Silviculture and Restoration in NDT 4 Ecosystems

Recommendations to Promote Ecological Integrity

Prepared for
The BC Ministry of Environment
1259 Dalhousie Drive
Kamloops, BC V2C 5Z5

Prepared by Dave Jones and Associates
Kamloops, BC
daveljones@shaw.ca

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"One must learn by doing, for though you think you know it, you can have no certainty until you try." Sophocles (ca. 450BC)

Introduction

The intent of this document is to guide foresters and other land managers in protecting, recovering and managing high priority grasslands, open forests, and associated values. Dry forests and grasslands are collectively referred to as 'Natural Disturbance Type 4' (NDT 4), as they are assumed to share a similar natural disturbance regime that consists of relatively frequent, low intensity fire.

Many scientists and land managers consider NDT 4 forests (forests in the Interior Douglas fir and Ponderosa Pine zones) to be in need of management attention. These forests are potentially outside of their natural range of variability for stand structure and composition, due to suppression of fire in the past century. More frequent fire is expected to have maintained a significantly greater area of the IDF and PP zones as open forest, compared to conditions today. These changes to the forest affect biodiversity, range and timber values, and forest health, as well as creating conditions for high intensity wildfire.

Similarly, managers are concerned regarding the condition and dwindling extent of grasslands. Significant areas of grasslands that remain as Crown land are affected by and lost to tree encroachment. The natural boundary between grassland and forest has always changed with varying climatic conditions over time, but large amounts of tree encroachment onto grasslands this past century is attributed to fire suppression. Encroachment of conifers on grasslands varies across the province and in some areas is very extensive. This loss of grassland area is additional to the large areas permanently lost to agriculture and urbanization. The condition of the remaining grassland areas is another concern, given the widespread negative impacts of invasive plant species, and the potentially negative impacts of poor ranching and recreation practices.

Climate change is another factor to consider in NDT 4 management. Warmer conditions are becoming more prevalent – during the 20^{th} Century, BC's central and southern interior regions warmed by 1.1°C, or twice the global average (BC MWLAP 2002). Assuming this warming trend continues, dry ecosystems will likely expand, and will likely experience more fires related to longer periods of dry, warm weather. With climate change, species will likely migrate northward, and the connectivity and health of dry ecosystems becomes an important consideration.

This document accompanies a longer report entitled: "Addressing Forest Encroachment And Understory In-Growth In NDT 4 Ecosystems in the Southern Interior Forest Region: Short-term Priorities, Information Gaps and Management Recommendations." This longer report describes the current management context for NDT 4 ecosystems, as well as giving management recommendations.

Definition of Open Forest

It is helpful to define what is meant by the terms open forest and grassland. We have crafted definitions for this report based on various sources – no one definition exists in British Columbia, particularly for open forests. A standard, agreed-upon definition would greatly assist restoration/ management planning. The definitions offered here are considered to be starting points.

One definition of open forest is where at least 50% of primary productivity occurs in non-tree species. Based on conditions that will allow at 50% of the site's primary productivity to be produced in the understory, open forest can be defined as:

> **11-20% overstory crown closure, with overstory trees >30 cm dbh arranged in a clumpy distribution and ranging in density from 76 – 150 stems per hectare. Less than 10-20% cover of understory trees, saplings and seedlings.**

Almost all aspects of this definition require further investigation, and more specific management objectives will be required depending on desired understory and overstory conditions. Some definitions of open forest range higher than the above definition, i.e., under the Kootenay Boundary Land Use Plan (KBLUP), open forest densities range from 76 to 400 stems per hectare (sph), with a target density of 150 sph and maximum crown closure of 40%. The tree density target of 150 sph is a reduction from the previous target of 250 sph, and is a result of ungulate winter range guidelines brought into force in early 2005, as well as a 2003 report that evaluated the relationship between timber volume/forage production and crown closure/tree density (Trench Committee 2006). In the East Kootenays, treatments in both open range and open forest emphasize retention of a percentage of the largest trees on site.

Open forests are often expected to provide a balance between timber and forage production. However, the low tree densities that may be required to provide for some understory and habitat values will affect the timber potential of the site. Modeling work done in 2004 suggests that 50% of the timber potential will likely not be achieved at densities below 250 stems per hectare (Klenner 2004).

Management Objectives for Open Forests

Management objectives for NDT 4 forests will vary depending on the values of interest. An example of a general management objective might be:

> **Manage NDT 4 forests to support their ecological integrity, timber values, range values, and to minimize wildfire risk. "Ecological integrity" refers to an ecosystem in which natural ecological processes (e.g. natural disturbance regimes) are sustained and biodiversity is maintained into the future.**

Specific locations or values will have more specific management objectives, and not all values can be accommodated on all sites. Areas near to communities will have the reduction of fire hazard as the key management objective, with other objectives secondary (but often compatible). Likewise, critical habitat for listed species will be key in some areas, and will often require a reduction in stand density that is compatible with some but not necessarily all other values (e.g., timber production and domestic forage objectives may be incompatible). Timber values are compatible with other values to a point: at low stocking densities (e.g., below 250 sph) the quality declines due to large knots in the lower bole.

When based on the estimated range of natural variability, the target stand densities and stand composition will be specific to BEC zones or subzones, and to slope, elevation and aspect. Various studies have been done and are underway (e.g. Blackwell et al 2003 and various studies mentioned in Wong *et al.* 2004) to determine the range of historic (pre-fire suppression) fire frequencies and associated stand characteristics for various zones, site characteristics (e.g. aspect/slope) and areas of the province.

Definition of Grassland

Grassland can be defined as:

> **Sites where grass species (family Gramineae) are the dominant form of plant life, and where tree cover (crown closure) ranges from absent to a maximum of 10%.**

The maximum 10% crown closure in this definition is taken from the Grasslands Conservation Council (2004), who used this number in their grasslands mapping project. This 10% number is also commonly by other jurisdictions as the cut-off point between open habitat and forest. This definition will exclude other kinds of open sites such as wet meadows and rocky terrain.

Management Objectives for Grasslands

A general management objective for grasslands might be the maintenance of a defined area (e.g. grassland benchmark or designated range or management unit) in an open and intact condition, with scattered veteran trees or tree islands as appropriate to the site conditions. Within this defined area, further objectives may include some of the following:

- Minimize % cover of invasive plants, and actively discourage new invasions;
- Maintain a certain percentage of the benchmark or certain management units in a climax (late seral) grassland condition;
- Minimize disturbance and subsequent changes to plant communities caused by overgrazing and poor recreation practices;
- Provide for a designated quantity of forage (animal unit months (AUMs)), to a maximum of 50% of the productivity of the site;
- Provide connectivity between grassland fragments;
- Manage for particular habitat features, species or rare plant communities (e.g. antelope brush).

Individual areas will usually have more specific management objectives, related to the biodiversity and commodity values provided, and the threats to those values.

Silviculture Strategies: Addressing Multiple Values

Silviculture strategies are the primary planning tool for offsetting negative impacts on timber supply, and silviculture strategies can also be used to address habitat supply. In either case, silviculture strategies can be used to direct activities into problem areas within NDT 4 forests and encroached grasslands.

In many areas in NDT 4 forests, Douglas-fir and ponderosa pine regeneration forms dense thickets. These thickets tend to stagnate, as the sites are usually moisture-limited. In this state there is very little height or diameter growth and the risk of insect and disease attack increases, as does the risk of higher-intensity wildfire. Directing silvicultural activities into these types of stands will improve habitats for a variety of wildlife as well as potentially enhancing timber values/supply and forest health. Thinning these dense forest stands can benefit timber supply: one study at Knife Creek (UBC Research Forest) near Williams Lake found growth to be 3.4 m^2/ha per decade in an unregulated stand, compared to an average of 8.3 m^2/ha per decade in thinned stands

Focusing thinning treatments on recruitment Old Growth Management Areas (OGMAs) and species at risk should be a priority. Mule deer winter ranges are also considered a management priority. Many areas within mule deer winter ranges would benefit from commercial or pre-commercial thinning, which would enhance mule deer habitat in the future and potentially provide access to commercial timber. Without such a program it is unlikely that the areas will grow the necessary large trees for snow interception in a timely manner, or produce the forage that mule deer need.

Silviculture Prescriptions: Addressing Open Habitats

Typical silviculture prescriptions can be modified to better sustain open forest and grassland values. In areas designated as grassland 'benchmarks', or in locations where open habitat values are considered important, trees should be harvested with no obligation to restock. Similarly, areas burned by wildfire should not be restocked with trees if the newly burned area will contribute to regional targets for open forest or grassland. In some cases, salvage harvesting should occur in burned sites to minimize the potential damage from a 're-burn'. This can be important, because depending on site conditions, the second burn can be of greater intensity and severity than the first. Also, it may be necessary to manage natural regeneration to densities compatible with open forest conditions.

In areas that are to be managed as open forest, restocking will typically not be necessary. Selection harvesting in these areas will often require different prescriptions from the norm in order to remove the majority of the small stems present. Commercial harvesting should target stems down to 12.5 cm in diameter if at all feasible. (See the next section regarding restoration approaches for open forest.)

Guidance for desired site conditions - e.g. grassland benchmarks and areas to be managed for open forest (outside of the East Kootenays) - will likely come from regional committees that may regroup to address these issues. A grassland benchmark is currently defined in the Cariboo-Chilcotin, though areas to be managed as open forest are not yet defined. In the Thompson-Okanagan, it is expected that 10% of the area classified as NDT 4 will be targeted to be maintained as open grassland or open forest, as an interim measure.

Restoration Approaches for Open Forests and Grasslands

The main activities used to address forest in-fill and grassland encroachment are harvesting, slashing/non-commercial thinning, knockdown, and prescribed burning. Depending on the site in question, one or all of the above activities may be called for. Current Forest Investment Account standards (under which non-commercial restoration activities can be funded) provide general guidance for terrestrial restoration projects of all kinds[1]. The following is an overview of the kinds of restoration techniques employed; site level considerations will always be unique.

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[1] see: http://www.env.gov.bc.ca/wld/fia/terre_treatment_effeval.html for Forest Investment Account standards and related information.

Prescribed Burning

Prescribed burning is carried out on sites that are open enough to control fire risks. When treating mostly open grassland sites suffering from encroachment, prescribed burns will predictably kill only the small seedlings. Mortality will be based on the heat of the burn and typical spring burning will not remove the larger encroachment accumulated over time (Knezevich 2000) – see Figure 1. Individual larger trees may or may not be harmed by the fire and if their removal is desired, manual (or mechanical - see below) treatments will often be necessary. Cattle may have to be removed for one or two seasons to allow sufficient fuel build-up to carry a fire, and for at least one growing season following treatment to minimize weed establishment and to allow the native vegetation to recover. Once treatments are made to remove encroachment on grasslands or in-fill in open forests, timing between follow-up fires could be 10-15 years (Knezevich 2000). These repeated burns will be necessary to maintain open conditions.

For mostly open grassland sites, the unit cost of burning is generally quite low, e.g., $50/hectare. For sites that have been harvested and/or slashed to attain open forest conditions, prescribed understory burning is considerably more complicated and expensive, and may not always be possible if near communities, private holdings or other infrastructure. The management of fuels to prepare for understory burning will vary by site and may require piling and curing or removal of slashed stems, and removal of accumulated fine litter around trees that are retained. Fire scarred trees and snags may require special attention (e.g. surrounding fuel control, fire retardants) in order to persist.

Generally, burns are conducted in the spring. Prescribed burns are lit only when various critical factors come together on the same day. During the six or seven weeks in spring when burning is safest, there may be only three to five suitable weather events, and on particularly poor years there may be none. Understory burning is more complex than grassland burning, as it can only be done during a very limited set of parameters: it has to be dry enough to consume the fine fuels but not too dry that fire intensities will cause tree crown scorching. Even when the indices are right, other factors on the day such as wind speed and direction and temperature and relative humidity can affect the decision to burn (Phil Ranson, personal communication). Experience in the northwestern United States shows that burns can be successfully and safely carried out in the autumn (Rocky Mountain Trench Committee 2006), however fall burns are not typically done in BC. Often the drier ground fuel conditions in autumn will cause greater fire intensities and depth of burn, while in spring there is still good moisture at the sub surface level.

Costs associated with the burn will vary greatly depending on site layout, size, the preparation required to provide secure control lines and the degree of mop-up. Burning must be overseen by a ‘burn boss’ (often associated with the MOFR Protection Program) and done according to a burn plan (Phil Ranson, personal communication).

Photo: Fred Knezevich (Knezevich 2000)

Figure 1: After spring burning. Note that only the small trees were killed.

Photos: Rocky Mountain Forest District

Figure 2: Burning in a sloop is a low-impact way to dispose of the small trees cut during slashing. Sloop-burning produces less smoke and less soil damage than pile-burning slash on the ground. Sloops used in the Trench restoration program are made in the East Kootenay from ore cars once used underground in Kimberley's Sullivan Mine (photos and text from Rocky Mountain Trench Committee 2006).

Knockdown and manual removal of encroachment

Knockdown is a technique recently used to remove encroaching trees from grassland sites in the Cariboo region. Provincial staff have had positive results with this pilot project. The temperature must be –5^{o} C or lower (with night-time temperatures –10^{o} C or lower) for trees greater than 2.5 cm basal diameter to break off using a Caterpillar 966 loader or similar machine with the blade (or replacement tubing) elevated at 15 – 30 cm above ground level (see Figure 3). Speed is important. Various other logistics and equipment are described by Knezevich (2000). Cost-wise, the preliminary results for knockdown compare very favourably against manual removal, as densities and tree species do not significantly affect the cost per unit area. In treating 0.4 hectares (1 acre), machine costs were $15/acre compared to manual labour costs that varied widely based on density, but averaged between from $16.25 to $360 for the same area. The few big trees scattered among smaller encroachment (i.e., bigger than 30 cm diameter) are removed by chainsaw. A prescribed burn is required afterwards to deal with the ground debris, and properly timed (to generate maximal heat) will kill those trees that were not completely severed from their root system, or kill live branches attached to stumps. Some trees may be too small to be killed by knockdown, and too large to be killed with the first fires (before grass fuels build up – which may take five or more years) and the site may need to be mechanically re-treated (Knezevich 2000).

Photo: Fred Knezevich

Figure 3: Typical encroachment at the edge of a tree island.

Photo: Fred Knezevich

Figure 4: Aftermath of trees, post-knockdown. Note how the smaller trees did not break.

Encroaching trees are also removed using chainsaws and brushsaws, and depending on size the trees can be used for Christmas trees. Mechanical control is an effective option for older encroachment. Prescribed fire can prune the lower branches making the trees easier to cut.

Harvesting/Slashing for Open Forest

Traditional selective harvesting removes stems from across all diameter classes, or removes only the larger, higher quality stems. Thinning from below removes mainly the smaller diameter classes, to create more open forest conditions, usually with a remnant stand of larger trees. In some cases this activity is commercial (i.e. where the stems are larger than 12.5 or 17.5 cm in diameter and can be sold to a mill), but there is often a mix of stems including sizes that are non-merchantable. Those are handled differently, i.e., they may be 'slashed' or non-commercially thinned instead. Often, little of the volume to be removed is commercially viable. Depending on volume slashed and subsequent fire risk or prescribed burn planning, stems may be left where they fall, may be piled and cured for later burning (typically the following year), or may be removed from the site altogether. Gray and Blackwell (2000) discuss various fuel management options tested for thinned stands near Squamish, B.C. In these operations, choosing which trees to leave behind is the most important activity, and the leave trees should have good form and vigour.

Photo: Tanis Douglas

Figure 5: Slashpile drying before burning in the East Kootenays

Thinning from below is often discussed as a strategy for mule deer winter range, and the commercial logistics for this kind of activity are discussed in detail by Day *et al.* (2000 and 2003). In general, the economics are marginal due to the low volumes per hectare of small logs.

Once the stands are opened up, open forest conditions will need to be maintained over time, typically by utilizing prescribed fires applied at 10-20 year intervals. After harvesting and slashing activity, multiple fires under conditions that gradually remove fuels may be required.

The series of photographs below depict the steps used to open up a closed forest in a demonstration project overseen by the Ministry of Forests, Cariboo Region in 2002, and are taken from Douglas (2003). The commercial harvesting portion of this project was undertaken by Riverside Forest Products.

Photo: Ordell Steen

Figure 6: Dense, closed Douglas-fir stand pre-treatment. Note the lack of understory vegetation and the mosses.

Photo: Ordell Steen

Figure 7: The same stand post timber harvest, all stem diameters down to 12.5 cm dbh were taken and stand openings were purposely created by the harvest of these small stems, by widening skid trails and by intentional damage to many juvenile stems.

Photo: Ordell Steen

Figure 8: The stand post juvenile thinning. The Ministry used the same contractor that Riverside hired to do the mandatory post-harvest stand slashing, thereby realizing cost efficiencies. The thinning treatment removed stems not likely to have a strong growth response or that weren't likely to form a quality crop tree.

Photo: Ordell Steen

Figure 9: Following thinning, an underburn was conducted on a portion of the area. This was the first of a two-stage burn and was conducted primarily to remove fine fuels and reduce fire hazard. A future burn will be needed to remove larger fuels. On unburned area, the thinning slash was left on-site.

Treatment Costs

Costs vary greatly depending on conditions and the below provides only a very rough estimate based on limited data. Outside of the Trench (East Kootenays), the levels of activity, workforce capacity and techniques are not yet developed enough to have predictable unit costs. It is expected that once more restoration activity ensues, the unit costs will come down. Additionally, when commercial harvest is done, revenues received are not generally put against the cost of the restoration work - in those situations a true accounting is not done.

Any burning near to infrastructure or values at risk will be more expensive. Costs don't typically include the cost of government staff time in prescription development and oversight – the costs below are primarily labour costs.

Treatment Type	**Estimated Cost Range per hectare**		
	Okanagan	Trench	Cariboo
Prescribed grasslands burning	$100-$300	$50 - $100	$50
Prescribed understory burning			$200 - $250
Pile burning		$150 - $225	
Slashing and Thinning (some merchantable volume removed before treatment)	$500-$800		$300
Slashing and thinning without commercial harvest (open forest condition	$2,000-$4,000		
Slashing, and piling (burning)		$150 - $300	$400*
Logging costs			$40 per m3 to truck, logging cost depends on volume per hectare

**estimate for thinning, for a future where a restoration program is underway and various contractors are for hire. Current costs would be much higher*

Adaptive Management Trials/ Effectiveness Monitoring

While some techniques to create or restore open habitat conditions are relatively well known, many questions remain about how best to address the conditions of NDT 4 forests and grasslands. The success of restoration treatments needs to be evaluated against the original objectives, and the results shared and learned from. Adaptive management trials are needed to test and learn from various treatments and to understand their longer-term effects. Adaptive management trials and effectiveness monitoring are already happening on a mostly ad hoc basis, but more of this work is needed, and it needs to be centrally coordinated by regional-level committees (e.g., Cariboo and Thompson-Okanagan). The Rocky Mountain Trench Ecosystem Restoration Steering Committee currently has an effectiveness monitoring plan, and their approach could be used as a starting point for other areas of the province.

For good effectiveness monitoring to happen, restoration objectives must be clearly stated in advance and must be measurable (quantitative). Questions that could be answered or further clarified by effectiveness monitoring/adaptive management trials include the following:

1) Which tree densities/basal areas/crown closures or other (e.g., understory) characteristics are optimal for which specific resource values (e.g., desirable species or habitats, biodiversity or commodity values, reduced fire risk) in open forests?

2) What effect do various treatments have on open habitat-dependant listed species, and other managed species?
3) What effect do various density reduction treatments have on timber values?
4) What effects do various density reduction and burning treatments have on range and forage values (understory response)?
5) What effects do treatments have on the establishment and spread of invasive plants?
6) How can invasive plants be minimized on treatment sites?
7) Which prescribed fire treatments (e.g. timing) or combination of treatments are optimal, under which conditions?
8) What effect do treatments have on fuels and fire risk?
9) What effect do treatments have on forest health (insect/disease presence)?
10) What effect do treatments have on forest stand structure and composition, wildlife trees and coarse woody debris?
11) What effect do treatments have on soils?
12) Which treatment methods are the most ecologically- and cost-effective?
13) Is the restoration program as a whole meeting its goals (e.g. forage, biodiversity and timber targets, area treated annually)?

Effectiveness monitoring is different from implementation monitoring, which involves a mostly qualitative post-treatment assessment to determine if the desired prescription has been achieved. Most treated locations will have only this lower level of monitoring. Effectiveness monitoring is much more resource intensive and will occur only at a small sub-set of treated sites. Good implementation monitoring sets the stage for effectiveness monitoring. Implementation monitoring is particularly critical in correctly evaluating the effectiveness of prescribed burning, as fire and post-fire conditions cannot be predicted based on the prescription.

Monitoring efforts will need to be well documented and communicated to promote adaptive management. Good project tracking will be critical and needs to be done in a centralized manner.

Monitoring should be done across the different biogeoclimatic zones in the NDT 4.

Conclusions

The condition of many forests and grasslands in the NDT 4 zone needs to be addressed, to lower risks to biodiversity, timber, and range values, and to lower the risk of major wildfires. The need to address the condition of these forests may be heightened by climatic changes that increase the likelihood of wildfires and ecosystem stress. With good planning, silviculture and other treatments can address multiple values. In fact, forestry planning and policy, and operational forestry practices are key to improving the condition of NDT 4 ecosystems.

In order to become more cost effective at maintaining and managing open forest conditions, it is imperative that new economic opportunities be found to utilize the smaller diameter products. There may be opportunities for ethanol generation or co-generation projects, or other technologies to use these products. Similarly, forest policy can be changed to develop incentives to encourage the commercial harvest of small trees. The possibility of non-replaceable forest licences or new forest licences to manage some of the conditions currently existing in many of the dry and very dry forest landscapes should be explored. Similarly, the specific designation of a harvesting volume to restoration needs is a promising approach, recently adopted in the East Kootenays.

Regional-level direction is required to determine which areas of the landscape are to be managed as open habitats, and regional coordination is required to plan and prioritize treatments and monitoring. Currently, strategic prioritization frameworks are being developed and tested in the Okanagan and in the Cariboo MOE Regions, and the knowledge gained should be shared and synthesized.

Synergies can be realized with the planning and treatments currently underway to reduce fire risks in 'interface' areas near to communities. Monitoring programs and sharing of this information with other users is critical to improvements in NDT 4 management.

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