The Sanctuary's Forest and Climate Change

Introduction

The Morrell Nature Sanctuary lies within the Coastal Douglas-fir zone of British Columbia's biogeoclimatic ecosystem classification system. Forests in this zone are characterized by Douglas-fir, grand fir, western redcedar, bigleaf maple, and western flowering dogwood on moist sites, while on drier rocky outcrops arbutus, Garry oak, and shore pine grow alongside Douglas-fir. Recent reports of western redcedar dieback during a series of particularly dry summers have given rise to the concern that climate change may already be exerting some influence on forests in the area.[1] This paper briefly reviews some predicted responses of two important tree species in the Morrell Nature Sanctuary, western redcedar and Douglas-fir, to the desiccating effects of climate change and considers implications for the future of the sanctuary's forests.

Tree Physiology and Moisture Stress

Plant physiology is adapted to take up carbon dioxide for photosynthesis and simultaneously release water vapour from transpiration through pores in the leaf surface called *stomata*. During transpiration a water potential gradient is created which draws water from the soil through the root cortex into a system of long-distance ducts known as the *xylem*. Water is translocated by conduction up through the xylem to the leaves, where it is liberated via the stomata to the outside air as vapour. A fine balance must be established by the plant to avoid excessive water loss from transpiration while at the same time acquiring sufficient carbon dioxide to manufacture food (carbohydrates) using energy from the sun to power the process of photosynthesis. Under drought conditions, soil moisture is in short supply and the plant must protect itself from losing too much water. Some control is possible with special cells known as *guard cells*, which regulate the opening and closing of the stomatal pore by altering turgor pressure in the two guard cells surrounding the pore. In mature trees, with their extensive evaporating surfaces and the long distances water must travel from roots to leaves, appreciable water deficits can develop and water loss must be dealt with quickly. The entire crown of a tree can transpire without limit on cloudy or overcast days when an adequate water supply is assured, but on clear days, especially around noon, trees typically encounter difficulty keeping up with the rate of water loss and the guard cells temporarily restrict transpiration. Later in the day, when the tree's water content has been restored, the stomata open again and the rate of transpiration increases. Under prolonged conditions of moisture stress due to drought, however, trees may start to show signs of declining growth and productivity, dieback, premature leaf drop, chlorosis, and eventually death. Catastrophic failure of the plant's water conducting system is a principal mechanism involved in extensive crown death and tree mortality during drought, but the multi-dimensional response of trees to desiccation is complex.

Western Redcedar and Moisture Stress

Western redcedar occurs over a wide geographic range in British Columbia, but the populations from various habitats may differ in their ability to withstand water stress. For example, one study has shown that western redcedar populations from drier inland habitats had greater tolerance and more efficient use of water in response to drought than populations from coastal origin with temperate maritime habitats.[2] Another study examined the distribution and potential causes of western redcedar dieback on the east coast of Vancouver Island.[3] Dieback was defined as a condition where foliage is dropped and whole branches die. Dieback was found in varying intensity in three of the four driest biogeoclimatic units on the island, but it was primarily concentrated near the Qualicum Beach area. Warm and dry summer climate was found to reduce radial growth of redcedar, suggesting that moisture stress may be the major determinant of redcedar dieback. Subsequent causes include well-drained coarse-textured soil, drought periods over the growing season, and other factors such as insects and pathogens. The researcher concluded, however, that over the next few hundred years it is unlikely that redcedar will be lost completely from Vancouver Island due to the resilient nature of this species. Nevertheless, redcedar growing on low elevation sites vulnerable to moisture stress may experience increased dieback occurrences and eventual decline in these areas. A third study reviewed literature on the vulnerability of western redcedar to climate change and concluded that western redcedar may not be severely affected by future climate warming.[4] They speculate that the species may remain in its current range, and that productivity may actually increase in some settings. Despite this optimistic prediction, researchers have found that western redcedar seedlings grown experimentally under different levels of soil water conditions showed an inherent intolerance to water stress, explaining the better growth on moist sites in humid environments and the inability of this species to occupy very dry sites in the same biogeoclimatic regions. Thus, regeneration of western redcedar may be severely impacted under drought conditions.[5]

Douglas-fir and Moisture Stress

Water availability during late spring and summer strongly influences productivity of Douglas-fir and is a function of site (slope position, rooting depth, soil texture) and weather (rainfall, air temperature, humidity, solar radiation) conditions. Global warming is predicted to result in winters that are warmer and wetter, and summers that are warmer and possibly drier in southwestern BC, suggesting that the range of Douglas-fir may move northward in location and upward in elevation as a consequence of climate change. Such a shift would likely leave the current area of coastal Douglas-fir in BC unchanged and could increase it by making higher elevations more suitable for Douglas-fir. A study by the BC Ministry of Forests examined the impact of changing water supply and evaporative demand on the productivity of managed second growth Douglas-fir stands in the Georgia Basin by determining future water availability based on various climate change scenarios combined with water/growth relationships.[6] Their simulations indicated that climate change will not result in large fluctuations in water availability for tree growth in the Georgia Basin. However, there may be significant reductions in productivity over the long term, with sites at the lowest end of the water availability range at greatest risk because they are already moisture stressed during the summer in most years. Predicted changes in winter and summer temperature and precipitation for the Georgia Basin should result in a climate that is still within the range hospitable to Douglas-fir. Warmer temperatures might result in reduced carbon uptake, affecting productivity. For example, respiration due to warm summer conditions has been found to decrease the annual net carbon dioxide uptake of a Douglas-fir stand on Vancouver Island compared to cooler years. Productivity of Douglas-fir could decline by up to 30% in response to increased potential evaporation exacerbated by a reduction in summer precipitation; however, this could be considered a worse case scenario. In general, it is expected that Douglas-fir will respond positively with future changes in climate,[7] given its extensive geographical and elevational range along with the broadest ecological amplitude of all the western North American tree species.[8]

Conclusions

Recent assessments in western North America have concluded that forests are being affected by climate change and will become increasingly vulnerable to mortality as a result of the direct and indirect effects of climate change.[9] Droughts associated with higher temperatures may accelerate levels of tree mortality because elevated temperatures increase metabolic rates without increasing photosynthesis rates, thus compromising a tree's ability to create defenses against insects and pathogens. However, other researchers point out that, given the high uncertainties in predicting climate, vegetation, and disturbance responses to increasing carbon dioxide, the assessment of vegetation change and vulnerabilities is currently more of an educated guess based on inconsistent and contradictory studies rather than a highly confident evaluation of comprehensive scientific investigation.[10]

With regard to the Morrell Nature Sanctuary, and in particular to western redcedar and coastal Douglas-fir, the general conclusion is that these two tree species are relatively resilient and can be expected to remain as important components of our forest in the foreseeable future despite the threat of climate change. On the other hand, newly established western redcedar and Douglas-fir seedlings under drought conditions may be more sensitive than mature trees to water stress. As well, it is unclear whether other trees in the sanctuary's forest community, as well as some shrubs and herbs, may be more vulnerable to drying conditions than western redcedar and Douglas-fir since other plants have not been considered in this brief report. Secondary impacts of changing climates on plants weakened by drought, such as the possibility of increased susceptibility to insects and disease, have also not been investigated. While there is a potential for loss of some species in the sanctuary's forest, the stated mission of the Morrell Sanctuary Society is to preserve the character of the sanctuary's *evolving ecosystem* and this implies that the system is expected to change over time. Thus, there is no burden to try and conserve the forest as it exists today, and changes in species composition can be regarded to some extent as a consequence of the natural evolution of forest ecosystems.

An interesting question, though, is whether the sanctuary's forest will remain classified as part of the Coastal Douglas-fir zone in the province's biogeoclimatic ecosystem classification (BEC) as climate change eventually exerts an influence on species composition. For example, the sanctuary includes several common site associations in the Coastal Douglas-fir zone representing different plant communities along a soil moisture gradient ranging from very dry to wet: Douglas-fir—Shore pine—Arbutus; Douglas-fir—Salal; Redcedar—Grand fir—Foamflower; and Redcedar—Skunk cabbage.[11] It has been stated by the BC Ministry of Forests that the BEC framework will become even more important as species and ecosystems are transformed in response to climate change.[12] It was further noted that currently described BEC site series will remain viable in identifying site quality in mature forests for at least the next few decades because the indicators of a site generally have a broad climatic tolerance. In the longer term, with more pronounced climate change, vegetation will continue to reflect site conditions but the value of individual species as indicators could shift. For instance, Douglas-fir may become less frequent on dry, rocky knolls with low soil water content where it presently grows with shore pine and arbutus, but this species could persist as a significant indicator of site associations in moister habitats within the zone. Only time will tell.

Endnotes

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[3] Seebacher, *op. cit.*

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