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Historic Disturbance Rates for Interior Biogeoclimatic Subzones of the Prince Rupert Forest Region

Research Issue Groups:

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Introduction

Natural disturbance regimes are an important characteristic of forest ecosystems affecting landscape patterns, stand structure and biodiversity (Steventon 1994, Bunnell 1995). Using natural disturbance regimes as models for comparison to managed forests is the approach recommended in the Forest Practices Code *Biodiversity Guidebook* (Ministry of Forests/BC Environment 1995).

One important parameter of natural disturbance regimes is the frequency at which stand initiating events such as severe fire have historically occurred, and how this has shaped the age structure of forest landscapes. In this note, using the forest inventory database, I examine the historic rate of stand initiating disturbances in the SBPSmc, SBSdk/mc and ESSFmc/wk/mk Biogeoclimatic (BEC) subzones of the Lakes, Morice, and Bulkley forest districts (Table 1), Prince Rupert Forest Region (PRFR).

Theoretical Framework

BEC subzones/variants are the most logical landscape units to use for disturbance regime analysis as they are based on climate (Meidinger and Pojar 1991), a primary factor affecting disturbance frequency and intensity (e.g., fire).

The theoretical framework used in the analysis is described by Johnson and Van Wagner (1985) and Johnson and Gutsell (1994) for fire disturbance. In brief, natural disturbance has created landscapes that are shifting mosaics of patches of varying age. If there is a constant rate of disturbance through time, and no strong effect of stand age on the probability of disturbance, the age distribution of forests over the landscape will have the shape of a negative exponential (reverse J-shaped) curve.

The negative exponential relationship results from older disturbances being obscured by more recent events until they finally disappear. How steeply the curve drops with age is a function of the disturbance rate, or the probability of a hectare of forest being disturbed in a given time interval (usually a year). The average disturbance return interval can be simply calculated as the average age of all the stands in the landscape. With real landscapes, we rarely see a tidy negative exponential curve because disturbance rates are not constant through time. None-the-less, the negative exponential model still provides a valid calculation of the average disturbance rate over long periods of time and large areas.

The expected proportion of the landscape older then a given age (as presented in table A4.2 of the *Biodiversity Guidebook*) can also be calculated using the equation $y = \exp^{-(t/b)}$ where b is the mean return interval, and t is the age of interest.

Methods

I obtained the area in 10-year age intervals for each BEC subzone from the forest inventory database (Table 1). The mean disturbance return interval was then calculated as the average age of the landscape (average of stand ages weighted by their area) using the midpoint of each 10-year age-class.

One problem in describing historic disturbance regimes is the confounding effect of recent timber harvest. As most of the large scale timber harvesting in the region has occurred in the past 20 years, I reassigned the area less then 20 years of age to age-classes > 130 years, proportional to the area those older age classes comprise of the landscape. Those are the ages typically harvested, and it is assumed there is no strong bias by age above 130 years in stands selected for harvest. All the stand ages in the analysis were then reduced by 20 years, to recreate the age distribution of the landscape prior to extensive harvesting(~ 1970).

One potential problem is a possible bias in the age estimates from forest cover mapping. Inventory standards call for estimated stand ages to be within 15% of true ages (Ministry of Forests 1992), but there are no independent data from this area to confirm the accuracy of the mapping. It is generally thought that the ages of older stands (> 150 years) tend to be under-estimated, and this seems plausible given that the time since the last stand-replacing disturbance can exceed the age of the oldest tree in a stand (Clark 1995). To examine the potential effect of this bias, I recalculated the disturbance rate, using the truncated age-distribution procedure of Johnson and Gutsell (1995), assuming only those stands less then 160 years of age are correctly aged.

Table 1. Area of BEC subzones in study area and PRFR.

BEC Unit	Hectares in Analysis	Gross Area of Subzone in PRFR[a]
SBPSmc	48,659	54,928
SBSdk	564,113	849,383
SBSmc	1,015,301	1,550,314
ESSFmc	411,219	638,602
ESSFmk	74,038	149,322
ESSFwv	48,659	1,709,398

[a] *from Banner et al. 1993 including non-forest areas.*

To illustrate the variability of disturbance through time, the area by age-class can be used as an estimate of the area disturbed in a given decade. Due to the effect of more recent disturbances masking older events, the area disturbed will be increasingly under-represented the further we look back in time. To correct for this effect, the area in each age-class is sequentially added to all older age-classes proportional to their occurrence on the landscape (Delong and Tanner 1996).

Results and Discussion

The differences in estimated average disturbance rate by BEC subzone (Table 2) are consistent with differing climatic characteristics (Banner et. al. 1993) and the assignment of subzones by "Natural Disturbance Type" in the *Biodiversity Guidebook*. Using the truncated age method, there was little difference from the non-truncated method for the SBPS and SBS subzones. The estimates for the SBSdk and SBPSmc are similar to those for the adjacent SBSmk in the Prince George Forest Region (Delong and Tanner 1996).

There was a considerable difference in the two estimation procedures for the ESSFwv and ESSFmk subzones. The difference results from the large

Table 2. Estimated stand-initiating disturbance rates by BEC subzone.

BEC Unit	Guidebook[a] Mean Return Interval (yrs)	All Age Data % Disturbed by decade	All Age Data Mean Return Interval (yrs)	Truncated Age Data % Disturbed by decade	Truncated Age Data Mean Return Interval (yrs)
SBPSmc	100	10.9	91	10.9	92
SBSdk	125	10.7	93	10.5	95
SBSmc	125	8.0	124	6.8	148
ESSFmc	200	6.0	166	3.5	284
ESSFmk	200	2.9	337	0.1	810
ESSFwv	350	4.5	220	0.1	1150

[a] ***Biodiversity Guidebook (Ministry of Forests/BC Environment, 1995)***

area in stands greater then 240 years of age, for which the true age is unknown. This suggests the possibility of an over-estimation of stand-replacing disturbance rates in the ESSF, and a resulting under-estimate of the expected proportion of old forests. The present Guidebook estimates should be considered minimum estimates for those subzones.

Disturbance regimes are known to vary through time with climate changes (Johnson et al. 1995) and other influences, thus no single number fully describes the historic regime (Figure 1). This variability is itself an important aspect of natural regimes. In the SBS, SBPS, and ESSFmc there was an apparent period of frequent disturbance in the late 1700's and through much of the 1800's. This was followed by a declining disturbance rate this century, except during the 1920's and 1930's. A similar trend was reported for the SBSmk of the Prince George Forest Region. The ESSFmk and wv subzones do not show similar evidence of major shifts in disturbance frequency.

An important assumption of the methodology is that the probability of a stand-initiating disturbance is independent of forest age. If there is an increasing risk of disturbance with forest age, the mean rate of disturbance will be under-estimated. Most evidence supports the age independence assumption, at least for fire-dominated forests (Delong and Tanner 1996, Johnson and Larsen 1991). This is not true for some major insect outbreaks (e.g., Mountain Pine Beetle). Over the long run it appears that fire patterns obscure the effects of other disturbances, but the interaction of these forces is a poorly understood facet of landscape ecology.

Despite the shortcomings, I suggest that mean disturbance rates based on the negative exponential model are reasonable working estimates and serve to illustrate fundamental differences by subzone. To further refine the estimates would require substantial field sampling to quantify potential age bias in the forest cover mapping, but would not likely change the general outcome.

Application to Ecosystem Management

A basic premise of ecosystem management is that forests are adapted to the natural disturbance regime with which they evolved, and that management should recognize this linkage and that forests are different in different environments.

In the interior portion of the PRFR, the drier and warmer SBS and SBPS subzones have had higher rates and variability of intensive natural disturbance (mostly fire and insect epidemics) then the wetter, cooler, higher elevation ESSFwv/mk subzones. This is reflected in the much higher occurrence today of seral lodgepole pine and aspen stands, with relatively low amounts of coarse woody debris, in the SBSdk and SBPS. Even in these subzones, however, some stands can be expected to reach ages of hundreds of years simply by chance avoidance of severe disturbance (Johnson et. al. 1995). The SBSmc and ESSFmc are intermediate in disturbance frequency and resulting landscape composition.

It is important to understand that a natural disturbance return interval is not equivalent to a harvest rotation age. Natural disturbances occur both in young and old stands, while harvesting occurs only in mature stands. Comparisons of managed versus natural regimes are therefore

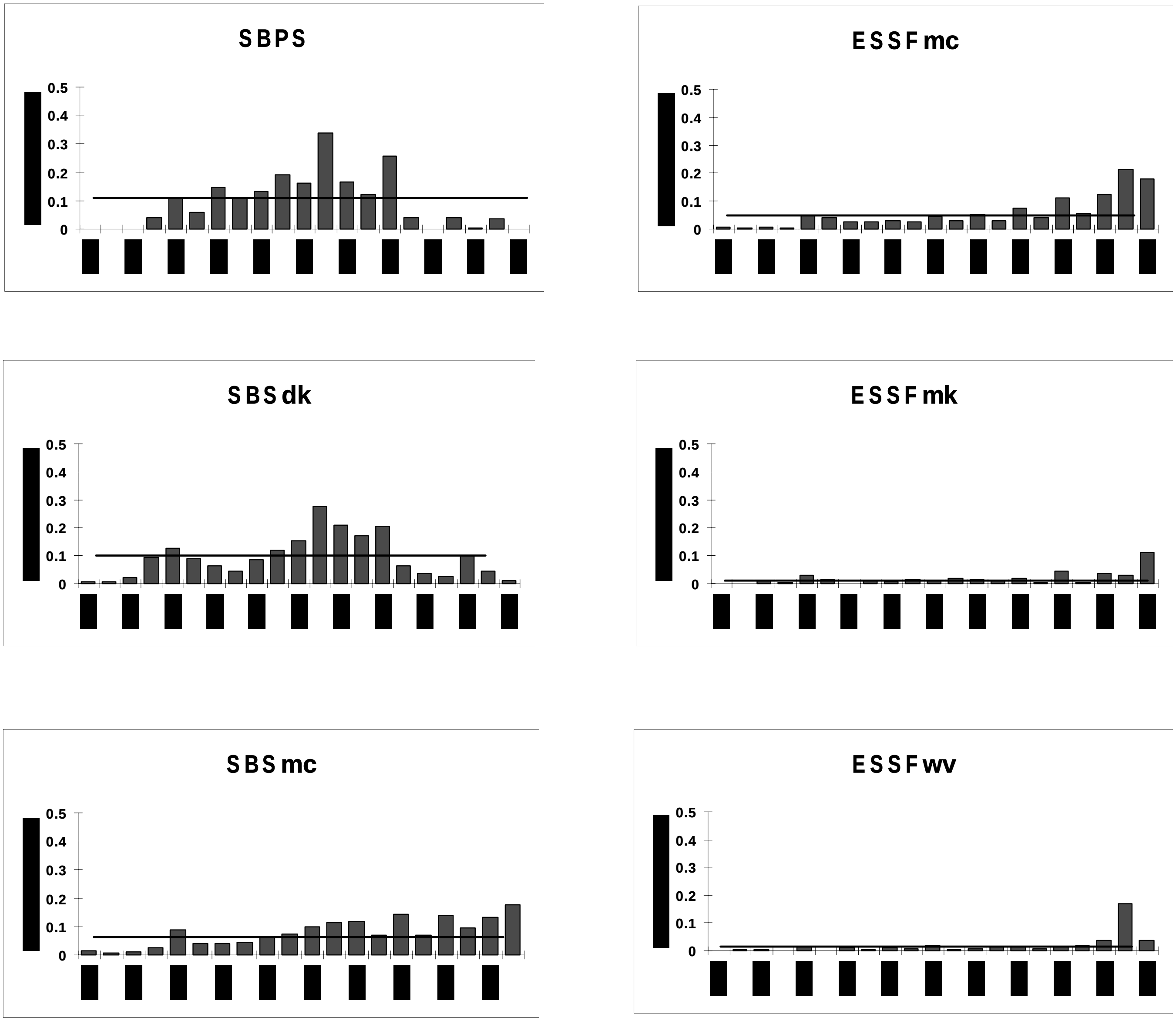

Figure 1. Estimated proportion of subzone disturbed by decade. Horizontal line represents average using truncated age data technique.

most appropriately based on the resulting age distribution of the landscape (*Biodiversity Guidebook;* Burton and Coates 1996), rather than the area disturbed per year or decade.

If approximating natural disturbance regimes is the objective, ESSF forests should be managed for lower rates of disturbance (or greater amounts of old forest) then the SBS or SBPS. This can be accomplished through reserves, extended rotations, or partial cutting (Burton and Coates 1996). While using the full range of silvicultural systems is justified in all subzones, the SBS and SBPS are adapted to greater use of even-aged management, while in the ESSF greater application of partial cutting would better simulate the dominant single tree and patch mortality dynamics.

Other aspects of disturbance regimes such as structural legacies (survivor patches after fire, for example), and the sizes, shapes and spatial distribution of openings are equally important attributes to consider in designing managed disturbance regimes (Coates and Steventon 1994, Delong and Tanner 1996, Wallin et al. 1994). The recent trend towards a very limited range of harvest unit sizes, shapes and spacing is creating landscapes very different from natural patterns.

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