Suitable Tree Species Under a Changing Climate

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Successful agroforestry practices depend on the ability of the trees to survive and grow well enough to provide the benefits sought. Local climate is a major factor in determining which tree species could be effective in an agroforestry practice, and a great deal of variability in this regard exists among different species. As climate changes, local climate can shift beyond tolerable thresholds for some species and move to within tolerable thresholds for other species (table B.1). In a changing climate, agroforestry species must be able to survive and grow under both current and future climatic conditions. If species that are currently used cannot adapt to future climate, risk is high that the desired functional lifespan of the agroforestry practice will not be achieved.

Geographic ranges of naturally occurring forest tree species are predicted to shift in response to climate change (Iverson et al. 2008). Agroforestry, by contrast, avoids many vectors that affect natural reproduction and growth in natural forests. Agroforestry systems typically consist of planted trees that may be protected from environmental stresses, at least initially, through weed and insect control, fertilization, and irrigation. A list of tree species suitable for agroforestry in a given region consequently may look very different from that of naturally occurring forest.

The Chicago Botanic Garden conducted a study in which it evaluated effects of a changing climate on the region's urban trees. The study predicts that climate conditions for species now flourishing in the Chicago, IL, area will become less suitable after 2020. The predictions were made using the MaxEnt (Maximum Entropy Modeling) computer model (Merow et al. 2013, Phillips et al. 2006), which assesses suitability of species under future climate regimes based on bioclimatic parameters related to those listed in table B.1.

Climate change will not affect all species in the same way. The ranking of different species by their relative suitability in the Chicago area will change substantially by mid-century (table B.2). Some species will be able to tolerate future climates better than others. Among species that are well suited under current conditions—pecan, eastern redcedar, and silver maple—may continue to thrive under climate conditions expected in 2080; however, several other species, such as Norway spruce, American linden, and sugar maple, are likely to fare poorly in those conditions.

Based on these results, alley cropping-type agroforestry in the Chicago area should favor pecan over sugar maple. Both species could produce marketable products, but climate conditions within the lifespan of the tree crop may favor only pecan. Practices like windbreaks and riparian forest buffers should favor silver maple and eastern redcedar over other species for environmental benefits over the longer term.

Table B.1. Climate changes and their impact and consequences on tree species. In a changing climate, the success of agroforestry practices depends on planted trees being able to survive and grow under both current and future climate regimes. Changes in specific aspects of climate will have specific consequences, often negative, but not always, for tree growth and health. Suitable tree species will be able to tolerate such changes in climate over the designed lifespan of the agroforestry practice.

Change in climate	Consequences for tree growth and health
Higher carbon dioxide concentrations; longer growing season	Increased growth rate of most species
Higher average winter temperature	Winter chilling requirements for flowering and seed germination might not be met
	Reduction in cold-associated mortality of insect pests
Higher temperature in early spring	Earlier budburst and potentially increased damages by late frosts
Increased frequency of drought	Reduced growth rate and increased mortality, especially for newly planted trees
Increased frequency of high or extreme temperature episodes	Increased susceptibility to damaging effects of pests
Increased frequency of floods	Waterlogging of soils; killing of tree roots Physical erosion/removal of trees

Source: Adapted from European Environmental Agency: http://www.eea.europa.eu/data-and-maps/figures/impacts-and-consequences-of-climate.

Table B.2. Ten tree species are ranked in order of suitability for planting in the Chicago, IL, area under current, 2050, and 2080 climate scenarios predicted by the Intergovernmental Panel on Climate Change in 2000. All species in the current column are suitable if current climate conditions do not change. By 2050, however, the climate will have changed, and some species will be favored and others disfavored by those conditions, so the rankings will change. By 2080, climate will have changed beyond the tolerance limits of several species (shaded). Agroforestry plantings in the Chicago area that are expected to function beyond 2080 accordingly should focus on the species that would still be suitable at that time, such as pecan, eastern redcedar, and silver maple.

Current	2050	2080
Norway spruce (*Picea abies*)	Eastern redcedar	Pecan
Silver maple (*Acer saccharinum* L.)	Pecan	Eastern redcedar
Northern red oak (*Quercus rubra*)	Hackberry	Silver maple
Sugar maple (*A. saccharum* marshall)	White oak	Hackberry
Hackberry (*Celtis occidentalis*)	Silver maple	Sycamore
American basswood (*Tilia americana*)	Northern red oak	White oak
Eastern redcedar (*Juniperus virginiana*)	Sycamore	Northern red oak
White oak (*Q. alba*)	Sugar maple	Sugar maple
Sycamore (*Platanus occidentalis*)	Norway spruce	American basswood
Pecan (*Carya illinoinensus*)	American basswood	Norway spruce

Source: Data from Bell (2014).

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