R. Schneider

7. Protected Areas

Limitations of the Natural Disturbance Model

The fundamental assumption of the Natural Disturbance Model (NDM) is that biodiversity can be maintained in the presence of industrial use of the forest if industrial practices are made to approximate natural disturbances (Hunter, 1993). In practice, the goal is to maintain forest structures and patterns similar to those produced by fire and succession. However, the NDM has a substantial number of inherent limitations that make the conservation of all species highly improbable under this model. These limitations do not invalidate the NDM, but imply that a complementary system of management, specifically designed to maintain biodiversity, must be implemented on a portion of the land base.

Problems in Defining the NDM Targets.

The first step in the implementation of the NDM is to define operational targets that provide a close approximation to the natural disturbance regime. However, because of the extreme variability in fire occurrence (see Fig. 6.2), and the limited availability of fire-history data, the mean rate of burning cannot be accurately determined for Alberta (Armstrong, 1999). Furthermore, Cumming (2001) has demonstrated that the rate of burning differs among stand types, implying that even if the mean rate of burning were known for the province, it would not be sufficient to predict landscape patterns. The characterization of other forms of natural disturbance is even less developed than for fire. Finally, there are major gaps in our understanding of forest succession, particularly for mixedwood stands which have multiple potential outcomes after disturbance (Lieffers and Beck, 1994).

An alternative approach is to base operational targets on the forest structures and patterns that result from fire, as reflected in forest inventory data and field studies. This approach also has several limitations. In particular, even at large scales (e.g., FMAs) inventory data are influenced by the legacy of large fires (Cumming et al., 1996). The variability introduced by these large but infrequent fires effectively obscures long-term trends. Forest inventories also systematically underestimate the age of older forest stands (Cumming et al., 2000), and the effects of fire suppression and pre-existing industrial use may further confound the determination of the natural patterns. Finally, given that the current inventory represents just a "snapshot" in time, the determination of the range of natural variation over time remains an unresolved issue.

As a consequence of the aforementioned problems, the targets we define for the implementation of the NDM are necessarily coarse and of unknown reliability. Furthermore, because the targets are based on a very limited number of attributes (i.e., those that are amenable to measurement), they provide only a partial characterization of forest structure and pattern. Ecological processes are for the most part represented only indirectly, and disturbances other than fire are generally ignored. The implication of these limitations is that natural patterns and processes cannot be truly emulated — a target that cannot be defined cannot be achieved. This represents a risk that the NDM will not be successful in realizing its goal of maintaining biodiversity.

Differences between the NDM and Fire

Our ability to emulate natural patterns and processes under the NDM is further limited by a number of fundamental differences between fire and industrial use of the forest. Foremost among these differences is the road infrastructure that by necessity accompanies industrial operations (Fig. 7.1). Roads result in habitat loss, reduced habitat effectiveness through fragmentation, altered permeability of the landscape to animal movement, negative impacts on aquatic systems, and increased human access (resulting in increased

Fig. 7.1. Forestry access road (Photo: Al-Pac)

hunting and poaching) (Reed et al., 1996; Trombulak and Frissell, 2000). Other linear disturbances, such as seismic lines, pipeline corridors, and power transmission lines add to the fragmentation and access problems resulting from roads (see Chapter 4). None of these linear disturbances has a natural analogue in fire or any other natural disturbance.

Another key difference between fire and forest harvesting is that most burning occurs in infrequent large fires associated with “fire years”, whereas sustainable mill operation requires a relatively constant flow of timber from year to year (Armstrong et al., 1999). Furthermore, harvesting operations target only merchantable stands, whereas fire affects all forest types (Armstrong et al., 1999). Consequently, the landscape patterns produced by fire and harvesting are fundamentally different.

Several additional differences between fire and forestry operations are apparent at the stand scale. Forest harvesting, by definition, involves the removal of most trees from a harvest block, whereas fire generally kills trees but leaves them in place. Even when attempts are made during harvest to leave residual trees on the site, the amount of structure left is only a fraction of what generally remains after fire. Furthermore, residual live trees do not have the same ecological function as charred dead trees (e.g., Murphy and Lehnhausen, 1998). The removal of trees from a site can also result in cumulative nutrient depletion (Xu et al., 1999). Erosion, soil compaction, and site preparation (e.g., ploughing) are additional byproducts of forestry operations that differ from fire (Keenan and Kimmins, 1993). Finally, regeneration techniques, even under mixedwood management (Lieffers and Beck, 1994), remain focussed on speeding the regeneration of conifers over rates that would occur naturally.

Each of the aforementioned differences between fire and industrial use of the forest represents a violation of the fundamental assumption of the NDM. This constitutes further risk that the NDM will not be successful in realizing its goal of maintaining biodiversity.

Problems in Implementation

Additional difficulties in the emulation of natural processes and patterns relate to limitations in our ability to implement the planning and practices necessary to realize NDM targets. Economic constraints, in particular, play an important role in determining the extent to which companies can and will implement practices in support of the NDM. Several key elements of the NDM, such as the retention of merchantable old-growth stands and the retention of residual trees on cutblocks, decrease the volume of timber available for harvest (Armstrong et al., 1999). For companies with limited flexibility in wood supply (i.e., most coniferous-based operations) a reduction in annual allowable cut may translate into reduced economic return. As a consequence, few companies are likely to completely implement the NDM unless required to do so.

There are also a number of logistical and technical constraints that impede the implementation of the NDM. For example, the scheduling of stands for harvest must be planned far into the future so that uncommon stand types and age classes are not periodically lost from the landscape and so that natural spatial patterns are maintained. At large spatial scales such planning can only be done with computer models; however, the harvest planning models currently in use (e.g., GIS-FORMAN, Stanley, Woodstock) cannot incorporate ecological outcomes into the modelling process. Furthermore, these models also fail to incorporate the impacts of wildfire, and they utilize simplistic assumptions concerning forest regeneration and succession.

Given that the petroleum industry annually disturbs an area of forest similar to that of the forestry industry (see Chapter 4) it will be impossible to achieve NDM landscape targets unless petroleum industry activities are integrated into the NDM planning process. However, petroleum companies plan on very short time scales (months to years) and at small spatial scales (most leases are less than a township in size). Furthermore, there are currently no legislated requirements for maintaining natural landscape patterns and no limits on the cumulative impact of their activities (see Chapter 4). Consequently, getting the petroleum sector involved in long-term landscape-scale planning, with new limits on exploration and extraction activities, is likely to be problematic and presents a serious barrier to the successful implementation of the NDM.

Past and present government policy presents another barrier to the implementation of the NDM. Almost all of the merchantable forest has been allocated on the basis of sustained-yield management (AEP, 1996a: 17), and annual allowable cut rates and operating regulations continue to be based on this approach. Furthermore, losses of timber due to fire and the activities of the petroleum sector are still not being accounted for. As a consequence, there remains little flexibility in the existing system for reducing harvest levels under the NDM. A large-scale reallocation of the timber supply on a combined deciduous/coniferous land base could provide much of the required flexibility (Cumming and Armstrong, 1999), but there is no indication that the government is willing to implement such changes.

The above limitations in our ability to implement the NDM (among others that were not specifically mentioned) make it unlikely that NDM targets can be achieved, however they are defined. This constitutes additional risk that the NDM will not be successful in maintaining biodiversity.

Roles of Protected Areas

Maintenance of Biodiversity

Given the aforementioned limitations of the NDM, and the inherent unpredictability of natural systems, a complete reliance on the NDM to maintain biodiversity would entail substantial risk and would violate the Precautionary Principle, as described in the Alberta Forest Conservation Strategy (AFCSSC, 1997: 4):

> *Caution will be exercised when the consequences of actions in the forest are uncertain. Where there is a threat of serious or irreversible damage to any forest ecosystem, lack of full scientific certainty will not be used as a reason for failing to implement appropriate ecological measures to avert the threatened damage.*

The limitations of the NDM do not invalidate its use, but imply that a complementary system of management, specifically designed to maintain biodiversity, must be implemented on a portion of the land base (Noss, 1992). This is the primary role of protected areas (EC, 1995: 22). A system of protected areas designed and managed to maintain ecological integrity can provide a refuge for populations that are adversely affected by industrial activities and a source for repopulation of the industrial land base once deleterious operations are identified and changed (Noss, 1992).

Ecological Benchmarks

Protected areas also serve as ecological benchmarks in support of adaptive management, another integral component of Ecological Forest Management (Walters and Holling, 1990; Gunderson, 1999). Under adaptive management, operational plans are considered to be experiments, not fixed expectations. Central to this approach is an ongoing evaluation of whether the system is responding as predicted, and whether desired management outcomes are being achieved (AFMSC, 1997: 11). Using this feedback, adjustments can be made to assumptions, models, and operating practices in an effort to rectify any observed deviations.

As with any experimental approach, adaptive management requires reference areas (controls) to provide a contrast to the experimental treatments (i.e., industrial practices) that are applied to the forest landscape (AFCSSC, 1997: 9). Without effective controls it would not be possible to determine whether observed changes were due to industrial activities, natural local fluctuations, or external influences such as climate change (Arcese and Sinclair, 1997). Protected areas, acting as ecological benchmarks in which natural processes are maintained, are able to act as such controls, and this constitutes a second major role for these areas (Sinclair, 1998).

Ecological benchmarks are primarily required for the detection of changes at the landscape and regional scales. The issues of concern include most of the limitations of the NDM listed previously (e.g., the impact of fragmentation, access, representation of old growth, etc.). Evaluation efforts should include the monitoring of forest structure and pattern as well as selected indicators of biodiversity and ecological processes (Schneider, 1997). Indicators should facilitate the evaluation of the cumulative effects of industrial activities as this is a key role for benchmarks (AFMSC, 1997: 11). For stand-level issues (e.g., regeneration rates, coarse woody debris, etc.), ecological benchmarks would provide important information on the interaction between landscape-level effects and stand-level processes. Small permanent sample plots imbedded in the industrial land base would also be useful for stand-level monitoring because they can be easily replicated and spatially matched to specific management areas.

Although the adaptive management approach significantly augments the ability of the NDM to achieve its objectives, it should not be expected that it will resolve all problems that occur as a consequence of industrial activities. A variety of barriers typically hamper the successful application of adaptive management, including the complexity of the natural systems being managed, time lags between cause and effect, economic and logistical constraints, and institutional and political factors (Walters, 1997). In a review of 25 adaptive management initiatives, Walters (1997) found that 18 did not proceed beyond the initial planning stages, and most of the others were inadequately planned.

Conservation of Wilderness

Although the public clearly understands and appreciates the economic benefits flowing from Canada's forests, this is not what they feel is most important to them when presented with a direct comparison of benefits (Corporate Research Associates, 1997: 8). Canadians are most likely to value forests for ecological benefits (such as protecting water, air and soil), providing habitat for wildlife, and wilderness preservation (Fig. 7.2). When surveyed, 77% of Albertans expressed an interest in participating in outdoor activities in natural areas (EC, 1999: 41), 58% favoured curtailing access of resource companies to wilderness lands (Angus Reid Group, 1994), and 93% thought it important to protect examples of the full range of Alberta's landscapes and wildlife by setting aside wildland areas where there is no industrial activity (Dunvegan Group Ltd., 1994). The public demand for the preservation of wilderness, which by definition implies the prohibition of industrial activities and associated road-building, constitutes a third role for protected areas in northern Alberta.

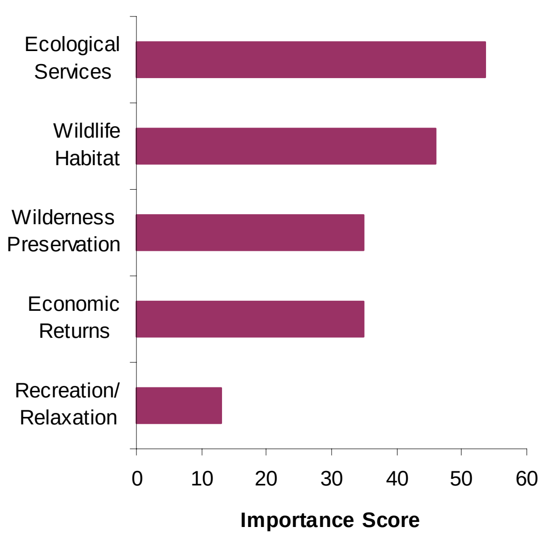

Fig. 7.2. Importance of forest values held by Canadians in 1997. Scores range from 0 (least important) to 100 (most important). Source: Corporate Research Associates, 1997: 36.

Research

Although there has been a substantial increase in research on boreal systems over the past decade, our knowledge of forest ecosystems remains little more than rudimentary. Much study, over an extended period of time, will be required before we can claim to understand the processes that we are attempting to emulate with the NDM. Unfortunately, as the natural landscape becomes fragmented and modified by road building and resource extraction, it will become progressively more difficult to find study areas in which to investigate natural processes. Consequently, protected areas will take on an increasingly important role as study areas for future research initiatives. In the words of Maser (1990), "Natural areas are the parts catalogs and the maintenance manuals not only for that which *is*, but also for that which can *be*."

Design Considerations

Representation

Protected areas maintain biodiversity by maintaining the habitat and ecosystem processes that species require for their existence (Noss, 1992). However, the habitat requirements of most species are not known (in fact, most species have not even been described). For this reason, among others, a species by species approach to habitat conservation is unworkable (Franklin, 1993). The alternative, termed the "coarse-filter" approach, attempts to meet the habitat requirements of the majority of species by ensuring that the full spectrum of ecosystem types is represented within the system of protected areas (Noss, 1992; Kavanagh and Iacobelli, 1995: 10).

The distribution of major ecosystem types in Alberta is provided by the Natural Regions and

Subregions classification developed by the provincial government (see Fig. 1.6). This system of classification delineates ecosystems on the basis of differences in geology, landforms, soils, hydrology, climate, and dominant vegetation patterns (AEP, 1994a: 2). For a system of protected areas to be fully representative, protected areas should be established within each Natural Subregion (AEP, 1994b: 2).

In addition to broad-scale representation, protected areas need to provide representation of smaller-scale landscape features (e.g., riparian zones, bogs, etc.). A report produced as part of the Special Places 2000 initiative identifies the key landscape features that should be considered and summarizes (by Natural Subregion) the area of each that is represented in existing protected areas (AEP, 1994b: 26).

Representation is also a factor in the selection of areas to be used as ecological benchmarks (AFMSC, 1997: 11). To provide the greatest statistical power in detecting changes due to industrial practices, benchmark areas should be matched to major resource management units (e.g., FMAs) in terms of ecological composition and spatial proximity.

Ecological Integrity

Representation of ecosystems and landscape features is only the first step in protected area design. Representation alone cannot ensure that natural processes will be maintained or that native species will survive (Noss, 1995: 6). Thus, a complementary goal to adequate representation is the maintenance of ecological integrity. Ecological integrity is defined as the degree to which all ecosystem components and their interactions are represented and functioning (Quigley et al., 1996: 29).

A fundamental requirement for the maintenance of ecological integrity within protected areas is the maintenance of disturbance-renewal cycles (Noss, 1992). Fire is the dominant disturbance agent in the boreal forest and is responsible for much of the structure, pattern, and ultimately biodiversity, present in boreal landscapes (see Chapter 6). It follows that a key design consideration for protected areas in northern Alberta is the maintenance of a natural fire regime.

Several researchers have suggested that protected areas must be substantially larger than the largest disturbance for the natural fire regime to be maintained (Pickett and Thompson, 1978; White, 1987; Baker, 1992). In a computer simulation study using historical fire data from northern Alberta I determined that protected areas of 5000 km^2 had a high probability of maintaining stable rates of burning, with full representation of the natural range of fire sizes (Schneider, 2000). The implication is that all forest age classes and patch sizes will continue to be represented (though not necessarily in a steady state). In contrast, burning in protected areas of 500 km^2 was highly variable, generally resulting in either inadequate or excessive amounts of burning relative to what is required to maintain full representation of forest age classes and patch sizes over ecologically relevant periods of time (Schneider, 2000). These findings imply that in northern Alberta protected areas approaching or exceeding 5000 km^2 are required for maintaining fire regimes and, by extension, ecological integrity.

Limiting the use of fire suppression within protected areas and implementing prescriptive burns would help ensure that fires continue to be represented within protected areas (Richards et al., 1999). Buffer zones around the protected areas could be used to prevent fires from burning into the surrounding commercial forest. The restriction of fire suppression may not be possible during periods of extreme weather conditions, because of the risks associated with large uncontrollable fires. However, this caveat may ultimately not be of great importance, given the limited effectiveness of fire suppression when conditions are extreme (Johnson et al., 1998).

Other natural processes, such as nutrient cycling, forest succession, hydrological cycles, and so on, can be maintained within protected areas simply by limiting human interference. This can be achieved by (1) prohibiting industrial activities and the development of new access routes, (2) placing limits on motorized activities, and (3) design that incorporates a large core area and a buffer zone (Noss, 1992). Hunting and trapping of game species need not be prohibited if the viability and ecological role of all species can be maintained through careful regulation. The acceptability of hunting and trapping must be determined on a species by species and site by site basis (Kavanagh and Iacobelli, 1995: 20). Boundaries must be permanent (i.e., legislated) to ensure that natural processes are maintained indefinitely (Kavanagh and Iacobelli, 1995: 21).

Connectivity

The boreal forest is structured as a mosaic of patches that differ in vegetation type, age, size, and other attributes (see Chapter 6). Consequently, for most species the landscape is comprised of islands of optimal habitat within a matrix of suboptimal or unsuitable habitat (Knight and Morris, 1996). The spatial distribution of these islands is different for each species, reflecting the unique habitat requirements of each (Fig. 7.3). For species with small home ranges, movement among habitat islands is necessary for basic population processes such as juvenile dispersal and mating. For species that are more mobile, movement among patches is a common part of foraging behaviour (Taylor et al., 1993). Connectivity among patches will be highest within protected areas because they are designed to maintain natural patterns and processes and have few human-made barriers to movement.

There is a general consensus among researchers that populations of a few thousand individuals are required for the long-term viability of most species, and even more for species that exhibit wide fluctuations in population size (Soule, 1987; Thomas, 1990; Nunney and Campbell, 1993). This is because small isolated populations are prone to the loss of genetic variability and to extreme fluctuations in size, both of which increase the probability of extinction (Gilpin, 1987). Protected areas that are designed to maintain ecologi-

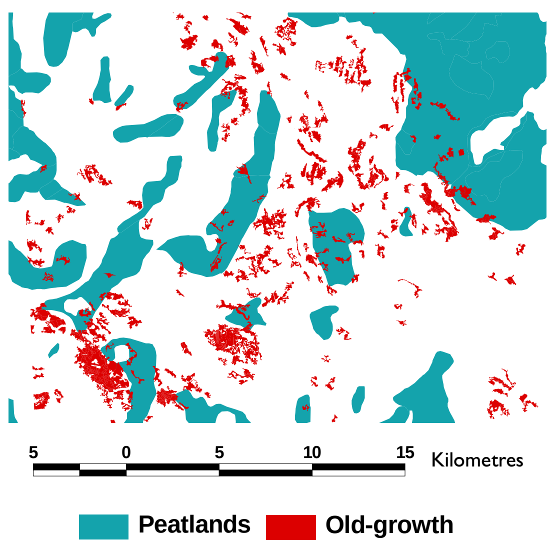

Fig. 7.3. Distribution of patches of peat and forest greater than 100 years in a 625 km^2 region north of Lac la Biche. (Map: Forest Watch Alberta)

cal integrity (i.e., several thousand square kilometres in size) should be capable of providing both the habitat and connectivity needs of viable populations of most native species in a given Natural Subregion (even if habitat availability is altered by large disturbances). The alternative approach of establishing several smaller protected areas is less preferable to a single large protected area per Subregion, even if the area and habitat representation are equal, because it implies greater reliance on the industrial landscape for connectivity.

Some species have such large area requirements that viable populations cannot be achieved in individual protected areas, even if they are several thousand square kilometres in size (Table 7.1). Many of these wide-ranging species have important ecological roles and their presence is critical for maintaining ecological integrity (Noss et al., 1996). Consequently, a system of protected areas must be designed to facilitate the movement of individuals among sites so that viable populations of all species can be achieved in the system as a whole (Noss, 1992). Connectivity among protected areas is also required to facilitate the movement of species in response to climate change (see below).

Facilitating the movement of individuals among protected areas is difficult in a boreal setting because of the vast distances involved. Assuming that an emphasis is placed on establish-

Table 7.1. Estimated area required for 1000 individuals of wide-ranging boreal species.

Species	Density/Home Range (km^2)[1]	Area for 1000 Individuals (km^2)[2]	Source[3]
Marten	2.3 (HR: females)	1150	Powell, 1994
Pileated woodpecker	4.1 (HR: pair)	2050	Bull and Holthausen, 1993
Black bear	7.5 (HR: females)	3750	Fuller and Keith, 1980a
Moose	4.0 (D)	4000	Schneider and Wasel, 2000
Great-horned owl	9-16 (D)	12,500	Rusch et al., 1972
Fisher	27.8 (HR: females)	13,900	Pinsonneault et al., 1997
Goshawk	15-50 (HR: pair)	16,250	Schaffer et al., 1996
Lynx	3.3-33.3 (D)	18,300	Poole, 1994
Grizzly bear	33-50 (D)	41,500	Mace and Waller, 1997
Wolverine	105 (HR: females)	52,500	Whitman et al., 1986
Wolf	90-158 (D)	124,000	Fuller and Keith, 1980b
Caribou	711 (HR)	several thousand[4]	Stuart-Smith et al., 1997

[1]Density (D) listed if available (animals per km^2), otherwise home range (HR) is listed (total area, in km^2).
[2]Area = Density*1000. For species for which density is unknown a crude estimate of the area is calculated as: Mean Home Range/2*1000 (assuming that female territories cover the entire landscape, without overlap, and that the number of males is equal to the number of females).
[3]Data from Alberta, unless unavailable.
[4]Because caribou exist in herds their density cannot be determined from home range estimates.

ing large protected areas (to maintain ecological integrity) and that sites are located in different Natural Subregions (to attain adequate representation) the minimum distance between major sites will be on the order of 100 km, with the exception of sites adjacent to Wood Buffalo National Park. Furthermore, dispersal patterns will be not be dictated by the location of the nearest protected area (which will be unknown to individuals) but by local habitat availability. Therefore, movement between sites will generally not occur in a single episode, but over a period of years, even for wide-ranging species (Harrison, 1992).

To facilitate movement between sites, special management of the intervening landscape will be required (Noss, 1992). Animals will have to reside in these special management zones for extended periods; therefore, the zones will need to provide high-quality habitat and be wide enough to fully accommodate the territory size requirements of wide-ranging species (i.e., many kilometres) (Harrison, 1992). Barriers to movement must be minimized by setting low thresholds for road density, prohibiting intensive forestry operations, and the use of low-impact practices by the petroleum industry. The rate of forest harvesting must be relatively low and operations must strictly adhere to the NDM. Initially, the special management zones will differ little from the surrounding landscape and, therefore, will receive little preferential use. However, their effectiveness as movement corridors will steadily increase as the cumulative impact of industrial use of the surrounding landscape increases.

Ecological Benchmark Areas

In addition to their role in maintaining biodiversity, sites designed according the aforementioned criteria will also effectively serve as ecological benchmarks. The maintenance of natural ecological processes in these areas will provide an appropriate contrast to changes observed on the industrial land base (Sinclair, 1998). Furthermore, the sites will be large enough to provide statistically robust measurements of biodiversity indicators, including those applicable to large-scale phenomena (e.g., cumulative impacts).

An additional design consideration for ecological benchmarks is location. Benchmark areas should be located as near to major regions of industrial activity as possible and should include upland forests that are the focus of forest industry activities, while maintaining representation of Natural Subregions.

It is sometimes argued that the lack of truly pristine areas in northern Alberta invalidates the benchmark concept. However, benchmark areas that have had some human impact will still provide a very strong contrast with the industrial land base, which is ultimately what determines their usefulness. This contrast will increase as industrial impacts accumulate over time and will be critical for providing early warning of problems associated with industrial activities (Sinclair, 1998).

Climate Change

Recent climate models predict that the western Canadian interior will warm by several degrees as a consequence of increased levels of CO_2 and other greenhouse gases (Hogg and Hurdle, 1995). The increased CO_2 and temperature are expected to increase forest productivity, lengthen growing seasons, alter disturbance regimes, and change patterns of precipitation (Burton and Cumming, 1995; Hogg and Hurdle, 1995). As a consequence of these changes vegetation patterns within protected areas may change and animal species may need to shift their range in order to maintain viability (Graham, 1988).

To accommodate the potential impacts of climate change, the system of protected areas should be designed to maximize the diversity of landforms, ensure broad geographic representation, and incorporate redundancy (Halpin, 1997). In this way individual sites will always be able to maintain a diverse mix of species, even if the composition of habitat and the distribution of species changes over time (Halpin, 1997). It is essential that connectivity among protected areas be maintained so that species are able to track their preferred habitat (Graham, 1988).

Implementation

In the following sections I develop a framework for a system of protected areas in northern Alberta designed to help maintain biodiversity and function as ecological benchmarks. Although the proposed protected areas will help preserve wilderness in northern Alberta, public demand for wilderness preservation is difficult to quantify and, therefore, is not explicitly incorporated in the framework. Public demand for additional preservation of wilderness may arise in future years.

Existing Protected Areas

In 2001, the Special Places 2000 program, that was intended to complete the protected area system in Alberta, was concluded (AEP, 1995). Unfortunately, the selection of sites was based almost entirely on the representation of landscape features and the minimization of conflict with existing industrial users (AEP, 1994b: 2). Neither the maintenance of ecological integrity, the connectivity needs of wide-ranging species, nor the role of protected areas as benchmarks were utilized as design criteria. Despite acknowledgement by Alberta Environment that: "*large wilderness areas in the order of 4000 km^2 and larger are recommended for complete biodiversity and wilderness protection*" (AEP, 1994b: 2), only one site of this size was established (the Caribou Mountain Wildland). Finally, existing industrial dispositions were maintained in the new parks, making it questionable whether these sites are protected in any real sense.

With the conclusion of Special Places 2000, 12.8% of Alberta is now under some form of protection (Fig. 7.4). In northern Alberta, 14.0% is protected. However, these figures belie an significant imbalance in representation. Most of the area protected is in the Rocky Mountain parks and in Wood Buffalo National Park (WBNP). Many of the other Natural Regions are not adequately represented in the system (Fig. 7.5). Furthermore, very little of the area protected is representative of the merchantable forest that has been allocated to the forest industry. Finally, most of the parks in northern Alberta are not large enough to adequately maintain ecological integrity (Fig. 7.6).

Establishment of Core Protected Areas

Additional large core reserves distributed among the Natural Subregions of northern Alberta are required to address the design considerations presented earlier. Large size (i.e., in the range of 5000 km^2) is necessary to ensure that the sites are capable of maintaining ecological integrity, which is in turn required for the maintenance of biodiversity and the use of sites for scientific study and as benchmarks. Large size is also required to ensure that viable populations of most native species can be maintained without dependence on

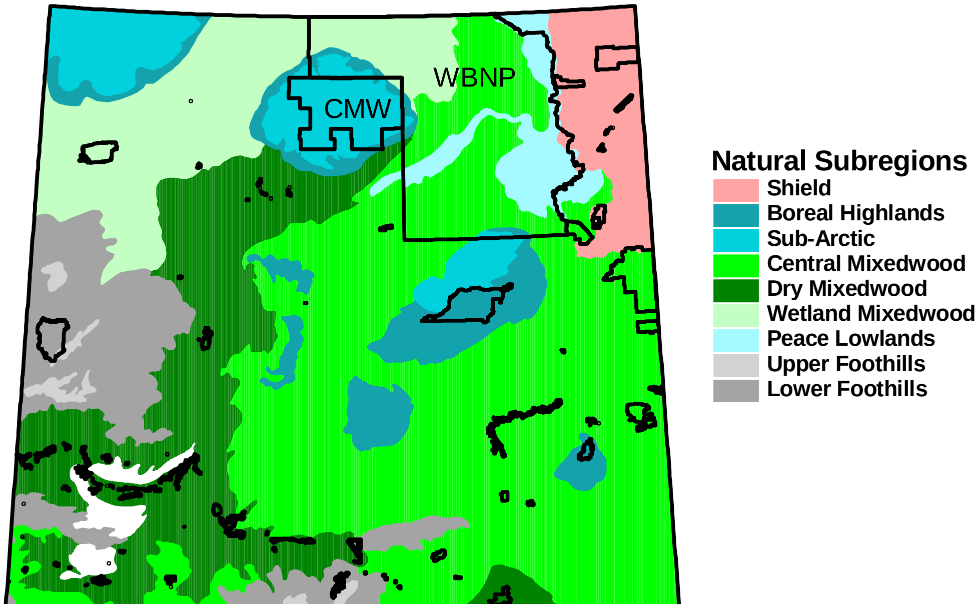

Fig. 7.4. Protected areas (outlined in black) in northern Alberta in 2001, superimposed on a map of Natural Subregions. WBNP = Wood Buffalo National Park; CMW = Caribou Mountains Wildland. Source: AE, 2001

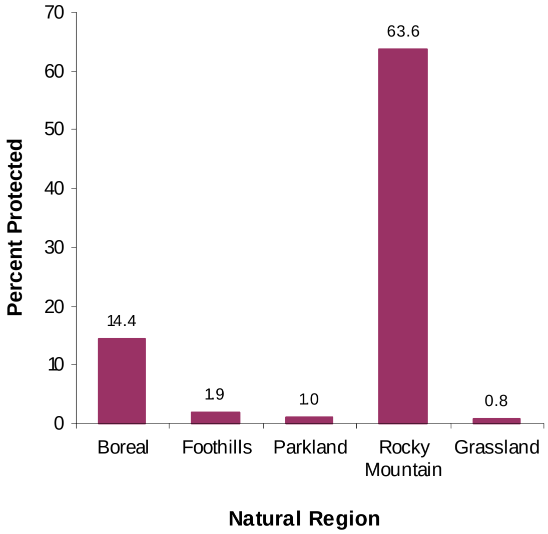

Fig. 7.5. Percent of area protected in 2001, by Natural Region. Source: AE, 2001.

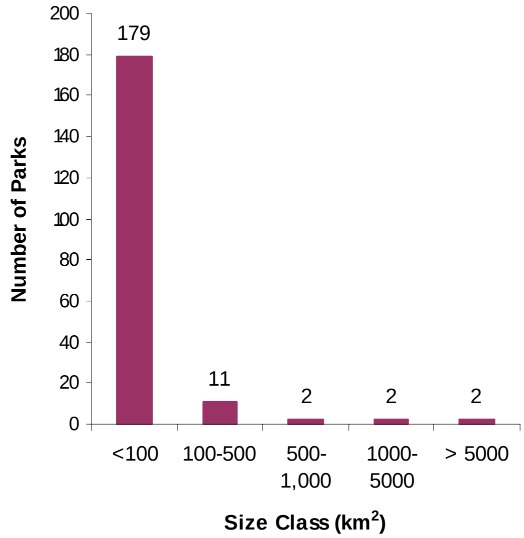

Fig. 7.6. Number of protected areas in northern Alberta in 2001, by size class. Source: AE, 2001.

the industrial landscape for connectivity. Finally, large size is required to enable adequate sampling in the context of benchmark areas.

The requirement for multiple core reserves reflects the need to (1) represent all ecosystem types, (2) ensure wide geographic distribution to facilitate recolonization of the industrial land base, if required, (3) facilitate the matching of benchmark areas to regions of high industrial use, and (4) incorporate redundancy into the system to accommodate climate change and unforeseen changes. Although the Central Mixedwood Subregion is represented in WBNP, at least one other large core area is warranted in this Subregion given that it constitutes almost one quarter of Alberta (AEP, 1994b: 26). Furthermore, most of Alberta's oil sands development, along with considerable conventional oil and gas activity and several forestry operations, are located in the southern half of the Central Mixedwood (AEP, 1998: 84). Consequently, there is a substantial need for a biodiversity reserve and ecological benchmark in this region.

The placement of the core protected areas requires consideration of the following factors (Noss, 1995: 1; AEP, 1998: 217):

- natural Subregion representation;
- representation of smaller-scale landforms;
- level of existing disturbance and road density;
- proximity to WBNP;
- potential for supplying habitat for rare or endangered species;
- incorporation of areas of high species richness; and
- minimization of conflict with existing industrial commitments.

With the exception of the Central Mixedwood Subregion, the optimal placement of sites, based on the above criteria, is readily apparent (Fig. 7.7). More than one potential site exists in the southern half of the Central Mixedwood (AEP, 1998, Fig. 50), and the two most likely candidates are shown in Fig. 7.7. Because there is minimal industrial activity in the Shield Natural Region, a large core area is not a priority for this Region. The delineation of actual boundaries is beyond the scope of this paper, but in general, emphasis should be placed on maximizing habitat diversity and ecological function (Noss, 1992). Because the sites are intended to be permanent, a long-term perspective is important, implying that landform diversity should be emphasized over transitory features such as old-growth or pre-existing human disturbance (Kavanagh and Iacobelli, 1995: 11).

Even if the large core reserves are several thousand square kilometres in size they will not be able to capture all of the ecological diversity of northern Alberta. Additional protected areas of smaller size (100-1000 km^2) will be needed to represent unique localized landscape features (e.g., sand dune complexes), areas of particularly high diversity (e.g., major river corridors), and the specialized habitat needs of rare or endangered species. These supplemental sites are intended to meet the habitat requirements of a select group of species, in contrast to the coarse-filter objectives of the large core sites. The locations of most of these supplemental sites have been identified through the Special Places 2000 program (AEP, 1996b: 8-15; AEP, 1998: 236-267). Given the limited objectives of the program, not all sites were established and the size of many sites is inadequate.

The protected area system in northern Alberta must also incorporate corridors and buffers. The nature and management of corridors have been described earlier, and in general, the

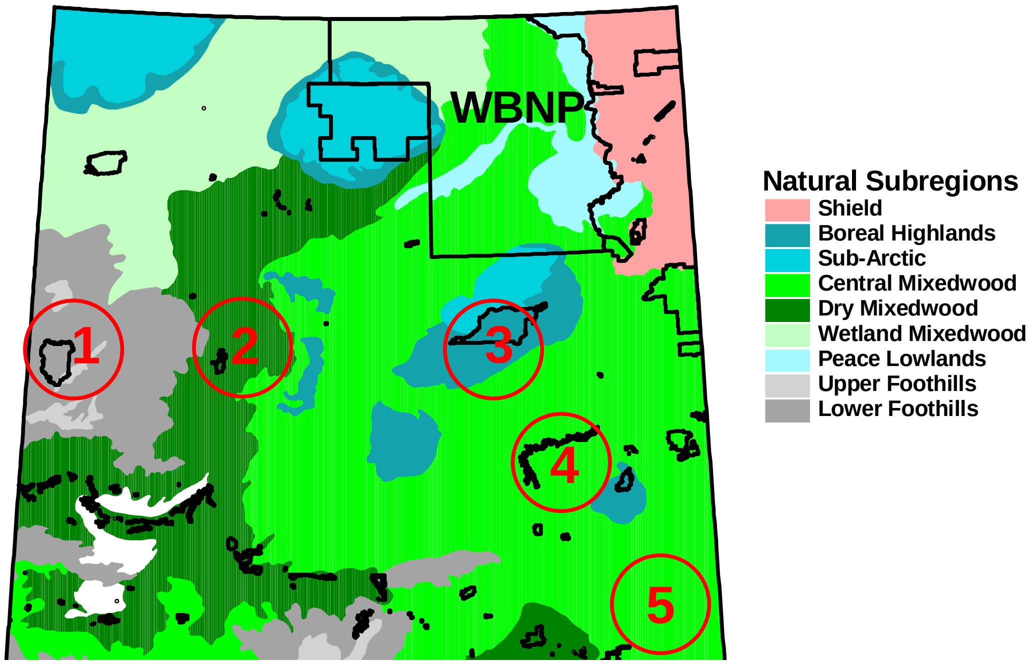

Fig. 7.7. Candidate locations for additional large core protected areas. Each area is 5000 km^2, drawn approximately to scale. Criteria used to select the sites are described in the text. Existing sites are outlined in black.

characteristics of buffer zones should be similar. Harvesting operations within buffer zones could occur at a low rate, with strict adherence to the NDM. Allocations would have to be based on the understanding that limited fire suppression would be practiced within the protected area, presenting a potentially higher risk of fire in the buffer zone. The size of buffers would be based on the nature and intensity of the industrial activities occurring outside protected areas and on the sensitivity of key species to these activities.

The protected area framework presented here is based on minimum requirements for representation and integrity necessary for the maintenance of biodiversity. The four core areas, at 5000 km^2 each, would add 4.9% to the 14.0% of northern Alberta that is currently protected (as of 2001). With the addition of supplemental sites required for the protection of unique landscape features and habitat types the total area of protection is in the same range as the 20% target that the Senate Sub-Committee on the Boreal Forest (1999) suggested is appropriate for the boreal forest.

The management of protected areas, once established, should focus on the maintenance of ecological integrity (Sinclair, 1998; PEICNP, 2000). As fundamental principles, the boundaries of the sites must be permanent (through legislation) and all industrial use must be prohibited (Kavanagh and Iacobelli, 1995: 20). In addition, access and motorized activities should be minimized, and natural disturbances should be permitted to occur (at least in the large core reserves) (Noss, 1992). Further management prescriptions will be largely site-specific. The report released by Parks Canada on the ecological integrity of Canada's national parks provides useful guidance (PEICNP, 2000).

Floating Reserves

The concept of so-called "floating reserves" has occasionally been proposed as an alternative to a system of permanent protected areas. The intent is to maximize the utilization of the landscape for resource extraction while still providing some protection. Industrial use is restricted in defined areas for a specified period of time (e.g., 50 or 100 years), and this land is then brought back into production in exchange for new reserves.

As an alternative for permanent protected areas, floating reserves are not a serious consideration. The obvious problem is that after the first rotation of sites, the "new" reserves will be incapable of fulfilling any of the core objectives of protected areas. They will not be repositories of natural ecological processes acting as safeguards for maintaining biodiversity, they will not be capable of acting as benchmarks by providing a contrast to other industrial areas, and they will not be considered as wilderness by the public.

Floating reserves could, however, play an important role in the maintenance of old-growth forest within the *industrial* land base. The maintenance of older forest stands on the landscape, in natural patterns of quantity, patch size, and distribution, is a central tenet of the NDM (Niemela, 1999). This application of floating reserves is discussed in the next chapter.

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