Risk Assessment for Forested Habitats in Northern Wisconsin

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We used a risk matrix to assess risk from climate change for multiple forest species by discussing an example that depicts a range of risk for three tree species of northern Wisconsin. Risk is defined here as the product of the likelihood of an event occurring and the consequences or effects of that event. In the context of species habitats, likelihood is related to potential changes in suitable habitat at various times in the future. Consequences are related to the adaptability of a species to cope with the changes, especially the increasing intensity or frequency of future disturbance events. Data were generated from an atlas of climate change for 134 tree species of the Eastern United States (USDA FS 2011).

A risk matrix allows managers to determine which species need adaptation strategies, further evaluation, or monitoring programs. For example, a two-dimensional framework of likelihood versus consequence was used to assess the risk of future flooding on infrastructure in New York City (Yohe 2010, Yohe and Leichenko 2010), providing qualitative judgments about the magnitude of vulnerability and the likelihood of flooding exposure at specific points in time. This matrix illustrated changes in risk (e.g., potential number of buildings damaged or destroyed) over time, generated by the implications of sea level rise on the return times of what are now considered a 100-year storm and a 10-year storm. This matrix was not intended as a basis for policy decisions, but rather to help organize individual and governmental thinking about near- and long-term risk around likelihood and consequence.

We adopted the same matrix structure to assess the likelihood of exposure and magnitude of vulnerability (or consequences) for three tree species in northern Wisconsin (fig. A2-4). Much of the climate change literature focuses on potential decreases in forest species (“losers”), but increases may also pose management challenges, so the matrix was modified to include species or forest assemblages that are projected to increase in suitable habitat in the future (“gainers”) (fig. A2-4). The risk matrix is demonstrated for black ash (*Fraxinus nigra* Marsh.) (loser), white oak (*Quercus alba* L.) (gainer), and yellow poplar (*Lireodendron tulipifera* L.) (new migrant).

Black ash carries more risk because, among other disadvantageous traits, it has low resistance to the emerald ash borer (*Agrilus planipennis* Fairmaire), which currently threatens all ash species in North America (Prasad et al. 2010). White oak is expected to gain habitat in northern Wisconsin, because it is well adapted to drier conditions and increased disturbance. Relative to other species, projected risk over time for this species is relatively low. Yellow poplar is not now recorded in northern Wisconsin, according to forest inventory information of the U.S. Forest Service. As a potential new migrant into the region, this species may provide new opportunities for habitat or wood products.

Using methods described in the DISTRIB system (Iverson et al. 2008, 2011; Prasad et al. 2009), data for the likelihood (x-axis) are based on a series of species distribution models to assess habitat suitability for 134 tree species in the Eastern United States, for current and future (2040, 2070, and 2100) climatic conditions. “Likelihood” in this context is, for any point in time, the potential that a section of forest within a specified region will have suitable habitat for a given species relative to its current suitable habitat. In this example, we use emission scenarios of modeled climate change, PCMlo and Hadhi, to elicit a range of possible risks, from low to high, associated with future climates. The

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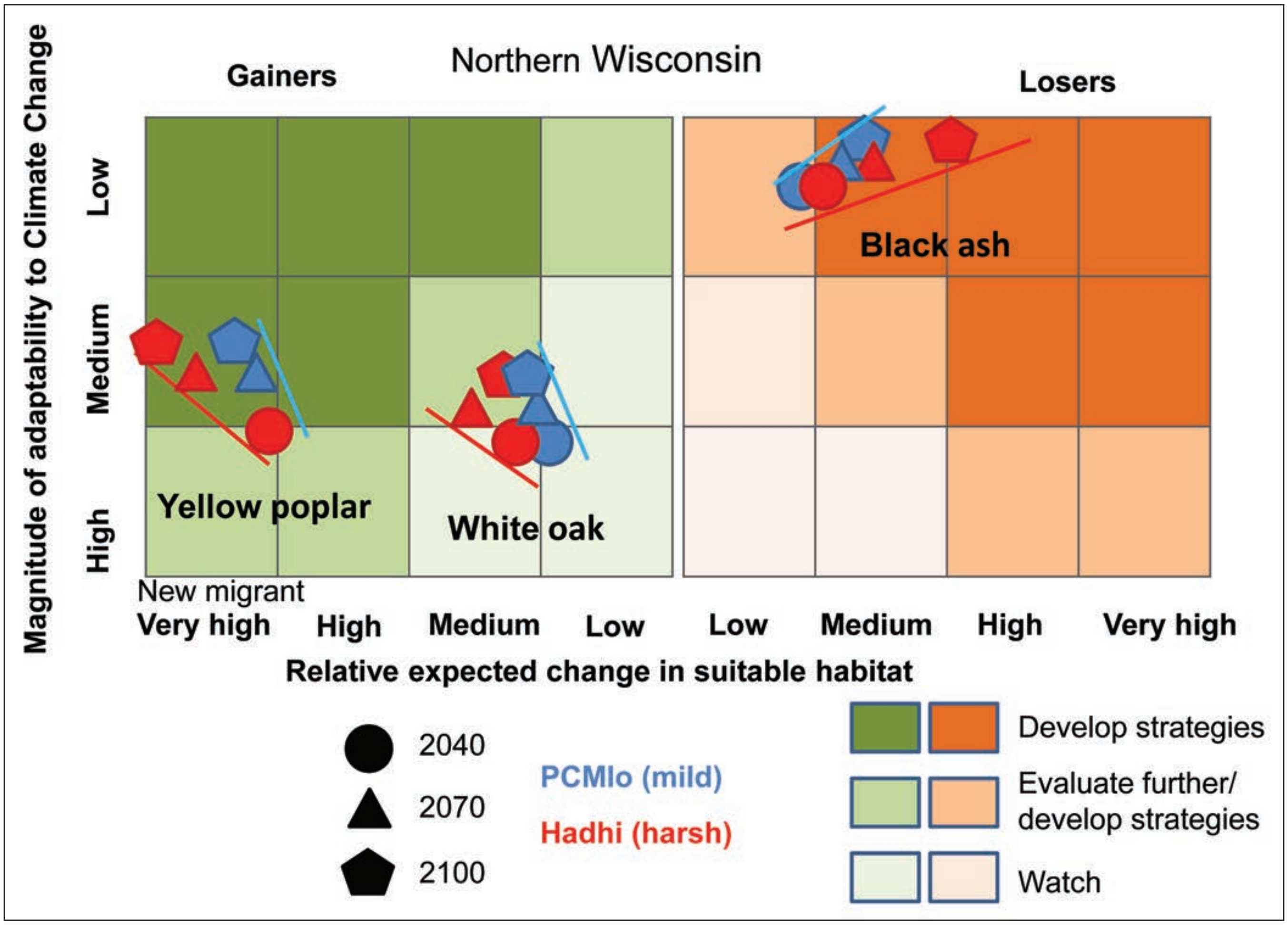

Figure A2-4—Risk matrix of potential change in suitable habitat for three tree species in northern Wisconsin that are expected to either lose habitat (black ash), gain habitat (white oak), or become a potential new migrant because of newly appearing habitat (yellow poplar).

matrix shows large variation between the emissions scenarios, with Hadhi causing larger changes in suitable habitat for all species. For black ash, which loses habitat, the x-axis ranges from 0 (complete loss of habitat over time) to +1 (no change in habitat over time). For white oak, which gains habitat, the x-axis ranges from +1 to +8. For yellow poplar, a species entering new habitat, the range is confined to the leftmost column of the graph. These numbers themselves are not directly the scale of "likelihood," but rather are scales of future:current importance values, and are plotted only to show the quantitative linkages.

Consequences in this context are related to the adaptability of a species or forest assemblage under climate change, based on a literature assessment of species biological traits and capacity to respond to disturbances that are likely to occur within the 21st century, including how those disturbances will be affected by climate change. Data for this axis comes from a literature-based scoring system, called "modification factors," to capture species response to climate change (Matthews et al. 2011). This approach was used to assess the capacity for each species to adapt to

12 disturbance types and to assess nine biological characteristics related to species adaptability. Each character was scored individually from -3 to +3 as an indication of the adaptability of the species to climate change. The mean, scaled values for biological and disturbance characteristics were each rescaled to 0 to 6 and combined as a hypotenuse of a right triangle; the resulting metric (ranging from 0 to 8.5) was used for the y-axis of the risk matrix (fig. A2-4). Because several disturbances (e.g., floods, droughts, insect attacks) are expected to increase over time, we also used a formula based on modification factors to enhance relevance for certain factors from 2040 to 2100. This analysis does not include socioeconomic consequences, such as the effects of decreased black ash on local basket-making economies of Native Americans.

The risk matrix has a number of useful applications. It provides a visual tool for comparing species risks relative to changing habitats associated with climate change. Trajectories displayed in the matrix reveal insights about species response to climate change and can be considered in the development of potential adaptation strategies, although they cannot account for nonlinear responses to extreme climate and altered disturbance regimes. The risk matrix can also help organize "climate change thinking" on a resource management team and communicate information to stakeholder groups and the general public. Finally, the risk matrix can be used to assess climate change risk for a variety of resource disciplines, and although the metrics may not be derived from the same methodologies, the capacity to rate one species against another, or one location against another, will promote a consistent approach to climate change risk management.

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