AN ECOSYSTEM MANAGEMENT APPROACH TO FIRE MANAGEMENT IN TERRA NOVA NATIONAL PARK

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An Ecosystem Management Approach to Fire Management in Terra Nova National Park

by

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ABSTRACT

Ecosystem management seeks to provide a mechanism for addressing the complexities of managing the natural environment and helping managers more efficiently and effectively handle planning and decision making in a particular ecosystem. It implies a holistic examination of social and biophysical issues which are addressed collectively, not independently, to arrive at the best possible management solution, while preserving the natural character and ecological integrity of an ecosystem.

The present research considers various biophysical and social issues related to fire management in the greater Terra Nova National Park (TNNP) region, within the ecosystem management setting in a Canadian national park. While a detailed examination of any individual social or biophysical issue related to fire management in TNNP could be undertaken, this research simultaneously examined several issues in lesser detail with the intent of integrating the results. The social research focussed on a questionnaire to Parks Canada employees, key informant interviews of regional representatives, and a preliminary visitor survey. Biophysical research consisted of a field study of regeneration in selected burnovers in and around TNNP, and an examination of the TNNP fire history study and endangered species research.

To illustrate the integration of several of the social and biophysical research

results, a linear framework is built upon and expanded to develop a conceptual framework which addresses fire management in TNNP in the ecosystem management context. Unlike other studies which "discuss" the ecosystem management concept, this conceptual framework contributes to the field of ecosystem management by proposing a means of implementing the concept. Feedback loops account for continually evolving management concerns through the incorporation of two key roles: coordinating the framework and integrating research. This conceptual framework is applied to the case study of fire management in TNNP. It can, however, also be broadened out to address specific management issues in other national parks or ecological settings.

The results from this ecosystem management based research indicate the value of integration in that the sum of the individual issues provides more comprehensive information than the separate analyses of these issues. On this basis, an ecosystem management conceptual framework is developed to facilitate management issues, such as fire management in TNNP. One strength of the integrative approach to ecosystem management is therefore the exploration of social and biophysical concerns as a whole and not as isolated variables. Another strength of integration is that 'integrated data' lead to results which would not be revealed had they been examined on an individual basis.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 – INTRODUCTION

1.1 OVERVIEW

Managers of natural environments and resources have struggled with what are the best techniques to use and how to implement management concepts. Ecosystem management has been offered as a possible mechanism to addressing the complexities of managing the natural environment and helping managers more efficiently and effectively handle planning and decision making. Ecosystem management implies a holistic examination of the issues at hand in that it considers the integration of various social and biophysical factors which traditionally have been segregated into separate disciplines.

The concept of integrating biophysical and social science factors in ecosystem based decision making is appealing to national park managers in Canada due to their unique mandate of protecting the natural environment while encouraging public enjoyment of that environment. This concept, however, can be difficult to operationalize. Hence this research focusses on an integrative approach, which entails the simultaneous examination of several distinct issues to provide an increasingly complete picture of a given management concern, within the context of ecosystem management. Specifically, fire management as a particular management issue facing Terra Nova National Park (TNNP) in Newfoundland, will serve as a case study.

1.2 RESEARCH RATIONALE

1.2.1 The ecosystem management concept

The ecosystem management concept provides a foundation for this study as it seeks to address both social and biophysical factors together. It has proven difficult to adopt a common definition for the term ecosystem management due to its interpretation by numerous researchers with viewpoints ranging from biocentric (eg. Alpert 1995; Grumbine 1994) to anthropocentric (eg. Freemuth 1996; Stanley 1995). In general, its intent is to combine social and biophysical information/issues to preserve ecosystem viability over the long term. Such integrations can be undertaken to develop timely ecosystem management techniques needed to preserve natural processes and environments.

1.2.2 Ecosystem management in national parks

In Canadian national parks, management plans have been designed in order to implement policies which serve to retain the ecological integrity and the character of the ecosystems they represent (NPA 1988; Parks Canada 1979, 1994). Through these policies ecosystem management is promoted as a means of preserving ecological integrity while increasing public involvement with interested groups, thereby managing for the greater park ecosystem (Parks Canada 1994, 1996a). Ecosystem management in Canadian national parks is viewed as a basis for protecting park ecosystems through an increasingly holistic approach by considering the interactions and dynamic nature of park ecosystems in light of human stresses (Parks Canada 1996b).

1.2.3 Fire management in national parks

Fire is a powerful and vital natural process in several Canadian national parks, and its ecological and societal repercussions should be understood if appropriate fire management strategies are to be implemented (Day *et al.* 1988; Lopoukhine 1993; Parks Canada 1996c). For this reason, an integrative research approach based on ecosystem management is suitable for the successful application of fire management in national parks. As will be discussed, ecosystem management can be undertaken by working with local interest groups to determine socially based issues, and cooperating with various researchers to address biophysical issues related to the past and present role of fire in an ecosystem.

1.2.4 Terra Nova National Park case study

Although a great deal of baseline research has been conducted in specific national parks with regards to fire management, little research has focussed upon the Atlantic Region parks. Terra Nova National Park (TNNP), located in eastern Newfoundland, is an Atlantic Region park representing the fire influenced boreal forest ecosystem (Pardy 1994). It is seeking to emulate the standards of other Canadian national parks, such as Banff, Jasper, Wood Buffalo, and La Mauricie, which have fulfilled certain fire management objectives to preserve the ecological integrity of their representative ecosystems (Heathcott 1996, pers. comm.; Mann and Kerr 1995; Pardy 1994; Parks Canada 1996c).

1.3 RESEARCH OBJECTIVES

While a detailed examination of any individual social or biophysical issue could be undertaken, this research simultaneously examined several issues in lesser detail with the intent of integrating these issues. Its strength therefore lies in the integrative approach to ecosystem management, with the exploration of social and biophysical concerns as a whole and not as isolated variables. The examination of a specific social aspect of fire management could, for example, lead to an entire thesis on its own (eg. Bath 1993), although this would not necessarily permit the integration of several issues.

One means of developing an ecosystem management based approach can involve the design and use of conceptual frameworks. In the context of continually evolving management concerns, such frameworks can incorporate feedback loops while outlining steps to facilitate the integration of varied information (eg. Armitage 1995; Bonnicksen 1991; Harwell *et al.* 1996; Hodge 1997). A conceptual framework will therefore be developed to address the integration of social and biophysical considerations under the ecosystem management concept.

1.3.1 Specific objectives

The objectives of this research are:

1) To integrate social and biophysical issues related to fire management in TNNP to illustrate that the examination of several issues simultaneously contributes a greater understanding than the sum of their individual parts.

2) To develop an ecosystem management conceptual framework based on the integration of social and biophysical issues related to fire management in TNNP.

These objectives will be addressed by identifying and examining unique social and biophysical conditions inherent to the TNNP region in the context of fire management. If ecosystem management is to be suitably implemented then socially and biophysically based concerns need to be addressed collectively, not independently, to arrive at the best possible management solution. The emphasis of this study is therefore on integrative and holistic research which considers the ecosystem as an inter-connected network of biotic and abiotic entities, and on the synthesis of social and biophysical research.

1.4 THESIS DIRECTION

Ideally, all effects of forest fires, be they social or biophysical, should be considered prior to the implementation of any fire management approach in a national park ecosystem. In TNNP these consequences include the ecological outcomes of forest fires on the native flora and fauna of the boreal ecosystem, as well as the consideration of impacts of fires on local interest groups, surrounding communities, and park visitors. As it is unrealistic for a manager to understand, for example, every effect of forest fires, then decisions must be made amongst some level of risk and uncertainty. By seeking to better understand as many effects as possible, efforts are made to reduce uncertainty. This research will contribute to such a reduction in uncertainty by presenting and integrating several social and biophysical effects related to fire management in TNNP under an ecosystem management concept. Such ecosystem management based research can be considered in developing future park management plans.

A review of the evolution and use of the ecosystem management concept will be outlined in Chapter 2. This review will focus on ecosystem management in Canadian national parks, and specifically on the fire management context of the present research. The social and biophysical setting of TNNP is then presented in Chapter 3, where the region's unique attributes are linked to fire management issues and the ecosystem management concept. The integrative methodologies based on an ecosystem approach are discussed in Chapter 4 in terms of two distinct components: social and biophysical. In Chapter 5 the social research findings resulting from a questionnaire to Parks Canada employees, key informant interviews of regional representatives, and a preliminary visitor survey, are outlined. The biophysical research resulting from regeneration surveys in selected burnovers in and around TNNP, an examination of the TNNP fire history study (Power 1996a), and consideration of endangered species research, are also summarized.

These results are integrated and discussed in Chapter 6 in view of their general contribution to ecosystem management. In Chapter 7, an ecosystem management conceptual framework is developed as a means of integrating the results of this social and biophysical research, and to illustrate that examining several issues at the same time leads to more than the sum of their individual parts. Finally, key findings are highlighted and the methodological applications of this work are summarized.

CHAPTER 2 – REVIEW AND APPLICATION OF ECOSYSTEM MANAGEMENT

This chapter will briefly summarize the history of ecosystem management. A variety of literature which discusses the definition of ecosystem management will be presented and grouped as either biocentric or anthropocentric. The literature will be grouped based upon the emphasis of the definition and the application of the concept. Literature which focusses on applying ecosystem management (as opposed to defining it), will also be highlighted in the context of the present research. Secondly, the use of linear and conceptual frameworks in the application of ecosystem management will be described as they can provide a means of organizing and integrating information. Thirdly, a description of ecosystem management in the Canadian national park context will be outlined. A linear framework will be presented at this point as a step toward an integrative approach for ecosystem management implementation, thereby setting the stage for the examination of this approach in fire management research in the national park context.

2.1 ECOSYSTEM MANAGEMENT: DEVELOPMENT OF THE CONCEPT

Ecosystem management has emerged as a potential solution to growing environmental problems (Grumbine 1994; Woodley and Forbes 1995). The concept of ecosystem management was formulated in the United States, with related ideas discussed as early as 1932 by the Ecological Society of America (Grumbine 1994; Woodley and

Forbes 1995). The term "ecosystem" was coined in 1935 by Arthur Tansley to demonstrate the interactions and equilibrium within nature's living and non-living biota (Bocking 1994). However it was Aldo Leopold (1949), a forester and wildlife biologist, who was regarded for his interpretation of what is now ecosystem management, by promoting sustainable land use and conservation (Grumbine 1994; Knight 1996; Salwasser 1994). By the late 1980s the ecosystem management concept was increasingly advocated and discussed in North America, leading to an abundance of research and literature throughout the 1990s, as will be further explored.

For clarity, ecosystem management should be differentiated from similar concepts, such as resource management, environmental management, and the ecosystem approach. Resource management, as presented by O'Riordan (1971), Mitchell (1989), Baerwald (1991), and Samson and Knopf (1996), is founded on human wants and needs, and the sustainable consumptive uses of natural resources based on labour and materials (as opposed to ecological factors). Savory (1988) developed the concept of holistic resource management (HRM) and Lang (1986) examined integrative resource management (IRM), both of which are increasingly holistic approaches emanating from resource management. Yet, the consistent factor among these interpretations is the focus on "human needs".

Environmental management on the other hand is a broader concept evolving from resource management (Eagles 1993a; Francis 1993; Mitchell 1997). With the goal of better protecting the earth's environment, it takes into account human and biotic interactions within and between ecosystems. It focusses on relationships to be maintained between development and the environment through, for example, regulatory measures for reducing pollution discharges into the environment (Francis 1993).

An ecosystem approach has been described by Vogt *et al.* (1997) as a broader concept, compared to ecosystem management which is management-unit specific, and by Slocombe (1993a) as a precursor to ecosystem management. An ecosystem approach presents core principles or characteristics to be applied to various management scenerios (Slocombe 1993a; Vogt *et al.* 1997). Core principles stress the collection, analysis, and integration of social and ecological information based on interdisciplinary work (Vogt *et al.* 1997), and the description of interactions within the environment in a holistic manner while considering human activities within the ecosystem (Slocombe 1993a). Thus an emphasis on the placement of humans within and dependent upon the natural system is put forth in an ecosystem approach (MacKenzie 1996, 1997; Slocombe 1993a, 1993b). It should also be noted that the terms ecosystem approach and ecosystem management are closely associated, and even sometimes used interchangeably (MacKenzie 1996).

One common element among ecosystem, resource, and environmental management, as well as the ecosystem concept, is the term "management". With respect to the earth's environment, "management" was outlined by Lewis (1969, 109) as "decision-making in the presence of uncertainty and involving the manipulation of one or more of the dependent and/or controlling factors", and by Spurr (1969, 3) as "the manipulation of the ecosystem by man [sic]". Therefore management is a culturally defined concept; however, management goals can be either biocentrically or anthropocentrically based. The differences between these perspectives are illustrated below to demonstrate the focus in the literature on the definition of the term ecosystem management, and the limitations of defining the concept from only one perspective, as has traditionally been the case.

2.1.1 Biocentric interpretations

A biocentric interpretation of ecosystem management primarily considers the ecological integrity and natural processes of ecosystems, and to a lesser extent accounts for factors which are significant to humans, with the overall intention of guarding natural environments from further degradation (Barkham 1995; Parks Canada 1994, 1996c; Stanford and Poole 1996; Woodley 1996; Woodley and Forbes 1995). Grumbine (1994) has been acknowledged for his contribution to the biocentric interpretation of ecosystem management, and his definition has been presented in the works of Alpert (1995), Woodley and Forbes (1995), Carpenter (1996), and Brunner and Clark (1997), to name a few. It states:

> Ecosystem management integrates scientific knowledge of ecological relationships within a complex sociopolitical and values framework toward the general goal of protecting native ecosystem integrity over the long term (Grumbine 1994, 31).

Grumbine (1994) sought to advance this interpretation by putting forth ecosystem management goals (Table 2.1). In addition, he highlighted dominant themes surfacing from his research, including the collection of scientific data, the definition of ecological boundaries and scales, the promotion of ecological integrity, and the role of humans as a part of nature. These ecosystem management themes were subsequently revised by Grumbine (1997), and additions were implemented based on updated studies. Ultimately his academic research, which is founded on ecological principles, infuses a biocentric ideal into ecosystem management while secondly striving to satisfy various human interests (Grumbine 1994, 1997).

Table 2.1: Five ecosystem management goals within the overall goal of sustaining ecological integrity (Grumbine 1994, 31).

Ecosystem Management Goals
* Maintain viable populations of all native species *in situ*.
* Represent, within protected areas, all native ecosystem types across their natural range of variation.
* Maintain evolutionary and ecological processes (ie. disturbance regimes, hydrological processes, nutrient cycles, etc.).
* Manage over periods of time long enough to maintain the evolutionary potential of species and ecosystems.
* Accommodate human use and occupancy within these constraints.

The biocentric perspective has also been highlighted by other researchers, resulting in varied interpretations. Frissell and Bayles (1996) stressed that the inherent complexity of ecosystems needed to be given due credit, and that the purpose of ecosystem management had to be clarified to achieve true conservation. The need to achieve measurable goals based on Table 2.1 was advocated by Wilcove and Blair (1995). Meanwhile, Kay (1993), Kay and Schneider (1994), and Crossley (1996) promoted the natural integrity of ecosystems, stressing that they are dynamic and always changing.

2.1.2 Anthropocentric interpretations

Anthropocentric definitions of ecosystem management generally conflict with biocentric interpretations due to the focus on the significance of humans in ecosystems. For example, Stanley (1995) felt that humans could manage ecosystems through technology, and that a biocentric outlook promised the impossible. Salwasser (1994) believed that ecosystem management was more about people and their choices, thus opposing Grumbine's (1994) convictions. Government departments or agencies generally present an anthropocentric viewpoint, utilizing ecosystem management to justify specific decisions (eg. USDA 1992). This view was espoused by Wood (1994), who stated that ecosystem management principles could form a new land ethic for sustainability and diversity with long term benefits, if ecological, economic and social factors were treated equally. He states:

> ...ecosystem management involves providing values, products, and services from the land in a manner that safeguards ecological sustainability. Expressed another way, ecosystem management entails setting limits on use of the land (Wood 1994, 7).

Various forestry related publications advocated this anthropocentric interpretation of ecosystem management when considering forest management issues, as evidenced by the work of Czech (1995), Jones *et al.* (1995), Freemuth (1996), More (1996), and Franklin (1997). For example, an emphasis on democratic approaches and consensus among all interested parties was stressed by Freemuth (1996), while Jones *et al.* (1995) saw the need to tackle issues of social conflict. The anthropocentric perspective has also been acknowledged by researchers such as Roe (1996) who stated that social science may be more important than biophysical science in ecosystem management. This focus on human dimensions research in ecosystem management has similarly been advocated by Williams and Patterson (1996).

2.1.3 Limitations of biocentric and anthropocentric interpretations

Using an ecosystem management definition which is either largely biocentric or largely anthropocentric has constraints for a comprehensive application of the concept (Figure 2.1). For instance, a drawback of a biocentric perspective is its focus on the maintenance of natural processes and ecosystems while not fully addressing the relevant concerns of all interested parties. On the other hand, an anthropocentric perspective is flawed since it stresses positions or stakes by these various interests, often disregarding

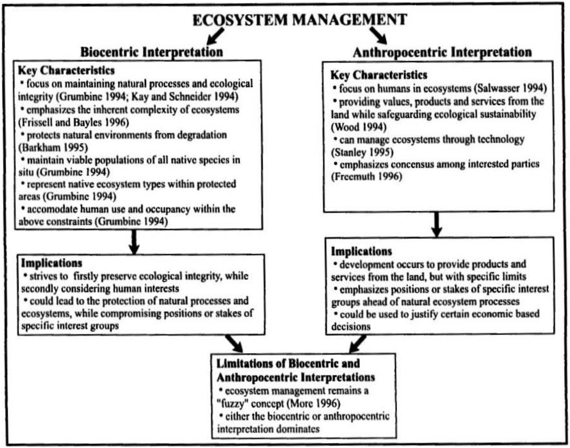

Figure 2.1: Biocentric and anthropocentric literature comparison.

significant ecosystems and ecosystem processes. The inherent differences between these two perspectives have also lead to continuing controversy regarding the establishment of appropriate definitions (Burroughs and Clark 1995; Haeuber 1996). For example, More (1996) claimed that ecosystem management remained a "fuzzy" concept that we need to move beyond by concentrating on its practical application. These are reasons why the present research seeks to operationalize ecosystem management, rather than further defining it.

2.1.4 Interpretations combining biocentric and anthropocentric approaches

Several reviews of ecosystem management have sought to combine biocentric and anthropocentric perspectives to provide a more holistic interpretation of the concept (Carpenter 1996; Christensen *et al.* 1996; Francis 1993; Galindo-Leal and Bunnell 1995; Gerlach and Bengston 1994; Haney and Power 1996; Irland 1994; Samson and Knopf 1996). For instance, Samson and Knopf (1996) stressed the maintenance of the health and integrity of ecosystems, while forming partnerships amongst various interest groups. Accordingly, Christensen *et al.* (1996) felt it was important to provide steps to move from concept to practice while addressing both anthropocentric and biocentric ideals (eg. defining sustainable goals and objectives, reconciling spatial and temporal scales, and ensuring adaptability and accountability). Also, in the forestry context, ecosystem management has been viewed as an applicable and evolving concept with an emphasis on furthering the understanding of the relationship of humans with nature (Galindo-Leal and

Bunnell 1995; Gerlach and Bengston 1994). It should be noted however that these interpretations, while reviewing ecosystem management, do not provide specific case studies or examples.

Although it is evident that efforts have been devoted to understanding and defining the ecosystem management concept, consensus has yet to be reached on a set of methods for its implementation (Alpert 1995; Christensen *et al.* 1996; Francis 1993). A general study evaluating approaches for ecosystem management established that a practice-based approach (i.e. learning by doing) is the most effective way to learn about, and improve upon, this concept (Brunner and Clark 1997). Yaffee (1996) reiterated this point by stating that attempts at ecosystem management have been undertaken through trial and error approaches. Research which is interdisciplinary in nature, where individuals from various professions work together to address both social and biophysical management concerns, could also help provide an initial step toward comprehensive and holistic ecosystem management (Baerwald 1991; Freemuth 1996; Mitchell 1989; O'Riordan 1995).

The review of 105 projects in the United States to determine goals and outcomes of ecosystem management by Yaffee *et al.* (1996), serves as an example illustrating applications relevant to ecosystem management and providing information that can benefit the development of new projects. It was found that ecosystem preservation was the top goal advanced by project managers, followed by ecosystem restoration and support by interest groups. Positive outcomes of projects included improved communication and cooperation, development of management plans and decision making structures, and changes in approaches to land management. Suggested improvements for future projects included the early involvement of interest groups in the planning process, having clear goals within a collaborative process, using flexible land management strategies, and understanding local community needs (Yaffee 1996; Yaffee *et al.* 1996).

2.2 ECOSYSTEM MANAGEMENT FRAMEWORKS

Functional frameworks are lacking in the interpretations of ecosystem management which have been presented. Frameworks provide a means of visually organizing steps and mechanisms required to achieve specific management goals (Armitage 1995; Bastedo *et al.* 1984; Bonnicksen 1991; Born and Sonzogni 1995; Harwell *et al.* 1996; Hodge 1997; Zube 1980). A linear framework is a basic framework which includes a series of steps leading to a set end; whereas the more elaborate conceptual framework includes the use of feedback loops, where relevant components are linked and simultaneously monitored and evaluated (Zube 1980). The latter can be useful for integrating social and biophysical factors in ecosystem management as the project proceeds, as will be advanced in the present research.

Conceptually based frameworks (a term sometimes used interchangeably with conceptual model) are increasingly common in both resource and environmental management. Bonnicksen (1991) presented a biosocial model incorporating a management subsystem (society) and an ecological subsystem (nature), each with inputs and outputs, to address resource management issues. Similarly, environmental sustainability was addressed by presenting a conceptual framework in which the human component was a subsystem of the ecosystem component (Hodge 1997). Additionally, Bastedo *et al.* (1984) developed a model for land use and environmental management based on the identification, mapping, analysis and evaluation of abiotic (A), biotic (B) and cultural (C) resources to classify areas of environmental significance – the ABC resource survey method.

This ABC resource survey method emerged from research on boundary delineation in environmentally sensitive areas (Theberge and Nelson 1983; Grigoriew *et al.* 1985), where an effort was made to include abiotic (e.g. landforms), biotic (e.g. vegetation composition) and cultural (e.g. historical land uses) resources into a resource inventory. More recently it has been applied to sustainable environmental planning and management issues such as classifying the environmental significance of a conservation area in Costa Rica (Armitage 1995).

Within ecosystem management the use of conceptual frameworks to integrate social and biophysical factors is not common. One example, however, was proposed by

Harwell *et al.* (1996) with the goal of achieving ecological sustainability in South Florida. In this case, a process model was developed through the United States Man and the Biosphere Program, to detail types and levels of interaction between humans and the environment, and move toward ecological sustainability.

A weakness of this latter model, along with the frameworks/models described above, is the omission of feedback loops, as called for in the use of conceptual frameworks (Zube 1980). While such frameworks have examined human and biophysical issues, and realize that it is important to do so, this is often done more as an inventory then in a truly integrated way. In addition, these frameworks do not fully recognize the societal context of ecosystem management, and as such are limited in their application to ecosystem management.

2.3 CANADIAN NATIONAL PARKS AND ECOSYSTEM MANAGEMENT

Ecosystem management goals and ideals can be examined within, and applied to, a national park setting. By focussing on the advocation of ecosystem management in a Canadian national park context, the use of frameworks as means of integrating social and biophysical components can be advanced. A description of the evolution of national park management in the last century will set the stage for recent literature advocating ecosystem management, and lead to the development of an initial framework.

2.3.1 Evolution of Canadian national park management

Since the inception of Canadian national parks in 1885, parks have undergone four phases of management (Dearden 1991; Eidsvik 1985; McNamee 1993). The first, the preservation phase (late 1800s/early 1900s), sought to establish boundaries and attract tourists. Second, the sheltering of parks from both natural disturbances and human-caused disturbances was the focus of the protection phase (early to mid 1900s). The management phase (mid 1900s) highlighted the increasing ecological understanding of ecosystems, and the need to allow inherent natural processes to take place. At present, the promotion of ecological integrity[1] in Canada's 38 national parks is pursued through cooperation with local land agencies, to monitor both internal and external activities, as part of the integrative management phase (1980s to present) (Day *et al.* 1988; Dearden 1991; Eidsvik 1985; NPA 1988; Parks Canada 1994, 1996b).

These phases parallel developments in Parks Canada policies and legislation over the last century (Table 2.2). As part of the amendments to the National Parks Act (1988), the maintenance of ecological integrity became the focus of national park management (Dearden and Rollins 1993; NPA 1988, Roszell 1996; Woodley 1995). Other amendments to the National Parks Act (1988) which were further emphasized in the Guiding Principles and Operational Policies (1994) are included in Table 2.2.

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1 Ecological integrity in national parks is attained when "ecosystem structures and functions are unimpaired by human-caused stresses and native species are present at viable population levels" (Woodley 1996, 50).

Table 2.2: History of important events and developments in Canadian national parks (compiled from Eagles 1993b; McNamee 1993; Roszell 1996).

Parks Canada Management Developments	
1885	Establishment of Canada's first national park, Rocky Mountain Park (presently Banff National Park) – tourism development is emphasized.
1911	Dominion Forest Reserves and Parks Act passed leading to the establishment of the Dominion Parks Branch (presently Parks Canada).
1930	National Parks Act formulated – mineral exploitation and game hunting is halted, and education and enjoyment in parks are emphasized.
1964	First national parks policy implemented – the preservation of natural features and processes is emphasized.
1979	Parks Canada Policy revised – the preservation of the ecological integrity of national parks is now considered.
1988	Major amendments to the National Parks Act implemented – the maintenance of ecological integrity is placed at the forefront of national park management.
1994	Guiding Principles and Operational Policies instituted for Parks Canada – key points emphasized, based on amendments to the National Parks Act in 1988, are: • maintaining the ecological integrity of national parks; • the preparation of park management plans for the Minister's approval, to be reviewed every five years; • the use of a zoning system for park management; • the promotion of ecosystem management in cooperation with land managers and interested parties; • the acknowledgement of active management to restore ecological integrity if it is required; and • the public understanding, appreciation and enjoyment of national parks.

2.3.2 The ecosystem management focus

The evolution of the use of ecosystem management in national parks began in the United States with the work of Agee and Johnson (1988, 7), whose anthropocentric definition promoted "regulating internal ecosystem structure and function, plus inputs and outputs, to achieve socially desirable conditions". An increasingly biocentric outlook to national park management in Canada was put forth by Dearden and Rollins (1993), who examined environmentally sound park management. At this time Nelson (1993) and Nepstad and Nilsen (1993) highlighted the idea that humans were a component of the ecosystem when managing Canadian national parks. Such outlooks were addressed when the Guiding Principles and Operational Policies were developed in 1994. Subsequently, Woodley and Forbes (1995) presented a biocentric view of ecosystem management in a Canadian national park context, examining its limitations and outlining principles relevant to protected areas. This has lead to the definition of ecosystem management in Canadian national parks as follows:

> Ecosystem management provides a conceptual and strategic basis for the protection of park ecosystems. It involves taking a more holistic view of the natural environment and ensuring that land use decisions take into consideration the complex interactions and dynamic nature of park ecosystems and their finite capacity to withstand and recover from stress induced by human activities (Parks Canada 1996a, 1).

2.3.3 An initial framework for Canadian national parks

A framework can be presented as a starting point from which the goals or objectives of all interest groups can be discussed with respect to the nature of ecosystem management undertakings in specific national parks. Such a framework could be used to illustrate a process under which decisions are made in individual park management plans.

In Figure 2.2, a general linear framework is presented as an initial step toward the development of a functional conceptual framework for ecosystem management in national parks.

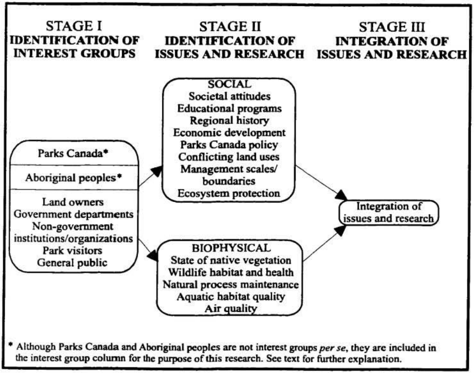

Figure 2.2: A linear framework incorporating components of ecosystem management in Canadian national parks.

In this linear framework, the various interest groups are identified in Stage I. The term "interest groups" is used in a general context as each group has different interests or values they wish to discuss with others. In Figure 2.2 there are two groups which have stronger interests, rights and responsibilities, and merit specific consideration: these groups are Parks Canada and Aboriginal peoples. They are included within the box of interest groups on purpose rather than separate to highlight a team building approach, as further discussed below.

It is recognized that Parks Canada has the regulatory authority and responsibility to manage national parks (NPA 1988; Parks Canada 1994), thereby placing it on a different plane from interest groups in general. However by including Parks Canada in the framework with other interest groups it illustrates that Parks Canada has the opportunity to become a player in a team approach. This is significant when discussing components of ecosystem management (see Stage II and III) as Parks Canada is one of several contributors to the identification, and subsequent integration, of issues and research.

Aboriginal peoples are another special interest group that have been included in the interest group category in Figure 2.2. It is recognized that Aboriginal peoples have rights beyond other interest groups (Parks Canada 1994). In the case of the present research in Terra Nova National Park, there are no Aboriginal peoples in the region which would be affected by park decisions. However, if this framework were to be applied to other national parks, the interests of Aboriginal peoples would be recognized above and beyond general interest groups, particularly under treaties and comprehensive claim agreements (Parks Canada 1994). These interests could then be fully integrated into the specific ecosystem management undertaking.

In Stage II of the framework, issues and research are presented, and associated with broad social and biophysical groupings. The completion of this framework (Stage III) involves the integration of issues and research results arising from the social and biophysical groupings. A limitation of this linear framework is that the integration only occurs at the end of the research project. A solution to this problem will be further examined as a more comprehensive ecosystem management conceptual framework, incorporating feedback loops, is formulated in Chapter 7.

2.3.4 The application of ecosystem management to fire management in Canadian national parks

Fire management is a specific ecosystem management topic which can be explored in the context of integrating social and biophysical issues. Fire management is a timely concern in many Canadian national parks (Alexander and Dubé 1983; CPS 1989; Lopoukhine 1993; Lopoukhine and White 1983; Parks Canada 1997; Woodley 1995), due to the mandate of Parks Canada which promotes the perpetuation of ecological processes inherent to the ecosystems and regions they represent (Eagles 1993b; Parks Canada 1994).

A prominent example of an alteration to a natural ecological process has been the suppression of lightning-caused forest fires in most Canadian national parks, particularly during the last century (BNP 1995; Lopoukhine 1992, 1993; Pardy 1994; Parks Canada 1997; Woodley 1995). Primarily since the 1980s however, the realization that fire is a natural component of many ecosystems has increased (Alexander and Dubé 1983; Day *et al.* 1988; Van Wagner 1983, 1985; Van Wagner and Methven 1980). Therefore the problem of "fixing" past mistakes has been examined to varying degrees from park to park, with Banff National Park (where the first prescribed burn occurred in 1983), leading the way toward implementing active fire management under the ecosystem management banner (BNP 1995; CPS 1989; Day *et al.* 1988; Parks Canada 1986; Walker 1995a, 1995b; Woodley 1995).

Within Parks Canada fire management has been divided into active and passive forms. Passive management is associated with fire suppression since it does not consider the ecological integrity of the particular ecosystem (Alexander and Dubé 1983; Pardy

1994; Woodley 1995). Prescribed burning[2], on the other hand, is a validated form of active management since it seeks to retain natural processes and promote ecological integrity while duplicating nature as closely as possible (Lopoukhine 1993; Parks Canada 1986, 1994; Woodley 1995). In considering the implementation of active fire management to individual parks it has been realized that both social and biophysical variables need to be considered (BNP 1995; Mann and Kerr 1995; Parks Canada 1997; Walker 1995b). An effective way of addressing fire management would therefore be to develop an ecosystem management framework (outlined in section 2.2). The linear framework presented in Figure 2.2 will therefore be built upon and described in the context of the TNNP fire management case study in Chapter 3.

2.4 SUMMARY

Ecosystem management is a continually evolving assembly of potential management approaches (Christensen 1997; Galindo-Leal and Bunnell 1995). Various definitions of ecosystem management have been presented, yet few specific examples or case studies have been noted in the literature. By integrating both social and biophysical issues and addressing the concerns of all interested parties, the operationalization, rather

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[2] According to Parks Canada (1986), prescribed burning is a random or planned ignition contributing to specific management objectives. A random ignition occurs when a fire is started accidentally or by lightning, and is contained and managed to meet park objectives (BHP 1995; Mann and Kerr 1995). A planned burn considers the exact size and location of the fire, in combination with climatic conditions and availability of natural fuel breaks such as lakes (BNP 1995; Johnson and Miyanishi 1995; Weber and Taylor 1992).

than the precise definition, of ecosystem management will be pursued, as espoused by the present research.

In a Canadian national park context ecosystem management can incorporate adjacent land uses and consider human values while fostering the ecological integrity of individual parks (Woodley and Forbes 1995). This concept can be put forth in advancing fire management research in the national park context, as will be demonstrated by its application in Terra Nova National Park through the development of a linear framework in the following chapter.

CHAPTER 3 – ECOSYSTEM MANAGEMENT: A CASE STUDY OF FIRE MANAGEMENT IN TERRA NOVA NATIONAL PARK

The establishment of national parks is critical to the protection of distinct ecological and cultural landscapes, particularly due to continuously increasing land use and development in surrounding areas (CPS 1990; Lopoukhine 1992; Woodley 1995). This chapter describes the unique biophysical and social attributes of Canada's most easterly national park, Terra Nova National Park (TNNP). Secondly, the roles of forest fires and fire management are explored in the context of the park's setting. Lastly this information is placed in the greater scope of ecosystem management.

3.1 PARK SETTING

TNNP is located in eastern Newfoundland, along the indented rocky coast of Bonavista Bay (Figure 3.1). It is approximately 250 km northwest of St. John's and 80 km southeast of Gander, and is bisected by the Trans-Canada Highway (TCH). The park, which extends over an area of 407 km^2, was established in 1957 to represent the Eastern Newfoundland Atlantic Terrestrial Region (Parks Canada 1996c). It is dominated by forested rolling hills with numerous bogs and fens, representing the boreal forest zone, an ecological community comprising 35 percent of the Canadian land mass (NRC 1996).

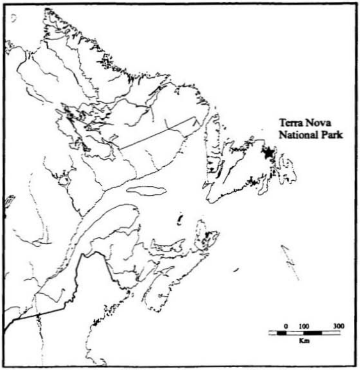

Figure 3.1 : Location of TNNP in the province of Newfoundland.

3.1.1. Biophysical setting

3.1.1.1 Climate

All areas of the park are within 12 km of the coastline, and hence the ocean's influence is considerable, resulting in a maritime boreal climate with cool summers and moderate winters (Deichmann and Bradshaw 1984). The average annual temperature is 4.5 °C; February is the coldest month with a mean temperature of -6.6 °C, while July, the warmest month, has a mean of 16.3 °C[1] (AES 1993). Winds are present 97 to 98 percent of the time, averaging 22 to 26 km/hr (AES 1993; Deichmann and Bradshaw 1984).

Within the North American boreal forest context the mean annual precipitation in TNNP is quite high at 1184.3 mm, with 75 percent of this total falling as rain (AES 1993). Fog and freezing rain are also common, while snow is generally present from late November to early May, with depths and total snowfall varying considerably from year to year (Banfield 1996, pers. comm.). Relative humidity is high in TNNP, averaging 68 percent during the summer months (AES 1993). It is also significant to note that there is a low incidence of thunderstorms and lightning strikes in the region relative to the North American boreal forest (Deichmann and Bradshaw 1984; McManus and Wood 1991).

3.1.1.2 Vegetation

TNNP protects most typical boreal forest tree species. Approximately 75 percent of the land area is forested, 81 percent of which is dominated by black spruce (*Picea mariana*), 15 percent by balsam fir (*Abies balsamea*) (both coniferous softwoods), and 5 percent by deciduous hardwoods, namely white birch (*Betula papyrifera*) and trembling aspen (*Populus tremuloides*) (Power 1997; Robinson 1989). The majority of the black spruce stands are quite old, averaging 98 years of age (Power 1996a). Other tree species

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1 Climate data from the Atmospheric Environment Survey (1993) is derived from 30 year normals (1961-1990).

present are: white pine (*Pinus strobus*) and white spruce (*Picea glauca*), both conifers, and eastern larch (*Larix laricina*), a deciduous conifer, as well as red maple (*Acer rubrum*) and balsam poplar (*Populus balsamifera*), two deciduous trees (Robinson 1989; Ryan 1978).

Vegetation types in TNNP also include small tree and large shrub species such as: pin cherry (*Prunus pensylvanica*), mountain alder (*Alnus crispa*), and serviceberry (*Amelanchier* spp.). Smaller woody shrubs are dominated by the Ericaceae family, which include the prominent sheep laurel (*Kalmia angustifolia*) (referred to as kalmia in this work), as well as low sweet blueberry (*Vaccinium angustifolium*), labrador tea (*Ledum groenlandicum*), and creeping snowberry (*Gaultheria hispidula*) (Deichmann and Bradshaw 1984; Power 1996a; Ryan 1978). There are numerous herbaceous plants in TNNP such as: bunchberry (*Cornus canadensis*), corn lily (*Clintonia borealis*), and starflower (*Trientalis borealis*). A variety of grass and sedge species, and several ferns and fern allies, also proliferate. Many moss (eg. *Pleurozium shreberi, Shagnum* spp.) and lichen (eg. *Cladonia* spp., *Cladina* spp.) species cover the forest floors, while old man's beard (*Alectria* sp. *Sarmatosa america*) is an arboreal lichen which is common on aging black spruce trees (Deichmann and Bradshaw 1984; Power 1996a).

3.1.1.3 Wildlife

TNNP has 22 species of land mammals (fifteen native and seven introduced), as well as 198 species of birds (Deichmann and Bradshaw 1984; Kalff 1995; Stroud 1997, pers. comm.). The park also protects one endangered species, the Newfoundland pine marten (*Martes americana atrata*), a small carnivorous mammal which thrives in old coniferous forests (O'Driscoll, 1991; Parks Canada 1996c). In 1982, pine marten were re-introduced to TNNP following local extirpation (Irwin 1992; Power 1996b), and in 1997 five marten were located and collared as part of a tracking program (Cox 1997, pers. comm.). Loss of habitat due to logging or trapping outside the park, or to disturbances such as forest fires, both inside and outside the park, are issues being examined (NMRT 1995; Power 1996b).

3.1.2 Cultural setting

3.1.2.1 Historical resource extraction

Significant land-based resource extraction in the TNNP region began following European establishment in the 17th century (Deichmann and Bradshaw 1984). Logging was the most common activity, and by the 19th and 20th centuries improvements in technology lead to increased shipbuilding in the area (Parks Canada 1996c). A few permanent logging communities and several seasonal communities had operational sawmills from the 1920s to the 1950s in what is presently TNNP (Kalff 1995; Lothian

1976). The influence of these communities on forest ecology is still evident (Parks Canada 1996c). For example, the selective logging of white pine for shipbuilding accounts for its current scarcity in the park (Deichmann and Bradshaw 1984).

3.1.2.2 Visitors

After its establishment in 1957, TNNP was promoted for its recreational potential, due to its proximity and accessibility to St. John's (Lothian 1976). This recreational emphasis continues at present, with visitation increasing 7 percent, from 1994 to 1997, to 237,674 individuals stopping in the park and using facilities (75 percent of which are provincial residents) (Briffett 1997, pers. comm.). Most visitors stay at the central Newman Sound campground near the visitor and marine centre, while a few backcountry camping sites are periodically occupied (Robinson 1996, pers. comm.). Primary recreational activities in the park are hiking, fishing, canoeing, and swimming, with limited mountain biking and sea kayaking (Parks Canada 1996c).

The TCH is a critical transportation link for TNNP, its visitors, and surrounding communities. It extends north-south for 42 km through the park, and is the primary route to mainland Canada from St. John's. During the summer months approximately 3,000 vehicles drive through the park each day, with 30 to 40 percent stopping within the boundaries (G.M. Sernas and Associates 1993).

3.1.2.3 Local communities

TNNP is a member of a regional liaison committee comprised of nineteen communities concerned with potential impacts of activities in and around the park (Figure 3.2). Historically, several of these communities were dependent on the cod fishery and have suffered financially since the moratorium began in 1992 (Macnab 1996). Currently, industries such as tourism/recreation, forestry, outfitting, and limited commercial fishing, are critical to their mainstay. In addition, TNNP plays a direct role in providing jobs to local residents, thereby benefiting the regional economy. Glovertown, with a population of approximately 2,200, is the largest community in the park vicinity and serves as the primary tourist and service centre (Kalff 1995).

There are, however, several areas of contention between local communities and TNNP. National park policy prohibits activities such as logging and hunting or trapping within park boundaries since these are not "natural" processes (NPA 1988). This policy can adversely affect local residents, especially in enclaves such as Charlottetown, who feel it is their right to participate in these activities without having to travel elsewhere (Robinson 1996, pers. comm.). These are issues being addressed by the park and local communities.

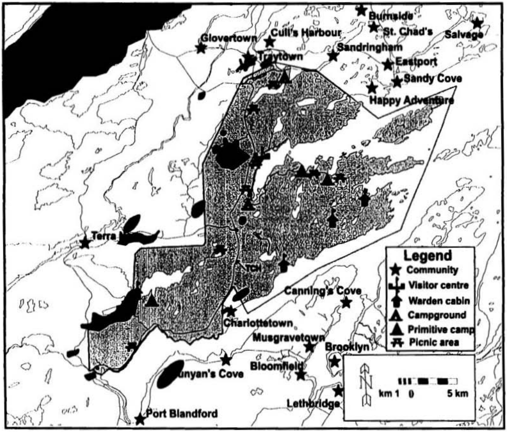

Figure 3.2: Location of communities and high human use areas in and around TNNP (darker shading represents burnovers).

3.1.2.4 Regional land use

The issue of land use adjacent to TNNP is significant for the protection of the greater park ecosystem which encompasses 4,278 km^2 (Power 1997, pers. comm.). This area includes major water bodies linked to TNNP's watersheds, potential corridors for migratory wildlife, and areas where human activities could lead to changes in the ecosystem (Robinson 1996, pers. comm.). Such activities include quarrying, farming, cottage developments, hydro electric development, and most importantly, commercial and domestic logging (Kalff 1995; Parks Canada 1996c). In the 1980s, forests were logged up to the western boundary of TNNP (Kalff 1995), and logging presently continues in surrounding forest stands (Robinson 1997, pers. comm.).

3.2 FOREST FIRES: APPLICATIONS TO TNNP

Fire in the boreal ecosystem serves to recycle nutrients for the renewal of vegetative associations, to diversify biotic communities, and to modify wildlife habitats (Heinselman 1981; Payette 1992; Wein and MacLean 1983). It is a natural process in all boreal forests, perpetuating the growth of new forest stands (Dyrness *et al.* 1986; Elliott-Fisk 1988; Heinselman 1981). Although the role of fire may be diminished in certain ecosystems, such as the maritime boreal forest of TNNP, fire is still present and can therefore result in both biophysical and social impacts.

3.2.1 Fire history

Fire history studies affirm patterns and cycles of forest fires in specific ecosystems, in addition to demonstrating regional influences of anthropogenic and natural processes (BNP 1995; Power 1996a; Van Wagner 1995). In 1995 a fire history study for TNNP was conducted to provide information on the fire regime such as fire frequency, climatic effects upon fire, and changes to vegetative associations (Power 1996a). A fire cycle of 98 years was proposed for the park based on forest stand age distribution (Power 1996a).

Evidence of a fire regime in TNNP was determined primarily in the form of charcoal in the upper soil horizons of plots in all forest stand types (Power 1996a). Between 1828 and 1995, 218 fires occurred in the region, the largest spanning 520,000 ha northwest of the park in 1867 (Power 1996a; Wilton and Evans 1974). Since 1961, 29 fires have been mapped, with 38 percent greater than 94 ha (the largest burning 23,045 ha near Gambo), and 62 percent under 49 ha (Table 3.1).

It is significant to note that only the 23,045 ha fire in 1979 was clearly known to have started by lightning (Power 1996a). All other documented fires were initiated directly or indirectly by humans (eg. defective power line, logging skidder, campfire), a pattern which began with European colonization (Power 1996a). For example, the

Table 3.1: Recent burnovers in the greater TNNP region (adapted from Power 1996a).

Year	Size (ha)	Location of burnover
1995	125	Spracklin's Road–Adam's Pit
1994	8	Northwest River--Railway Trestle
1990	67.2	Thorburn Lake
1990	0.1	Arnold's Pond
1988	<1	Dunphy's Pond
1987	2.5	Newman Sound Campground
1986	332	Blue Hill West Trail
1986	5.1	Charlottetown Community
1982	201.6	Charlottetown Boundary
1982	408.8	Bunyan's Cove Road
1981	0.5	Northwest River
1979	18.5	Port Blandford
1979	23045	Gambo Pond
1978	2	Northwest River
1977	313.6	Terra Nova Road
1976	485.6	Terra Nova Dump
1975	95	Traytown Community
1974	7.2	Charlottetown
1973	1.6	Maccles Lake
1972	48	Terra Nova
1971	212	Northwest Pond
1970	<2	Fox Pond
1968	<2	Terra Nova River
1967	<2	Newman Sound Campground
1967	10	Traytown
1965	0.2	Eastport
1964	5	Terra Nova
1963	13.5	Lake St. John
1961	800	Dunphy's Pond/Pitts Pond

establishment of the Newfoundland railway lead to many accidental fires in the late 1800s and early 1900s, closely correlating with the age of the majority of the park's forest stands

(Power 1996a). In the last 50 years, however, forest regeneration has been lacking due to the fire suppression policies advocated in and around TNNP which lead to the immediate suppression of all forest fires (CPS 1992; Parks Canada 1996c; Power 1996a).

3.2.2 Fire ecology

There are three conditions which must always be met for a fire to occur: a source of ignition, sufficient combustible fuel, and appropriate climatic conditions for combustion (Van Wagner 1983, 1985; Wein and MacLean 1983). In the boreal forest, lightning and humans are the main sources of ignition. Lightning is an uncontrollable source, and the leading cause of large fires, particularly in remote areas of the country's boreal ecosystem. However as evidenced in the fire history study (Power 1996a), its role in the TNNP region is limited.

Dry organic matter, such as arboreal lichens which proliferate on old black spruce trees in TNNP, provide good sources of combustible fuel for fire spreading (Deichmann and Bradshaw 1984; Power 1996a). Other fuel is made available through disturbances such as windfall, disease, and insect infestation. For example, the spruce budworm and hemlock looper outbreaks of the 1970s and 1980s resulted in the death of several balsam fir stands in TNNP, thereby leading to a large amount of combustible fuel which could affect future fire behaviour (CPS 1992; Furyaev *et al.* 1983; Mann and Kerr 1995; Péch

1993).

Climatic conditions in the TNNP region impact its fire regime. Greater precipitation and increased relative humidity (compared to central Canada's boreal ecosystem) account for a fire weather index (FWI) which is often below the Canadian average (Mann and Kerr 1995; Power 1996a; Stocks *et al.* 1989). The FWI is a measure of relative fire potential based on temperature, wind speed, precipitation, and relative humidity, combined with fuel availability and ratings of moisture in surface and organic layers (Stocks *et al.* 1989; Taylor *et al.* 1996). In TNNP, the consistent presence of wind can elevate FWI ratings from their generally low average, and subsequently increase the potential for fire spread (Power 1996a).

A ground, surface, or crown fire will result when the three conditions for fire ignition are met (Chandler *et al.* 1983; Heinselman 1981; Johnson 1992; Van Wagner 1983; Wein 1983). A ground fire burns the organic layer of the forest floor thereby exposing the mineral soil. Conversely, a surface fire burns loose litter, small shrubs, and herbaceous plants, but does not burn the organic layer or the tall tree canopy. Both ground and surface fires are uncommon in the park due to high soil moisture and abundant fuel in the canopy. This fuel, as well as the ladder structure of black spruce branches, will likely cause flames to rise into the tree canopy, thereby resulting in a crown fire. This is the most common type of fire in TNNP, burning trees and tall shrubs, but merely scarring the surface vegetation and organic layer (Power 1996a).

3.2.3 Adaptations of vegetation to fire

There are various adaptations by native species to the fire dominated environment of the boreal ecosystem (Ehnes and Shay 1995; Elliott-Fisk 1988; Heinselman 1981; Meades and Moores 1989; Van Wagner 1983). For example, coniferous trees have needles which decompose slowly and build up on the forest floor along with other decomposing vegetation, forming the organic layer (Heinselman 1981; Viereck 1983; Wein 1983). One of the roles of fire is the consumption of this organic accumulation, thus releasing nutrients which are required for new growth (Viereck 1983). Following fire, seed germination and vegetative reproduction through roots increase since mineral soil is exposed to light, enabling opportunistic shade intolerant species to grow (Chandler *et al.* 1983; Heinselman 1981). Both white birch and trembling aspen have wind dispersed seeds and vegetative reproduction from stems and roots providing excellent examples of fire adapted species (Dyrness *et al.* 1986; Heinselman 1981; Rowe 1983).

Another adaptation is displayed by certain coniferous trees, such as the dominant black spruce tree in TNNP, which have serotinous or semi-serotinous cones. Serotinous cones depend on the heat from fire to melt the resinous coating, thereby releasing seeds for post-fire regeneration (Heinselman 1981; Pielou 1988; Rowe 1983). With semi-serotinous cones seed release is heightened by fire since cones are partially sealed by resin. A few species adapt to fire in the boreal forest by resisting it. In TNNP white pine can often escape fires with only surficial scars (Heinselman 1981; Power 1996a). Conversely, balsam fir is a boreal species present in TNNP which is not adapted to fire, but which does succeed in sites with longer fire cycles since it is shade tolerant (Heinselman 1981; Meades and Moores 1989).

There are numerous examples of fire adaptations by shrubs and herbaceous plants in TNNP, but the most significant is that of the ericaceous shrub kalmia. Kalmia is found mainly along the eastern seaboard of North America, where it proliferates in moist and acidic soil conditions (Hall *et al.* 1973). It is the dominant understorey species in the black spruce forests of the TNNP region, but it also grows in bogs, heathlands, and other environments exposed to strong winds (Damman 1983; Hall *et al.* 1973; Mallik 1987; Meades 1983; Meades and Moores 1989). The key to its success is its vegetative reproduction by persistent root structures and woody stems which spread laterally over several metres through the organic layer (Hall *et al.* 1973; Mallik 1993). Additionally, kalmia is believed to have allelopathic properties which may inhibit the growth of other species (Mallik 1987, 1992, 1993, 1994), however this role is not conclusive.

The type of fire present (ground, surface, or crown) can impact kalmia's growth. In general, a severe ground fire will consume the organic layer, thereby destroying the root system and halting plant reproduction (Mallik 1994; Wein 1983). But a crown fire (the most frequent type in TNNP) could result in the survival and spread of kalmia through vegetative means, thus leading to a lack of forest regeneration due to its overwhelming presence (Mallik 1993, 1994; Mann and Kerr 1995).

3.2.4 Effects of fire on wildlife

In general, mammals and bird species benefit from habitat modifications at different stages during post-fire regeneration (Fox 1983; Pengelly 1995). In TNNP, browsing mammals such as moose (*Alces alces*) will quickly inhabit burnovers to feed on small shrubs and herbaceous plants, while black bear (*Ursus americanus*) feed from berries on small shrubs (Parks Canada 1997; Pielou 1988). Similarly, birds like ruffed grouse (*Bonasa umbellus*) browse in the low shrubs of open burnovers, and the hairy woodpecker (*Picoides villosus*) consumes wood boring insects in dead standing trees (Pielou 1988; Stroud 1996, pers. comm.). Yet a fire in the old coniferous forest stands which dominate the park could adversely affect certain species. One of these species is the endangered Newfoundland pine marten (see section 3.1.1.3). The old coniferous forests which are home to pine marten also require fire for renewal (CPS 1992; NMRT 1995; Parks Canada 1996c), thus fire could variably alter their habitat (CPS 1992;

Robinson 1996, pers. comm.).

3.2.5 Fire management options

Presently there are three approaches to forest fire management within the spatial dimension of a park management plan: letting a fire burn naturally, suppressing a fire, or prescribed burning (Alexander and Dubé 1983; CPS 1989; Lopoukhine 1993; Parks Canada 1996c; Weber and Taylor 1992). Prior to European colonization most fires were able to burn freely, but with increased human settlement fire was perceived as bad and suppression as good (Woodley 1995). This has been and continues to be the case in the TNNP region. A significant effect of suppression appears to be the lack of forest renewal from poor organic layer consumption (due to the dominance of crown fires), most often leading to the dominance of the site by kalmia (see section 3.2.3) (Mann and Kerr 1995; Power 1996a; Robinson 1989). The use of prescribed burning (defined in section 2.3.4) as a potential fire management solution to years of suppression is being advocated by park personnel, with the intended role of reintroducing a natural process to TNNP (Pardy 1994; Power and Deering 1996).

A zoning system is used in all national parks to classify areas based on required ecosystem and cultural resource protection (Table 3.2). The approaches to fire management described above should be considered in the context of the zoning system implemented in the TNNP management plan. For example, the use of prescribed burning may not be appropriate in the Outdoor Recreation Zone (Zone IV), yet could be of value in the Wilderness Zone (Zone II). This is the case in TNNP's Wilderness Zone, as restoration measures may be allowed to replace natural processes which have been altered through the influence of humans (Parks Canada 1996c). Thus under the park management plan, zoning would be a factor utilized to determine fire management planning in TNNP in an ecosystem management context.

Table 3.2: National park zoning classification system and the zones of TNNP (Parks Canada 1994, 1996c).

Zoning classifications	**TNNP zoning**
Zone I - Special Preservation • unique, threatened or endangered natural/cultural features are protected and access to motorized vehicles and to the general public is restricted	• covers 0.3 percent of the park
Zone II - Wilderness • natural regions are represented, natural processes and environments are not to be altered, and motorized access is not permitted since the wilderness experience is emphasized	• covers 94.9 percent of the park
Zone III - Natural Environment • natural environments are managed, low-density recreation is allowed, and motorized access may be allowed but will be controlled	• covers 0.8 percent of the park
Zone IV - Outdoor Recreation • visitor services are present, outdoor recreation and interpretive events are encouraged, and motorized vehicles are permitted	• covers 4.0 percent of the park
Zone V - Park Services • visitor services supported in communities located within national parks	• not applicable

3.2.6 Impacts on interest groups

In the TNNP region forest fires can have varying impacts on different values and interests, be they human or non-human. Risks of both planned and unplanned forest fires include: loss of human life, property, and livelihood, loss of economically valuable forest stands, loss of park infrastructure, disruption to park visitors, and loss of wildlife and vegetation species. Accordingly the park's ecosystem management objectives call for possible effects of prescribed fires on all park users, including park visitors and local communities, to be considered prior to being implemented (Parks Canada 1996c).

Due to fires in local communities which have destroyed private property, there is an inherent fear of wildfire by the region's inhabitants (Mann and Kerr 1995; Stroud 1996, pers. comm.). In field research conducted following the present research, Bath (1997) revealed that 26 percent of park community residents surveyed had experienced damage to life or property because of a forest fire. Risks to residents and park visitors, such as personal safety or the presence of smoke, are also issues which TNNP needs to address as it has been determined that 97 percent of park community residents have seen smoke from a forest fire, while 86 percent have seen flames (Bath 1997). Loss of livelihood is also a concern since many inhabitants are dependant upon the pulp and paper industry which, along with the Newfoundland forest service, is concerned about fires burning economically valuable forest stands (Mann and Kerr 1995; Parks Canada

1996c).

It is the mandate of TNNP to protect park infrastructure from forest fires, while simultaneously preserving natural ecosystems and processes. However the park will also consider the values and interests of other groups such as non-governmental organizations and institutions, or government departments (Parks Canada 1996c). These groups may share common values in examining the long term viability of the natural environment following forest fires.

3.3 THE ECOSYSTEM MANAGEMENT CONTEXT

As discussed in sections 3.2.5 and 3.2.6, it is evident that there are many different viewpoints, values and concerns regarding forest fires and their management in and around TNNP. By focussing upon the social and biophysical issues expressed by various interest groups, these could be addressed together as a means to implement fire management in TNNP in an ecosystem management context while applying the objectives of the park management plan (Parks Canada 1996c).

The present research considers the outcomes of fire management approaches on the park ecosystem, from both a social and biophysical perspective, as presented in a

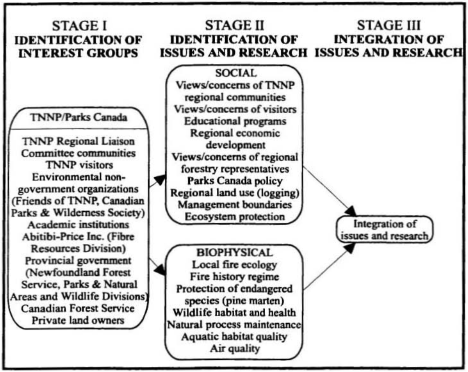

Figure 3.3: A linear framework incorporating components of ecosystem management in the TNNP fire management context.

linear framework (Figure 3.3). This framework is based upon Figure 2.2 (see section 2.3.3) but its content focusses specifically on the fire management case study in TNNP. As in Figure 2.2, it is recognized that TNNP and Parks Canada merit specific consideration due to their park management responsibilities. Yet they are included in the framework along with other interest groups as they are considered in the research and issues outlined in Stage II.

3.4 SUMMARY

In this chapter the ecological and cultural settings of TNNP were outlined, followed by fire management issues in the park context. In general, both biophysical and social impacts (either positive or negative) resulting from forest fires were examined with regards to TNNP. Issues emanating from these potential impacts have been presented in a linear framework, thereby setting the stage for the implementation of ecosystem management in the context of the park management plan. Through integrative methodological approaches (Chapter 4), means of examining diverse social and biophysical fire management issues will be explored and further discussed in this context.

CHAPTER 4 – METHODOLOGICAL APPROACHES

This chapter discusses the methods used to integrate social and biophysical issues under an ecosystem management approach. First, the use of integrative methodologies based upon the ecosystem management concept will be outlined. Secondly, specific descriptions of social and biophysical research conducted in and around Terra Nova National Park (TNNP) in the summer of 1996 will be presented. As it was the intent of this work to present the simultaneous examination of a variety of issues, the research methodology is based on the collection of data on a wide range of social and biophysical issues rather than an exhaustive study of a single issue. These approaches will serve to gain an understanding of fire management issues in the TNNP region in an ecosystem management context.

4.1 INTEGRATIVE METHODOLOGIES

Ecosystem management requires innovative and integrative approaches to addressing research problems (Grumbine 1994; Irland 1994; Wood 1994). Methods and processes which embody such approaches are rare (Slocombe 1993a). Hence, a challenging component of this study was developing and employing appropriate techniques to apply ecosystem management. Since both social and biophysical factors were examined, several data collection techniques ranging from key informant interviews to vegetative inventories were adapted to specific aspects of the research with the intent of integrating diverse information. The linear framework presented in Figure 2.2, and further detailed in Figure 3.3, will be elaborated upon below, prior to the development of a conceptual framework emphasizing research integration in ecosystem management for the TNNP fire management case study in Chapter 7.

4.2 SOCIAL RESEARCH

At the time of this study, the social research undertaken was the first of its type in the TNNP region. It was initiated to sample the concerns of interest groups, and provide a means to incorporate socially based issues into fire management research in the greater TNNP region. Typically such social research can offer both relevant qualitative and quantitative information on key management issues (Bailey 1994, Neuman 1991). In the TNNP case study, the social research undertaken was primarily qualitatively and subjectively based, and examined perspectives from Parks Canada employees, regional managers and employees from forestry related departments and businesses, and to a lesser degree, park visitors.

4.2.1 Parks Canada questionnaire

A questionnaire was sent via electronic mail to 65 Parks Canada employees across the country representing each of its five geographical regions, to determine local concerns in fire management planning. The recipients included national and regional managers, chief park wardens, park ecologists, and wardens/fire management specialists, who were currently involved with fire management based issues. The individuals were initially identified through personal communications with TNNP staff, and a snowball sampling technique ensued (Fowler 1984; Sheskin 1985).

In view of the fact that all national parks are unique, the questions sought to determine opinions and viewpoints from both a national and regional context which are grounded in legislation, policy, and the process of park management. Since the type of management practices implemented in Banff National Park, for example, may not be suitable to TNNP, this exercise was useful for differentiating the various levels of knowledge and experience in specific regions and ecosystems. As shown in Appendix 1, the five questions raised were broad, addressing issues such as the applicability of both vegetation and fire management objectives[1], the importance of active management techniques (such as prescribed burning), the promotion of ecological integrity, and the incorporation of local community and park visitor concerns. The responses were used to determine the range of fire management approaches from park to park, and to provide guidelines for the development of integrative ecosystem management based research in TNNP fire management context.

4.2.2 Key informant interviews

Through several key informant interviews, the attitudes, opinions, and interests of

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1 Fire management can be an important component of vegetation management. These terms were used in the questionnaire since they are often addressed together in a Parks Canada context.

managers and employees representing provincial forestry, federal forestry, provincial wildlife, provincial parks, and the pulp and paper industry were explored and documented. Each of these groups has a direct interest in the maintenance of healthy forest ecosystems in the TNNP region and throughout Newfoundland. It should be noted, however, that the respondents represent a limited range of values and interests which exist in the greater TNNP region, since they are confined to employees of forestry related departments and businesses. This sample of key informant interviews therefore acted as a initial step toward documenting the concerns, values, and interests of the various interest groups within and beyond the national park context.

Fifteen individuals were interviewed, in person when possible, or otherwise by telephone or a combination of fax and mail. Interviews lasted between fifteen minutes and one hour, and limited follow-up dialogue ensued. A series of fourteen quantitatively based statements and ten open-ended questions were presented to each individual (shown in Appendix 2). With respect to the statements, the respondents were asked to choose the number on a seven point Likert scale (strongly disagree to strongly agree), most fitting their opinion (Likert 1932). These statements were based on previous research examining public attitudes toward forest fires (Bath 1993; Cortner *et al.* 1984; Manfredo *et al.* 1990). The ten open-ended questions were developed and pre-tested by the author.

Since all of the individuals interviewed had training or a foundation in forestry or biology the statements presented were discussed with them in greater detail. Thus an emphasis was placed on reasons for the answers and opinions put forth, thereby seeking to reveal preliminary views and concerns among this general group.

4.2.3 Park visitor knowledge

To expose park visitors to work being undertaken in TNNP and to initially identify key issues, exploratory discussions ensued with ten randomly selected individuals. Although a sample of ten visitors is too small to generalize for all visitors, it is enough to identify significant issues and possible questions that could be used in a more quantitative study, thus acting much like a pre-test. As shown in Appendix 3, individuals were invited to agree or disagree on a few of the statements which were used during key informant interviews. These visitors were also asked: *What does 'prescribed' burning mean to you?*. Such research serves as an issue identification exercise and a step toward designing and implementing a representative quantitative study of visitor feelings toward fires.

4.3 BIOPHYSICAL RESEARCH

In this research the biophysical issues explored in TNNP (described below), were related to fire ecology and regeneration, and were undertaken due to the lack of information on post-fire regeneration as well as the timeliness of fire management issues in Canadian national parks (Parks Canada 1996c; Parks Canada 1997). Regeneration surveys in burnovers sought to provide quantitatively based data, while a review of previously completed research examined information pertaining to fire history and endangered species in TNNP.

4.3.1 Regeneration surveys in burnovers

Data on forest regeneration was gathered in the vegetative associations represented in burnovers as a result of forest fires in the greater TNNP region over the last three decades. Some biophysical research related to fire management had already been conducted in the park, as evidenced by the work of Kerr (1993), Breon (1996), and Power (1996a), on fire regeneration and history. However, this portion of the study sought to present pertinent information on post-fire regeneration research, and to integrate available information to provide an overview of vegetative succession as influenced by fire in the TNNP region.

A comparison of successional patterns was conducted in twelve sites of varying sizes and ages in the greater TNNP ecosystem which have been influenced by forest fires between 1961 and 1995 (Table 4.1). These sites were chosen to represent a broad variety of burnovers and were selected in consultation with park staff and other researchers. The specific data gathered was based upon biogeographical techniques (Colinvaux 1986; Gilbertson *et al.* 1985; Kent and Coker 1992; Tivy 1993; Wratten and Fry 1980). Guidance was also provided through the work on vegetative inventories in TNNP

Table 4.1: Burnovers in the greater TNNP region in which vegetative inventories were performed.

Year	Size (ha)	Location of burnover	Acronym (see Figure 4.1)
1995	125	Spracklin's Road–Adam's Pit	Sprkrd95-1, Sprkrd95-2
1994	8	Northwest River--Railway Trestle	Nwrvr94-1, Nwrvr94-2
1986	332	Blue Hill West Trail	Bhw-1, Bhw-2, Bhw-3
1986	5.1	Charlottetown Community	Chtcm86-1
1982	201.6	Charlottetown Boundary	Chtbd82-1, Chtbd82-2
1982	408.8	Bunyan's Cove Road	Byncv82-1
1981	0.5	Northwest River	Nwrvr81-1
1979	23045	Gambo Pond	Gambo-1, Gambo-2
1977	313.6	Terra Nova Road	Tnrd77-1, Tnrd77-2
1976	485.6	Terra Nova Dump	Tndp76-1, Tndp76-2
1967	<2	Newman Sound Campground	Nscmp67-1
1961	800	Dunphy's Pond/Pitts Pond	Dphy61-1, Dphy61-2

conducted by Scott (1993) and Power (1995), outlining methods for data collection.

One to three 10 m x10 m plots were selected in each of the twelve burnovers. The plot locations were determined according to the accessibility, size and uniformity of the particular burnover, for a total of 21 plots (Figure 4.1). A Global Positioning System (GPS), the Trimble Geoexplorer, was utilized to determine their specific location, and plots were flagged and marked with metal pins. According to methods of Gilbertson *et al.* (1985), Colinvaux (1986) and Kent and Coker (1992), the approximate abundance of each species was visually estimated (as a percent) to ascertain the approximate vegetation cover of these species.

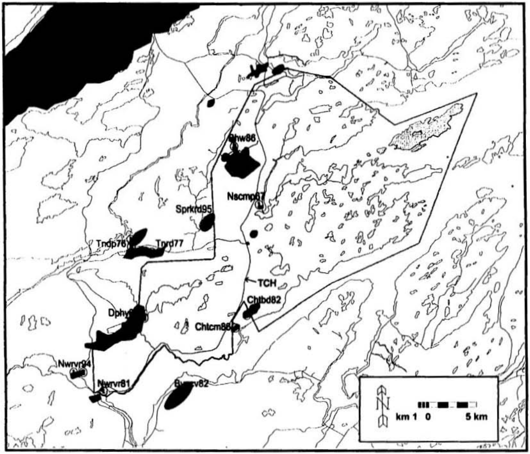

Figure 4.1: Locations of the twelve burnovers in the greater TNNP region in which regeneration was surveyed.

The number of trees or large shrubs growing in each plot was determined, along with measurements of their heights and basal diameters, to compare growth and regeneration patterns between burnovers. Secondary general site characteristics were also noted, including organic layer depth, soil properties, slope, ground cover, extent of dead standing and fallen trees, and surrounding vegetation. This information can be helpful in exploring relationships between size, intensity, age, and other aspects of specific fires, in more detailed research in the future.

As previously discussed, kalmia is the dominant ericaceous shrub in the TNNP region, and it is believed to hinder the germination and growth of black spruce (CPS 1992; Mallik 1992, 1993; Mann and Kerr 1995). In order to examine the effects of kalmia growth on forest regeneration patterns, the prominence of the shrub was noted in each of the 21 plots by determining the average height of the plant, along with its abundance and vitality.

The plots established in the present research were flagged and marked, and can therefore serve a similar role to permanent sample plots (PSP's), which have been established predominantly in unburned areas throughout TNNP to monitor long term changes in vegetational succession (Power 1995; Scott 1993). It is anticipated that these plots will be re-examined in the future to compare results from plot analyses to the information collected in the present research, and to document advances in burnover regeneration. This research therefore serves to establish a baseline against which future research can be compared and built upon.

4.3.2 TNNP's forest fire history

A fire history study has recently been completed at TNNP (Power 1996a), and was therefore utilized to advance the present study. Power (1996a) considered variables such as forest cover, stand age, and climate, to determine the fire cycle, fire interval, stand age classification, and fuel typing, for the forests of the greater TNNP[2] region. This information will be incorporated with, and used to understand, the data resulting from the vegetative inventories conducted in the present research.

4.3.3 Endangered species research

One fire management issue which is relevant to many national parks is the potential impact on rare or endangered species. In TNNP, a timely concern is the protection of the endangered Newfoundland pine marten (see sections 3.1.1.3 and 3.1.4). Recent research by TNNP on pine marten habitat and characteristics will therefore be incorporated into the present research since it is a significant biophysical factor with regards to fire management in TNNP's boreal forest ecosystem.

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2 It should be noted that some of the fire history results presented by Power (1996a) rely heavily on the analysis of human caused fires since they were dominant during the last century.

4.4 CONTRIBUTION TO FRAMEWORK

Based on the linear framework presented in Figure 3.3, Stage II is further detailed and expanded to reflect the specific methodological approaches in both social and biophysical issues discussed in this chapter (Figure 4.2). This continuing expansion of the linear framework evolving from Figure 2.2 and Figure 3.3 will serve as a step toward an increasingly complete conceptual framework to be presented in Chapter 7.

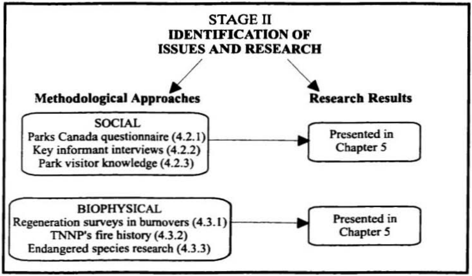

Figure 4.2: Expansion of the linear framework to reflect the specific methodological approaches for examining social and biophysical issues.

4.5 SUMMARY

The diverse information collected, organized, synthesized and analyzed within this document is timely as park managers contend with fire management and ecosystem management issues. In order to recognize the benefit of integration, a variety of issues were addressed rather than focusing on an in depth study of one particular issue. Three social issues (Parks Canada questionnaire, key informant interviews, and park visitor knowledge) and three biophysical issues (regeneration surveys in burnovers, TNNP's fire history, and endangered species research) were examined through different methodological approaches. In the following chapter (Chapter 5), the results stemming from each issue will be presented, and subsequently in Chapter 6 these results will be integrated to provide an increasingly effective and complete ecosystem management approach to fire management in TNNP.

CHAPTER 5 – SOCIAL AND BIOPHYSICAL RESULTS

The social and biophysical results of the fire management based issues explored in the greater TNNP ecosystem are outlined below. The linear framework presented in Figure 4.2 will then be modified to incorporate these results. This will set the stage for the integration of social and biophysical results in the next chapter, and the development of an ecosystem management conceptual framework.

5.1 SOCIAL DATA

The social research obtained from Parks Canada employees, regional representatives, and park visitors, revealed a variety of information including differences in viewpoints, knowledge base, and overall goals. The questions posed to Parks Canada employees resulted in qualitatively based responses, while interviews with regional representatives were both qualitatively and quantitatively based. This preliminary socially based data can begin to offer information for fire management research in TNNP within the ecosystem management context.

5.1.1 Parks Canada questionnaire

After several reminders to participate, eighteen of the 65 employees contacted completed or partially completed the questionnaire (see Appendix 1). The poor response rate is disappointing but the range of ideas and subsequent discussion with the respondents allows for an examination of some of the key issues. The respondents included five national or regional managers, one chief park warden, four park ecologists, and eight wardens/fire management specialists. The names of respondents and their affiliations will remain confidential.

When asked to outline the goals and objectives of vegetation and fire management in Canadian national parks, the respondents emphasized the maintenance of ecological integrity and the promotion of natural processes. Approximately half the individuals based their responses on official Parks Canada policy (eg. Parks Canada 1986, 1994). A few mentioned the protection of human life and property as an objective, while several supported the use of prescribed fire to maintain or restore ecosystem health. In general it was believed that fire management goals and objectives were not being implemented nationally, and when they were, these were inconsistently applied from park to park. Some respondents felt that the examination of these goals and objectives should only be discussed within Parks Canada management systems.

In response to the second question concerning the use of active management such as prescribed burning to maintain the natural character and ecological integrity of national parks, most believed that it is required to some extent due to human based interference such as fire suppression during the last century. A few felt that parks should duplicate the fire cycle which was present prior to the suppression period. However, some pointed out that traditional burning by Aboriginal people prior to European colonization, primarily in western parks, should be considered when discussing the "natural" fire cycle. The lack of scientific knowledge regarding natural processes was also addressed. For example, it was pointed out by one individual that "we must know what we want", and that prescribed burning may not always be required even though it is advocated by Parks Canada. Others felt active fire management was required to reduce fuel loads/hazards since some older forest stands were "just waiting to burn". Meanwhile letting natural fires burn while being monitored was suggested as a potential alternative if human livelihood was not at risk.

The third question sought to determine the presence of active fire management in vegetation management plans throughout Canadian national parks. The majority of the respondents generally believed that complete vegetation or fire management plans supporting active management were often lacking, even though they are validated in principle. Responses varied from park to park, but some stated that fire management guidelines were established mainly for suppression practices. Certain individuals were concerned with the lack of both internal and external support for active fire management, as well as poor public perceptions and attitudes toward fires.

When questioned about the overall contribution of active fire management programs to the promotion of ecological integrity within Parks Canada, several respondents felt past practices of total suppression neglected ecological integrity, resulting in the loss of fire-adapted species. It was also stated that present and future management may be conducted without a true knowledge of past fire cycles. Thus it was stressed that fire history studies be used only as guides, and that research on fire behaviour and effects be increasingly considered. A few believed that Parks Canada leads the way in promoting fire as a natural process, but that external agencies (such as provincial forestry departments) still advocate fire suppression. Yet the increasing cost of fire suppression, as stated by some individuals, could inevitably lead to a greater role for active fire management in the future. A minority maintained that good fire management–where managers and interest groups define objectives together–could enhance ecological integrity. In general, the overwhelming response was that active fire management is needed, and credible scientific evidence is necessary to achieve this.

The final issue addressed the incorporation of local and visitor concerns into vegetation and fire management planning in Canadian national parks. Respondents expressed that socially based issues have only recently been emphasized by Parks Canada, but were now being seen as an integral component of active management planning (with implementation varying greatly from park to park). One individual maintained that ecosystem management has not been fully embraced by Parks Canada due to the inherent complexity of incorporating social concerns into fire management. Hence several strategies were suggested including: 1) promoting the role of fire in specific ecosystems through educational tools, 2) involving various interest groups in fire management planning (such as the formulation of interagency groups and round table discussions with interested partners), and 3) gathering public support and addressing concerns early.

In addition to formal responses, many individuals provided additional comments and suggestions, and further communication with a few individuals ensued. Overall it was suggested that the implementation of "good" fire management was slow due to changes in government and staffing, and to the inherent complexity of an ecosystem management approach.

5.1.2 Key informant interviews

Fifteen regional managers or employees representing five different groups were interviewed and asked to comment on quantitatively based statements and open-ended questions related to fire management issues in the greater TNNP ecosystem. The names and affiliations of these individuals are found in Appendix 4. A summary of their responses is presented in Table 5.1, but individual comments remain confidential.

Most regional representatives (80 percent) agreed that fires play an essential role in regenerating forests, with 56 percent strongly agreeing. These individuals stated that this was particularly true for black spruce dominated forests in central Newfoundland, but not necessarily true for other forest types in the province. Similarly, 72 percent disagreed

Table 5.1: Summary[1] of responses to statements in the key informant interviews (number of respondents indicated in brackets).

Statement	Disagree	Neither	Agree
*Fires play an essential role in regenerating forests	13% (2)	7% (*1*)	80%(*12*)
*All fires are harmful	72%(*10*)	7% (*1*)	21% (*3*)
*There are no ecological benefits to fires	87%(*13*)	7% (1)	7% (*1*)
*Fires will generate a greater variety in plant and tree species	36% (*5*)	0% (*0*)	64% (9)
*Wildlife populations will decrease as a result of fires	54% (*7*)	15% (2)	31% (*4*)
*Outdoor recreation opportunities will decrease as a result of fires	0% (*0*)	23% (*3*)	77%(*10*)
*Fires that are started by lightning should be allowed to burn as long as they are monitored	67% (*8*)	8% (*1*)	25% (*3*)
*Fires that are started by human carelessness should be allowed to burn as long as they are monitored	83%(*10*)	8% (*1*)	8% (*1*)
*All fires, whether started by lighting or human carelessness, should be put out immediately regardless of cost	54% (*7*)	8% (*1*)	38% (*5*)
*All fires should be suppressed or stopped, regardless of how they start	73%(*11*)	0% (*0*)	27% (*4*)
*Managers should conduct prescribed burns to promote forest regeneration	21% (*3*)	14% (2)	64% (9)
*Managers should conduct prescribed burns to remove fuels built up on the forest floor	43% (*6*)	14% (2)	43% (*6*)
*Fires should not be deliberately set by managers in national parks	43% (*6*)	14% (2)	43% (*6*)
*Fires should not be deliberately set by managers on crown land	57% (*8*)	29% (*4*)	14% (2)

1 Responses are grouped into three categories based on the seven point Likert scale used for the statements during the interviews (see Appendix 2).

with the statement that all fires are harmful, and 87 percent disagreed that there were no ecological benefits to fires (with 60 percent strongly disagreeing). Some forestry-based employees claimed that fire could be harmful by "setting back" development and succession; but most of these employees recognized that fire was a natural component of the boreal forest ecosystem.

More than 60 percent of respondents agreed that fires would generate a greater variety of plant and tree species. One individual stated that fire would benefit "mature" (old) black spruce forests since they have low species variety. A few, however, felt that species variety in central Newfoundland is already limited, and that composition and type of regeneration is dependant on the size and location of the fire. Most regional representatives limited their comments to tree species, with several emphasizing that fire had a negative impact on the regeneration of black spruce due to the presence of the shrub kalmia. They termed these areas of high kalmia presence as "kalmia barrens".

Approximately one third of the respondents agreed that wildlife populations would decrease as a result of fires, yet in general it was expressed that wildlife would benefit in the long term, and that animals would eventually return to burned sites. Moose and ruffed grouse were thought to benefit the most, and pine marten the least. With regards to outdoor recreation, 77 percent indicated that activities would diminish after a forest fire, since, as one respondent expressed, it is believed that people do not like to camp in burnovers. In contrast, hunting or blueberry picking were recreational activities which were thought to be enhanced by fire. A list of positive and negative impacts of forest fires provided by regional representatives reflected the views of the individuals interviewed (Table 5.2).

Table 5.2: Impacts of forest fires provided by regional representatives (ordered by frequency of occurrence).

Positive impacts	**Negative impacts**
* renews the boreal forest ecosystem	* loss of timber
* good silvicultural tool	* loss of livelihood in local communities
* promotes commercial blueberry growth	* decrease in outdoor recreation
* increases wildlife habitat	* loss of wildlife habitat
* enhances black spruce regeneration	* loss of species variety
* can control insects or disease	* site degradation due to kalmia growth
	* poor aesthetics

When asked if fires started by human carelessness should be allowed to burn if monitored, the majority (83 percent) disagreed (62 percent strongly disagreeing); but fewer (73 percent) disagreed if the fire was lightning caused. These individuals clarified their answers by stating that this was dependent upon the location of the fire and the surrounding resources (these generally being timber supplies and local communities and businesses). One respondent affirmed that humans are not an integral part of the ecosystem thus human caused fire should not be allowed to burn.

When questioned about fire suppression, 38 percent agreed that fires started by lightning or human carelessness should be put out immediately regardless of cost, and similarly 27 percent agreed that all fires should be suppressed, irrespective of how they start. The monetary cost of suppression was a significant concern even though respondents felt that fire management from a suppression point of view has been efficient. The majority, however, agreed that decisions related to fire suppression should be made on a case by case basis. Some individuals recognized that this type of fire management[2] may be too efficient since no fires are left to burn, thereby disregarding their ecological role in the boreal forest.

When asked what prescribed burning implied, all respondents agreed with the suggested definition provided to them--*The knowledgeable application of fire to a specific land area to accomplish predetermined forest management or other land use objectives (Weber and Taylor 1992).* Most forestry representatives commented that prescribed burning was a silvicultural tool which enhanced regeneration, while a few asserted that it could be used to duplicate nature in fulfilling specific management objectives. There was a lack of consensus regarding the use of prescribed burning to remove fuels built up on the forest floor, with many respondents stating that this was not a concern in Newfoundland. Forestry representatives generally pointed out that there were other means of decreasing fuel loads near communities, such as thinning or cutting

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2 It is noted that in general respondents used the term fire management interchangeably with fire suppression.

old forest stands.

Two thirds of the respondents agreed that local managers should conduct prescribed burns to promote forest regeneration. Some saw this as a cost efficient way to facilitate tree growth, while a few (21 percent) believed this to be a high risk option. A minority (14 percent) agreed that fires should not be deliberately set on crown land, while 43 percent agreed that fires should not be deliberately set in national parks. The latter results are similar to those obtained through yes/no/not sure questions, with over half the respondents in favour of prescribed burning in national parks, and three quarters in favour of prescribed burning on crown land (Figure 5.1). In contrast, a few provincial forestry representatives expressed that they were in favour of prescribed burning in national parks to mimic nature and improve forest health, but they did not support this practice on crown land.

Respondents placed an emphasis on factors such as the location, size, and ecology of the area to be burned, as well as the use of less "risky" techniques when considering prescribed burning on crown land. With respect to prescribed burning in national parks, a variety of comments were heard, ranging from "No, we should let nature takes its course" to "I see nothing wrong with it if it's really needed" to "Yes, it's the natural thing to do". All respondents in favour of prescribed burning emphasized that precautions had to be taken, and potential impacts considered, prior to implementation.

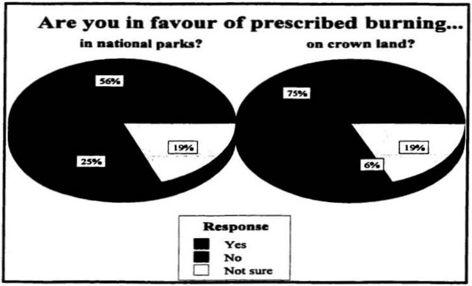

Figure 5.1: Opinions of respondents regarding the use of prescribed burning in national parks and on crown land.

When asked if there was a difference between prescribed burning on crown land versus protected lands such as national parks, most stated that the process was the same but that the general objectives differed. As one individual expressed, burning for silvicultural purposes is not like burning to promote natural processes since trees are harvested first. Others felt that the public has a different perception of parks compared to crown land, hence prescribed burning would have to be carefully thought out prior to its implementation.

5.1.3 Park visitor knowledge

Through informal questions and discussions with TNNP visitors (see Appendix 3), some preliminary issues and concerns regarding fire management were collected. The ten randomly surveyed individuals agreed that fire played an essential role in regenerating forests, yet four also maintained fires were harmful. Eight visitors believed that fire would generate a greater variety of plant and tree species, whereas half thought wildlife populations would decrease. Meanwhile, all respondents agreed that outdoor recreation opportunities would decrease. Most disagreed that both lightning and human caused fires should be left to burn if monitored, while they generally agreed that all fires be put out immediately regardless of cost.

Response was limited to the question *What does prescribed burning mean to you?*, with over half the visitors not answering. Those who did answer thought prescribed burning was conducted to: 1) promote new vegetation growth, 2) destroy dead trees for reforestation, and 3) satisfy human interests. Although the respondents represented a small portion of visitors, these questions did expose them to some of the management concerns being addressed in the park. In addition issues were identified which could be addressed through educational programs for visitors as well as for park employees and regional representatives. This exercise also revealed a willingness by visitors to respond to research oriented questions in the park, thus encouraging the use of similar types of surveys.

5.2 BIOPHYSICAL DATA

The biophysical component of this research examined both new and previously collected data pertaining to regeneration in burnovers, as well as to fire history and endangered species research in TNNP. The regeneration surveys resulted in predominantly quantitative data, while the fire history and endangered species research were explored and reviewed from a qualitative perspective.

5.2.1 Regeneration surveys in burnovers

Vegetation inventories were undertaken to determine the variety of successional stages in burnovers of different ages and sizes in the greater TNNP region (see Table 4.1 and Figure 4.1). These results were averaged to simplify presentation when two or more plots were located per site. One exception was the second plot in the 1986 Blue Hill West burnover which was originally a white birch stand (as opposed to the dominant black spruce stands). For this reason it was not combined with other data for this site. Illustrations and/or descriptions of vegetation cover, species variety, presence and size of trees, characteristics of kalmia, and organic matter depth, follow.

The vegetation cover in the burnovers was divided into four types (Figure 5.2). Kalmia had the greatest coverage, averaging between 50 and 90 percent in ten of the thirteen plots, with lows of 25 and 35 percent respectively in the 1994 Northwest River Railway and 1979 Gambo burnovers. The presence of trees was generally lower than

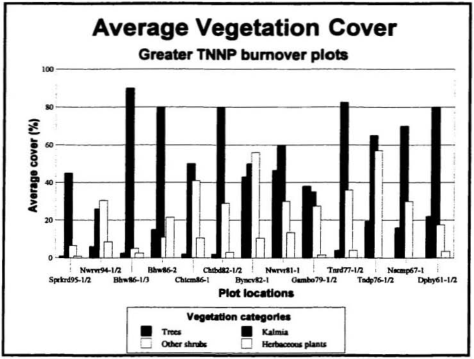

Figure 5.2: Categorized vegetation cover in burnovers in the greater TNNP region (Note that total vegetation cover of all species can surpass 100 percent since vegetation growth is layered and stratified).

kalmia, with coverage of greater than 20 percent in four of the thirteen plots, and a maximum of 46.5 percent in the 1981 Northwest River burnover. Shrubs (excluding kalmia) covered between 5 and 56 percent, with the greatest cover at the 1976 Terra Nova Dump burn (primarily due to blueberry, the second most dominant small shrub in the sites). Herbaceous plant cover (including ferns or grass species) was less than 15 percent, except in the burned white birch stand of the 1986 Blue Hill West burnover which had just over 20 percent. It was also noted that lichen or moss species were most abundant (80 percent) on the dry site at the 1967 Newman Sound Campground burnover, with a complete absence in the recent 1995 Spracklin's Road burnover. Less than half the sites had bare ground, with a maximum of 45 percent at the 1994 Northwest River Railway burn.

The average number of species (including mosses/lichens) was determined for each plot, with a high of 27 species at the 1982 Bunyan's Cove burnover, and a low of 6.5 at the 1995 Spracklin's Road burnover. Within the same burnover, the average species diversity ranged from 8.5 in the burned black spruce stands of the 1986 Blue Hill West burn, compared to 24 in the burned white birch stand. The oldest site, the 1961 Dunphy's Pond burn, had a mean of 13.5 species, 5 of which were trees. Shrubs and herbaceous plants represented between 1 and 6.5 species for all the sites (with kalmia always present, and blueberry present at all but the 1995 site).

More details on the regeneration of trees in the burnovers exist. The overall mean density was 22 trees per plot, while the greatest density occurred in the 1979 Gambo burnover with approximately 82 trees per plot, two thirds of which were black spruce (Figure 5.3). In general, conifers outnumbered deciduous trees, representing 75 percent of the trees in the older burnovers from 1961 to 1981 (with an average of 37 trees per plot); while deciduous trees accounted for 75 percent of the cover in burnovers between

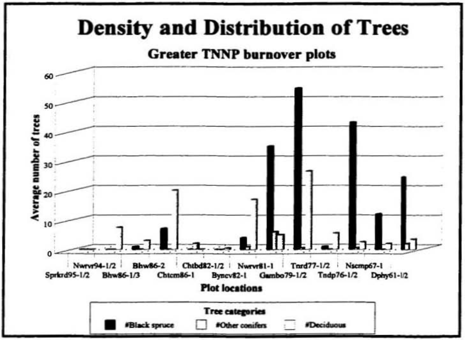

Figure 5.3: Number of trees present in the burnover plots of the greater TNNP region (Note the deciduous tree category also includes some large shrub species).

1982 and 1994 (with an average of 9 trees per plot). The black spruce tree was the dominant conifer, with limited presence of eastern larch and balsam fir. Deciduous tree species included trembling aspen and white birch, covering 27 and 23 percent respectively. A mixture of pin cherry, mountain alder, northern wild raisin, willow, serviceberry, mountain ash, and red maple, completed the deciduous coverage.

The largest basal diameters of trees (averaging 3 cm) were measured in the two oldest burnovers (1961 Dunphy's Pond and 1967 Newman Sound Campground), while the greatest heights averaged over 100 cm in the 1979 Gambo and 1982 Bunyan's Cove burnovers. For all burnovers, the mean basal diameter was 1.6 cm and the mean height was 75 cm, for all trees measured. The sizes of these trees were relatively small compared to neighbouring unburned areas or standing dead trees which had average basal diameters of 14.9 cm and average heights of 7.3 m. Coverage of dead standing and fallen trees was also noted, with dead standing trees remaining in most of the sites, except for the 1979 Gambo, 1967 Newman Sound Campground, and 1961 Dunphy's Pond burnovers.

Finally, by comparing black spruce and kalmia growth, it was determined that black spruce coverage was generally lower when kalmia coverage increased (Figure 5.4). Maximum black spruce cover (25 percent) occurred at the 1979 Gambo burn where the presence of kalmia was low, at 35 percent, relative to other burnovers. Meanwhile there was consistent evidence of black spruce in the three oldest burnovers (1961 Dunphy's Pond, 1967 Newman Sound Campground and 1976 Terra Nova Dump), even though kalmia cover was greater than 60 percent in these sites.

In Figure 5.4, the average height of kalmia as well as the depth of organic matter are presented for all burnovers. As a general observation, increased organic matter depth

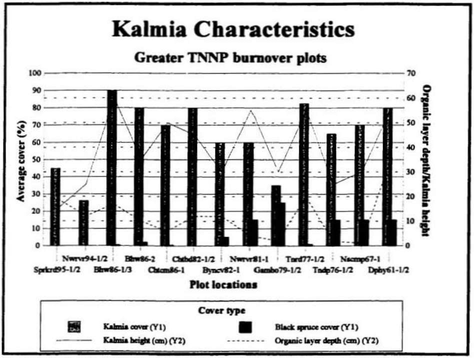

Figure 5.4: Kalmia height and organic layer depth in relation to black spruce and kalmia coverage in the greater TNNP burnover plots.

appears to coincide with increased presence of kalmia and kalmia height. For example, maximum depth averages of 34 cm at the 1961 Dunphy's Pond burn correlate with high kalmia height and presence. This is also the case at the 1986 Blue Hill West burn and the 1977 Terra Nova Road burn, with maximum height values and depths of 17 cm and 20 cm respectively. A low depth average of 2 cm was recorded at the 1979 Gambo burn, with a low kalmia height of 30 cm. This pattern was also evident at the 1976 Terra Nova Dump and 1967 Newman Sound Campground burn sites which were underlain by sandy soil.

5.2.2 TNNP's forest fire history

The TNNP fire history study by Power (1996a) was undertaken to provide an increased understanding of the role of fire in the region, as outlined below. The study revealed a fire cycle of 98 years, implying that 315 ha should burn annually. But it must be stressed that this result was based almost entirely on the recent history of human caused fires. For example, the numerous human caused fires at the turn of the century, corresponding with building of the cross-island railway, seem to account for the 80 to 120 year age group in which 70 percent of the forest stands belong (Power 1996a).

More recently, the largest fire season in the TNNP region occurred in 1979 (with a total of 27,733 ha burned), most of which burned during the 1979 lightning caused Gambo fire. Historical data from Wilton and Evans (1974) reveal other fire seasons of similar size in surrounding areas in 1935 and 1950. Based on this information Power (1996a) derives an average 15 year interval between large areas burned. This would imply that the TNNP area is due for another large fire season.

Evidence of fire was found in all the sample plots in and around the park. According to the fire data from 1957 onward which was reviewed, June has had the greatest number of fires and largest area burned, followed by July and August. The fire weather index (FWI) (see section 3.2.2) reached a maximum in July, averaging 8.5 (corresponding with a moderate fire danger rating). The only prominent relationship between a component of the FWI and fire occurrence was evident with the ISI (initial spread index) which accounts for the effects of wind. The ISI threshold for rapid fire spread was met by 74 percent of the fires since 1957, indicating a wind driven fire regime in the TNNP region. A weak correlation between fire starts and increased lengths of dry periods also existed. However, since most fires were caused by humans irrespective of weather conditions, it is understandable that only a few relationships between fire starts and FWI variables were apparent.

In Power's (1996a) fire history study it was observed that forest regeneration due to fire has been absent in the last 40 to 50 years. Regeneration in burnovers was said to be "anywhere from rare to nonexistent" (Power 1996a, 6). When discussing forest regeneration, the black spruce tree was the species most emphasized. This tree is believed to be out-competed by the kalmia shrub under open canopy conditions, and at the time of the study 17 percent of the park was covered with these kalmia dominated black spruce stands (Power 1996a).

The fire history study concludes by advocating that some forest stands in TNNP could be actively managed through prescribed burning, thus promoting higher density black spruce forests. It is suggested that prescribed burning could be introduced over a longer time frame, to meet the annual burn area of 315 ha. In addition, prescribed burning is put forth as a means for reducing fuel loads in aging forest stands, particularly near high use areas.

5.2.3 Endangered species research

As TNNP is home to the endangered Newfoundland pine marten, consideration is to be given to the protection of its habitat (see sections 3.1.1.3 and 3.1.4). Research on this endangered species is relevant to the fire management context of the present research since its ideal habitat is the same old growth coniferous forest which requires fire for renewal.

Research regarding the tendencies and habitat of this endangered species are being advanced in TNNP. For example, discussions with park staff have revealed that pine marten may have an ability to cope with disturbance by simply passing around or through the disturbed area (Gosse 1996, pers. comm.). This is evidenced by the fact that one of the pine marten monitored appeared to inhabit an area associated with high visitor use. Such studies are relevant and required to provide a comprehensive understanding of fire management in the ecosystem management context.

5.3 SOCIAL AND BIOPHYSICAL DATA COLLECTION

In this case study data on fire management in TNNP both social and biophysical data were collected. As presented in Figure 5.5, key findings from the different methodological approaches undertaken are summarized in the context of the evolving ecosystem management framework. This completes the expansion of Stage II (see Figure 3.3) which was initially presented in Figure 4.2.

5.4 SUMMARY

Results emanating from both social and biophysical issues regarding fire management issues in the greater TNNP ecosystem have been outlined in Figure 5.5. In the following chapter (Chapter 6) these results will be addressed together through integration, and examined from an ecosystem management perspective in the context of fire management in TNNP, ultimately leading to the development of an applicable conceptual framework (Chapter 7) for ecosystem management.

STAGE II
IDENTIFICATION OF ISSUES AND RESEARCH

Methodological Approaches → **Research Results**

Presented in Chapter 5 →

SOCIAL

Parks Canada questionnaire (5.1.1)
- emphasis on maintenance of ecological integrity in national parks, by prescribed burning if necessary
- support of active management such as prescribed burning
- suggest need for more scientific research to understand fire
- mixed opinions on the use/purpose of fire history research
- emphasis on the need for education to explain role of fire

Key informant interviews (5.1.2)
- concerns about quality of regeneration (eg. "kalmia barrens")
- concerns about loss of livelihood, timber and species variety
- some support for prescribed burning in national parks and crown land, depending on size and location of area
- suggest that prescribed burning is a good silvicultural tool

Park visitor knowledge (5.1.3)
- concerns about loss of wildlife in the event of forest fires
- recognition of role of fire in regenerating forests in TNNP
- belief that fires should be put out promptly regardless of cost
- poor understanding of prescribed burning

Presented in Chapter 5 →

BIOPHYSICAL

Regeneration surveys in burnovers (5.2.1)
- species variety did not correlate with age of burnover
- poor regeneration heightened by fire suppression, leading to an increase in kalmia growth
- greatest tree density found in the lightning caused burnover
- much of the organic matter is not being consumed by fire
- kalmia had the greatest coverage in the plots surveyed
- black spruce cover decreased as kalmia cover increased

TNNP's forest fire history (5.2.2)
- fire history based predominantly on human caused fires
- a 98 year fire cycle is put forth
- poor relationship between fire starts and fire weather index
- promotes the use of prescribed burning to meet a calculated area to be burned annually

Endangered species research (5.2.3)
- research on the tendencies and habitat of the endangered Newfoundland pine marten is being advanced
- pine marten may have ability to cope with disturbance

Figure 5.5: Expansion of the linear framework to reflect key findings from the different methodological approaches.

CHAPTER 6 – SOCIAL AND BIOPHYSICAL INTEGRATIONS

This discussion will examine the integration of social and biophysical information in an ecosystem management context. Based on the individual social and biophysical methodological approaches (Chapter 4), the highlights of various integrations will ensue. The integrations will be summarized in the context of the linear framework which has evolved through Chapters 3, 4 and 5, prior to the illustration of the ecosystem management conceptual framework in Chapter 7.

6.1 INTEGRATION OF SOCIAL AND BIOPHYSICAL DATA

Fire management issues in the greater TNNP region will be discussed in the context of the ecosystem management concept. Numerous socially based issues regarding fire management in and around Canadian national parks have been identified from a broad to an increasingly specific scale. Parks Canada employees emphasized the application of policies and the integration of stakeholder interests into planning approaches (section 5.1.1). Key informant interviews with regional representatives concerned with the role of fire in the TNNP region presented a variety of comments regarding local fire management issues (section 5.1.2). Initial steps were also taken to question TNNP visitors to aid in identifying issues pertaining to fire management to be addressed in the future (section 5.1.3).

Biophysical issues of varying scales in and around TNNP were examined with regards to fire management. Inventories of forest regeneration in burnovers provided a means of establishing relationships between species variety and vegetative growth (section 5.2.1). An analysis of the recent TNNP fire history study (Power 1996a) was combined with the results of the vegetation inventories (section 5.2.2). Further consideration of biophysical issues were initiated by addressing the role of an endangered species in TNNP (section 5.2.3).

The first objective of this research is to integrate social and biophysical data, while illustrating that integrated data provides more meaningful results than if the data were examined individually. For this reason several results emanating from various methodological approaches were explored as opposed to an extensive study of a specific issue. As little or no previous data related to fire management issues in TNNP existed, the majority of the data was collected as part of the present research. Selected integrations are presented below, each leading to conclusions which could not be reached without such integrations. These integration dependant results will be summarized in the evolving linear framework (to be presented in Figure 6.1).

6.1.1 Integration of key informant interview data and regeneration survey data

The quality of post-fire forest regeneration was found to be a concern for the regional representatives interviewed (see section 5.1.2). The regeneration survey data collected in the twelve burnovers included tree species, namely black spruce, which were observed in all but the most recent burn (see Figure 5.2). Some regional representatives viewed many of these burnovers as "kalmia barrens" since the amount and type of regeneration (e.g. black spruce) was not significant for pulp and paper production. However, when these two results are integrated it is evident that contrary to the beliefs of the regional representatives there is regeneration of various species, including the "important" black spruce tree, and as such these are not truly "kalmia barrens"[1]. Similarly, older sites which appear to be dominated by the shrub kalmia are considered by some regional representatives to be "poor sites". These sites actually have greater black spruce regeneration relative to some younger burnovers (see Figure 5.3). This indicates that the regeneration process may simply be slow, and strengthens the value of integration.

Certain regional representatives noted that site quality and type could affect species regeneration. This statement is supported by the regeneration survey data from some sandy sites which have a thin organic layer with decreased kalmia regeneration, compared with increasingly organic sites. In general, however, interview respondents discussed kalmia in terms of its negative effects on other species, rather than considering its natural role in the region. Conversely, the biophysical data indicated the inherent vigor and hardiness of the dominant kalmia shrub without associating positive or negative

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1 The proper term is kalmia heathlands (Meades 1983). These heathlands represent a natural component of Newfoundland's ecosystem (Damman 1983; Meades 1983).

values to its presence in the ecosystem.

Some regional representatives attributed poor forest regeneration to the proliferation of kalmia after disturbance by fire. Yet to these predominantly forestry-based employees, site degradation implied poor black spruce regeneration. It has been revealed however that black spruce forests in Newfoundland can only naturally regenerate to high densities after severe fires (Damman 1964; Meades 1983). Accordingly the regeneration survey results presented in section 5.2.1 show that poor regeneration was heightened by fire suppression. It is therefore predicted that the recent 1995 Spracklin's Road burn will be dominated by kalmia.

One regional representative stated that "if fire is out of control then we have to assume it will play a bad role in the forest". But according to the quality of regeneration in some burnovers this does not seem to be the case. Specifically, the lightning caused 1979 Gambo burn now has the greatest density of tree growth among the twelve sites inventoried (see Figure 5.3); yet it was an "out of control fire" which burned for fourteen days (Power 1996a). The fire suppression program advocated by the provincial forest service, and several regional representatives, could therefore be contributing to the lack of regeneration in some of the burnovers surveyed by decreasing organic layer consumption by fire. As such, the integration of biophysical data with social data (based on perceptions of regeneration), allows for the targeting of communication messages to better address fire management issues.

6.1.2 Integration of Parks Canada questionnaire and regeneration survey data

Parks Canada employees generally acknowledged that fire suppression has altered a natural process in the ecosystem and that new management alternatives need to be considered. In addition, several employees called for more scientific research to help understand ecosystem processes such as fire. The regeneration survey conducted in the greater TNNP region was a step in this direction, and revealed that much of the organic layer was not being consumed by fire. It suggests that fire suppression may prevent the consumption of organic matter, and decrease regeneration.

Overall, the comments provided by Parks Canada employees were reinforced by the data collected in the burnover plots in the greater TNNP region. Since TNNP is at the early stages of this process, the information provided by other national parks with regards to fire management alternatives such as prescribed burning or allowing hot spots to burn while being monitored, can be considered in light of recent biophysical research in and around the park.

6.1.3 Integration of Parks Canada questionnaire and fire history research

The distinct climatic setting of TNNP's boreal forest, with higher than average humidity and lower incidence of lightning (see section 3.1.1.1), has lead to a unique fire history. The 98 year fire cycle presented by Power (1996a) is consistent with average boreal forest fire cycles which are dominated by lightning caused fires (Heinselman 1981; Wein and MacLean 1983); yet TNNP's fire cycle is deceiving since it is based on fires which were predominantly human caused. Accordingly, due to differences in fire sources (human caused versus natural), some Parks Canada employees suggested that fire history research should be used merely as a guide for fire management, whereas others promoted it to apply active fire management such as prescribed burning.

The responses from Parks Canada employees strengthen the need to not depend solely on the estimated fire cycle from the fire history study. For this reason parks such as TNNP could be encouraged to consider the use of active fire management methods more comprehensively. By carefully regarding fire history studies such as Power's (1996a) in the context of experience and knowledge gained by Parks Canada employees throughout the country, future fire management can be completed with a greater degree of certainty.

6.1.4 Integration of key informant interview data and fire history research

While addressing the results of the key informant interviews in light of the fire history study conducted by Power (1996a), it was noted that many of the regional representatives were not aware of the fire history study until it was mentioned during interviews. Based on discussions in the interviews, some of these individuals expressed interest in reviewing such findings to better understand the role of fire in the region. Others, however, were more concerned about the present condition and health of the forest in terms of producing a quality tree harvest. Thus by considering these two results together, new directions for further research can evolve in the context of the distinct viewpoints and concerns in the greater TNNP region.

6.1.5 Integration of regeneration survey data with fire history research

Explanations for certain regeneration patterns in burnovers can be obtained by integrating the regeneration survey data with results from Power's (1996a) fire history research. The quality and extent of regeneration in the vegetation inventories can be partially associated to the site and climatic conditions presented in Power (1996a). Power (1996a) revealed that both the 1979 Gambo and 1982 Bunyan's Cove burnovers had extreme fire weather index (FWI) ratings and high winds, and burned for several days. Based on the regeneration survey data these sites now have the greatest regeneration among the twelve burnovers, with increased species variety and tree growth (see Figures 5.2 to 5.4). In contrast, the 1982 Charlottetown Boundary and 1986 Blue Hill West burns had low to moderate FWI's (Power 1996a), which is reflected in the regeneration survey data by decreased regeneration and the dominance of kalmia at the sites since the organic layer was not consumed by fire (see Figures 5.2 to 5.4). In the future the quality and extent of regeneration could be predicted in accordance with the FWI at the time of the burn, thus providing the relevant information in the event of possible active fire management undertakings.

When the vegetation inventories were integrated with information on the treatment of individual fires (Power 1996a), it was revealed that plots with fewer species and poorer regeneration occurred on sites which underwent immediate fire suppression and accordingly had limited organic matter consumption. Conversely sites with some unimpeded burning, usually in larger burnovers which are harder to control, did have increasingly varied and successful regeneration. The integration suggests that successful regeneration is the result of burning the organic matter under unsuppressed hot spots (or smouldering ground fire), and that fire suppression has altered the course of regeneration. As an example, hot spots at the 1995 Spracklin's Road burnover were extinguished after the fire was brought under control, therefore the organic layer was not consumed by fire, and poor regeneration may be the result, as suggested by Power (1996a) and by the regeneration survey data.

6.1.6 Integration of Parks Canada questionnaire and key informant interview data

The integration of data from the Parks Canada questionnaire with the results of regional key informant interviews provides social science based information both within and beyond the national park context. Parks Canada employees were generally supportive of prescribed burning to enhance ecological integrity. Regional representatives interviewed were, however, more concerned with suppressing fires in order to protect resources such as timber, as well as private property and local communities: yet several of these representatives supported the notion of prescribed burning on crown land and in national parks (see Figure 5.1). Some of these results differ from the views of certain Parks Canada employees who feel that interest groups and individuals such as the regional representatives interviewed are opposed to prescribed burning (see Section 5.1.1).

A few Parks Canada respondents stressed that the development of management goals and objectives should proceed in conjunction with the needs of communities, local forest harvesters, and provincial government departments. Regional representatives were also interested in fire management approaches being undertaken in TNNP. Therefore, if discussions were to ensue between interest groups, issues such as prescribed burning to achieve a specific fire management objective could then be contemplated. It is thus suggested that regional representatives, such as those interviewed in the present research, work closely with Parks Canada employees to accommodate each others objectives while proceeding with appropriate fire management actions.

One common issue presented by both Parks Canada employees and regional representatives was related to the limitations of prescribed burning based on the size of the park in question. It was felt that TNNP is relatively small, and therefore risk to interest groups and to infrastructure is heightened. However both groups did accept that fires in isolated regions of the boreal forest could burn as long as communities and resources were not negatively impacted.

6.1.7 Integration of Parks Canada questionnaire and park visitor knowledge

Although the sample size of the preliminary visitor survey is small, the opinions of TNNP visitors on fire management issues can provide a means of identifying specific concerns/issues which may need to be addressed by park staff. The majority of Parks Canada employees realize the significance of educating visitors, and gaining their support, when seeking to implement specific fire management objectives. As a result of these preliminary visitor surveys, Parks Canada may be able to recognize the potential use of future comprehensive visitor surveys to determine whether more research on visitor issues/concerns could help form a basis for the design of interpretive messages and appropriate educational efforts.

6.1.8 Integration of endangered species research and park visitor knowledge

The attitudes and opinions of park visitors can be integrated in a fire management context with ongoing research considering the endangered Newfoundland pine marten. For instance, preliminary results from park visitors suggest that fires could lead to a decrease in wildlife. Pine marten research in TNNP has revealed that some habitat zones are located near disturbed areas with high visitor use; thus home ranges may be quite broad and marten may be able to adapt to various conditions (Gosse 1997, pers. comm.).

Therefore to protect pine marten habitat the park, in cooperation with regional interest groups, could delineate zones based on known habitat and forest age and type, thereby protecting specific areas in and around the park from fire. Such a management approach could be presented to park visitors to help alleviate their concern related to the possible decrease in wildlife due to fire.

6.1.9 Summary of integration

Overall the results presented above provide a preliminary step toward the application of the ecosystem management concept as they reflect the integration of social and biophysical data, and provide results which would not be recognized if the data were examined on an individual basis. The last step of the linear framework initiated in Figure 2.2 is completed as selected integrations of research results are presented in Stage III (Figure 6.1). These integrations stem from the social and biophysical findings presented in Stage II of Figure 5.5.

These integrations will serve as a basis for the incorporation of new social and biophysical data collected in the future. As will be demonstrated in the conceptual framework presented in the concluding chapter, the integration of various social and biophysical data can be utilized to fulfil comprehensive ecosystem based management in the greater TNNP region, through the use of feedback loop mechanisms.

STAGE III
INTEGRATION OF
ISSUES AND RESEARCH

Research Results	Integrated Results
5.1.2 + 5.2.1	6.1.1 => Poor sites are not actually "kalmia barrens"; the regeneration process is merely slow.
5.1.1 + 5.2.1	6.1.2 => Confirmation that organic matter is not being consumed by fire as a result of fire suppression.
5.1.1 + 5.2.2	6.1.3 => Parks Canada should not solely base fire management objectives on the fire cycle.
5.1.2 + 5.2.2	6.1.4 => Realization of lack of communication between Parks Canada and key informants.
5.2.1 + 5.2.2	6.1.5 => Revealed that plots with fewer species and poorer regeneration occurred on sites which underwent immediate fire suppression, and had limited organic matter consumption.
5.1.1 + 5.1.2	6.1.6 => Lack of understanding between interest groups. Need for increased dialogue.
5.1.1 + 5.1.3	6.1.7 => Need for further research on visitor knowledge to determine role of education in fire management .
5.1.3 + 5.2.3	6.1.8 => Use results of further park visitor surveys to better manage and protect endangered species.

*Selected integrations are shown. Section numbers are described in Chapters 5 and 6, and Figure 5.5 presents a summary of key social and biophysical findings.

Figure 6.1: The integration of social and biophysical results in the context of the evolving linear framework.

CHAPTER 7 – IMPLEMENTING A CONCEPTUAL FRAMEWORK

One of the key messages of this research, and of the promotion of ecosystem management in Parks Canada (Woodley and Forbes 1995), is the need for implementing human-based research without compromising the inherent ecological integrity of the ecosystem. In this case study of fire management for TNNP, social research has been integrated with biophysical research in an ecosystem management setting. A conceptual framework will be presented based on a linear framework initiated in Figure 2.2 and progressively detailed in the TNNP fire management context in Figures 3.3, 4.2, 5.5 and 6.1. This conceptual framework will incorporate the use of feedback loops in a comprehensive approach to achieving ecosystem management. By presenting and integrating various issues through a conceptual framework, the ecosystem management concept can subsequently be used to facilitate management issues, such as fire management in TNNP.

7.1 DEVELOPMENT OF ECOSYSTEM MANAGEMENT CONCEPTUAL FRAMEWORK

The TNNP management plan outlines ecosystem management objectives which call for ecosystem management planning to be undertaken in cooperation with neighbouring land users (Parks Canada 1996c). It should be noted that although the ecosystem management concept has been discussed (Carpenter 1996; Francis 1993; Samson and Knopf 1996), methods for implementing ecosystem management are limited (e.g. Harwell *et al.* 1996). This research presents a methodology for the application of the ecosystem management concept using the example of fire management in TNNP. The two key components of this approach are the integration social and biophysical data, and the development of a conceptual framework.

The conceptual framework presented in Figure 7.1 evolved from the linear framework that was built upon through Chapters 3, 4, 5 and 6. This conceptual framework was developed by examining resource and environmental management frameworks (Armitage 1995; Bonnicksen 1991), as well as one ecosystem management framework (Harwell *et al.* 1996), and incorporates ecosystem management concepts which advocate social and biophysical integrations (Carpenter 1996; Christensen *et al.* 1996; Grumbine 1994, 1997; Samson and Knopf 1996; Slocombe 1993a). The advantage of a conceptual framework over a linear framework is that data is continually integrated during the study, by means of feedback loops, whereas in a linear framework the data is integrated only at the conclusion of the research (Zube 1980). Hence in a conceptual framework the study methodology can be modified to achieve the desired ecosystem management objectives.

7.1.1 Coordinating the framework and integrating research

As the framework for TNNP fire management case study evolved from linear (see Figure 3.3) to conceptual (see Figure 7.1), two key roles were put forth: coordinating the

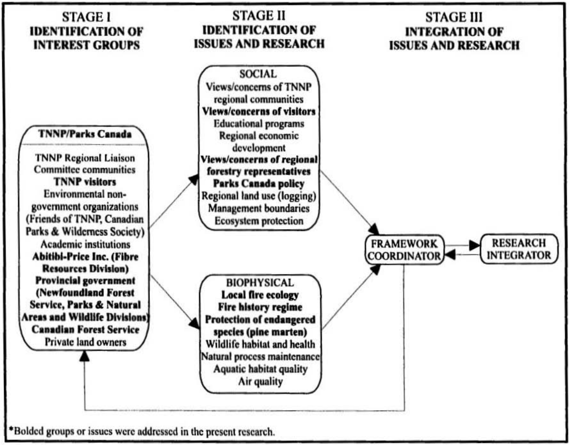

Figure 7.1: An ecosystem management conceptual framework to address fire management in TNNP.

framework and integrating research. The undertaking of these roles serve to facilitate feedback loops. The role of a framework coordinator would be to act as a liaison to interest groups, working closely with interest group representatives and with social and biophysical researchers, and facilitating events such as round table discussion and open-house meetings with these representatives.

The role of this individual could be undertaken by Parks Canada since it has the decision making power within Canada's national parks. However, if an increasingly collaborative or team approach is taken with interest groups[1], any qualified individual could take on the role of coordinating the framework within the confines of Parks Canada's management objectives, and with the support of all interest groups. Such approaches differ from the traditional way that Parks Canada has operated and could be an option for effective ecosystem management in national parks.

As shown in Figure 7.1 the framework coordinator fulfills an additional role as the link to a research integrator. The role of the latter is to work closely with the social and biophysical researchers to integrate research results in the TNNP fire management context. Results could subsequently be returned to researchers who could modify their methodology to achieve the desired ecosystem management objective. In essence this

1 To reiterate, the term interest group is used in a general context, as explained in section 2.3.3.

role would enable interdisciplinary research, and channel results back to interest groups through the framework coordinator. Again, such a role could be undertaken by Parks Canada given its first hand knowledge of the research being undertaken in the park. However, other groups or individuals with solid and broad backgrounds in environmental research could fulfil this role, if agreed upon by all interest groups involved in the ecosystem management project. In the present research the author partially fulfilled the role of research integrator on a smaller scale by integrating data based in different disciplines in the TNNP fire management context[2]. This research therefore provides the first step toward complete social and biophysical integration. As integration proceeds, further data collection can be focussed to address specific issues resulting from initial integrations.

A critical element of this conceptual framework relies on close contact between the research integrator and the framework coordinator. The former would attend discussions or meetings with key interest groups and researchers chaired by the latter. Similarly the framework coordinator could participate in meetings with the research integrator and social and biophysical researchers to learn about ongoing research and present concerns brought forth by interest groups.

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2 In reality the individual integrating research would concentrate specifically on data integration rather than both data collection and integration, as was the case with the present research.

By implementing these two roles a mechanism is provided for a feedback loop, with continual communication between interest groups and researchers via a framework coordinator and research integrator (see Figure 7.1). This mechanism provides a means to implement ecosystem management as well as to facilitate and encourage the integration of social and biophysical issues and research. These roles also provide a pathway to involve all interest groups in ecosystem management undertakings through a partnership approach. Such partnerships are emphasized in the TNNP ecosystem management objectives in that "communities and individuals will be encouraged to become involved in ecosystem management activities that affect their neighbourhoods" (Parks Canada 1996c, 18).

There have been initiatives which involve all interest groups in dealing with specific management concerns, namely wildlife management, as a means of obtaining complete and representative information through public participation (Johnson *et al.* 1993; Todd 1995). An example currently being undertaken in Gros Morne National Park (GMNP) in Newfoundland involves interest groups which are working together to deliberate issues surrounding snowmobiling in the park. In this case the facilitator of the group is not affiliated with the interest groups, and the spokesperson for the group is a member of the local community chosen by the group members, which include the national park (Bath 1999, pers. comm.). Local communities believe there has been more accomplished through four facilitated workshops than in the past ten years (Bath 1999, pers. comm.). Such examples could be applied to fire management in TNNP in the future.

7.2 CONCLUSION: CONTRIBUTION TO ECOSYSTEM MANAGEMENT

The two objectives of this research (see section 1.3.1) were fulfilled since:

1) Social and biophysical issues related to fire management in TNNP were integrated to provide strengthened and new results.

2) An ecosystem management conceptual framework involving the use of feedback loops to facilitate ongoing integration during the course of the research was developed for fire management in TNNP.

The first objective of this research consisted of the collection and integration of social and biophysical data as a means to illustrate that the value of integration provides more comprehensive information than the separate analyses of specific social and biophysical issues. Due to the lack of previous data on fire management in TNNP, the research conducted as part of this study was not an in depth examination of a particular issue, nor should it be regarded as a superficial examination of several issues. Instead, it is a holistic and innovative way of presenting the value of integration and provides an initial step toward the establishment of a mechanism for addressing the complexities of managing the natural environment in order to preserve the natural character and ecological integrity of an ecosystem.

As part of the second objective of this research, a conceptual framework was developed to implement fire management in TNNP in an ecosystem management context. The conceptual framework provides a means to illustrate ecosystem management in TNNP, including the identification of interest groups, the identification of issues and research, and the mechanisms for data integration. In particular the roles of coordinating the framework and integrating research are incorporated to ensure that data and results are passed between interest groups and researchers to account for continually evolving management concerns. As a result, increasingly effective ecosystem management decisions can be made by all groups involved when concerns and issues are continuously integrated with new and ongoing research in the context of the conceptual framework.

As situations will inevitably vary by park and by issue, this conceptual framework is flexible as it can be adapted according to the ecosystem management issues of other national parks or ecological settings. Such a flexibility is necessary to successfully address interests arising from all groups, and to work within a context where a team approach in decision-making will continue to grow. In the future, such an ecosystem management conceptual framework could form the basis for increasingly in depth integrated research according to specific management issues, such as the case study of fire management in TNNP.

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Personal Communications

Banfield, Dr. Colin. Department of Geography, Memorial University of Newfoundland.

Bath, Dr. Alistair. Facilitator of a workshop process in Gros Morne National Park..

Briffett, Betty. Visitor Activities Specialist, Terra Nova National Park.

Cox, Rod. Field Technician, Terra Nova National Park.

Gosse, John. Newfoundland Pine Marten Project, Terra Nova National Park.

Heathcott, Mark. Fire Management Officer, Parks Canada Directorate.

Power, Randy. Forest Technician, Terra Nova National Park.

Robinson, Kevin. Park Ecologist, Terra Nova National Park.

Stroud, Greg. Interpretation Specialist, Terra Nova National Park.

APPENDIX 1 – Copy of the questionnaire sent to Parks Canada employees

An Analysis of Fire Management in the Boreal Forest Ecosystem
of Terra Nova National Park.

My name is Michèle Culhane and I am currently pursuing my Masters of Science degree in Geography at Memorial University in St. John's, Newfoundland. I will be conducting research at Terra Nova National Park from May 13 to August 30, 1996, which will be related to fire management in this unique boreal forest ecosystem.

I am interested in applying and implementing an ecosystem management approach, which integrates and combines both biophysical and social concerns while promoting the ecological integrity of Canadian national parks. This approach should be applied to vegetation and fire management issues, particularly in the Atlantic Region parks, where the potential use of active management has only recently been considered. As the implementation of Parks Canada's mandate and policies are not consistent throughout national parks, however, it is therefore critical to re-examine and deliberate their goals and objectives, as they relate to fire management concerns, before active management techniques are employed.

With your cooperation, I wish to pose a series of questions to obtain a general view of the impressions and opinions of various Parks Canada officials and employees, regarding fire management in the Canadian national park system.

I will keep the questions to a minimum, and you may answer them as generally or as detailed as you wish. I hope to gather as much information as possible and would appreciate any responses. If you are not able to answer the questions, however, please let me know via E-mail. As well, if you would like to answer the questions on a separate document, or to fax answers, this is not a problem.

Thank you for your time.

The questions are as follows:

1. To your knowledge, what are the overall vegetation and fire management goals and objectives for Parks Canada? Are these being suitably applied at this time on a national basis, and on a specific park or regional basis?

2. Do you believe active management--such as prescribed burning in the case of vegetation and fire management--is required to maintain the natural character and ecological integrity of Canadian national parks? Specific examples can also be included.

3. Is active fire management a component of vegetation management plans in Canadian national parks, and in individual national parks?

4. What is the contribution of past/current/future active fire management programs within Parks Canada to the overall promotion of ecological integrity in Canadian national parks, and in individual national parks?

5. How are local community and park visitor concerns incorporated into vegetation and fire management planning in Canadian national parks? Please provide specific examples at the local or regional level if applicable.

Thank you very much for answering the above questions.

To meet time lines for my research I would like to compile the answers to this questionnaire by June 28, 1996. If this is a problem, however, please let me know. I would also appreciate any feedback, including comments and/or questions regarding any aspect of this study. Please enter them below your answers, or feel free to contact me via mail, phone, fax, or E-mail, at:

Michèle Culhane
Terra Nova National Park
Glovertown, Newfoundland
A0G 2L0

Phone: (709) 533-2291 Ext. 184 or 156
Fax: (709) 533-2706
E-Mail: barbara_linehan@pch.gc.ca (c/o: Michèle Culhane)
or michele@cs.mun.ca

I thank you for your time, and hope to hear from you in the near future,
Sincerely,

Michèle Culhane

APPENDIX 2 – Copy of interview questions presented to regional representatives

Key Issue Identification in the Greater Terra Nova National Park Region

The following questions are being asked to determine basic knowledge, opinions and attitudes towards forest fires. They will be applied to individuals, such as yourself, who have a particular interest in fire management issues in Newfoundland. Representatives from provincial forestry, federal forestry, provincial wildlife, national parks, provincial parks, and the pulp and paper industry will be contacted. A series of quantitatively and quantitatively based statements and questions, as found below, will be presented to each individual. Since it is evident that all interest groups should be considered when ecosystem management issues are addressed, the responses and comments provided will undoubtedly be useful in implementing appropriate fire management in the greater Terra Nova National Park region, and in Newfoundland as a whole.

Thank you very much for your time,
Sincerely,

Michèle Culhane

Department of Geography
Graduate Studies
Memorial University of Newfoundland

Fire Effects

1) Fires play an essential role in regenerating forests.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither	Slightly Agree	Moderately Agree	Strongly Agree
1	2	3	4	5	6	7

2) All fires are harmful.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither	Slightly Agree	Moderately Agree	Strongly Agree
1	2	3	4	5	6	7

3) Fires will generate greater variety in plant and tree species.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither	Slightly Agree	Moderately Agree	Strongly Agree
1	2	3	4	5	6	7

4) Wildlife populations will decrease as a result of fires.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither	Slightly Agree	Moderately Agree	Strongly Agree
1	2	3	4	5	6	7

5) Outdoor recreation opportunities will decrease as a result of fires.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither	Slightly Agree	Moderately Agree	Strongly Agree
1	2	3	4	5	6	7

6) There are no ecological benefits to fires.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither	Slightly Agree	Moderately Agree	Strongly Agree
1	2	3	4	5	6	7

7) Fires that are started by lighting should be allowed to burn, as long as they are monitored.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither	Slightly Agree	Moderately Agree	Strongly Agree
1	2	3	4	5	6	7

8) Fires that are started by human carelessness should be allowed to burn, as long as they are monitored.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither	Slightly Agree	Moderately Agree	Strongly Agree
1	2	3	4	5	6	7

9) All fires, whether started by lightning or human carelessness, should be put out immediately regardless of cost.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither	Slightly Agree	Moderately Agree	Strongly Agree
1	2	3	4	5	6	7

i) An issue of interest to me is fire management. Based on your answers to the above questions, what are your opinions about forest fires? What are the best and worst impacts of forest fires? (Prioritize these impacts).

ii) Should naturally caused fire be allowed to play a role in the forest?

iii) Should human caused fire be allowed to play a role in the forest?

iv) Are forest fires well "managed"?

Prescribed or Controlled Burning

v) What does "prescribed" or "controlled" burning mean to you? Do you agree with the definition provided below?

The following is an official definition: "The knowledgeable application of fire to a specific land area to accomplish predetermined forest management or other land use objectives."
(From Weber, M.G. and S.W. Taylor (1992). "The use of prescribed fire in the management of Canada's forested lands." **The Forestry Chronicle**, 68(3): 324-334.)

10) Managers should conduct prescribed burns to promote forest regeneration.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither	Slightly Agree	Moderately Agree	Strongly Agree
1	2	3	4	5	6	7

vi) Why?

11) Managers should conduct prescribed burns to remove "fuels" (ie. dead wood) built up on the forest floor.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither	Slightly Agree	Moderately Agree	Strongly Agree
1	2	3	4	5	6	7

vii) How do you feel about prescribed burning as a safety tool, to reduce the amount of fuel in the forest?

12) Fires should not be deliberately set by managers in national parks.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither	Slightly Agree	Moderately Agree	Strongly Agree
1	2	3	4	5	6	7

13) Fires should not be deliberately set by managers on crown land.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither	Slightly Agree	Moderately Agree	Strongly Agree
1	2	3	4	5	6	7

viii) Is there a difference between prescribed burning on crown land and prescribed burning on protected land (ie. national parks)?

14) All fires should be suppressed, or stopped, regardless of how they start.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither	Slightly Agree	Moderately Agree	Strongly Agree
1	2	3	4	5	6	7

15) Are you in favour of prescribed burning in national parks?

Yes Not Sure No

ix) Why?

16) Are you in favour of prescribed burning in the forests on crown land?

Yes Not Sure No

x) Why?

APPENDIX 3 – Copy of survey tested on park visitors

An Analysis of Vegetation and Fire Management in the Boreal Forest Ecosystem of Terra Nova National Park.

A series of questions has been developed to determine the basic opinions and thoughts of a sample of the general public with respect to the natural role of fire in the boreal forest of Terra Nova National Park. The following questions are aimed at park visitors such as yourself. By analyzing the responses, suitable fire management actions can be taken in the future while considering your opinions and concerns.

The questions will take approximately 10 minutes to answer. They simply consist of circling a number from 1 to 7 according to your opinions. If you have any concerns or comments feel free to indicate them on the questionnaire, or ask me.

Thank you very much for your time.

Sincerely,

Michèle Culhane

Department of Geography
Graduate Studies
Memorial University of Newfoundland

Fire Effects

1) Fires play an essential role in renewing forests.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither	Slightly Agree	Moderately Agree	Strongly Agree
1	2	3	4	5	6	7

2) All fires are harmful.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither	Slightly Agree	Moderately Agree	Strongly Agree
1	2	3	4	5	6	7

3) Fires will generate greater variety in plant and tree species.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither	Slightly Agree	Moderately Agree	Strongly Agree
1	2	3	4	5	6	7

4) Wildlife populations will decrease as a result of fires.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither	Slightly Agree	Moderately Agree	Strongly Agree
1	2	3	4	5	6	7

5) Outdoor recreation opportunities will decrease as a result of fires.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither	Slightly Agree	Moderately Agree	Strongly Agree
1	2	3	4	5	6	7

6) There are no ecological benefits to fires.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither	Slightly Agree	Moderately Agree	Strongly Agree
1	2	3	4	5	6	7

7) Fires that are started by lighting should be allowed to burn, as long as they are monitored.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither	Slightly Agree	Moderately Agree	Strongly Agree
1	2	3	4	5	6	7

8) Fires that are started by human carelessness should be allowed to burn, as long as they are monitored.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither	Slightly Agree	Moderately Agree	Strongly Agree
1	2	3	4	5	6	7

9) All fires, whether started by lightning or human carelessness, should be put out immediately regardless of cost.

Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither	Slightly Agree	Moderately Agree	Strongly Agree
1	2	3	4	5	6	7

10) What does "prescribed" burning mean to you?

Please provide any further comments below

APPENDIX 4 – List of individuals interviewed to explore regional fire management concerns

Ed Blackmore
Regional Director
Forest Protection Centre
Department of Forest Resources & Agrifoods
Newfoundland Forest Service
Gander, Newfoundland

Richard Carroll
Director of Restructuring
Forest Protection Centre
Department of Forest Resources & Agrifoods
Newfoundland Forest Service
Gander, Newfoundland

Ed Stewart
District Manager
Forestry Division
Department of Forest Resources & Agrifoods
Newfoundland Forest Service
Clarenville, Newfoundland

Dave Cheeks
Forest Unit Manager
Central Region
Department of Forest Resources & Agrifoods
Newfoundland Forest Service
Gambo, Newfoundland

Glenn Butt
Forest Fire Protection Specialist
Central Region
Department of Forest Resources & Agrifoods
Newfoundland Forest Service
Gander, Newfoundland

Roger Pike
Public Relations Manager
Abitibi-Price Inc.
Grand Falls-Windsor, Newfoundland

Merle Lingard
Supervisor of Silviculture & Environment
Fibre Resources Division
Abitibi-Price Inc.
Grand Falls-Windsor, Newfoundland

anonymous
Fibre Resources Division
Abitibi-Price Inc.
Grand Falls-Windsor, Newfoundland

anonymous
Thomas Howe Demonstration Forest
Gander, Newfoundland

anonymous
Canadian Forest Service
St. John's, Newfoundland

Alex Murley
Forest Fire Protection Specialist
Western Region
Department of Forest Resources & Agrifoods
Newfoundland Forest Service
Corner Brook, Newfoundland

Tom Molloy
Forest Fire Protection Specialist
Eastern Region
Department of Forest Resources & Agrifoods
Newfoundland Forest Service
St. John's, Newfoundland

Wayne Martin
Fire Co-ordinator
Forest Protection and Resources Division
Department of Forest Resources & Agrifoods
Newfoundland Forest Service
Corner Brook, Newfoundland

anonymous
Wildlife Division
Department of Natural Resources
St. John's, Newfoundland

anonymous
Parks and Natural Areas Division
Department of Natural Resources
St. John's, Newfoundland

APPENDIX 5 -- Summary of regeneration survey data

PLOT	LATITUDE	LONGITUDE	DATE	ALL SPECIES	COVER (%)	TREE SPECIES	BASAL DIAMETER (cm)	HEIGHT (m)
Sprkrd95-1	48.5333	54.0407	23/08/96	Kalmia angustifolia	50	Picea mariana (dead standing--corner1)	11.9	8.0
				Rhododendron canadensis	5	P. mariana (dead standing--corner 2)	7.0	6.0
				Vaccinium angustifolium	2	P. mariana (dead standing--corner 3)	3.0	3.9
				Ledum groenlandicum	2	P. mariana (dead standing--corner 4)	11.7	8.0
				Amelanchier spp	1			
				Bare ground	50			
Sprkrd95-2	48.5305	54.0506	23/08/96	Kalmia angustifolia	40	Picea mariana (dead standing--corner1)	5.7	3.0
				Rhododendron canadensis	3	P. mariana (dead standing--corner2)	4.7	3.0
				Vaccinium angustifolium	1	P. mariana (dead standing--corner3)	13.5	8.0
				Amelanchier spp	1	P. mariana (dead standing--corner4)	9.1	6.0
				Cornus canadensis	1			
				Maianthemum canadensis	present			
				Pleurozium schreberi (dead)	2			
				Cladonia spp (dead)	10			
Nervr94-1	48.4068	54.2232	21/08/96	Betula papyrifera	1	Picea mariana (dead standing--se corner)	9.7	7.0
				Populus tremuloides	2	P. mariana (dead standing--sw corner	4.1	4.0
				Viburnum cassinoides	5	P. mariana (dead standing--nw corner)	9.1	6.0
				Sorbus americana	2	P. mariana (dead standing--ne corner)	9.2	6.0
				Kalmia angustifolia	50	Betula papyrifera	n/a	0.4
				Vaccinium angustifolium	2	Populus tremuloides	n/a	0.6
				Ledum groenlandicum	1	P. tremuloides	n/a	0.6
				Lonicera villosa	1	Viburnum cassinoides	n/a	0.3
				Ribes glandulosum	1	V. cassinoides	n/a	0.8
				Rubus pubesens	5	V. cassinoides	n/a	0.5
				Linnaea borealis	1	V. cassinoides	n/a	0.5
				Epilobium angustifolium	1	V. cassinoides	n/a	0.6
				Trientalis borealis	present	Sorbus americana	n/a	0.4
				Clintonia borealis	3	S. americana	n/a	0.3
				Aralia hispida	2	Lonicera villosa	n/a	0.4
				Cornus canadensis	2			
				Aster spp	2			
				Shpagnum spp	5			
				Dicranum spp	5			
				Bare ground	40			
Nervr94-2	48.4083	54.2223	21/08/96	Prunus pensylvanica	2	Picea mariana (dead stump--sw corner)	16.0	n/a
				Populus tremuloides	present	P. mariana (dead stump--se corner)	25.0	n/a
				Kalmia angustifolia	2	P. mariana (dead stump--ne corner)	20.0	n/a
				Vaccinium angustifolium	2	P. mariana (dead stump--nw corner)	26.0	n/a
				Aralia hispida	50	Prunus pensylvanica	n/a	0.2
				Cornus canadensis	5	P. pensylvanica	n/a	0.4
				Juncus/grass spp	5	P. pensylvanica	n/a	0.3
				Bare ground	50	Populus tremuloides	n/a	0.3
Bhw86-1	48.5860	53.9902	22/08/96	Picea mariana	1	Picea mariana (dead standing--sw corner)	25.0	10.0
				Prunus pensylvanicum	3	P. mariana (dead stump--se corner)	10.3	7.0
				Salix spp	present	P. mariana (dead stump--ne corner)	12.4	8.0
				Kalmia angustifolia	85	P. mariana (dead stump--nw corner)	8.1	6.0
				Vaccinium angustifolium	5	Prunus pensylvanica	1.3	0.5
				Rhododendron canadensis	3	P. pensylvanica	0.4	0.3
				Ledum groenlandicum	1	P. pensylvanica	1.2	0.5
				Dicranum spp	10	Salix spp	1.0	0.3
				Cladina spp	2	Picea mariana	0.7	0.3
				Bare ground	10	P. mariana	0.8	0.3
Bhw86-2	48.5862	54.0010	22/08/96	Picea mariana	2	Betula papyrifera (dead standing--se)	17.0	n/a
				Betula papyrifera	5	B. papyrifera (dead standing--ne corner)	29.0	12
				Populus tremuloides	3	B. papyrifera (dead standing--sw corner)	21.0	n/a
				Amelanchier spp	1	Picea mariana (dead standing--nw corner)	26.0	n/a
				Sambucus pubens	present	P. mariana	1.3	0.5
				Alnus crispa	1	P. mariana	1.8	0.9
				Prunus pensylvanica	2	P. mariana	0.6	0.4
				Sorbus americana	present	P. mariana	2.0	0.9
				Kalmia angustifolia	60	P. mariana	0.5	0.5
				Vaccinium angustifolium	2	P. mariana	2.1	1.0
				Rubus idaeus	5	P. mariana	1.0	0.6
				Rubus pubescens	1	Betula papyrifera	0.8	0.4
				Ribes glandulosum	1	B. papyrifera	0.7	0.6
				Aralia hispida	2	B. papyrifera	0.5	0.7
				Solidego spp	present	B. papyrifera	0.5	0.7
				Epilobium angustifolium	1	B. papyrifera	0.5	0.7
				Cornus canadensis	15	B. papyrifera	0.5	0.7
				Clintonia borealis	1	B. papyrifera	0.9	0.5
				Trientalis borealis	2	B. papyrifera	0.4	0.4
				Maianthemum canadensis	2	B. papyrifera (browsed)	1.3	0.5
				Pleurozium schreberi	1	B. papyrifera	0.9	0.6
				Dicranum spp	2	B. papyrifera	0.7	0.4
				Cladonia spp	1	B. papyrifera	1.3	1.1
				Cladina spp	2	Populus tremuloides	0.4	0.4
						P. tremuloides	0.7	0.8
						Amelanchier spp	0.4	0.4
						Amelanchier spp	0.6	0.5
						Alnus crispa	0.9	0.8
						Sambucus pubens	1.8	0.9
						Sorbus americana	1.0	0.6
						Prunus pensylvanica	1.2	0.7

Bhw86-3	48.5862	54.0017	22/08/96	Sorbus americana	present	Picea mariana (dead standing—se corner)	6.5	4.0
				Prunus pensylvanica	present	P. mariana (dead standing—ne corner)	9.0	5.0
				Kalmia angustifolia	95	P. mariana (dead standing—nw corner)	9.0	5.0
				Vaccinium angustifolium	1	P. mariana (dead standing—sw corner)	18.0	8.0
				Clintonia borealis	2	Sorbus americana	1.4	0.8
				Cornus canadensis	2	Prunus pensylvanica	1.7	0.9
				Pteridium aquilinum	1			
				Dicranum spp	2			
Chicm86-1	48.4336	54.0079	19/08/96	Picea mariana	present	Abies balsamea	0.5	0
				Abies balsamea	1	P. mariana	1.0	0.6
				Amelanchier spp	present	Abies balsamea (browsed)	1.2	0.4
				Kalmia angustifolia	70	Picea mariana (stump)	17.0	n/a
				Vaccinium angustifolium	15	P. mariana (stump)	28.0	n/a
				Rhododendron canadense	5	P. mariana (stump)	19.0	n/a
				Rubus idaeus	5	P. mariana (stump)	11.4	n/a
				Gaultheria hispidula	10	P. mariana (dead standing)	6.9	2.0
				Vaccinium vitis-idaea	1	P. mariana (stump)	25.0	n/a
				Ledum groenlandicum	5	P. mariana (stump)	19.0	n/a
				Linnaea borealis	1	P. mariana (stump)	6.0	n/a
				Aralia hispida	2	P. mariana (stump)	24.0	n/a
				Hieracium spp	present	P. mariana (stump)	5.0	n/a
				Epilobium angustifolium	2	P. mariana (stump)	3.5	n/a
				Cornus canadensis	5	P. mariana (stump)	6.0	n/a
				Anaphalis margaritacea	2	P. mariana (stump)	3.5	n/a
				Dicranum spp	5	P. mariana (dead standing)	12.0	6.0
				Cladina spp	1	P. mariana (stump)	3.1	n/a
				Grass spp	1	P. mariana (stump)	5.3	n/a
						P. mariana (stump)	6.7	n/a
						P. mariana (stump)	9.0	n/a
						P. mariana (stump)	2.7	n/a
						P. mariana (stump)	3.5	n/a
						P. mariana (stump)	3.3	n/a
						P. mariana (stump)	30.0	n/a
						P. mariana (stump)	7.0	n/a
Chbdd82-1	48.5867	53.9728	19/08/96	Betula papyrifera	present	Picea mariana (dead standing)	5.8	3.0
				Viburnum cassinoides	present	P. mariana (dead standing)	3.4	1.5
				Nemopanthus mucronata	present	P. mariana (stump)	15.0	n/a
				Alnus crispa	present	P. mariana (dead standing)	5.2	4.0
				Kalmia angustifolia	70	Alnus crispa (very browsed)	n/a	0.2
				Vaccinium angustifolium	10			
				Rhododendron canadense	15			
				Ledum groenlandicum	15			
				Chamaedaphne calyculata	present			
				Cornus canadensis	1			
				Dicranum spp	1			
				Cladonia spp	10			
				Cladina spp	30			
Chbdd82-2	48.4522	53.9912	19/08/96	Populus tremuloides	present	Picea mariana (dead standing)	9.6	7.0
				Nemopanthus mucronata	present	P. mariana (dead standing)	18.0	10.0
				Amelanchier spp	present	P. mariana (dead standing)	28.0	8.0
				Kalmia angustifolia	90	P. mariana (dead standing)	38.0	10.0
				Rhododendron canadense	10	P. mariana (dead standing)	9.4	5.0
				Vaccinium angustifolium	2			
				Ledum groenlandicum	5			
				Cornus canadensis	5			
				Dicranum spp	1			
				Cladonia spp	1			
				Cladina spp	1			
Byncv82-1	48.3870	54.0917	07/08/96	Picea mariana	5	Picea mariana	1.0	0.5
				Larix laricina	present	P. mariana	0.7	0.5
				Alnus crispa	20	P. mariana	2.0	1.0
				Nemopanthus mucronata	5	P. mariana	0.8	0.4
				Amelanchier spp	present	Larix laricina	n/a	0.2
				Betula papyrifera	10	Alnus crispa	n/a	1.0
				Viburnum cassinoides	present	A. crispa	n/a	2.0
				Salix spp	present	A. crispa	n/a	1.0
				Acer rubrum	present	A. crispa	n/a	2.0
				Sorbus americana	present	A. crispa	n/a	1.0
				Kalmia angustifolia	60	Nemopanthus mucronata	n/a	1.0
				Vaccinium angustifolium	40	N. mucronata	n/a	1.0
				Vaccinium vitis-idaea	5	N. mucronata	n/a	1.0
				Rubus pubescens	present	Amelanchier spp	n/a	1.0
				Ledum groenlandicum	5	Betula papyrifera	n/a	0.5
				Rhododendron canadense	present	B. papyrifera	n/a	1.0
				Gaultheria hispidula	5	B. papyrifera	n/a	1.0
				Linnaea borealis	1	B. papyrifera	n/a	1.5
				Trientalis borealis	present	Viburnum cassinoides	n/a	1.5
				Cornus canadensis	2	Salix spp	n/a	1.5
				Epilobium angustifolium	2	Acer rubrum	n/a	1.5
				Solidago rugosa	2	Sorbus americana	n/a	1.0
				Pteridium aquilinum	3			
				Pleurozium schreberi	present			
				Dicranum spp	2			
				Sphagnum spp	present			
				Cladina spp	2			
Nwrvr81-1	48.3902	54.1914	19/08/96	Picea mariana	15	Picea mariana	1.1	0.8
				Larix laricina	5	P. mariana	0.5	0.5

				Betula papyrifera	20	P. mariana	1.0	0.5
				Sorbus americana	present	P. mariana	1.0	0.5
				Prunus pensylvanica	5	P. mariana	1.3	0.6
				Viburnum cassinoides	present	P. mariana	2.5	0.9
				Acer rubrum	present	P. mariana	0.9	0.8
				Kalmia angustifolia	60	P. mariana	0.6	0.5
				Rhododendron canadense	5	P. mariana	0.5	0.3
				Vaccinium angustifolium	25	P. mariana	0.7	0.5
				Cornus canadensis	10	P. mariana	0.5	0.5
				Epilobium angustifolium	2	P. mariana	0.9	0.5
				Trientalis borealis	1	P. mariana	1.1	0.5
				Solidago rugosa	present	P. mariana	0.7	0.6
				Pleurozium schreberi	40	P. mariana	1.0	0.6
				Dicranum spp.	present	P. mariana	1.7	0.6
						P. mariana	0.6	0.5
						P. mariana	1.0	0.9
						Larix laricina	1.8	0.9
						L. laricina	0.8	0.5
						Picea mariana	1.3	0.7
						P. mariana	1.0	0.5
						P. mariana	1.0	0.6
						Larix laricina	1.0	0.6
						P. mariana	1.8	1.0
						P. mariana	0.8	0.6
						Sorbus americana	n/a	0.8
						Larix laricina	2.2	1.1
						Picea mariana	2.1	1.1
						P. mariana	1.3	0.9
						P. mariana	1.5	0.7
						P. mariana	1.1	0.6
						P. mariana	1.1	0.7
						Larix laricina	1.5	0.5
						Alnus crispa (clump)	n/a	3.0
						Viburnum cassinoides	n/a	1.0
						Picea mariana	1.0	0.9
						P. mariana	1.1	0.9
						P. mariana	3.3	1.0
						Larix laricina	2.0	1.3
						P. mariana	1.5	1.1
						P. mariana	1.5	1.0
						P. mariana	1.7	0.8
						P. mariana	1.5	0.9
						Prunus pensylvanica	n/a	0.7
						Betula papyrifera (20% cover)		
Gambo79-1	48.7046	54.1365	21/08/96	Picea mariana	10	Populus tremuloides	1.3	0.6
				Populus tremuloides	10	Picea mariana	1.2	0.5
				Betula papyrifera	present	P. mariana	2.0	0.8
				Salix spp.	2	P. mariana	0.7	0.4
				Kalmia angustifolia	40	Populus tremuloides	1.1	0.7
				Vaccinium angustifolium	30	P. tremuloides	1.1	0.4
				Rhododendron canadense	10	P. tremuloides	2.1	0.4
				Vaccinium boreale	1	P. tremuloides	2.0	0.9
				Dicranum spp.	present	Picea mariana	1.1	0.5
				Cladonia spp.	40	P. mariana	2.1	0.7
				Cladina spp.	20	P. mariana	1.6	0.5
				Bare ground	30	Populus tremuloides	1.0	0.8
						P. tremuloides	1.1	0.8
						P. tremuloides	0.8	0.6
						Betula papyrifera	0.8	0.5
						Picea mariana	2.2	0.7
						Populus tremuloides	1.0	0.8
						P. tremuloides	2.7	0.8
						Picea mariana	1.2	0.5
						P. mariana	1.1	0.3
						P. mariana	2.0	0.8
						P. mariana	1.3	0.6
						Populus tremuloides	2.3	1.3
						P. tremuloides	2.4	1.2
						Picea mariana	2.4	1.0
						P. mariana	2.0	0.8
						P. mariana	3.3	1.4
						P. mariana	3.1	1.3
						Populus tremuloides	1.8	0.9
						P. tremuloides	2.4	1.4
						P. tremuloides	2.7	1.4
						Picea mariana	1.4	0.4
						P. mariana	1.7	0.6
						P. mariana	1.5	0.7
						P. marian	2.2	0.6
						Populus tremuloides	2.5	1.0
						P. tremuloides	1.6	0.7
						Picea mariana	2.3	0.8
						P. mariana	3.3	1.5
						P. mariana	2.7	1.4
						P. mariana	1.7	0.8
						P. mariana	1.6	0.6
						P. mariana	1.3	0.6
						Salix spp. (clump)	n/a	0.5
						Populus tremuloides	2.8	1.3
						P. tremuloides	2.4	1.1
						P. tremuloides	2.4	1.5

						P tremuloides		2.6	0.8
						Picea mariana		2.0	0.6
						P mariana		1.8	0.6
						P mariana		1.1	0.5
						P mariana		1.3	0.4
						P mariana		1.5	0.5
						Populus tremuloides		0.7	0.6
						P tremuloides		2.2	1.6
						P tremuloides		1.2	0.7
						P tremuloides		1.7	0.5
						Picea mariana		1.5	0.6
						P mariana		1.3	0.5
						P mariana		1.7	3.7
						P mariana		1.7	0.6
						Populus tremuloides		2.5	0.6
						Salix spp (clump)		n/a	0.6
						Picea mariana		1.6	0.5
						P mariana		1.7	0.7
						P mariana		1.9	0.6
						P mariana		1.9	0.7
						Populus tremuloides		2.0	0.9
						P tremuloides		1.8	0.9
						P tremuloides		1.8	0.7
						P tremuloides		2.1	1.0
						P tremuloides		1.3	0.6
						P tremuloides		2.7	1.2
						Picea mariana		1.5	0.6
						P mariana		1.2	0.6
						Populus tremuloides		1.9	1.0
						P tremuloides		1.1	0.6
						P tremuloides		1.3	0.7
						P tremuloides		1.7	0.7
						Picea mariana		1.4	0.5
						P mariana		1.3	0.7
						P mariana		1.4	0.4
Gambo79-2	48.7079	54.1889	21/08/96	Picea mariana	40	Picea mariana (ne corner)		4.1	2.0
				Larix laricina	present	P mariana		1.3	0.4
				Betula papyrifera	5	P mariana		1.1	0.4
				Prunus pensylvanica	5	P mariana		1.6	0.7
				Nemopanthus mucronata	1	P mariana		3.1	1.3
				Salix spp	2	P mariana		2.0	0.9
				Kalmia angustifolia	30	P mariana		2.0	0.9
				Vaccinium angustifolium	5	P mariana		2.0	0.9
				Gaultheria hispidula	5	P mariana		2.0	0.9
				Ribes palustre	2	P mariana		3.1	1.1
				Kalmia polifolia	present	P mariana		4.2	1.4
				Vaccinium vitis-idaea	1	P mariana		5.1	2.5
				Ledum groenlandicum	1	Prunus pensylvanica		n/a	0.7
				Epilobium angustifolium	1	P pensylvanica		n/a	0.3
				Cornus canadensis	1	Picea mariana (has cones)		3.0	2.0
				Trientalis borealis	present	P mariana		2.3	1.2
				Cladonia spp	1	P mariana		2.3	1.2
				Sphagnum spp	2	P mariana (cones)		3.1	1.4
				Cladina spp	1	P mariana		4.1	1.8
						Prunus pensylvanica		n/a	1.1
						Picea mariana		2.5	0.8
						P mariana		3.2	1.5
						P mariana		2.6	1.2
						P mariana		2.6	1.2
						P mariana		2.6	1.2
						P mariana		2.8	1.6
						P mariana		3.2	1.9
						P mariana		2.0	1.4
						Betula papyrifera		2.2	0.8
						Prunus pensylvanica		1.4	0.7
						Picea mariana		2.5	1.5
						P mariana		2.5	1.5
						P mariana		2.5	1.5
						P mariana		2.5	1.5
						P mariana (cones)		4.6	3.3
						P mariana		2.8	1.4
						P mariana		2.8	1.5
						Prunus pensylvanica		n/a	0.7
						Salix spp (clump)		n/a	0.9
						Picea mariana		4.2	2.7
						P mariana		3.0	1.4
						P mariana		3.0	1.4
						P mariana		2.2	1.1
						Larix laricina		0.4	0.2
						Prunus pensylvanica		2.7	1.0
						Picea mariana		3.0	1.7
						P mariana		2.6	1.3
						Prunus pensylvanica		1.4	0.8
						Betula papyrifera		n/a	1.0
						Picea mariana (ne corner)		4.0	1.6
						P mariana		3.0	1.6
						Prunus pensylvanica		3.3	1.2
						Betula papyrifera		2.0	1.3
						Picea mariana		3.2	1.4
						P mariana		3.2	1.4
						P mariana		3.2	1.4

						P. mariana (cones)	3.2	2.4
						P. mariana	3.0	1.5
						P. mariana (cones)	4.0	3.0
						P. mariana	2.5	1.4
						P. mariana	2.8	1.1
						P. mariana (se corner)	2.4	1.4
						Prunus pensylvanica (se corner)	2.4	2.0
						Picea mariana	2.8	1.6
						P. mariana	2.8	1.6
						P. mariana	2.8	1.6
						P. mariana	2.8	1.6
						P. mariana	2.7	2.4
						Salix spp	1.0	1.2
						P. mariana	3.5	2.0
						P. mariana	5.0	2.5
						Betula papyrifera	n/a	1.4
						Prunus pensylvanica	n/a	1.3
						Picea mariana	3.5	2.0
						P. mariana	2.6	1.4
						Betula papyrifera	5.3	1.8
						P. mariana	4.3	1.6
						P. mariana	3.4	1.4
						P. mariana	3.0	1.7
						P. mariana (sw corner)	4.4	2.7
						P. mariana	4.3	1.4
Tnrd77-1	48.5032	54.1878	25/07/96	Picea mariana	2	Picea mariana (40 new cones, 60 old)	7.0	3.0
				Alnus crispa	2	P. mariana	1.4	0.5
				Amelanchier spp	present	Alnus crispa (clump browsed)	0.5	1.0
				Kalmia angustifolia	65	A. crispa (clump browsed)	0.5	1.0
				Vaccinium angustifolium	10	Amelanchier spp	0.5	0.6
				Rhododendron candadense	20	Prunus pensylvanica (browsed clump)	0.5	0.7
				Ledum groenlandicum	3			
				Vaccinium vitis-idaea	1			
				Pteridium aquilinum	5			
				Pleurozium schreberi	3			
				Dicranum spp	40			
				Cladonia spp	3			
				Cladina spp	1			
Tnrd77-2	48.5048	54.1087	25/07/96	Betula papyrifera	1	Amelanchier spp. (clump)	0.5	0.6
				Salix spp	1	Amelanchier spp. (clump)	0.4	0.3
				Prunus pensylvanica	1	Prunus pensylvanica (clump)	0.5	0.8
				Amelanchier spp	1	Betula papyrifera	0.3	0.3
				Kalmia angustifolia	80	Salix spp (clump browsed)	0.4	0.6
				Vaccinium angustifolium	15	Salix spp (clump browsed)	0.3	0.5
				Ledum groenlandicum	5	Salix spp (clump browsed)	0.2	0.3
				Rhododendron canadense	15			
				Kalmia polifolia	2			
				Myrica gale	1			
				Cornus canadensis	present			
				Coptis groenlandica	present			
				Drosera rotundifolia	present			
				Dicranum spp	15			
				Sphagnum spp	1			
				Cladonia spp	5			
				Cladina spp	2			
				Grass spp	1			
Tndp76-1	48.5032	54.1878	25/07/96	Picea mariana	25	Picea mariana	2.5	0.6
				Larix laricina	present	P. mariana	2.4	0.6
				Betula papyrifera	present	P. mariana	1.5	0.6
				Alnus crispa	5	P. mariana	2.0	0.7
				Prunus pensylvanica	present	P. mariana	2.0	0.7
				Salix spp	present	P. mariana	1.0	0.2
				Kalmia angustifolia	70	P. mariana	1.0	0.3
				Vaccinium angustifolium	40	P. mariana	1.0	0.3
				Ledum groenlandicum	20	Betula papyrifera	2.5	0.8
				Rhododendron canadense	40	Picea mariana	1.0	0.2
				Vaccinium vitis-idaea	5	P. mariana	1.0	0.3
				Pleurozium schreberi	5	P. mariana	2.4	0.6
				Dicranum spp	10	P. mariana	2.5	0.8
				Cladina spp	40	P. mariana	1.5	0.5
				Cladonia spp	20	Salix spp (clump)	n/a	0.8
				Bare ground	40	Picea mariana	1.5	0.6
						P. mariana	1.2	0.6
						P. mariana	1.5	0.6
						P. mariana	1.5	0.6
						P. mariana	1.0	0.3
						P. mariana	1.5	0.5
						P. mariana	1.0	0.4
						P. mariana	1.5	0.6
						P. mariana	2.0	0.7
						P. mariana	1.0	0.4
						P. mariana	1.5	0.4
						P. mariana	2.2	0.7
						Larix laricina	1.7	0.9
						Picea mariana	1.3	0.4
						P. mariana	1.5	0.6
						P. mariana	1.5	0.6
						P. mariana	2.5	0.7
						P. mariana	0.5	0.2

						P. mariana	0.7	0.3
						P. mariana	1.5	0.4
						P. mariana	2.2	0.5
						P. mariana	2.0	0.6
						P. mariana	1.6	0.6
						P. mariana	3.5	1.2
						P. mariana	1.3	0.4
						P. mariana	1.7	0.8
						P. mariana	1.4	0.6
						P. mariana	1.3	0.6
						P. mariana	1.7	0.8
						P. mariana	1.4	0.6
						P. mariana	1.3	0.6
						P. mariana	1.0	0.4
						P. mariana	1.2	0.4
						P. mariana	2.5	1.1
						P. mariana	2.1	0.9
						P. mariana	1.5	0.6
						P. mariana	1.5	0.6
						P. mariana	2.3	0.7
						P. mariana	1.7	0.6
						P. mariana	2.7	1.0
						P. mariana	1.5	0.5
						P. mariana	1.3	0.5
						P. mariana	1.7	0.8
						P. mariana	1.5	0.7
						P. mariana	2.2	1.0
						P. mariana	2.0	0.8
						P. mariana	4.0	1.4
						P. mariana	1.5	0.5
						P. mariana	1.7	0.7
						P. mariana	1.2	0.6
						P. mariana	1.6	0.6
						P. mariana	2.5	1.1
						Alnus crispa (clump)	n/a	1.5
						Picea mariana	1.2	0.4
						P. mariana	1.4	0.5
						P. mariana	1.5	0.6
						P. mariana	2.0	0.6
						P. mariana	2.2	0.8
						P. mariana	2.2	0.8
						P. mariana	1.4	0.5
Tndp76-2	48.5018	54.1860	25/07/96	Picea mariana	5	Picea mariana	1.5	0.5
				Salix spp	1	P. mariana	1.5	0.6
				Kalmia angustifolia	60	P. mariana	1.5	0.6
				Vaccinium angustifolium	40	P. mariana	2.4	0.9
				Ledum groenlandicum	5	P. mariana	1.0	0.6
				Rhododendron canadense	35	P. mariana	1.2	0.6
				Dicranum spp	20	P. mariana	2.0	0.6
				Cladonia spp	5	P. mariana	0.5	0.2
				Cladina spp	1	P. mariana	1.2	0.6
				Bare ground	30	P. mariana	1.0	0.3
						P. mariana	1.0	0.4
						P. mariana	0.7	0.2
						P. mariana	0.7	0.2
						P. mariana	1.5	0.6
						P. mariana	1.0	0.5
						Salix spp. (clump)	n/a	0.5
						Salix spp. (clump)	n/a	0.6
Nacmp67-1	48.5368	53.9730	26/07/96	Picea mariana	15	Picea mariana	2.1	0.9
				Pinus resinosa	5	P. mariana	5.6	1.6
				Populus tremuloides	present	P. mariana	1.5	0.5
				Salix spp	present	P. mariana (cut down after my malle)	5.4	1.5
				Kalmia angustifolia	70	P. mariana	1.0	0.5
				Vaccinium angustifolium	30	P. mariana	3.0	1.4
				Dicranum spp	5	P. mariana	1.4	0.6
				Cladonia spp.	70	P. mariana	6.3	1.5
				Cladina spp	5	P. mariana	0.9	0.4
				Bare ground	20	P. mariana	n/a	0.2
						P. mariana	n/a	0.2
						P. mariana	n/a	0.2
						Populus tremuloides (browsed)	n/a	1.5
						Salix spp	n/a	0.5
Dnphy61-1	48.4504	54.1408	20/08/96	Picea mariana	20	Picea mariana	3.7	1.2
				Larix laricina	1	P. mariana	3.0	1.0
				Betula papyrifera	present	P. mariana	1.5	0.6
				Amelanchier spp	present	P. mariana	3.4	1.2
				Alnus crispa	5	Larix laricina	1.5	0.3
				Kalmia angustifolia	80	L. laricina	0.8	0.3
				Rhododendron canadense	10	Picea mariana	1.6	0.4
				Vaccinium angustifolium	5	P. mariana	0.8	0.4
				Ledum groenlandicum	5	P. mariana	2.2	0.6
				Cornus canadensis	2	P. mariana	2.1	0.6
				Pteridium aquilinum	2	P. mariana	2.6	0.6
				Sphagnum spp	2	P. mariana	1.3	0.7
				Cladonia spp	90	P. mariana	3.8	1.1
				Grass spp	1	Larix laricina	1.7	0.7
						Picea mariana	2.1	0.8
						P. mariana	4.9	1.4

						P. mariana	2.2	0.7
						P. mariana	2.1	0.8
						P. mariana	1.6	0.7
						P. mariana	4.2	1.4
						P. mariana	4.3	1.2
						P. mariana	4.3	1.3
						P. mariana	3.2	1.5
						P. mariana	4.3	1.8
						P. mariana (20 cones)	6.4	3.0
						P. mariana	4.7	2.0
						P. mariana	3.2	0.9
						P. mariana	4.0	1.8
						P. mariana	4.1	1.3
						P. mariana	3.0	1.0
						P. mariana	2.9	0.9
						P. mariana	3.2	1.0
						P. mariana	2.6	0.9
						P. mariana	2.8	0.6
						P. mariana	2.2	0.9
						Betula papyrifera	n/a	0.2
						Amelanchier spp	n/a	0.2
						Alnus crispa	n/a	0.6
						A. crispa	n/a	0.3
Dnphy61-2	48.4502	54.1391	20/08/96	Picea mariana	10	Picea mariana (40 cones)	6.9	2.0
				Larix laricina	present	P. mariana	1.5	0.5
				Amelanchier spp	5	P. mariana	0.8	0.4
				Alnus crispa	present	P. mariana	4.8	1.7
				Betula papyrifera	present	P. mariana	1.5	0.8
				Kalmia angustifolia	80	P. mariana	3.1	0.8
				Rhododendron canadense	5	P. mariana	1.1	0.6
				Vaccinium angustifolium	5	P. mariana	1.3	0.5
				Ledum groenlandicum	5	P. mariana (few cones)	7.4	2.5
				Cornus canadensis	1	P. mariana (few cones)	4.4	1.8
				Pteridium aquilinum	1	P. mariana	5.5	2.0
				Sphagnum spp	2	P. mariana	4.1	1.5
				Cladonia spp	70	P. mariana	1.4	0.4
						P. mariana	1.3	0.4
						P. mariana	3.1	1.2
						P. mariana	2.0	0.6
						P. mariana	2.7	0.6
						Larix laricina	2.0	0.5
						Amelanchier spp	n/a	0.5
						Alnus crispa	n/a	1.0
						Betula papyrifera	n/a	0.3