Climate Change and Indiana's Non-Timber Forest Resources[1]

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Climate Change

For several years, all major models have predicted a long-term increase in temperature for the Midwest, with the magnitude of the increase depending on global energy scenarios. Early precipitation predictions were less consistent, with the major Canadian model (CGCM1) predicting decreased precipitation across much of the state and the second Hadley model (HadCM2) predicting increased precipitation throughout (Southworth 2002). Recent regional modeling using the widely-accepted HadCM3 and other updated models suggests slightly increased precipitation is most likely (Diffenbaugh et al. 2005). However, with the increase in precipitation, an increase in intense storms is also expected. Rain will tend to run off more, and infiltrate soils less, leading to drier soils, particularly in summer, despite the increase in annual rainfall. The overall "hotter, drier summers" and "warmer, wetter winters," coupled with an increase in extreme storm events and temperature events is the scenario addressed here

Values of Indiana Trees and Forests Beyond Timber Value

Indiana's trees and forests contribute to the state's economy in a number of ways beyond their value as timber. Trees increase property values, in one study by as much as 10% (Holmes et al. 2006, Dimke 2008) and contribute to the attractiveness and coolness of homes and cities. In addition, while many landowners profit from the timber value of their forests, many also value their forests for recreation and aesthetics (Ross-Davis and Broussard 2007). A pilot study in 2004 indicated that the value of urban trees in Indiana, calculated only in terms of replacement value, was $55.7 billion (Nowak et al. 2006).

Hikers, mushroom hunters, wildflower enthusiasts, and birdwatchers flock to the largest remaining blocks of forests in the Midwest – the state and national forest lands of the southern counties. Travel to enjoy fall color contributes substantially to tourism income in these same counties. Forest-related recreation (including hunting and fishing) and tourism contributed $1 billion to the state's economy in 2001 (Bratkovich et al. 2004). Wildlife-watchers alone contributed nearly $400 per person. "Enjoying scenic beauty" was the most common activity during tourism visits.

[1]This policy brief was written at the request of the Indiana Chapter of The Nature Conservancy and has been reviewed by that organization.

Climate-change Impacts on Forests and Trees

Forest composition: Individual tree species will respond to climate change on the basis of their tolerance to the new climate – the forests of the future will have a new composition (Iverson and Prasad 1998, 2002). The trees favored by moist soils, particularly walnut, sugar maple, black cherry and beech, will become less common. Tourism revenues may decrease as the proportion of colorful trees in the fall canopy declines. Species that tolerate dry soils, particularly oak, are predicted to increase. However, other factors (shady understories, high population of deer) may prevent oak from increasing as much as climate predictions indicate.

Extreme events may hasten changes in forest composition by creating openings in the canopy, providing an opportunity for species better suited to the changing environment to become established. The severe drought that Indiana experienced in 2005 produced noticeable increases in tree mortality. Red oak and tulip poplar were common casualties in southern Indiana, and ornamental pine trees suffered throughout the state. Ice storms and high winds associated with thunderstorms and tornados can remove the canopies from wide swaths of forests. The resulting openings not only provide sites for saplings of new species, but also for invasive species that have no economic or wildlife value and may outcompete native species that do (Millar et al. 2007). Extended droughts increase the possibility of forest fire (Kling et al. 2003), which, although likely to remain relatively small, given Indiana's ability to respond to fire, may more often become large, also creating areas in which new species can settle. Individuals of formerly more southern species will help to conserve those species and will create a new forest at least temporarily better suited to new climate conditions (Millar et al. 2007). However, individuals of nonnative, invasive species can prevent such forward-looking changes among native species and kidnap the process of revegetation.

Forest acreage: Indiana straddles the western boundary of the eastern hardwood forests. Climate, particularly soil moisture, determines the forest-prairie boundary, which has historically run through western Indiana. If summer soil moisture decreases as predicted, the forest-prairie boundary will shift eastward, decreasing forest acreage in Indiana and potentially increasing fragmentation in forests at the new western edge.

Forest pests and pathogens: Several invasive plant species, plant diseases, and insect pests may present an increased threat to Indiana forests under climate change. Kudzu, "the weed that ate the South," is already increasing in southern Indiana. In 2003, kudzu reportedly cost $500 million annually across in the South in lost production from forests and croplands and in costs to eradicate the species. Eradication costs for chemical treatments run approximately $200/acre, without considering labor costs. Indiana is already considered highly vulnerable to the tree disease called sudden oak death, which has been destroying oaks in California since 1995 (USFS 2002). The disease has been detected once and destroyed in Indiana (DNR 2006), but all Indiana oaks, particularly red and pin oaks, would be vulnerable, and warmer winter temperatures would increase vulnerability. Many of the pest and invasive plant species that presently threaten Indiana forests – emerald ash borer, tree of heaven, Japanese stilt grass – are relatively recent arrivals. As Indiana's climate warms, it becomes compatible with a wider range of pests, increasing the potential for future invasions.

Impacts to Forest Wildlife

Indiana's forests represent the largest forest blocks in the Midwest and harbor important populations of several migrant songbirds that are increasingly at risk from many treats. Many other Indiana species depend on forests for some or all of their life cycle. Stressed trees initially are more vulnerable to insects, and an increase in insect food would be useful for many birds as well as to the insects themselves. However, as stress leads to increased mortality, the impacts on forest species will depend on the changes in forest structure and composition that result. In the long term, stress will lower forest productivity in all aspects of the food web, and simplify the forest by eliminating vulnerable species. Species and populations that are already at risk, in particular, may be extirpated from the state.

Timing issues. Synchronization of plant-insect, plant-vertebrate, and vertebrate-insect cycles has been shown to be weakening under climate change (Parmesan and Yohe 2003, Inkley et al. 2004, Parmesan 2006). As temperatures warm in spring, migrating birds, trees leafing out and flowering, and herbivorous and pollinating insects emerging from winter dormancy all seek to synchronize their schedules with their important nesting opportunities, prey, and hosts. As these various species adjust differently to earlier spring warmth, migrating birds that use day length for timing, rather than temperature, arrive before insects emerge, insects emerge before leaves are available, and, in general, mismatched timing reduces fitness of many of the species involved. Forest pollinators near agricultural areas can help to offset pollination deficiencies caused by recent collapses of honeybee hives, but only if their own populations are not in decline.

A longer-term synchronization problem threatens species that move their ranges northward in response to climate change. Because the physical environment – soils, hydrology, seasonal patterns of weather – change over space, species may find suitable temperatures further north, but not suitable soils or water regimes. In addition, species that rely on other species for food or pollination may not relocate on the same schedule as the species on which they rely. Thus, even those species mobile enough to move in response to climate change will not necessarily find suitable conditions. As a result, influxes of new species from warmer areas will likely not keep pace with the loss of species to range shifts or to extirpations.

Drier forests. Drier forests will lead to decreases in species that rely on forest wetlands and on bottomland forests. Indiana's conservation community has only recently begun to restore bottomland forests; this forest type was the hardest hit by agricultural activity in the state, and bottomland-forest restoration had been a specific target of interest, in part because of rare species, such as cerulean warblers, and swamp rabbits, and popular species, such as wood ducks, associated with them. Renewed beaver populations may help to protect them against drying; dams can hold flood waters on the land, offsetting the effects of increases in extreme events.

Many Indiana amphibians – frogs and salamanders - use ephemeral forest wetlands for breeding. These species are not adapted to reproduce in larger ponds and lakes as they are heavily preyed upon by fish (fish are absent from ephemeral wetlands because they dry up during the summer). Historically, these amphibians were numerous enough to be important parts of the forest food web, and today, some likely continue to hold that position in Indiana's larger forests. Drier soils will reduce the time span over which ephemeral wetlands are available and recent changes in federal wetland law have already reduced protections for these seasonal wetlands, further reducing their numbers (Zedler 2003). Amphibians have some flexibility to metamorphose and leave wetlands early in response to early drying, but the resulting adults are less healthy and produce fewer offspring (Inkley et al. 2004). And if ephemeral wetlands dry too quickly, they will outpace the development of even the faster-metamorphosing species.

Warmer forests. Increases in forest rodents and in deer that may occur as a result of milder winters will increase available hosts for Lyme disease and other tick-borne diseases, as well as extending the mosquito season (Parmesan and Martens 2009). In addition, warming may increase the severity of the Lyme disease strains in the Midwest (Gatewood et al. 2009). Although wildlife are not affected by Lyme disease, they are affected by other insect-borne diseases such as West Nile, epizootic hemorragic disease, and various strains of encephalitis.

Winter cold is also important for hibernating species, including the endangered Indiana bat and several other bat species. Bats provide useful ecosystem services by eating insects in and near agricultural lands. If winter temperatures warm too much to support hibernation, populations of these species will likely move north, as Indiana bats have apparently already moved out of Missouri. However, Indiana may lose its hibernating bats under any circumstances, due to the present epidemic of cold-loving fungal disease: white-nose syndrome.

Reducing Uncertainty in Climate Change Outcomes

For all the negative aspects of climate change in forests - unpredictable changes in composition, loss of forest acreage, productivity, and biodiversity – the most difficult aspect of climate change for managers and other stakeholders is the overall uncertainty concerning how long the process of change will go on and how severe the changes will be (Millar et al. 2007). Scientists predict that change may last a millennium, because greenhouse gases already in the atmosphere will continue to affect climate long into the future. But severity of change is more malleable. Mitigation can reduce the damage; but, to date, the major players, including the US, are still in the planning phase. Only by taking charge of greenhouse gas emissions can we begin to inject some certainty into the discussions of managing natural resources under climate change.

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