Using Natural Disturbance Patterns to Guide Management of a South-Western Alberta Landscape

Part I: What is a Natural Pattern Approach?

A Foothills Research Institute, Natural Disturbance Program Project

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A natural pattern approach to managing landscapes involves three elements:

1) Landscape health is directly related to biodiversity & ecosystem function.
2) Natural disturbance patterns are a proxy for biodiversity.
3) Landscape health can be used as the basis for land management.

1) Landscape health is related to biodiversity & ecosystem health.

Ecosystem health is something we all agree is important to maintain. Even the draft Land Use Framework (LUF) for Alberta suggests that "healthy ecosystems and environment" is one of its three desired outcomes. Unfortunately, succinct *and* useful definitions of ecosystem health are few and far between.

A healthy ecosystem is one in which the natural functions and structures are intact. This is what Aldo Leopold meant when he first introduced the idea of keeping all of Mother Nature's "cogs and wheels". Our modern day version of natural functions and structures is *biodiversity* – the diversity of individuals, populations, and ecosystems. So a landscape ecosystem with natural levels of biodiversity is a healthy landscape.

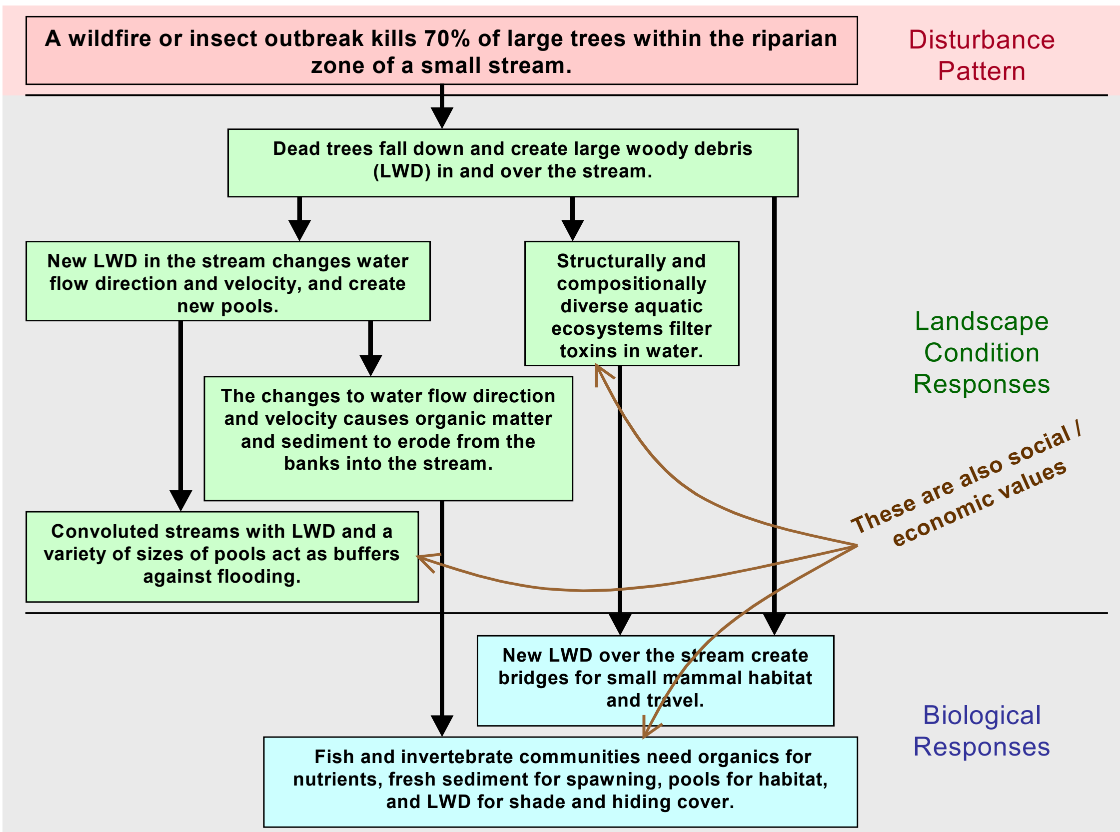
Note that "natural levels of biodiversity" covers a lot of territory, some of which may even be socially unpopular. The vision of a diverse, healthy forest as vast areas of attractive disease-free old growth forest with lakes and rivers full of crystal clear water, and eagles, bears, caribou, and fish in abundance represents only part of the biodiversity story. Other elements include burnt-over forests and grasslands, creeks murky with sediment, swamps and bogs, dead and dying trees, and even local species extinctions. These are all equally relevant cogs and wheels.

As one can imagine, the number of cogs and wheels in a natural system is tremendous. Imagine, for example, the number of possible combinations of sizes, density, and species of trees and plants that a single small area of ground will experience over a 100-year period. This variability in structures and functions is known as the "natural range of variation" or NRV. Species populations, water level, tree density, soil pH, and wildfire sizes all have an associated natural range, and it is this variability that allows the system to recover from perturbations. Thus, it is not the structural characteristics of forested landscape at any single point in time that makes it "healthy" (for example), but rather the degree to which it can and does experience and respond to change - its natural range of variation. Landscape health is therefore directly related to the degree to which biodiversity stays within the natural, historic range.

2) Natural disturbance patterns are a proxy for biodiversity.

Biodiversity is often described as the diversity of individuals, species, and ecosystems. The reality of biodiversity is far more complex. To demonstrate, consider a wildfire that burns through parts of the riparian zone of a small stream. The ***pattern*** of disturbance is the level of tree mortality, the size and number of any un-burnt residuals, or the size and shape of the wildfire. One of the many changes to ***landscape condition*** caused by the wildfire is that the some of the dead trees remain standing for several years, and others will fall down and become large woody debris (LWD) in the riparian zone. Trees that fall in the stream create pools and change the direction and velocity of the water flow. Changes in water flow cause the stream to erode its banks, providing a new source of organic matter and sediment into the water. And the combination of LWD, pools, and convoluted stream shape buffer the system against both floods and droughts.

Figure 1. An Example of a Natural Sequence of Landscape Ecosystem Inputs and Outcomes.



The ***biological responses*** of these various changes to landscape condition include both terrestrial and aquatic elements. Aquatic ecosystems need organic matter and sediment for food, habitat, and reproduction. The pools and LWD in the stream create a variety of habitat options for fish and other aquatic life. The LWD that fall over the creeks and the dead standing stems provide hiding cover, habitat, and travel corridors for small animals.

Everything shown in Figure 1 has a corresponding natural range of variation (NRV); disturbance patterns, species population levels, and LWD. And the light grey shaded areas in Figure 1 are all elements of biodiversity. We broke it down in this example to demonstrate that the trigger for change - and thus *the foundation for biodiversity* - is disturbance. One can imagine that if the timing, frequency, type, or severity of disturbance activities undergoes a significant shift, there will be a corresponding shift in both landscape condition and biological response. Disturbance patterns are therefore excellent proxies for managing and monitoring biodiversity.

3) Landscape health can be used as the basis for land management

If healthy landscapes are ones in which the NRV of all types and levels of biodiversity remain at historic levels, and natural disturbance patterns are a proxy for biodiversity, then the ideal measure for landscape health is the NRV of disturbance patterns. Furthermore, one could argue that the ultimate measure of a sustainable landscape is the (biological) health of a landscape. For example, note that at least three of the **landscape condition responses** in Figure 1 are social and / or economic values; mitigation of the impacts of flood and drought, water quality, and local fish populations.

Adapting this *natural disturbance (ND) model* in Figure 1 to a (ND-based) *management model* is conceptually fairly simple. First, the **disturbance patterns** become the management actions. Second, add in a decision-making filtering process whereby different disturbance choices and their outcomes and associated risks can be evaluated and compared. The filtering process includes the needs of the identified social, economic, and ecological values. The last change is to identify the other ecological, social, and economic outputs (see Figure 2).

Note that there is no requirement in this model for the disturbance management decisions to stay within the natural range – only that it is the universal benchmark against which to compare management actions and assess risk. The filtering process may identify social or economic issues that favour disturbance activities that stray far beyond NRV for several functions or structures. Roads are an excellent example of this phenomenon. The biological risks of roads are fairly well known, but we continue to choose to increase road density to accommodate other values.

Now let's compare this sequence of events to our traditional land management model (Figure 3). Our starting point in this case is values – **social and economic issues**. The need for oil, gas, water, timber, hunting, or recreational experiences all become starting points for management activities. In our example, the LWD/water issues might be 1) potable water, 2) flood risk, and 3) recreational fishing opportunities (Figure 3). We then identify **management actions** designed to optimize or maximize the amount of that issue; engineered flood control installations, stocking streams and lakes, and so on. The final step is to filter those management actions through a series of other social, economic, or ecological concerns. Each management action tends to be unique and intimately tied to the original value it is meant to serve, as is its filtering process. The energy sector, parks, and water agencies all use different disturbance tools, and vastly different filtering processes. As a result, a single landscape may be subjected to dozens of independent and uncoordinated management actions simultaneously.

Whether the specified management actions from our traditional model achieve the desired outcomes, there are always related, and often unintended, **landscape condition** and **biological responses**. In our example, the exclusion of all disturbance activities in riparian zones will ultimately create a landscape with large quantities of old riparian forest and little or no young riparian forest. This increases the risk of insect and disease outbreak and fire threat for the landscape. Similarly, within systems where disturbance frequency is constant and high, early successional vegetation provides vital detritus, food, habitat, and water recharge in and around streams and creeks.

Figure 2. An Example of a Natural Pattern Based Forest Land Management Process.

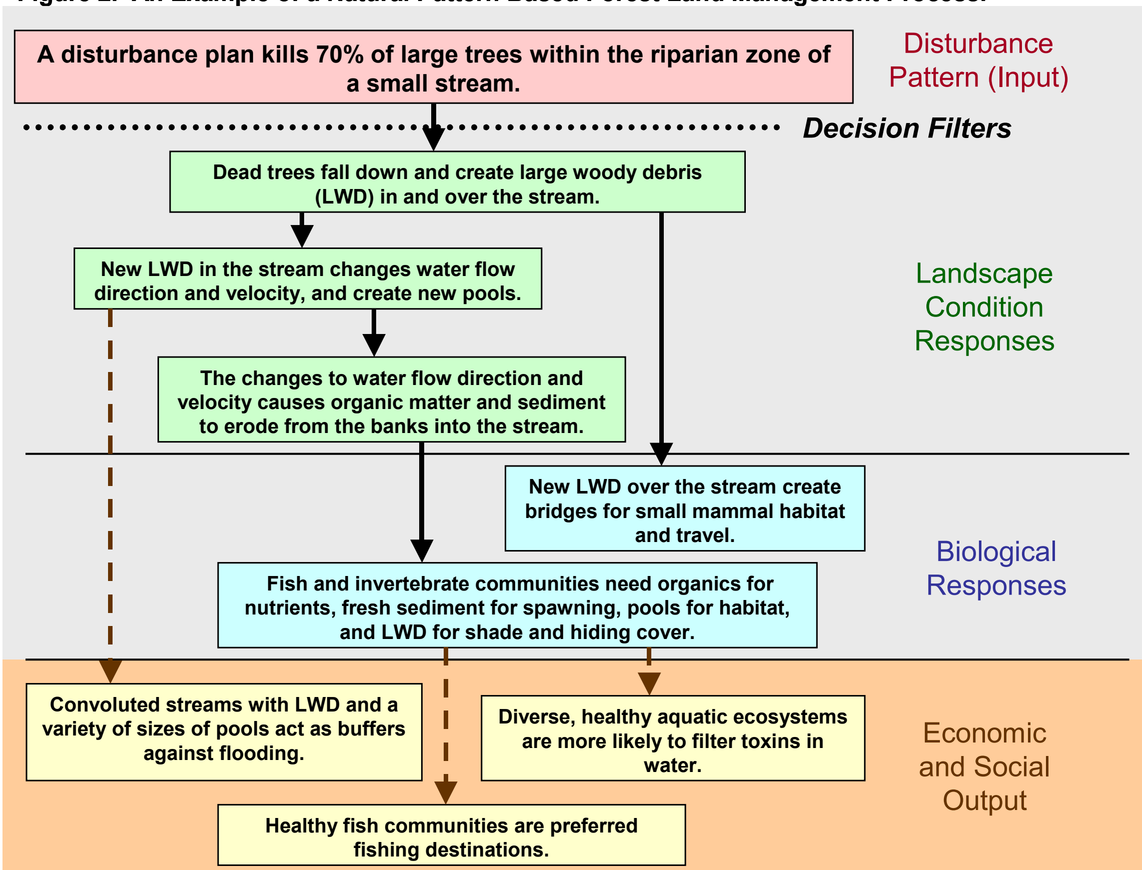
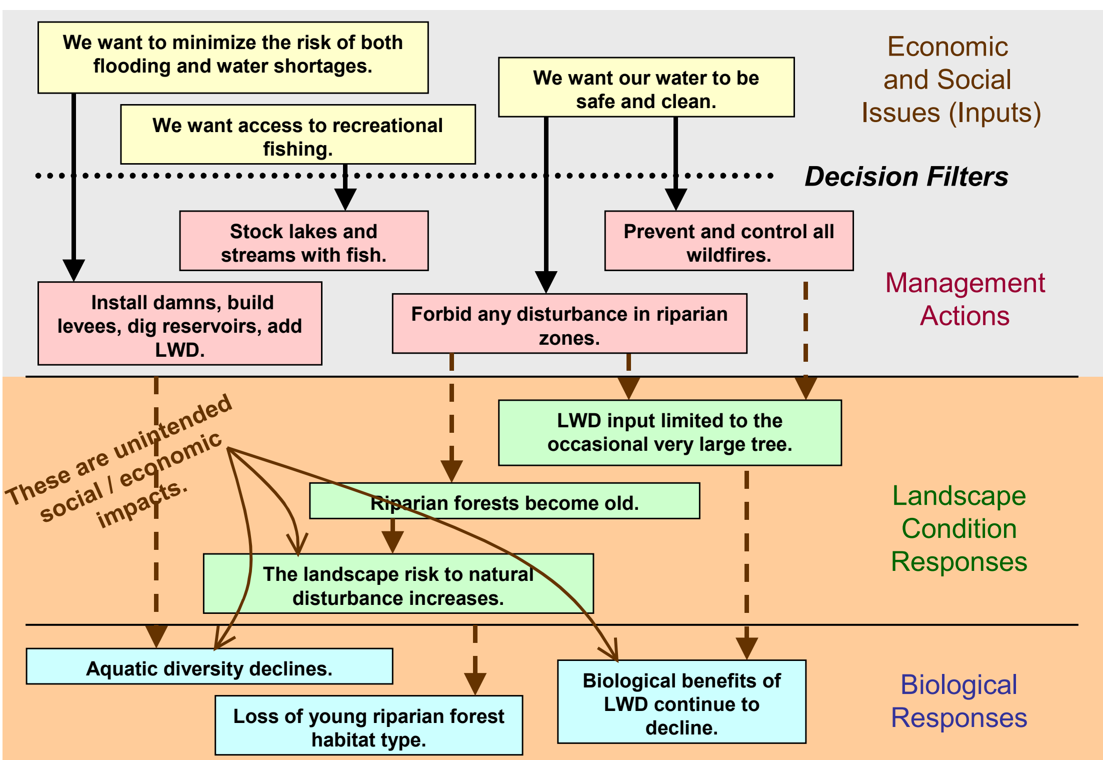


Figure 3. An Example of the Traditional Forest Land Management Process.



It is not difficult to see how these outcomes either create new social and economic issues, or conflict with existing ones. An increase in the risk of insect or wildfire activity resulting from the protection of riparian zones is only one of many such examples. The problem is that no one is tracking or monitoring the cumulative impacts of management activities.

Expanding the two extremes of management model beyond our LWD/water example to an entire landscape (Figures 4 and 5), several key differences between the traditional and an ND-based model of landscape management are obvious;

1) **Issue optimization vs. ecological health as the management foundation.** Social and economic issues are the starting point for traditional management system. For an ND-based management system, ecosystem health becomes the common starting point, and social and economic issues function as both a) decision-making filters, and b) outputs.

2) **Many plans vs. one.** There are dozens of uncoordinated management actions in the traditional management system, each one serving a single issue. An ND-based system generates a single, fully coordinated (disturbance) management scenario. Impacts and risk cannot be evaluated unless disturbance is cumulative.

3) **Many filtering processes vs. one.** Traditional land management involves dozens of different types and intensities of filtering and public consultation processes. An ND-based management model needs only one standardized filtering and public input process.

4) **Biodiversity as an output vs. an input**. Landscape condition and biological responses are (often unforeseen) outputs of a traditional management system since a) they are incidental to achieving success of the original value, and b) it is extremely difficult to predict the cumulative effects of all disturbance activities. (However, it should be noted that some biological values are sometimes used as filters under traditional land management). This means any biological risks are outputs as well. Under an ND-based model, landscape condition and biological responses - and any associated risks - can be linked directly to the one disturbance plan, and thus used as inputs to planning.

5) **Social, ecological, and economic issues as inputs vs. outputs.** Traditional land management models treat identified social, ecological, and economic issues as inputs to planning. Under an ND-based management model, they are outputs. However, it should be noted that such issues are included in the filtering process and may in the end be powerful influences. But in this case, such occurrences are a product of societal choices, not process-based biases.

6) **Issue management vs land management.** The traditional model of land management in reality involves many different sub-models, each one designed to deal with a specific issue; water, forest management, oil and gas, fisheries, recreation, etc. Although an ND-based approach could work for any one, two, or more of these issues, the conceptual foundation encompasses and accounts for all land and water issues. *It is a universal, holistic management model,* and could be applied to any landscape in Canada.

Figure 4. Cumulative Effect of a Traditional Forest Land Management Flowchart for a Landscape.

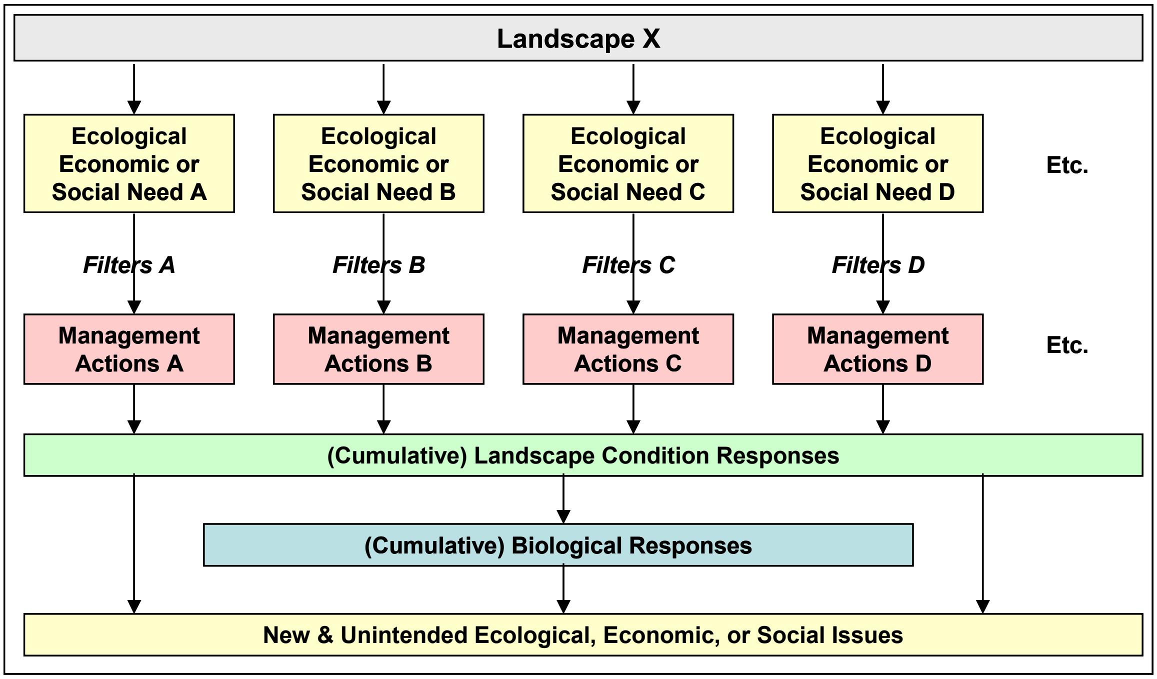
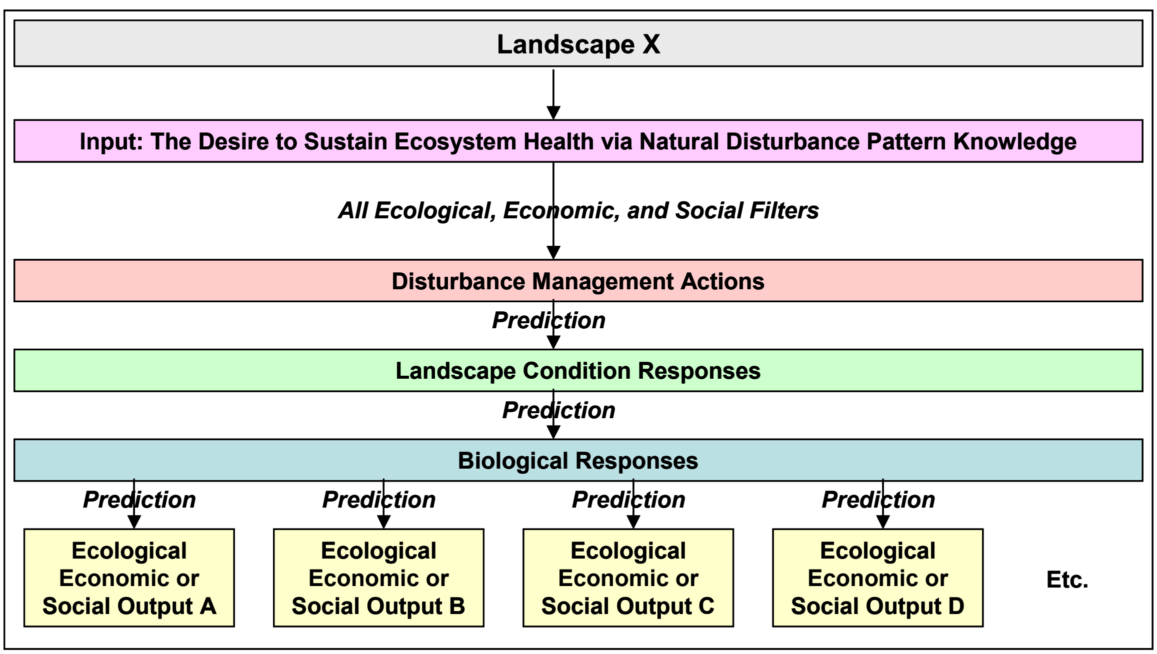


Figure 5. Cumulative Effect of an ND-Based Forest Land Management Flowchart for a Landscape.



Is an ND Planning Foundation Always Appropriate?

There are many cultural activities that have no natural equivalent; roads, well-sites, seismic lines, water contamination, open pit mining, oil and chemical spills, etc. The natural range of such entities is zero – they are entirely unnatural. A simple ND approach would suggest that minimizing any (risk of) unnatural disturbance events is prudent since we already have a fair idea that it will result in unnatural levels and types of biodiversity. This in and of itself (ie, "minimize road or well site density" or "minimize the risk of spills") is not particularly useful information for planning.

However, these all qualify as "disturbances", and thus have associated landscape condition and biological responses. In other words, one could still track the responses of unnatural disturbance events and compare them to NRV as demonstrated in Figure 1. Remember that we are using disturbance activities only as a means to an end – landscape health via biodiversity.

What we have lost in a situation like this is the guidance of natural patterns as a backdrop or foundation for disturbance management actions. In its place, we can, and have, moved to secondary indicators of landscape condition and biological response to help generate meaningful thresholds. For example, the impact of permanent roads on landscape condition can be captured in several meaningful ways; proportion of area in a long-term disturbed state, amount of disturbance edge per unit area, or the size of intact old forest areas. Note that these are all landscape patterns with NRV equivalents. Such measures can be used by other models to determine the presence and location of thresholds for impacts on individual species such as Grizzly Bear. Similarly, water contamination has measurable water condition and biological responses that could be compared to NRV to evaluate impacts on key indicators.

Note that we do this already – identify thresholds based on elements of biodiversity. What we have not done to this point is packaged it together as an ND approach along with those thresholds that can be identified more holistically through the NRV of disturbance patterns.

Is an ND Planning Foundation Right for Alberta?

Technically, the natural disturbance regimes in Alberta already align quite well with current cultural disturbance activities. For example, the frequency, size, severity, and shapes of wildfires are well within our grasp to emulate with mechanical means.

Philosophically, the concept seems to be timely. For example, the Draft Land Use Framework for Alberta is largely built around many parallel ideas, including "land stewardship ethics", "healthy ecosystems and environment", "cumulative effects management approaches", and even "integrating provincial policies". In fact, a natural pattern approach could prove to a highly successful interpretation of how to achieve the LUF goals and objectives on the ground.

The second part of this report describes a process for developing an ND-based plan for any landscape. We ultimately propose demonstrating this planning system on the K-country landscape, and the Foothills Research Institute land base.