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Silvicultural Decisions XII: Considering Climate Change in Silcultural Prescriptions

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Forest ecosystems are complicated and ever changing. Landowners and managers must consider a vast array of information to meet either specific stand objectives and/or the broader goals of landscape level management. In many situations, land management objectives integrate measurable products such as timber and forage, and less tangible assets, often collectively described as aesthetics. On other lands, production of timber or other products may be primary, but a broad consideration of ecosystem functions and processes is still required for sustainable success.

Managers and landowners with years of experience in evaluating forest conditions and applying management can consistently predict results and achieve silvicultural objectives. Forests have always been dynamic and variable and are a constant challenge to understand and manage. But, with collective experience, basic and applied research, and the modern tools of computerized data collection, interpretation, and modeling, silviculture has advanced to sometimes more of a science and less of an "art" in the 40 years since I made my first timber cruise and marked my first harvest. However, because of the complexities of increasing social concerns, landscape-level management, emphases on uneven-aged and mixed species management, and our unfulfilled ability to measure and analyze more intricate environmental factors with new methods and equipment, silviculture may actually be more "artful" than ever.

The reliability of silvicultural predictability and achievement of objectives has greatly diminished with climate change. While the specific climatic impacts of human activities are still open for debate in some respects, there is no longer any doubt in my own mind, or for most in the scientific community, that climate change is real and a serious factor in nearly every aspect of our lives and economy. There are many credible, scientifically validated measures of how the climate has changed dramatically in regard to global warming, but many other aspects of climate change other than temperature are still under investigation or are not yet on the radar screen of all scientists and funding agencies.

Forest and agricultural scientists and managers are beginning to develop basic models to predict the factors that determine the health and productivity of forest vegetation and agricultural crops in a changing climate. These frameworks will require many years of substantial research to achieve reliability. The most dramatic ecosystem responses to climatic changes are occurring at the poles, where the average global change is magnified by a factor of 3…..a global change in mean annual temperature of 2 degrees averages 6 degrees in the arctic, and about 4 degrees in much of the boreal forest. More locally, where our temperate forests are somewhat below the average global temperature change, some puzzling declines in some tree species on specific sites, such as Alaska yellow-cedar described below, are now being explained in terms of climatic impact. One reason the global average temperature has not shown a more dramatic increase is because several regions within the tropics have actually decreased in average annual temperature, and also because of the heat sinks provided by the vast waters of the ocean and by melting glaciers and ice caps at the poles. Consequently, scientists and managers need to look at a broader spectrum of climate changes than just temperature.

To conceive how climate change can and is affecting temperate and boreal forests, it is necessary to first understand how different species in these ecosystems

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relate to each other (synecology) and how individual species relate to their environment (autecology). Additionally, we all need to understand that many of the fundamental ecological principles we have learned and accept were developed from research and experience in more tropical ecosystems. About 65 million years ago the dinosaurs and an estimated 70% of all other species on earth became extinct due to, according to most authorities, a cataclysmic meteor impact. Since that time, the earth and its organisms have experienced many additional geologic and atmospheric changes, with corresponding climate changes that challenged current vegetation, animals, and other organisms, including humans. But for millions of years, the tropics have had little climate change or large-scale disturbance impact. As a result, tropical species have co-evolved to extreme specialization with highly developed adaptations to specific ecological niches and a finely-tuned interdependence. Thus, the widely accepted principle that, as John Muir often said, everything on earth is "hitched to everything else" is an accurate description of tropical ecosystems.

As you move north (and I presume south) more regular and dramatic disturbances occurred. The plants and animals of the Inland Northwest have only been associated for less than 10,000 years, and in boreal and arctic regions far less time. Consequently, the synecology of these plant and animal communities is much less developed. Most species are linked more by competition and adaptation to disturbance than by the refined interdependence we see in tropical ecosystems. Some of our pathogen/host interactions in this temperate region would seem to be a result of co-evolution, but many of these pathogens show the ability to infest diverse hosts, such as the white pine weevil infecting mostly spruce and lodgepole pine, the mountain pine beetle's success in several pines, and the spruce budworm shifting from grand fir to Douglas-fir to hemlock depending on availability and host condition. Another factor operating here is that there may be more selection pressure for "generalist" pathogens and other opportunistic adaptations of many plants and animals because of more frequent and dramatic disturbances.

As we go from temperate to boreal to arctic forest ecosystems, we find an increasing ability of organisms to adapt to change, but also more dramatic disturbances and their effects on species survival, often evident in epidemic pathogen outbreaks with some species being reduced or eliminated. Other species in these changing situations may greatly increase their range, vigor, and percent of the population. Rather than the current focus on seeing any species decline as a result of human activity that must be countered, we need to look at the bigger picture and understand and accommodate changes in species and environments. While we can, and in some cases should, modify human impacts on climate change, there are many interrelated but inevitable changes we must understand and plan for to reduce, as far as possible, the undesirable effects of climate change. In silvicultural decisions, this is a challenging, but not impossible, task when we consider the life spans of trees and forests.

These generalizations about climate change effects on large-scale ecosystems are only part of a very complex and dynamic interaction of the physical and biological environments. However, they can guide our decisions on how specific sites may be affected, and how these changes may affect silvicultural objectives and the prescriptions we make to achieve them. Many of these changes in climate are not directly manifest in warming, but in when and where precipitation occurs, particularly in having rain instead of snow during winter, and in very early or late severe cold. ***It is the species with narrow ecological amplitude (they require very specific ecological conditions to succeed) and those with wide amplitude (they are adaptable to a wide range of conditions) where these wide-ranging species are at the fringes of their tolerance, that will show the first and most dramatic climate change impacts***. For example, subalpine fir has a rather narrow ecological amplitude or tolerance to temperatures, requiring the more constantly cool conditions at night found both in alpine and lowland frost pockets. The Palouse fringe around Moscow Idaho, and areas east of there were notable locations for subalpine fir at elevations of only 2,200 to 2,600 feet. During the last 10 years, most of those locations no longer support living subalpine fir, and I believe the circumstantial evidence is strong for climate change as the cause. Some might contend that it is an

introduced pest, balsam wooly adelgid, responsible for this decline, but this insect has been found in the same localities for about 30 years and only recently became a cause of subalpine fir mortality, probably because of tree stress related to environmental changes on these sites.

This past winter, I and several other resource professionals I have spoken with experienced winter kill on western larch trees of all sizes, a species with relatively wide ecological amplitude. Larch has always been one of the species recommended for frost pockets and other colder sites where late spring frosts damage other conifers. However, I do not believe frost is the culprit. Rather, I think the cause was the "unseasonably" warm winter conditions of December, 2005 and January and early February, 2006, followed by a dramatic drop in temperature to minus 20 degrees F in mid-February that killed these larch trees. Western larch is easily "roused" from deep dormancy by prolonged warmer temperatures regardless of day length, and then it is vulnerable to freezing damage, both to roots and cambium. This process is further accelerated by the absence of snow cover that can protect root systems from sudden and unusual cold. Another complication is the probability of drought from lack of precipitation coupled with transpiration demand from the "wakened" trees. These presumptions are, of course, just that until scientific research can verify or reject them. However, a similar situation has now been scientifically documented as the cause of the dramatic decline of Alaska yellow-cedar throughout southeast Alaska, western Canada, and the northwestern United States. In this case, the lack of protective snow cover combined with rapid temperature drop has been determined to be the cause of this problem which was thought to be a pathological (insect or disease) puzzle for several decades. Another Intermountain West species, aspen, is in severe, recent decline across much of it wide range. A conference of forest experts met recently to share scientific and observational information on aspen decline but failed to reach any conclusions. The cause of mortality is definitely physiological as no pathogens have been discovered in any part of the trees, and climatic effects on the ecosystem are the most likely, but undocumented, cause.

Silviculture deals with management decisions in ecosystems dominated by trees. But, other organisms and ecosystem components besides trees are affected by climate change. Trees, however, can be the barometer of change and because they are usually the dominant organisms in forests, changes in trees have many ecological as well as economic consequences. Most temporary, as well as long-term, changes are beneficial to some organisms and detrimental to others.

To incorporate climate change into silvicultural prescriptions, research must be broadened and intensified. Some of this is already being done, such as the work on snowpack and watershed hydraulics at the Mica Creek Watershed (http://www.cnr.uidaho.edu/micacreek/). However, the examples I gave for subalpine fir, western larch, aspen, and Alaskan yellow-cedar do provide some current insights that can be considered. We may need to rethink the stand densities we manage for in particular, as well as what species we favor. Snowpack is highly affected by interception and melt rates. Stand densities that allow more snow to reach the ground yet still provide some shade to regulate melting should be beneficial to water budgets as well as root protection. Orientating the long axis of patch cuts or clearcuts east to west can also preserve snowpack by maximizing the shade on the north side of the cut from the spring sun. Stand density also affects the water budget and the impact of warming on both tree's transpirational demand and on the amount and effectiveness of precipitation. Less dense stands allow more precipitation to reach the ground and percolate more deeply into the soil rather than being intercepted and evaporated off dense crown cover.

Species selection in regard to climate change is more complicated. The generalization that the most shade tolerant species on the site is the most susceptible to stress still holds, but some sites don't leave much choice. Drier sites will only support ponderosa pine, perhaps in combination with Douglas-fir, so there is not much we can do there unless we trend towards exotics. The wettest sites, those that support western redcedar and/or western hemlock, have lots of species options and we should make sure we are not at the drier end of these habitats in making species selections. Where we are, we should select among more drought tolerant

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species such as Douglas-fir, western-larch, western white pine, grand fir and lodgepole pine. This, of course, only covers the drought effects of warming. For species such as Engelmann spruce and subalpine fir that require the coolness found on some of these cedar/hemlock sites, we may have additional concerns that favor removal and discouragement of these species depending on the silvicultural objectives and integrated site factors.

Silviculturists, other natural resource professionals, and landowners need to think through the entire site and stand data they have gathered as part of the prescription process and understand how these factors may interact with climate change. In the future, I expect to see more exact science developed that provides more specific guidelines. As a final note, we need to recognize that "art" is an even stronger component of silviculture, and that many of the potential adaptations and ecological amplitudes of species of trees, other plants, and many animals have not been adequately studied and defined. I have bald cypress trees growing in Moscow, and while they are not thriving, they are surviving conditions unknown in their native range and growing quite well. There are many tolerances in plants and other organisms that have not been tested in current environments and a few surprises may be in store for all of us. Certainly, we may need to research and redefine seed transfer zones. Equally important, we need to place more emphasis on thresholds of response: for example, ponderosa pine has a threshold of low temperature that limits its presence on higher elevations even though other factors are suitable. Ultimately, climate change will be diverse across the landscape, and some areas my actually become cooler and wetter.

Most landowner objectives do not include surprises, and climate change poses a real challenge for silvicultural prescriptions that avoid or accommodate the unexpected, especially given the long life of trees and even greater longevity of managed ecosystems.

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