Studying Natural Ecological Processes in the National Parks:
Plant Community Diversity and the Vermilion Burn

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ABSTRACT

Our National Parks afford a great opportunity to study natural ecological processes that are more intensely managed in other jurisdictions. In 1999 a plant community diversity study was undertaken in Vermilion Pass, Kootenay National Park, an area along the Continental Divide that burned in July 1968. This research is a component in a broader mandate - the vegetative composition of the Vermilion Burn in 1999 was compared to the immediate post-fire composition, mapped by Dr. Stuart Harris in 1971.

Hierarchical cluster analysis of a stratified random sample of 217 vegetation plots was used to determine the vegetative composition of 10 distinct plant communities. Indicator species were then used to model the distribution of plant communities throughout the burn against topographic and terrain-related variables.

This research points to the need in Parks management policy to implement a longitudinal fire ecology study, to be performed regularly throughout the duration of a bicentennial fire return interval within the mountain parks. The goals of such a study might include an increased understanding of plant community succession within naturally regenerating burns, the unique possibility parks afford to compare natural regeneration to that found in altered burn areas or replanted clearcuts, or the assessment of changes that fire catalyses in associated plant communities such as avalanche paths.

KEYWORDS: fire ecology, biodiversity, GIS, spatially explicit modeling, longitudinal study

INTRODUCTION

Fire is an essential force shaping the ecological landscape in the subalpine ecoregions of the Canadian Rocky Mountains. The constant revolution of the fire cycle ensures the promotion and maintenance of ecological health and diversity.

Only relatively recently have popular attitudes begun to change, to recognise fire's importance in maintaining ecological balance. This is perhaps why the regeneration of natural plant communities from fire is not well documented or understood. It points to the need for further exploration into the nature of this process (Bailey 1996; Achuff et al. 1984; Harris 1976). Canada's National Parks provide the ideal environment in which to seek a deeper understanding of such natural processes.

This article provides an overview of the 1999 distribution and composition of plant

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communities in Vermilion Pass – the result of natural regeneration in an area that burned in July 1968. The 1999 state of regeneration in the burn is compared to patterns that were identified immediately after the 1968 fire (Harris, 1976), to provide some insight as to how the vegetation of the Vermilion burn is changing over time. More technical aspects of the research are found in Chernoff (2002).

Longitudinal studies of this nature are useful for predicting the effects of prescribed burning, the landscape-dependent variability of regeneration patterns, and the impact of anthropogenic factors on regeneration. The study of processes with little anthropogenic input is a unique opportunity afforded by the existence of parks and protected areas. Such further study is required in order to gain a more coherent understanding of fire and its role in the broader context of forest ecology. Research of this type has implications not only within parks, but also – and arguably especially – in areas where land and resources are developed more intensively, and natural processes are commonly regarded as the benchmark against which the sustainability of land management is measured.

BACKGROUND - THE VERMILION PASS BURN

Vermilion Pass straddles the continental divide, and the border between Kootenay and Banff National Parks (figure 1) as well as the Alberta-British Columbia provincial border. It is situated among the high peaks of the Eastern Main Ranges of the Rocky Mountains, and experiences high precipitation, low temperatures, and a short growing season (Achuff et al. 1984). Its location within the mountain parks assures that regenerative processes are allowed to run their natural course, free from human intervention beyond minor removal of dead material that poses a safety hazard.

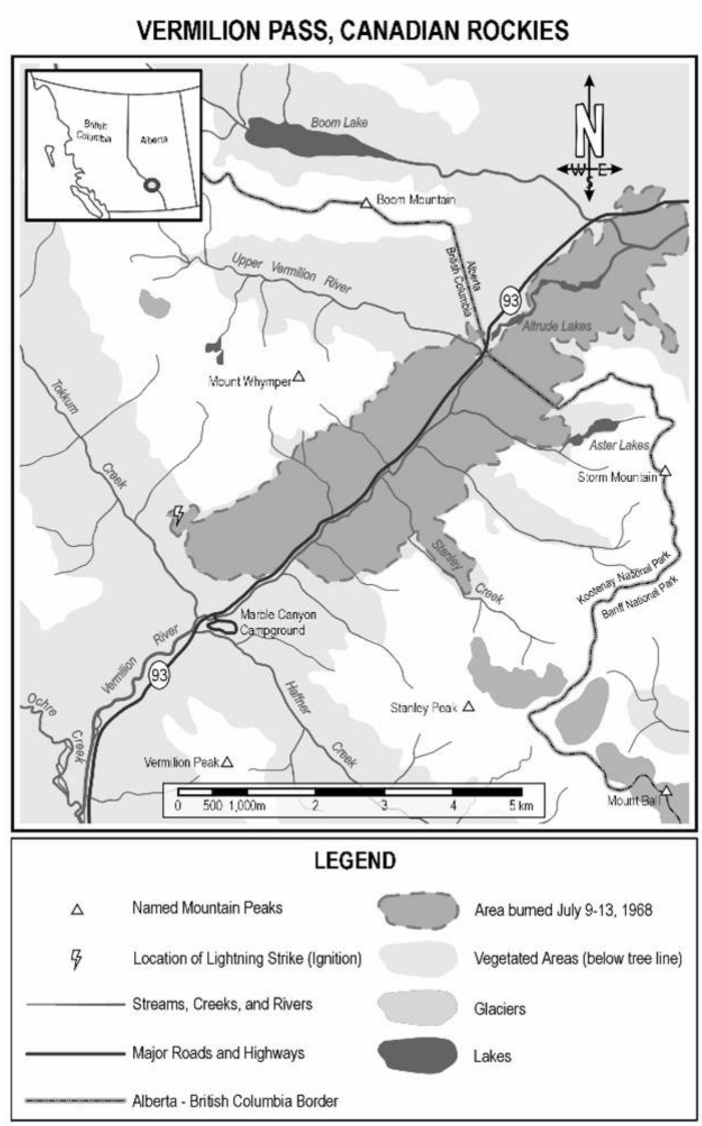

Figure 1: *Vermilion Pass and ignition point/spatial extent of the 1968 burn.*

A dry lightning strike in the Tokkum Creek Valley, on the shoulder of Mount Whymper, ignited the Vermilion Pass Fire on July 9, 1968. Extremely dry fuel conditions coupled with steady wind from the west caused the fire to spread quickly and burn intensely (Personal Communication, Parks Canada Staff (Marble Canyon Campground), 1999). By the time the fire was brought under control on July 13, it had consumed 2430 ha, ranging in elevation from just over 1500m to just under 2400m (figure 1). The

Vermilion burn was the largest recorded in the subalpine ecoregion of Kootenay, Yoho, and Banff National Parks between 1961 and 1985 (Johnson & Miyanishi, 1991). Johnson and Larsen (1991) have demonstrated that climatic conditions are much more significant than forest stand composition or age structure in determining when an area will burn. For this reason, the concept of a “fire return interval” (the time required for a landscape to go through a fire regeneration cycle) can only be regarded as a rough estimate. Johnson & Miyanishi (1991) estimated the fire return interval in Vermilion Pass to be approximately 185 years. In fact, one of the 2003 “North Kootenay” fires, which ignited at the north end of Tokkum Creek, consumed the western end of Vemilion Pass, including large portions of the 1968 burn.

METHODS

During the summer of 1999, vegetation cover was assessed and recorded for 217 randomly selected 10X10m sample plots. This percent cover data was entered into SPSS for hierarchical cluster analysis (after La Roi et al. 1988), which grouped the data set into 10 distinct plant communities (figure 2 and Table 1).

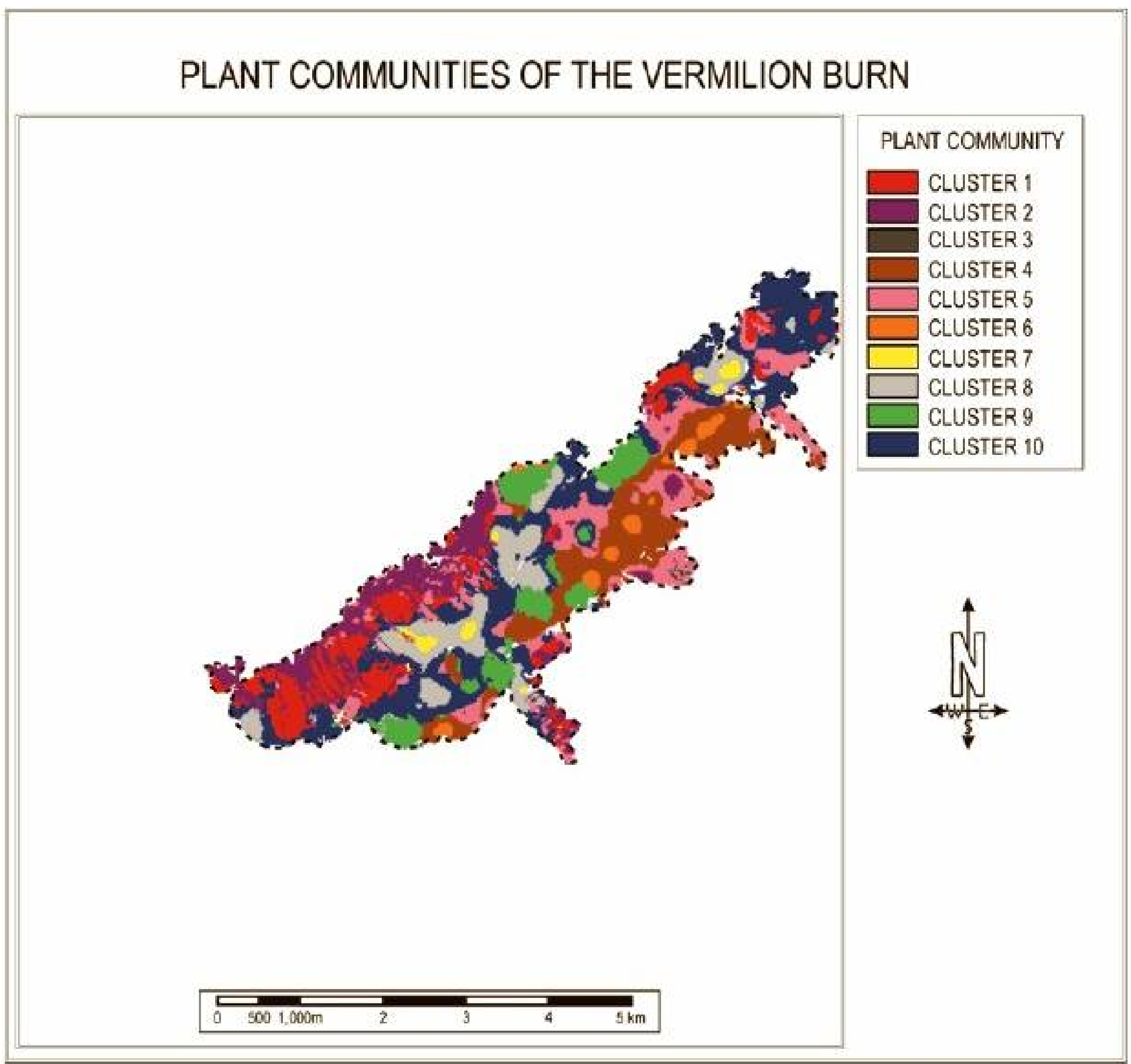

Figure 2: Distribution of plant communities, Vermilion Pass burn, 1999 (see Table 1).

A 1:20,000 scale digital elevation model (DEM) and Satellite Imagery of the study area were used to delineate the burn boundary and to identify other physical features. The DEM was also used to derive ancillary topographic variables (slope, aspect, cross-slope and down-slope curvatures) used to model vegetation distributions (after Peddle & Duguay 1995, and Eyton 1991). A point coverage consisting of sample plot locations was created, and ancillary variable values were spotted for each sample plot.

Three "diagnostic species" – lodgepole pine (*Pinus contorta* Dougl. ex Loud.), rusty menziesia (*Menziesia ferruginea* Sm.), and grouseberry (*Vaccinium scoparium* Leib. ex Coville) – were determined to be most useful in deciding plant community membership. Diagnostic species were selected according to the three criteria of ubiquity, high correlation to ancillary topographic variables, and improved community differentiation. The distribution of each diagnostic species was modeled using a three-stage process (after Lister et al. 2000). First, the species' percent cover values were regressed against highly correlated ancillary variables to get a general regression surface. Next, ordinary kriging interpolation was performed on regression residuals at sample plot locations to generate a continuous residual surface. Finally, the regression surface and the kriged residual surface were combined in an additive overlay.

The final stage of the modeling process was to map the ten plant communities' spatial distributions. This was achieved through a maximum likelihood classification of the study area, using diagnostic species' percent cover distributions as input layers. Figure 2 shows the modeled distribution of the plant communities of the Vermilion burn.

PLANT COMMUNITIES OF THE VERMILION BURN

Table 1 briefly describes each of the ten plant communities of the Vermilion Burn. The numbers beside each plant community correspond with cluster numbers in the legend of figure 2.

Table 1: PLANT COMMUNITIES OF THE VERMILION BURN

Name	General Remarks	Avg. Elev. (Range)	Avg. Slope (Range)	Dominant Vegetation by Stratum*		
				A	B	C
#1 Mount Whymper Open Pine/Buffaloberry	Open pine forest, found mostly on NW side of Vermilion valley, adjacent to avalanche tracks.	1,760m (1,554-2,068)	25^{o} (7-35)	lodgepole pine	russet buffaloberry	downy ryegrass, twinflower
#2 Subalpine Meadows and Avalanche Tracks	Sparsely vegetated areas, mostly on slopes of Mt. Whymper - likely a combination of two distinct plant communities.	1,930m (1,586-2,246)	31^{o} (8-51)	very few trees	heterogeneous assemblage of low-lying, resilient herbs and shrubs	
#3 Storm Mountain Grouseberry	Anomalous and highly localized, found exclusively on S-SE-facing shoulder of Storm Mountain.	2,208m (2,196-2,232)	19^{o} (16-20)	very few trees	juvenile or krummholz conifers	grouseberry**
#4 South Side Open Pine/Menziesia	Open pine-spruce forest, most common on the SE side of Vermilion valley, near Continental Divide.	1,767m (1,590-2,066)	18^{o} (5-34)	lodgepole pine, Engelmann spruce	rusty menziesia	grouseberry, fireweed

Table 1: PLANT COMMUNITIES OF THE VERMILION BURN

#5 Open Pine/Menziesia/ Bunchberry-Grouseberry	Very open pine forest, distributed throughout burn in small patches, frequently at avalanche track termini and in valley bottoms.	1,789m (1,565-2,170)	19^{o} (7-30)	lodgepole pine	rusty menziesia, willow species	Heterogen-eous assemblage of species
#6 Ribbon of Menziesia	Highly localized and anomalous, confined to a narrow band along SE side of Vermilion valley. May be related to localized groundwater resurgence.	1,788m (1,659-1,898)	21^{o} (10-38)	lodgepole pine, Engelmann spruce	rusty menziesia**	grouseberry, fireweed
#7 Dog Hair Pine	Impenetrably dense pine forest, found only in a few isolated patches within the burn.	1,656m (1,570-1,849)	18^{o} (3-28)	lodgepole pine**	russet buffaloberry	twinflower, grouseberry
#8 Bottomlands Dense Pine	Stereotypical regenerating closed pine forest, widespread at lower elevations and in valley bottoms.	1,696m (1,537-1,942)	16^{o} (3-42)	lodgepole pine	rusty menziesia, russet buffaloberry, juvenile Engelmann spruce	grouseberry, twinflower, Canadian bunchberry, fireweed, heartleaf arnica
#9 Midslope Closed Pine/Menziesia	Closed pine forest with a very homogeneous understory, found at middle elevations throughout the burn.	1,735m (1,673-1,847)	15^{o} (10-19)	lodgepole pine	rusty menziesia	grouseberry
#10 Closed Pine/ Buffaloberry/Grouse-berry-Twinflower	Closed pine forest, most common of all plant communities, widespread at middle elevations throughout the burn.	1,678m (1,549-1,903)	15^{o} (1-34)	lodgepole pine	russet buffaloberry	grouseberry, twinflower

** plant species' common names from Integrated Taxonomic Information System (ITIS*ca). Scientific names have been omitted to conserve space.*

*** denotes plant species that are overwhelmingly dominant in a given plant community.*

LONGITUDINAL MONITORING OF THE VERMILION BURN

The research described here provides the second “time slice” in what was envisioned as a longitudinal monitoring project to record the vegetative conditions within the Vermilion burn at regular intervals throughout a complete fire cycle. This would improve the understanding of the spatial and temporal dynamics of vegetation communities regenerating from fire. The 1999 distribution and composition of plant communities in Vermilion Pass is compared to that found in 1972, as reported by Harris (1976).

The areas of highest lodgepole pine seedling recruitment in 1972 had become some of the most densely covered areas by 1999. Some new high-density areas had appeared, particularly on the slopes of Mount Whymper, at the mouth of the Stanley Glacier hanging valley, and at the far southwest end of the burn. Spruce and Fir seedlings were scarce in 1972, and confined to areas immediately adjacent to the burn boundary or to patches of mature forest. By 1999, these tree species were nearly ubiquitous within the burn. The densest concentrations of spruce and fir were located east and just west of the divide.

In 1972, most of the Vermilion burn was dominated in the shrub layer by rusty menziesia, with the exceptions of three areas: the “avalanche complex” on the slopes of Mount Whymper, some unvegetated areas at high altitudes, and a diverse assemblage of shrubs at the northeast end of the burn. By 1999 shrubs had re-established in all areas, and species richness had increased. There were 2 more shrub species identified in 1999 than in

1972 – 17 species in total. Dominance patterns also changed. While rusty menziesia was still dominant over large areas (especially on the southeast side of the Vermilion Valley), russet buffaloberry became dominant over much of the northwest side of the valley, and co-dominant with rusty menziesia in the valley bottom. Russet buffaloberry and willow species co-dominated avalanche tracks, and juvenile or krummholz limber pine (*Pinus flexilis* James) and subalpine larch (*Larix lyallii* Parl.) dominated the Storm Mountain grouseberry plant community.

Figures 3 and 4 illustrate the change in dominance patterns in the herbaceous layer over the three decades.

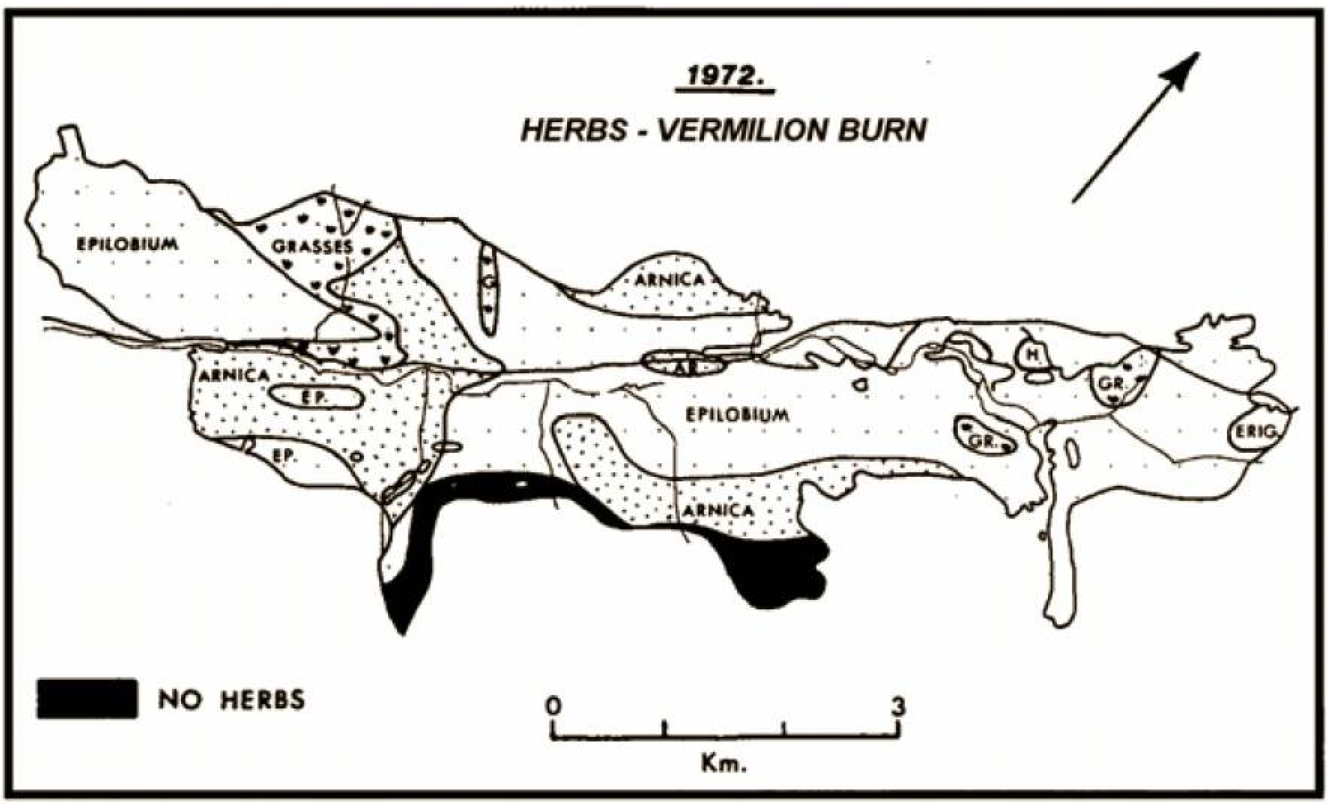

Figure 3: 1972 map showing post-fire distribution of dominant herb species in the Vermilion burn. Source: Harris, 1976.

In 1972, Harris (1976) refers to a “major battle for dominance” in the herbaceous layer between fireweed and heartleaf arnica. Other dominant herbs included an assemblage of grasses and, in small areas at the northeast end of the burn, aspen fleabane (*Erigeron speciosus* (Lindl.) DC.) and hawkweed (*Hieracium* L.) (figure 3). By 1999, the “battle” had subsided, and species richness increased by 7, so that 62 herbaceous plant species were identified. Grouseberry was by far the most dominant herbaceous plant, sharing dominance with fireweed (sub-dominant on the southeast side of the valley), and most commonly with twinflower and Canadian bunchberry (at low to middle elevations and in valley bottoms). Downy ryegrass and twinflower were co-dominant in the open pine forests on the northwest side of the valley, and the subalpine meadows and avalanche tracks were too heterogeneous to declare any species as dominant.

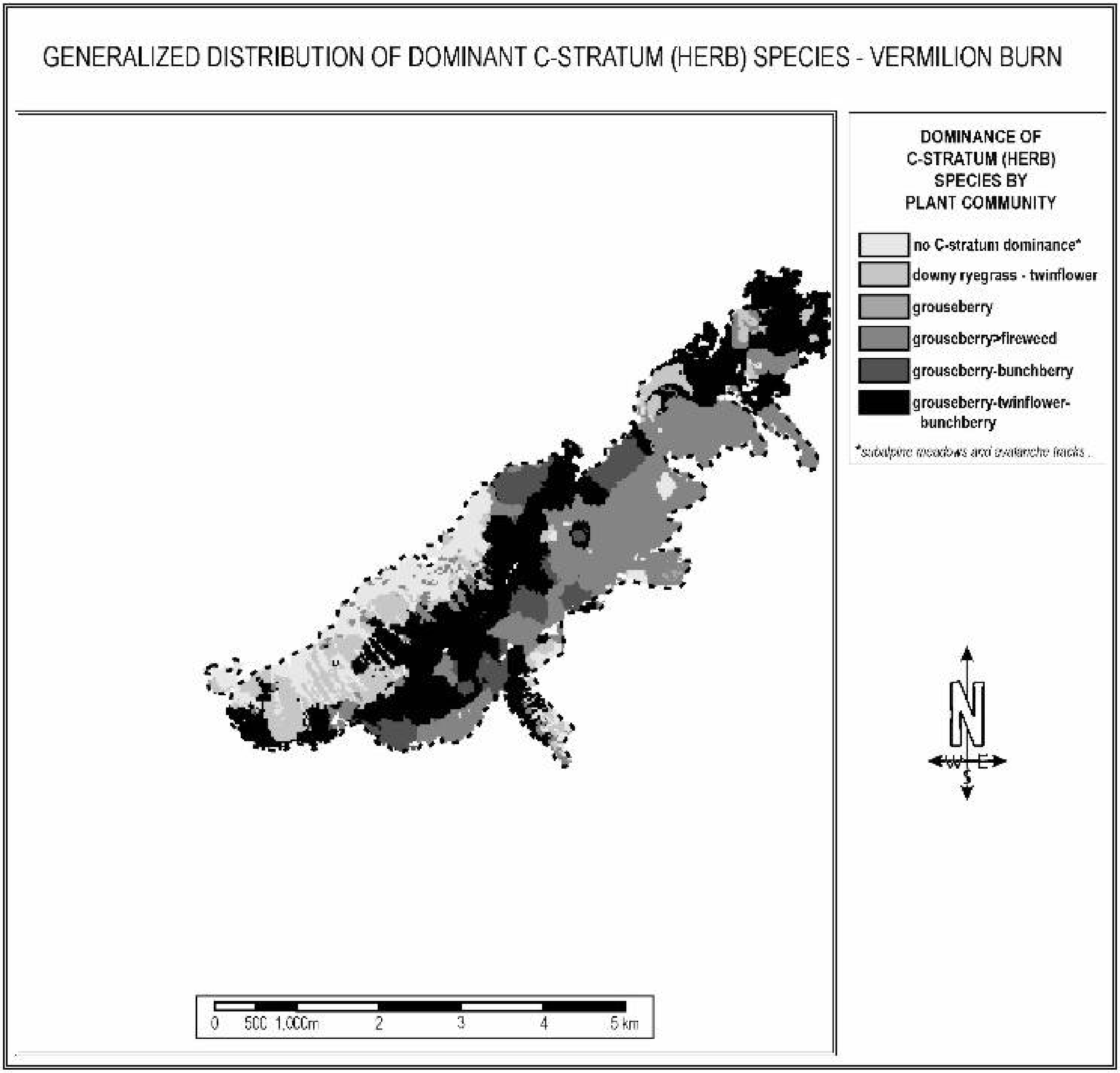

Figure 4: Generalized 1999 distribution of dominant C-stratum (herb) species in the Vermilion burn.

DISCUSSION - RECOMMENDATIONS FOR FUTURE MONITORING

The unique nature of Parks allows this stand to continue to develop without commercial pressure for salvage logging or profit maximization. As was the original intention of the research after the 1968 burn, a similar vegetation study should be performed again around 2030. The regeneration of the Vermilion burn should continue to be regularly monitored throughout the remainder of the current fire cycle. A significant portion of the area that burned in 1968 was untouched by the 2003 North Kootenay fires, and hence remains as a record of continued regeneration in a landscape that last burned four decades ago.

The area which burned in 2003 and which overlaps with the 1968 Vermilion burn would make an interesting subject of study, particularly since an accurate record of the regeneration in the area from the early 1970's exists for comparison. What does the regeneration look like now compared to then? How do we account for any variation in the patterns observed – are they influenced by the biogeography of the landscape that burned in 2003 (young regenerating burn) versus 1968 (mature forest burn)? By the ecological characteristics of the surrounding forest? By changes in climatic conditions or seasonal weather changes? All of these questions present possibilities offered by longitudinal study of this uniquely protected landscape.

Similar studies could be undertaken in other burn areas, prescribed and natural, both in and out of National Parks, so as to determine the variability in regeneration patterns that may be attributed to management strategies, climate, size of burned area, and other locally sensitive natural and anthropogenic factors. Drawing generalizations in such a highly variable landscape as the Canadian Rockies would require careful study site selection and a potentially large number of different studies. Recent advances in the quality of satellite imagery and the technology used to interpret them could greatly improve the efficiency and consistency with which such studies can be performed.

In recent years, the forest industry and government agencies that regulate it have widely adopted a practice of burn emulation (or fire emulation), touting this approach as a more sustainable harvesting strategy that both respects and mimics nature. Given how little is understood about the natural processes of fire regeneration and the factors which influence them most strongly, one can only expect that these complexities are underestimated in current forest management practices. The real and practical need for a deeper understanding of post-fire ecology suggests a significant role for parks and protected areas in addressing this critical gap in our understanding.

Some suggestions for improving the modeling process include incorporation of data on precipitation, microclimate and moisture distribution, soils and geology, wildlife, surrounding forest ecology, and additional topography-related variables that may influence the distribution of plant communities.

CONCLUSION

This study, and its predecessor Harris (1976) are biogeography, in other words the description of the plant communities of the Vermilion burn and the mapping of their distributions. The vegetation maps produced in both provide baseline data, to be interpreted and applied by ecologists, wildlife biologists, land managers, and Parks staff.

An important part of the mission statement of Parks Canada is a commitment to the preservation of ecological integrity, and to ensuring that “(Kootenay National) park’s ecosystems and their component native species and natural processes are free to function and evolve” (Parks Canada, 2000, p.13). While there is an inherent utility accrued from the preservation of these natural processes for their own sakes, there is a further benefit to be gained when we seek to understand and learn from them. To understand processes that function and evolve over time spans that are longer than a human life requires patience, humility, and vision, and a dedication to the continued ideals expressed in management plans of National Parks and similar Protected Areas in Canada and elsewhere.

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