TOTAL RESOURCE DESIGN:

Documentation of a method and a discussion of its potential

for application in British Columbia.

by

JULIE ELIZABETH DUFF

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Abstract.

Total Resource Design (TRD) was developed for application in British Columbia (B.C.) by Simon Bell of the British Forestry Commission. It is based on a process called Landscape Analysis and Design developed by the U.S. Forest Service and uses a design process to translate broad objectives for a forest landscape into a design of 'management units' and guidelines for their future management. This design is based on an analysis of the ecological functioning of the landscape, its visual character and the various resource uses and values present in the landscape. Although the process of design is widely used in other professions, its application in a forestry context in B.C. is new. Therefore, in January 1994 a test application of the process was carried out by the Ministry of Forests in the West Arm Demonstration Forest, Nelson, B.C.

This thesis documents the detailed method for the application of TRD which evolved during this test case. It is hoped that this method can be used as guidance for future applications of TRD in the Province.

The final results of the West Arm Demonstration Forest test case are not yet known. However, based on the concepts used in TRD and its predicted outputs, it is suggested that Total Resource Design has the potential to address many current deficiencies in forest planning in British Columbia. Despite its potential to address these issues, it is emphasized that TRD is still in the test stages in B.C. It is also merely a framework to guide the design and management of a landscape. Its success will rely on the quality of the information available and the commitment of the team responsible for its implementation. It has the potential to greatly improve the effectiveness of integrated resource management of forest lands in British Columbia.

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Chapter 1.

Introduction

1.1 Scope of the thesis.

Total Resource Design (TRD) is an integrated approach to the planning and design of forest landscapes. It was developed by Simon Bell, a landscape architect and forester with the British Forestry Commission, and was modeled closely on work by Nancy Diaz and Dean Apostol of the Mount Hood National Forest, Oregon. Essentially, TRD provides a strategy for the design of a pattern of management units across a forest landscape, based on an understanding of how the subject landscape functions as an ecological system. Within the structure of a design process, this understanding is combined with objectives for the landscape and the resources it contains, and with any policies or direction from higher level planning processes to synthesize solutions for the position, attributes and ultimate management of these units. It is a framework for compromise and provides a forum for all parties involved with the management of a landscape, to become actively involved with the creation of solutions for its integrated management.

Total Resource Design is at present, merely a 'proposed process' in British Columbia (B.C.). Bell, who had been involved with Diaz and Apostol in the development of a precursor process (called 'Landscape Analysis and Design'), introduced TRD to members of the B.C. Ministry of Forests in 1993. Recognizing its potential value, and encouraged by the results from Mount Hood in Oregon, it was quickly realized that TRD could have a future in British Columbia and thus should be tested and assessed in a practical application. The initiative for such a test came from administrators in Nelson Forest Region and the Kootenay Lake Forest District, who decided to try to apply Total Resource Design to the West Arm Demonstration Forest (WADF) which is situated just north of the town of Nelson, in south-eastern B.C.

A workshop, bringing together all the parties responsible for the management of the West Arm Demonstration Forest and members of the local community, was held in Nelson in January 1994 . Its purpose was to take Bell's outline method for TRD, to apply it to the WADF and then to analyze the results. Simon Bell returned to British Columbia on 23rd January 1994 to lead the workshop, bringing with him an outline of the method and an idea of the results it should produce. However, in order to actually implement the steps of this method, Bell and the participants had to determine the details of *how* each step was to be carried out using the information resources available and the extent of the resource conflicts present in the area of study. Throughout the workshop he presented a set of goals which he felt should be achieved by each step, and, in essence the workshop then became a series of problem solving exercises - how could the team work together, within the information constraints present to fulfill each of these goals and thus implement Total Resource Design? By tackling these problems, the workshop resulted in the clarification of a more detailed method for the B.C. application of the concepts and original outline method provided by Bell.

The emphasis of this thesis is to take the experience gained from the West Arm Demonstration Forest application and to combine it with the work of Bell (MOF 1993a) and that of Diaz and Apostol of the US Forest Service (Diaz and Apostol 1992) to produce a detailed method for the future application of TRD in British Columbia. This will provide step by step guidance on how each stage of the method can be approached in the future, with details on some of the problems which can be expected along the way. It will reach beyond the conclusions of the workshop itself and will be the first in-depth documentation of the Total Resource Design approach as applied in British Columbia. It is hoped that it will therefore facilitate further applications of the process in the Province, leading to a wider empirical testing of its performance within various ecosystems, climatic regions and areas of differing resource use. Ultimately, the results of this testing could be used to determine whether Total Resource Design can live up to its objectives and so provide the Province with a practical and feasible forest planning tool.

In addition the application of Total Resource Design in B.C. is likely to also be of interest to members of the international forestry community. For example, based on his involvement with the process here, Simon Bell is currently attempting to apply a modified version of Total Resource Design to areas of forest in Great Britain. Diaz and Apostol continue to refine and adapt their Landscape Analysis and Design model in Oregon, and will be watching the results of Total Resource Design with interest. Documentation of the application of TRD in British Columbia, as provided by this thesis, will communicate the progress which has been made with Total Resource Design in this province to date.

A second component of this thesis will be to examine the attributes of Total Resource Design which may influence whether it can be considered for general use in British Columbia. The application of TRD to the West Arm Demonstration Forest was initiated to establish whether the process could be realistically applied in B.C., and to evaluate whether or not it would be feasible to implement. Unfortunately, the final results of the WADF application lie at least a year away and so only limited analyses of its performance can be carried out. However, other questions which relate not to the specific details or results of its application but to the concepts and attributes of the overall process, also need to be addressed before it could be considered for wider application. For example, is an approach like Total Resource Design required in British Columbia? Is there a similar approach currently in place? If there is, would TRD be an improvement on the *status quo* ? How would Total Resource Design fit into the current forest planning framework, and are there any particular scenarios in B.C. for which TRD would seem to provide an obvious planning solution ? The answers to these questions should help to identify the potential Total resource Design may have for application in B.C.

To conclude this introductory chapter, a brief overview of Total Resource Design and its aims will be provided, followed by an outline of how and why it evolved to this point. This will explain why TRD was initially deemed potentially useful in British Columbia and thus worthy of testing and further study. Then, in chapter 2, the ecological principles which form an important part of Total Resource Design will be examined. An account of the development of the TRD method, a description of the steps involved and an illustration of each using the WADF example will be provided in Chapter 3. Finally, Chapter 4 will discuss attributes of the Total Resource Design process which may contribute to its potential for application in B.C.

1.2 Background : Total Resource Design and its evolution to date

Total Resource Design - an overview

Total Resource Design is an integrated and holistic approach to forest design. Applied to a forest landscape, its purpose is to provide a means of translating a general direction for the landscape provided by a higher level plan, into a design for the shape, size and position of units in the landscape, which can then be managed for various objectives, such as timber, range or wildlife. The process of Total Resource Design, as its name suggests, is one of *design.* A design team made up of representatives of the different resources within the landscape work together, guided by the design framework of the TRD method, to identify objectives for the landscape and to carry out a series of analyses (ecological, visual and practical opportunities and constraints for management). Based on all of these, they then develop a 'target' for the landscape .This is a desired landscape pattern of patches, corridors and background matrix, which will fulfill all of the resource objectives for the landscape.

The designer on the team, skilled in the design process and the use of visual design principles, takes this target and the results of the various analyses and attempts to fit units onto the landscape. These will comply with the analyses, will fit visually into the landscape, and if managed appropriately in the future, should allow the target landscape pattern to be achieved. Through this type of approach, the goal of Total Resource Design is to allow the objectives for the landscape to be met while ensuring the maintenance of the ecological functioning and visual quality of the landscape.

The evolution of Total Resource Design

TRD is an inherently multi-disciplinary process, combining different approaches and principles to produce a solution to a problem. Total Resource Design was developed through the combination of approaches and thoughts of individuals trained in different ways to tackle a common problem the design of forest landscapes. Simon Bell, while working on visual landscape design in the Mount Hood National Forest, Oregon, started to discuss some of the landscapes with Nancy Diaz, the resident landscape ecologist. Her work in the forest was concerned with designing the management of the ecological attributes of its landscapes. In essence, what followed was a period of 'brain-storming' between Diaz, Bell and Dean Apostol, the landscape architect for the national forest. The main question they addressed was whether they could use landscape ecology as a basis for design. In other words, could the naturally occurring shapes and distributions of ecological elements in the landscape be used as a template or key to guide the design of management units in the landscape? If so, the product would produce a design which would allow timber harvesting and management of the landscape to take place in a way which would be both ecologically and visually acceptable(D. Apostol. pers, com, 1994).

Through discussions and refinement a method developed for the production of such a design. This was called *Landscape Analysis and Design* and the results of an application of this technique to an area of the Mount Hood National Forest were published by Diaz and Apostol in 1992. The original stimulus for Diaz's work on the use of landscape ecology in the design of forest landscapes, and the incentive behind the application of Landscape Analysis and Design, was in response to a growing concern, both by the public and within the scientific community, over the effects of forestry on visual and wildlife resources at the landscape level. Forest operations at a stand level were normally well planned and executed in the Pacific Northwest, but their effects on other stands, or cumulatively over a forest landscape, were rarely considered (Diaz and Apostol 1992). A pattern of clear-cuts and different age classes of younger forest was being imposed on the landscape without consideration of the implications for the biological resources and human interactions. As articulated by Diaz and Apostol:

> "As long as forest management agencies carry out activities that change vegetation, new landscape patterns will be created. The paramount question is 'will we allow that process to be informed by our understanding of landscapes as ecological systems, or will landscape patterns continue to evolve as a proliferation of independent actions?' The hope is to encourage a more enlightened, purposeful and objective development of forest landscapes." (Diaz and Apostol 1992:1.1).

Landscape Analysis and Design suggested a methodology which avoided forcing a uniform set of restrictions or requirements on the management of forest landscapes but rather recognized that each landscape had its own characteristics which should be managed in an individual way. The logic of the process was summarized by Diaz and Apostol as follows:

> "1. The landscape should be understood as an ecological system.
> 2. This understanding should be used, along with existing direction and local issues to derive objectives about landscape pattern.
> 3. The spatial design of that pattern should be used to inform and evaluate the progressive implementation of land management strategies."(Diaz and Apostol 1992:1.2).

Bell, through work with the Ministry of Forests in British Columbia, became familiar with the difficulties faced by forest managers in the Province in trying to reconcile the different resource values in the landscape with the extraction of timber. He also recognized some similarities with those issues which had stimulated the work of Diaz and Apostol in Oregon. Thus, he introduced the concepts Landscape Analysis and Design to B.C., modified to accommodate the different forest planning framework which exists here and customized them to incorporate the forestry and ecological terms used in this jurisdiction. To avoid confusion with the Oregon model, he also gave it a new title - *Total Resource Design.* This thesis is a study of the continued evolution of Total Resource Design in British Columbia and the potential it may have for widespread application here in the future.

1.3 Objectives

In summary, the objectives of this thesis are to:

1. Document the method for the application of Total Resource Design in British Columbia;
2. Document, where available, the results of a case study application carried out by the Ministry of Forests on the West Arm Demonstration Forest, Nelson Region;
3. Estimate, where possible, the logistical requirements for carrying out Total Resource Design, and the implications for the resources involved;
4. Gain a knowledge and understanding of current Ministry of Forests administrative and planning processes, their deficiencies and possible future trends.
5. Discuss the ability of TRD to incorporate or accommodate existing planning frameworks, guidelines and the Forest Practices Code (Province of British Columbia 1994); and
6. Use the findings from the case study application to draw conclusions on the potential role of Total Resource Design in the planning of provincial forest lands in British Columbia.

Chapter 2

An introduction to the ecological principles employed in Total Resource Design

2.1 Introduction

The purpose of this chapter is to provide an introduction to the ecological principles used in Total Resource Design and so to facilitate an understanding of the contents of subsequent chapters. These principles were employed by Diaz and Apostol in their process of Landscape Analysis and Design, and as the two processes are conceptually very similar, they have also been applied in Total Resource Design. The linch-pin of the approach adopted in TRD is the concept that landscapes function as ecological systems. A major aspect of the method is therefore to analyze the subject landscape to try to achieve an understanding of how the subject landscape functions in this regard. This analysis was developed by Diaz, a landscape ecologist, and thus it is structured using the principles of landscape ecology (Diaz and Apostol 1992).

The unit of study in Total Resource Design is, as has been mentioned, a landscape. Therefore at this point, a definition of a 'landscape' will be provided. This should clarify from the outset, both the contents and scale of a landscape, as interpreted by this thesis.

2.2 Landscape : a definition

The word 'landscape' is one which has undergone an expansion in meaning in the history of its use, with the result that it is currently used with various meanings and connotations. The English word *landscape* came from the Dutch word *landschap* in reference to their early landscape paintings. This term gradually developed "from a mere indication of an area somewhere in space.....to the character of an area according to its contents" (Zonneveld 1988). So, through time its meaning has been taken beyond the realms of scenic and aesthetic description and has become more synonymous with the land itself and its structural composition.

Landscape ecology is concerned with the ecological functioning of spatial units, and a landscape in this context became defined as:

> "a part of the space on the earth's surface, consisting of a complex of systems, formed by the activity of rock, water, air, plants, animals and man and that by its physiognomy forms a recognizable entity " (Zonneveld 1979 in Forman and Godron 1986:7).

Forman and Godron in their treatise on landscape ecology, further define a landscape as:

> " a heterogeneous land area composed of a cluster of interacting ecosystems that is repeated in similar form throughout....a landscape is a distinct, measurable unit defined by its recognizable and spatially repetitive cluster of interacting ecosystems, geomorphology and disturbance regimes" (Forman and Godron 1986:11).

This is a much quoted definition in the literature (see Risser 1987, Rowe 1988, Merriam 1988). It was the one used by Diaz and Apostol in their development of *Landscape Analysis and Design* (Diaz and Apostol 1992) and has been carried through into Total Resource Design. According to this definition, a landscape is a holistic combination of all the structural and functional attributes of an area. The interactions between these structures and functions determine its characteristics and enable the landscape to be recognized as a distinct area of land. In designing a landscape it is obvious that TRD must be based on an understanding of how all of the components and structures in a landscape function and interact.

2.3 The ecological functioning of landscapes

The principles of landscape ecology are used in Total Resource Design to try to 'piece together' an understanding of how landscapes function ecologically. Many of the principles used are derived from a text written by Forman and Godron, called simply *Landscape Ecology* (Forman and Godron 1986).

Forman and Godron argue that there are three major components to understanding ecological systems - structures, functions and the interactions among them (Forman and Godron, 1986). Structures can be thought of as the tangible, physical elements of an ecosystem, and functions as the processes performed by the structures. It is the functional interactions among the structures which make the ecological system dynamic.

Structure:

The internal **structure** of a landscape has been defined by Forman and Godron as :

> "the spatial relationships among the distinctive ecosystems or 'elements' present - more specifically the distribution of energy, materials, and species in relation to the sizes, shapes, numbers, kinds and configurations of the ecosystems" (Forman and Godron 1986 :11).

Forman and Godron define these landscape elements as the basic, relatively homogeneous, ecological elements or units on the land which can be of either natural or human origin.

Once it had been recognized that landscapes are composed of structural elements, Forman and Godron set out to try to identify a fundamental classification of these elements which would hold true for every landscape. To do this they flew over four very different landscapes: an agricultural landscape in the mid-western United States; a coniferous forest landscape in Labrador; a tropical rainforest in Columbia; and a Mediterranean landscape in southern France. On each flight they noted their observations of the patterns on the landscapes beneath them. Here is an example from their flight over the coniferous forest in Labrador:

> " No evidence of people anywhere. Yet **patches** very distinct. Peatlands, recent burned areas, lakes, beaver meadows, insect defoliation area. Patch sizes and shapes vary greatly. No straight borders on patches. Narrow **corridors** are present, though not very common. Stream corridors and low curving sandy ridges covered with pine and larch. Occasional intersections where stream tributaries come together. Background forested **matrix** of spruce and fir. Natural disturbances evident..." (Forman and Godron 1986:19).

From similar descriptions of each of the landscapes, the authors observed that despite the extreme differences which existed between the landscapes, they did appear to share a common, fundamental structure and "they were composed entirely of **patches, corridors** and a background **matrix**" (Forman and Godron 1986:23).

Function:

How do these structures function and how do they contribute to the overall functioning of the landscape as an ecological system? The observations of Forman and Godron can be summarized as follows:

Matrix: The most contiguous and connected vegetation type. This influences movement within the landscape as often objects will travel through the matrix itself, or will travel through corridors and have to cross the matrix at gaps in the corridors. The characteristics of the matrix, such as its connectivity and how hospitable it is to the objects involved, will determine how the matrix functions in this regard.

Patches: Areas which contrast with the surrounding matrix. These often act as special areas of habitat for species, and the species they contain depends largely on the size and shape of the patch. For example, a small patch will be penetrated easily by wind and other meteorological forces, and will therefore contain a lot of edge habitat, and so will support only those species adapted to 'edge conditions' (Pickett and Thompson 1978). This area of landscape ecology, dealing with the affects of patch size etc. has been comprehensively discussed in the literature. Island biogeography and recent concerns over habitat fragmentation are also concerned with patch size and the connections between patches (Harris 1984).

Corridors: Linear features forming connections between patches or areas of matrix. Forman and Godron identify four main functions of corridors : habitat for certain types of species; a conduit for movement along corridors; a barrier or filter separating areas; and a source of environmental and biotic effects on the surrounding matrix (Forman and Godron 1986). Again, the existence and function of corridors has been widely discussed in the literature, particularly within island biogeography theory in relation to their contribution to species flows within a landscape (Harris 1984).

Interactions:

According to Forman and Godron, it is the interaction of the individual elements and their functions as identified above, which determines how the landscape will function as a whole (Forman and Godron 1986). A wide range of landscape flows facilitates interaction both within and between landscape elements, and with the landscape pattern in aggregate (thus enabling the landscape to function as a system).

As well as recognizing the role of the internal components of landscapes, landscape ecology has identified change as an important influence on how a landscape functions ecologically. For example, change agents such as natural disturbances, are often responsible for the creation and alteration of the pattern of structures on the landscape. Forman (1987) observed that a natural disturbance event is generally "an excess in the level of objects (such as animals, plants, water, mineral nutrients, heat etc.) entering an ecosystem" (Forman 1987:219). Thus disturbances are much larger events than the normal *flows* entering and leaving landscape elements. They can be distinguished from flows by the fact that they cause a change in the landscape pattern.

The major natural disturbances recognized in most forested landscapes are fire, wind and insect attack (Baker 1989, Kimmins 1990). These events cause changes in the numbers and groupings of organisms occupying an area and are followed by a sequence of changes in the animal, plant and microbial communities that will successively occupy the area. This process is known as ecological succession (Kimmins 1987).

Although landscapes are dynamic and changing, it has been identified that for any given landscape there is a relatively predictable disturbance regime which will result in a particular pattern of vegetation on the landscape over time (Noss and Harris 1986). This has led to the proposition that an understanding of the scale, extent and type of these 'natural' changes in a landscape could conceivably provide some pointers for the design of proposed man made alterations to the landscape (Agee 1993). This is the route followed by

Total Resource Design, and a further description of the rationale used in the process is given below.

When attempting to understand the dynamics and effects of disturbances in the landscape, an important factor to consider is the scale at which they occur. As Urban et. al.(1987) observe, the pattern imposed on a landscape is generated by processes at various scales, both spatially and temporally. To conceptualize these different scales of process, a 'hierarchical theory' has been proposed. This recognizes that a landscape itself is part of a spatial hierarchy (i.e., larger than a landscape element and smaller than a region) and that the change agents which operate in a landscape also have a spatial hierarchy which must be understood. That is, that natural processes operate within landscape elements, throughout landscapes, and also over a wider extent (such as a region) where they may cross several landscape boundaries. Landscape boundaries are permeable, and flows can cross them easily. Zonneveld(1988) therefore considers landscapes to be 'open systems', and in his mind a landscape can only be described adequately if the influences of "other spatially linked components are also considered" (Zonneveld 1988:7). Thus, in any consideration of landscape functioning, the influences of adjacent land areas must be considered, as they can act as either a source or a sink for flows crossing the boundaries of the subject landscape.

Where does this understanding of a landscape as a functioning ecological unit lead? Diaz and Apostol followed the logic that once identified, the characteristics of the natural landscape pattern (and its associated functions), should be retained in any man-induced alteration of the landscape, if the natural ecosystem functioning of the landscape was to be retained. Landscape ecology has identified that landscape patterns influence the ecological functioning of a landscape (Franklin and Forman 1987), and that human induced patterns on a landscape can alter the natural pattern and thus the natural functioning of a landscape. Based on this argument, Diaz and Apostol then made the assumption that if resource management is to proceed without detriment to the natural functioning of the landscape, any actions taken should retain, emulate or mimic the natural landscape pattern. Any design of, for example, forestry operations in a landscape, should take direction from the ecological patterns on the landscape, and from the natural processes which created them.

Forman and Godron provide further advice. The type of forest mosaic desired in a landscape, and therefore the type of management which can be used (for example, even aged or uneven aged management), can be estimated from an examination of the natural disturbance regime of the landscape at one point in time. For example:

> " if extensive fires, pest outbreaks and the like are present, then whole tracts are typically even aged stands. If small fires, floods or blowdowns are present - a finer scale mosaic of even aged stands is naturally produced. If the natural disturbance is at an even finer scale, such as single tree blowdowns and defoliation, a multi-aged stand develops naturally" (Forman and Godron1986:503).

Within Total Resource Design, this information is used to guide the design of management units (principally their size and the method by which they can be managed) so that individually and together they contribute to a ' pattern' based on that which would be produced by natural forces in the landscape.

It must be emphasized that Total Resource Design does not follow 'nature' in a narrow and inflexible manner. This is due, in part, to the difficulties in defining just what 'natural' may be for a landscape. It is recognized that it is not always possible to determine what the natural disturbance patterns, or their effects, on a landscape are or have been in the recent past. This may be due to suppression of these disturbances over time, or to significant human manipulation of the landscape which may obscure any natural patterns previously present. Thus, TRD takes the clues that are available from the natural patterns and disturbance history of a landscape, and tries to adapt them to produce or maintain a distribution of 'desirable' structures in the landscape. This 'desirable ecosystem character' will not be truly natural (Agee 1993), but it is hoped that it will be a step towards maintaining natural components of landscapes during resource management, and that it will be more meaningful and useful than merely being given the vague concept of a 'natural forest' to aim towards. In the future, with an improved understanding of the natural dynamics of a landscape, it may be possible to develop a method through which human impacts on a landscape can mimic nature more effectively. For now, however, methods like those of Total Resource Design can only work within the bounds of the limited information available and an awareness of this limitation is very important. Guess work may be required in many cases.

Recognizing that our information on how natural landscapes function is not complete, the method derived for Total Resource Design provides a framework for analysis based on the principles of landscape ecology, which aim to provide as great a level of understanding of the subject landscape as possible. It is hoped that the results of this analysis, despite limitations, will be sufficient to allow a desirable pattern to be estimated, from which design and management solutions for integrated resource management can later be derived.

Chapter 3 Total Resource Design - the method

3.1 Introduction

The aims of this chapter are to outline the steps in the Total Resource Design method, and to explain how each step evolved through an application of the process to the West Arm Demonstration Forest, Nelson, B.C., which took place during a workshop held in Nelson from 24th-28th January 1994.

It is hoped that this chapter can, if desired, stand alone as a set of instructions for any future application of Total Resource Design in British Columbia. Its value lies in the fact that it presents all current work on Total Resource Design in B.C. and combines this with the concepts and lessons developed from a similar application in Mount Hood National Forest in Oregon (Diaz and Apostol 1992). The result is an interpretation of how Total Resource Design should be practically implemented if it is to be successfully applied in British Columbia. It is based on a brief outline for the method for TRD produced by Bell (Bell 1993a) which was found to be insufficient for implementation of the process in a practical case study (the West Arm Demonstration Forest) and is supplemented by reference to the work of Diaz and Apostol, and the experience gained through involvement in the application of TRD to the West Arm Demonstration Forest. The results of the WADF application are presented in this chapter both as an illustration of the process, and as a record of the added detail required to make Bell's outline applicable in practice. The results from the WADF application should also help to highlight some of the strengths and weaknesses of the method, which became evident on its application. Where steps of Total Resource Design have not been completed for this example, the design team involved have, in effect, made forecasts to allow future completion of the steps to occur according to a decided direction.

Total Resource Design proceeds in a logical series of steps. Before these are described, the overall design process which acts as a framework for the steps of the method, will be examined to set a context for the subsequent description of each of the steps.

3.2 Total Resource Design : a design process

Total Resource Design is a design process. The process is common to all design professions, whether they are concerned with buildings and structures, landscapes or clothing. Each starts with a problem and arrives at a series of solutions within a context, and, in the end, each has designed an item which must work (Nelson 1975 in Thiel 1981). The design process involves purposeful planning, i.e., "the designing of courses of action aimed at changing existing situations into preferred ones" (Thiel 1981:32). Thiel continues:

> "More specifically design may be said to be a means of optimizing the use of limited resources, time and materials in the realization of predetermined objectives in circumstances where no satisfactory precedents exist. Since we are interested in the "best" way of accomplishing this goal, we face the necessity of originating and evaluating alternatives and then choosing among them."(Thiel 1981:32)

Total Resource Design is an application of this design process to forest landscapes. As such it follows the same fundamental steps as those followed in the design of, for example, a building or a golf course (S. Bell pers, com, 1993). It progresses from an identification of the problem to the production of various possible solution scenarios. Figure 1 shows one interpretation of a general design process, and the steps it involves.

Notice the logical progression of steps in a design process, and the various points where feedback occurs, so that the results of each phase can be iterated and modified. The process is dynamic and ensures that there is always scope for improvement and the accommodation of new issues and stakeholders as they arise. The results of scenario generation are simulated visually, in drawings, sketches or using a computer. It is this visual articulation of the solutions which takes design beyond the realms of planning, and provides graphics which can easily be assimilated and evaluated by the public or the client.

This basic design process is the template on which the method for Landscape Analysis and Design , and later Total Resource Design were based. Details and refinements were added to this framework to make the design process specific to its subject - the forest landscape - and to allow the logic and aims of Total Resource Design to be met.

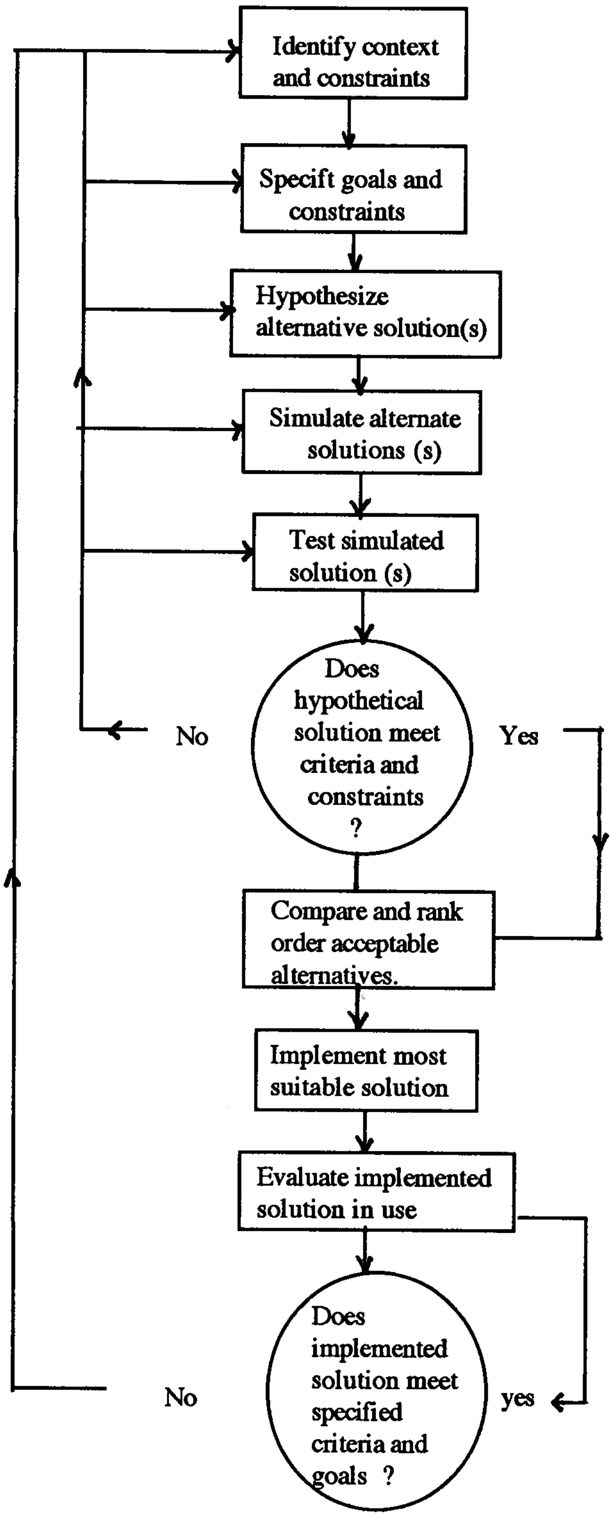

Figure 1. The steps involved in a design process (Thiel 1981:33)

Bell (1993a) presented the method for TRD as a series of seven steps as follows:

1. Assembly of the design team;
2. Identification of design units;
3. Setting objectives;
4. Landscape survey;
5. Landscape analysis;
6. Design concept generation; and
7. Sketch design .

Glancing at these simple steps, it is unclear how they fit together to form a sequential and iterative design process as outlined in Figure 1. For this reason,the seven steps proposed by Bell have been re-labeled in this chapter and presented in a manner which allows the logical sequential order of the process to be easily identified. In essence, the fundamental framework outlined in Figure 1 has been revisited and the generic titles of each step have been replaced with labels specific to Total Resource Design. Six main steps have been recognized, with the following titles:

1. Preparation;
2. Setting objectives for the landscape;
3. Survey of the landscape;
4. Analysis of inventory information;
5. Scenario development; and
6. Assessment and choice of final design.

These steps can be grouped into two phases :analysis and design. Figure 2 below, shows each of these steps and how they interact to form a design process in Total Resource Design. Shading has been used to differentiate between the two phases of the process.

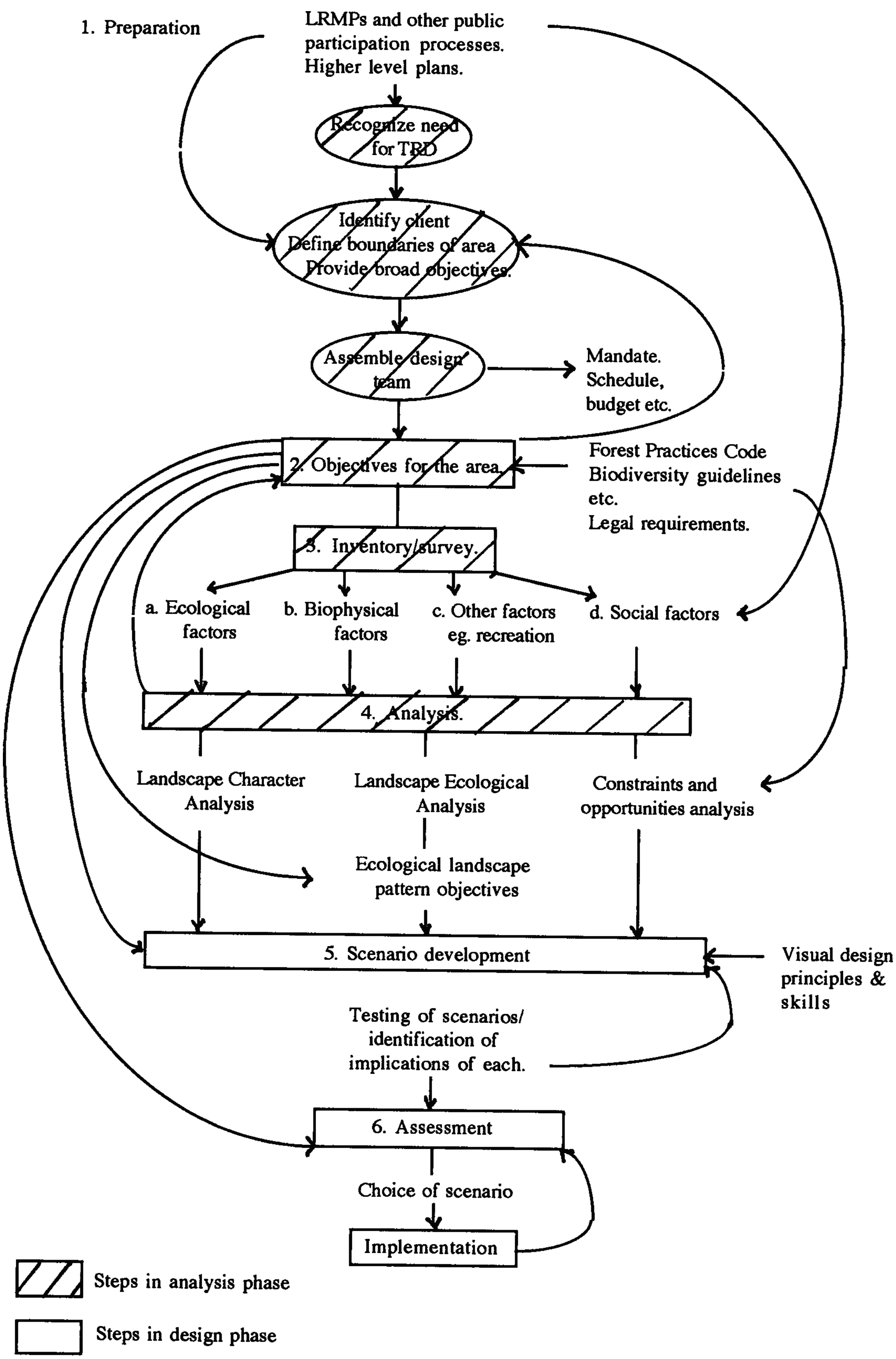

Figure 2. The steps involved in the Total Resource Design process.

It is hoped that this revised presentation of Total Resource Design will illustrate that it is really a 'customized' design process which follows an accepted framework used by all design professions.

3.3 The Total Resource Design workshop

3.3.1 Aims of the workshop

The application of Total Resource Design to the West Arm Demonstration Forest took place in Nelson from the 24th to the 28th January 1994. The workshop was set up, funded and administered by Ministry of Forests staff from the Nelson Region and Kootenay Lake District offices. It was led by Mr. Simon Bell and involved staff from the Ministry of Forests, the Ministry of Environment, Lands and Parks, B.C. Parks Service and several members of the local public.

The aims of the workshop were three- fold:

1. To apply the method and to answer the question, 'can TRD be practically applied in B.C.?';

2. To produce a Total Resource Design for the West Arm Demonstration Forest, to be used for the promotion and demonstration of up-to-date planning and design processes to industry and the wider public; and

3. To evaluate and analyze the end product, in terms of costs, harvest projections and resource implications, primarily in comparison to current Integrated Resource Management planning approaches.

Objective 1 is the only one which has been achieved to date, and is the primary focus of this thesis. The remaining two steps will be completed by the Ministry of Forests within the next year or two.

3.3.2 The Study Area.

The West Arm Demonstration Forest is an area of approximately 14, 500 hectares located on the north shore of Kootenay Lake, within Kootenay Lake Forest District.

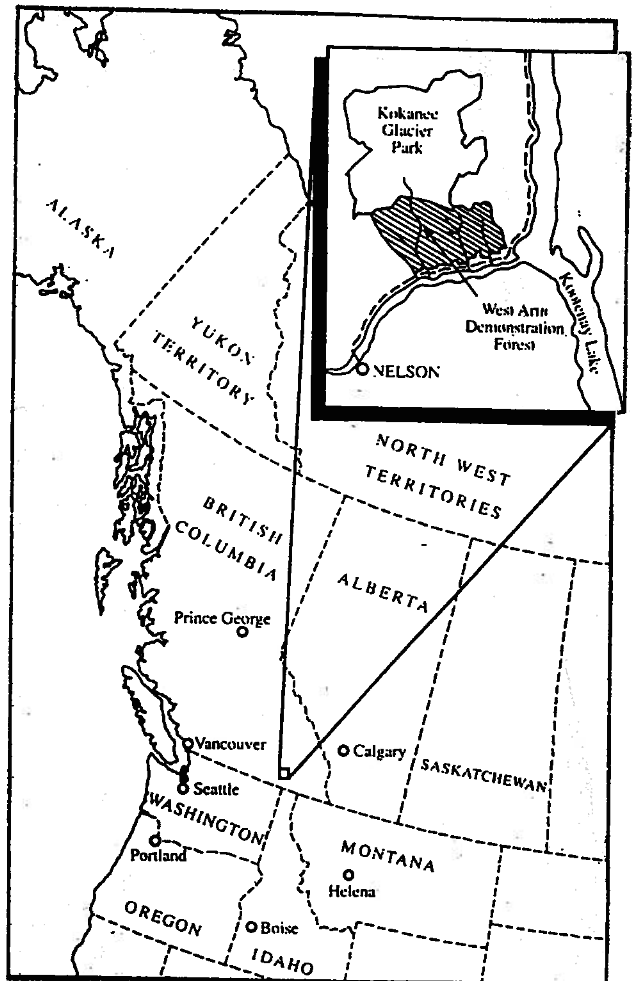

Figure 3. The West Arm Demonstration Forest[1]

This forest was originally designated as a demonstration forest in response to local public concerns with current forest management practices. It was fconsidered to be an excellent site for an application of Total Resource Design because of its size, its many resource values and the extent of the inventoried information which exists for each resource in the area. The specific resource values of the West Arm Demonstration Forest (WADF) have been listed by the Ministry of Forests, Nelson Region as follows:

- Five domestic watersheds with a total of 166 water licenses;

[1] Graphic provided by Simon Bell, British Forestry Commission.

- Tourism values because of its adjacency to Kokanee Glacier Provincial Park and the West Arm of Kootenay Lake;
- Large number of wildlife species;
- An ecological reserve of old growth ponderosa pine forest;
- Two spawning channels for Kokanee salmon; and
- A viewscape for the towns of Harrop and Proctor and for boaters on the West Arm of Kootenay Lake (MOF (Nelson Region) 1992, unpublished).

Two biogeoclimatic zones (Meidinger and Pojar 1991) are represented in the West Arm Demonstration Forest: The Interior - Cedar Hemlock (ICH) Zone , which is found in the lower to middle elevations (within this zone the two subzones ICHdw and ICHmw are the most common); and the Engelmann Spruce - Subalpine Fir (ESSF) zone, which is the uppermost forested zone in the WADF.

With such a wealth of resource values, in addition to timber and research interests, the West Arm Demonstration Forest provided a challenging site for the first application of Total Resource Design in British Columbia.

3.4 The Method and the results of its application to the WADF

This section will describe the method which evolved from the West Arm Demonstration Forest workshop in a step by step manner, with the results from the WADF application used as an illustration for each step.

3.4.1 Preparation.

This step encompasses all of the stages which have to be completed before the Total Resource Design process itself can be started. Once it has been established that a Total Resource Design is required for an area (which may come from a public planning process such as a Land and Resource Management Plan (LRMP)[2] or from a higher level forest plan, such as a Regional plan) a 'client' should be identified. This client is the person or party for whom the Total Resource Design is being prepared and could be, for example, a senior member of the Ministry of Forests, a public planning group, a forest company etc. The 'client' will outline the boundaries of the area of study and provide broad objectives and direction for its management. These decisions should be related to any issues identified for the area in higher level plans and LRMPS, etc.

This step also gathers those individuals with expertise and knowledge of the area together in a design team. This team will include local staff from Ministry of Forests District office, the appropriate Forest Regional Office, other agencies (such as Ministry of Environment, B.C. Parks, etc.), several interested members of the public and any other important stakeholders.

At this point it is also advisable to divide the total area into sub-units on paper, for final design purposes. This will facilitate the design process, making data management and the visual design process less complex.

WADF Example.

The client:

The client, although not formally identified in this case, was assumed to be a senior member of staff of the Nelson Forest Region. A design team was brought together, and was responsible for the collection of data, its analysis and the development of the design. It consisted of 19 participants, representing different disciplines within the Ministry of Forests, Nelson Forest Region and Kootenay Lake Forest District, the Ministry of Environment (Fish and Wildlife, and Water Management representatives) and several members of the public. The team was led by Mr. Simon Bell, who also participated as the

[2] LRMP - 'A strategic,multi-agency, integrated resource plan at the sub-regional level. It is based on the principles of enhanced public involvement, consideration of all resource values, consensus-based decsiion making, and resource sustainability' (Province of British Columbia 1994:183)

team 'designer', due to his expertise in visual design. For a complete list of the design team and the agencies they represented at the workshop see Appendix 1.

Design Area:

The design area for this case study was the entire West Arm Demonstration Forest. This was divided into 16 sub-units, which were determined using the natural features of the landscape. Often the entire face of a hillside or the areas between two side valleys were identified as units. To do this, possible units were first identified on a topographic map. These areas were then photographed from the ground and from a helicopter, ensuring that the photo points and elevations were noted accurately, thereby compiling a comprehensive panoramic photographic record for each unit. Using the photographs, the final boundaries of each unit were decided and plotted on a base map by Kootenay Lake Forest District staff prior to the workshop.

Broad objectives and guidelines:

Various existing plans for areas of the West Arm Demonstration Forest, and regional resource guidelines were used to provide several broad objectives for the resources present. For example, the draft Interior Fish, Forestry Wildlife Guidelines (MOE and MOF 1993), Soil Conservation Guidelines for Timber Harvesting (Interior B.C.) (MOF 1993a); and the Kootenay Lake Domestic Water Contingency Plan (MOE Nelson 1993 unpublished) were all consulted. Specific standards for the region for the implementation of the Forest Practices Code had not been released at the time of the workshop, and so the design team could only estimate any restrictions this might confer on the management of the area in the future. All of this information was collated into a report prior to the workshop by members of the design team and provided useful reference in the steps which were to follow (MOF Nelson 1994 unpublished).

3.4.2 Setting objectives for the area.

This step interprets directions and guidelines from higher level plans and refines them into more specific objectives for the area and its resources. At this stage any requirements which must be met in the area under the Forest Practices Code (Province of British Columbia 1994), biodiversity or wildlife guidelines and other legislation should be identified and outlined so that they can be incorporated in subsequent steps. The objectives determined at this stage will not necessarily be fixed, as later analysis of the area may provide evidence that some of the objectives require modification. It is important that this information can be fed back into the objectives and that they can be altered accordingly.

WADF Example :

Having carried out the background preparation, decided broad objectives for the area and selected relevant information from available plans and guidelines, landscape objectives for the resources present in the WADF were developed by the design team. A series of measures were devised to accompany each objective. These were essentially a set of directions which, if followed, would ensure that the objectives would be met and were felt to be a useful addition to the method originally proposed by Bell.

During this stage of TRD, it was often necessary to remind the design team that the objectives being set were those for the landscape, as there was a tendency for many of the design team to become embroiled in stand level detail.

The landscape objectives and measures finally produced are outlined in Table 1.

3.4.3 Survey of the area.

The landscape survey collates information for the area for all resources present, from available inventories and local knowledge. Information on ecological, biophysical and social factors is collected, along with any inventory information on the recreation and landscape characteristics of the area. Social issues, such as local community concerns and

Table 1: Landscape Objectives for the West Arm Demonstration Forest.

Resource	Objective	Measures
1.Water Resources	To maintain and enhance water quality and the quantity and timing of flows.	. do not exceedrecommended equivalent clear cut areas (ECAs)[3] for watersheds. . leave buffer zones (width relative to stream class) . maintain natural drainage patterns (e.g, avoid areas with multiple small watersheds as the quality of these will be difficult to maintain if development takes place).
2.Fish &Wildlife Resources.	To protect and enhance fish and wildlife resources.	. establish protective zones for critical /sensitive habitats over time. . ensure all site/seral types and stages are present at a suitable level at any time (to ensure that the quantity and distribution of habitat types is maintained through the forest as a whole).
3.Soil and Landform Resources.	To maintain soil/ site productivity and reduce site degradation.	. minimize presence of roads and landings and other permanent features (i.e.,the minimum number necessary to implement the plan). . identify and specify operations for sensitive units.
4. Roads (and logging systems).	To minimize the impact of roads while meeting engineering specifications.	. ensure optimum density of roads is proposed. . ensure that locations avoid sensitive areas and blend into the landscape. . ensure that road access can be arranged to protect wildlife values.
5.Timber Resources.	To maintain a sustainable supply of timber while integrating other resources.	. determine the AAC[4] resulting from the silvicultural systems to be used in those units that are planned for intervention (as opposed to those planned for non-intervention/reserve etc.) over the plan period. . ensure that these units are feasible.
6.Old Growth Resource.	To maintain sufficient quality, quantity, types and distribution of old growth over time and landscape.	. ensure existing old growth areas are identified and managed. . ensure that areas are identified to be managed to produce old growth to fill gaps or replace areas in due course. . ensure that as much' old growth' value is maintained or enhanced throughout the forest.
7.Forest Health.	To ensure that forest health problems remain at an endemic level (i.e. not catastrophic - below level that can pose an economic risk).	. ensure that proposed practices/silvicultural systems do not promote pests and pathogens.
8. Recreation.	To provide for a variety of recreational uses appropriate to the carrying capacity of the forest ecosystem.	. ensure that significant features are preserved. . ensure that use is dispersed in space and time. . ensure that recreation opportunities are protected, specifically in the Kokanee Creek valley. . ensure that the recreational settings are maintained or enhanced in quality.
9.Visual landscape.	To retain a high standard of visual integrity across the forest.	. ensure that units and openings fit the landscape. . ensure that the optimum level of visual diversity is maintained or enhanced. . ensure that areas of special *genius loci* [5] are protected.

[3] ECAs. The hydrological impact of harvesting is proportional to the % of crown closure removed. The % is expressed in terms of the number of ha of clearcut it is equivalent to.

[4] AAC - Allowable Annual Cut: 'the volume of timber approved by the chief forester to be harvested annually' (Province of British Columbia 1994:173)

[5] Genius loci- the 'spirit of place', unique quality one place has over another (Bell 1993)

existing public use of the area may already be known from previous public participation processes such as Land and Resource Management Plans (LRMPs). This information can be input into Total Resource Design at this point. If such information has not been previously collated for the area, it should be obtained at this point so that social issues can be incorporated into the design process.

WADF Example :

Maps of all of the inventoried information for the WADF which had been produced to date were assembled and an attempt was made to fill in any gaps in this information using the design team's knowledge of the area. One colour copy of each map was then prepared at a standard scale (1:20 000) and with the study area boundary marked.

Table 2 provides a list of the inventory information prepared for the WADF application.

3.4.4. Analysis.

Landscape analysis is carried out to provide an understanding of how the subject landscape functions ecologically and visually and to determine how its attributes could constrain or provide opportunity for the development of the forest resources. This understanding is used along with a knowledge of existing direction and local issues, to derive objectives about a desired 'landscape pattern' for the area of concern.

Three different aspects of the landscape are analyzed in this step:

. constraints and opportunities

. landscape ecology

. landscape 'character'

The implementation of these analyses requires a multidisciplinary approach in which the design team work together to build a 'picture' of how the landscape functions in respect to all the resources present. They must take the data collected in step 3 and assimilate it into something which will form the basis of a design.

Table 2: The inventory information collated for the WADF workshop.

Resource	Inventory Information Prepared (Mapped)
Landscape Quality/visuals	Landscape units with labels for Landscape Sensitivity Rating[6], Visual Absorption Capability[7], Visual Quality Objectives[8] and viewpoints Areas of high *genius loci.*
Recreation	Inventory of sites and trails Description of how the public use the landscape Recreation Opportunity Spectrum (ROS)[9] objectives Potential for interpretive trails
Silviculture	Previous silvicultural activities and NSR (Not Satisfactorily Restocked) areas.
Forest Health	Areas of known or suspected insect / disease attack Types of pathogen and population estimation
Timber	Area of land by timber age classes and inoperable areas AAC for the area
Transportation and logging	Location of existing roads and potential road locations Inoperable areas The scope of available logging systems
Riparian areas	Location of riparian zones along all water bodies showing minimum protection required
Hydrology	Location of watersheds and areas where buffer zones are required. Routes of water movement. Location of domestic water intakes.
Soils - sediment yield hazard	Hazard calculated and mapped, on the basis of the combined potentials for sediment delivery, mass wasting and surface erosion (using Map Attribute Data Manager Program)
Soils - mass wasting hazard	Calculations of hazard rating based on soil texture and types. Location of each rating - mapped
Research	Location of areas required for existing and planned research, and of the protection zones required around each plot.
Botany/plant ecology	Main biogeoclimatic zones, subzones and site associations Location of any rare, unique or sensitive vegetative types
Fisheries	List of the species present in each water body Location of sensitive sites List of any threatened or endangered species
Wildlife biology	Location of known habitats of some species Patterns of migration or movement List of any sensitive or 'at risk' populations
Archaeology	Location of areas of historical use by indigenous inhabitants, position of stone oven.
Estimated tree height class	Map of tree height classes
Forest cover	Map of forest cover inventory information and complete labels Topographic features such as mountains and water bodies
Topography	Topographical map showing contours at 20 m intervals, streams, roads and any other man made features.

[6] LSR: extent to which people may be concerned about landscape alterations (MOF 1991)

[7] VAC:ability of landscapes to absorb physical alterations without damage to their scenic values (MOF 1991)

[8] VQOs:Degree of acceptable alteration of the characteristic landscape (MOF 1981)

[9] ROS: A system of categorizing recreation opportunities according to the degree of solitude, roaded access, and type of recreational activity. Categories include: Rural, Roaded Resource, Semi-primitive Motorized, Semi-primitive Non-motorized, and Primitive.

3.4.4.1 Constraints and Opportunities analysis

The constraints and opportunities analysis is fairly straight forward and does not require much explanation. In brief, it sorts the inventory information into two sections : those factors which will constrain the designer's options for action, and those which will provide opportunities, thus providing guidance on areas in the landscape where certain types of development might be possible, or where they should be avoided. Generally, constraints are often obvious and manifest themselves in guidelines for operations produced for a region. Others are a result of landscape characteristics and are identified through an analysis of the information collected for the area. Opportunities are often less obvious than the constraints but can be identified when there appears to be a certain option, or a number of options available for the management of a specific resource in an area. Ideally, the location of the opportunities and constraints should be illustrated on a map of the area, and annotated with a description of their characteristics. They should also be placed on perspective views of the subject landscape, so that it can be easily incorporated into the later design of the management units.

WADF Example:

Each member of the team representing a particular resource, briefed the team on the various constraints and opportunities associated with 'their' resource. The list of constraints and opportunities on each resource across the landscape was then expanded or narrowed through discussion with the team. Those constraints and opportunities which would affect the overall design were located on acetate overlays of the base map and later transferred to perspective photographs, in preparation for the design phase.

Figures 4 provides an illustration of how the results of this analysis were illustrated for one area of the WADF (Queens/Laird Creek area), in perspective view. The locations of the constraints and opportunities across the entire landscape are illustrated in plan form in Figure 5. Table 3 then provides a summary of their main characteristics.

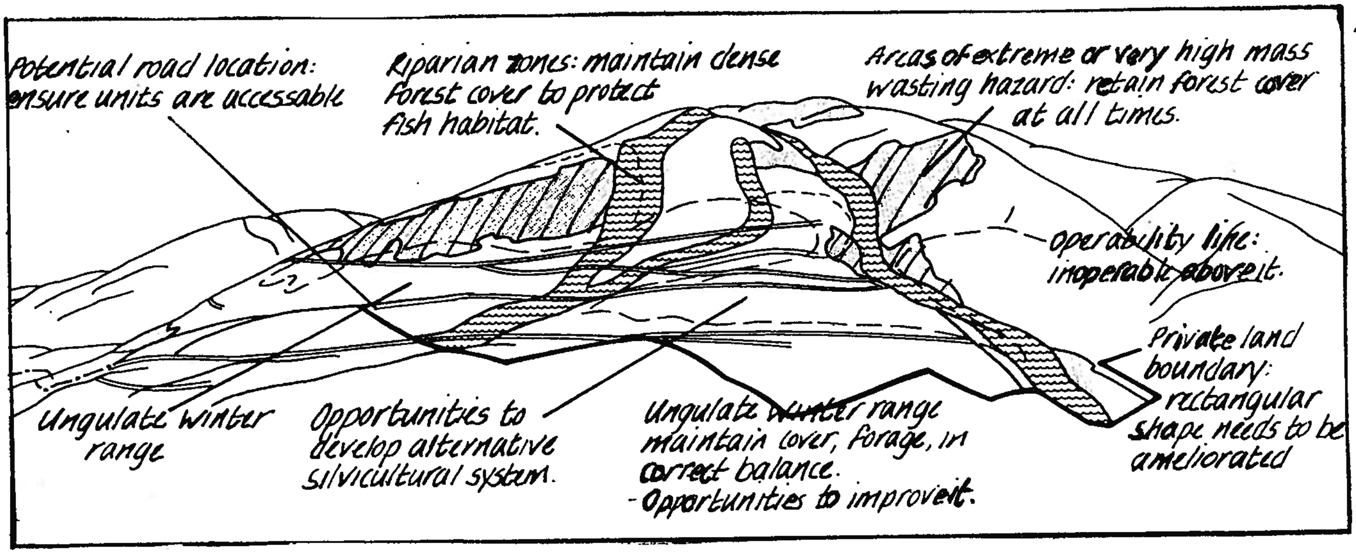

Figure 4. Perspective illustration of the constraints and opportunities on the Queens/Laird creek area of the WADF (south east corner)[10].

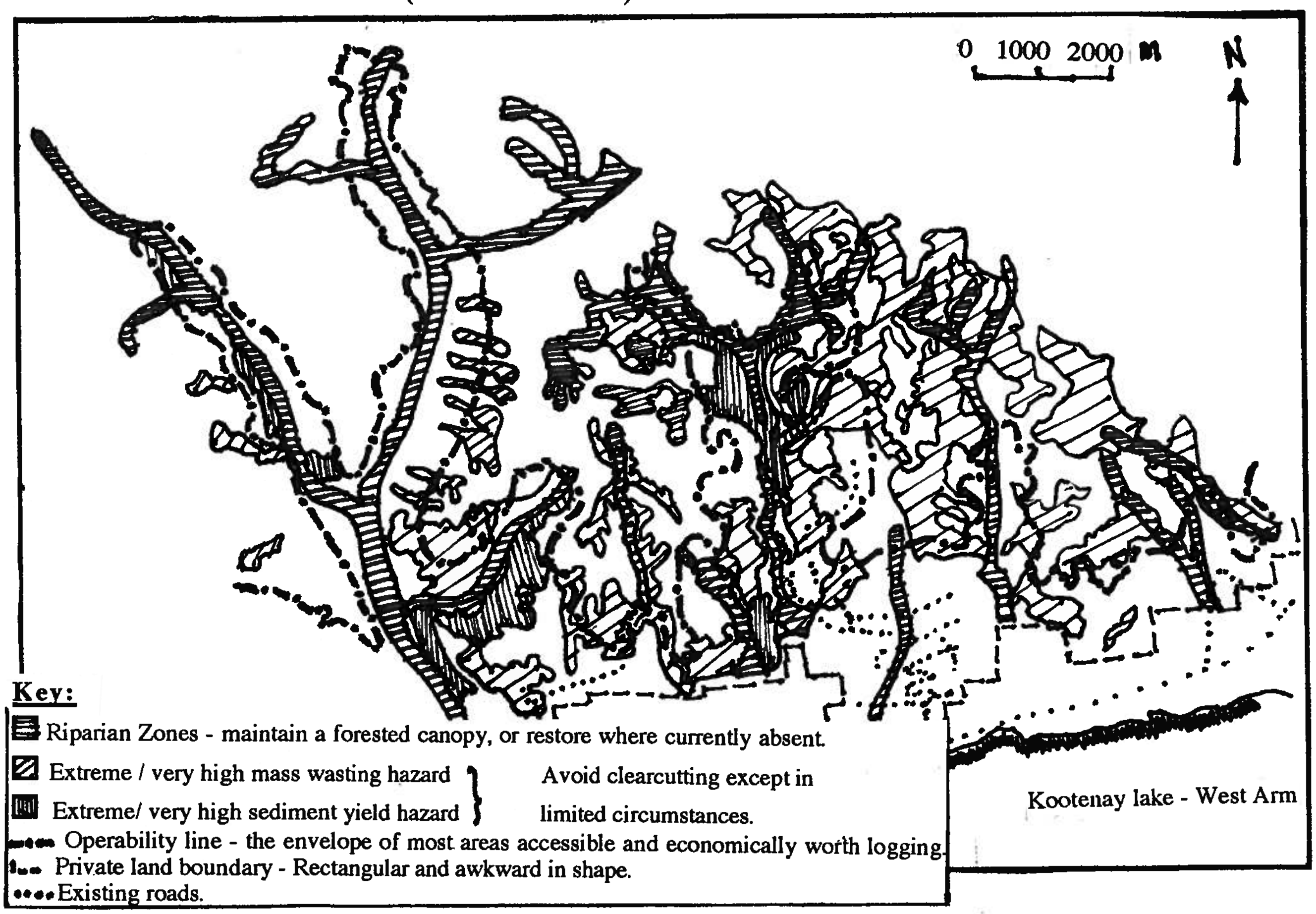

Figure 5. The location of the main opportunities and constraints in the WADF.

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[10] Graphic provided by Simon Bell, British Forestry Commission

Table 3: Constraints and Opportunities for the WADF.

Resource	Constraints on development	Opportunities for development
Landscape/ visuals	Future modification or improvement of the shapes of existing blocks may be constrained by public opinion VQOs of preservation/retention suggest that the landscape is of high quality and that this should be maintained, thus constraining clearcut harvesting in these areas	Modification of the shapes of existing blocks would provide opportunities for further harvesting In some areas the existing visual condition is better than the VQO stipulates - thus there are opportunities for further harvesting in these areas
Recreation	Logging roads would increase access to pristine areas; the negative impacts of this should be considered	Kokanee Creek corridor provides the greatest potential for increasing recreation opportunity by taking in part of West Kokanee road and trails Further opportunities for trail access to small lakes for day hiking Alteration of the shapes of the 'square' recreation areas would provide opportunity for harvesting while improving their shape
Timber and engineering	Siting of roads close to trails would not be publicly acceptable Areas of high mass wasting and sediment yield require precautions Most harvesting in this area is constrained to some extent by existing visual and recreation activity	Only great opportunity for clearcut timber extraction in west Kokanee where no VQOs have been assigned by the MOF Some higher elevation areas could be harvested using helicopter
Wildlife & fish habitats	Riparian areas and zones of influence of streams. Activities limited in these areas. Avalanche tracks are important bear and goat habitat : suggest retain 60% crown closure forest cover 100m along at least one side of the avalanche track Old growth reserves and potential reserve areas should be preserved	Late winter habitat on south slopes (and to a lesser extent, mid winter habitat) - requires open canopy. This is a harvesting opportunity providing 40% of forested habitat of height class 3 or greater and 60% crown closure are left behind. There are several areas of old growth which could be reserved thus increasing representation of old growth in the landscape
Research plots	Maintain forested buffers around existing research plots - constraint to harvesting. Identified areas have been removed from operable forest base for period of 4 years for research purposes	There may be opportunities for more harvesting as a part of future research

3.4.4.2 Landscape ecological analysis.

The landscape ecological analysis employed in Total Resource Design was developed by Diaz and Apostol in the Mount Hood National Forest in Oregon (Diaz and Apostol 1992). To quote them directly, the logic behind this stage was to "understand the landscape as an ecological system, in terms of structure, function, processes and context within the larger landscape" (Diaz and Apostol 1992: 4.1). It is based on the principles of landscape ecology and proceeds in a series of five logical steps, designed to identify the following factors:

i) Landscape structures;

ii) Landscape Flows;

iii) The relationship between the structures and the flows;

iv) Natural disturbance and succession patterns in the landscape; and

v) 'Linkages' beyond the landscape.

This analysis, as a whole, aims to identify landscape pattern objectives and give guidance to the designer so that ecological issues can be fed into the development of design scenarios (Bell 1993a). Figure 6 illustrates how the five steps fit together.

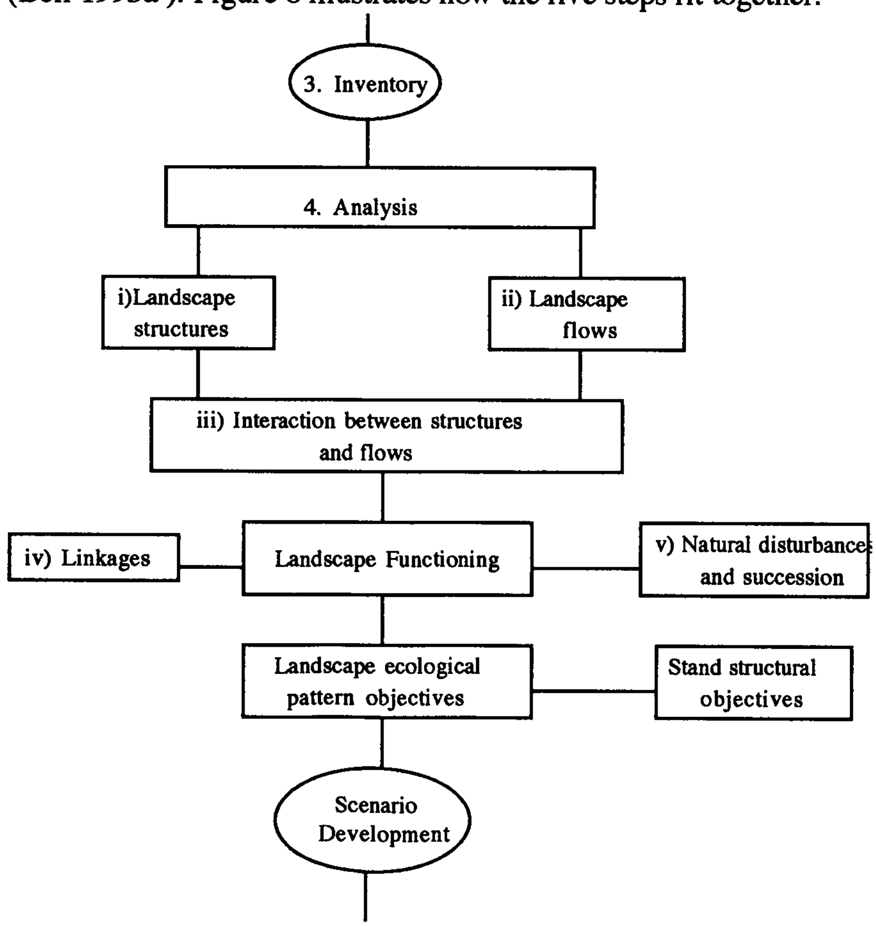

Figure 6. The steps of landscape ecological analysis.

i) Landscape Structures.

Structures in the landscape are identified from an examination of inventory information and aerial photographs. These are then classified according to the following descriptions:

Matrix : the most contiguous and connected vegetation type, terrain or land use.

Patches : areas which contrast with the surrounding matrix. They may be homogeneous areas of vegetation, or non- living areas such as rock outcrops, wetlands, clearcuts etc.

Corridors : linear features forming connections between patches or areas of the matrix (Diaz and Apostol 1992).

To help visualize this classification of landscape structures, Diaz and Apostol used the analogy of a chocolate chip cookie : the cookie dough is the matrix and the chocolate chips are the patches.

WADF Example:

Deciding on the criteria to be used for the identification of the forest matrix in the WADF proved to be difficult as no exercise of this nature had been done before for the forest types present. Appearance and physical characteristics alone were not sufficient to allow the team to delineate between structures. Therefore the functions they carried out in the landscape were also considered.

The first step taken by the team was to examine the available aerial photographs of the area and the mapped information of forest cover, age classes, height classes and biogeoclimatic zones and subzones. The matrix (following the definition given above) was identified as all those areas of mature forest which had reached the stage of crown closure. Continuous forest cover was felt to be the deciding criteria in this decision. The team initially attempted to identify a single age class or group of age classes which would constitute the matrix, but when identified on a map of the area these did not conform to the definition of matrix; often one or two age classes were not abundant enough in the landscape to be considered as the 'background' within which the other elements sat. Hence, the wider classification, which used both age and height classes to identify the matrix, was chosen. Different 'elements' of the matrix were then identified. These were areas of the continuous forest cover which were felt to have different functions and often, different appearances, but which together constituted the matrix. For example, age classes 8 and 9 were identified as an element of the matrix because their old growth attributes support different organisms and functions than younger areas of the matrix. Table 4 provides an outline and description of the different elements identified.

The remaining 'non-matrix' vegetation in the landscape was all of age class 1. Therefore to identify vegetation patches height classes were used, with the premise that stands of different heights carried out different functions, especially in relation to wildlife habitat. Other patches, such as avalanche tracks, rock outcrops and water bodies were also identified, as were the various corridors present in the landscape, using the definitions given above as guidance. People were recognized as an important component of the landscape and therefore the patches and corridors created and used by them were also included.

All of the structures identified are outlined in Table 4. Their distribution or pattern within the West Arm Demonstration Forest are illustrated in Figures 7 and 8 .

Table 4 Landscape structures identified in the WADF

Elements of forest matrix	**Description**
Alpine /Forest Parkland	
Old Growth	Age class 8&9. If areas of age class 7 show old growth characteristics they could be included in this category.
Mid seral	Age class 3-6 . Age class 7 may be included in this category if it shows mid seral characteristics
Pole stage	Forest stages from crown closure to 20m height. (Essentially height class 2.)
Patches:	
Sapling	Height 2-5 m
Shrub/forb	Height 0-1m
Avalanche Tracks	
Rock Outcrops	
Water	Lakes and Wetlands
Old burns/berry patches	
Hardwood areas	
Corridors:	
Riparian Areas	
Streams	
Roads/Skid Trails	
Powerlines	

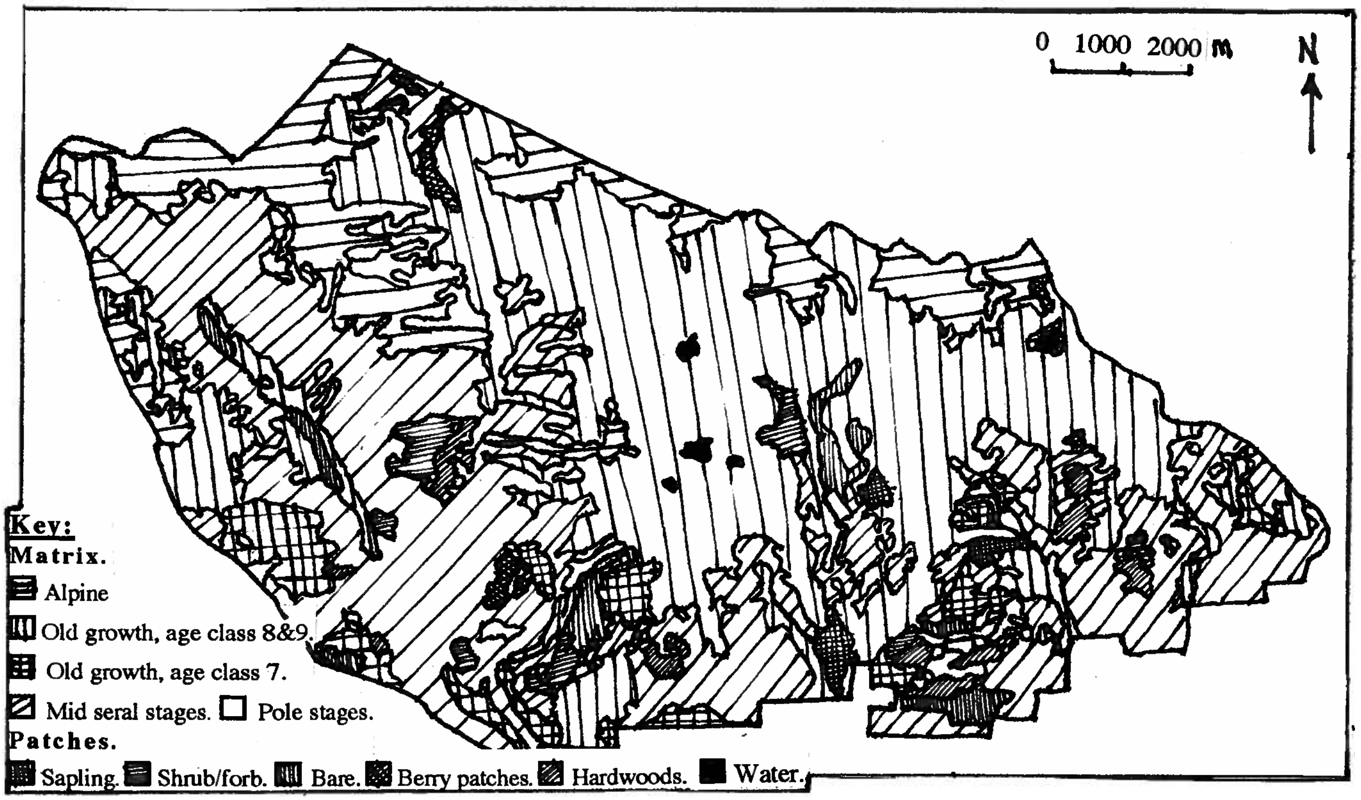

Figure 7. Location (and pattern) of landscape matrix and patches in the WADF.

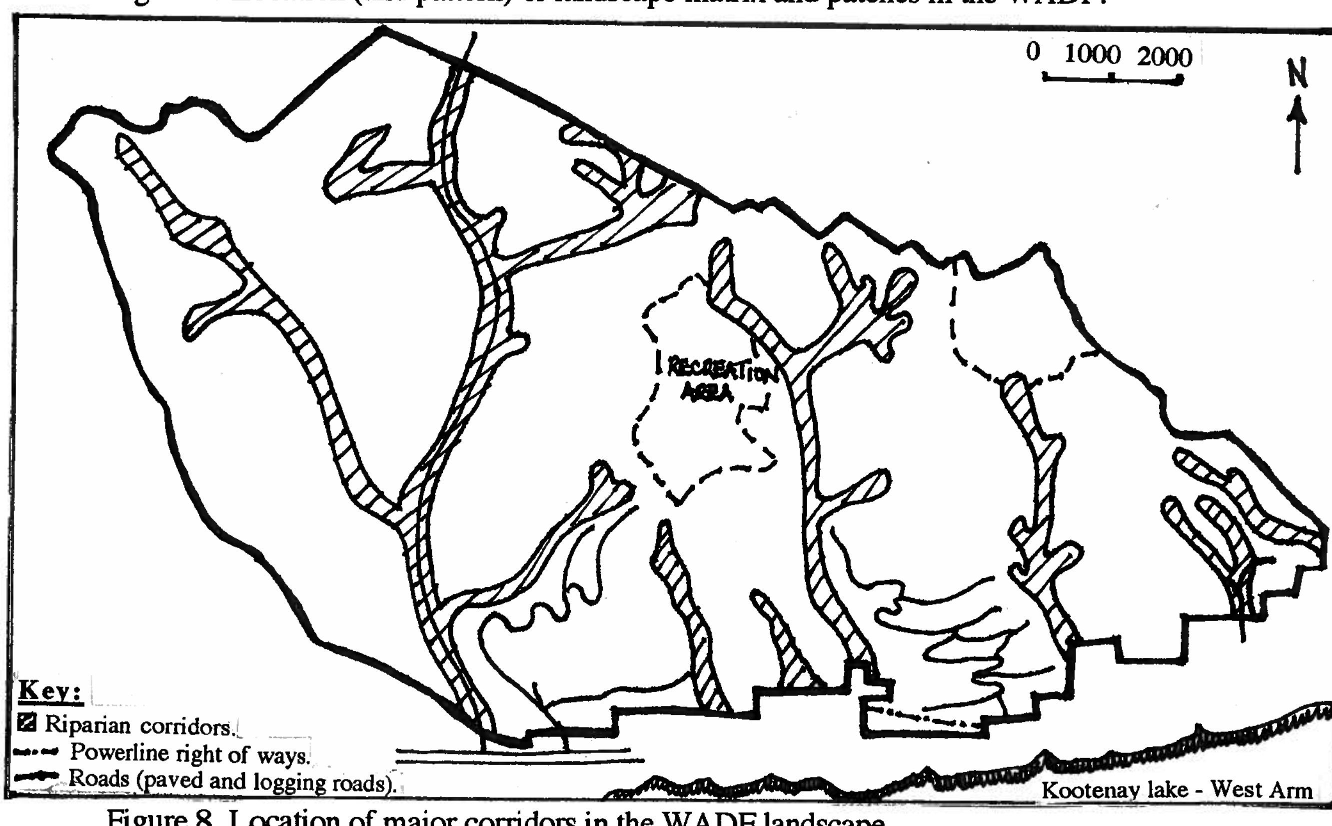

Figure 8. Location of major corridors in the WADF landscape

As implied above, a solution to this step of the analysis required discussion and experimentation, especially in areas where no single type of vegetation was evident as a matrix. It was felt to be a very valuable exercise as it challenged the team to think about the landscape and its component parts in relation to their ecological contribution to the landscape. Any difficulties which were encountered related mostly to a lack of detailed survey information on the ecological attributes of the area. Generally speaking, inventories are carried out within the Forest Service with the purpose of providing information for timber harvesting prescriptions, not ecological analyses. Labels on forest cover maps therefore do not tend to yield much detailed information about 'non tree' species. In this case the team had to find the original survey information and stand descriptions for the WADF to obtain any detailed information on the different seral stages and species of understory vegetation present in the landscape. It is recommended that this information be obtained from files and made available to the design team from the outset in any future application of this process.

ii) Landscape Flows:

Landscape flows can be thought of as those things that move across or through landscapes, whether in the air, over land or in the soil (Diaz and Apostol 1992). Diaz and Apostol identify water, wind, fire, animals (flying, swimming and ground based), plants and humans (of various user groups) as the most important flows in a landscape. They stress that an aim of flow identification is to develop a pattern of landscape elements which will encourage the continued presence of important landscape flows. To help determine what this pattern should be, they suggest that the following questions can be asked:

> " In the future, what flow phenomena will be critical in this landscape?"
> "Which flow phenomena are most likely to be affected by human activities?" (Diaz and Apostol, 1992:4.18).

The aim in answering these questions and incorporating the results into the design is to ensure that the temporal variations in flows through the landscape are accounted for. Similarly, the spatial arrangement of the flows in the landscape can be identified and mapped by answering the following questions:

> "Where in the landscape does a particular flow occur?"
> "Is it dependent on a particular landscape element (matrix, patch, corridor)?"
> "What is the direction of the flow?"
> "What is the timing (e.g., is it seasonal?)" (Diaz and Apostol 1992 :4.19).

WADF Example:

In order to answer these questions for the West Arm Demonstration Forest, flows were identified as those movements which occurred across the landscape elements, ignoring those which were confined within stands or vegetation types. This emphasis on the landscape level was to ensure that only those factors which influence, or are influenced by, the landscape structure were identified.

This step provoked much discussion within the design team. For example, it was recognized that flows would not only have to be identified, but also mapped in this exercise. This revealed a major gap in the knowledge of the ecology of the West Arm Demonstration Forest. The team members were able to identify many of the animals and otther resources which moved within the landscape, but were unable to accurately locate these movements in many cases. Nevertheless, an attempt was made, based on the information available and the expertise of the team members. They started with those flows for which accurate information was available:

People:

Movement of people within the West Arm Demonstration Forest has been inventoried. The main flow within the West Arm Demonstration Forest is for recreation purposes, along Kokanee Creek Road to and from Kokanee Glacier Provincial Park. An estimated 2000 vehicles and 4,200 people use this road annually. Hiking also takes place along West

Kokanee Creek Trail (an average of 70 registered users annually), and the other trails within the forest, especially those leading to and from the alpine lakes. Berry picking, hunting, fishing and mushroom gathering also occur in the West Arm Demonstration Forest, taking people throughout much of the landscape. Such general flows were not mapped but were noted for further reference by the team.

Water:

Water is an important flow within the WADF, as the area contains several community watersheds and a total of 274 registered water licenses. Both the quality and quantity of water flows in the landscape must therefore be maintained for these reasons, as well as for the important ecological, recreational and visual roles the water resources of the landscape play. The main surface flows occur from the high elevation, down the creeks to Kootenay Lake.

Fish :

A resident fish population is present throughout Kokanee Creek and its tributaries. These fish both spawn and rear fish in these creeks and then flow downstream into Kootenay Lake. These flows provide a food resource for some of the wildlife species, as well as recreation opportunities (fishing). Management of the streamsides affects water quality and can impact fish population numbers. This flow is vulnerable to human impacts for this reason.

Flows of mammals and birds were less easy to identify. It was known that certain animals move within the WADF landscape in order to utilize different habitats for food, cover, nesting and den sites. For certain groups, such as ungulates and bears, the locations of these habitats are known but the precise position, timing and extent of their flows to and from these habitats is not. The team felt however that these flows could be roughly estimated and that an outline of the different types of forest matrix elements, patches and corridors required for this movement could be provided.

Ungulates:

Areas of early, mid and late winter and summer habitat for ungulates (white tail deer, mule deer and elk) have been identifed in the West Arm Demonstration Forest. These species move through the landscape seasonally between these areas, mainly in an elevational flow. For their populations to be supported, these habitat types need to be retained in the landscape and the movement of the animals between them must not be inhibited by human impacts.

Bears:

Excellent black bear and grizzly bear habitat is present throughout the West Arm Demonstration Forest. The black bears move throughout the drainages utilizing a wide variety of habitat types. Grizzly bears utilize and move through the avalanche tracks, riparian zones and remote alpine and subalpine areas.

Birds:

It was difficult to identify any particular flows of birds within the landscape, except for those species such as osprey, which regularly used different habitat areas for nesting and feeding and so moved within the landscape in a predictable pattern.

Forest pests and diseases were identified in most areas of the WADF, but no major flows or trends could be identified. Similarly the flows of small mammals and insects in the landscape could not be estimated due to lack of information on their behavior within this landscape. It was suspected that much of their movement takes place within stands and that their requirements would be met by sound stand level management.

The design team limited their investigation of landscape flows to those which they felt would be obviously affected by any future manipulation of the landscape pattern. They were also severely limited to those flows for which information was available. Despite this limitation, they did feel that they had identified the flows which were of primary concern in the WADF at the present time, and that if these flows could be maintained in the landscape, there was a good chance that other flows, as yet unidentified, would simultaneously be preserved.

Table 5 summarizes the flows identified. The locations of most of these flows are estimated in Figure 9.

Table 5 : Important flows in the WADF landscape.

Flow	Description
Fish	Obvious movement through landscape in stream channels
Ungulates	Have predictable seasonal movement patterns and specific habitat requirements
Osprey	Use identifiable areas of the landscape for nesting and perching. Move in and out of the landscape at different times of year.
Grizzly	Have areas of traditional use for forage. Move in and out of the area from park area to the north.
People	Movement in landscape for recreation or industry (logging) purposes.
Water	Movement within stream channels. Additional movement along ground surface and within soil. Important areas identified if possible.
Avalanches	Downward movement of snow with consequences for underlying landform, distribution of snow within landscape and flora and fauna.

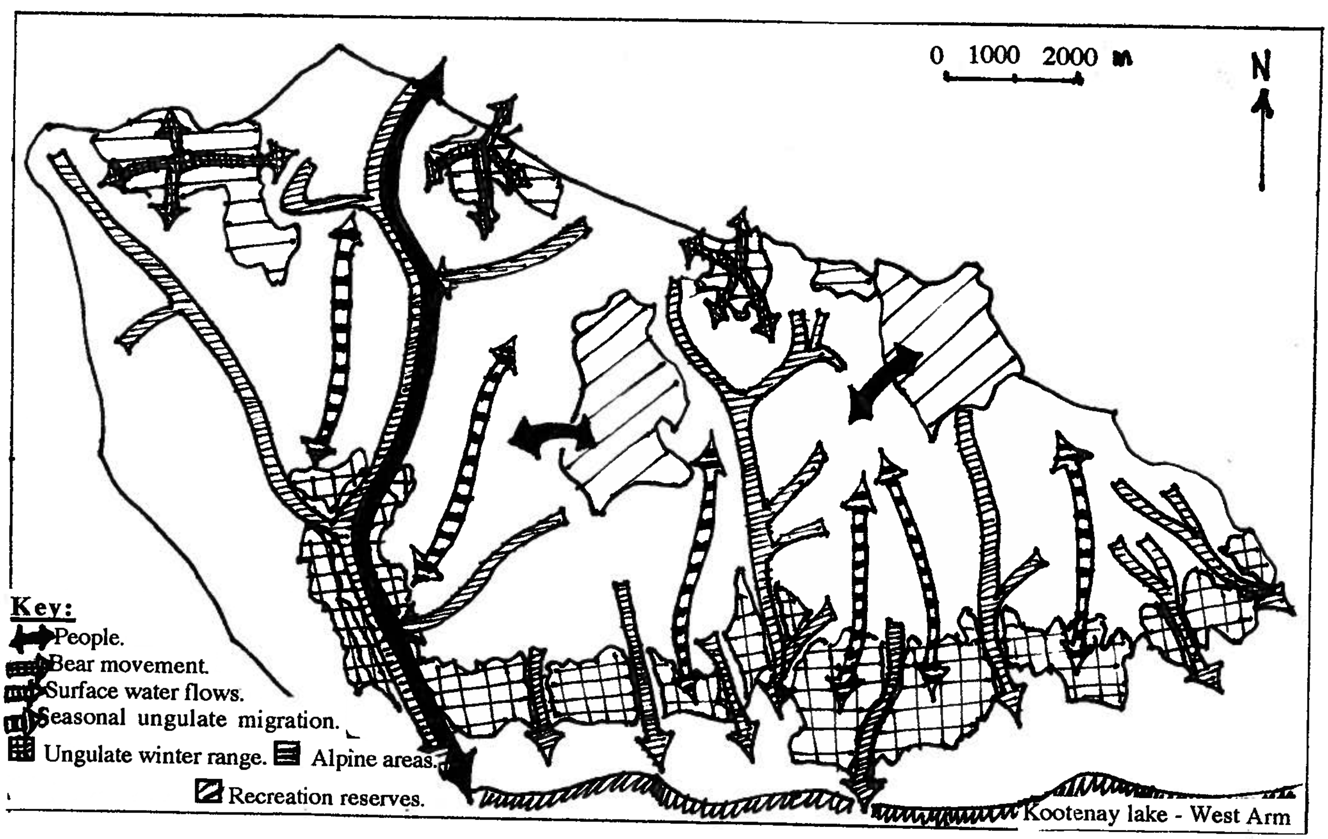

Figure 9. An estimation of the location of major flows in the WADF Landscape.

iii) The relationship between the structures and the flows.

This stage of the process explains how landscape structures function in relation to landscape flows. Specifically, it attempts to identify how the individual structures, and the pattern they form on the landscape, interact with or affect landscape flows. Discussion within the design team, with extra input from local members of the public or user groups, is used to identify how the main flows 'use' the various landscape elements, and when. This is often not an easy step to complete due to an inadequate knowledge of the ecology of the subject landscape, in addition to the general lack of understanding of how landscapes function. However to facilitate this step, Diaz and Apostol suggest that the design team keep the five main functions of ecological systems in mind. i.e.

. capture (resources are brought into the system);

. production (resources are manufactured within the system);

. cycling (resources are transported within the system);

. storage (resources are conserved within the system); and

. output (resources leave the system) (Diaz and Apostol 1992).

For example, streams or corridors connecting areas of habitat within a landscape may provide cycling functions. Corridors between two adjacent landscapes may support cycling, capture and output functions. Patches, such as areas of wetland, may act as storage sites within the landscape (Diaz and Apostol 1992). In addition to these broad functions, specific definitions of the functions of matrix, patches and corridors provided by Forman and Godron can also be used to try to decide how the structures and flows identified in the previous two steps interact. These were described in the previous chapter but are summarized here for convenience.

Matrix: This influences movement within the landscape. The characteristics of the matrix, such as its connectivity and its 'hospitableness' to the objects involved, will determine how the matrix functions in this regard.

Patches: These are often special areas of habitat for species, and the type and number of species they contain often depends on the size and shape of the patch.

Corridors: Four main functions of corridors have been identified: habitat for certain types of species; a conduit for movement along corridors; a barrier or filter separating areas; and a source of environmental and biotic effects on the surrounding matrix (Forman and Godron 1986).

The definitions given above should provide some guidance in the identification of the functions of each of the landscape structures. The team must try to determine how these functions relate to the flows in the subject area, and how the flows 'tie' different areas of the landscape together and allow the landscape to function as an ecological system. Important pattern relationships between structures which may contribute to functions, such as adjacency or dispersal of patches, connectivity of matrix,etc., should also be identified at this point.

WADF Example:

The main relationships between the structures and the flows in the West Arm Demonstration Forest were identified through a series of discussions within the design team. Each landscape structural type was considered in turn. Its functional contribution to each flow was then determined. For example, the old-growth elements of the matrix provided thermal cover, snow interception and hiding cover for ungulates, snags and nest sites for ospreys, and had important stabilizing functions for water flows. All of this information was tabulated in a spreadsheet, which plotted landscape elements against flows, with the relationship between them outlined in the units of the spreadsheet. These results are shown in Tables 6, 7 and 8 which show the interactions between the landscape flows and the matrix, patches and corridors, respectively.

The intention was that, in the subsequent design steps, the team could easily identify the ecological requirements for each major landscape flow from these tables. The elements supporting these functions could then be included in the design for the landscape.

Table 6. Flows within elements of the forest matrix in the WADF

ELEMENTS OF FOREST MATRIX	FISH	UNGULATES	OSPREY	GRIZZLY	PEOPLE	WATER	AVALANCHE
Old -Growth	Large Organic Debris (LOD) Stream bank stability Water quality Shading Litter fall Insect drop	Thermal cover Snow interception Hiding cover	Snags and nest sites proximal to fishing areas in ICH dw zone	Thermal cover. Food source Bedding sites. Downed wood - food. Better in wet ESSF	Genius loci High quality interior landscape High recreation value High timber value Wildlife viewing Visually forested. Medicinal plants	Evapotrans-piration Maintain natural peaks and low flows Decreases sediment delivery	
Mid seral	Less LOD Shading Litter fall High water quality Bank stability. Insect drop	As above	Lesser value for nest sites- unless legacies of old growth present	Similar as above - but less Better in wet ESSF and less in ICH MW2	High recreation value High carrying capacity. Better hunting (than OG) Wildlife viewing	As above	
Pole	As above	Low thermal cover Low snow interception	Legacies needed for this stage to be of use	Less use unless in or near avalanche areas Wet ESSF Less in ICH MW2	Generally low use Minor forest products Wildlife viewing	As above	
Alpine	As above	Very little forage Hiding cover	No use	Very important for den sites, foraging and cover	Very high recreation and scenic value in summer & winter, if accessible Winter recreation-high commercial and recreation value Views. Alpine meadows. Low carrying capacity	Snow accumulation zone Creek head-waters Late snow melt-summer flows	Snow accumulation

Table 7: Flows within the patches in the forest landscape.

PATCHES IN LANDSCAPE	FISH	UNGULATES	OSPREY	GRIZZLY	PEOPLE	WATER	AVALANCHE
Sapling	Less shade (than matrix) Organic material Insect drop	More forage than in matrix Hiding cover	Little use unless legacies present	As for matrix	Impenetrable Gathering Christmas trees	Less snow (than matrix) Increased runoff (and temperature change)	
Shrub/forb	Increased water temperature due to decreased shade Increased predation Easy access for fishermen Decreased stability of stream channel	High quality forag Little hiding cover	As above	As above	Berry picking Wildcrafting Hunting Views out Not visually forested Wildlife viewing Adverse comments if badly designed	Increased snow accumulation, but also increased peak flows Decreased summer flows	Colonization can increase risk if in avalanche zone
Bare/Grass/ Forb	As shrub/ forb but more extreme	Moderate forage Very little hiding cover	As above	As above	As above Firewood	Severe alteration to hydrology Increased sedimentation	Can increase risk if in avalanche zone
Hardwoods	Increased litter LOD Shading Insect dropping Nutrient gain	Little snow interception Little cover Moderate/ little forage production	Big, old cottonwoods are used	Little use	Firewood Visual diversity Fall colours Special woods Some hunting Some gathering	Little snow interception	
Avalanche Tracks.	Affect quality of water Adds substrate Dams	Forage throughout- use different elevations seasonally Movement		'Home' Forage	View-points Landscape diversity Wildlife viewing Gathering Danger (winter)	Affect quality of water Adds substrate Dams Affect water channels and change bank characteristics	Avalanches tend to run down existing tracks
Rock outcrops		Salt licks Goat habitat South aspect - warming			Rock climbing Viewpoints Prospecting Hang gliding Visual diversity	Fast runoff	Often sources Can be used to control direction of avalanche
Lakes	Sport fish	Water source Cooling			Fishing Camping/ hiking Swimming/ rafting	Storgae Filtration/ sediment traps Pollution Giardia	
Wetlands	Food. Filtering Rearing habitat (connected to lake or stream) Fresh water connector	Forage at edges Water source		Forage Cooling	Wildlife viewing. Hunting. Educational value	Filtration/ sediment traps	

Table 8: Flows within corridors in the WADF forest landscape.

CORRIDORS IN LANDSCAPE	FISH	UNGULATES	OSPREY	GRIZZLY	PEOPLE	WATER	AVALANCHE
Riparian areas	As for old growth matrix	Movement corriors. Forage and shelter.	Snags	Forage	Travel areas Trails Fishing Aesthetics	Filtration Bank atability Temperature controls Debris loading	Source of runoff Vegetation control Catchment zone for debris
Streams	Movement corridors Spawning - in low gradient streams	Water supply		Cooling Water supply	Fishing. *Genius loci* Water abstraction	Conduit. Human consumption Water for spawning. Agricultural use	Sediment/ debris
Trails/ Powerlines	Pollution. Increased access for fishermen	As above		Travel corridors Intrusion into habitat	As above. Not usually visually intrusive		
Powerlines		Forage and movement in right of way	Nesting sites - perching in towers		Christmas trees Horse back riding Snowmobil es and cross country skiing in right of ways	Sediment. Effects on temperature	Not constructued in these areas

The effect of the pattern of the patches, corridors and matrix elements on landscape functioning was also estimated at this point. For example, in the upper elevations of the landscape, alpine and alpine/huckleberry patches are frequently found adjacent to wetland complexes. Thus areas used by bears for feeding are closely adjacent to watering areas, making this group of patches a valuable habitat area for bears.

In the lower elevations of the landscape, there is a varied mixture of old growth, younger seral stages and open areas of shrub, forb and grass. This provides many of the attributes required by ungulates in winter range areas, i.e., thermal cover, hiding cover and good quality forage . Thus this pattern is a valuable one for ungulates in the landscape. Figure 7 illustrates the pattern of structures in the WADF landscape.

iv) Natural Disturbance and Succession.

The purpose of this step is to understand how the composition and arrangement of landscape elements results from the action of large scale natural change agents. It is proposed that once the natural processes and the patterns they create have been identified, this knowledge can be used to guide the design of future landscape patterns (Diaz and Apostol 1992). A method for mimicking natural processes in this way will be discussed in a later section. This section applies merely to the identification of natural change agents in the landscape, their characteristics and the impacts they have on the landscape pattern.

Disturbance can be defined as 'those events that cause change in the existing pattern in a system' (Forman 1987:219) and they are therefore larger events than the normal flows entering and leaving landscape elements. The major disturbances recognized in most forest landscapes are fire, wind and insect attack (Baker 1980, Kimmins 1990). These events often cause changes in the numbers and groupings of organisms occupying an area and are followed by a sequence of changes in the animal, plant and microbial communities which will successively occupy the area (ecological succession) (Kimmins 1987). To try to determine what effect natural disturbances have had on a landscape, the following questions can be posed:

> " What agents of change at the landscape level would have existed in the natural ecosystem?
> What would their effect have been on the landscape pattern (arrangement, composition, size and shape of patches; connectivity; characteristics of the matrix ; etc.)?
> How might natural landscape patterns have influenced the behavior of disturbance phenomena?" (Diaz and Apostol, 1992 : 4.26).

The answers to these questions should guide the design team towards a *picture* of what 'natural appearing' is most likely to mean for the landscape in question. They should be answered with the primary objective of this analysis in mind, i.e. that it is the effects of the disturbance and succession on the composition and arrangement of the landscape pattern which is important and the scale and type of pattern produced by these events is of particular importance.

<u>WADF Example:</u>

The design team identified fire, wind and insects as main agents of disturbance in the West Arm Demonstration Forest. They felt they could estimate the size and probable return period of such events for different areas of the landscape, based on the vegetation type, biogeoclimatic subzone and their knowledge of the area and its history.

<u>Fire:</u>

In this area, most of the fires which occur are started by lightning, with the largest number of strikes occurring in the higher elevations. However these do not tend to develop into fires very often in this zone (Engelmann Spruce Subalpine Fir zone). When they do, it has been observed that they burn areas of approximately 5 to 50 hectares in size, with a return period of 300- 400 years. They are likely to be stand replacement fires of high intensity.

At lower elevations, in the Interior Cedar Hemlock zone, fires are more frequent and burn in larger areas (50-500 hectares). Both surface and crown fires occur. These alter the stands but do not often replace them. Thus the fire disturbance pattern can be visualized as produing small but intense disturbances infrequently at high elevations. Larger areas of disturbance are produced more frequently at lower elevations where they are less intense and tend to leave vegetation behind. In all cases, return frequencies vary with aspect : fires on south and west faces have shorter return periods than those on north and east faces.

As the current policy is to suppress all wild fire in this area, the above information was derived from historical records and from examining the patterns and structures of those stands aged 100 years or more. Studies of the fire characteristics of each of the biogeoclimatic zones were also useful in this exercise.

Other disturbances:

The team considered fire to be the dominant disturbance regime in the West Arm Demonstration Forest. However insects, wind and snow have also impacted areas of the landscape in the past. It was noted however, that these factors usually worked in combination to produce landscape scale disturbances. For example, wind, in association with insects, can have a landscape scale impact in all zones, one which insects or wind alone would not produce.

Table 9 provides a summary of the disturbance patterns which have shaped the landscape of the WADF, and have the potential to do likewise in the future. The disturbances are listed by biogeoclimatic subzone.

Succession:

The design team found that very little information was available on the successional pathways in the WADF. The Biogeoclimatic classification of the ecosystems of B.C (Meidinger and Pojar 1991) deals mainly with climax vegetation and provided few clues on the successional pathways of these ecosystems. However, members of the design team suggested that it may be possible to draw on research carried out by the United States Forest Service in Montana (Fischer and Bradley 1987). The regions studied in this research lie just to the south of Nelson Forest Region and the use of their data may be possible if the

Table 9: Disturbance patterns identified for the WADF.

Zone	Fire	Insects	Wind	Snow/Ice.
Alpine ESSFwc4	Freq. 300-400 years Size: 5-50 hectares. Stable pattern for 300-400 years. Occur on S&W facing slopes: short returns. Produce more open stands; coarser soils. Occur in ridges rather than hollows.	Cold and short season. Spruce bark beetle; western balsam beetle. 3 year life cycle; episodes infrequent. Linked to storm / avalanche.	Wind funnels up and down lake. Deflects occasionally into side creeks. Creates small gaps with trees left behind. Linked to dead / dying trees.	
ESSF	Freq: 200-300 years. Size : 50-500 hectares. Stable pattern for 200-300 years. Occur on S&W facing slopes & ridges. Stand replacement fires.	Spruce bark beetle; Western balsam bark beetle. Follows ice/snow damage. Pine beetle in Lodgepole pine - depends on size of tree. Can cause catastrophic stand loss.	As above.	
ICHmw2	Freq : 150-250 years. Size : 150- 500 years. Less intense fires than above. N&W slopes burn less frequently.	Lot of insects in this zone. Armillaria in hardwoods. Eventually replaced by conifers (35-40 years). Allow for seral stage species to change composition of stands.	As above.	Snow break on stems - thinning agent and changes stand structure. Occurs in low elevation mw2. Douglas fir is most susceptible. Elevational belt.
ICHdw	Surface fires - Freq: 10-20 years. Start on rock outcrops & coarse soils. S&W facing slopes. Produce open stands; less dense & less fuel loading. Surface & crown fires : 100-150 years.	As above.	As above.	

ecosystems are found to be sufficiently similar to those in the West Arm Demonstration Forest.

The two fire 'groups' recognized by Fischer and Bradley which appear to correlate to those found in the WADF are 'group nine' (moist, lower sub alpine habitat types), and 'group eleven' (warm, moist grand fir, western red cedar and western hemlock habitat types).

The fire characteristics and successional pathways followed by these types are summarized in Table 10. Although the application of this information directly to the WADF should be approached with caution, it may be useful as a pointer on the types of succession to expect in the WADF following certain fire disturbances.

Table 10. Fire characteristics and successional pathways for fire groups nine and eleven (Fischer and Bradley 1987).

Fire Group	Fire characteristics	Description of expected succession.
Group 9. Moist lower sub alpine habitat types. (Fischer and Bradley 1987:55)	The relatively high loadings of both live and dead fuels, combined with periodic summer drought increases the chance for severe, stand replacement fires when fires do occur.	The potential climax forest would be composed of pure stands of subalpine fir, spruce or hemlock. The climax situation on any of these sites requires a long time to develop and consequently is rarely found. Near climax situation is more common and is characterized by a dense understory of subalpine fir, spruce and hemlock, while Douglas fir, lodgepole pine and spruce often form the overstory. A stand destroying fire in the climax or near climax stage results in a herb/shrub stage, followed by a seedling/sapling stage which may include Douglas fir, lodgepole pine, larch, white pine or spruce. Any fire in the seedling/sapling stage reverts the stand to the shrub/herb condition. Moderate fires in pole sized stands will favour fire resistant Douglas fir and larch over lodgepole pine, spruce, hemlock or sub alpine fir. A severe fire destroys the stand. Where serotinous lodgepole pine is present, seedlings of this species may form a pure or nearly pure stand.
Group 11. Warm, moist grand fir, western red cedar and western hemlock types. (Fischer and Bradley 1987:69)	Moist weather conditions predominate, but the region is occasionally subject to severe summer drought. Heavy fuel loadings exist in most stands because of the overall high plant productivity. This sets the stage for severe, widespread fires. Stands are replaced and revert to pioneer species. Pole and mature stands are usually dense and although this leads to high fuel loading, severe fires are infrequent due to the high moisture status.	Theoretical climax condition is stands of grand fir, western hemlock or western red cedar. This is rarely achieved as the seral species are long lived and fire occurs frequently enough that stands seldom develop beyond the near climax stage. Following a stand replacement fire, succession begins with shrub/herb field. The duration of this stage depends on the availability of tree seed and the occurrence of multiple burns. If seed is available and multiple burns do not occur, seedlings of both climax and seral trees will establish on a burned site. Low/moderate fires in pole/mature stands favour intolerant seral species over climax cedar, grand fir or western hemlock as these are less fire resistant. Climax stands may withstand low thinning fires, but moderate/severe fires will return the site to a shrub/herb stage.

<u>v) Linkages beyond the plan area:</u>

This stage of Total Resource Design identifies any functional 'linkages' which exist between the subject landscape and its surroundings, to try to 'fit' the landscape into the context of its surroundings. It examines how the most important flow phenomena in the analysis area interact with areas beyond its boundaries, and identifies the landscape structures which contribute to that interaction.

The contribution that the analysis area makes to the wider landscape is also considered. For example, the area may contain a portion of a critical migration route for a particular species. The positions of the linkages on the landscape, with an idea of their scale and importance should be indicated on a map. Diaz and Apostol (1992) recommend that the design team let the amount of analysis done in this section be guided by logic, information and time available as there does not seem to be any systematic way of determining when the analysis of the functional linkages is sufficient.

WADF Example:

This step was carried out by several members of the design team in consultation with staff from B.C. Parks who administer both the Kokanee Glacier Provincial Park (which lies along the northern boundary of the demonstration forest) and the Kokanee Creek Provincial park (a small area of intensive public use to the south of the WADF).

Through this collaboration, the main areas and routes used by wildlife (mainly ungulates and grizzly bear) for movement into and out of the demonstration forest from Kokanee Glacier park were identified. Estimations were then made as to the extent and timing of these flows The main areas of use by the public in both parks and the main areas of use in the demonstration forest were also identified. Concerns on their management voiced by park staff were noted by the team for consideration later in the design process.

Other linkages with the surrounding landscape, such as water flows, were also identified. All of the flows and annotations describing the flows are marked on the map shown in Figure 10 .

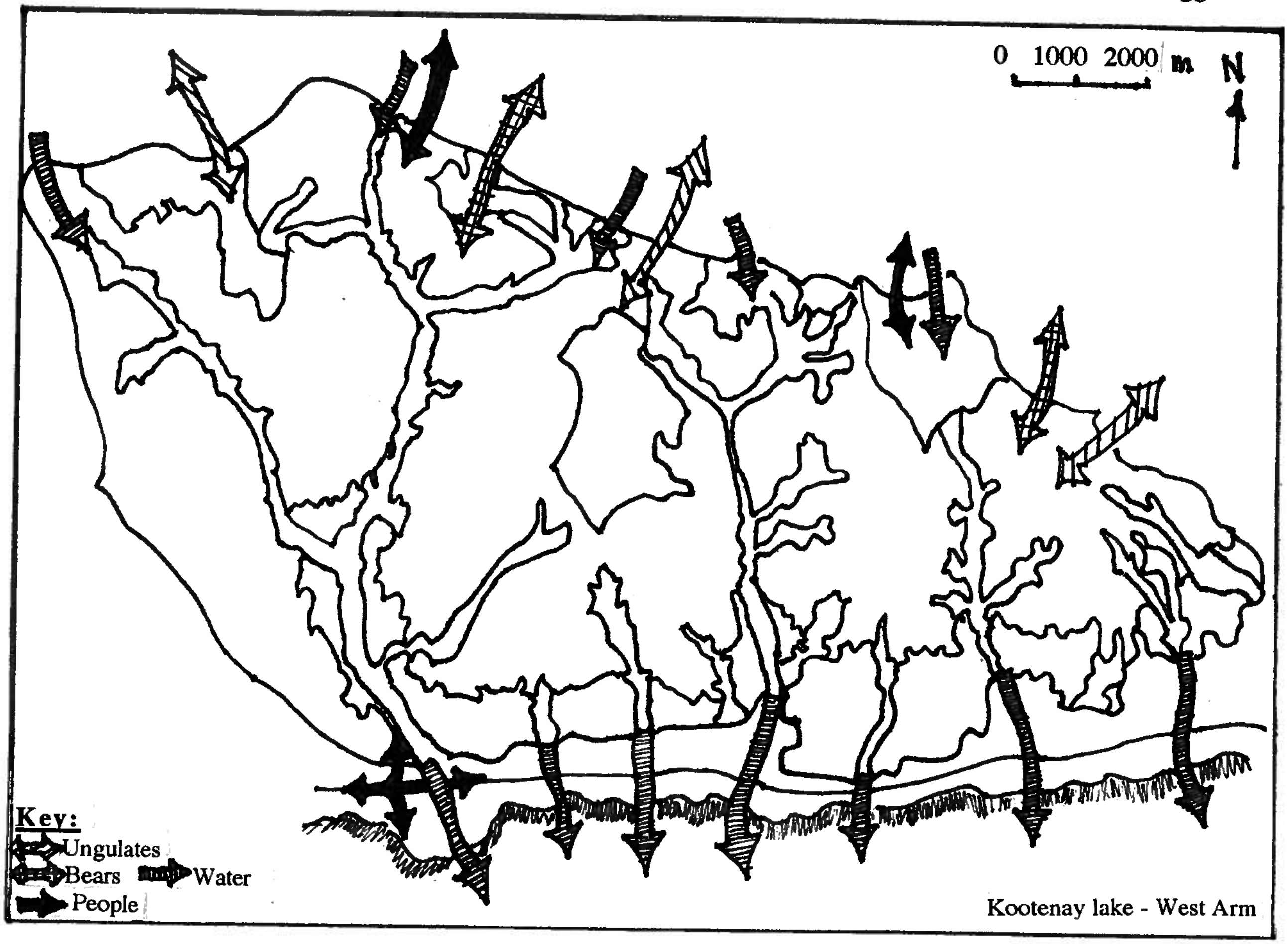

Figure 10. An map of the flows in the WADF which link with the surrounding landscapes.

vi) Ecological landscape pattern objectives:

Thus far, a method for analyzing the ecological functioning of a landscape has been described. In section 3.5, the design phase of the process will be outlined, in which the design team will be concerned with actually designing the shape, location and characteristics of management units. Before this is done, this step is carried out to act as a bridge between analysis and design. It involves making sense of the ecological analysis, within the context of the overall objectives for the landscape to produce a 'vision' of what the ecological landscape pattern should be in the future, if the objectives are to be met while maintaining or enhancing the ecological functioning of the landscape. It produces a conceptual map of the pattern of desired landscape structures, illustrating their optimal location, shape , size and relationship to each other.

Three main steps are involved in the production of landscape ecological pattern objectives.

i) Mapping of existing pattern decisions;

ii) Inclusion of public concerns and desires for landscape pattern; and

iii) Preparation of target landscape pattern objectives.

i) Mapping of existing pattern decisions

Any 'patterns' provided by the broad objectives for the landscape, higher level plans or other guidelines and specifications are identified and mapped at this point. For example, there may be habitats or resources within the landscape which have been identified as important or may require preservation or special management in the future. Specifications may exist for harvest unit size, silvicultural systems, proportion of forest cover to be retained, number of openings for wildlife habitat etc. These are all decisions about the future landscape pattern which have already been made. These should be described and mapped. The result will act as a first 'building block' for the establishment of ecological pattern objectives.

ii) Public concerns and desires for landscape pattern

Public participation processes (such as LRMPs and Local Resource Use Plans (LRUPs)[11]) may have taken place for the subject area and will have provided information on which areas or management practices are of concern to the public, or which take priority from their point of view. This information should be described and mapped at this point so that the design team can be sure that they are incorporating public values in the final design. If public participation processes have not been set up for the area in question, serious consideration should be given to initiating one in advance of attempting a Total Resource Design so that this information can be obtained. TRD itself is a detailed planning process and as such cannot incorporate complex public debates. However, several representatives of public groups may be directly involved with the team during Total Resource Design, so that the exact locations of areas of interest in the landscape can be determined.

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[11] LRUP: A strategic plan for a portion of a Timber Supply Area or Tree Farm Licence that provides management guidelines for integrating resource use in that area (Province of British Columbia,1994)

iii) Preparation of target landscape pattern objectives.

Once both of the above stages have been completed, the design team must interpret the analysis information to produce a target landscape pattern which will include the existing pattern decisions and issues of public concern identified in the previous steps.

To facilitate this process, questions suggested by Diaz and Apostol can be followed. These should prompt the design team into thinking about the functions in the landscape which need to be maintained, enhanced or restored, and to identify a pattern and distribution of landscape structures which would achieve this. If different zones or management areas with different resource emphases have been identified in a higher plan, then landscape patterns can be compiled more easily for each zone.

The questions recommended by Diaz and Apostol are as follows:

> " Are there some rare, unusual, critical or unique landscape elements we want to protect or enhance, e.g. wetlands, travel corridors, blocks of old growth with interior habitat etc.?"
> "Are there patches or areas of the matrix between which connectivity should be maintained?"
> "Is there anything missing that should be introduced or restored?"
> "To what extent, and where, do we want to emulate certain elements of natural landscape patterns? If one believes that 1) 'natural ' levels of diversity (of composition, structure and process) sustains ecosystem resilience and 2) species diversity is fostered by habitat diversity, then there is much to be gained by mimicking some aspects of landscape patterns created through natural processes. Just what these are and how they can be recreated in a managed landscape deserves serious consideration at this step."
> "Are there areas of the landscape where it is desirable to minimize fragmentation?"
> "Are there areas where a high degree of edge and contrast is desirable? "
> "Are there areas where gradual changes rather than sharp edges are desirable? " (Diaz and Apostol 1992:4.45).

When carried out by a design team, it will become obvious that there will always be more than one possible target landscape pattern - there is no one 'right answer' and subjective decisions will be required. However, a framework has already been established to provide guidance on these decisions, based on the direction and pattern decisions established in plans and guidelines, and from public input . The challenge for the team is to work within this framework to produce a creative solution scenario which will provide a 'vision' for the future and which is not too rigidly bound by current thinking and management restrictions.

Once ecological landscape pattern objectives have been produced, the design team must then be aware of the limitations of this target pattern before it is incorporated into the design phase. Essentially, this pattern will have been produced based on a limited knowledge and understanding of the landscape function, with available expertise, and with the incorporation of current social concerns and desires. Over time, knowledge of landscape functioning will grow, social concerns and desires for the landscape will change, as will the pattern decisions contained in higher plans and guidelines. Natural disturbances may intervene and completely alter the landscape pattern. Any of these occurrences will require the target pattern to be revised. Thus the pattern must not be regarded as a long term fixed target. It should be flexible and open to re-evaluation and iteration when necessary. Apostol suggests that the team should think twenty years ahead when developing a target pattern or vision (D. Apostol. pers. com. 1994). This can be taken into the design phase and used to guide design in the short term such as the first five years. Then the landscape pattern objectives should be re-evaluated. The team should ask, "does this pattern objective still provide sound guidance? Is it still the 'desired future objective?" This revisiting of the ecological vision for the landscape will ensure that the design and management of the landscape will continue to adapt and incorporate change, thus reducing rigidity and future dissatisfaction with the results.

WADF Example:

When given the goal of producing desired ecological landscape pattern objectives, the design team for the West Arm Demonstration Forest decided to tackle it in two phases. The first phase, which arose out of discussion, deviated from the proposed method and tried to predict a dynamic future pattern based on their understanding of the disturbance regimes in the area. This phase was completed during the workshop. The second phase returned to the above method. It was initiated during the workshop and continued in the months to follow.

Phase 1:

The team examined the current ecological patterns present on the landscape (shown in Figure 7). They then considered how these related to the disturbance regimes they had determined for the landscape (shown in Table 9). The thought processes which then occurred within the team can be described as follows:

'1. An estimation of the natural disturbance patterns in the WADF has been made.

2. It is suspected, based on existing knowledge of the area, that the vegetation pattern which currently exists is a function of these disturbances and the climatic conditions at the time they occurred.

3. This current pattern is a snapshot in time. Disturbance and succession produce an ever changing, dynamic pattern on the landscape. Areas of matrix, patches and corridors are not fixed in space. Therefore it would appear necessary to try to manage for a 'dynamic pattern'.

4. This can perhaps be done by mimicking the dynamics of the disturbances over time .i.e. mimic the cause of the change in the belief that this will produce a 'natural' result. If this is to happen, it must be done while maintaining the ecosystems' successional pathways, so that they can recover naturally.

5. In proposing prescriptions for mimicking natural disturbances, the following information must be known:

- what natural disturbances occur in a landscape (or have occurred in the past)?
- what areas of the landscape or vegetation types do they affect?
- what are the characteristics of these disturbances (size, frequency, intensity)?
- what landscape structures do they produce (i.e what is their effect on the vegetation? Are any trees or other living vegetation left behind? If so, what density and distribution of dead trees are left ?)

6. This information can be combined to derive a set of 'structural objectives' for areas of similar vegetation type, climate and disturbance regime, which if achieved will successfully mimic local patterns and processes over time.'

Resulting from this train of thought was an identification of the characteristics of the natural disturbances associated with the different biogeoclimatic subzones present in the landscape. These are outlined in Table 11. From these characteristics, a set of 'stand structural objectives' was produced. These outline how stand types in certain biogeoclimatic zones could be managed (in terms of a residual structure after harvesting) to mimic the natural disturbances occurring in the respective zones. A description of the subzone to which each structural objective applied accompanied each objective. This is illustrated in Table 12. The position of each of these subzones in the West Arm Demonstration Forest was located on a map (Figure 11) and provided guidance on how the components of the current vegetation pattern could be managed to maintain, to some degree, the dynamic changes occurring naturally in the landscape, and thus perpetuate a natural ecological pattern.

Table 11: Characteristics and suggested intervention for vegetation types in the WADF. Letters in italics are the codes given to each of these types.

<table>
<tr><th>Zone</th><th colspan="4">Characteristics (and suitable intervention.)</th></tr>
<tr><td>Alpine</td><td colspan="4">Krummholz and parkland - petering out. No intervention recommended. Climatically controlled dynamics. AT</td></tr>
<tr><td>ESSF</td><td colspan="4">Inoperable...Operable</td></tr>
<tr><td></td><td colspan="2">100- 500 hectare natural burns in the higher more remote locations. Control?
En</td><td colspan="2">50 hectare openings in the section nearest to mw2. Openings contain refugia patches, irregular shapes, bigger areas. Occur on NE, S & W aspects. 150 year disturbance frequency.
E50</td></tr>
<tr><td>ICHmw2</td><td colspan="4">Low probability of fire..High probability of fire</td></tr>
<tr><td></td><td>Low fire hazard. This type found in valley bottoms. Old growth areas.
Low/no intervention recommended. MWn</td><td>Areas of mature forest. Has pockets of root rot etc. Found on N&E slopes. Group selection is suggested.
MWg</td><td>This zone is on a NE-SW orientation. Openings usually have much left behind - islands, 'vets' etc. MWi</td><td>High fire hazard. Found on S & W ridges. Similar to ESSF. Could burn patches.
MWb</td></tr>
<tr><td>ICHdw</td><td colspan="4">Moister...Drier</td></tr>
<tr><td></td><td colspan="2">Moist area.
Fairly open stands similar to drier mw2. Mature stands with root rot pockets. Run into drainages with a W or E aspect. Little present.
DWm</td><td colspan="2">Drier areas.
S & W slopes and coarse soils. Open stands with 2 story structure. Dense patches left in locally moist pockets. Occasional clearance with large 'vets' left behind. Group selection suggested.
DWd</td></tr>
</table>

Table 12: Summary of stand structural objectives:

Stand Type	Description	Structural Objective
Alpine/ parkland	Open structure; some krummholz, clusters of trees of all age classes.	No intervention recommended.
$ESSF_n$	Located in non-operable areas. Likely disturbance 100-500 ha natural fires.	Will let fires burn to some degree in most remote areas. In non-burned areas stand structure: mature forest interspersed with large openings (100-500 ha) with 'treed' exclusions and some standing dead trees. Patches left in seeps, along streams and on some benches.
$ESSF_{50}$	Found in operable forest. 50 ha treatment units (mean area). Similar fire periodicity as $ESSF_n$, however fire suppression is a requirement. Management could mimic fire disturbance.	Structures as a result of fire (300 year periodicity), insects and diseases: standing dead trees; openings with refugia patches - irregular shapes; larger areas on S&W aspects that on N&E aspects.
$ICHmw2_n$	Low fire hazard in valley bottoms, wet riparian areas and old growth, due to wet habitat.	Low/no intervention recommended. Structural objective: canopy closure, large trees, large organic debris, multistoried canopy, small gaps (1-2 tree lengths) - typical old growth habitat.
$ICHmw2_g$	Found on moist, N&E slopes. Fire disturbances, frequency 200 years - producing openings of approx 150 ha in size. Standing veterans remain after fires.	Mid-late seral stages with some old growth patches and standing veterans; mainly even-aged, many species and closed canopy (60-80%);2 storied stand,understory of climax species. Openings of 150 ha. Group selection suggested.
$ICHmw2_i$	Found on mesic/submesic sites. Fire periodicity increased from mw_g Smaller unburned patches survive fires (0.25 - 2 ha in size).	Even aged, two storied canopy. Crown closure 50-70%. Individual large veterans within the canopy. Clearcut with reserves suggested.
$ICHmw2_b$	Found on xeric and sub-xeric sites on S&W ridges. Increased fire periodicity, similar to ICHdw - 150 years, scale 100-500 ha.	Few patches left & individual large veterans. Understory present in open patches, mostly Lodgepole pine & Western larch regeneration.
$ICHdw_m$	Found on N&E aspects/wetter areas with patches of grand fir and western red cedar on wet areas. Fire periodicity : surface fires every 30-50 years. Stand replacement fires every 100-150 years.	Open stands with a mosaic of age classes present in patches.
$ICH dw_d$	Found on S&W aspects. Predominantly Ponderosa pine, Douglas fir and some Western larch. Hardwood patches present. Fires : surface fires 30-50 years and stand replacement fires every 100-150 years, Heavily diseased with frequent insect attacks.	Wide spacing; multistoried canopy; some patches on wet sites and fire exclusions. Numerous large veterans.

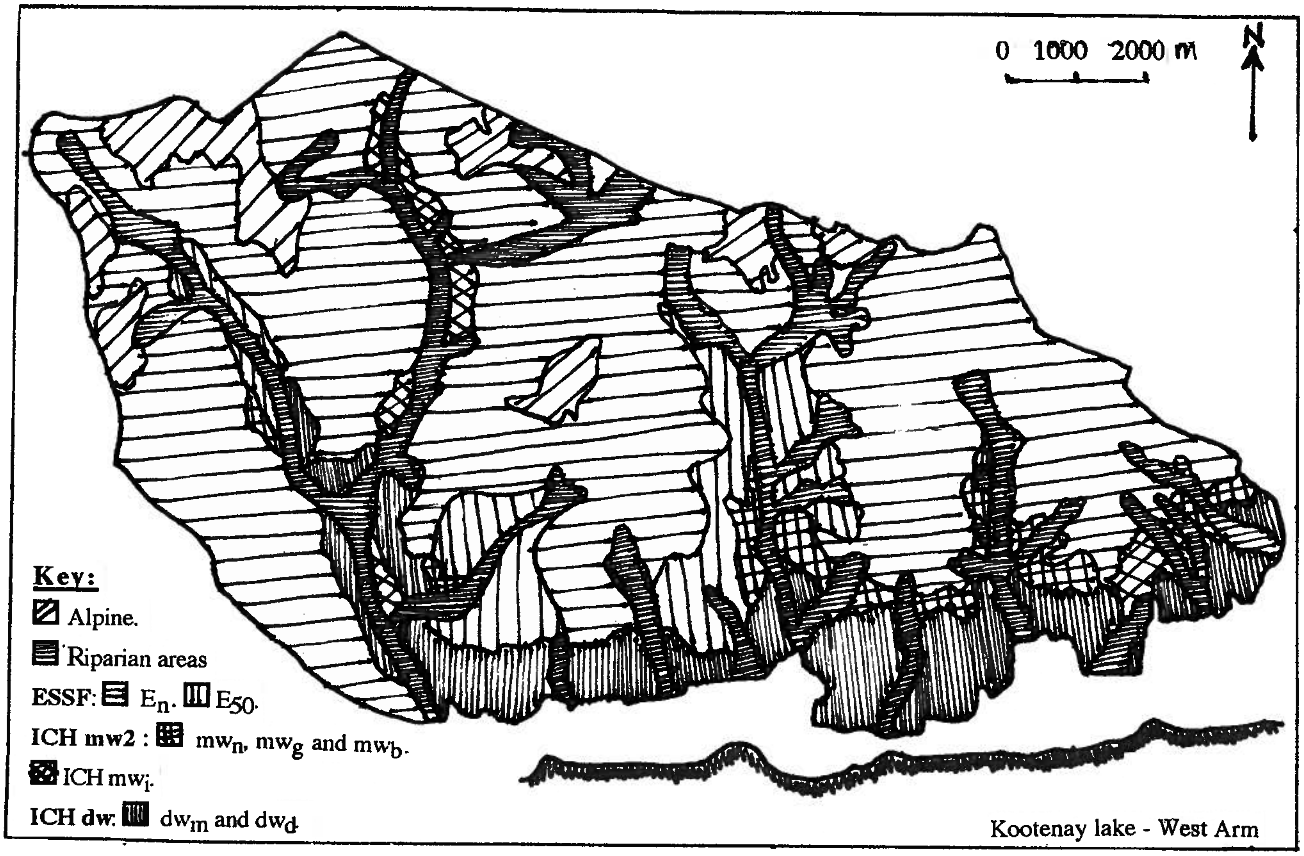


Figure 11: Location of 'ecological units' to which stand structural objectives can be applied in the WADF.

Limitations to this approach have since been recognized by members of the design team. It relies on a sound knowledge of disturbance and succession patterns in the subject landscape. As has been noted already in this chapter, details of many of the successional pathways in the ecosystems of British Columbia are not currently known. Similarly, the impacts of disturbances are intensity dependent (D. Crampton pers, com, 1994) and presently little is known about the effects of different intensities of disturbances such as fire on the succession pathways followed by the vegetation. Despite these limitations and the estimates which were required as a result, the design team did feel that this was a useful process to go through and that it will provide some logical direction for the future management of the landscape pattern.

Stage 2.

Having provided a method for mimicking the natural disturbance pattern on the landscape, the design team realized that they still had to return to the proposed method for this step, in order to provide a framework which would guide the designer in deciding where units should be designed, and within which the stand structural objectives could be applied. This framework would include public concerns, administrative specifications and guidelines, and incorporate areas for protection, special management or restoration which were recognized in the ecological analysis. It is reasonable to assume that large scale mimicking of natural fires in the West Arm Demonstration Forest would not necessarily be acceptable, due mostly to the visual impact that this would have. Such patterns would probably also be in conflict with existing pattern decisions present in plans and guidelines for the area and would not be welcomed if they impacted on, for example an ecological reserve or recreation area. Thus it was felt that a target ecological pattern would help to reach such a compromise, within which the stand structural objectives could be used as tools for the implementation of the pattern.

WADF Example:

This stage of TRD has not yet been completed for the West Arm Demonstration Forest. There was not enough time available at the initial workshop to do this; however a subsequent meeting of the design team took place in Nelson to discuss this next step (August 1994). It identified many difficulties in establishing a 'target landscape pattern', the most limiting of which was felt to be the current lack of information on the amounts of certain landscape elements required for the maintenance of, for example, wildlife populations. It is known by the team that late winter and mid-winter habitat is required for ungulates in the WADF. Similarly, there is a desire to increase the proportion of old growth forest represented in the landscape. In order to come up with a target pattern are it was to be decided where these areas should be located in the landscape and what size they should be.

The team admitted that this might be difficult to determine, but that it should be possible. So, they decided to arrange a subsequent set of meetings of the design team and to prepare individual target patterns for each of the resources present in the landscape before the first of these meetings, in the fall of 1994. At this meeting, the team will sit down together, with all relevant parties around the table, to discuss an overall target landscape pattern. This will necessitate optimisation of the various resources, guided by the overall objectives for the landscape, and based on the results of the ecological analyses carried out.

Several comments were made by the team while discussing this step of TRD. It was observed that difficulties would be encountered in coming up with resource target patterns, simply because such a process required a radical change in approach, especially for those individuals administering non-timber resources. For example, at the moment, staff of the Ministry of Environment, Habitat Protection Branch, are mostly reacting to the proposals to harvest produced by the Ministry of Forests. They try to protect habitats by restricting the terms of the harvesting and in effect saying 'no - we don't want that!'. Total Resource Design requires all resource representatives to say to the rest of the team "this is what we want'. It requires them to be pro-active. This is a position which many resource representatives consider to be ideal, but yet have not had the time or resources to address in the past (G. Fox. pers,com, 1994). Thus they are largely unprepared to provide an answer as their informational and inventory resources are not designed to produce this kind of information. This step will thus stimulate a change of approach to forest planning by making all representatives at the table equal partners in their right to state their 'desires' from the landscape. The final decision on a target landscape pattern will be decided and endorsed by the team as a whole, providing a common management goal.

It was felt that this would be difficult to achieve in practice, but the team recognized that this was an approach which was necessary and timely and so aimed to have it completed before the end of 1994.

3.4.4.3 Landscape character analysis

Landscape Character applies to the collective result of all of the different components of a landscape - visual, cultural, ecological, historical - working together to produce what is in essence the 'identity' of a landscape. To date in the Total Resource Design method, primarily the ecological character has been analyzed. Other aspects of landscape character such as historical or cultural associations with the landscape, or some of its parts, can be determined from local knowledge and archived or inventoried information. This should be relatively accessible to the design team. What remains to be analyzed is the visual character of the landscape. The ability to 'read' the landscape character will enable the design team to determine where and how management units can be fitted into the landscape in a manner which is sympathetic to its visual character.

The method employed in Total Resource Design is based on an approach used extensively by the British Forestry Commission which concentrates on an examination of landform (Lucas 1991). It contributes to an understanding of the visual character of the landscape by identifying the characteristics of its topography, its undulating ridges and hollows, the combinations of mass and space and other aspects of landform and how these are arranged. This landform analysis is accompanied by an examination of features in a landscape which also contribute to its character. Together these analyses aim to provide the fundamental understanding of the visual characteristics of the landscape, which can later be harnessed when attempting to design the management units.

Thus this section is split into two parts:

a. Landform analysis : an analysis of landform structure using 'visual forces'.

b. Landscape feature analysis : an analysis of the elements of diversity, natural features and vegetation.

i) Landform analysis:

On a topographic map and corresponding perspective photographs of each design unit, the dominant 'lines of visual force' in the landscape are identified. 'Visual force' is explained as the "illusion or sensation of movement created by a static image, object, or the juxtaposition of a number of elements in a composition or landscape" (Bell 1993 draft:7). Put simply, in a natural landscape the eye tends to be drawn down spurs, ridges and convex landforms and up into hollows, valleys and concave landforms. The implication for forestry is that if a harvesting block is shaped or positioned in a manner which disrupts these 'lines of force', a strong visual tension will occur causing the block to look out of place in the landscape.

For each design unit, identifying the main lines of force on both plan and photographic perspective, and between different views, will ensure accuracy. Major ridges and convexities are identified on a map in red, with the valleys and concavities identified in green. On completion, the structure of the topography will become clear, giving an understanding of the three dimensional structure and form of the landscape. This can then be used by the designer when designing the shapes and positions of units on the landscape. Figures 12 and 13, prepared by Bell for one area of the WADF, show how these analyses can be illustrated in both plan and perspective views.

ii) Land Feature Analysis.

This part of the analysis identifies features in the landscape which contribute to its character, especially those which help to determine its diversity and visual absorption capability. Important in this step is the identification of a pattern to the presence of these features, why they occur in the landscape and where. As Bell explains:

> "There will be some underlying logic to why some features occur where they do - rock outcrops related to geology, erosion and landform; vegetation to drainage; water features to landform structures and geology" (Bell 1993 draft :53).

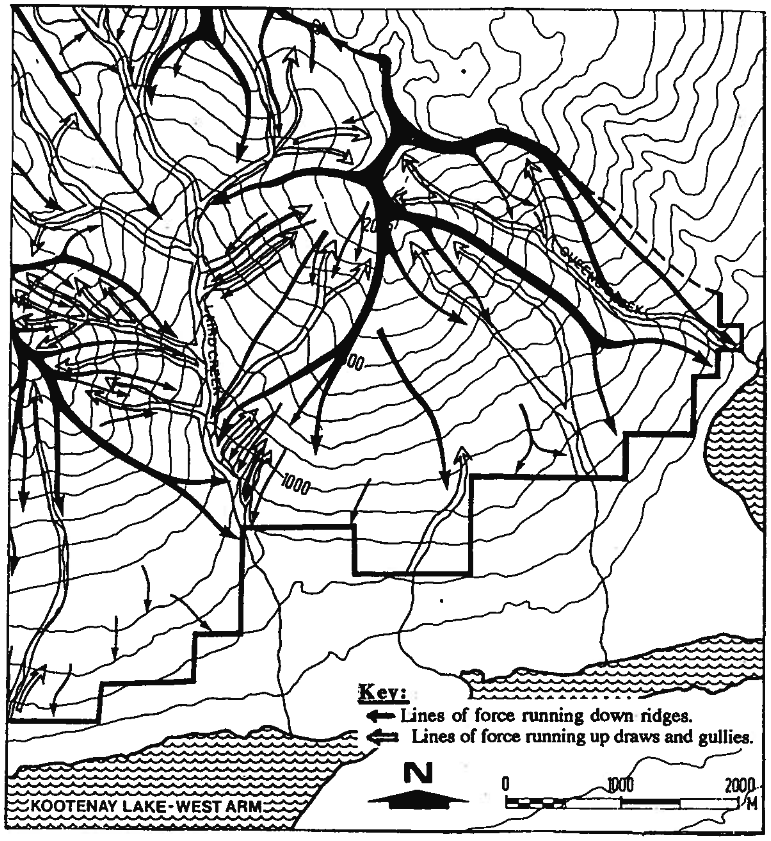


Figure 12 . Landform analysis of Queens/Laird area of the WADF, planimetric form [12]

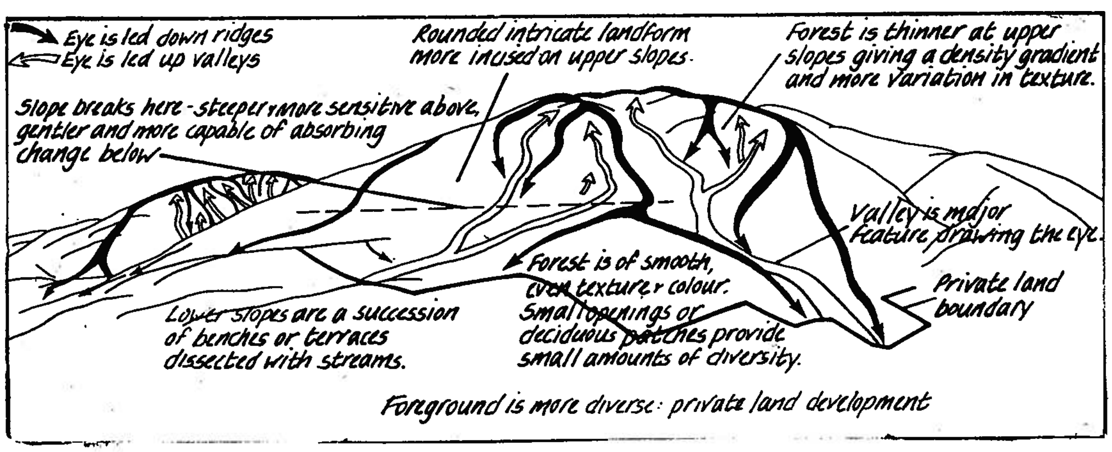


Figure 13. Landform analysis of Queens/Laird area of WADF - perspective view [13]

12 Graphic provided by Simon Bell, British Forestry Commission.

13 Graphic provided by Simon Bell, British Forestry Commission

The location of each of these features is recorded on overlays on the perspective photographs for each design unit and accompanied by detailed annotations, to provide a more detailed description of their contribution to the landscape character.

In addition to the landform and land feature analyses, notes on *genius loci* and the scale of the landscape can be added to further assist the designer's understanding of the landscape.

WADF Example:

These analyses were completed by the team during the workshop, proving that a landscape character analysis could be carried out by everyone, regardless of design skills, after a little practice, and with a surprising degree of consistency. It thus provided a fairly objective way of determining the composition and nature of the landforms in the study area, providing guidance for the designer in subsequent steps of the TRD process.

The 'lines of force' were marked on both a copy of the base map for each of the 16 sub-units, and on overlays of the perspective photographs for each sub-unit. When identified early in the Total Resource Design, process the lines of force acted as 'links' between plan and perspective and were used to help the team when they were attempting to transfer factors (such as the constraints and opportunities) from the planimetric inventory maps onto the perspective views.

The result of the landform analysis for the whole of the WADF is shown in Figure 14.

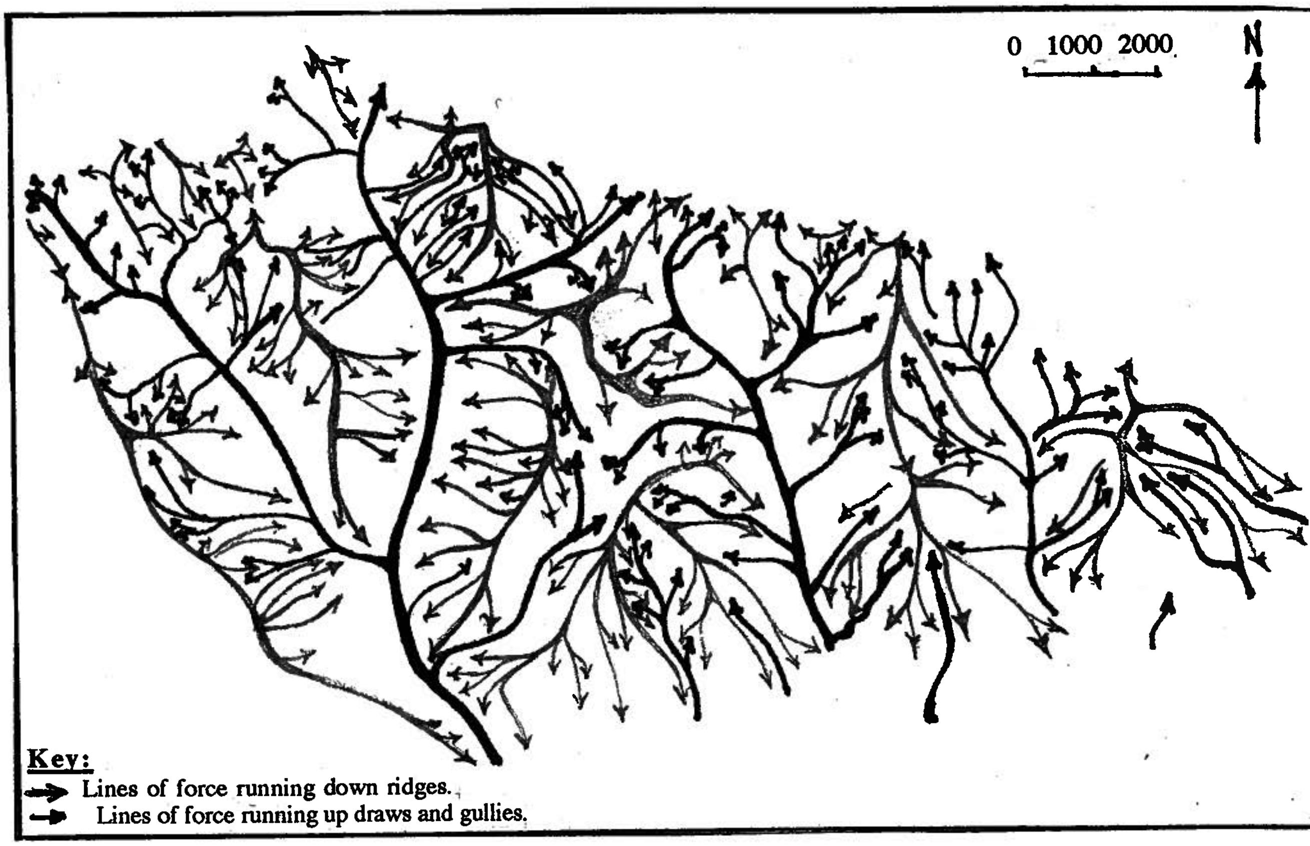


Figure 14. Landform Analysis of the WADF, planimetric illustration

3.4.5. Scenario Development

This stage of Total Resource Design is the design stage of the process, that is, the stage when solutions are actually produced on paper in a graphic form. It consists of two steps which proceed in a sequential manner. They have been called 'concept design generation' and 'sketch design generation' by Bell, but whatever the labels, the approaches applied in these steps are recognized components of any design process (Booth 1983).

3.4.5.1 Concept design generation

This is the first step of the design phase. It pulls together all the conclusions and ideas which have emerged from the previous steps, to produce general and loose arrangements of a solution. This 'concept' design step is described further by Booth:

> "The purpose is to identify the best and most appropriate relationships that should exist between the major proposed functions and spaces of the design. The intent is to gain an insight about which functions and elements should be associated with each other, and which should be separated. The designer is striving for the absolute functional relationships among the various parts of the design"(Booth 1983:294).

Diagrams produced at this stage are simplistic and abstract, representing the design functions and spaces as general outlines or 'bubbles' , which can be arranged to produce 'ideal relationships' among the elements and their functions. Important to the whole process of design is the investigation of alternative solutions. Thus several scenarios should be produced at this stage, to allow comparisons to be made at a later date in the search for an appropriate design solution.

The basis of Bell's design process lies in the fact that the landscape itself will provide "structure, pattern and context" from which the designer can perceive a number of possible 'directions' for the design (Bell 1993a).

The ecological landscape pattern objectives, constraints and opportunities analysis and the landform/features analysis should be overlaid on a base map. They should also be presented in perspective form for each design unit of the landscape and overlaid onto perspective photographs, so that the design can occur in both plan and perspective. The ecological pattern objectives will provide the designer with direction as to where certain types of units (for example, corridor units, patches, areas to be preserved) should be placed on the landscape and will also provide pointers as to the necessary scale of these units. The constraints and opportunities analysis will identify where the location of units might be inadvisable due to practical constraints on management. It will also remind the designer of all the resource factors which have to be considered in the design of each unit. The landscape character analysis will provide information about the underlying nature of the landform. Because of the strong influence that topography has over vegetation patterns and flows in a landscape, it will help the designer to understand how patterns might be placed on a landscape in a way which will promote connectivity and reflect natural landscape diversity (Diaz and Apostol 1992).

This step is one of assimilation, innovation and compromise. Bell suggests that a period of contemplation of the landscape and experimentation with shapes should help the designer envision how the landscape could be divided into shapes following topography and vegetation patterns. As these shapes emerge and are sketched roughly, they can then be compared with the ecological pattern objectives to see how the two can be linked together (Bell 1993a). The resulting concept designs can then be discussed within the design team and with the public, and iterated until it is felt that the designs adequately meet all of the objectives for the landscape. The sketches should then be annotated with notes on what the shapes might represent in the landscape (for example, areas to protect, areas where harvesting is possible) as well as notes on the general magnitude of these shapes. This step is thus a rough assimilation of previous analyses into an outline for the design of management unit shapes.

<u>WADF Example:</u>

This step was incomplete at the end of the workshop and was carried out by Simon Bell in Great Britain, where an estimation of the ecological pattern objectives (as these had not been quite completed or mapped by the design team) were overlaid (in perspective view) and examined in relation to the objectives for the area. Rough 'bubbles' were drawn on perspective photographs of the different design units, which corresponded to areas where units could be placed. These diagrams were annotated with notes on the characteristics of the underlying landscape, which would be important in the final design of their shape and location and eventual management.

These concept sketches were developed straight into final sketch designs by Bell, without any iteration or discussion with the design team, due mostly to the fact that Bell was working in Britain. This is a fault with this particular application and should not be repeated in any subsequent applications.

3.4.5.2 Sketch design.

This stage of scenario development is again present in any general design process and is described by Booth as follows:

> "with the basic theme of forms in mind, the designer converts the bubbles and abstract symbols of the concept design into specific and exact forms. While trying to adhere to the functional and spatial arrangement of the concept plan, the designer is also attempting to create a composition of forms that are attractive to the eye. The composition should be based on the basic principles of design and form composition"(Booth 1983:299).

To facilitate this step in Total Resource Design, Bell has imported the principles of forest landscape design which have been developed by the British Forestry Commission and have been used by Bell and his colleagues in Britain in the design of forest plantations and harvesting over the past decade. They attempt to provide a vocabulary which will allow the individuality of landscapes to be described and understood. Those components of the landscape which contribute to its attractiveness can be identified and used as a basis for the formation of a design for forestry in that landscape, be it planting or harvesting. The major principles identified by the Forestry Commission for use in forest landscapes are : shape, scale, visual force, diversity, unity and *genius loci* (Lucas 1991).

The most valuable aspect of the British approach to forest landscape design, is the emphasis placed on the characteristics of the underlying landscape (D. Apostol pers. com. May 1994), an approach first developed by Dame Sylvia Crowe (Crowe 1966, Crowe 1978). Crowe recommended that the topographical base of the landscape be 'allowed to speak' and provide guidance, primarily on the shape of the blocks on the landscape. This understanding is brought to the design phase of TRD in the form of the landscape character analyses. The principles of visual landscape design can then be used to determine the spatial characteristics of the units being designed, to ensure that they fit in with these underlying characteristics.

WADF Example:

Simon Bell was asked to finish the design of the management units on the perspective photographs of the area. These were then transferred into a planimetric form, to produce a final map of the West Arm Demonstration Forest showing the management units, to which appropriate stand management objectives could be attached. This perspective to planimetric transformation is tedious and difficult to achieve with accuracy when done manually. However, the British Forestry Commission has the software capability to carry this out by computer, a capability which is not present within the B.C. Ministry of Forests at this time.

Only one design scenario was produced by Bell for this application. This was because the WADF application was a demonstration project, set up to illustrate the Total Resource Design process and to illustrate some of its results. Again, in any subsequent applications, several scenarios should be produced if the 'client' is to have sufficient choice in the outcome.

The final product of the Total Resource Design plan, the map of the location and shapes of the management units accompanied by perspective view simulations produced by Bell are shown below. Both illustrations show the ecological units (biogeoclimatic subzones) within which the designed units are located. This allows reference to be made to the stand structural objectives applicable to each designed unit.

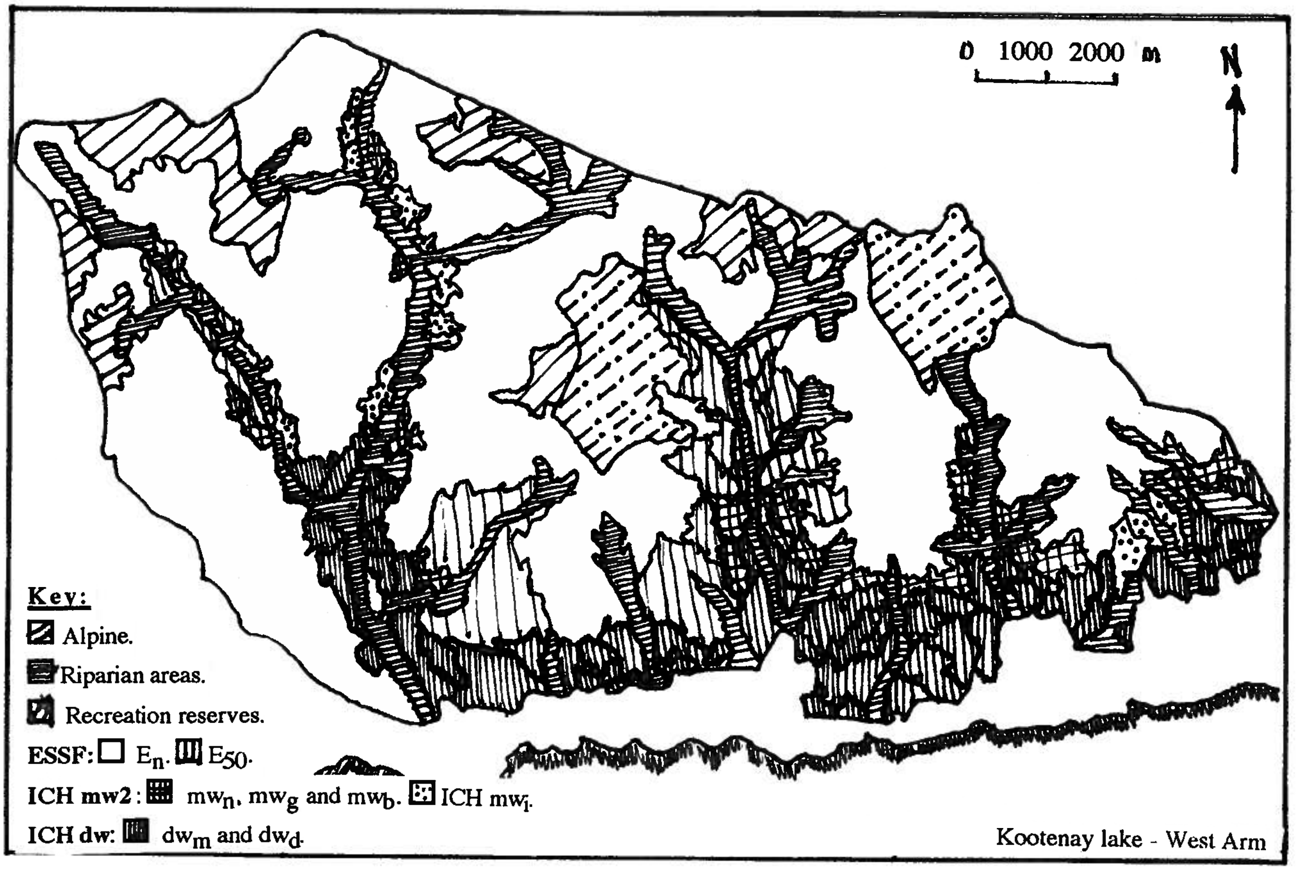


Figure 15. Final sketch design for management units of the WADF - planimetric view.

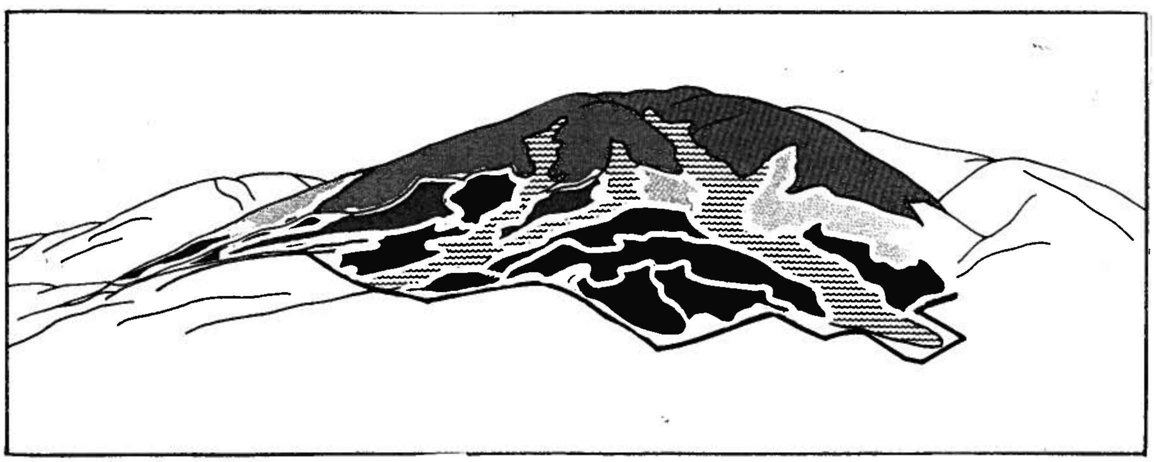


Figure 16. Sketch design for designed units in the Queens/Laird face of the WADF - perspective view[14].

[14] Graphic provided by Simon Bell, British Forestry Commission

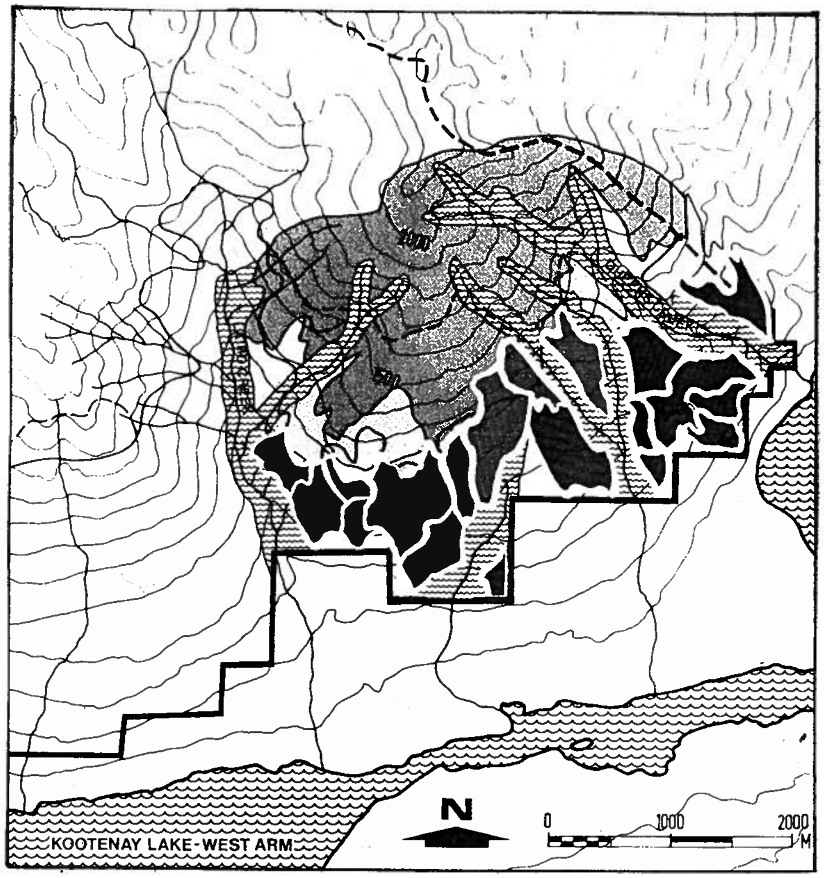


Figure 17. Sketch design for designed units in the Queens/Laird face of the WADF - planimetric view[15]

3.4.6 Assessment.

Once the sketch designs have been completed by the designer for each scenario, and agreed to by the design team, decisions must then be made as to how the designed units in each scenario will actually be managed. These decisions are based on an assimilation of the results of the analyses and are guided by the general objectives for the landscape, the ecological landscape pattern objectives and the stand structural objectives. Once these decisions have been made, the implications of each scenario on the various resources present in the landscape such as timber, recreation, wildlife, landscape quality etc. can be estimated. Simulations for each scenario can also be produced, using simple graphic techniques or computer generated graphics, to illustrate how the management units will appear on the landscape under these management decisions. The different scenarios ,

[15] Graphic provided by Simon Bell, British Forestry Commission.

accompanied by the implications of their implementation and the graphic simulations, can then be take to the 'client' for assessment.

This step requires the 'client' to examine each scenario and its identified implications, and to question the ability of the designs to meet the objectives defined for the landscape at the start of the process. A decision can then be made as to which scenario is most suitable to the 'client's' requirements, or if none are suitable, that iteration and alteration of a scenario may be required to reach a compromise.

Once a decision has been made, the chosen scenario can be implemented by the client. The results of this implementation must be monitored carefully and evaluated against the original objectives. Alterations of the design can be made if this performance is not satisfactory and observations made can be used in the compilation of any future designs. It is important that this step is carried out and that the process does not stop with a decision on the design to be implemented. As landscapes are dynamic and may change unexpectedly, and because societal values and objectives for a landscape will also change through time, it is vital that any Total Resource Design produced be updated and revised at frequent intervals. This will ensure that management of the landscape remains flexible and can react rapidly to any situation.

WADF Example:

A final sketch design has been produced by Bell for the West Arm Demonstration Forest application (shown in Figure 15). This is however, merely an illustration of the shapes and location of management units across the landscape. No decisions as to how and when each of these units is to be managed, has yet been made. Thus, although there is a completed pattern of shapes, there is no firm concept as yet, of how the structure and appearance of these units will change through time. This pattern, which will determine whether a unit will act as a component of the landscape matrix, or as a patch of a certain age class, or as an area of ungulate winter range or a riparian zone, is necessary before any assessment can be made on the effectiveness of TRD in meeting its objectives. Once it has been completed, quantitative assessments of timber flows and road costs can then be carried out, and the attributes of the landscape patterns created can be examined in respect to the other non timber resources, such as wildlife habitat, water quality and quantity, recreation experience, etc. In terms of visual resources, the management units have been designed to 'fit' the landscape, so that they flow around contours and relate to the characteristics of the landscape, such as its scale, diversity etc. However, the management of each unit will dictate its appearance in terms of colour and texture, and scheduling will also determine the amount of disturbance in the landscape at any one time. Thus the final management regime for the landscape is required before a full idea of the impact of the design on the visual character of the landscape can be made.

Until the Total Resource Design process is completed for the West Arm Demonstration Forest, little can be determined about its potential impacts on the landscape. It is hoped that the method followed will produce favorable results which can be realistically implemented. Production of several management scenarios for the designed units should allow the Ministry to the take the final design to the local community for discussion and feedback, to determine their response to this new approach to forest planning in their area. Each scenario should be accompanied by the results of an evaluation of its potential effects on the resources of the landscape, so that an informed decision can be made by the client as to whether or not a Total Resource Design should be applied, and if so - which scenario would be the most acceptable.

3.4.7 Presentation of the Total Design Plan

The final landscape design plan document has not yet been compiled by the Ministry of Forests. When this is done, Bell recommends that the plan should be presented as a sequence of maps and graphics, with verbal descriptions kept to a minimum (Bell 1993a). This level of planning provides landscape level guidance, so detailed site specifications need not be included. The necessary information can be effectively presented in a visual form as a series of maps showing each step in the Total Resource Design process, i.e., the survey information, the results of the analyses, and the final maps and perspective sketches showing the management unit boundaries. These should be accompanied by introductory paragraphs to provide a familiarization with the area and its objectives, and with the lists and tables of landscape and stand level objectives which have been derived by TRD (Bell 1993a). Simulations showing how the landscape will appear through time will also be useful.

3.5 Conclusion

The end results of the application of Bell's proposed method for Total Resource Design to the West Arm Demonstration Forest were two fold. Firstly, the workshop necessitated and resulted in the evolution of a detailed method for the application of TRD in British Columbia. Secondly, it initiated the first major steps in the production of a Total Resource Design for the West Arm Demonstration Forest. This should be completed by the Ministry of Forests (WADF management team) in the near future, hopefully by the end of 1995. This Total Resource Design will provide the guiding direction for all operations in the West Arm Demonstration Forest over the short term, and if re-evaluated at regular intervals, it should also provide sound long term guidance. As well as these tangible outputs of the workshop, it also introduced many of the staff of Nelson Forest Region to the Total Resource Design approach and consequently provided a source of feedback on the attributes of the process itself.

The design team felt that the TRD process had many benefits, related to its capability to contribute to an increased public acceptance of forest operations, the maintenance of long term sustainability of the forest and an increased level of job satisfaction for forest managers. This approach would, after all, provide an opportunity for the holistic treatment of forest landscapes and would enable the profession to return to the practice of stewardship of all forest resources. The dominant negative aspect of Total Resource Design recognized by the team was related to its cost and the time required for its completion. Although no timber forecasts have yet been estimated from the results of the workshop, it was suspected by the team that it would result in a smaller yield of timber from the West Arm Demonstration Forest, at least over the short term. It would also require silvicultural systems, such as group selection and partial cutting, which themselves would be less economically efficient than clear cutting practices. The cost of Total Resource Design as a planning process was also found to be high. The WADF workshop cost $2300 in preparation and materials alone, 232 person hours for preparation and a further 560 person hours which were spent by the design team participating in the workshop and away from their other duties. At the end of the workshop, the process had not been completed. The design of the management unit shapes was finished by August 1994, approximately six months after the original workshop. A considerable amount of group discussion within the design team is still required to provide management decisions on how each of these will be managed in the future. There is no question that future applications of TRD should not take as long as the initial test case, as the steps will have been clarified and expertise will have been generated. However, bearing in mind that Simon Bell did much of the design work on this project, to implement Total Resource Design in the future the Ministry of Forests will need to recruit or train their own staff in visual design techniques and will have to purchase the CAD (Computer Aided Design) software necessary to produce accurate planimetric representations of perspective designs. When considering any future application of Total Resource Design in B.C., these costs will have to be balanced against the many positive benefits discussed above. The design team accepted that the approach provided by Total Resource Design will be increasingly desired in the coming years, given the growing pressures on the Ministry of Forests to perform in an environmentally and visually responsible manner, which may possibly make the justification of economic costs easier in the future.

The next question to be asked regarding Total Resource Design concerns its future application in British Columbia. The WADF example has provided a method and an estimation of the capabilities, advantages, limitations and costs of the process. However, there are many other practical considerations concerning the suitability of Total Resource Design for widespread application in B.C. These will be the subject of the next chapter.

Chapter 4

The potential of Total Resource Design for general application in British Columbia

4.1 Introduction

The purpose of this chapter is to examine the attributes of the Total Resource Design process in the context of current and possible future forest planning and design requirements in British Columbia. Primarily, it will try to determine whether a process such as TRD is actually needed in B.C. at the present time. To do this it will identify deficiencies in the current planning framework which TRD could help fill. It will then try to estimate if Total Resource Design would be an improvement on the *status quo*, and whether it would easily fit into the current forest planning framework. It is therefore anticipating a scenario where staff in the Ministry of Forests headquarters are introduced to Total Resource Design and are required to evaluate its potential as a planning tool.

It must be remembered that current planning and policy conditions may change through time and thus if the performance and suitability of TRD is currently judged unsuitable for some reason (for example economics) the possibility exists that the criteria for making this decision may change in the future. This could result in Total Resource Design being considered in a more, or less favorable light at some future time.

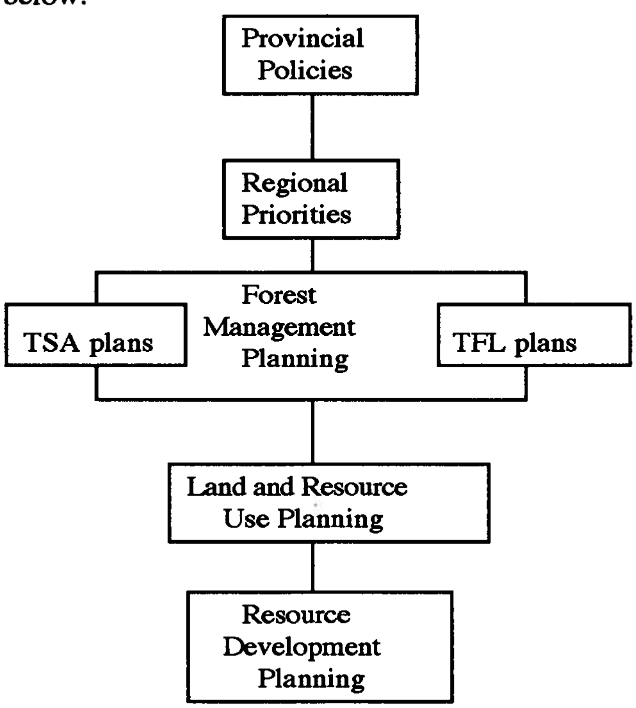
This chapter is composed of five sections. The first four address the following questions:

1. Are there any 'gaps' in forest resources planning in B.C. which could be filled by TRD?
2. How does its approach compare with that of current integrated resource planning procedures?
3. How would Total Resource Design fit into the forest planning framework?
4. Would TRD meet the legal requirements for forest management in B.C. contained in the Forest Practices Code (Province of British Columbia 1994).

To conclude the chapter, an example of a particular resource management scenario whose properties suggest the use of Total Resource Design will be investigated to illustrate the potential the process may have for the coordination of multiple resource interests in sensitive forest areas.

4.2 TRD - could it fill any 'gaps' in current forest resource planning in B.C.?

The Ministry of Forests is responsible for the administration of the provincial forest lands in B.C. It has a broad mandate to carry out Integrated Resource Planning of these lands (provided by the *Ministry of Forests Act, The Forest Act* and the *Range Act* (Duffy 1990)) which it currently attempts through the hierarchical planning framework illustrated below:



TSA: Timber Supply Area (a form of volume-based tenure of provincial forest lands)

TFL : Tree Farm License (a form of area-based tenure of provincial forest lands)

Figure 18. Forest Planning Framework (Duffy 1990 :29).

An important deficiency in the current forest resources planning framework, for which Total Resource Design could potentially provide a solution, has been recognized by the Ministry of Forests (A. Lidstone. pers, com, 1994). Within this framework, planning 'jumps' from strategic coverage of large spatial areas at the forest management level and above, to detailed operational plans, often carried out for small portions of the forest management plan area. Planning at the intermediate spatial scale of the landscape, applied consistently across the provincial forest land base is absent. Local Resource Use Plans (LRUPs) do provide strategic direction, objectives and guidelines at the scale of the watershed. However, these are only carried out in circumstances where complex resource issues require detailed planning for their resolution (Ness 1992), and are not in place for every area of provincial forest land in the province.

Discussion within the Ministry of Forests (between ministry planners and managers) and with industry identified that landscape level planning might address some of the long term planning needs and conflicts which currently exist by providing forest planning at this 'missing' intermediate spatial scale (A. Lidstone. pers, com, 1994). Recognition of the value of landscape level planning has thus been included within the proposed Forest Practices Code (Province of British Columbia 1994), where landscape level planning will be officially recognized and required. The *Forest Practices Code of British Columbia Act* will provide 'enabling' legislation to allow District Managers to establish *landscape units* [16] and objectives for their management wherever and whenever they are needed (Province of British Columbia 1994). What are not yet in place, however, are detailed guidelines for the formulation of these objectives, or for the production of coordinated prescriptions for these landscapes. This suggests a possible future role of TRD, which provides a method by which such integrated landscape management could be achieved.

As alluded to above, as well as providing a spatial link between planning levels, landscape level planning is intended to provide an important link between strategic and

[16] Landscape Unit: "A planning area, up to 100 000 ha in size, based on topographic or geographic features such as a watershed or series of watersheds". (Province of British Columbia 1994:183)

operational planning. It will take broad objectives and guidelines for a large area and refine them into more specific directions for a landscape, from which detailed operational plans for cutblocks and road layouts, for example, can take their direction. Landscape level planning will therefore attempt to provide a firm planning base which will ensure that all operational plans for small areas within a landscape are compatible with each other and with the overall objectives for the landscape (M. Platz. pers, com, 1994). The ability of TRD to provide such a 'translation' between strategic and operational plans would also suggest it as a possible method for bridging this gap.

The Ministry of Forests has not progressed significantly beyond an identification of the need for landscape level planning but they have expressed an interest in Total Resource Design and its application in the West Arm Demonstration Forest . They have recognized that it provides a practical example of a method for the application of a landscape level planning and design process in B.C. and as such is a source of ideas for the type of approach which may be required to implement the management of landscape units.

4.3 TRD - how does its approach compare with that of current integrated resource planning procedures ?

In addition to its contribution to the development of landscape planning, Total Resource Design may also offer a more effective approach to Integrated Resource Management (IRM) than that provided by current integrated resource planning procedures .

Two key advantages of TRD in achieving effective integrated resource management can be noted.

i) Total Resource Design offers a coordinated approach to resource planning.

ii) Total Resource Design approaches the planning from a different perspective, one that is 'landscape led'

i) A coordinated approach to resource planning.

Currently, IRM is carried out on provincial forest lands through the establishment of guidelines, requirements and the implementation of objectives from higher level plans. These attempt to protect non-timber resources through the restriction of harvesting. Each resource, such as, biodiversity, wildlife and fish, water, visual resources, range etc., is protected by its own set of guidelines or restrictive mechanisms and each tends to be administered by a different branch of the Ministry of Forests, or with the involvement of other Ministries, such as the Ministry of Environment. Often, the management of one resource is planned to meet its own objectives, independent from other resources in that landscape. The division of responsibility in this approach, makes coordination of the management of resources difficult, providing an obstacle to effective integrated resource management of forest resources.

The advantage of Total Resource Design over this piecemeal approach, is that it incorporates all resource interests into one planning and design process. This provides a forum for interaction, discussion and compromise within the design team and produces one plan (a Total Resource Design) for the landscape. This provides a vision for the landscape and for all resources - resulting in a common direction, common goals, and a framework for the coordination of the actions of all the resource managers present. This is communicated in the form of a design for all possible management units on the landscape, and a description of the agreed direction for their management through both the short and long term. In theory, this should provide for less conflict, improved communication and fewer misunderstandings in the subsequent management of the landscape.

ii) A 'landscape led' approach to the planning of timber extraction in the landscape.

Total Resource Design adopts a different philosophy to the management of natural resources in the landscape than existing IRM mechanisms. As mentioned above, the current approach to integrated resource management is to allow timber harvesting to occur under a set of constraints. In other words, within non-reserved provincial forest lands the potential for forest operations exists everywhere where harvesting is technically and economically feasible, and this land base is then diminished with the imposition of restrictions to accommodate the other resources. An observation of this approach reveals that there is a tendency for merely the minimum requirements for non timber values to be met, as the process sets standards beyond which there is little incentive to perform.

Total Resource Design adopts an almost 'inverted' approach to the protection of non-timber values. The main focus of TRD is to ensure that all of the identified resources in the landscape are adequately provided for, at which point proposals for harvesting can be then be developed in the land base which remains. It thus concentrates on planning what is to be left behind after harvesting, rather than what is to be removed. This approach suggests that non-timber interests will be more successfully integrated into forest operations and thus maintained through time. For each of these reasons, TRD would seem to possess some advantages over the *status quo* in pursuing effective integrated resource management. It certainly attempts to consider all the resources as 'equal partners' and avoids letting one resource, such as timber extraction, dominate the decisions taken for the management of the landscape. Its addition to the current planning hierarchy would certainly seem to be justified given the current need for a landscape level approach to IRM.

4.4 Incorporation of TRD into the current forest planning framework

As suggested above, Total Resource Design could most likely be incorporated into the forest planning framework at the landscape planning level. i.e. between forest management planning, and resource management planning, providing guidance at this spatial level and a link between strategic and operational planning. In addition, the ability of Total Resource Design to coordinate the management of many resources in a landscape suggests that it could be incorporated into Total Resource Planning - a new landscape level planning initiative being developed by the Ministry of Forests. In 1993, before TRD had been formally introduced into British Columbia by Simon Bell, the Integrated Resources Branch in Victoria developed the concept of Total Resource Planning (TRP). It evolved in response to a number of factors , most notably public demands for 'ecosystem management', the ideas of landscape ecologists such as Franklin in the Pacific Northwest of the United States (Franklin and Forman 1987), and questions as to how foresters in British Columbia could implement new Fish Forestry and a Wildlife Guidelines (MOE and MOF 1993). As its name implies, Total Resource Planning emphasizes the consideration of all resource values when proposing any forest operations in an area. In theory this should already happen as forest planning should be carried out under the Ministry of Forest's integrated resource management policy. However, many objectives of integrated resource management are not consistently addressed in the current planning framework (MOF 1993b). In response to this and the other stimuli mentioned above, the Ministry of Forests released a proposal for Total Resource Planning in August 1993. In their introductory document they define TRP as:

> " a process that designs long term forest development and guides timber harvesting over an entire area, such as a watershed and confirms how approved objectives for identified resource values will be achieved in the ground" (MOF 1993b :1).

It is proposed that TRP will translate the broad resource management objectives provided by higher level plans into on-the-ground development direction, in a method which will consider all known resource values and the environmental limitations of the planning area. It is aimed to be a landscape level planning process, which if developed will help to fulfill the Ministry's new landscape level planning initiatives, with the added dimension of considering all resources in an area before deciding on how timber should be extracted. It is intended to be a planning tool which is to be implemented only after land use decisions for an area have been made which permit the harvesting of timber. TRP will then enable this harvesting to be planned with consideration of all other resources (M. Platz. pers, com, 1994).

Feedback on the proposed process from government staff, industry representatives, environmental organizations and members of the public has been mostly positive, with Total Resource Planning considered to have many benefits (MOF and MOE 1993). However, the details as to how these 'Total Resource Plans' will be completed have yet to be determined, and how exactly broad management objectives can be 'operationalized' into on the ground prescriptions is as yet unclear (A. Lidstone. pers, com, 1994). It must be stressed that Total Resource Planning is still in the conceptual stages of development, yet some forest districts in B.C. are currently carrying out TRPs - with little guidance or consistent method of application (MOF Golden Forest District 1993).

From this perspective, Total Resource Design and the methodology it suggests for the actual design of operational prescriptions is of interest to the Ministry of Forests as they search for an appropriate method for the implementation of TRP (A. Lidstone. pers, com, 1994). The objectives and final products of the two processes, although developed independently, are very similar and so it is possible that TRD could merely be considered as a method by which Total Resource Planning can be implemented. Within the current emphasis on planning for all resources, Total Resource Design could also ensure that visual resource management and ecological functioning in particular are included in Total Resource Planning.

4.5 How TRD incorporates the requirements for forest management in B.C. contained in the Forest Practices Code

On 16th May 1994, the *Forest Practices Code of British Columbia Act* was introduced in the Provincial legislature. This act will be accompanied by a series of *standards* and *regulations*, which will set out the mandatory requirements which must be met, under the authority of the new Act, when carrying out any forest operations on Provincial forest land in B.C. (Province of British Columbia 1994). 'The Code' encompasses all aspects of forest practices; it outlines requirements for planning, the protection and management of forest resources and specifications for on-the-ground operations. As such, under law, any new planning approach such as Total Resource Design would have to comply with the requirements of the Code in its approach, its treatment of resources and its results. This section will briefly outline whether TRD meets the Forest Practices Code, and will also examine whether there are areas of the Code itself which could constrain or actively support the use of TRD in the Province.

From an inspection of the proposed regulations and standards which have been produced to date (Province of British Columbia 1993, Province of British Columbia 1994), it would appear that Total Resource Design incorporates many of the requirements outlined, and does not seem to conflict with them in any significant way. This is due in most part, to the ecological basis of TRD, and to the emphasis placed within the process on accommodating all forest resources present in the production of the final design. In the West Arm Demonstration Forest example, the broad objectives used to guide the design process came from a draft management plan for the forest (MOF Nelson Region 1994). All of the guidelines and recommendations set out in this plan met the specifications laid out in the Code, and in most cases were more stringent. With such a plan providing direction to a Total Resource Design, it can be assumed that a framework for compliance with the Forest Practices Code is already in place. If no such plan exists for an area, it will be important that objectives and any prescriptions developed by a TRD are checked against the requirements of the Code so that no conflicts ensue. This will have to be done so that the final design will comply with the law, even though there may be some instances where doing so may interfere with its 'landscape led' approach.

For example, a constraint to Total Resource Design may come from the requirement for the "establishment and adherence to Visual Quality Objectives" (VQOs) (Province of British Columbia 1993: iii). When TRD is used to design a landscape level plan for an area, it aims to accommodate any descriptive VQOs provided for the area. For example, in a landscape with a retention VQO, the level of disturbance advocated will be minimal, and the alteration of the landscape will not be visually apparent. This does not conflict with Total Resource Design and can be incorporated into its process. However, a problem may become evident if the design team are bound by the numerical descriptors attached to each VQO. For example, where there is a retention VQO, up to 5% of the landscape may be changed by forestry operations (MOF 1993c). This is 5 % of the planimetric representation of the landscape unit. This percentage may seem small when illustrated in planimetric form, but depending on the scale of the landscape, the slope involved, the position of the viewer and the Visual Absorption Capability of the landscape, 5% can look very different from landscape to landscape. It may be too large for a small scale landscape, or far too small in one where large shapes and patterns are naturally occurring. These numerical descriptors for VQOs will constrain the Total Resource Design process by imposing an arbitrary scale of disturbance on a landscape, irrespective of the nature and scale of the landscape being considered.

Within the Forest Practices Code, it states that "forest operations planned in visually sensitive areas must be designed and carried out to meet approved Visual Quality Objectives" (Province of British Columbia 1993 :30). The pertinent question regarding this requirement is 'will this requirement be enforced qualitatively or quantitatively - by measurement of the % of the landscape disturbed?' Total Resource Design can work comfortably within the framework of VQOs and produce landscape alterations which meet the descriptions provided by VQOs. However, if VQOs are enforced quantitatively, they will provide a severe constraint on the Total Resource Design philosophy by imposing an irrelevant and non-site specific scale of disturbance on the landscape.

A second instance of the use of numerical values to restrict management has also been included in the Forest Practices Code in the form of a limitation on the size of cutblocks (40 ha for the Vancouver, Nelson and Kamloops Regions, and 60 ha for the Cariboo, Prince

George or Prince Rupert regions (Province of British Columbia 1994:107)). At first glance this might also seem to constrain Total Resource Design as the essence of TRD lies in the fact that it allows the landform and natural disturbance patterns of a landscape to suggest how the landscape should look, which in turn dictates the size, shape and position of harvesting units on the landscape and the type of silvicultural system used. There may be areas where, all resources considered, a larger than mandated block size could be advocated and would fit with the landscape. In such scenarios, rigid constraints, such as a maximum allowed block size, would prevent TRD from providing a result which is 'landscape led'. However, the Code goes on to state that in certain cases, there will be exceptions to this size restriction where :

> "the cutblock incorporates characteristics of natural disturbances. Characteristics that must be incorporated are irregular edges and green-tree retention or forested patches, and may include wildlife trees and coarse woody debris" (Province of British Columbia 1994 :107).

In the West Arm Demonstration Forest application of TRD, stand structural objectives were produced which were based on the effects of natural disturbances and which, for the most part, advocated the retention of forested patches and green trees. Therefore, in this case cutblock size limits would not be a major restriction. Where natural disturbances in a landscape are used to guide TRD in this way, this section of the Code should not provide a major obstacle.

As well as merely complying with the Code and adapting to incorporate its requirements, the approach used in Total Resource Design would also seem to gain support from the Forest Practices Code. Most notably, by providing a method for coordinating multiple resources towards an integrated solution for landscape management Total Resource Design would seem to provide a vehicle for the achievement of many of the Integrated Resource Management requirements outlined in the Code. For example, concerning the planning of timber harvesting the Code states:

> " To achieve IRM objectives, the prescription of cutblock sizes, shapes and patterns should be based on a consideration of such factors as windfirmness, edge effects, desired wildlife travel and dispersal corridors, fisheries sensitive zones, aesthetic values, biological diversity, roles of ecosystem components in ecological processes, natural disturbance regimes and the feasible application of harvesting and site preparation methods" (Province of British Columbia 1994:101).

To carry this out without any kind of guiding framework or method would be very complex, confusing and time consuming. Total Resource Design provides such a method, could incorporate each of the resource concerns mentioned and would result in the design of the cutblock shapes, sizes and distribution across the landscape. As no other method has yet been suggested other than the *status quo* of reactive, piecemeal alterations to harvesting proposals, Total Resource Design, or a similar approach, would appear to have a contribution to make towards an effective implementation of the Forest Practices Code.

4.6 An example of a scenario in B.C. whose properties suggest the use of Total Resource Design

Finally, in this chapter, a general management scenario to which the application of Total Resource Design would seem to be very suitable will be examined. It is hoped that this will identify a further aspect of the possible scope this process could have in forest planning in British Columbia.

From the stand-point that it provides a mechanism within which the design of timber harvesting units is driven by the ecological and visual characteristics of the landscape, TRD could be considered as a responsible approach to forestry which should have wide application throughout the province. However, there are resource management scenarios in the province at present, with certain resource characteristics and concerns, which would lend themselves specifically to the application of Total Resource Design.

The particular strengths of Total Resource Design lie in its use of the design process to lead a multidisciplinary design team to a series of spatially illustrated solutions for the integration of resource uses in the landscape. Thus, TRD would appear to predispose itself for application to areas of the provincial forest lands which require extensive cooperation between various agencies and stakeholders, whose ecological functioning and visual quality are particularly important and for which detailed and explicit management guidance is required. However, as Total Resource Design cannot efficiently include extensive public input or resolve complex social or political issues related to forest lands, it is not suitable for making land use decisions. It should be applied only to those landscapes for which a land use decision has been made, and thus for which guidance on the nature of suitable resource uses is available. The role of TRD is to take this guidance and produce a design for the integration of these resource uses across the landscape.

In light of these attributes of TRD, one particular scenario appears to suggest itself as an ideal future subject for Total Resource Design namely the design of resource uses on provincial forest lands adjacent to parks and protected areas.

In general, protected areas are established to provide for recreation enjoyment, to "stimulate educational and scientific interest and to conserve ecosystems in a pristine state" (Dearden 1988:256). It has been suggested that nature conservation in particular is not necessarily being achieved by these areas, based on a survey of the 'State of the World's Parks' carried out by Machlis and Tichnell in 1985 (cited in Dearden 1988). Most of the threats to the natural components of protected areas appear to originate outside their boundaries (Dearden 1988), for example from forestry, mining, agriculture and commercial development. A report on the parks and protected areas of British Columbia by the B.C. Caucus of the Canadian Assembly on National Parks and Protected Areas in 1985 also recognized the increasing threats to the protected areas in B.C. from external sources:

> " Resource developments around parks as well as potential access corridors through parks are perceived as significant threats to several of our large wilderness parks " (Dooling 1985:244).

Much of this concern is based on the recognition that administrative boundaries of protected areas act as 'filters' allowing flows to move both into and out of the areas, thus making them permeable to external influences (Schonewald-Cox and Bayless 1986). One result of this realization has been the recent emphasis on the management of complete ecosystems, which often requires the management of lands beyond the administrative boundaries of the protected areas.

In British Columbia, there is no doubt that forestry operations occurring adjacent to protected areas are of considerable concern to protected area agencies (Dearden 1988; Dunster 1985). This is especially true around those parks whose areas are too small to incorporate complete ecological systems or landscapes. These protected areas cannot provide all of the necessary habitat elements for their resident wildlife species and rely on adjacent lands to provide these requirements. Forestry operations on these areas have the potential to eliminate such habitats, isolate populations by providing obstacles to movement between habitats and effectively decrease the size of the park, as the effects of logging to the park boundary often extend beyond the cut area into the park itself. As Dearden observes:

> "When logged to the boundary, windthrow may take down further trees inside the boundary. Even when no trees fall inside the boundary, the ecological effects of logging will still be apparent for some distance into the reserve, through for example, a greater abundance of ecological edge species and hydrological and micro-climatic effects"(Dearden 1988 :257).

Parks whose mandates include the preservation of scenic beauty and the provision of isolated wilderness recreation experiences can also be impacted visually by resource uses along their boundaries. Dunster observed this situation in the Rocky Mountain National Parks :

> "within the national parks the extent of wilderness area is rapidly shrinking, even though the physical boundaries are not changing. This reflects the increasing activities beyond the boundaries, with logging on the western side and oil/gas exploration on the eastern side"(Dunster 1985 :24).

He continues, "in many of these areas, evidence of exploitation is visible from a long way within the park, thus eliminating the sense of isolation that these areas once had"(Dunster 1985:24).

If the ecological and visual values of protected areas are to be preserved, these observations suggest that each park and its surrounding landscapes should be managed as an interacting unit . They possess common resources, such as wildlife, recreation users and viewsheds, which 'flow' throughout and between the naturally defined landscapes, ignoring the administrative boundary. Different management objectives and practices on either side of this boundary have obviously resulted in the compromise of many of the flows originating within protected areas. But how can these distinct mandates be preserved, while allowing the provincial forest lands to be managed in a manner which is sympathetic to both the adjacent protected areas and the forestry sector?

The following case study involving Glacier and Mount Revelstoke National Parks, will highlight the present concerns the Canadian Parks Service has regarding the effects of forest operations in the adjacent Revelstoke and Golden Forest Districts. It will attempt to illustrate why, in this situation, Total Resource Design may provide an effective approach to the management of these areas.

Glacier and Mount Revelstoke National Parks are situated just 20 kms apart and are managed by the same staff and with similar objectives. Glacier National Park is situated in the Northern Selkirk ranges of the Columbia Mountains. It is 1350 km^2 in size and is recognized for its diverse wildlife and especially for its large grizzly bear population, and for its spectacular mountain scenery. Mount Revelstoke National Park is much smaller (260 km^2) and lies to the east of Glacier National Park in the Clachnacudainn Range of the Columbia Mountains and is also known for its wildlife populations.

Currently, despite the broad management responsibilities of the Parks Service, the primary concern of the staff of these parks is the maintenance of healthy populations of wildlife within the parks, and the continued functioning of their ecological systems (S. Hall, pers. com. 1993). Despite the large numbers of visitors which enter both parks via the Trans-Canada highway, management of the recreation and visual resources in and around the parks is given relatively little consideration, due to the current difficulties the staff have in meeting their ecological mandate.

This difficulty is due to :

i) The small size of the two parks, and the resulting reliance on adjacent provincial forest lands for the provision of vital wildlife habitat attributes.

ii) Forestry practices on these adjacent lands which alter the forest cover and have a negative impact on the wildlife populations using these areas.

This is explained in more detail by Susan Hall, the park ecologist for both Glacier and Mount Revelstoke National Parks:

> "Mount Revelstoke and Glacier National Parks are too small and lacking in key habitats to maintain viable populations of moose, caribou and grizzly, the species thought to have the most stringent habitat requirements in our area. The parks encompass about half the land area required to support a small population (150 individuals) of grizzly and caribou. For the parks to function as ecological reserves, park boundary areas need to be managed with compatible goals and in terms of the park's limitations. For example, with an estimated 16% old growth remaining in the parks, and little of it below 3000 feet, provincial land will have to fulfill most of this area's immediate requirements for old growth"(memo from S. Hall to R.O. Planning, Golden Forest District. 1993).

The response by the park staff to this situation has been to inform the Ministry of Forests of their concerns and to provide guidance on how these habitat requirements can best be incorporated into forestry operations. In effect, they have provided Golden and Revelstoke Forest Districts with an outline of the park's ideal objectives for the management of adjacent forest lands, and a description of what is, in essence, their vision for a desirable future ecological pattern for these areas.

Table 12 details some of the desired landscape elements the park staff would like to see maintained or enhanced in lands adjacent to the parks.

Table 12 Habitat requirements in lands adjacent to Mount Revelstoke and Glacier National Parks (information contained in a memo. from S. Hall to R.O. Planning, Golden Forest District. 1993)

Habitat	**Description**
Grizzly spring range	Low elevation (less than 915 m) feeding areas, also comprising winter and spring ungulate range. Forest-riparian-avalanche complexes comprise high use early spring range that is mostly lacking in the parks. The Mica and Revelstoke dams eliminated a large portion of the formerly available grizzly and ungulate spring range, so this habitat is now in critically short supply in our area.
Grizzly summer and fall range.	Mid elevation(1220-1524 m) - berry producing areas. Since logging cultures at mid-elevations have created extensive berry producing areas, while infrequent and small fires within the park in recent years have resulted in relatively few berry producing areas in the park, bears are expected to leave the parks in the summer to access this habitat. Bears are subsequently at risk from hunting and poaching , hence our major concern is about open access to park boundary areas.
Moose winter and spring range.	Low elevation (less than 915 m), south facing mature forest (for snow interception) adjacent to forage producing areas. Brushed-in cultures adjacent to remaining old growth at low elevations now provides winter range which is threatened by subsequent second pass logging and programs of brush control.
Caribou early winter (Nov. 1-Jan 15) range.	Low elevation (less than 1220m), north facing, old growth (greater then 140 years) cedar- hemlock and lower spruce-fir forests. Caribou are unable to access their high elevation ranges because snow has not yet firmed up sufficiently to support their weight and allow them to access lichen found high in the canopy of old growth high elevation forests. Old growth cedar hemlock forests are therefore critical habitats during Nov-Dec - early January. These forests are however slated to be cut and maintained as a mixture of young to mature forests, which are not likely to provide caribou requirements for shelter, predator avoidance and food.
Caribou late winter (Jan 16-April 15) range.	Upper slopes (above 1525m) and ridge tops in old growth spruce fir forests and parkland. Lichen on standing or fallen trees is only food source. Although this habitat may not be as threatened by logging, it is vulnerable to fragmentation.
Caribou spring (April 16-June 30) range.	Similar to early winter ranges: low elevation areas with green foliage. Access to these areas for movement and security from predators is critical.
Caribou movement corridors.	Vertical corridors of mature open forest, linking high elevation late winter and summer ranges with low elevation early winter and spring ranges are required. Caribou will not use dense semi-mature forests. Plantation establishment in the absence of open mature forest movement corridors has the potential to prevent caribou from accessing low elevation ranges which are important forage areas for pregnant females and are critical for successful calf production.

It is obvious from this information that parks staff have identified all of the elements of the landscapes surrounding the parks which are of importance to the maintenance of their wildlife populations. This has been passed to the relevant Forest Districts, who try to incorporate it into the development of harvesting blocks and Pre-Harvest Silvicultural Prescriptions. The park staff appear to be relatively satisfied with the cooperation they receive from the Ministry of Forests and most of the companies operating in the area.

However they are concerned that the current process has a tendency to achieve only the minimum requirements and that it is time consuming and piecemeal in its approach, requiring park review of and comment on Ministry of Forest wildlife guidelines, sub-regional plans, resource management plans and even PHSPs at the individual cut-block level (S. Hall. pers, com, 1993). This leaves park staff with little time or resources for the management of other park resources, which itself makes any integration of these resources with wildlife and ecological values very difficult (S. Hall. pers, com, 1993).

In contrast, TRD could incorporate the information in Table 12 as ecological pattern objectives for these landscapes, from which a spatial representation of the patterns could be used to design the location and attributes of possible harvesting units. Thus necessary patches of habitat, and corridors or areas of forest matrix required for movement of wildlife through the landscape could be integrated into the design of units in the landscape. Use of visual design principles in this process would also ensure the integration of visual resource management concerns.

The development of a Total Resource Design could be carried out by a design team comprising members of the two main agencies involved. The design process itself could then facilitate compromise and result in a total resource design for each landscape abutting the parks, providing a common direction for the management of these areas through time . It is hoped that this would reduce the need for continual communication between park staff and the Ministry of Forests. Regular re-evaluation of the design plans would ensure that any changing requirements of either agency could be inserted into the design process.

There is no doubt that any future implementation of TRD on these lands will require the commitment of both Parks Canada and the Ministry of Forests to this ecologically based design approach. It is possible that this approach will result in smaller volumes of timber from these areas, at least for the short term. This impact, if known, will have to be weighed against the benefits to the park resources that TRD can bring. It is also possible, in some scenarios, that the design of the block shapes for timber harvesting over time through TRD could result in the production of more timber over the next three to four passes by ensuring that all suitable timber is accessible and preventing the isolation of timber stands which can occur due to a lack of forward planning. Whatever the decision reached on the economic impacts of TRD, it is probably realistic to predict that only an ecologically based approach to the management of lands around protected areas, such as that provided by Total Resource Design, will ensure the effective realization of their purpose.

This is only one proposed application of Total Resource Design in British Colombia, but it is hoped that it has provided an example of the particular capabilities of such an approach, and specifically an illustration of its potential to integrate ecological and visual values into the planning of harvesting units.

While the impacts of Total Resource Design on timber flows and other economic factors are still unknown, many points have been raised in this chapter which would suggest that it has the potential to meet many forest planning needs in the province at the present time. Most of the arguments in its favour stem from the predicted ability of the process to provide more effective integrated resource management, at a landscape level, and within a method which would link strategic direction to on-the-ground operational prescriptions. While the evidence on whether TRD will live up to this expectation rests on the completion of the West Arm Demonstration Forest example, conceptually it would appear to offer many factors which are currently needed in British Columbia.

Chapter 5

Conclusions

The main objectives of this thesis were to document a detailed method for the implementation of Total Resource Design in British Columbia, and to speculate on the potential role of TRD in the future of forest planning in B.C. Through an investigation of both of these topics it was possible to draw the following conclusions.

5.1 A method for Total Resource Design.

It was possible to take an outline of a method for TRD provided by Bell (Bell 1993a), combine it with the work of Diaz and Apostol (1992) and experiences from the application of Total Resource Design to the West Arm Demonstration Forest (WADF), to document a detailed method for the application of TRD in British Columbia.

The use of the WADF example illustrated problems encountered in a practical application of TRD, and provided an insight into how these problems could be overcome by pooling information and intellectual resources available.

This example also provided an illustration and clarification of many of the concepts employed in Total Resource Design.

The method should be regarded merely as a framework or strategy to facilitate the production of solutions for the management of a forest landscape, solutions which will both maintain ecological functioning and allow each of the objectives set for the landscape to be met. Its success will depend on the quality of information available, and the commitment of the team to working through a method which may be complex and time-consuming in places.

Unfortunately, because of additional responsibilities and commitments on the part of the design team for the West Arm Demonstration Forest, the final sections of the WADF example and thus the details of the method have not yet been completed. It may be over a year until the project is finally finished, a time frame which was felt to be beyond the scope of this thesis. However, a future direction for completion of the final steps of the project has been outlined by the design team . This direction was used to try to complete the method description produced in Chapter 3. The final sections of the method must therefore be approached with a little caution in any subsequent applications, and communication made with the WADF design team to confirm whether the predicted approach was altered once their project was completed.

As a final Total Resource Design has not yet been completed for the West Arm Demonstration Forest, an analysis of the final product cannot yet be made. This is unfortunate as it would have been useful to discuss the performance of the method in a practical example in this thesis. Such an analysis will also be required to evaluate the suitability of the process for future application in B.C. For example, what will the impacts of such a design be on timber flows from a landscape? What will timber extraction and road costs be under this design? On a more qualitative note, will it effectively maintain important ecological functions of the landscape? Will maintaining certain patches and corridors in the landscape actually maintain or enhance population numbers of certain species? The TRD method will allow the team to prescribe a certain target pattern for the landscape which it is hoped will meet wildlife objectives, but will this pattern actually prove effective in meeting these objectives in practice? As TRD is based on an incomplete knowledge and understanding of landscape dynamics, even the design team involved with the project are not certain of its likely results. A final design implemented on the ground and closely monitored through time should provide not only an illustration of whether the process can produce an effective form of Integrated Resource management, but should also allow scrutiny of many of the ecological concepts incorporated into the process. Further projects throughout the Province, based in areas of differing ecological conditions and resource pressures should also be implemented to try to determine the flexibility of Total Resource Design and determine whether or not it could be applied effectively across the wide range of ecological and resource use pressures in British Columbia.

5.2 The potential role of Total Resource Design in forest planning in B.C.

Despite the absence of an analysis of the performance of TRD in the WADF application, it was felt that there were several attributes of the approach which could be examined to determine whether it could contribute to forest planning in B.C. This examination concluded that Total Resource Design would provide a new and more effective approach to forest landscape planning in B.C. The main reasons behind this conclusion are summarized as follows:

TRD involves the application of the design process to a forest subject in B.C.

The design process itself is not new. It is routinely used and tested in many other fields such as architecture and urban design. The application of design principles to forestry is also not new. For example, the British Forestry Commission has developed a process called 'landscape design planning' which assimilates analysis information with objectives to produce integrated design of forest plantations (S. Bell pers, com, 1993). The Mount Hood project (Diaz and Apostol 1992) was also an application of the design process to a forest subject. It combined British expertise in forest design, with landscape ecological principles to produce an integrated design for management units in a natural forest landscape. The use of integrated design in forestry in B.C. is, however, a new concept, and the WADF application of Total Resource Design was the first example of its kind in the Province. Traditionally, within the Ministry of Forests design has been synonymous only with visual resources and Visual Resource Management has been under the administration of the Recreation Branch and not the Integrated Resources Branch. This is not an ideal framework for the promotion of the wider capabilities of design, nor the integration of visual resources into forest planning or management. However, based on both the WADF example and the experiences in other jurisdictions, the design process would appear to have much to offer forest resource planners in B.C. It would provide a guiding strategy for the integration of resources and the design of management units across the forest landscapes of the Province.

TRD provides an opportunity for the 'proactive' management of all resources.

Total Resource Design provides an opportunity for resource managers of non-timber resources to say 'this is what we want to see in a landscape for the positive management and promotion of our resource'. Currently, managers of resources such as wildlife, water, recreation and visual resources rarely get such an opportunity. Their primary role is 'reactive' and involves imposing restrictions on harvesting and demanding changes in harvesting proposals to ensure the protection of their resource (G.Fox. pers. com. 1994). Total Resource Design encourages positive management goals for all resources, and attempts to put all of these resources on an equal footing at the stage of the planning process where operations are being prescribed.

TRD provides a step by step method for linking strategic and operational plans.

The Forest Practices Code, and the proposed Total Resource Planning process have both recognized the need for a 'bridge' between these two types of plans, preferably at the landscape scale, and both claim to provide that link (Province of British Columbia 1994, MOF 1993a). However, neither provide a complete step by step method which would lead a team of resource managers from strategic direction to actual prescriptions for operations, in a manner which would integrate and give consideration of all resources across a landscape and through time. One of the major contributions TRD could make to forest planning is B.C. is the provision of such a method.

Testing and application of TRD across B.C. in a variety of landscape types and resource use pressures should be thought of as a long term goal in the development and analysis of the process. However, a short term goal may be to apply TRD to those landscapes which have specific problems to which its application may be particularly suitable. For example, those landscapes on the periphery of protected areas where coordinated cooperation between agencies and resource users is required for the effective management of these areas could benefit greatly from the application of TRD. It is suggested that the next step in the development of Total Resource Design in B.C. should be to test the process in such a scenario to determine whether or not it would indeed facilitate the planning and management of these areas and allow management agencies to work towards a common goal.

It has been suggested that the approach advocated in Total Resource Design could meet several important deficiencies in current forest planning approaches. This conclusion has not yet been supported in practice and would seem to be 'a lot to live up to'. Whether or not it can be met may well determine the future of TRD in the Province. However, the individuals involved in the West Arm Demonstration Forest application, although reserving judgment on the process for the time being, feel that if they can get through the last stages and produce and implement a final design, the results will be good. It is seen as an opportunity to actively design the landscape of the West Arm Demonstration Forest towards a target 'vision' of landscape structure and function and (at the stand level) towards desirable stand structures. This vision, once complete, will be based on the natural dynamics of the landscape and should provide a sound framework for future operational prescriptions.

The WADF team agree that the concept of a 'landscape led' process such as Total Resource Design is much needed in B.C. and that the time has come to consider the feasibility of such processes for future application across the Province. The application of TRD to the West Arm Demonstration Forest is a first step towards evaluating the performance of a 'landscape led' approach to forest design in B.C. The important question is, can TRD live up to the expectations? Those involved with the WADF application are hopeful that it will, and that it will prove to be a realistic and feasible approach to forest landscape management, not only in the West Arm Demonstration Forest, but across the Province as a whole.

References.

Personal Communications.

Apostol, D. Landscape Architect, U.S Forest Service, Mount Hood National Forest. Telephone conversation, April 1994.

Bell, S. Landscape Architect, British Forestry Commission. Meeting, 1993.

Crampton, D. Research Branch, Ministry of Forests, Nelson Forest Region. Telephone conversation, June 1994.

Fox, G. Habitat Protection Branch, Ministry of Environment, Nelson. Meeting, August 1994.

Hall, S. Park Ecologist, Canadian Parks Service, Revelstoke. Meeting, November 1993.

Lidstone, A. Integrated Resources Branch, Ministry of Forests, Victoria. Telephone Conversation, April 1994.

Platz, M. Integrated Resources Branch, Ministry of Forests, Victoria. Telephone conversation, May 1994.

Publications cited.

Agee, J.K. 1993. *Fire Ecology of Pacific Northwest Forests* . Island Press. Washington D.C.

Baker, W.L. 1989. Landscape ecology and nature reserve design in the Boundary Waters Canoe Area, Minnesota. *Ecology* 70(1): 23-35.

Bell, S. 1993a *Forest Landscape Design Handbook* . B.C. Ministry of Forests. Victoria.

Bell, S. 1993. *Elements of visual Design in the Landscape* . E&FN Spon. London.

Booth, N.K. 1983. *Basic Elements of Landscape Architectural Design.* Elsevier. New York.

Crowe, S. 1966. *Forestry in the Landscape.* Forestry Commission Booklet No.18. H.M.S.O. London.

Crowe, S. 1978. *The Landscape of Forests and Woods.* Forestry Commission Booklet No. 44. H.M.S.O. London.

Dearden, P. 1988. Protected Areas and the Boundary Model: Meares Island and Pacific Rim National Park. *The Canadian Geographer 32* : 256-265.

Diaz, N. and D. Apostol. 1992. *Forest Landscape Analysis and Design : A Process for Developing and Implementing Land Management Objectives for Landscape Patterns.* USDA Forest Service. Pacific Northwest Region.

Dooling, P.J. 1985. Parks and Protected Areas in British Columbia in the Second Century. British Columbia Caucus Report. In R.C. Scace and J.G. Nelson (ed.). *Heritage for Tomorrow. Canadian Assembly on National Parks and Protected Areas,* Vol 3. Canadian Parks Service. pp 157-316.

Duffy, D.M. 1990. A Review of the British Columbia Crown Land Allocation and Management Planning Process. A background paper prepared for the British Columbia Forest Resources Commission. Forest Resources Commission. Victoria .

Dunster, J.A. 1985. Coordinated co-operation: The need for understanding. In R.C. Scace and J.G. Nelson (ed.) *Heritage for Tomorrow. Canadian Assembly on National Parks and Protected Areas.*, Vol 3. Canadian Parks Service. pp.157-189.

Fischer, W.C. and A.F. Bradley. 1987. *Fire Ecology of Western Montana Forest Habitat Types.* United States Department of Agriculture, Forest Service. Intermountain Research Station. General Technical Report INT-223.

Forman, R.T.T. 1987. The Ethics of Evolution, the Spread of Disturbance and Landscape Ecology. In M.G. Turner (ed.) *Landscape Heterogeneity and Disturbance*: Springer Verlag. New York .pp 213-229.

Forman, R.T.T. and M. Godron. 1986. *Landscape Ecology.* John Wiley and Sons. New York .

Franklin, J.F. and R.T.T. Forman. 1987. Creating landscape patterns by forest cutting : Ecological consequences and principles. *Landscape Ecology.* 1 (1): 5-18.

Hall, S. 1993. Memorandum to D. Monchek, R.O. Planning, Ministry of Forests, Golden Forest District (unpublished).

Harris, L.D. 1984. *The Fragmentaed Forest: Island Biogeography Theory and the Preservation of Biotic Diversity.* University of Chicago Press. Chicago .

Kimmins, J.P. 1987. *Forest Ecology* . Macmillan Publishing. New York .

Kimmins, J.P. 1990. Designing disturbance in the B.C. forest landscape : the prediction of ecological consequences. In A.F. Pearson and D.A. Challenger (ed.) *Forests - Wild and Managed : Differences and Consequences.* Students for Forestry Awareness. January 19-20 1990. University of British Columbia. Vancouver. pp. 177-192.

Lucas, O.W.R. 1991. *The Design of Forest Landscape.* Oxford University Press. Oxford.

Meidinger, D and J. Pojar. 1991. *Ecosystems of British Columbia.* Ministry of Forests [B.C.]. Victoria.

Merriam, G. 1988. Landscape ecology : The ecology of heterogeneous systems. In M.R. Moss (ed.) *Landscape Ecology and management : Proceedings of the First symposium of the Canadien Society for Landscape Ecology and Management.* University of Guelph. May 1987. Polyscience Publications. Montreal. pp.43-50.

Ministry of Environment, Lands and Parks [B.C.] and Ministry of Forests [B.C.]. 1993. *Interior Fish, Forestry and Wildlife Guidelines (draft).*

Ministry of Environment [B.C.], Nelson. 1993. *Kootenay Lake Domestic Watershed Contingency Plan* (unpublished).

Ministry of Forests [B.C.]. 1981. *Forest Landscape Handbook.* Province of British Columbia. Victoria .

Ministry of Forests [B.C.]. 1991. Forest Landscape management. In Ministry of Forests [B.C.]. *Recreation Manual* , Chapter 11. Province of British Columbia.

Ministry of Forests [B.C.]. 1993a. *Soil Conservation Guidelines for Timber Harvesting (Interior B.C.).* Province of British Columbia. Victoria.

Ministry of Forests [B.C.] 1993b. *Total Resource Planning. An Integrated Resource Management Approach to Forest Development: A Proposed Process - August 1993.* Province of British Columbia. Victoria.

Ministry of Forests [B.C.] 1993c. *Provincial Visual Landscape Management Guidelines* (draft). Province of British Columbia. Victoria.

Ministry of Forests [B.C.], Golden Forest District. 1993. *Total Resource Planning - guidelines* (unpublished).

Ministry of Forests [B.C.], Nelson Region. 1992. *Forest Sciences, Nelson Forest Region Research Summary.* Sept 1992 (unpublished).

Ministry of Forests [B.C.], Nelson Region. 1994. *West Arm Demonstration Forest Plan. Draft.* (unpublished).

Ministry of Forests [B.C.] and Ministry of Environment, Lands and Parks [B.C.]. 1993. *Total Resource Planning : A proposed process - August 1993. Summary of Comments.* Province of British Columbia. Victoria.

Ness, K. 1992. *Resource Planning in the Ministry of Forests : A Glossary of Past and Present Terms.* Ministry of Forests [B.C.]. Victoria.

Noss, R.F. and L.D. Harris. 1986. Nodes, Networks and MUMs: Preserving diversity at all scales. *Environmental Management* 10 (3) : 299-309.

Pickett, S.T.A. and J.N. Thompson. 1978. Patch Dynamics and the Design of Nature Reserves. *Biological Conservation* 13: 27-37.

Province of British Columbia. 1993. *British Columbia Forest Practices Code : Rules.* Province of British Columbia. Victoria.

Province of British Columbia. 1994. *British Columbia Forest Practices Code : Standards with revised rules and field guide references.* Province of British Columbia. Victoria.

Risser, P.G. 1987. Landscape Ecology : State of the art. In M.G. Turner (ed.) *Landscape Heterogeneity and Disturbance.* Springer-Verlag. New York . pp. 3-14.

Rowe, J.S. 1988. Landscape Ecology : The study of terrain ecosystems. In M.R. Moss (ed.) *Landscape Ecology and Management. Proceedings of the First symposium of the Canadien Society for Landscape Ecology and Management.* University of Guelph. May 1987. Polyscience Publications. Montreal. pp. 35-42.

Schonewald-Cox. C.M. and J.M. Bayless. 1986. The Boundary Model : A geographical Analysis of Design and Conservation of Nature Reserves. *Biological Conservation* 38: 305-322.

Thiel, P. 1981 *Visual Awareness and Design : an introductory program in conceptual awareness, perceptual sensitivity and basic design skills.* University of Washington Press. Seattle.

Urban, D.L., R.V. O'Neill and H.H. Shugart Jr. 1987. Landscape Ecology : A hierarchical perspective can help scientists understand spatial patterns. *BioScience* 37 (2):119-127.

Zonneveld, I.S. 1988. Landscape Ecology and its application. In M.R. Moss (ed.) *Landscape Ecology and management : Proceedings of the First symposium of the Canadian Society for Landscape Ecology and Management.* University of Guelph. May 1987. Polyscience Publications. Montreal . pp. 3-14.

Appendix 1

Participants : Total Resource Design Workshop, Nelson 24-28th January 1994

Simon Bell................British Forestry Commission.

Ministry of Forests:

Dave Crampton...........Research - Nelson Forest Region.

Harry Quesnel.............Research - Nelson Forest Region.

Dave Grant ....Engineering - Nelson Forest Region

Bernie Peschke...........Silviculture - Nelson Forest Region.

Larry Price.................Planning - Nelson Forest Region

Jim Schafthuizen.........Small Business - Kootenay Lake District.

Jim Annunziello..........Silviculture - Kootenay Lake District.

Chris Mulvihill............Inventory - Kootenay Lake District.

Steve Flett..................Recreation - Kootenay Lake District.

Heather Smith............ Recreation - Kootenay Lake District.

Dale Anderson............Planning - Kootenay Lake District.

Peter Lewis................Planning - Kootenay Lake District.

Ministry of Environment:

Gerry Fox..................Habitat Protection Branch - Ministry of Environment - Nelson.

Dwain Boyer..............Water management - Ministry of Environment - Nelson.

BC Parks :

Gary Price..................Boundary Zone Manager, West Kootenay District - Nelson.

<u>Public:</u>

Hans Elias.................Public Representative

Diane Luchtan............Public Observer

<u>Observers:</u>

Ralph Archibald...........Integrated Resources Section - Victoria (Observer).

Julie Duff...................Masters Student, UBC.