Forest Sciences

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The Blanket Bog – Upland Forest Complex of North Coastal British Columbia: Succession, Disturbance and Implications for Management

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Introduction

The vegetation on the outer north coast of British Columbia is largely a complex mixture of blanket bog and upland forest. The upland forest consists of several types, including lower productivity redcedar-dominated stands. For the most part these redcedar forests have little or no history of forest harvesting. In recent years, however, interest has grown in determining whether these forests can be harvested and regenerated in a sustainable manner. Understanding ecological processes, such as succession and disturbance, is critical to this determination because of the close ecological relationships between forests and bogs on the north coast, and the importance of disturbance in controlling bog and forest succession.

Ecological succession is the process of change in species composition and cover of plant communities over time, ultimately leading to a climax vegetation type. This process is often accompanied by changes in soil composition and hydrology, sometimes initiated by the vegetation itself, especially in wetlands. Bog development represents the extreme, where the build-up of organic matter over hundreds or thousands of years can produce conditions detrimental to tree growth. On the outer north coast, the gentle terrain of the Hecate Lowlands, combined with high levels of precipitation and low levels of disturbance, favour bog development. This process is minimized on steeper terrain by adequate soil drainage, and by windthrow and landslide disturbances, which tend to retard organic matter build-up and maintain forest productivity. Research suggests that sustainable forestry is only possible on those sites where conditions that inhibit tree growth have not developed and will not be promoted by harvesting practices.

This extension note provides an overview of succession on the north coast, including recent data from the HyP^3 project (Pattern, Process, and Productivity in Hypermaritime Forests). The aim of the project is to understand the ecological processes operating in the lower productivity cedar-dominated forests of the north coast. From this knowledge, ecologically based sustainable forestry guidelines will be developed. An overview of the HyP^3 Project is provided in Extension Note #38 (Banner and Shaw 1999).

The Vegetation of the Blanket Bog – Upland Forest Complex

The vegetation associations of the hypermaritime north coast can be divided into four broad types: upland productive forest, upland scrub forest, bog woodland and open blanket bog (Banner et al. 1987). These communities occur on the landscape in complex patterns, mostly related to disturbance history and drainage. Banner et al. (1993) further subdivide these generalized units into several site series, based on species composition and site characteristics, using the Biogeoclimatic Ecosystem Classification (BEC) system. For the purpose of this discussion, however, we will use the more generalized units.

Upland productive forests occur on steep, sometimes unstable colluvial slopes, with a relatively frequent disturbance regime and better drainage than gentler sloping areas (Figure 1). The soils are usually Podzols or thin Folisols over rock. These forests can also occur on well-drained fluvial sites with Regosolic and Brunisolic soils. Major tree species are western hemlock (*Tsuga heterophylla*), Sitka spruce (*Picea sitchensis*), amabilis fir (*Abies amabilis*) and western redcedar (*Thuja plicata*).

Figure 1. Upland productive forest.

Upland scrub forest covers much of the landscape and occurs on gentler terrain than the upland productive forest or occasionally in steeper areas without a disturbance history (Figure 2). The soils generally have a thick surface organic layer (20 – 50 cm) over imperfectly drained Podzols, or directly over rock, although they have also been found over peat deposits, indicating a transition from wetland to forest (Banner et al. 1983). Upland scrub forests are dominated by redcedar, yellow-cedar (*Chamaecyparis nootkatensis*), and western hemlock, but can also contain shore pine (*Pinus contorta* ssp. *contorta*), mountain hemlock (*Tsuga mertensiana*), and (rarely) Sitka spruce.

Figure 2. Upland scrub forest.

Bog woodland is most common on gentle to moderate slopes (<30%), but has been found on slopes of up to 65%. Trees are stunted and the canopy is open (Figure 3). The soils are usually Organic (mainly Mesisols) but Folisols and Gleysols also occur. Disturbance (windthrow and landslides) in these woodlands is very uncommon and most sites have escaped disturbance for thousands of years. The most abundant tree species are shore pine, yellow-cedar and redcedar, with western hemlock and mountain hemlock also occurring.

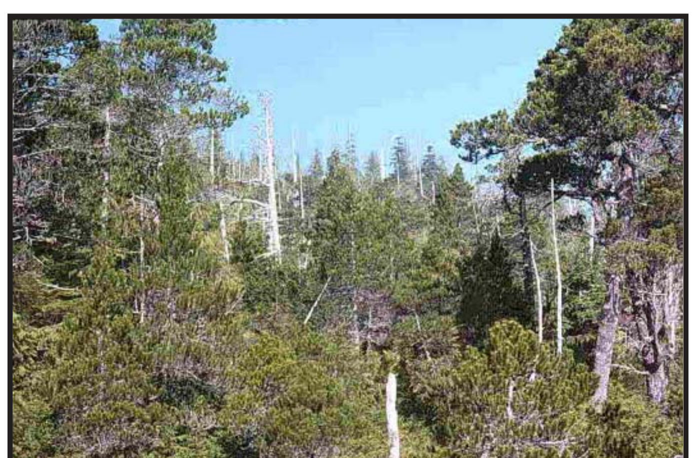

Figure 3. Bog woodland.

Open blanket bog occupies much of the level and gently sloping terrain on the north coast, and often intergrades with bog woodland (Figure 4). Disturbances of any sort are virtually absent in this vegetation type. The soils are Organic (mostly Mesisols and Fibrisols), and peat depth is highly variable, ranging from 50 cm to over 4 m. Shore pine and yellow-cedar are the most common tree species in open blanket bogs, mainly as shrubby individuals.

Figure 4. Open blanket bog.

Successional Trends

There is evidence that the plant communities of the outer north coast have long-term successional linkages. Successional histories spanning thousands of years are reconstructed by analyzing the peat stratigraphy of bogs using pollen, spores and plant remains in peat cores, and C^{14} dating. Cores collected by Banner et al. (1983) near Prince Rupert have shown an 8000 year sequence from an initial lodgepole pine – red alder (*Alnus rubra*) pioneer forest, to a Sitka spruce – western hemlock productive alluvial forest, then to a redcedar – yellow-cedar scrub forest, and finally to a lodgepole pine – yellow-cedar – western hemlock bog woodland. Some areas have been shown to have further changed from the bog woodland to the open bog stage (Turunen 1999) (Figure 5). This shift in productivity and biomass allocation from trees to bryophytes appears to represent the dominant successional direction on the outer north coast. Areas have been found, however, with productive forests growing over peat deposits, indicating succession from wetland to forest (Banner et al. 1983). One such transition has been dated at approximately 2100 BP (before present) (Banner et al. 1983), but the successional history of these sites is not well documented and detailed descriptions are not presently available.

Figure 5. Open bog development on 2m of accumulated peat.

These successional trends highlight an important difference between the north coast and other less maritime areas of British Columbia. In most interior ecosystems of the province, successional pathways lead to a climax of productive forest, but on the outer north coast research suggests that the main long-term successional pathway is from upland productive forest to lower productivity forest types, and eventually, open bog (Klinger 1996). This successional pattern is not unique to the northwestern coast of North America. Other hypermaritime areas where sloping blanket bogs are extensive include: Newfoundland, Ireland, England, Scotland, Scandinavia, Southern Chile, and southwestern New Zealand. In the United Kingdom, human forest clearing activities are thought to have played an important role in the development of open blanket bogs over large areas that were formerly forested (Moore 1987).

The Role of Climate

Based on studies of peat stratigraphy, there is good evidence that a period of peatland expansion, triggered by a cooler and wetter climatic trend, occurred during the middle part of the Holocene. Estimates of when this expansion began range from 3500 to 6000 years ago. (Heusser 1960, Mathewes and Heusser 1981, Banner et al. 1983, Hebda 1995) (Figure 6). On the north coast, this cooler and wetter trend was evidently sufficient to trigger succession from productive forest to scrub forest, thus setting the stage for the development of the blanket bog communities that characterize much of the area today.

Disturbance Regimes in the Hypermaritime

Most north coast forests, and especially cedar-dominated lower productivity forests, rarely have stand-initiating disturbance events, and consequently are classified as being in Natural Disturbance Type 1 (NDT1) (BC Ministry of Forests and Ministry of

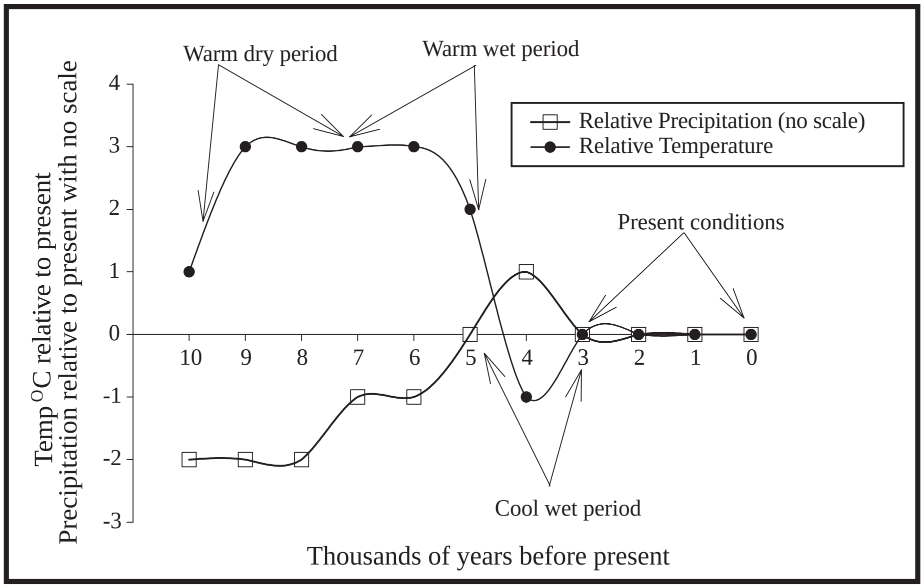

Figure 6. Historical climatic conditions on the north coast relative to present conditions (interpreted from Hebda 1995).

Environment, Lands and Parks 1995). In these forests the majority of disturbances are small in scale and localized, with the most gaps being created by stem breakage (Lertzman et al. 1996, Nowacki and Kramer 1998) or localized blowdown events (covering less than 5 - 10 ha.). Landslides are less common on the outer coast than further inland in the Kitimat Ranges due to the more subdued terrain. Patterns of past landslide disturbances as evidenced by subtle differences in stand age, density and species composition, can be seen on many of the steeper coastal slopes. Fluvial disturbances, such as flooding, occur along larger rivers. In general, large-scale disturbance events, such as major blowdown or fire, are infrequent (Neiland 1971, Nowacki and Kramer 1998), and the return interval for disturbances is >250 years. Some areas on northern Vancouver Island and southeast Alaska have been identified as being subject to hurricane force winds with a return interval of <100 years. Similar areas may occur on the mid and north coast and would be included in Natural Disturbance Type 3 (NDT3), ecosystems with frequent stand-initiating events (BC Ministry of Forests and Ministry of Environment, Lands and Parks 1995).

The Role of Disturbance in Succession

Disturbance, especially windthrow and landslides, has been shown to play a role in slowing and reducing organic matter accumulation. The churning of soil that occurs when a root wad is turned up or a landslide occurs, speeds the decomposition of accumulated organic materials, brings mineral soil to the surface and prevents or reverses hardpan formation (Bormann et al. 1995, Kayahara and Klinka 1997). After a windfall disturbance, new organic horizons on the exposed tree root mounds can form about as rapidly as the long-term peat accumulation rates in peatlands (Bormann et al. 1995, Turunen 1999). Without regular disturbances, this organic matter will continue to accumulate to considerable depths. Studies in southeast Alaska suggest that a disturbance return period of less than 200 – 350 years is needed to prevent tree roots from being confined to an increasingly thick organic horizon (Bormann et al. 1995). Longer disturbance return intervals may result in declining forest productivity and a trend toward bog formation.

Management Implications

The successional dynamics on the outer north coast have implications for forest management, both in the currently operable, productive forests as well as in the lower productivity cedar-dominated scrub forests where little harvesting has occurred to date.

On the productive, currently operable sites, activities such as suspension cable logging and helicopter logging, that keep stumps intact and promote the development of young windthrow - resistant stands, may result in declining forest productivity over time. In this case, forest harvesting could act to lengthen the disturbance return interval, thereby reducing mineral soil disturbance and allowing organic matter accumulation to proceed without the setbacks caused by windthrow-induced mixing of mineral and organic horizons (Bormann et al. 1995). This lack of disturbance could set the forest on a trajectory of organic matter accumulation that would be difficult to alter, especially where forests are managed on shorter rotations (100 years or less) that pre-empt the natural windthrow disturbance cycle.

On steep slopes susceptible to mass wasting, however, forest harvesting may promote excessive disturbance with potential negative impacts on productivity, especially in the short term. Studies on the Queen Charlotte Islands have shown that timber harvesting can leave hillslopes susceptible to accelerated rates of mass wasting for 15 to 20 years following logging, or until stabilizing root systems re-establish themselves. A comparison of mass wasting rates on the steep west coast of the Queen Charlotte Islands revealed a 15 times greater rate of occurrence on man-modified terrain than on forested terrain (Banner et al. 1989). Impacts are the greatest in areas of large clearcuts and road networks.

In the natural forest landscape, mass wasting events are spread out in time and space, and are at least in part responsible for maintaining forest productivity. Where landslide activity is accelerated by man's activities, however, negative impacts such as regeneration delays, initial loss of productivity near the slide source where soil is scoured to bedrock, and sediment loading/ scouring of aquatic habitat often result. These very visible and immediate negative impacts tend to outweigh any potential improvement to long-term productivity that may occur in downslope areas. While disturbance is critical for maintaining productivity, managing that disturbance on a site-specific basis and in a way that, as much as possible, mimics the natural system is one major challenge we face.

In the lower productivity forests that have escaped major disturbance events for thousands of years, logging and site preparation may provide the necessary surface disturbance and soil churning to mix mineral and organic horizons and improve soil nutrient availability and aeration. Given the appropriate site conditions, where surface organic horizons are underlain by mineral soil, such treatments show some promise for improving tree productivity. On sites with deep organic soils or where mineral soils are very shallow or absent, this mixing as a form of site treatment may not be possible. Differences in soil properties and site productivity are often a reflection of differences in bedrock geology. Mineral soils have been found to be thinner over the hard, massive granitic rocks in comparison to the softer metamorphic rocks, especially the schists. If timber harvesting expands into these lower productivity forests, careful assessment of candidate sites based on specific site and stand criteria will have to be carried out in order to apply treatments that will ensure acceptable second growth regeneration and productivity.

Initial trends from an operational trial at Port Simpson, north of Prince Rupert, have shown that mounding and mixing treatments on the lower productivity sites may result in increased tree growth, at least in the early stages of establishment (for details see Shaw and Banner 2001a & b). An additional site treatment trial, designed to explore the effects of soil mixing and fertilization on seedling growth response, has recently been initiated at Oona River on Porcher Island, south of Prince Rupert (LePage et al. 2002).

Although site disturbance can be beneficial to long-term site productivity, questions remain surrounding the hydrological impacts of harvesting these wet sites. We suspect that the moisture received on harvested sites will increase due to the removal of the forest canopy and disruption of below-ground water flows. Preliminary results have shown that the canopy of these lower productivity stands intercept approximately 20 to 30% of annual rainfall (Maloney et al. 2002). Immediately following harvest, canopy interception will be reduced to zero (or nearly so) and will gradually increase again as canopies close in the young regenerating forests. Also, disturbance from machinery during harvesting and site preparation may disrupt drainage patterns by damaging soil pipes that aid soil drainage on these low productivity sites. The positive effects of soil mixing may thus be partially offset by disrupted hydrology. This combination of reduced canopy interception and disrupted drainage patterns may increase soil moisture levels, eventually leading to site paludification (bog formation). Depending on specific site factors such as slope, soil depth, and internal drainage, this additional moisture may have negative impacts on conifer regeneration. We are currently examining these issues at the Port Simpson and Oona River operational trials.

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