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Potential Effects of Climate Change on Tree Survival and Forest Pests in the Great Plains

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POTENTIAL EFFECTS OF CLIMATE CHANGE ON TREE SURVIVAL AND FOREST PESTS IN THE GREAT PLAINS[1]

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ABSTRACT: Global increases in concentrations of carbon dioxide and other greenhouse gases during the next 50 to 100 years are predicted to cause a rise in temperature and a decrease in precipitation for most of the Great Plains. These environmental changes will reduce tree growth and survival and increase the abundance of tree insect pests. The eastern edge of the prairie-forest border is expected to migrate 60 to 100 miles northeast for every 1°F rise in temperature. If the most widely held climate model predictions are correct, moisture stress could increase throughout most of the region, and tree species least tolerant of the drier conditions may slowly disappear. Bark beetles, borers, leaf feeders, and sap suckers are expected to increase as a result of higher environmental temperatures, increased phloem levels, and lower tree defenses. In contrast, the continued decline in environmental conditions may also cause a decline in leaf quality and quantity and, thus, a decrease in the abundance of leaf feeders. Environmentally safe, practical, and fuel conserving techniques will be needed to effectively manage this potential increase in tree pests. Massive planting of windbreaks in the Great Plains may help alleviate some of the potential effects of global climate change by sequestering carbon and reducing the consumption of fossil fuels.

INTRODUCTION

The Great Plains is a vast area that extends from the Missouri River to the Rocky Mountains and covers one quarter of the continental land mass of the United States. It is predominantly grassland, with trees along the boundaries or restricted to rivers, sloughs, and drainages. The Great Plains has a continental climate characterized by severe droughts, temperature extremes, and desiccating winds. Precipitation is limited and unpredictable. It varies from more than 50 inches in the southeast to about 12 inches in the west and occurs primarily during spring and early summer. Severe droughts occur approximately once every two decades; the most recent from 1987 to 1990. Wind erosion is a major problem, with three-fourths of the highly wind-erodible land in the United States located in the region.

This paper discusses the present and past environments of the Great Plains, the potential effects of global climate change on trees and pest abundance, and the impact of proposed initiatives for decreasing the impacts of global warming on the resources of the region.

PAST, PRESENT, AND FUTURE ENVIRONMENT

Twenty thousand years ago glaciers covered the northern Great Plains, and coniferous (spruce) forests were present over most of the eastern and central United States. This glacial climate was replaced by the semiarid climate that is present today. As the

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glaciers receded, the coniferous forests and grasses from surrounding areas, especially the southeast, slowly invaded the region (Wright 1970). Today, only a few of the species of grasses and other vegetation found on the prairie are indigenous only to the Great Plains; most species are also distributed widely throughout the United States (Wells 1970). Pollen counts indicate that woody species such as sagebrush (Artemisia spp.) and juniper (Juniperus spp.) invaded different parts of the Great Plains, died out when weather was unfavorable or because of fire, and then reinvaded when weather conditions became favorable again (Wells 1970, Wright 1970). Because of fires, trees were restricted to areas along the river bottoms, on buttes, or on escarpments (Wells 1970).

Analyses of tree rings from eastern red cedar (Juniperus virginiana) and ponderosa pine (Pinus ponderosa) in Nebraska and white oak (Quercus alba) in Iowa indicate a cyclic weather pattern during the past 400 to 700 years. Droughts or periods of below normal rainfall have occurred every 21 years and lasted an average of 13 years in Nebraska. During the period 1539 to 1939 there were 13 droughts longer than 5 years in Nebraska, 6 longer than 10 years, and 2 longer than 20 years. During these droughts, the abundance of many trees and other vegetation declined (Weakley 1943, Meko et al. 1985).

Although droughts occurred in the 1930's and as recently as 1987-1990, overall weather patterns suggest that droughts in this century have not been as severe as those indicated in the fossil records. As a consequence, trees have spread from escarpments and drainages onto grasslands from Texas to Nebraska. This invasion of trees is due mostly to the suppression of fires, intense grazing, and tree planting by the settlers (McPherson et al. 1988, Brown and Archer 1989).

Predictions about future changes in the climate of the Great Plains vary from grim to mildly optimistic. Several global climate models predict that by 2050 temperatures will increase by as much as 5°F and droughts will increase in frequency and severity. An arid climate similar to that of the southwestern United States would likely cover large areas of the Great Plains (Robert 1987, Woodman 1989). Moisture stress of plants throughout the region could increase, and tree species less tolerant of drier conditions could rapidly disappear. The eastern edge of the prairie-forest border could migrate 60 to 100 miles northeast for every 1°F rise in temperature (Woodman 1989). Tree pests, such as bark beetles, borers, leaf feeders, and sap suckers, would become more abundant, because insect development would be favored by higher temperatures, increase in phloem nutrient levels in stressed trees, and lower tree defenses (Mattson and Haack 1987, Hedden 1989). However, a continued decline in environmental conditions may also cause a decline in leaf quality and quantity and, thus, a decrease in the abundance of leaf feeders (Mattson and Haack 1987, Woodman 1989).

Other models predict that the climate will not change appreciately, and that temperatures will increase by less than 2°F or will decrease. There also is disagreement about the amount of precipitation that will occur in the Great Plains and how soon the effects of global climate change will be evident. These models likewise predict that global climate change will have very little impact on trees growing in the Great Plains. Because the recent climate in the Great Plains has not been as severe as it has been in the past, it will be difficult to determine if future increases in the number and severity of droughts or increases in temperatures in the Great Plains are due to global climate change or fluctuations of the typical climate for the region (Rosenberg 1988, Cosgrove 1989, Wheeler 1990).

TREE STRESS AND PEST ABUNDANCE

Trees growing in the Great Plains are subject to both biotic and abiotic stresses and may be stressed by one or more of the following: insufficient moisture, saline or alkaline soils, an impermeable hardpan, desiccating winds, cold winter temperatures, early

spring and early autumn freezes, insects, diseases, and herbicides (Cunningham 1990). Many trees planted in the region are not native to the area and are poorly adapted to stressful conditions. If an extensive drought occurs, many of these poorly adapted trees may die.

Stressed trees can be severely damaged by insects during or immediately after a drought (Mattson and Haack 1987). For example, during and immediately after the most recent drought (1987-1990) sawfly (Neodiprion spp. (Hymenoptera: Cimbicidae)) abundance increased and damage to Scotch (Pinus sylvestris), Mugo (P. mugo) and other pines (Pinus spp.) increased dramatically in the central Great Plains.[3] In 1990, ash borer (Podosesia syringae (Harris) and P. aureocincta Purrington and Nielsen (Lepidoptera: Sesiidae)) populations increased in the central and northern Great Plains, and ash bark beetle (Hylesinus spp. (Coleoptera: Scolytidae)) damage was widespread in the northern Great Plains.[4] Grasshopper (Orthoptera) abundance and damage to woody plants also increased. In North Dakota, grasshoppers severely defoliated hackberry (Celtis occidentalis) seedlings during the spring 1990.[5] Abundance of grasshoppers, leaf miners, gall forming insects, and certain other defoliating insects commonly increase the year after a severe drought because the trees have started to recover and are producing the highly nutritious leaves needed by nymphs and young larvae (Edwards 1960, Dempster 1963, Gage and Mukerji 1977, Capinera and Horton 1989).

TREE PLANTING INITIATIVES

Tree planting to achieve reductions in fossil fuel consumption and long-term sequestration of carbon dioxide has been proposed by the National Association of State Foresters (Hamilton et al. 1990) and has received considerable attention at recent Society of American Foresters conventions and during the 1990 sessions of Congress. This concern and the availability of large areas in tree planting has resulted in two tree planting initiatives for the Great Plains in the 1990 Farm Bill, "America the Beautiful" and the Semiarid Agroforestry Center. The "America the Beautiful" initiative proposes planting trees on 78 million rural acres in the Plains states and improving tree plantings on 2 million acres (Anonymous 1990). The Semiarid Agroforestry initiative proposes planting 50,000 miles of windbreaks to protect 12 million miles of highly erodible land by the year 2002.[6]

Trees planted in shelterbelts or windbreaks on the Great Plains could be used to provide wind protection and enhance the microclimate for homes, crops, livestock, and roads. This could lower fossil fuel consumption and reduce carbon dioxide emissions. For example, a modest windbreak planting program of 4.9 million acres could result in the storage of 86 million metric tons of carbon. Indirect benefits in the agricultural sector would reduce diesel fuel consumption by 300 million gallons. Wind protection of homes could reduce home heating needs and conserve over 180 billion cubic feet of natural gas.

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[3]M.E. Dix, personal observations.

[4]A. Tagestad, North Dakota Forest Service, Bottineau, ND, and J. Staley, City Forester, Grand Forks, ND, personal communications; and M. E. Dix, personal observations.

[5]R. Cunningham, USDA Agricultural Research Service, Mandan, ND, personal communications.

[6]Rietveld, W. 1990. Trees in semiarid environments: a new perspective, the Semiarid Agroforestry Center. USDA Rocky Mountain Forest and Range Experiment Station, Lincoln, NE. (Unpublished Report) 4 pp.

These reductions in fossil fuel use could reduce carbon dioxide emissions by 548 million tons over the 50-year life span of a windbreak.[7]

These massive tree planting programs will, however, raise a number of problems. Many trees planted on urban and rural sites in the Great Plains are poorly adapted to the site and are severely stressed; consequently they perform poorly. Stressed trees are extremely susceptible to insects and diseases, and widespread epidemics of forest insects may occur, especially if only a few species are widely planted. The "America the Beautiful" program has no provisions for providing adapted sources, maintaining tree health, or preventing pest damage. Furthermore, adapted seedlings are not available in large quantities.

CONCLUSIONS

Fossil records indicate that drought plays a major role in the Great Plains ecosystem and that severe droughts are common. The potential impact of global climate change on the Great Plains could be worse than impacts of recent droughts, and existing forests may disappear. Trees in the Great Plains may play an important role in alleviating the potential effects of climate change by providing permanent year-round protection for soil, water, and crops, and thereby reduce the burning of fossil fuels. We need to protect tree resources by identifying and planting stress-resistant trees. As tree stress increases, insect problems will magnify. Some species will become more abundant, others will die out, and new pests will appear. Research is needed to develop methods for measuring tree stress, to determine the effects of environmental factors on tree vigor and insect abundance, to develop methods for minimizing damage, and to identify new potential pests. The proposed Semiarid Agroforestry Center will address these needs.

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ARE FORESTS THE ANSWER?

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