis and modelling, change analyses in mapping of surface water bodies and wetlands. They have used a methodology and an action plan for evolving a nationwide network of conservation preserves of wetlands. The major elements of this methodology involve use of IRS LISS III sensors for delineating turbidity, aquatic vegetation and major geomorphological classes of wetlands. An extensive fieldwork to generate attribute information on biodiversity and socioeconomic themes is a significant component of the suggested methodology. GIS tools to integrate habitat information with the field information are envisioned to be the final component in evolving a conservation network of wetlands for the entire country (Prasad et al. 2002).

Researchers developed a working GIS for Monterey Bay National Marine Sanctuaries that allows interpretation of many terrestrial and marine data sets, including inter-tidal monitoring data, permit locations, seabird stranding, fisheries catch data, habitat types, marine political boundaries, as well as land cover classification from satellite imagery, watersheds, streams, roads, and political boundaries. They linked terrestrial and marine data to create a broad spatial and temporal database that will be used in a variety of ways such as evaluating natural processes, permitting and monitoring coastal development and assessing environmental impact (Stanbury et al. 1999).

A GIS-based Land Transformation Model-LTM was developed to forecast land use change over large regions (Pijanowski et al. 2001). A variety of social, political, and environmental factors contribute to the model's predictor variables of land use change. This study presented a version of the LTM parameterized for Michigan's Grand Traverse Bay Watershed and explores how factors such as roads, highways, residential streets, rivers, Great Lakes coastlines, recreational facilities, inland lakes, agricultural density, and quality of views can influence urbanization patterns in this coastal watershed. The predictive ability of the model improved at larger scales when assessed using a moving scalable window metric. Finally, the individual contribution of each predictor variable was examined and shown to vary across spatial scales. At the smallest scales, quality views were the strongest predictor variable. They interpreted the multi-scale influences of land use change, illustrating the relative influences of site and situation variables at different scales (Pijanowski et al. 2001).

Martin et al. (2009) developed a fire model project to map wildland fire risk for several regions of Spain. They discussed the methods used to generate the risk parameters and presented a proposal for their integration into synthetic risk indices. The generation of input variable was based on an extensive use of geographic information system and remote sensing. All variable was mapped at 1 km^2 spatial resolution and were integrated into a web-mapping service system. The whole evaluation system was based on two group of factors: those associated to the probability that a fire occurs and those related to potential damage of fires. The assessment showed significant difference between two integrated indices and fire ignition in study regions located in Spain. However, these regions had different ecological and fire conditions and might be considered a representative sample of the potential of the indices (Martin et al. 2009).

Computer-based Decision Support Tools (DST) help to integrate information to facilitate the decision-making process that directs development, acceptance, adoption, and management aspects in agroforestry (Ellis et al. 2004). Computer-based DSTs include databases, geographical information systems, models, knowledge-base or expert systems, and ‘hybrid’ decision support systems. Agroforestry lacks the large research foundation of its agriculture and forestry counterparts, even though the development and use of computer-based tools in agroforestry have been substantial and are projected to increase as the recognition of productive and protective role of these tree-based practice expands. The utility of these and future tools for decision-support in agroforestry must consider the limits of our current scientific information, the diversity of aspects that must be incorporated into the planning and design process, and, most importantly, who the end-user of the tools will be. Incorporating these tools into the design and planning process will enhance the capability of agroforestry to simultaneously achieve environmental protection and agricultural production goals (Ellis et al. 2004).

Remote sensing technology has the potential to monitor and manage groundwater (Jha et al. 2006). Rapidly expanding GIS technology played a central role in handling the spatio-temporal data that represent space and time information and their effective interpretation, analysis and presentation. The study highlighted these two emerging technologies in ground water management which are limited to six areas in ground water hydrology: exploration and assessment of groundwater resources, selection of artificial recharge sites, GIS-based subsurface flow and pollution modeling, ground water pollution hazard assessment and protection planning, estimation of natural recharge distribution, and hydrogeological data analysis and process monitoring (Jha et al. 2006).

The Geographic Information System used to compare soil and landscape attributes with its historic vegetation, current land use, and patterns of land-use change in Illinois over the past 160 years (Iverson 1988). Patch structural characteristics among land types in four geographic zones were also compared. The assessment of patch characteristics revealed a highly modified State with most land patches controlled by human influences and relatively few by topographic and hydrologic features. They embarked on plan to boost forest and forestry within the State. Results from this study were incorporated into that plan where marginal hectarage land with high slopes and relatively low productivity indexes targeted for reconversion to forests and encouraged through economic incentives (Iverson 1988).

Identification of potential ecotourism sites in West District, Sikkim, India using geospatial tools has been done with integration of five indicator indices, wildlife distribution index (WDI), ecological value index (EVI), ecotourism attractivity index (EAI), environmental resiliency index (ERI) and ecotourism diversity index (EDI), (Kumari et al. 2010). The primary variables used for generating various indices were landform, elevation, land use/forest cover, vegetation diversity, density and endemism, wildlife, tourism attraction features and the infrastructure facilities. Data and information from remote sensing and other sources were used. The analytical hierarchical process and geographic information system were effectively used for identification of the potential ecotourism sites. This study provided scope for future studies using ecotourism indicators for identification of potential ecotourism sites in other ecosystems such as coastal, mangrove, and desert. It may also include other environmental parameters like environmental vulnerability index, environmental disturbances index to make it applicable in other conditions as well (Kumari et al. 2010).

Dominguez et al. (2007) developed a GIS application for the rural electrification with renewable energy. This application was based on Arc Info and it improved upon the first version of Solar GIS in several ways. The GIS application also carried out the calculation of capacity factors for conventional system with professionally contrasted design criteria and assigns new variables and eliminate other irrelevant or redundant factors (Dominguez et al. 2007).

Land degradation is recognized as one of the major threats to the buffer zones of protected areas in Vietnam (Khoi et al. 2010). The expansion of land degradation into the protected areas is exerting pressure on biodiversity conservation efforts. This degradation is partially the result of mismanagement of land use. This study includes delineate the areas suitable for cropland in the Tam Dao National Park (TDNP) region using a GIS-based multi-criteria evaluation of biophysical factors and Landsat ETM^{+} imagery. GIS is used to generate the factors, while MCE is used to aggregate them into a land suitability index. The results indicate the location and extent of crop farming areas at different suitability levels, *i.e.*, most suitable (28.10%), moderately suitable (23.96%), marginally suitable (28.77%), and least suitable (19.17%). The current cropland covers 46.5% of the study area, while most and moderately suitable areas are estimated to be 52.06% of the territory. The results can be used to identify priority areas for crop farming and sustainable land-use management (Khoi et al. 2010).

A GIS based model has been developed to evaluating ecological sensitivity for tourism development in fragile environment in southeast Iceland (Olafsdottir et al. 2009). The model was based on classification of identified impact factors and variables, as well as selected classification algorithms that were used to assess categories of ecological sensitivity that may aid decision makers in planning and managing sustainable tourism in sensitive areas that are facing the risk of being subjected to ecological degradation (Olafsdottir et al. 2009).

Geographical Information Systems (GIS) can be regarded as providing a tool box of techniques and technologies of wide applicability to the achievement of sustainable tourism development (Bahaire et al. 2010). Spatial data can be used to explore conflicts, examine impacts and assist decision-making. Impact assessment and simulation are increasingly important in tourism development, and GIS can play a role in auditing environmental conditions, examining the suitability of locations for proposed developments, identifying conflicting interests and modelling relationships (Bahaire et al. 2010).

A multiple purpose wetland inventory is being developed and promoted through partnerships and specific analyses at different scales in response to past uncertainties and gaps in inventory coverage (Rebelo et al. 2007). A partnership approach is being promoted through the Ramsar Convention on Wetlands to enable a global inventory database to be compiled from individual projects and analyses using remote sensing and GIS. Individual projects that are currently part of this global effort are described. They include an analysis of the Ramsar sites' database to map the distribution of Ramsar sites across global ecoregions and to identify regions and wetland types that are under-represented in the database. Given the extent of wetland degradation globally, largely due to agricultural activities, specific attention is directed towards the usefulness of Earth Observation in providing information that can be used to more effectively manage wetlands. As an example, a further project using satellite data and GIS to quantify the condition of wetlands along the western coastline of Sri Lanka is described and trends in land use due to changes in agriculture, sedimentation and settlement patterns are outlined. At a regional scale, a project to map and assess, using remote sensing, individual wetlands used for agriculture in eight countries in southern Africa is also described. Land cover and the extent of inundation at each site is being determined from a multi-temporal data set of images as a base for further assessment of land use change (Rebelo et al. 2007).

A variety of existing maps, data and information, a new Global Lakes and Wetlands Database (GLWD) has been created (Lehner et al. 2004). The combination of best available sources for lakes and wetlands on a global scale (1:1 to 1:3 million resolution), and the application of Geographic Information System (GIS) functionality enabled the generation of a database which focuses in three coordinated levels on large lakes and reservoirs, smaller water bodies, and wetlands. Level 1 comprises the shoreline polygons of the 3067 largest lakes and 654 largest reservoirs worldwide and offers extensive attribute data. Level 2 contains the shoreline polygons of approx. 250,000 smaller lakes, reservoirs and rivers, excluding all water bodies of level 1. However, level 3 represents lakes, reservoirs, rivers, and different wetland types in the form of a global raster map at 30-second resolution, including all water bodies of levels 1 and 2 (Lehner et al. 2004).

The integrated habitat suitability index approach, as produced in this study, is based on the combined use of empirical evaluation models and models based on expertise in the GIS environment (Store et al. 2003). GIS was used to produce the data needed in the models, as a platform to execute the models and in presenting the results of the analysis. However, the suitability models for the case study species were constructed outside the GIS. This study showed that several GIS-based approaches and Multi criteria evaluation techniques are immediately available for habitat suitability evaluation of a group of species. The biggest advantages of the method are connected to the possibilities to consider habitat factors on different scales, to combine habitat suitability evaluations for several species, and to integrate empirical models and the knowledge of experts (Store et al. 2003).

The influence of both local habitat and landscape variables on avian species abundance at forested study sites situated within fragmented and contiguous landscapes has been examined (Howell et al. 2000). The study was conducted over a six-year period (1991– 1996) at 10 study sites equally divided between the heavily forested Missouri Ozarks and forest fragments in central Missouri. They found greater species richness and diversity in the fragments, but there was a higher percentage of Neotropical migrants in the Ozarks. They also found significant differences in the mean number of birds detected between the central Missouri fragments and the unfragmented Ozarks for 15 (63%) of 24 focal species. They used stepwise regression to determine which of 12 local vegetation variables and 4 landscape variables accounted for the greatest amount of variation in abundance for 24 bird species. Seven species (29%) were most sensitive to local vegetation variables, while 16 species (67%) responded most strongly to one of four landscape variables. Landscape variables are significant predictors of abundance for many bird species; resource managers should consider multiple measures of landscape sensitivity when making bird population management decisions (Howell et al. 2000).

GIS data processing and spatial analysis with modern decision analysis technique were used to improve habitat suitability evaluation over large areas (Store et al. 2001). The habitat requirement of species was described as map layer within GIS so that each map layer represented one criterion. GIS was used as platform in managing, combining and displaying the criterion data and as a tool for producing new data. Sensitivity analysis was applied to consider the temporal factor in the analysis and found out the effect of different criteria weights on the spatial patterns of suitability index (Store et al. 2001).

Chapter 2: Management Project

Introduction

Geographic Information Systems (GIS) have been widely used in various applications of natural resource management. This includes land use management, wetland management, watershed management, soil science, forestry, wildlife habitat monitoring, agriculture, and response natural disasters. The integrated use of GIS and GPS (Global Positioning System) enable natural resource managers, researchers, and consultants in government agencies, conservation organizations, and industries to develop management plan for a variety of natural resource management applications (Tsou 2004). GIS technology provides a flexible platform for storing, analyzing and displaying digital data for both temporal and spatial dynamics and database development. There has been increased emphasis on the potential utility of GIS precision agricultural, which has the potential to reduce the use of fertilizers, pesticides, and minimize soil erosion (Nemenyi et al. 2003). Precision agriculture also promotes variable management practices with crops.

GIS provides information regarding wildlife habitat, habitat assessment and habitat prediction which is useful to introduce any new species to the particular area (Danks et al. 2002). A biodiversity gap analysis is a method, now usually run with GIS for identifying deficiency in existing biodiversity protection (James et al. 1995). This method allows to develop the preserve design and assessment plan.

Soil properties are spatially variable and the traditional method of soil analyses are laborious and time consuming. With the advancement of GIS, soil analysis models can be developed to identify soil types in an area and to delineate soil boundaries (Zhu et al. 2001). Land-use suitability analysis is a tool used to identify the most suitable places for locating future land uses (Collins et al. 2001). Suitability techniques enable environmental managers and planners to analyze the interactions among three broad factors: location, development actions, and environmental elements. A GIS analysis assistis investigators with mapping these interactions in a variety of ways, including which land uses will have the least adverse impact on environmental processes and environmental impact of proposed development. It also helps in preventing environmental deterioration associated with misuse of land (Collins et al. 2001).

Much of this work can be frames in watershed management units (Gonzalez 2002). Watershed management is a process of land use practices and water management practices to improve water quality and other natural resources within watershed by managing those land and water resources in a comprehensive manner. It is required to protect and improve water quality (Gonzalez 2002). In long-term forest management with biodiversity conservation and timber production, GIS allows to create planning model with spatial distribution dataset (Naesset 1997). This can help guide harvest rates leading to sustainable forest management. Extensive spatial data is required for the management of natural disasters such as flooding, earthquake and landslides. For natural disaster management, GIS is an ideal tool that offers information over large areas and at varying time intervals which can be utilized in different responses phases, such as prevention, early warning, and monitoring (Cutter 2003).

This study will identify available natural resources in the Governor State University campus and the surrounding Thorn Creek Nature Preserve. The objectives of this study were:

- To identify locations of available natural resources for future management.

- To provide information about type of habitats occurring in the study area.
- To identify teaching and research sites for protection and development or ecological research and education projects.
- Build a GIS database for developing a future land use management plan.

Materials and Methods

Study Area---The Governors State University campus (41.4491721, -87.714434) covers about 303 hectares with 58 hectares of preserve, located in eastern Will County, Illinois, U.S.A. The Biology Field Station manages different trails: Link Trail, Loop Trail, Pond & Prairie Trail, and Thorn Creek Trail. The remnant tall grass prairie on campus is comprised of a diverse plant community. One management objective is to conserve, restore, and enhance the native prairie plant species. This prairie area is dominated by Indian grass (*Grass sp*.), tall goldenrod (*Solidago altissima*), stiff goldenrod (*Solidago rigida*), prairie dock (*Silphium terebinthinaceum*), bidens (*Bidens coronata*), buck thorn (*Rhamnus fragulata*), poison ivy (*Rhus radicans*), wild quinine (*Parthenium integrifolium*), big bluestem (*Andropogon gerardii*), heath aster (*Aster ericoides*), hairy aster (*Aster pilosus*) and queen anne's lace (*Daucus carota*). The Pond & Prairie Trail connects with the GSU Sculpture Park. The Nathan Manilow Sculpture Park is a collection of 30 master works of large-scale sculpture situated within 100 acres of prairie landscape. The Park provides programs for adults and children that integrate art and nature. It was founded and is maintained through grants and donation from businesses and individuals.

The available ponds are increasing beauty of the campus and also providing habitat for aquatic ecology. These ponds are constructed to create water resources. The ponds by the main building are cover approximately 4.64-hectares of the campus area, collecting runoff water of the parking lots. The ponds along the trail are in about 1.12 hectares, providing water resources to the wildlife.

Thorn Creek Nature Preserve is about 364 hectares and protects examples of upland, bottomland, and ravine forests, glacial potholes, prairie, and the riparian environments of Thorn Creek, plus several small wetlands. Today, the forests on the slopes of the ravines are dominated by black oak (*Quercus velutina*) and white oak (*Quercus alba*). Sugar maple (*Acer saccharum*), black walnut (*Juglans nigra*) and basswood (*Tilia americana*) are generally associated with the more mesic, low lying areas. The mesic sites of Thorn Creek Preserve also support a rich and diverse herbaceous flora, including many spring wildflowers common to the Chicago region: yellow trout-lily (*Erithronium americanum*), jack-in-the-pulpit (*Arisaema triphyllum*), and a variety of asters. A small area of wet and mesic prairie is located on the western edge of the woods. Prairie cordgrass dominates the low wet areas while little bluestem is more typical of drier areas. Common forbs of the prairie include wild hyacinth (*Camassia scillinoides*), Turk's-cap-lily (*Lilium superbum*), Culver's root (*Veronicastrum virginicum*), swamp saxifrage (*Saxifrega pensylvanica*), swamp thistle (*Cirsium muticum*), sand violet (*Viola fimbriatula*) and sunflowers (*Halienthus annuus*). Blue spotted (*Ambystoma laterale*) and spotted salamanders (*Ambystoma maculatum*) breed in wetland depressions. Eight species of frogs have been recorded: western chorus frog (*Pseudacris triseriata*), northern cricket frog (Acris crepitans), eastern gray tree frog (*Hyla versicolar*), wood frog (*Rana sylvatica*), green frog (*Rana clamitans*), pickerel frog (*Rana palustris*), American bull frog (*Rana catesbeiana*) and northern leopard frog (*Rana pipiens*).

The grassland area of Thorn Creek watershed was historically comprised of 70% prairie, pre-settlement, but these areas are only less than 12% prairie now because the landscape has been converted to cropland and suburban development. There is an active headwater restoration which is about 57-hectare of prairie and savanna. These headwaters are wooded along Thorn Creek.

Methods --- ArcGIS 10.5.1 (Environmental Systems Research Institute) was used for all GIS data storage, analysis, and mapping. For field data collection, GPS (Garmin Montanna, 5-meter accuracy) coordinates of ten different tree species and approximately 7.5-meter integrals along all trails have been recorded. In addition, locations of sites for teaching, research, sustainable garden, artificial constructed pond for water collection, and the sculpture park have been recorded.

Landsat 7 data (www.copernicus.com., Table 1) has been used for classing land cover categories. Landsat 7 uses both thematic mapping and multispectral scanning imagery (USGS EROS Data Center) The 15-meter resolution imagery was used. Copernicus open Access Hub has been used to access these land cover data

Apart from that, some existing databases have been collected including land cover, ground water resources, human population, soil survey, streams and ponds and elevation data from Illinois Natural Resource Geographical Data Clearinghouse (Table 1). The land cover data set comprised of Landsat-7 data with 20 different color band and 30-meter accuracy was used to categorize land-cover types (Table 1). Out of these, there are around 8 different bands according to habitat type. The population data set of the study area is a TIGER file, describes land attributes such as roads, building, river as well as census tracts (Table 1). The ponds and streams data shape file provides information about location of available ponds and streams in the study area. The DEM (Digital Elevation Model) data set is a digital elevation model of Illinois in Arc Info grid format. The data are stored in

UTM coordinates, using a Transverse Mercator projection with the parameters of UTM Zone 16, NAD27. The data have a 10-meter ground resolution (Table 1). The soil survey data is a polygon feature class showing soil associations in Illinois, from the General Soil Map of Illinois (Fehrenbacher, 1982), created in 1984 by ESRI. It shows twelve different color band and each color represent an order of soil, example: alfisols, andisols, aridisols etc. The General Soil Map of Illinois (scale 1:500,000) identifies the location and extent of 50 soil association types (Table 1).

Table 1. – Existing GIS databases and their sources.

Layer	Database	Description	Source
Topography	Topography elevation data with reference datum.	Digital elevation model data is a 3D representation of a terrain's surface, commonly of planet.	Illinois Natural Resource Geographical Data Clearinghouse
Human Population	Population data base map by US Census Bureau.	Topologically Integrated Geographic Encoding and Referencing, or TIGER, or TIGER/Line is a format used by the US Census Bureau.	U.S. Bureau of the Census, 2011
Land cover	Landsat 7	This data is a raster, geo-referenced, categorized land cover data layer produced using satellite imagery from the Thematic Mapper (TM)	Illinois Natural Resource Geographical Data Clearinghouse

		instrument on Landsat 5 and the Enhanced Thematic Mapper (ETM+) on Landsat 7.	
Streams and ponds	Streams and Shorelines	Data provides information of topographic features, generally occur in a characteristic pattern of landscapes.	Illinois Natural Resource Geographical Data Clearinghouse
Soil	Soil Map of Illinois	A soil association is a group of related soil series that generally occur in a characteristic pattern of landscapes that have identifiable topographic features, slopes, and parent materials.	Illinois Natural Resource Geographical Data Clearinghouse

Results and Discussion

The GSU campus is surrounded by agricultural fields, residential areas, Thorn Creek Nature Preserve and a golf course. Both entrances of the campus are connected to main roads. The Biological Field Station serves as an outdoor laboratory for the university's Biological Department. It is comprised of shrub land, oak woods, non-native grasslands, and prairie relics. The teaching and research sites of the field station offer to conduct field experiments. The vegetation of the campus area is very diverse including tall grass prairie and tree species. The location of the available prairie area and 10 different tree species including basswood (*Tilia americana*), catalpa (*Catalpa speciosa*), sugar maple (*Acer saccharum*), hickory (*Carya*), ginkgo (*Ginkgo biloba*), white oak (*Quercus alba*), Kentucky coffee tree (*Gymnocladus dioicus*), domestic apple tree (*Malus pumila*), black locust (*Robinia pseudoacacia*) and Osage orange (*Maclura pomifera*) have been mapped into study (Fig. 1). The sustainable garden, near the Early Childhood Development Center, is mainly used for growing one's own food in a sustainable manner. This garden can successfully sustain itself without requiring many outside resources, pesticides or herbicides. The ponds southwest of the main building collect runoff water from parking lots and drain to Thorn Creek. The different trails of campus allow walk to the field station from the campus, birdwatching, photography, hiking, skiing and running (Fig. 1).

A tagging should be done on tree species for identification purpose along the trails. It can be done by creating database of number of tree and different species available in the campus. The tag should be made of the metal, contain a common name of the tree species. To maintain the biodiverse environment of field station, development should be avoided in in the field station area including experimental sites.

The GSU campus and surrounding area support rich biodiversity, mostly covered by approximately 122.34 hectares in agricultural land and 64.4 hectares in deciduous forest. As we can see in land use type map (Fig. 2), there is a medium intensity developed area with few spots of high intensity development in University Park. In addition, there are a few patches of open pasture and herbaceous vegetation. The available wetlands and ponds on the campus, covering approximately 11.18 hectares of water body of the campus area. Based on map, this study area covered by eight land use categories (Fig. 2). However, the available wetlands should be conserved and development on surrounding area should be avoided. The headwater of Thorn Creek Preserve forms small streams which are running through campus area. The available ponds and streams provide water resources to the wild animals of the campus (Fig. 3). In term of ground water resources, there are three major aquifers, sand and gravel wells, shallow bedrock wells and Cambrian sand stone well. Out of these three, shallow bedrock wells have been found in most of the study area. This aquifer is an important source of groundwater for municipalities, industry and private homeowners throughout the area (Fig. 4).

The human population has been increased in Will County in past few years which create stress on available natural resources. The population dynamics map (Fig. 5) indicates that, from 2000 to 2010 human population reached 188951 to 502266. The continued rapid growth of human population in Will County has been stopped in 2008. The current population of will county is 692661. To minimize the population impacts on natural resources, some restoration work is required on vacant space of Thorn Creek

Preserve. From an ecological perspective, biological interactions can be increased by extending the preserve area further to the west of the Field Station (Fig. 1). This expansion will provide increase in wildlife habitat and vegetation cover. The Illinois Department of Natural Resources, Will County Forest Preserve and Thorn Creek Nature Preserve are the main responsible stakeholders for the preserve extension.

The digital elevation model shows that GSU campus is relatively flat, with a majority of area consisting of slope less than 4%. The steepest slopes, found in the Field Station preserve (Fig. 6), are about 7% to 8%. With the help of having a slope information, possible soil erosion can be prevented by creating diversions, adding vegetation to the slope and building a terraces, which can be reduce erosion risk to the adjacent agricultural area. According to the soil survey map, out of 12 different order, the campus and surrounding areas are comprised of alfisols and molisols (Fig. 7). This may be attributed to forested land, mostly deciduous hardwoods. Most alfisols are found in deciduous forest.

This study mapped the spatial distribution of available natural resources and other features within the Governor State University campus and Thorn Creek Preserve using a GIS. Maps serve for visual representation of the data and it can be utilized in effective means of management. The attribute data of each shape file gives a database for the study area which can be used in management perspective. The employment of natural resources mapping can be used in future land use management of this area. Based on outcome of the study, the following recommendations are made:

- The University should consider putting speed backers by the major roads in campus and fencing around sculpture park to reduce automobile accident risk due to wild animals.
- I recommend that there should be no roads in preserve area, it should be passed through agricultural area if road expansion is necessary.
- From an ecological perspective, biological interactions can be increased by extending the preserve area further to the west of the Field Station. This expansion will provide increase in wildlife habitat and vegetation cover.
- A tagging of tree species with common name should be done within the campus and field station for education purpose.
- The expansion of agricultural land around the preserve area should be controlled. The expansion of east southern portion of preserve should be done in about 9.5 hectares' area of adjacent agricultural area (Fig. 1).

Figure 1. – Governor State University Campus and Field Station.

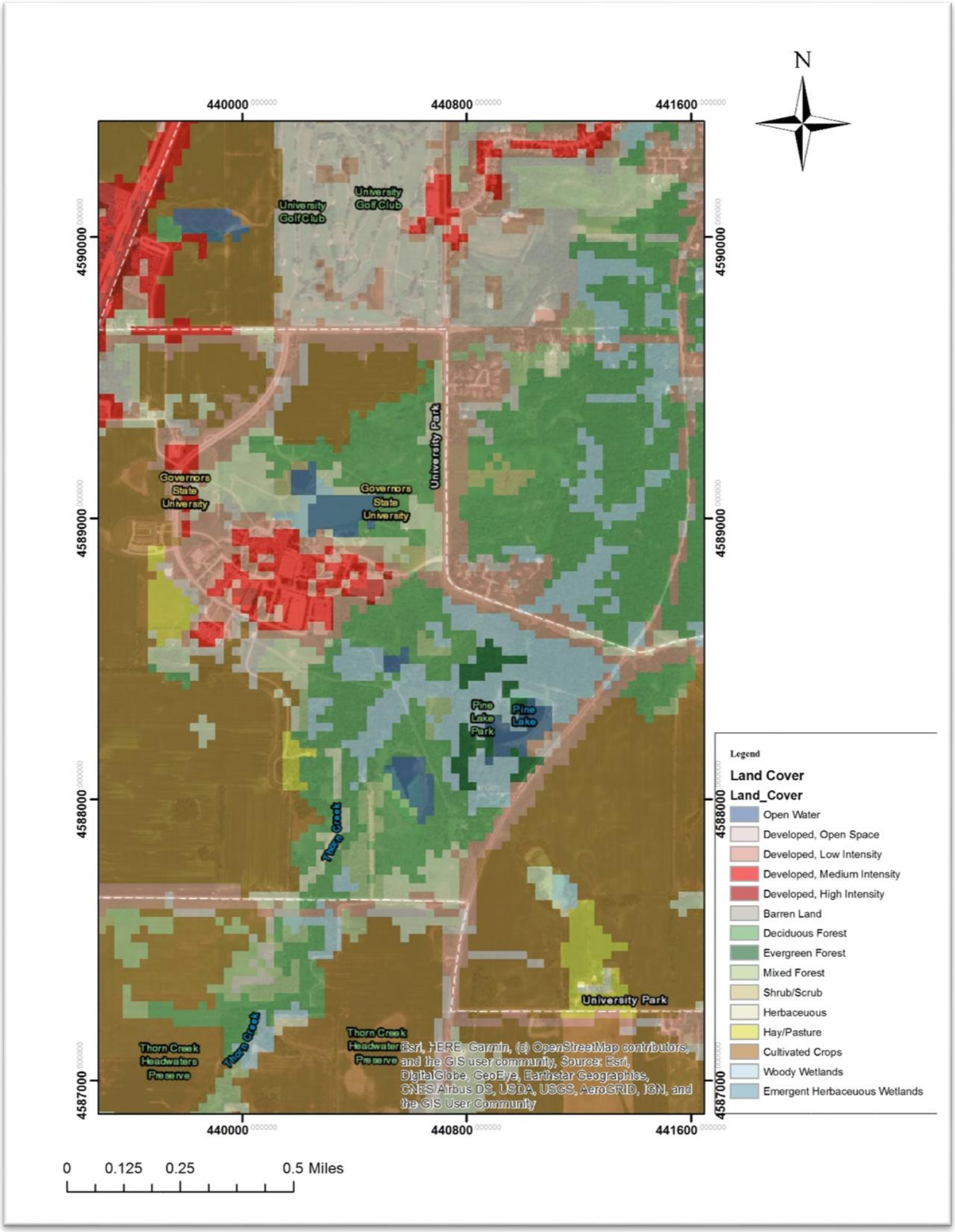

Figure 2. – Land Use Types of the Study Area derived from Landsat-7.

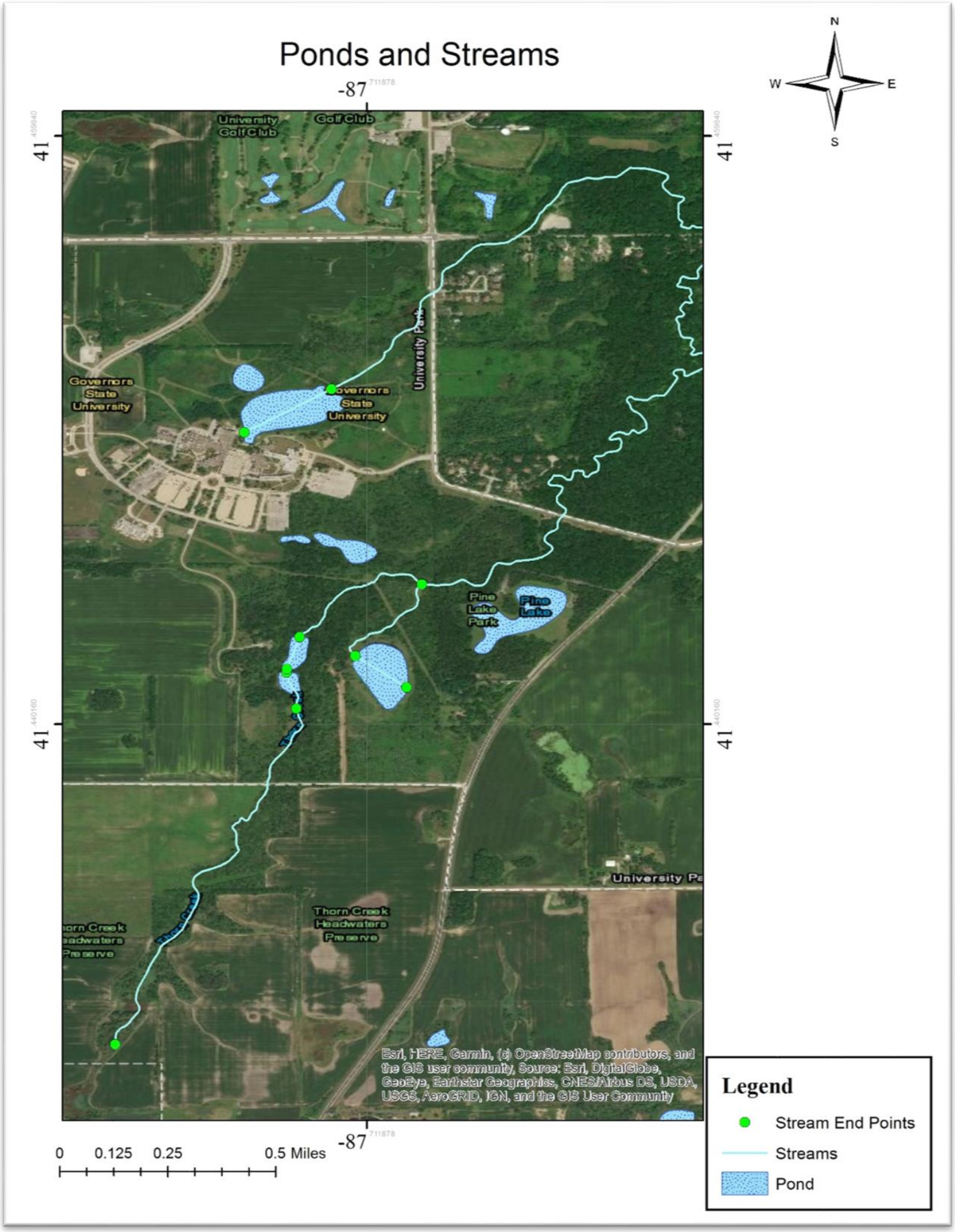

Figure 3. – Available Streams and Ponds of the Study Area.

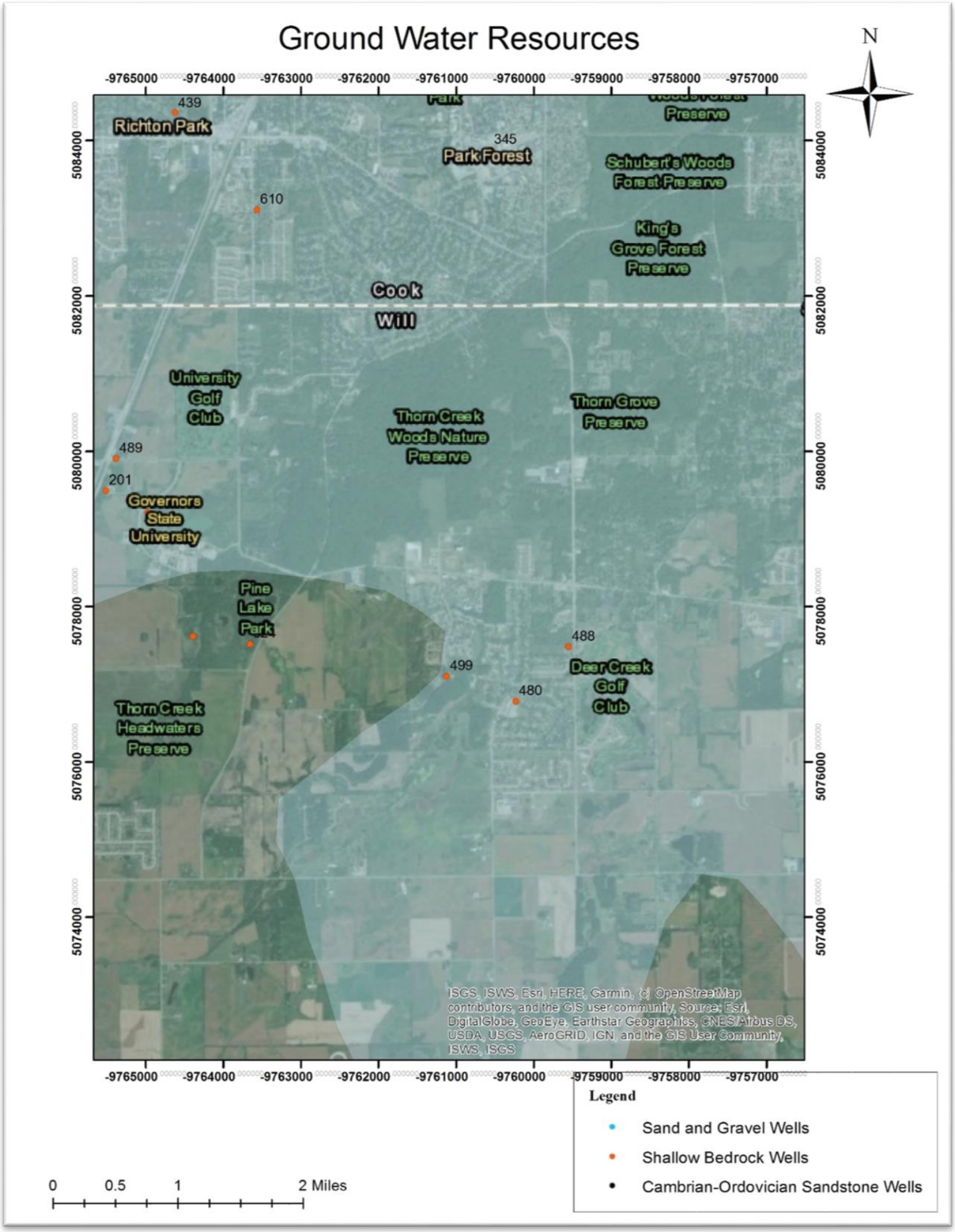

Figure 4. – Available Ground Water Resources in the Study Area.

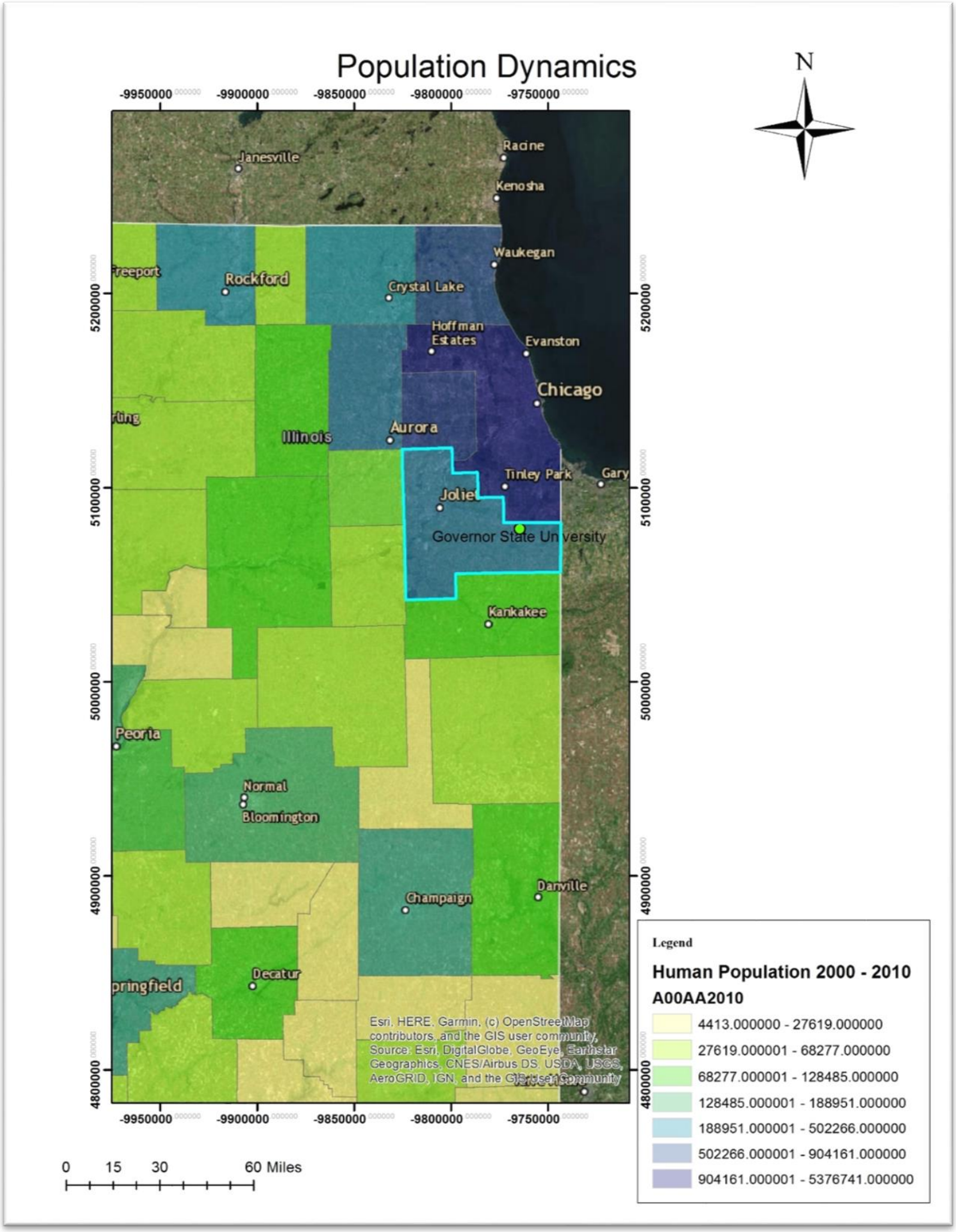

Figure 5. – Population Dynamics over 2000-2010 of the Study Area.

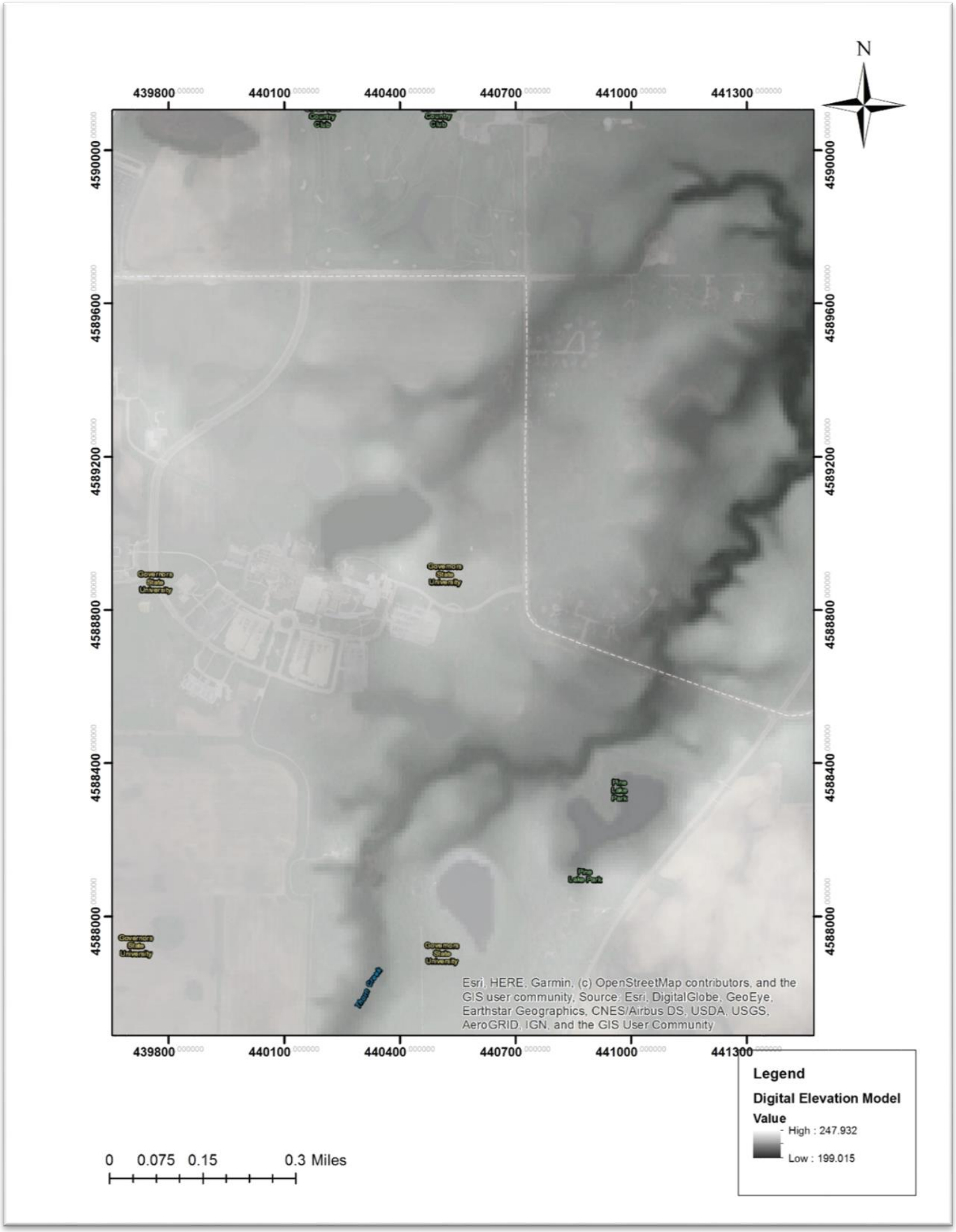

Figure 6. – Digital Elevation Model of the Study Area with 10m Resolution.

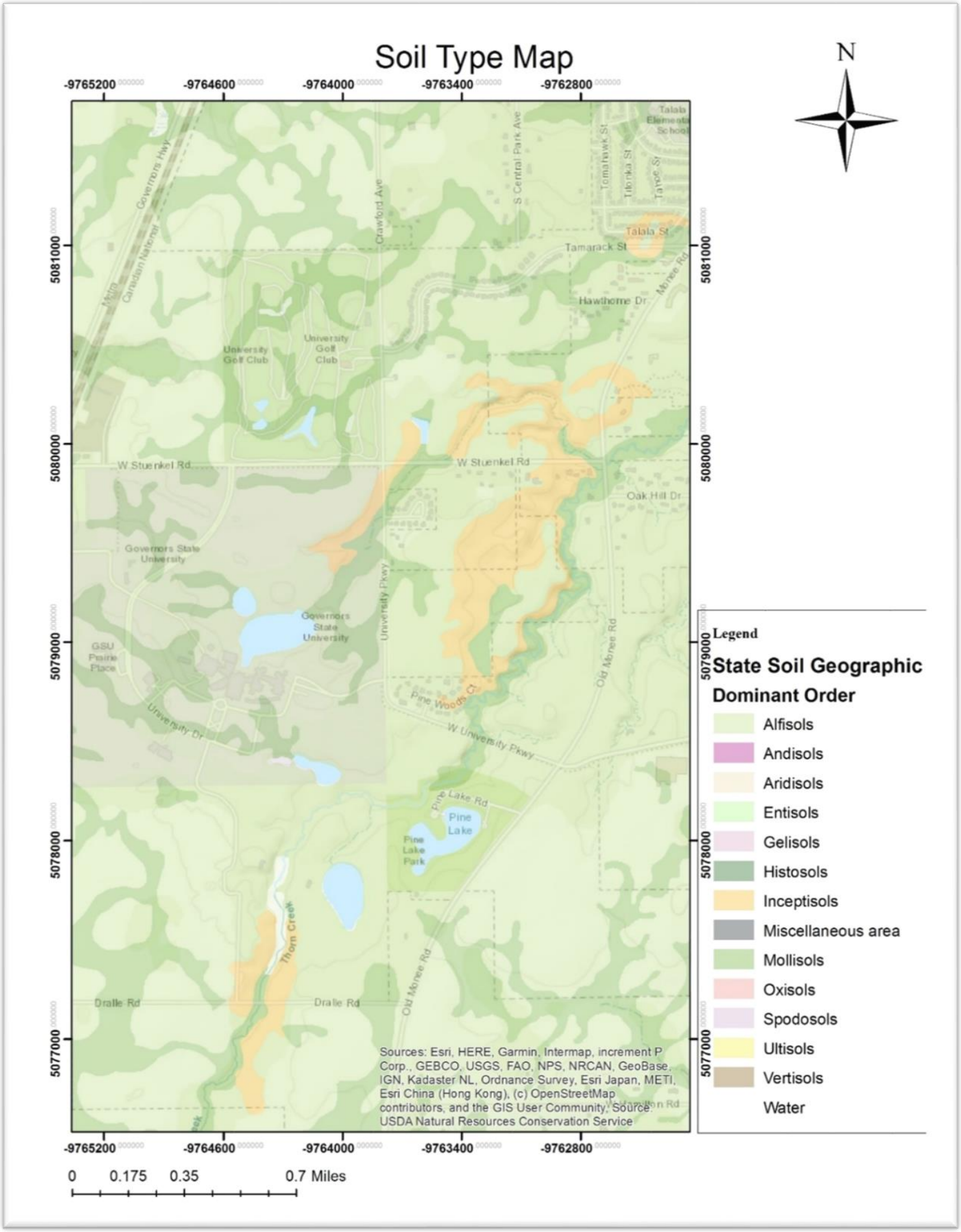

Figure 7. – Different Soil Types occurring in the Study Area.

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Literature Cited

Bahaire M. and Elliot-White, M. 1999. The application of Geographical Information Systems (GIS) in sustainable tourism planning: A review Journal of Sustainable Tourism. **7**, 159–174.

Chuvieco E. M., Martina Pilar, Vilarb Lara, Martin Javier, Martin Susana, Paloma Ibarra, Juan de la Jaime Baeza, Francisco Rodriguez, Juan R. Molina, Miguel A. Herrera and Zamora Ricardo. 2009. Development of a framework for fire risk assessment using remote sensing and geographic information system technologies. Ecological Modelling **221**: 46-58.

Collins M.G., Steiner F.R and Rushman M.J. 2001. Land-Use Suitability Analysis in the United States: Historical Development and Promising Technological Achievements. Environmental Management **28**: 611-621.

Cutter Susan L. 2003. GI Science, Disasters, and Emergency Management. Transaction in GIS **7(4)**: 439-445.

Danks F. S and Klein D.R. 2002. Using GIS to predict potential wildlife habitat: a case study of muskoxen in northern Alaska. International Journal of Remote Sensing **23 (21)**: 4611-4632.

Dominguez J. and Amador J. 2007. Geographical Information System applied in the field of Renewable energy sources. Computer and Industrial Engineering **52**: 322-326.

Ellis E. A., Bentrup C. and Schoeneberger M.M. 2004. Computer-based tools for decision support in agroforestry: Current state and future needs. Agroforestry Systems **61**: 401–421.

Ellis E.A., Nair P.K.R., Linehan P.E., Beck H.W. and Blanche C.B. 2000. A GIS-based database management application for agroforestry planning and tree selection. Computers and Electronics in Agriculture **27**: 41–55.

Gajos, M. and Sierka, E. 2011. GIS Technology in Environmental Protection: Research Directions Based on Literature Review. Polish Journal of Environmental Studies **21**: 241-248.

Gonzalez Rhodora M. 2002. Joint learning with GIS: multi-actor resource management. Agricultural Systems **73**: 99-111.

Howell C. A., Steven C. L., Therese M. D., Porneluzi P. A, Geoffrey R. and Faaborg J. 2000. Landscape effects mediate breeding bird abundance in midwestern forests. Landscape Ecology **15**: 547–562.

Iverson Louis R. 1988. Land-use changes in Illinois, USA: The influence of landscape attributes on current and historic land use. Landscape Ecology. **2**: 45-61.

Strittholt J. R and Boerner R. E. 1995. Applying Biodiversity Gap Analysis in a Regional Nature Reserve Design for the Edge of Appalachia, Ohio (U.S.A.).

Jha Madan K., Chowdhury Alivia, Chowdary V. M. and Peiffer Stefan. 2006. Groundwater management and development by integrated remote sensing and geographic information systems: prospects and constraints. Water Resource Management **21**: 427–467.

Khoi Duong Dang and Yuji Murayama. 2010. Delineation of Suitable Cropland Areas Using a GIS Based Multi-Criteria Evaluation Approach in the Tam Dao National Park Region, Vietnam. Sustainability **2**: 2024-2043.

Khwanruthai B. and Yuji, M. 2012. Land Use and Natural Resources Planning for Sustainable Ecotourism Using GIS in Surat Thani, Thailand. Sustainability. **4**: 412-429.

Kumari S., Behera M.D. and Tewari H.R. 2010. Identification of potential ecotourism sites in West District, Sikkim using geospatial tools. Tropical Ecology **51**: 75-85.

Lehner B. and Doll P. 2004. Development and validation of a global database of lakes, reservoirs and wetlands. Journal of Hydrology **296**: 1-22.

Naesset Erik. 1997. Geographical information systems in long-term forest management and planning with special reference to preservation of biological diversity: a review. Forest Ecology and Management **93**: 121-136.

Nemenyi M., Mesterhazi P. A., Pecze ZS and Stepan ZS. 2003. The role of GIS and GPS in precision farming. Computers and Electronics in Agriculture **40**: 45-55.

Pijanowski B.C., Brown D.G., Shellito B.A. and Manik G.A. 2001. Computers, Environment and Urban Systems **26**: 493-590.

Prasad S.N., Ramachandra T.V., Ahalya N., Sengupta T., Kumar A., Tiwari A.K., Vijayan V.S. and Vijayan L. 2002. Conservation of wetlands of India – a review. Tropical Ecology **43**: 173-186.

Rannveig, O and Micael, C. 2009. A GIS approach to evaluating ecological sensitivity for tourism development in fragile environments: A case study from SE Iceland. Scandinavian Journal of Hospitality and Tourism **9**: 22–38.

Rebelo L.M., Finlayson C.M and Nagabhatla N. 2007. Journal of Environmental Management **90**:2144-2153.

Stanbury Katherine B. and Starr Richard M. 1999. Applications of (GIS) to habitat assessment and marine management. Oceanologyca Acta. **22**: 699-703.

Store Ron and Jokimaki Jukka. 2003. A GIS-based multi-scale approach to habitat suitability modeling. Ecological Modelling **169**: 1–15.

Store Ron and Kangas Jyrki. 2001. Integrating spatial multi-criteria evaluation and expert knowledge for GIS-based habitat suitability modelling. Landscape and urban planning **55**: 79-93.

Tripathi Nitesh and Bhattarya Shefali. 2004. Integrating indigenous knowledge and GIS for participatory natural resource management: state-of the-practice. The Electronic Journal on Information Systems in Developing Countries **17**: 1-13.

Tsou Ming-Hsiang. 2004. Integrating web-based GIS and image processing tools for environmental monitoring and natural resource management. Journal of Geographical Systems **6**: 1-20.

Van lonkhuyzen Robert A., Lagory K. E and James A. K. 2004. Modeling the Suitability of Potential Wetland Mitigation Sites with a Geographic Information System. Environmental Management **33**: 368–375.

Zhu A.X., Hudson B., Burt J., Lubich K and Simonson D. 2001. Soil Mapping Using GIS, Expert Knowledge, and Fuzzy Logic. Soil Science Society of America Journal **65**: 1463-1472.