LAND ECOLOGY SECTOR REPORT

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INTRODUCTION

The Land Ecology breakout group included participants from universities, federal agencies, and private industry. Several issues particular to the Upper Great Lakes region were discussed. Detailed results from the discussion are included as the main content of this report. Concise results of this discussion are included in tabular form at the end of this report.

THE 4 QUESTIONS ADDRESSED

1. What are the current concerns?

The session began by considering maps of land-use and land cover (USGS), eco-regions, and locations of public lands in the Upper Great Lakes region. The natural ecosystems of the region occur along a north-south transition from prairie to forest in the west, and from eastern deciduous forests to northern mixed hardwood forests in the east. This transition corresponds to climatic and soil gradients, and is reflected in a steep south-north land-use gradient from predominantly agriculture to predominantly forest. The region is at the southern margin of the boreal forest and has a large number of inland lakes and wetlands, including the prairie potholes in the western portion of the region.

Without ever achieving a fully satisfactory definition of what qualifies as a "stress", the group focused initial discussions on identifying the current "stresses" on the ecosystems of the region. The effects of human and natural disturbances on the landscape are numerous. Important bio-indicators such as deformed frogs in Minnesota may be indicative of air, land, and water quality problems. During the discussion, one overarching theme emerged as central to current and future land ecology concerns – namely, **ecological disturbances**. These include both anthropogenic (e.g. human population patterns, lnd-use practices, forest management, and agricultural pressures) and natural disturbances (e.g., fires, pests, and extreme weather and climate events). Additionally, the group considered the importance of extreme climatic events for ecosystem functioning. The frequency, intensity, duration, and location of climatic extremes may be influenced by human activity but the group considered them to be fundamentally natural factors.

Anthropogenic disturbances.

- ***Human Population.*** Through extensive logging, mining, urban and dispersed-rural development, and agricultural activities, the human population in the Upper Great Lakes region has had a significant impact on the ecological patterns and processes in the region. Ongoing changes in the numbers and distribution of population are likely to result in further impacts. Despite these land-use changes, the amount of forested land in all three states (MI, MN, and WI) has increased over the last decade.

- ***Rural development.*** In rural areas, settlement is consuming more land, increasing commuting distances, and increasing rural infrastructure demands. Although some attempts at policy remedies have been made, the demand for some rural land continues to rise, and a strong home-rule tradition has limited effectiveness of statewide controls. For example, in Michigan, the Subdivision Control Act was designed to reduce these problems by requiring land to be sold in larger lots (i.e., greater than 10 acres). But it also increased the effects of dispersed development by increasing the number of these now-larger lots that are sold. The result is an increase in the rate at which farm land and natural ecosystems are being lost.

• ***Urban development.*** Several impacts of urban development on natural ecosystems were discussed, including forest fragmentation (which limits the ability of ecosystems to respond to pressure by migrating); impervious surfaces (which increasing runoff and erosion); increased fire suppression (occasional fire is a natural part of the Great Lakes ecosystem), and air pollution (e.g., nitrates and ozone).

• ***Retirement.*** Population growth and redistribution are being compounded by the fact that people are living longer. Retirement-related development has had a profound impact on rural land-uses in the region.

• ***Recreation and Tourism.*** Another aspect of the complex urban expansion is tourism. One estimate puts the recreation and tourism industry in the region at $9 billion per year. Michigan is second in the U.S. only to Florida in the percentage of homes that are used only seasonally and first in the in the U.S. in the number of registered boaters.

• ***Demographic Changes.*** The strongest drivers of land-use change in the region within the last several decades have been the changes in human demographics and economics (e.g., a more affluent, older, less agrarian, and globalized society with net migration from urban to rural areas). These drivers are likely to continue and to interact with climate forcing. It is not clear that climate forcing will dominate the land-use changes. Possible economic impacts include increases in energy consumption and tourism in the region.

• ***Agricultural land-use***. In the western portion of the region, intensification of agriculture is a concern. Feedlots and hog farms, which confine huge numbers of animals to small spaces, have proliferated in recent years. Also, the combination of abandonment of marginal farmland and conversion of other farmland to urban-type development has reduced the available productive farmland in the region.

• ***Pest management.*** Reactions to pests, such as spraying pesticides, can have serious negative consequences for ecosystems unless management efforts are designed to minimize them.

• ***Mining.*** Another land-use practice in the region affecting ecosystem health is *mining*, which includes the extraction of oil, gas, metals, minerals, and peat.

• ***Air pollution.*** Atmospheric deposition of ammonium and other sources of nitrogen from agricultural regions to the west and increasing amounts of tropospheric ozone due to urbanization can place stresses on natural ecosystems.

• ***Loss of habitat.*** In the southern portion of the region, where agriculture and urban development are extensive, there is clearly evidence of loss of habitat. This is especially true in the Maple/Basswood Forests of Southern Michigan, which exist mostly as small wood lots scattered amongst agricultural fields. Other sensitive habitats experiencing loss and fragmentation include prairie within forested areas. This loss has had negative implications for threatened or endangered species (TES), like Pitcher's Thistle and Karner Blue Butterflies. Other TES in the area include Kirtland's Warbler, which has also suffered loss of habitat through fire suppression.

• ***Stresses on Native Peoples.*** Many indigenous cultures that depend on water resources and species in fragile habitat for maintenance of their traditional lifestyles have experienced intense pressure. For example fire suppression has altered traditional burial grounds. The deterioration in water quality has had a great impact on many groups of Native Americans as they rely on water resources for their livelihoods (fishing, etc.). Most Native Americans are universally aligned against mining because of its affect on water quality through ground water.

- ***Exotic Species.*** The advance of exotic species, (that were introduced by people) like buckthorn and honeysuckle, also represents a major cause for concern. Exotics can spread rapidly and push out native species.

Natural disturbances

- ***Pests and diseases.*** Natural ecosystems are subject to the impacts of pests and diseases resulting in significant and sometimes devastating results.

- ***Fire.*** Fire has always been an important process to which many of the ecosystems in the region have adapted. Dramatic alterations in fire regimes, through suppression, have led to similarly dramatic changes in ecosystem composition and structure. Encroachment of forests into prairie openings was noted as a particularly important example of these changes.

- ***Wind.*** The atmosphere is an important factor to consider because it can alleviate or intensify existing problems. Wind-throw acts as a direct disturbance in forested ecosystems.

- ***Precipitation and temperature extremes.*** The flora and fauna of the region are dependent on climatic moderation. Periodic extreme droughts, flooding, late-spring or early-autumn frost, low minimum and high maximum temperatures punctuate the climatic variability of the region. Any consideration of the interaction between climate and land ecosystems must account for the magnitude, frequency, and duration of these events.

2. How may climate change impact our lives?

Some analyses of temperature and precipitation trends and predictions for the Upper Great Lakes region reveal a climate that is getting warmer and wetter. There is significant uncertainty in both the historical trends and the future projections at the regional scale. Therefore, the discussion tended to focus on identifying the sensitivities of the region's ecosystems to change, rather than predicting the future.

In order to address the question of impacts, it was clear to the group that average climatic conditions would not be the only, or even the dominant, climate-change related effects on terrestrial ecosystems. Other potential changes (e.g., changes in extreme events) are even less well understood than average conditions. Three general areas in which climate change is likely to impact terrestrial ecosystems were identified in the breakout group:

Land-use Issues

Disturbances and Extreme Events

Species Adaptation and Migration

Land-use Issues

- ***Agricultural productivity.*** A changing climate may have direct impacts on agricultural productivity in the region. Because farming tends to occur at the margins of profitability, some climate change scenarios could favor significant increases in agricultural productivity. Furthermore, declining productivity in other regions may encourage agricultural intensification in the Upper Great Lakes region. This intensification would likely result in drained wetlands and other consequences in the region. Uncertainties in such a scenario, however, are large.

- ***Agriculture and climate variability.*** One confounding factor is the influence of climate variability, which currently directly affects agricultural productivity. Increases in the occurrence of extreme events may limit real gains in productivity.

- ***Pests and diseases.*** The interactions of pests and disease with climatic variability are unclear but are likely to confound analysis of how natural ecosystems will respond to climate change. Although they might be managed through integrated pest management, pest increases could mean an increase in the use of pesticides and herbicides. Reactions to pests can have serious negative consequences for ecosystems unless management efforts are designed to minimize them.

• ***Soil-imposed limits to land-use.*** A significant cause of uncertainty is the degree to which land-use is limited by soil type. In addition to climate, the land-use gradient from agricultural production in the south, to forest and recreation in the north, is controlled to some extent by soils (i.e., sandier and/or more acidic soils to the north).

• ***Trees.*** Forest productivity may also be affected by climate change. There are implications for both the forest products industry and the amount of carbon sequestration accounted for in the forests. Like agricultural systems, forested ecosystems are complicated by many interacting effects. The combined effects of climate change, changes in disturbance regimes, nitrogen deposition, CO_2 fertilization, and increasing ozone levels are not yet known.

Disturbances and Extreme Events

Changes in natural disturbance regimes caused by climate change are critical to the future functioning of the ecosystems. Climate change will likely have effects on insect populations, fire regimes, extreme temperatures, precipitation, wind events, and tropospheric ozone. There has already been tree damage due to increased ozone concentrations throughout the rural Upper Great Lakes region.

• ***Pests and diseases.*** The populations of forest pathogens may increase. For example, Beech bark disease and the Woolly Adelgid, currently in the eastern U.S., might affect forests in the Upper Great Lakes region. Because of a warmer winter and spring in 1998, there were predictions of a 40% increase in gypsy moths, black flies, and mosquitoes for that summer. Indeed, gypsy moth populations were substantially larger in the summer of 1998 than in the previous two years.

• ***Climate variability.*** Changing climatic variability is critical to understanding ecosystem responses. Understanding changes in patterns of events (e.g., more frequent periods of extended drought, timing of last frost) may be more important than understanding changes in climate means.

• ***Fire.*** The peak fire season in the Upper Great Lakes region is May. For this reason, changes in late winter snow cover and early spring precipitation will be strong determinants of fire frequency and severity. In addition, fire management practices have important indirect effects on increased fire potential. The more fires are controlled, the higher the probability will be of a catastrophic fire – unless management includes prescribed burns.

Species Adaptation and Migration

• ***Change and the rate of change.*** Shifting ecological zones and interactions with soils have serious implications for the natural ecosystems and for biodiversity in the region. The rate of climate change is expected to be more rapid than anything experienced in the historical record. There is some question as to whether plant species will be able to migrate and/or adapt sufficiently fast.

• ***Forest adaptation.*** Trees with wind-dispersed seeds will have more trouble, especially if they need special habitats or if their habitats are fragmented. There is some potential for migration and replacement, such as the hemlock migration evidenced by paleoecological records.

• ***Limits to migration***. The Great Lakes themselves and expanses of agricultural land-use in the southern part of the region will likely act as barriers for species migration.

• ***Atmospheric chemistry.*** It is difficult to assess the changes of CO_2 fertilization on community composition, since it will improve the growth of some species but not others. It will be hard to isolate the effects of CO_2 fertilization from those of climate change. Nitrogen deposition may cause only small changes in prairie communities because of the small size and fragmentation of prairie reserves. However, nitrogen deposition will likely affect forests more significantly, especially those with deciduous trees.

• ***Temperature.*** Physical ecosystem properties (e.g. temperature) are tied to ecosystem diversity. The group discussed recent results from the Linkages Model, which illustrates the temperature effects on forest structure and, subsequently, on avian diversity.

• ***Intraspecies genetic diversity.*** An important determinant of the ability of populations to adapt to climate change is their genetic diversity. So far, there has been very little direct research on genetic diversity and its effects on adaptation through evolution. As regional climate change continues, some genotypes and local phenotypes will likely become much more abundant at the expense of more narrowly adapted species. An example is Trembling Aspen, a species with one of the broadest tolerance limits and adaptation to fire.

• ***Species distribution and sprawl.*** There will be interactions due to changing human settlement patterns. Several different types of examples include sprawl, leading to urban-dwelling deer in the Twin Cities; the escape into forest habitats of exotic, ornamental plants; and the spread of bovine tuberculosis from domestic to wildlife populations.

3. What additional information do we need?

The monitoring of ecosystem status and trends, and the acquisition of scientific knowledge about the functioning of ecosystems form the core of information needs in the region. With these in mind, more information is needed in the following areas (discussed in detail below):

Land-use Options/Scenarios

Disturbance Trends/Patterns

Determinants of Species Patterns

Other Data/Issues

Land-Use Options/Scenarios

Ultimately, the development of land-use scenarios under various assumptions of climate change would be a valuable tool for evaluating possible land policy responses in the region. To develop such scenarios, additional data, scientific investigations, and models are needed to understand the interactions among climate, land-use, demographics, economics, soils, and other factors.

• ***Monitoring data.*** The information needs include a better attempt to monitor ongoing changes in land-use and land cover. Monitoring data will help identify future ecosystem impasses as well as provide data for scenario development.

• ***Carbon budget data.*** Concurrently, more information is needed on the changes in the amount of forest cover and the rate of carbon sequestration in the forested lands. This information will help improve quantification of the regional, national, and global carbon budgets.

• ***Economic modeling.*** A better understanding is needed of the settings under which expansion or intensification of agriculture in the region makes sense economically. Agricultural practices have significant impacts on ecosystems.

• ***Competing uses.*** Ecosystem models should account for competition for land among various sectors and should attempt to evaluate how the competitive advantages in the region shift under various climate scenarios.

Disturbance Trends/Patterns

• ***Historical disturbances.*** Information is needed on the historical and long-term trends in the regimes of various disturbances (including fire, pests, disease, and extreme climatic events). Data that can be used to address this gap include long term proxy records and historical records. Research is needed to interpret the data in ecologically meaningful terms.

• ***Improved monitoring.*** Monitoring of ecologically significant climatic extreme events (e.g. frost, drought) needs to be in place. In addition, improved data collection and monitoring systems regarding all ecosystem disturbances should be established.

• ***Modeling.*** The following factors need to be modelled: a) The responses of ecosystems to current stresses, b) How those responses are affected by climate change, and c) The interactions between the responses and other ecosystem stress factors. Such comprehensive, interactive models might allow better prediction of ecosystem responses to stresses that are part of climatic change.

• ***Regional climate models.*** As regionally specific climate modeling improves, it is hoped that extreme events and climate variability might be better predicted.

Determinants of Species Patterns

Better knowledge of the elements that are required by species for survival, such as the relationships between habitat patterns and species abundance, is needed. This knowledge should come from both the compilations of data sets, for example on the current distributions of different species, and the scientific investigations of the relationships between the species and their environment.

• ***Interdependence data.*** More information is needed regarding the interacting processes affecting species distributions, e.g., the interacting effects of climate, nitrogen deposition, CO_2 fertilization, and migration mechanisms on intraspecies competition. More stand-level investigations of species response are needed in attempts to account for these interactions.

• ***Migration studies.*** A better understanding is needed, perhaps through better modeling, of the ability of species with various dispersal mechanisms, to migrate through fragmented landscapes.

• ***Robustness and adaptability.*** Better knowledge of the responses of species to interannual variability in climate is needed. For example, species react very differently to a single severe drought year than to several drought years in a row. Furthermore, the equilibrium state of species with respect to climate, needs to be known. The rate of change now is greater than ever recorded before. It is necessary to know what to measure in order to be able to determine the robustness of the system, i.e., whether or not the system can quickly adapt to changes.

Other Data/Issues

• ***Data existence.*** A variety of good data on species distributions exists, but many are not easy to access. A good example is the data on tree distributions held in the General Land Office survey records. In Minnesota, the Department of Natural Resources has compiled a digital database from the survey records. Every state has a national heritage program, which is doing something similar, but the efforts are inconsistent. In Michigan, for example, the decision was made not to compile the data in a digital database. Some forms of data will be more helpful than others. For instance, palynological records cannot be used to distinguish between red and white oak pollen and yet the species have very different interactions with wildlife (e.g., deer).

• ***Data availability.*** Many data on ecosystems in all regions of the country reside within various federal and state agencies, as well as with many various scientific investigators. It is often difficult to know what data are, in fact, available. The breakout group agreed that some effort to catalogue, or create a meta-database on biological and ecosystem data would be valuable. Such "data about data" would serve to minimize the duplicate collection of data.

• ***Remote sensing.*** It was also felt that, given improvements in the spatial, spectral, and temporal resolutions of satellite remote sensing instruments, the ecosystem research and management communities should be able to make more effective and efficient use of remote sensing. Land-use and land cover changes, at the very least, can be monitored with remote sensing. There was some hope that remote sensing could be used to improve both the thematic content of existing data (e.g., by giving species-level distributions) as well as the temporal frequency, to improve interannual investigations. An example of the latter is a current prototype use of remote sensing to potentially increase the temporal frequency of the Forest Inventory and Analysis (FIA) program at the USDA Forest Service.

• ***Public education.*** Another major information issue is education. Providing the public with a regional scale prediction of changes in their area might help personalize the issue of climate change for people and get them involved with the changes that are likely to occur. People will not react to global change until they can be told specifically how it will affect them.

4. How do we cope with climate change?

The discussion of this last question was abbreviated because many in the group were unable to attend the discussion. The remaining members of the group discussed several possible coping strategies to encourage sustainability of the terrestrial ecosystems in the region under changing climatic conditions.

• ***Zoning reform.*** Land-use conflicts may occur as a more dispersed settlement pattern develops and as competition among various land-uses changes with changing climate. Policies, such as land-use planning and/or "sprawl" taxes, might be used to minimize land-use conflicts. However, it must first be understood how and why the current strategies are failing. For example, attempts to minimize sprawl (e.g., Subdivision Control Act, zoning) in the past have not met with great success. The political costs of abridging land ownership rights in the region could be high.

• ***Facilitate adaptation.*** The migrations of plant species with the shifting of ecological zones should be facilitated where possible. The establishment of migration corridors was suggested as a possible mechanism to reduce the effects of fragmentation. However, maintaining a corridor may not be successful if flowering is limited due to climatic changes. For certain birds and for wolves, preservation corridors are working, but they may not work for some plant species. Following harvest, tree species that are better suited to a changed climate might be planted to encourage adaptation of the ecosystem. Species and genetic diversity should also be encouraged to improve natural adaptive capacity.

• ***Genetic manipulation.*** In some industries, selective breeding and/or genetic engineering may provide an option to improve adaptation. These strategies are probably more likely to be successful in high-value agriculture crops (e.g., fruit production in Michigan) than in the forestry industry.

• ***Management.*** Existing fire and pest management strategies may need to be reevaluated for a changing climate. Incorporation of integrated pest management and prescribed burning may reduce the indirect effects of these disturbances with a changing climate.

• ***Education.*** Finally, and most importantly, a public education program regarding the potential risks and consequences associated with rapid changes in climate should be in place. For example, the potential for increasing fire danger associated with warmer and drier conditions should be communicated to homeowners in high fire-risk ecosystems. The increased potential for flooding with an increase in the frequency of heavy rain events should be communicated to flood plain landowners. With better information, the residents of the region will be better prepared to respond to a more variable and less certain climate.