SOME EFFECTS OF CAMPGROUND USE ON THE NATURAL ENVIRONMENT IN MANITOBA AND THEIR IMPLICATIONS FOR PARK PLANNING

by

Wendy A. Celentino

A Thesis

submitted to the Faculty of Graduate Studies

in partial fulfillment

of the requirements

for the degree

of

Master of Arts

University of Manitoba

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ABSTRACT

The adverse effects of recreational use on the natural environment are examined with respect to the influence of campers in the peripheral areas of campsites in the Whiteshell Provincial Park.

An analysis of vegetation data collected using the relevé method indicates that there are several types of disturbance occurring around campsites. These include; the trampling of vegetation, the creation of paths from centres of activities, soil erosion resulting from the removal of vegetation, and 'vagrant impacts' such as tree scarring and littering. The data also indicates that six species are particularly useful as 'indicators' of disturbance within the peripheral area of the four campgrounds used in this study.

The causes of the spread of these impacts include; human disturbance, environmental, and planning and design factors, and the importance of the latter two are illustrated by applying the findings of the field study to the example of the new Black Lake Campground in Nopiming Provincial Park.

It is concluded that ways to alleviate extensive deterioration in campgrounds should include a consideration of the following : periodic monitoring of the indicator species, planning campgrounds with more attention to the physical characteristics of the site, and designing the campground in such a way as to best protect the natural environment.

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CHAPTER ONE

INTRODUCTION TO THE PROBLEM

1.1 Introduction

The interrelationships between man and his environment are often stated as a primary concern within the discipline of Geography (Thomas, 1970; Krueger, 1976). A good example lies in a study of man-environment interactions taking place in recreational areas.

National and provincial parks in Canada occupy land where interference by man has been controlled. As a result, large tracts of vegetation are protected by park boundaries and appear to be in a 'natural' state. Most parks were originally selected for their natural beauty, but their ecological importance has also been recognized in that they are "respiring, energy trapping, oxygen producing, nutrient cycling, gigantic living organisms, enmeshed...with life in thousands of forms..." (Theberge, 1976;194). Preservation of these natural systems is frequently stated as one of the dominant aims of policies protecting these lands, but the use of parks for recreational purposes is also recognized in most mandates. For example, the policy governing provincial parklands in Manitoba states that:

> Provincial parklands shall be developed and maintained
> a) for the conservation and management of flora and fauna therein;
> b) for the preservation of specified areas and objects therein that are of geological, cultural, ecological and other scientific interest; and
> c) to facilitate the use and enjoyment of outdoor recreation therein.
>
> (Manitoba, 1972B;373)

When the demand for recreational opportunities in a park is great, the preservation and conservation aims of park policy appear less important. When recreational use exceeds the ability of the environment to cope with this interference, physical deterioration results. This tolerance level, in the recreational context, is known as the carrying capacity and refers to the type of use that can be supported over a specified time by an area developed at a certain level, without causing excessive damage to either the physical environment or the experience of the visitor (Lime and Stankey, 1971).

The increasing popularity of many campgrounds in North America has caused the carrying capacity to be exceeded in several parks, and has resulted in many adverse effects or 'impacts' on the natural environment. Some of these include the loss of ground level vegetation, the creation of numerous paths from centres of activities, and vandalism (Wagar, 1964; Bohart, 1968). The degree of damage to the natural environment has many dimensions and depends on such factors as: the physical-biological components of the natural system, the type of visitor using the campground, and the duration and intensity of visitor usage.

Another element that can influence the extent of deterioration is the design of the campground. Camping areas are usually constructed with sections of relatively undisturbed vegetation between and around campsites. When these areas contain dense vegetation, a natural barrier is formed to deter movement. However, in many campgrounds, either this barrier is not present or it has been destroyed as a result of various camping activities. If this impact pattern continues into the surrounding natural environment, as it does in campgrounds experiencing growth in their utility beyond their carrying capacity, then one can predict that the resultant deterioration could affect an ever increasing part of the park. The spread of such impacts is not desirable because it contradicts two of the three aims of the provincial park policy, namely conservation and preservation. If these areas are to remain in their natural state, the camping activities must be confined within the campground.

This thesis uses a popular camping area in eastern Manitoba, the Whiteshell Provincial Park, to explore one aspect of the man-environment interaction described above. In order to examine the nature of the effect of recreational activity on the natural environment surrounding campsites, several questions were posed. For example, what effects of campground use are found in the periphery of campsites? Are there any components of the natural environment that can be used as 'indicators' of the degree of disturbance? What factors explain the spread of disturbance into these areas, and how could this information be applied usefully in the future planning and design of campgrounds in order to limit deterioration of the surrounding natural environment?

To answer the above questions, the following objectives were formulated:

1. To examine the effects of campers' use on the vegetation in the area peripheral to specific campsites in four campgrounds

in the Whiteshell Provincial Park.

2. To select several plant species as indicators of the degree of disturbance occurring in these areas.
3. To examine the degree to which environmental, human disturbance, planning and design factors were responsible for the amount of disturbance observed.
4. To apply this information to the development of Black Lake Campground in Nopiming Provincial Park, located north of the Whiteshell Provincial Park.

1.2 Literature Review

Many of the previous studies on park disturbance have examined the effects of visitor use on either the soil or vegetation components of the environment. Because of their intricate causal relationship, impacts to one of these parameters are reflected in the other element. For example, soil compaction may be caused by people walking along a trail and this can affect the future growth and reproduction of vegetation species (LaPage, 1967; Ward and Berg, 1973).

Hiking trails have been the focus of many park disturbance studies. The process of trail degradation involves the disturbance of vegetation cover by trampling and the disappearance of sensitive species. Once the vegetation disappears, the exposed soil becomes vulnerable to removal by water, or when dry, by wind erosion (Bryan, 1977). The process of trail erosion itself has been found to be two-dimensional, involving a vertical dropping of the trail surface by soil compaction and erosion, as well as a horizontal movement at approximately the same rate (Ketchledge and Leonard, 1970). Trampling has also been found to have both direct and indirect effects on plant growth. Indirectly it influences growth by reducing soil aeration and soil moisture, and directly it affects root penetration, reduces the infiltration of rainfall and lowers the moisture status (Landals and Scotter, 1973).

Changes in soil conditions are important to consider in the explanation of the effects of disturbance on the natural environment, but some authors feel that vegetational changes are more sensitive indicators of the intensity of recreational use, and can be more easily measured (Burden and Randerson, 1972). As a result, several studies on the effects of vegetation disturbance have taken place, many of them in campgrounds.

A study of intensive recreational use in California revealed that over half of 137 camping and picnic areas lacked tree seedlings or shrubs , and that 95% of the individual camping sites lacked a ground cover of grasses and forbs (Magill and Nord, 1963). Other studies of the "on-site" effects of camping concurred with Magill and Nord's reporting of a lack of ground cover, for example Lesko and Robson (1975) in Banff National Park, and Frisell and Duncan (1965) in the Quetico-Superior canoe country.

One solution to the problem of a lack of ground cover was found to be a combined treatment of fertilizing, grass seeding, and watering (Herrington and Beardsley, 1970; Beardsley and Wagar, 1971). While this treatment may help in some areas, it is not always feasible to undertake a management programme such as this, especially in an area which is supposed to be natural. In several campgrounds in Manitoba, the problem of decreasing ground cover is avoided by the provision of a gravel pad for camping. Many of these sites contain a picnic table and fire pit and are designed to confine use to the more durable gravel surface (Fig.1).

In a study of the effect of recreational use on soil and vegetation in Rushing River Provincial Park in Ontario, it was suggested that gravel use for campsites be halted, because the gravel kills vegetation immediately nearby, particularly birch trees (James et al., 1976). However, where soil depth is shallow or where drainage is poor, the use of a gravel pad protects the ground from further degradation.

As expressed earlier, this study is concerned with the effects and extent of disturbance in the area peripheral to the campsite. Movements beyond the campsite are usually planned to direct users along roadways or well-maintained paths. Natural vegetation can act as barriers to movement in undesired areas and if campgrounds are planned effectively, movements around campsites should be minimized.

> Observations of the many trails in Rocky Mountain National Park, Colorado led to the conclusion that whenever the trail 1) goes where people want to go, 2) is well-routed and well-constructed, and 3) is well-maintained, the impact of visitor activities on adjacent ecosystems is very slight. In a number of cases, rare plants have even been found growing at the side of the trail surface, indicating how little deviation from the trail occurs.
> (Scott-Williams, 1967;116)

Therefore, planning can play a major role in the protection of the natural environment and studies on the peripheral areas of campsites are important as an indication of the effectiveness of a

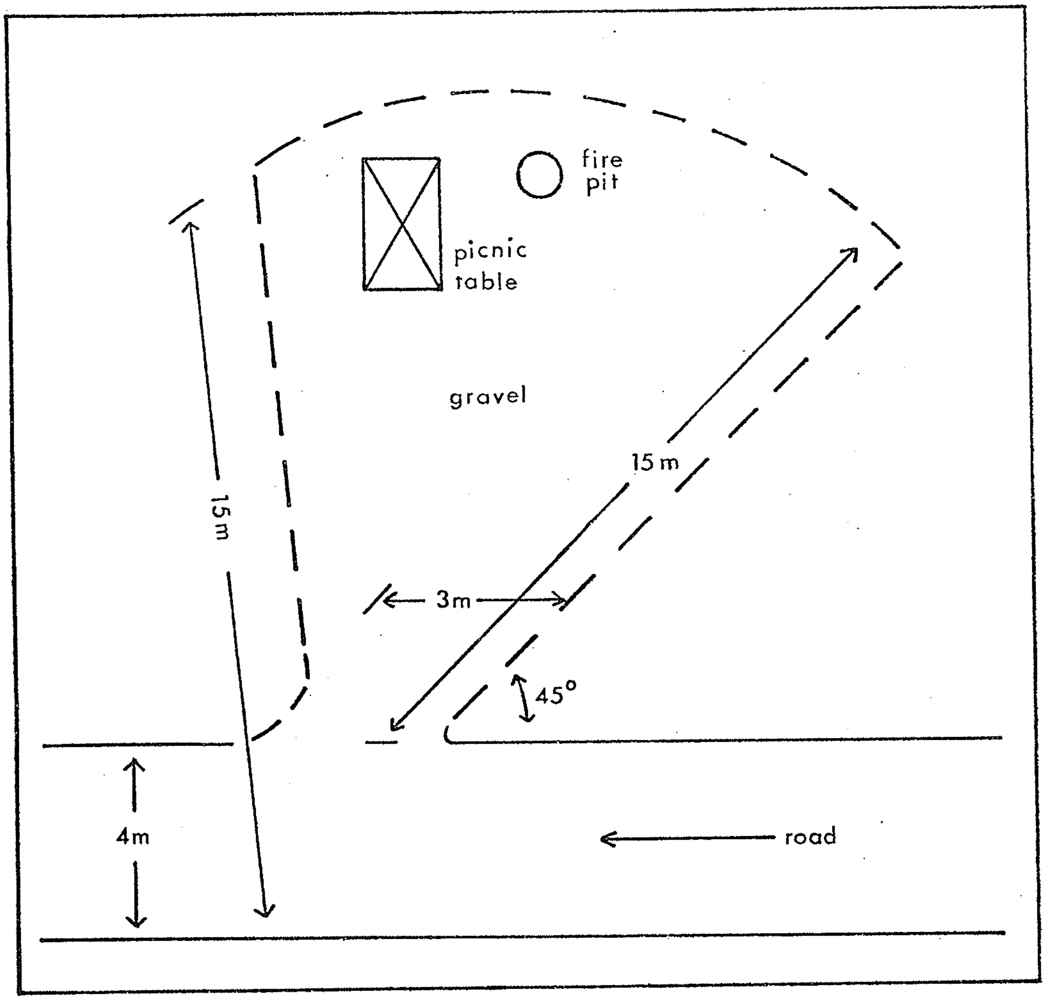

Fig. 1 Dimensions and components of a typical campsite.
(after : Manitoba, 1977A)

campground design. If use is spreading into the natural area, then the reasons for the impact should be explored and the results of that information should be incorporated in the planning and design of future campgrounds.

Only a few studies have dealt with the influence of campers beyond the campsite itself. In alpine and sub-alpine meadow ecosystems in Yoho National Park, Landals and Scotter (1973) found that impact in the peripheral area of the campground was concentrated within thirty metres of the meadow edge. Damage to the forest margin was caused by campers collecting wood for fires and tent poles. This may seem trivial as a short-term impact, but as nearby sources of wood are depleted and campers are forced further and further from the meadow edges, open spaces are created in the forest margins which attract the establishment of campsites in this area, and lead to further degradation.

Another study located in Rushing River Provincial Park (Hoffman et al., 1975) evaluated the effects of recreational use in areas of high impact, i.e. the campsite, to areas of low impact, i.e. the periphery. They concluded that there was a gradient of decreasing impact from the campsite to the periphery and that there were more plant species present as the distance from the campsite increased.

One other campground impact study, that of Lesko and Robson (1975) took place along hiking trails and in primitive campgrounds in Banff National Park. They found that visitor impact outside of the campgrounds and off trails was very small and that most hikers did not seem to stray from the trails at all. Evidence of littering and of tents pitched illegally near the lakeshore were the only signs of disturbance recorded in this particular ecosystem. However, degradation of campground areas has been shown by others to be a more severe problem in some parks than that expressed by Lesko and Robson's study (Wagar, 1964; Lavery, 1974). Generally the spread of disturbance beyond the campsite appears to be more prevalent in areas that experience intensive use, such as Rushing River Provincial Park, and Banff, Yoho and Rocky Mountain National Parks. When the carrying capacity of a campground is exceeded or when campgrounds are not designed effectively, the potential for deterioration of the surrounding natural environment is present.

In Manitoba, environmental deterioration can be expected in the Whiteshell Provincial Park, an area which contains 33% of the total number of campsites in the province (Nuxoll, 1978, personal communication). This research examines the condition of the natural environment around campsites in four of its campgrounds and analyzes factors responsible for the degree of disturbance found there. The results of this analysis are then applied to the future planning and management of campgrounds in similar environments.

CHAPTER TWO

THE STUDY AREA

2.1 The Selection of Suitable Campgrounds

The Whiteshell Provincial Park is an area of 1700 square kilometres in southeastern Manitoba and was selected for this study for a variety of reasons. Its location on the Pre-Cambrian Shield, where there are numerous lakes and rivers in a forested setting, make it attractive to many people for a variety of recreational uses. Some indication of its increasing popularity can be seen in the growth of summer vehicle attendance from 232,263 in 1968 to 308,743 in 1977, an overall increase of 32.9% in nine years (Lenton, 1977, personal communication). Much of the park's popularity is due to its proximity to a major urban centre (less than a two-hour drive from Winnipeg), and to its accessibility from the Trans-Canada Highway (Fig.2).

A total of 2,087 campsites are found in the park spread between fourteen transient and three seasonal campgrounds[1]. These areas occupy a variety of different ecosystems within the park's eighty kilometre latitudinal extent. For example, the dominant vegetation varies from the pure trembling aspen cover (*Populus tremuloides*) of Falcon Lake's Overflow Campground, to the white birch (*Betula papyrifera*) at West Hawk Lake Campground, to the mixed species found

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[1] Seasonal campgrounds issue camping permits for the whole summer season (last week in May to Labour Day in September), while transient campgrounds restrict camping to three weeks maximum (Manitoba, 1977B).

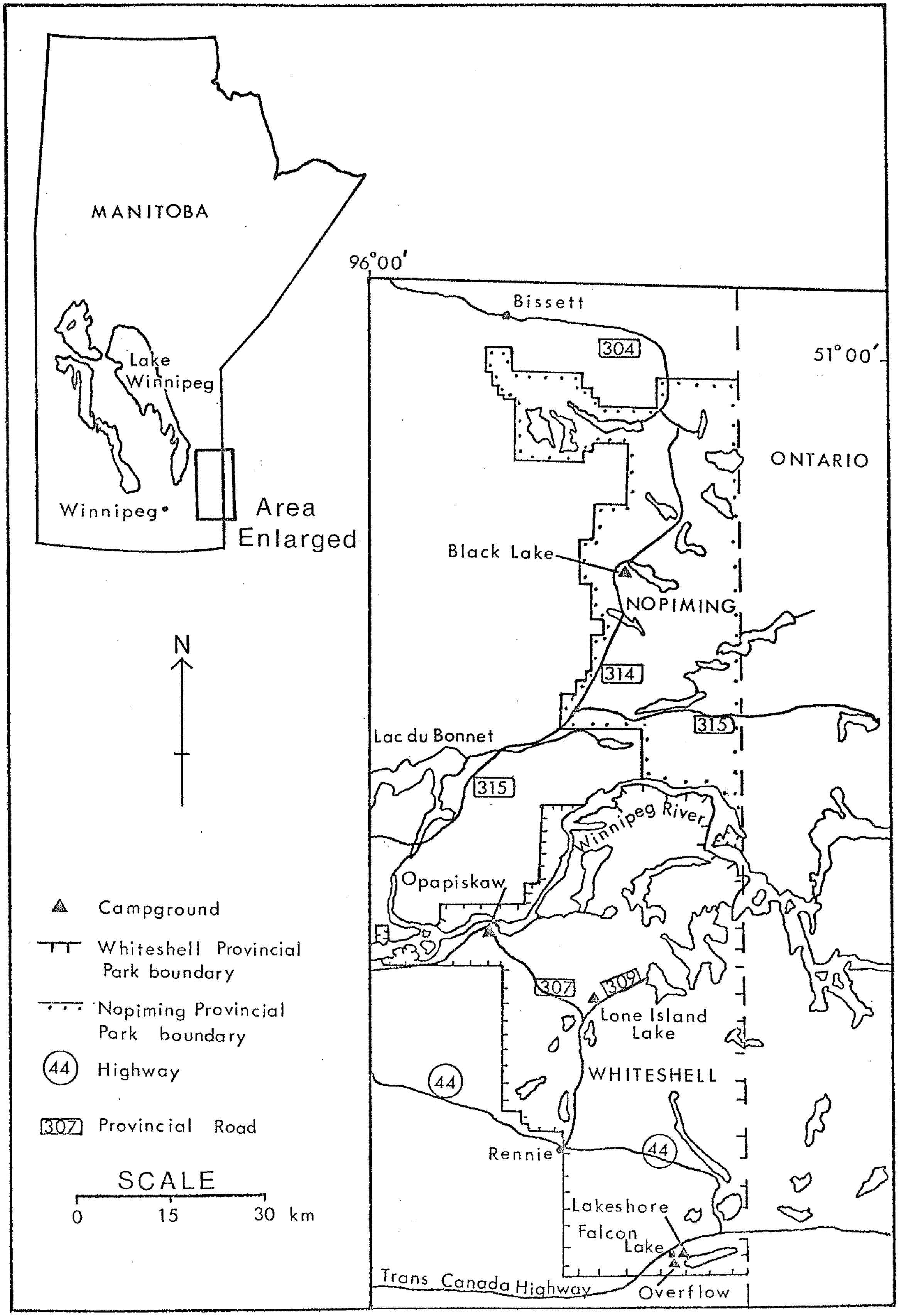

Fig. 2 The study area, showing the location of the Lakeshore, Overflow, Lone Island Lake, and Opapiskaw Campgrounds in the Whiteshell Provincial Park, and Black Lake Campground in Nopiming Provincial Park.

in the northern part of the park. This variation reflects differing soil, topography and drainage characteristics throughout the area.

Another reason for the selection of the Whiteshell is that the park has been operating since 1931 and contains many campgrounds of different ages. The amount of deterioration the natural environment experiences is a function of both the number of years that a campground has been open, and the intensity of use experienced within it and thus, the older campgrounds were expected to show more signs of the effects of human disturbance than the newer ones. Confined use over a long period of time will have adverse effects on the environment and areas such as Falcon Lake's Beach and Brereton Lake Campgrounds show exposed soil throughout the campsites and a lack of young trees as two results of intensive recreational use, a finding similar to that of Magill and Nord (1963) in California.

The 'peak' of the tourist season occurs in July and August when children are out of school and the climate is most favourable for camping. Statistics on the average occupancy of campgrounds in the Whiteshell Provincial Park between 1970 and 1976 indicate the intensity of use experienced there, and these are illustrated in Table 1. An average occupancy of 100% indicates that all available campsites are occupied, and the campground has reached its planned carrying capacity. It is important to note that due to the system of calculating average occupancy[1] , several campgrounds have average values greater than 100% during different years, (for example, Brereton Lake, White Lake

[1]The formulae for calculating the average occupancy are included at the bottom of Table 1.

TABLE 1 : PERCENTAGE AVERAGE OCCUPANCY[1] FOR JULY AND AUGUST 1970-1976, WHITESHELL PROVINCIAL PARK CAMPGROUNDS

Campground		1970	1971	1972	1973	1974*	1975*	1976*
Betula Lake		92	80	108	85	104	100	100
Brereton Lake		93	140	148	64	60	78	85
Caddy Lake		29	44	62	77	81	80	82
Falcon Lake	Beach	94	93	88	94	78	75	89[2]
	Lakeshore					82	76	77
	Overflow	figures n.a.						
Nutimik Lake		30	54	59	59	76	70	100
Opapiskaw		39	45	61	61	42	44	50
Otter Falls		35	42	53	65	30[3]	46[4]	65
Toniata Beach		57	88	82	76	70	66	67
West Hawk Lake		39	80	68	67	64	61	58
White Lake		71	108	113	63	104	75	69
Big Whiteshell Lake	Old	n.a.	122	89	99	130	100	100
	New					170	93	91
Lone Island Lake		overflow campground - figures n.a.						
Falcon Trailer Village				100	98	92	80	90
West Hawk Trailer Village				99	100	80	76	75
Dorothy Lake Campground		100	100	100	99	100	97	100

[1]Percentage occupancy = 100 x $\dfrac{\dfrac{\text{total number of permits sold}}{\text{number of days in month}}}{\text{number of campsites (excluding overflow)}}$

Average occupancy = $\dfrac{\text{\% occupancy July + \% occupancy August}}{2}$

[2]figures only available for July 1976

[3]1974, Otter Falls closed May 27 to July 25 due to wet conditions

[4]based on Administration Branch data due to field error

*1974-1976 data as reported by field staff

n.a. - not available

SOURCES :(Manitoba, 1970, 1971A, 1972A, 1973, 1974, 1975A, 1976).

and Big Whiteshell Lake Campgrounds in 1971; Brereton Lake, White Lake and Betula Lake in 1972; and White Lake, Betula Lake and Big Whiteshell Lake in 1974). This is a strong indicator of potential overuse in these campgrounds. Also, many of the seasonal campgrounds such as Falcon Lake and West Hawk Trailer Villages,and Dorothy Lake Campground have experienced nearly 100% occupancy since their origin. In a sense these statistics hide an important fact. Since the values represent the average for July and August, peak fluctuations which occur on weekends are hidden by the overall figure. For example, in 1976 the Lakeshore Campground had a 77% occupancy average, whereas in actual fact, the Overflow Campground was used on twelve days during this time (Manitoba, 1976). Thus, the average occupancy indicates that the campground is operating at only 77% of its capacity, when on weekends it is operating at 100% capacity. This is true of many of the campgrounds in the Whiteshell, and this extensive human use of the natural area provided the opportunity to study whether campers were confined to the campsites, or were actually spreading their effects into the natural environment beyond the sites.

Many of these campgrounds were not suitable for this research and a selection process took place to reduce the number of study units from fourteen campgrounds to four. Those showing signs of extensive deterioration such as the Beach, Betula Lake, Otter Falls, Toniata Beach and Big Whiteshell Campgrounds were eliminated because damage was so extensive that a temporal study of the effects of camping activities on the vegetation cover over one growing season would yield little, if any, significant results. Other campgrounds have been developed to the extremes of their boundaries and now appear to be sandwiched between a road and a lake. Brereton Lake and White Lake Campgrounds were eliminated for this reason. West Hawk and Caddy Lake Campgrounds were also eliminated because the area where people could wander was well-used, and site features such as large rock outcrops restricted any further spread of disturbance within these sites.

The campgrounds selected had to have a buffer zone of vegetation around the campsites so that the effects of campers near the sites could be studied. The design of each campground was also considered, as well as the physical characteristics of the site that could be comparable to the Black Lake Campground, further north. Falcon Lake's Lakeshore and Overflow Campgrounds, Lone Island Lake Campground in the central portion of the park, and Opapiskaw Campground in the northern part were selected as the four study units. These areas provide a variety of natural settings and have experienced differing intensities and duration of visitor usage in the past. They possess different campground designs and many aspects of impacts occurring in these areas were thought to be useful in the comparison with Black Lake Campground. The similarities and differences of the physical characteristics between these five recreational areas are listed in Table 2.

2.2 Description of Campgrounds and Relevé Locations

2.2.1 Falcon Lake - Lakeshore Campground

Falcon Lake is probably the most popular part of the Whiteshell Provincial Park. Located close to the Trans-Canada Highway (Fig.2), the area contains such modern facilities as a shopping centre, golf course, sports area and several campgrounds. The Beach and Lakeshore

TABLE 2 - SOME PHYSICAL CHARACTERISTICS OF THE FIVE CAMPGROUNDS USED IN THIS STUDY

Campground (Date Established)	Parent Material	Soil Name & Dominant Texture, Profile Type	Topography & Stoniness	Natural Drainage	Dominant Vegetation[1]
Falcon Lake - Lakeshore (1957)	granitic rock with stratified drift and peat deposits	Indian Bay Complex orthic and gleyed luvisols, orthic and gleyed podzols, organic soils	level to irregular, steeply sloping, slightly to extremely stony	good to poor	trembling aspen, white birch, balsam fir, white spruce
Falcon Lake - Overflow (1973)	15-76 centimetres of fine sand over clay, loam to clay, till deposits	*Vassar Series (fine sand) Brunisolic Grey Luvisol (Bisequa Grey Wooded)	level to irregular, very gently sloping, stone-free to slightly stone-free	good (moderately well-drained)	trembling aspen
Lone Island Lake (1970)	*non-calcareous sandy glacial till and granitic bedrock, considerable bedrock outcrop	*Sandiland Series- degraded eutric brunisol on fine sands, Hunt Series- degraded eutric brunisol on sand and gravel, Telford Series- degraded eutric brunisol on stony sandy till, rock outcrop	*complex, gently sloping variable; non to very stony	*dominantly well-drained	jack pine, trembling aspen, white spruce, birch

...continued

TABLE 2 - CONTINUED

Campground (Date Established)	Parent Material	Soil Name & Dominant Texture, Profile Type	Topography & Stoniness	Natural Drainage	Dominant Vegetation[1]
Opapiskaw (1964)	slight to moderately calcareous, saline lacustrine clay	Lettonia Series- (clay) (Solonetzic) luvisolic, rock outcrop	level to irregular, gently sloping, stone free	good	trembling aspen, balsam poplar, white birch, white spruce
Black Lake (1978)	*non-calcareous coarse glacial-fluvial deposits and thin dis-continuous non-calcareous, stony, sandy glacial till of granitic and volcanic origin underlain by Pre-Cambrian rock	*Hunt Series- fine sand, degraded dystric brunisol developed on non-calcareous sand and gravelly glacial-fluvial deposits Nora Lake Series- loamy sand, rock outcrop	*very gently sloping to irregular moderately sloping, variable: slight to very stony	*moderately well to well-drained	jack pine, with minor trembling aspen, white spruce, white birch, tamarack

[1]The authorities for the scientific names of plants are found in Appendix 1.

*Source:(Michalyna, 1977, personal communication).

**Source for all other soil information:(Smith and Ehrlich, 1964; Smith et al., 1967).

Campgrounds contain 610 transient and seasonal campsites which have been occupied almost to capacity during July and August in the period between 1970 to 1976 (Table 1). Whenever these two campgrounds are full, the 200 site Overflow Campground is used.

The Lakeshore Campground has an interesting vegetation cover. Bay One and Two are located in a dense stand of mature balsam fir (*Abies balsamea*), while the third and fourth bays have a mixed dominant vegetation cover of fir, white birch, trembling aspen, and white spruce (*Picea glauca*). Established in 1957, this area provides an example of an intensively used campground which has experienced impacts for a number of years.

To study the degree of disturbance caused by campers in the periphery of campsites, the vegetation was sampled by the use of the relevé method which is explained in Chapter Three. Sampling areas, known in this study as 'relevés' were used to examine the effects of campers on the natural environment. One control plot for each campground was also established to provide information on the natural life cycle of the species.

The first seven relevés were located in the Lakeshore Campground (Fig. 3). Relevé no.1[1] was found between two campsites in Bay One. As campers travelling between the two sites had already worn a path under the dense fir cover, this site provided an opportunity to study changes in path width, as well as the effect on vegetation along trail edges. To study this effect more intensively, relevés no.1A and 1B represented areas one-half metre parallel to the middle of

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[1]Unless size is otherwise specified, all relevés are five metres square as determined by the minimal area study discussed in Chapter Three.

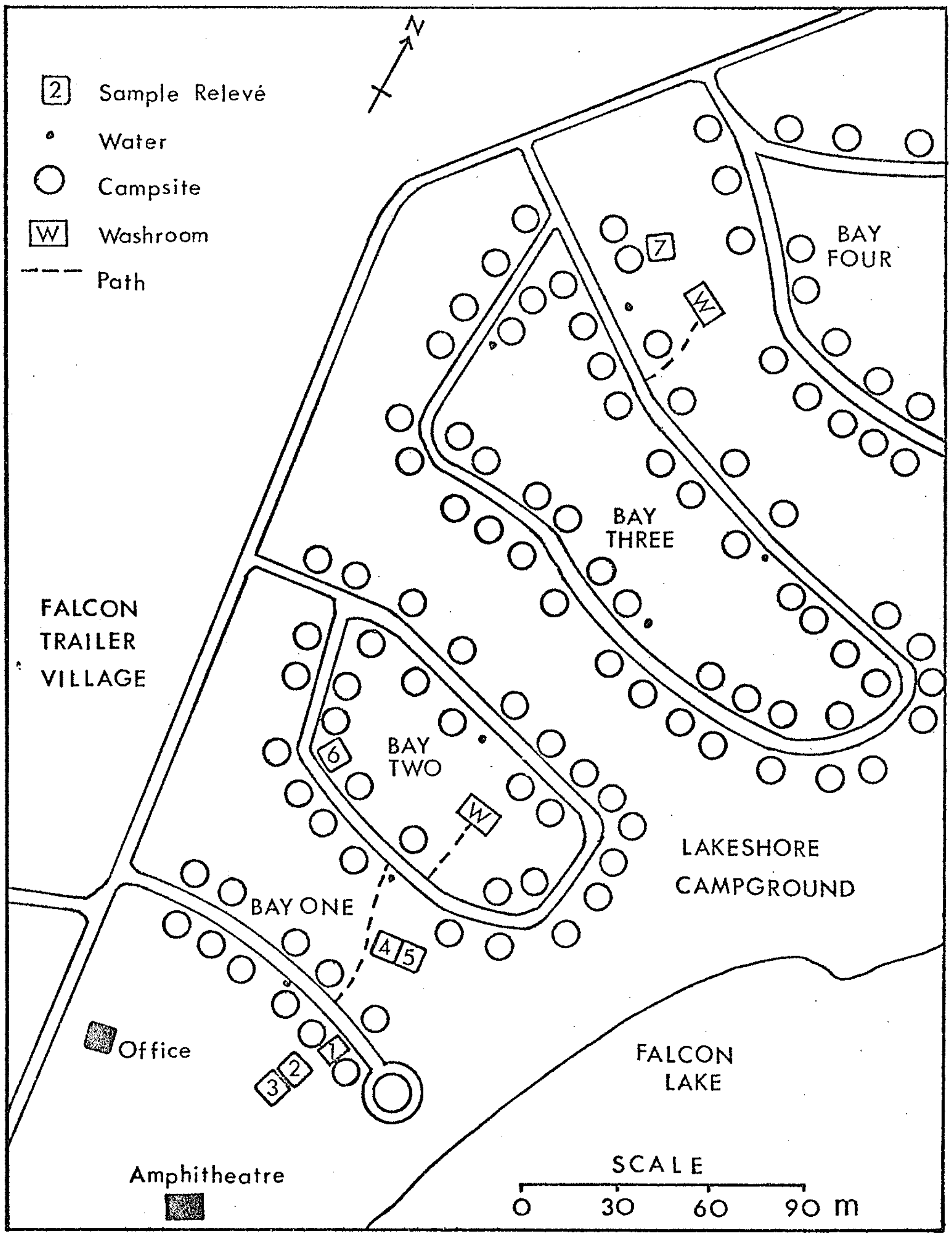

Fig. 3 The location of sample relevés in the Lakeshore Campground. (after : Manitoba, 1971B)

the path on the right and left sides, respectively, and five metres long. Two other relevés, numbers 1C and 1D were selected within relevé no.1 representing an area two metres by one metre on either side of the path. In this way, changes to the herbaceous cover could be closely observed.

Relevé no.2 had a more open canopy than no.1. Directly south of this was relevé no.3 which was under a closed canopy similar to that of no.1. These two sites provided the opportunity to study the effects of differing light conditions on the ground cover and were also chosen to see if a path would develop through the relevé by people going to the amphitheatre.

Located near the back of no.3 was a small mound with a slope that was barren of vegetation. Two boulders were exposed along this slope and measurements were made to see if more of these boulders would be exposed over the season due to soil erosion.

Relevé no.4 was located beside a gravelled path which led to a water source and washroom facilities. An undesignated path passed directly through this site, and so an intensive study of vegetation one metre deep by five metres long on each side of this path was initiated. Relevé no.5, directly west of no.4 was chosen for its denser cover, and to see if path development would take place in this area.

Relevé no.6 was selected under a closed stand of trees and was used as a 'tree monitor' site to study impacts on the tree layer. Relevé no.7 was located on the periphery of a 'dual-use' site which has facilities for two campsites on one large gravelled area. This relevé was situated at the edge of the gravel with two mature trees on each side. There was room in between these trees to pitch a tent if so desired. Therefore, this area was chosen to see if encroachment would take place in this peripheral section.

2.2.2 Falcon Lake - Overflow Campground

Located only about one mile from the Lakeshore Campground, the Overflow is composed of an almost pure stand of mature trembling aspen. More importantly, this area was selected because of its campground design. Instead of the individual or dual-use sites found in the other three campgrounds, the Overflow is designed in a semi-circle, where one cleared area serves four camping units (Fig.4). These sites do not offer as much privacy as individual campsites but do allow easy access by vehicular traffic. This presents an interesting alternative in campground design for intensively used camping areas. Four sample relevés were selected here to analyze any changes beyond the limits of the area cleared for campground use.

Relevé no.8 was located along the border of the grassed area to see if path development occurred in the periphery, and covered an area 16.6 metres long and one and one-half metres wide. Relevé no.9 was selected in an area that appeared to be used as an access between two camping semi-circles, and was studied to observe path and vegetation changes. Relevés no.10 and 11 were selected behind campsites to monitor vegetation changes in the periphery.

2.2.3 Lone Island Lake Campground

Lone Island Lake Campground is located in the central area of the Whiteshell Provincial Park, near the junction of Highways No.307

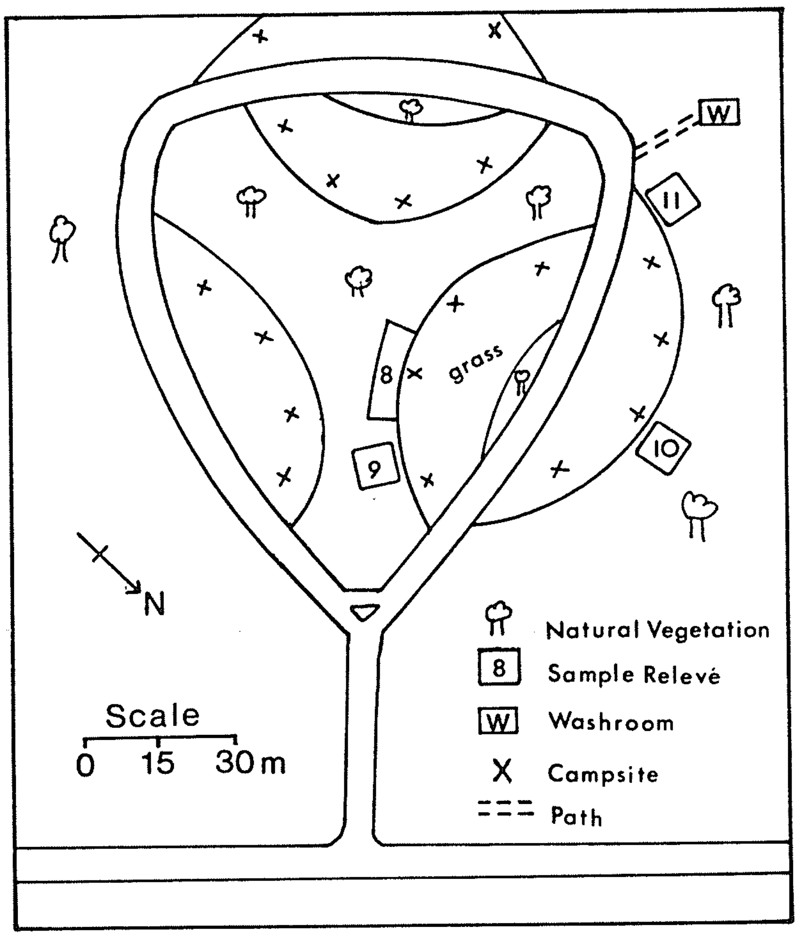

Fig. 4 The location of sample relevés in Loop One of Falcon Lake's Overflow Campground.

and No.309 (Fig. 2). This campground does not have an office and therefore no figures are available as to the amount of use that this campground experiences. Like Black Lake Campground, it is situated on sandy soil with several bedrock outcrops, and the dominant vegetation cover is composed of mixed species such as jack pine (*Pinus banksiana*), trembling aspen, white birch and white spruce. Evidence of stumps and burn areas indicate that the campground had been logged at one time. An old logging road is still partly visible, despite efforts to "fill it in" with planted red pine (*Pinus resinosa*). This revegetated site was selected for one of the sample relevés,(no.12, Fig. 5) for the purposes of studying the effects of man on a 'planted' area. Three other sample relevés, numbers 13. 14 and 15, were chosen in this campground, principally to study changes in natural vegetation cover following human disturbance. Relevé no.13 was located near the roadway and was selected because of the presence of an old fire pit which may be used again by campers. Relevé no.14 was directly north of no.13 and was chosen to see if any effects would result from campers finding their way to the washroom (Fig. 5). Finally, relevé no.15 was selected to see if paths would be formed towards the roadway, and this sample area measured 2.5 metres by 2.5 metres.

2.2.4 Opapiskaw Campground

The northernmost campground, Opapiskaw is located on the banks of the Winnipeg River. Here, bedrock outcrops occur and a shallow soil depth in some areas is only able to support a sparse vegetation cover. On deeper soil profiles, trees grow well and the cover is composed of trembling aspen, balsam poplar (*Populus balsamifera*),

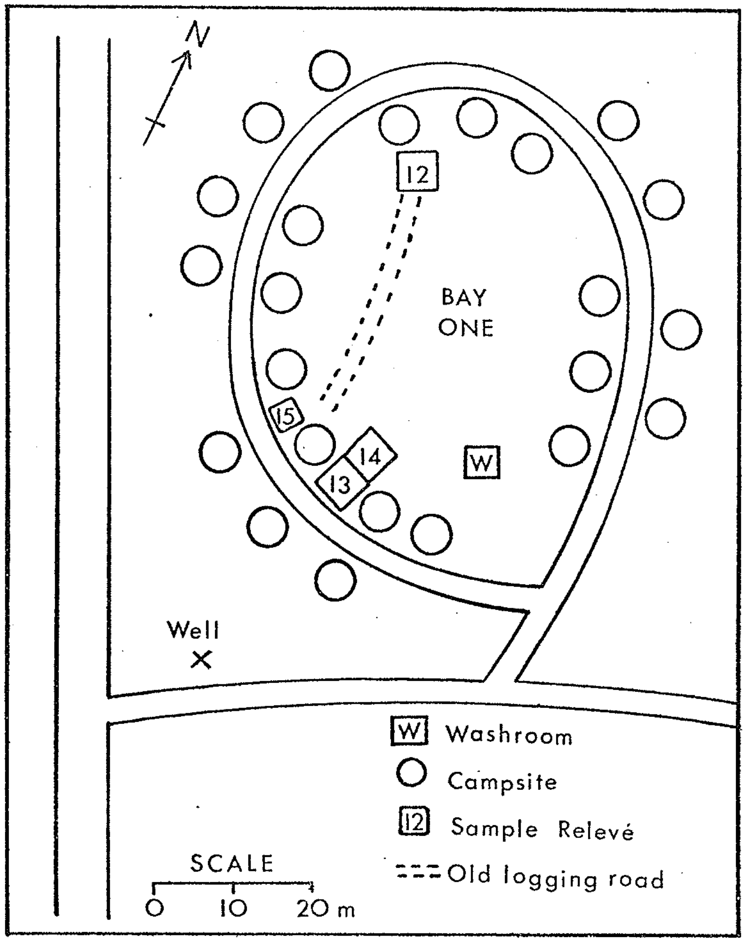

Fig. 5 The location of sample relevés in Lone Island Lake Campground.

white birch and white spruce.

Five sample sites were chosen in this campground and their location is illustrated in Fig. 6. Relevé no.16 was located between the road and a rock outcrop in Ispuchaw Loop. Here a path had developed in the periphery and was very visible on the outcrop where soil had been completely worn away. This provided the opportunity to study changes to the soil cover on the path, and more detail was gathered by relevé no.16A which sampled a five metre strip of vegetation one metre deep along both sides of the path.

A soil 'oval' with mainly moss cover, situated on a rock outcrop, provided the opportunity to study erosion in relevé no.17. This was located near a path which crossed the outcrop leading to a washroom (Fig. 6) and it was believed that people stepping on the soil would loosen the edges and promote erosion by wind and precipitation. Measurement of the width and length of the soil area was taken during each visit.

Relevé no.18 included three measurements of widths along a soil-covered path between Ispuchaw and Tukotamutin Bays. Relevé no.19 led to a scenic lookout on the periphery of the last loop. Two paths were visible at the beginning of the study and widths were measured along with an examination of vegetation change in this area. The final relevé, no.20, was just northeast of no.19 and consisted of a partial soil surface on exposed bedrock. Soil erosion studies were also done in this relevé by taking a series of measurements of soil cover along transect lines during each of the six field visits.

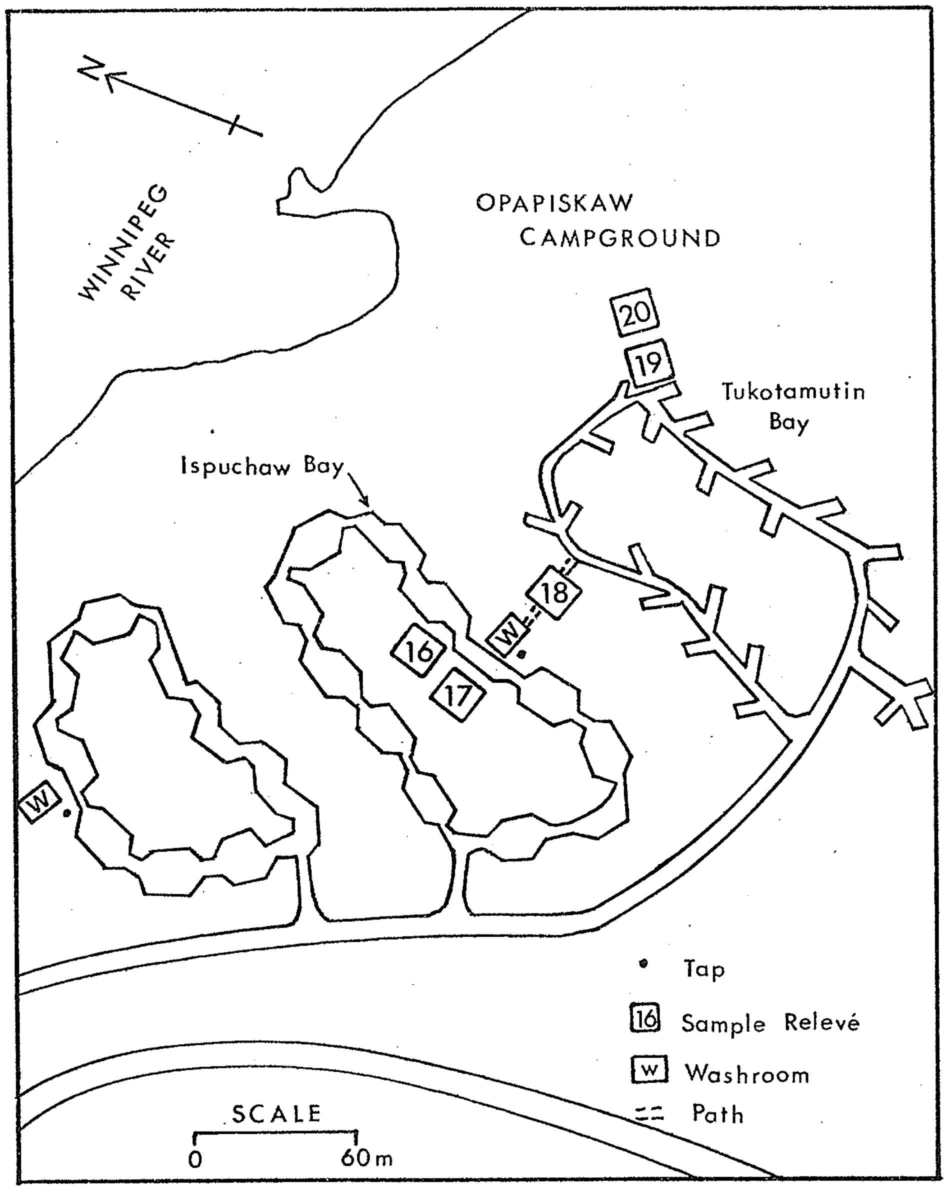

Fig. 6 The location of sample relevés in Opapiskaw Campground. (after : Manitoba, 1975C)

2.2.5 Black Lake Campground

Black Lake Campground is located on the Pre-Cambrian Shield north of the Whiteshell Provincial Park in Nopiming Provincial Park (Fig. 2). It has a fairly well-drained sandy soil of glacial origin and contains many bedrock outcrops. In comparison with the physical characteristics of the four campgrounds in the Whiteshell (Table 2), Black Lake appears to have most similarity to Lone Island Lake Campground. The parent material of the soil is the same non-calcareous, sandy, glacial deposit with bedrock outcrops, but the soil profile of Lone Island Lake is better developed. Many plant species are common to both areas, but Black Lake has a very dominant layer of closely-spaced jack pine, while to the south Lone Island Lake Campground's cover is a mixture of jack pine, trembling aspen, white spruce and white birch.

The mature jack pine cover of Black Lake allows very little light to penetrate to ground level. As a result, little ground level vegetation is present, and needle litter and mosses cover the majority of the forest floor. In areas where the canopy is more open, the ground cover is composed of herbaceous species such as : blueberry (*Vaccinium myrtilloides*), wild strawberry (*Fragaria virginiana*), vine-leaf petasites (*Petasites vitifolius*), red raspberry (*Rubus pubescens*), leatherleaf (*Chamaedaphne calyculata*), grasses and various mosses. It should be noted that all of the species except leatherleaf are also found in the sample relevés of the Whiteshell Provincial Park.

This new campground provides the opportunity to illustrate the importance of knowing the limitations of the natural environment in the design of a campground. Results of the disturbance studies in the Whiteshell Provincial Park will be applied to this area in Chapter Six in order to predict how campers will cause changes to the natural environment of the campground when they begin to use the area in 1978.

CHAPTER THREE

THE VEGETATION ANALYSIS OF THE PERIPHERAL AREAS

The purpose of the vegetation analysis was to examine changes to plant species in the periphery of campsites which may have been caused by human disturbance. Other studies have shown that trampling of vegetation occurs, and can lead to a reduction in plant growth and thus, ground cover (Dotzenko et al., 1967). Other effects or impacts have been described such as the hand picking of flowers or plants, tree-culling or bark removal, and the presence of litter which can obstruct the passage of light and air resulting in the death of plants underneath the refuse (Willard and Marr, 1970). These types of impacts were examined in several sampling sites in the Whiteshell Provincial Park and any change was noted during the field season from June 1 to September 7, 1977.

Trampling of vegetation can lead to a decline in ground cover and an increase in the exposure of soil, and therefore measurements of the widths of bare areas were made during each of the six field visits in this study. Changes in the vegetation cover itself were examined by the use of the community sampling technique known as the relevé method.

3.1 The Relevé Method

The first step in the relevé method requires the determination of the size of the relevé by a 'Minimal Area Study'. The minimal area is defined as the smallest area on which the species composition of the community is adequately represented (Mueller-Dombois and

Ellenberg, 1974). Briefly, the procedure involves outlining a small area, for example, one metre by one metre, and recording all of the species present within this plot. Then the area is increased to twice the size, then to four and eight times the size, and so on. Plotting the number of species over the size of the sample area, a "species/area" curve is determined. When this curve becomes almost horizontal, that point gives the minimal area of the sample plot or relevé. It must be remembered that this method is not exact, and "it is therefore advisable to decide on a somewhat larger area for an adequate size of the sample plot" (Mueller-Dombois and Ellenberg, 1974;48). Thus, using a safety margin of 10% and rounding the size of the sample plot to the nearest square metre, the size is determined.

Because the aim of this field work was to examine the effects of disturbance in several different sites, the size of the sample relevés varied. The majority of the twenty-four sample areas was five metres square, as determined by the minimal area study, but more intensive studies were done on smaller areas, and occasionally larger samples were used, as in the Overflow Campground in relevé no.8. The size of these relevés is smaller than the empirical values usually given for sampling forest areas. For example, a size of fifty to five hundred square metres is usually employed for sampling tree stratum and undergrowth vegetation (Mueller-Dombois and Ellenberg, 1974). However, the size determined by the minimal area method was justified in this study because of the width of the vegetation border in many of the campsites and because of the intensive nature of the vegetation analysis which emphasized the herbaceous cover. A larger area would have required the researcher to disturb the vegetation to do the relevé analysis, an action that would bias the results. Therefore, five metres square was considered to be a suitable size for this study.

The next step in the relevé analysis is to compile the field notes. All of the species present in the relevé were listed according to a height stratification of :

T = Tree layer, any plant taller than five metres

S = Shrub layer, woody plants between thirty centimetres to five metres tall

H = Herb layer, herbaceous species from zero to 100 centimetres high

M = Moss and lichen layer. This usually refers to a ground-appressed low carpet of less than five or ten centimetres height.

(Mueller-Dombois and Ellenberg, 1974)

The identification of species was made according to Scoggan (1957) and was also aided by a field guide entitled Forest Flora of Canada (Cunningham, 1975).

The field notes also contained a detailed sketch map for use in the re-location of each relevé on subsequent visits, and other pertinent information was added, such as the date, a general description of the vegetation community, soil type, the size of the relevé, and additional remarks about the phenology of the vegetation or effects of use found in and near the relevé.

The final step in the method is to employ a technique for estimating ground cover[1], because numbers of species cannot always be counted accurately. Several other methods have been used in previous studies. For example, Willard and Marr (1970) developed a "Campground

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[1]Cover is defined as the "vertical crown or shoot-area projection per species in the plot (Mueller-Dombois and Ellenberg, 1974;60).

Rating Scale for Visitor Impact" which estimates the amount of vegetation cover in an area exposed to visitor impact. This is presented in Table Three.

TABLE 3 : CAMPGROUND RATING SCALE FOR VISITOR IMPACT

Degree 1 -	Vegetation receiving visitor impact, but is not showing any measurable or visible alteration; total vegetation cover = 100% of natural
Degree 2 -	Ecosystem obviously affected by visitor impact, but vegetation is not significantly altered, total vegetation cover = 85-90% of natural
Degree 3 -	Ecosystem definitely altered by visitor impact; plants show reduced vitality; attrition effects to normal growth rate; normal growth persists in protected sites; soil exposed and eroding; total vegetation cover = 25-85% of natural
Degree 4 -	Ecosystem radically altered by visitor impact; vegetation gone except in protected sites; 'A' horizon exposed over most of area and eroding; total vegetation cover = 5-25% of natural
Degree 5 -	Ecosystem virtually destroyed by visitor impact; plants existing only in very protected sites, if at all, and not growing normally;'B' and 'C' horizons exposed by erosion; total vegetation cover = 0-5% of natural.

(Willard and Marr, 1970)

There are several drawbacks to this scale. For example, the user is required to estimate the percentage of vegetation cover on the site that is "natural". Since these types of studies are dealing with disturbed environments, it is impossible to compare the present cover of a site to what it would have been in a natural state. Another problem occurs when distinguishing between Degree 1, the stage where vegetation is "receiving visitor impact but is not showing any measurable or visible alteration", and Degree 2 where the ecosystem is "obviously affected by visitor impact, but vegetation is not significantly altered" (Willard and Marr, 1970). Any decision differentiating between these two degrees of impact would be very subjective.

A final drawback to this scale is the range of vegetation cover represented in Degree 3. This category refers to vegetation cover that is 25-85% of the natural cover. With such a broad range, this scale would only be sensitive to very drastic changes. Therefore, it was not suitable for a short-term study such as this, where small scale changes in the cover and numbers of individuals would be expected as a result of only one season's impact within the relevés.

Another method that has been used in many disturbance studies is the 'line intercept' method (Bogucki et al., 1975; Hoffman et al., 1975). This technique involves the laying down of a meter tape and recording only the vegetation cover which intercepts the tape. This technique is suitable for sampling a large area, where in effect, a sample of the sample is taken, but was not suitable for the present study because information on the total cover was needed within each relevé.

Small scale techniques such as that used by Scotter (1976) were also considered unsuitable. He plotted vegetation cover on graph paper using a plot-frame and a one-inch wire mesh. This method is very time consuming and does not allow for species which overlap. In the communities sampled in the Whiteshell Provincial Park, many layers of vegetation are present and must be considered. A further drawback is that the researcher may disturb the vegetation when charting the cover accurately, and therefore in this disturbance study, the plot-frame method was not considered appropriate.

A scale that has been widely used for estimating vegetation cover is the Braun-Blanquet Cover-Abundance Scale. It consists of seven easily-estimated classes and has an added advantage of indicating numbers of species in the lower classes (Table 4). Used in the present study, the number of individuals per species were often recorded in the last three categories, providing both a quantitative measure of cover as well as the more qualitative estimate by the cover values. The scale also allows for overlapping species and can be used to provide detailed information for a large number of sites. Therefore, the Braun-Blanquet Scale was considered to be the most suitable method for estimating vegetation cover over three-week intervals during the growing season, particularly as it would be sensitive enough to show changes occurring within each relevé over time.

TABLE 4 : THE BRAUN-BLANQUET COVER-ABUNDANCE SCALE*

Class	Description
5	Any number, with cover more than 3/4 of the reference area (> 75%)
4	Any number, with 1/2 to 3/4 cover (50-75%)
3	Any number, with 1/4 to 1/2 cover (25-50%)
2	Any number, with 1/20 to 1/4 cover (5-25%)
1	Numerous, but less than 1/20 cover, or scattered, with cover up to 1/20 (5%)
+	(Pronounced cross) Few, with small cover
r	Solitary, with small cover

*From Braun-Blanquet, 1965.

The first three steps of the relevé method described above, i.e. determining the 'minimal area', estimating the cover of individual species, and compiling the field notes, have been used in previous vegetation studies (Lesko and Robson, 1975). The relevé method provides the type of information on the vegetation in a sample which can be analyzed in a number of ways, depending on the purpose of the study. In this research, changes in the number of individuals in each species or in species' cover were analyzed to discover if the cause was due to a natural change in its life-cycle or to human interference.

CHAPTER FOUR

RESULTS OF THE PERIPHERAL DISTURBANCE STUDIES

The results of the data collected in each sample relevé are presented in this chapter. Since the main purpose of the field study was to examine the extent and effects of disturbance in the area surrounding campsites, visible results of campers' use of this area were recorded and are discussed as 1) vegetation cover changes; and 2) other changes to the peripheral area.

4.1 Vegetation Cover Changes and Indicator Species

The field study resulted in the collection of information on the vegetative composition of each relevé. This 'raw' data was summarized into "Cumulative Tables" which showed the results of each visit in a concise form. Table 5 showing the information gathered from relevé no.1 in the Lakeshore Campground is an example of this. Measurements of path widths in the relevé were also summarized at the bottom of these tables.

To condense this material further into a form which would indicate significant changes in vegetation cover within the relevé, a method of tabular comparison which results in a "Constancy Table" was used (Mueller-Dombois and Ellenberg, 1974). All species found in each campground were listed by strata (tree, shrub, etc.) and a constancy value was given during each time interval to represent the number of relevés in which the species occurred. This can best be illustrated by an example, Table 6, which is part of the constancy

TABLE 5 : AN EXAMPLE OF A CUMULATIVE TABLE FOR RELEVÉ NO.1, LAKESHORE CAMPGROUND

Stratum	Species	June 1-2 No.	June 1-2 Cover[1]	June 21-22 No.	June 21-22 Cover	July 12-13 No.	July 12-13 Cover	Aug. 2-3 No.	Aug. 2-3 Cover	Aug. 23 No.	Aug. 23 Cover	Sept. 6-7 No.	Sept. 6-7 Cover
Tree	*Abies balsamea*[2]	12	3	12	3	12	3	12	3	12	3	12	3
	Populus balsamifera	1	r	1	r	1	r	1	r	1	r	1	+
Shrub	*Abies balsamea*	5	+	5	+	5	+	5	+	5	+	5	+
Herb	*Abies balsamea*	30	+	29	+	27	+	27	+	25	+	21	+
	Populus balsamifera	1	r	4	r	5	r	5	+	5	+	3	+
	Lathyrus ochroleucus	2	+	2	+	4	+		+		+		+
	Aralia nudicaulis	50	3	38	2	36	1	35	1	23	2	19	2
	Petasites vitifolius		+	2	+	1	r	0			+	0	
	Fragaria virginiana		+		+	0			+	0			+
	Rosa blanda	3	+	2	+	6	+	5	+	1	r	1	r
	Smilacina trifolia		1		1		+		+		+	0	
	Cornus canadensis		1		1		2		2		2		2
	Gramineae (clumps)		+	11	+	3	+	13	+	6	+	8	+
	Linnaea borealis						+		+		+		1
Moss and Lichen	*Hylocomium splendens*		4		4		2		2		2		3
	Polytrichum juniperinum		+		1		1		1		1		2
	Peltigera aphthosa						+		+		+		1
	Cladonia rangiferina						+		1	0		0	
	Rhytidiadelphus triquetrus						+		+		1		1
Path Width (cm)	centre of relevé at												
	rock	48.8		48.8		45.7		57.9		54.9		61.0	
	mid-path					36.6		48.8		48.8		54.9	

[1]Cover values refer to Braun-Blanquet Cover-Abundance Scale (Table 4).

[2]Authorities are contained in Appendix 1.

table for the Lakeshore Campground[1].

TABLE 6 : EXAMPLE OF A CONSTANCY TABLE FOR THE LAKESHORE CAMPGROUND (SEVEN RELEVÉS)

Stratum	Species	June 1-2	June 21-22	July 12-13	August 2-3	August 23	Sept. 6-7
Tree	*Abies balsamea*	6	6	6	6	6	6
Herb	*A. balsamea*	5	5	5	4	4	4
Herb	*Equisetum sylvaticum*	1	1	2	1	1	1
Herb	*Smilacina trifolia*	4	4	4	4	4	0
Herb	*Corylus cornuta*	1	2	2	2	2	2

On June 1-2, balsam fir (*Abies balsamea*) in the tree layer was present in six out of a possible seven relevés. Because the figure remained constant throughout the season, no significant change was indicated in the tree layer. Balsam fir seedlings in the herb layer were present in five relevés until August 2-3 when they were eliminated from one site, and the constancy value dropped to four, indicating a change in the presence of this species. Another species, threeleaf smilacina (*Smilacina trifolia*) was found in four sites until September 6-7 when it disappeared from all of the relevés. Thus, the constancy tables revealed an indication of change in vegetation cover occurring within the relevés. An increase in the constancy value indicated the establishment of a new species and a decline of this value indicated the elimination of a species due to human disturbance factors, or to a natural change in the plant's life cycle.

An examination of the Constancy Results (Appendix 2) revealed that there were many species which showed fluctuations in constancy value. Several trampled species were recorded in the field and

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[1]Constancy Table results for all four campgrounds are found in Appendix 2.

identified as those plants toppled over or crushed by human use of the periphery, and these are listed in Table 7. A comparison of this list and the constancy values resulted in six species which showed the most change, and are selected here as "indicators" of disturbance[1]. These species, sarsaparilla, bunchberry, threeleaf smilacina, balsam fir seedlings, wild strawberry, and meadow rose will be discussed in the above order to analyze if the changes in their number and cover could be attributed to human interference in the relevé, to the natural life cycle of the species, or to a combination of both factors.

4.1.1 Wild Sarsaparilla

SCIENTIFIC NAME	*Aralia nudicaulis* L.
FAMILY	Araliaceae
RANGE (Canada)	Newfoundland and Nova Scotia to southern Mackenzie, northern Alberta and the interior of British Columbia
HABITAT	Common in shady, rich woodlands and deep wooded ravines throughout the prairies.
APPEARANCE	It has a fifteen to thirty centimetre high stalk which is divided into three parts, each of which is again divided into three to five leaflets. Flowers occur in June and are greenish, produced on a flowering stalk which grows from the rootstock. The fruit is round, purplish black and occurs in July.

[1]A limitation to the constancy class method is that it only reveals changes in species' presence or absence. For example, if sarsaparilla plants (*Aralia nudicaulis*) are trampled and some die in a relevé, the constancy value will not change until the species has been totally eliminated. However, when the constancy results are compared to the list of trampled species, changes in cover are indicated and can be verified by the actual field information contained in the Cumulative Tables.

TABLE 7 : TRAMPLED SPECIES IN ORDER OF TOTAL TIMES RECORDED BETWEEN JUNE 1 AND SEPTEMBER 7, 1977

Stratum	Trampled Species (Common Name)	Times Recorded
herb	bunchberry	7
"	balsam fir seedlings	6
"	wild strawberry	5
"	threeleaf smilacina	4
"	sarsaparilla	4
"	meadow rose	4
"	bracken fern	4
"	trembling aspen seedlings	4
"	downy viburnum	3
"	spreading dogbane	3
"	balsam poplar seedlings	2
"	sour-top blueberry	2
"	twinflower	2
"	bush honeysuckle	2
moss	mountain fern moss	1
herb	creamy peavine	1
"	Canada thistle	1
"	vineleaf petasites	1
"	red pine seedlings	1
"	white spruce seedlings	1
"	dandelion	1
"	red baneberry	1
"	woodland horsetail	1
"	wood lily	1

LIFE SPAN[1] Perennial

TOLERANCE TO IMPACT Not tolerant

Because of its fifteen to thirty centimetre height, sarsaparilla can easily be affected by trampling and is therefore a good indicator of disturbance occurring around campsites.

Figure 7 illustrates the results of changes in numbers of sarsaparilla observed in selected relevés during the field study. These four relevés were chosen to show the more extreme changes recorded in all of the sample areas. These plants were present in the control plot throughout the season, and only in September 6-7 was there evidence of a natural end to its life cycle, by the wilting and browning of its leaves. Therefore, the decline in numbers from June 1-2 to August 23, 1977 cannot be attributed to natural causes and is therefore the result of human impact in this area. This conclusion can be further supported by an analysis of the results of the intensive studies carried out in relevé no.1. In this Lakeshore Campground site, a path was visible across the relevé at the beginning of the study. In no.1A on Fig. 8, four sarsaparilla plants had died off by July 12-13. Similarly, no.1B represents the decline on the left side of the path from seven individuals to one in September 6-7. Significant declines were also found in no.1C and no.1D. This indicated that mature plants or seedlings on or adjacent to the path were greatly affected by the presence of campers in this area. However,

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[1]Descriptive information about the indicator species comes from: Gleason, 1958; Budd and Best, 1969; and Cunningham, 1975.

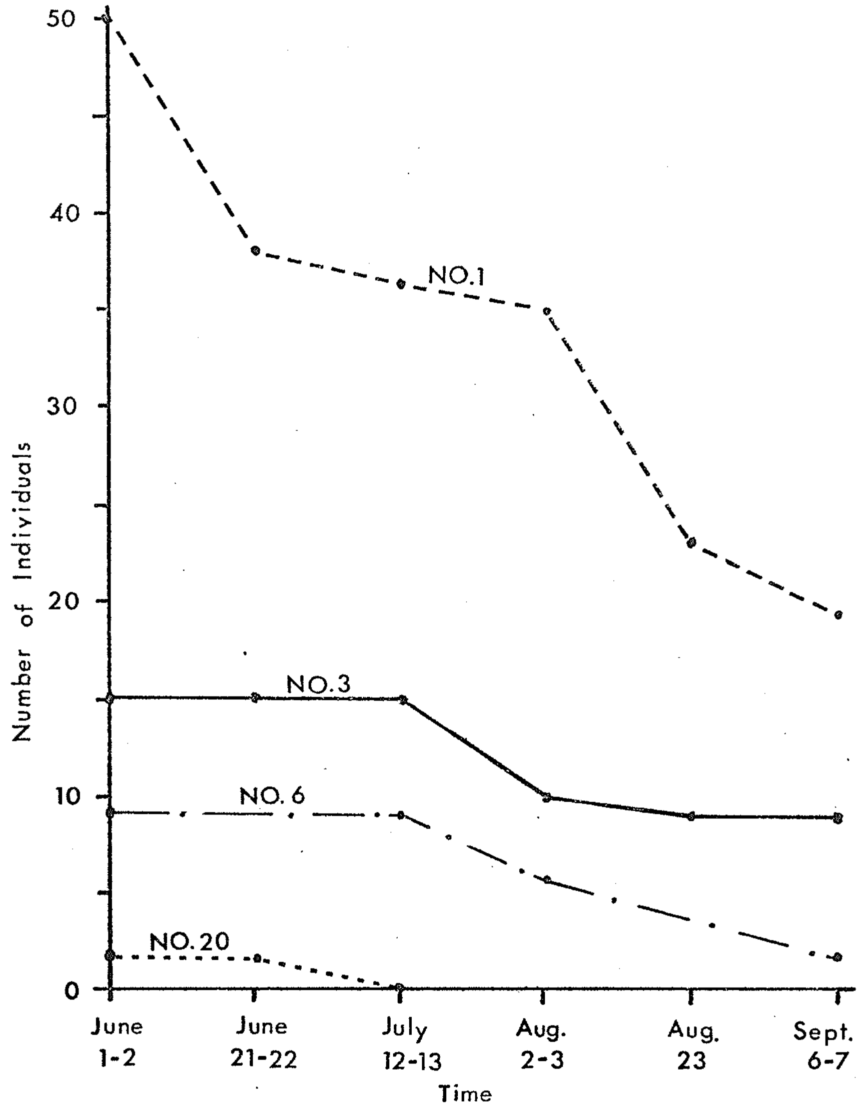

Fig. 7 Observations of changes in sarsaparilla populations for selected relevés.

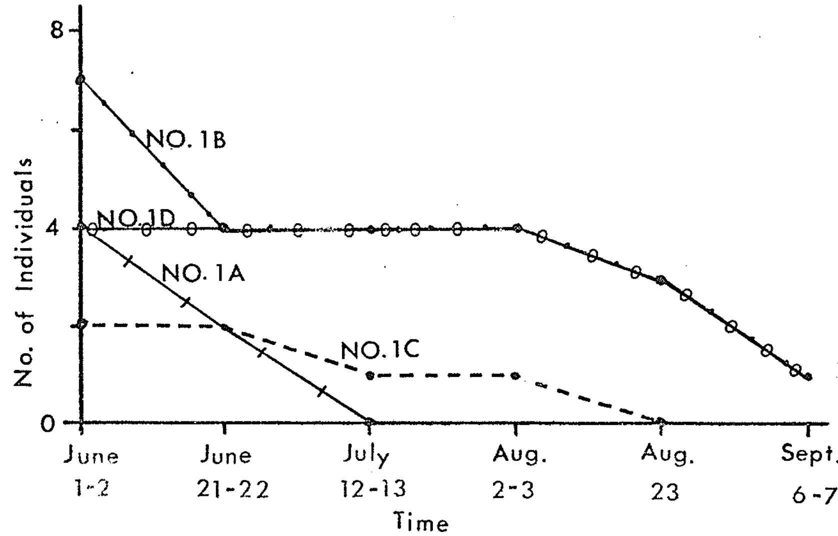

Fig. 8 Observations of changes in sarsaparilla populations for the intensive study of relevé no.1 in the Lakeshore Campground.

not all of the decline in numbers of sarsaparilla can be attributed to the direct effects of trampling on the plants. Other indirect effects can alter the micro-habitat of a plant, and many authors have found that an increase in soil compaction and a decrease in infiltration rates are responsible for the decline of vegetation cover (Dotzenko et al., 1967; James et al., 1976). These indirect effects, while not measured in the present study, must also be considered as part of the cause in the decline in the population of sarsaparilla.

These examples indicated that sarsaparilla found in the area between and around campsites was not able to tolerate disturbances created by humans, and the result was a general decline in the number of individuals during the growing season. In order to fully understand the damage to the species caused by trampling, it is necessary to observe the number of original plants which are able to recover over the winter season and grow again the following year. As the time limitations of this study prevented this possibility, it is suggested that this might be a profitable area for further research.

The decline in numbers of sarsaparilla and the resultant loss in ground cover is important to the condition of vegetation in the peripheral areas of campsites. Sometimes hardier species that are able to tolerate more disturbance may grow in these areas, for example members of the grass family (LaPage, 1967). However, if the disturbance is too great patches of bare soil will result which can be enlarged further by wind and water erosion.

4.1.2 Bunchberry

SCIENTIFIC NAME	*Cornus canadensis* L.
FAMILY	Cornaceae
RANGE (Canada)	Labrador, Newfoundland and Nova Scotia to the Yukon and British Columbia
HABITAT	Very common in shady woodlands throughout the prairies.
APPEARANCE	This is a low-growing herb of eight to fifteen centimetres high with a woody based stem and a whorl of ovate leaves near the head. Flowering in June, it produces four petal-like bracts surrounding a cluster of tiny greenish flowers. The fruit is a cluster of bright red drupes, appearing in mid-July to early August.
LIFE SPAN	Perennial
TOLERANCE TO IMPACT	Not tolerant

Bunchberry is a second species that can be used as an indicator of disturbance. Figure 9 shows the general pattern of decline observed in several of the sample relevés. The unexpected increase in relevé no.1D between June 1-2 and June 21-22 is explained by the fact that all individuals had not surfaced at the time of the first visit. Again, the intensive study of relevé no.1 gave the clearest results. Sharp drops occurred in two of the relevés, and coincide with two holiday weekends. The July Fourth long weekend occurred between June 21-22 and July 12-13, and campsites on either side of no.1 were occupied. Many of the bunchberry plants were trampled and data on the left side of the path (relevé no.1D) shows a decline during this time of nine to five individuals. Similarly, the August First long weekend took place between July 12-13 and August 2-3, and on the right

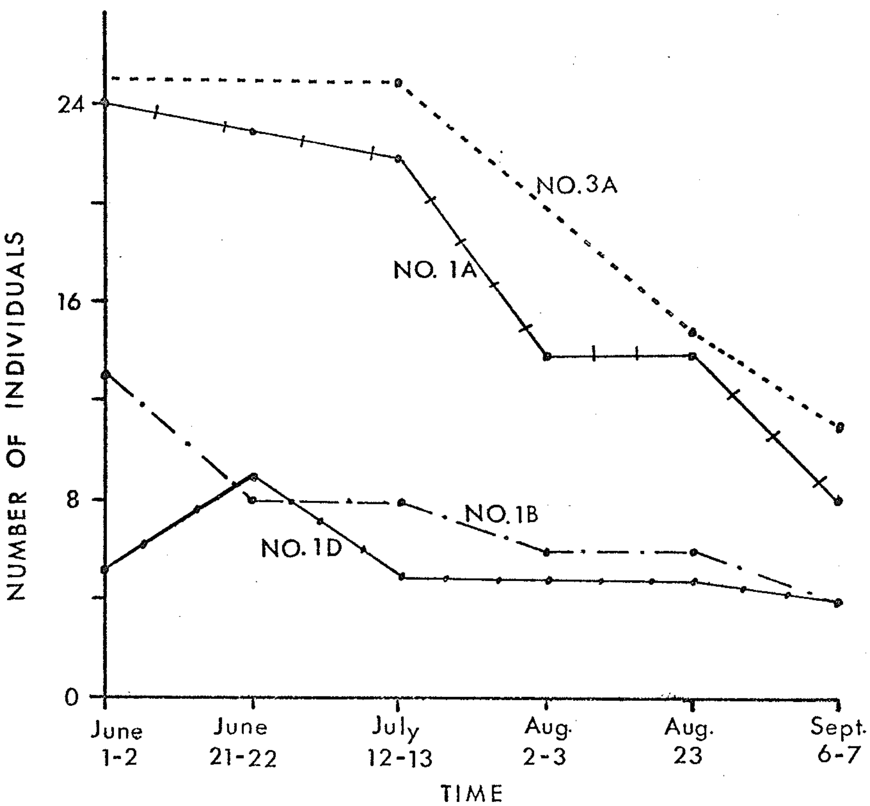

Fig. 9 Observations of changes in bunchberry populations for selected relevés.

side of the path, no.1A, the number of bunchberries declined from twenty-two to fourteen individuals. The effects of trampling are even more noteworthy because of a 12.2 centimetre widening of the path between July 12-13 and August 2-3.

The other notable decline of bunchberry occurred in relevé no.3A and is illustrated in Fig. 9. This site was positioned on a mound of soil which was bare of vegetation on its slope and had a path running along side of it. Because of its location, surrounded by a fairly dense cover, the noted decline in bunchberry individuals is likely due to both the effects of trampling along the path and to a change in lighting conditions on the site.

The final decline between August 23 and September 6-7 is likely due to natural causes, and was aided by cool weather experienced in the latter part of August, 1977.

Bunchberry serves as a good indicator of the impact of campers. Its attractive flowers and colourful fruit leave it susceptible to picking, and because it is found near many paths, this low-growing herb was often trampled. Although picking the flowers may not affect the well being of the individual, it does affect the species by reducing the potential seed crop (Willard and Marr, 1970). Thus, declines in species numbers and reduced ground cover can be expected in the following year where disturbance has been great, such as in relevé no.1 in the Lakeshore Campground.

4.1.3 Threeleaf Smilacina

SCIENTIFIC NAME *Smilacina trifolia* (L.) Desf.

FAMILY	Liliaceae
RANGE (Canada)	Labrador, Newfoundland and Nova Scotia to Mackenzie, southern Alberta and northern British Columbia
HABITAT	Wet woods and bogs, fairly common in the north and east of Manitoba.
APPEARANCE	It is a short, slender plant growing five to thirty centimetres high. It usually has three alternate leaves without stalks, and produces three to eight white flowers in early June. Its fruit are dark red berries which occur in July.
LIFE SPAN	Perennial
TOLERANCE TO IMPACT	Not tolerant

Figure 10 illustrates the general decline in numbers of smilacina that occurred. The trampling in relevé no.1 and the growth of the path width is reflected in the changes in the numbers of smilacina, similar to the changes stated earlier for bunchberry and sarsaparilla. This figure also shows the numbers of smilacina in relevé no.20, the area selected for an intensive study of soil erosion and vegetation change on a rock outcrop in Opapiskaw Campground. Climatic factors can play an important role in explaining changes in vegetation or soil cover in a study such as this, and a good example occurred on July 15, 1977 when a severe storm occurred in this area. Strong winds and heavy precipitation could be partly responsible for changes in the vegetation cover on relevé no.20 during this time. Field data showed a complete elimination of sarsaparilla (Fig.7) and a decline of sixteen to three individuals of smilacina on August 2-3. No.20 is also located at a scenic lookout point, and thus it is reasonable to assume that the change in vegetation cover of these two species is due both to site conditions

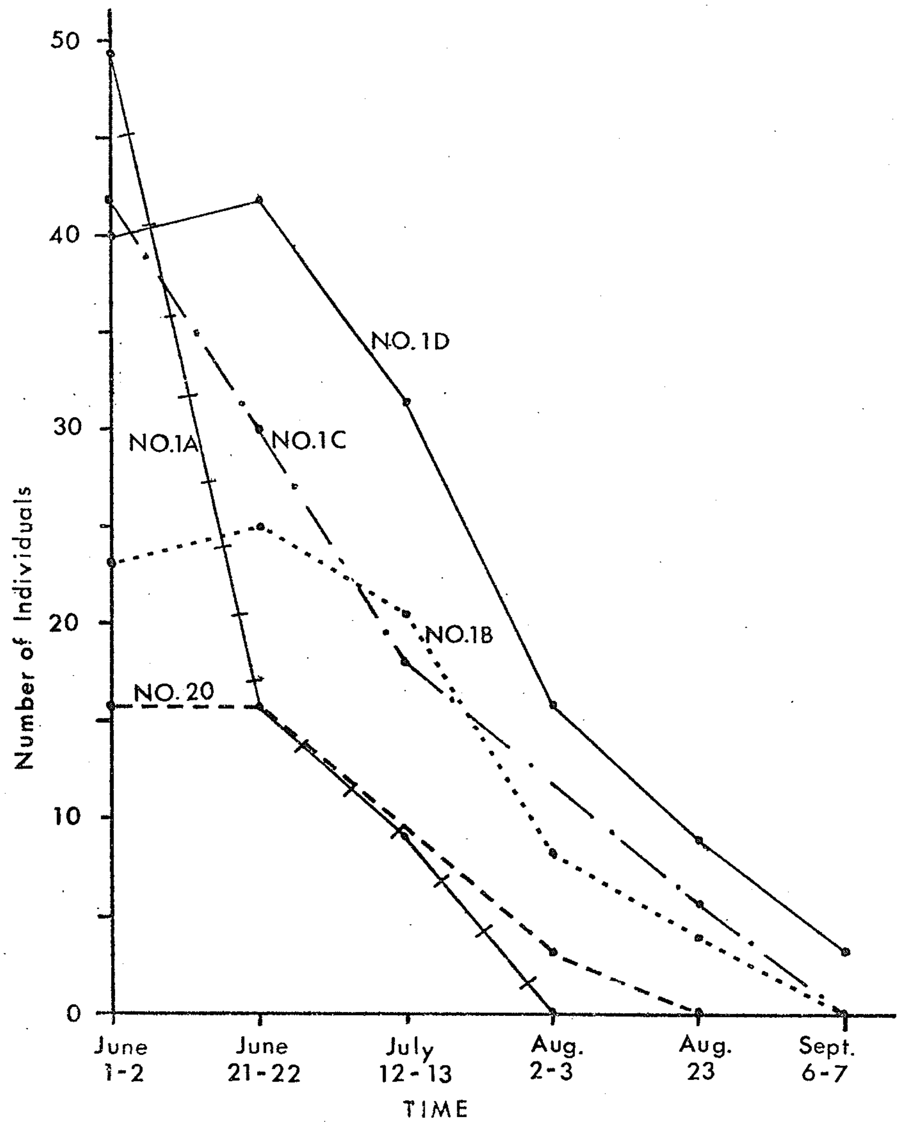

Fig. 10 Observations of changes in threeleaf smilacina populations in selected relevés.

resulting from the effects of the storm, and to the effect of humans walking on this area. Erosion is also likely to be promoted when kicking or 'scuffing' loosens the edges of the soil, and rain from the storm washes it away.

The final decline between August 23 and September 6-7 (Fig.10) is a natural decrease which occurred in seventeen out of nineteen areas that originally contained smilacina.

The three indicator species that have been discussed so far are all perennials found in the herb layer which may wither and die at the end of each growing season and, if not permanently affected by disturbance, will establish themselves again the following year. The fourth indicator species, seedlings of the coniferous balsam fir, are present year-round and were analyzed to see if changes could be related to the future growth of the forest in the peripheral areas where these seedlings were found.

4.1.4 Balsam Fir Seedlings

SCIENTIFIC NAME	*Abies balsamea* (L.) Mill.
FAMILY	Pinaceae
RANGE (Canada)	Newfoundland and Labrador to northern Alberta
HABITAT	Common in woodlands along the eastern and northern borders of the prairies.
APPEARANCE	It is an evergreen species with trees growing to twenty-five metres tall. The grey bark becomes scaly on old trees and the branches are arranged in whorls, usually from four to six. The longest branches occur at the bottom and are successively shorter towards the top. Leaves are about one centimetre long. It flowers in May and produces

	oblong cones which are five to ten centimetres long and are rounded at the tip.
LIFE SPAN	Perennial
TOLERANCE TO IMPACT	Not tolerant

The regeneration of this species will not take place in a dense canopy where light is not able to filter down to ground level, as was noted in the control plot in the Lakeshore Campground. Therefore, regeneration of this species often occurs in disturbed areas where the canopy has been opened up. Chances for the seedling's survival depends on favourable site conditions and, if established in areas subject to impact from campers, these chances can be reduced. Figure 11 shows the pattern of occurrence of fir seedlings observed during the field study. In relevé no.1, most seedlings occurred on the right side of the path, and on September 6-7, nine seedlings appeared to be dying (their leaves were brown and the one to three year old trees would have little chance to survive over the winter season). It was important to note that the majority of the dead seedlings, that is seven out of nine, were found within one metre of the path. This would indicate the possibility that changes to the habitat caused by use of the path would be responsible for the decline in their number.

This result is also supported by data from relevés no.2,3,4 and 16 (Fig. 11). These areas all contained seedlings at the beginning of the field study but by the end of the growing season, significant declines were noted. The effects of the impact along paths are shown in relevés no.4A and 16A, on the right sides of these sample areas, where three seedlings died in each of these segments by the end of the

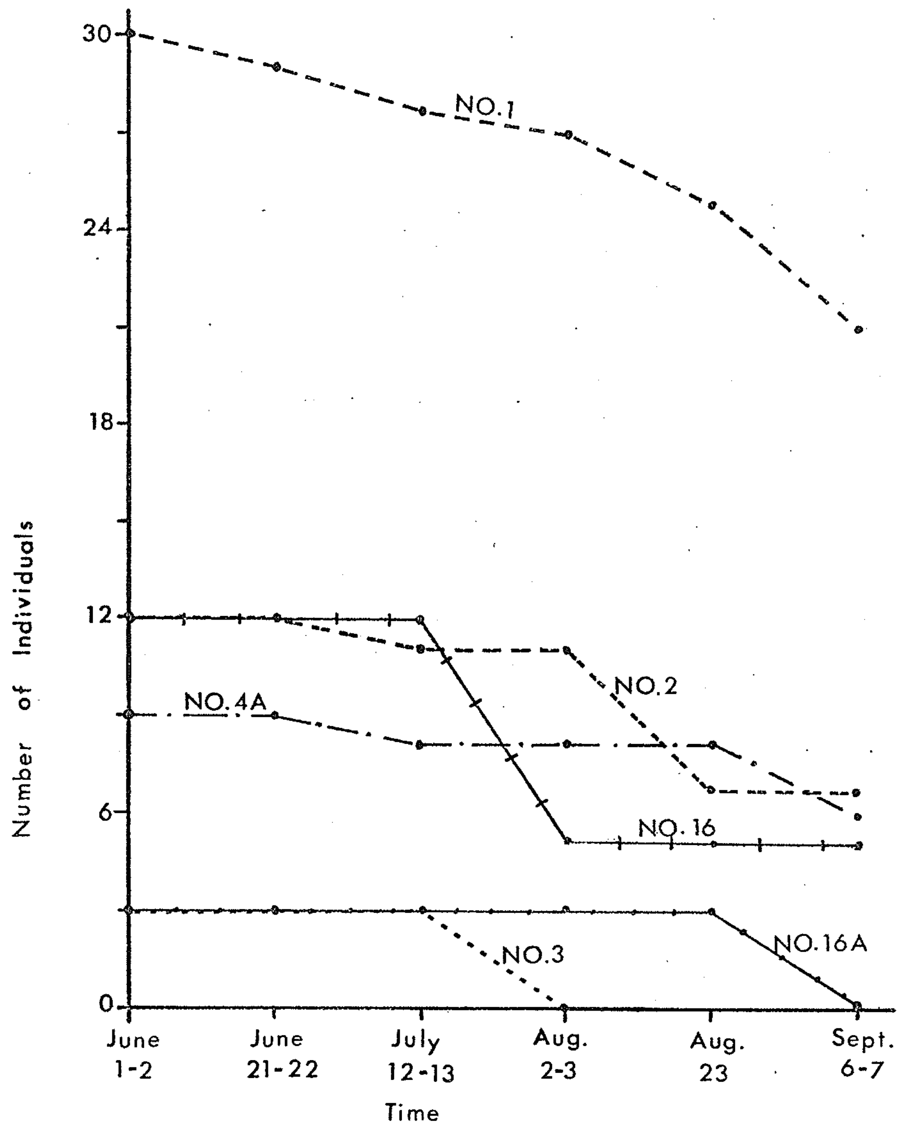

Fig. 11 Observations of changes in numbers of balsam fir seedlings for selected relevés.

season.

The impacts affecting this species are thus important because they have implications for the future growth and vitality of the forest ecosystem. If seedlings of a species are not able to establish themselves in an area, then eventually the dominant cover of the forest will change. Regeneration is a necessary process for keeping the ecosystem stabilized, and therefore, declines in the number of seedlings due to disturbances and natural factors have important implications for the future stability of the ecosystem under study.

Not all species are intolerant to human impact. The final two indicator species are examples of species which in fact thrive when human interference is modest.

4.1.5 Wild Strawberry

SCIENTIFIC NAME	*Fragaria virginiana* Duchesne
FAMILY	Rosaceae
RANGE(Canada)	Newfoundland and Nova Scotia to Alberta
HABITAT	Common in open woodlands and moist areas throughout the prairies.
APPEARANCE	It is a low-growing herb with three-foliate leaves and running stems which root at the tips and produce new plants. White flowers occur in April-June, and a round, red, 'tasty' fruit is produced in June-early July.
LIFE SPAN	Perennial
TOLERANCE TO IMPACT	Resilient

Even though the attractiveness of its flowers or the tastiness of its fruit may have encouraged people to pick wild strawberry plants, and the leaves may have been bruised by trampling, this species appeared to recover quickly after damage. Figure 12 shows the fluctuations of cover noted during the study. This graph uses the Braun-Blanquet cover values rather than the actual numbers because it was often impossible to obtain an exact count of these creeping plants. Some of the pattern of decline can be seen, but it is striking that this species was completely absent from relevé no.1 on July 12-13 but reappeared on August 2-3, disappeared on August 23, and reappeared again on September 6, 1977.

Thus, wild strawberry sees to be able to tolerate some degree of human disturbance and would therefore afford some protection to the soil in areas where it is found.

4.1.6 Meadow Rose

SCIENTIFIC NAME	*Rosa blanda* Ait.
FAMILY	Rosaceae
RANGE (Canada)	Eastern Quebec and New Brunswick to Manitoba
HABITAT	Dry woods, hills and dunes, especially in southeast and south-central parts of the prairies.
APPEARANCE	It is a low bush, 1.5 metres tall with very few, straight prickles. It has leaves of five to seven leaflets and produces pink flowers in late June-early July.
LIFE SPAN	Perennial
TOLERANCE TO IMPACT	Resilient

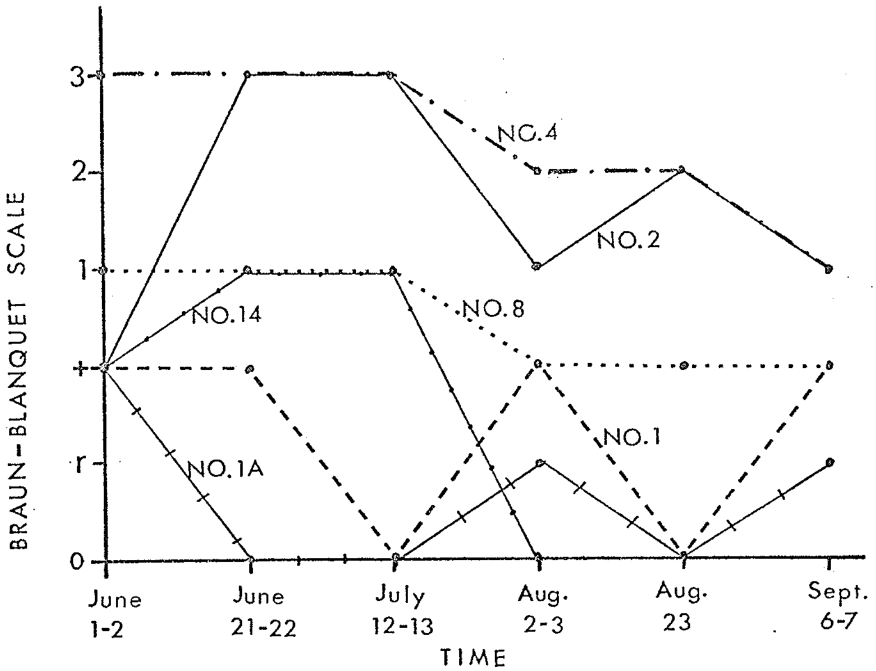

Fig. 12 Observations of changes in wild strawberry cover for selected relevés.

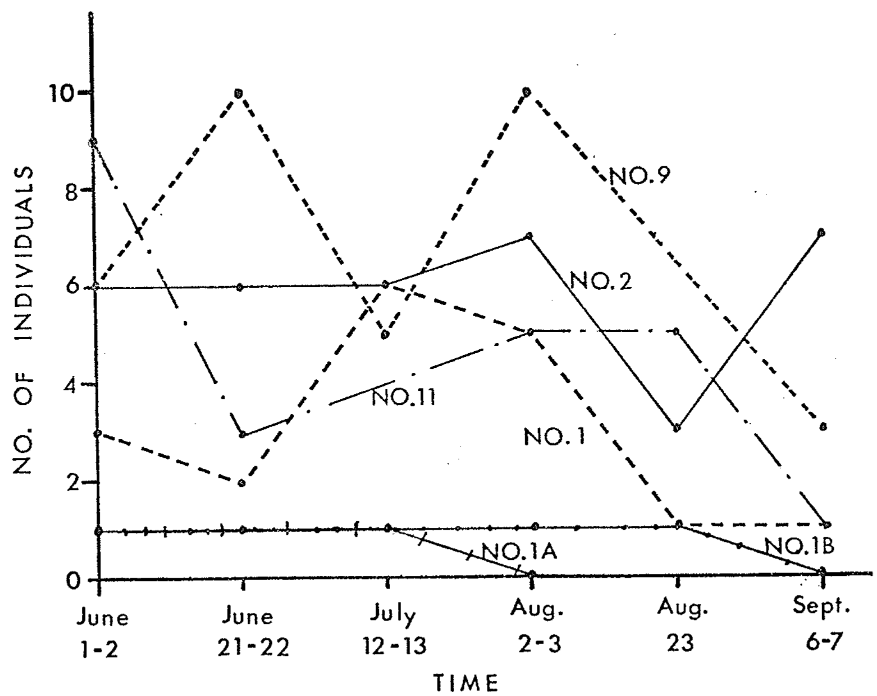

Fig. 13 Observations of changes in meadow rose populations for selected relevés.

Many fluctuations in the numbers of meadow roses can be seen in Fig. 13. This species, like the wild strawberry, seems to be able to tolerate the effects of modest human disturbance. Even though its leaves may be stripped or its attractive flowers picked, meadow roses were able to grow new foliage at different times of the year. This therefore, would account for some of the apparent fluctuations in the numbers of this species shown on Fig. 13.

In summary, changes in the number of individuals of the six indicator species described above have shown that disturbance to the peripheral area of campsites can affect vegetation cover in as little as one growing season. These results show that use is not being confined to the campsite in many of the campgrounds, and is spreading into the peripheral areas of the park. The discussion will now focus on the other effects of disturbance that are occurring in the peripheral areas of the Whiteshell Provincial Park.

4.2 Other Changes to the Peripheral Area

4.2.1 The Creation of Paths and Results of the Soil Erosion Studies

Many paths resulting from campers choosing their own routes were found scattered beyond the area of the campsites. Of the twenty main relevés chosen for this study, 50% contained measurable paths either at the beginning of the study in June or by the end in September. Table 8 shows the changes in path widths measured over the field season. The final column indicates the overall change, a positive value referring to an increase in path width, and a negative

TABLE 8 : MEASUREMENTS OF CHANGES IN PATH WIDTHS AND OF AREAS CRUSHED BY TENTS[1]

Relevé Number	Path	Measurement Location	June 1-2	June 21-22	July 12-13	Aug. 2-3	Aug. 23	Sept. 6-7	Overall Change*
1	1	at rock	48.8	48.8	45.7	57.9	54.9	61.0	+12.2
		mid-path			36.6	48.8	48.8	54.9	+18.3
2	2	at front	39.6	39.6	42.7	42.7	42.7	36.6	-3.0
3	3	mid-path	39.6	39.6	39.6	54.9	57.9	48.8	+9.2
4	4	mid-path		42.7	39.6	39.6	39.6	39.6	-3.1
6	5	mid-path		36.6	51.8	48.8	36.6	51.8	+15.2
	6	interior path				61.0	48.8	79.3	+18.3
9	7	front		61.0	51.8	48.8	45.7	36.6	-24.4
16	8	front			36.6	39.6	42.7	48.8	+12.2
		mid-path		45.7	45.7	42.7	42.7	45.7	0
		back boundary			39.6	42.7	42.7	48.8	+9.2
17	9	top of crack		109.7	109.7	125.0	131.1	125.0	+15.3
18	10	top	54.9	51.8	51.8	67.1	70.1	64.0	+9.1
		middle	51.8	57.9	54.9	64.0	64.0	70.1	+18.3
		bottom	61.0	51.8	57.9	67.1	64.0	73.2	+12.2
19	11	mid-path	67.1		48.8	45.7	51.8	42.7	-14.4
	12	path to left	48.8		39.6	42.7	42.7	42.7	-6.1
7		horizontal width of tent area			365.8	411.5	402.3	442.0	
12		crushed area from tents			313.9 long 280.4 wide	317.0 long 347.5 wide	313.9 long 362.7 wide	341.4 long 350.5 wide	

[1]All measurements in centimetres.

*Overall Change = September 6-7 value minus the first measurement value indicating a decrease in width. In the sample relevés, seven out of twelve paths widened over the season (Table 8). The fact that these paths occur in the area beyond the campsite indicates that campers are not confined to the sites. Continued use of these paths creates a number of 'artificial scars' on the edge of the campground which could lead to the degradation of more and more vegetation in this part of the park. With continued use over time, the vegetation on the path is affected by trampling as was illustrated by the decreases of the indicator species described previously. When these plants die off, hardier species may try to establish themselves and, depending on the amount of use along the path, it may decrease in breadth. This was noted in relevés no. 2,4 and 9 which were all located in open areas with an abundance of grass cover. (As was mentioned earlier, certain grasses are more resistant to trampling than broad-leaved herbaceous species). However, if use of the path continues, all vegetation cover may be destroyed through trampling. This will increase the likelihood of soil erosion by wind, raindrop impact, and runoff. This is particularly critical in areas where the soil depth is shallow and the vegetation cover is important for protecting the soil which is present. A good example of this occurs in Opapiskaw Campground where the path along a rock outcrop in relevé no.17 increased markedly from 109.7 centimetres on June 21-22 to 125.0 centimetres on September 6-7, an overall increase of 15.3 centimetres over one season. The bare path surface, worn to the bedrock, allows water and wind to erode the edges of the thin soil cover, which may be loosened by people using the path and this results in the loss of soil and vegetation on the rock surface.

This process was also noted in relevé no.20, the rock outcrop located on the banks of the Winnipeg River. Two paths through relevé no.19 led to this area, indicating that many people visited this site. Figure 14 shows that the area of soil cover on the bedrock decreased markedly over the season due to the combined effects of human impact which destroyed vegetation and loosened the edges of soil cover, and the effects of climatic elements such as wind and rain which work together to wash away loose soil and damage the vegetation. Figure 14 illustrates the changes in soil cover over one season, but it must be remembered that the increase in the amount of barren rock surface that was charted on June 1-2 was not a wholly natural occurrence, but had resulted from a combination of human impact and erosion factors.

In hardier areas where the vegetation cover is more dense, vegetation barriers on either side of a path can sometimes serve as a natural check on the growth of the path. A good example of this is seen in relevé no.18 in Opapiskaw Campground. This path was established by park management as a linkage from the fourth loop to the washroom facilities located in the third loop. The path width was measured in three places and until August 2-3, fluctuated very slightly (Table 8). The storm of July 15, 1977 damaged three of the mature balsam fir trees located along the path and parks officials had to cut them down. By the subsequent clearing of debris, the path could no longer restrict movements along it, and measurements show that it increased 15.3 centimetres at the top of the path, 9.1 centimetres at the mid-point, and 9.2 centimetres closest to the facilities between July 12-13 and August 2-3. Not only is this a good example of increased exposure affecting the vegetation along a path, but it also shows that movement

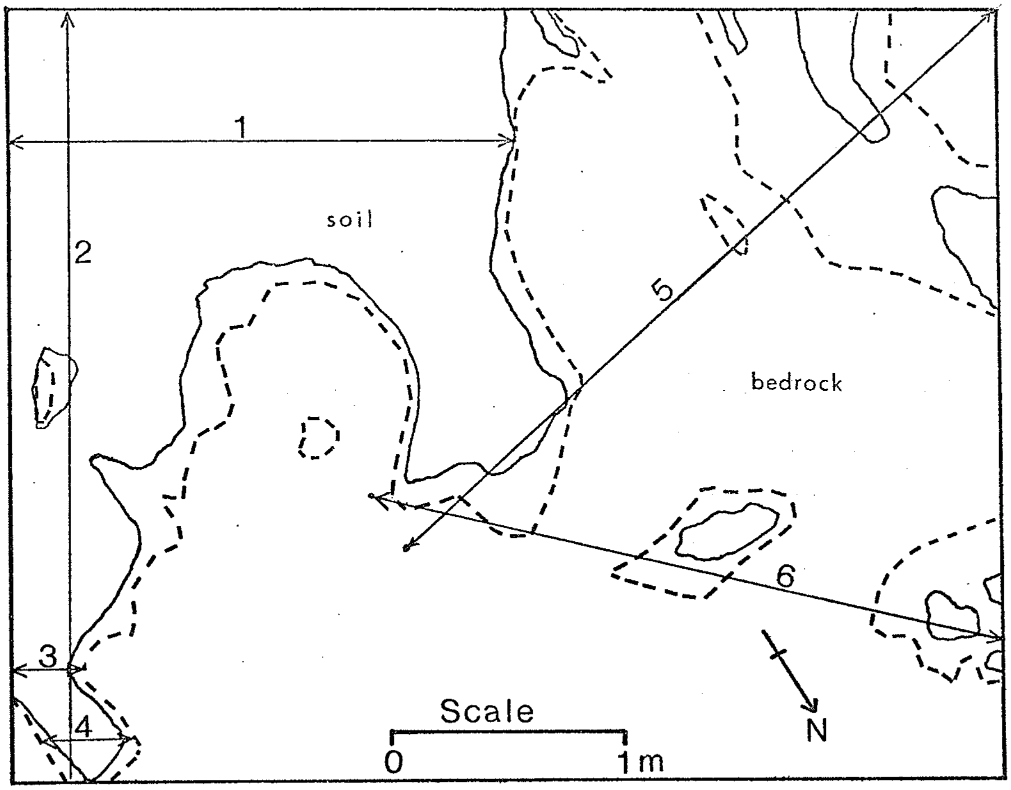

Fig. 14 Soil erosion in relevé no.20 in Opapiskaw Campground. Diagram compiled from measurements made along numbered transect lines shown above, and from photographs. Dotted lines shown above represent the extent of soil cover on June 2, 1977. Solid lines represent cover remaining on September 7, 1977 and the difference is due to erosion of the soil edges.

can be confined or directed by vegetation barriers, and this can be an important element of campground design.

4.2.2 Width of Areas of Crushed Vegetation in the Periphery

The final two sets of measurements in Table 8 indicate another type of impact that occurs in the periphery of campsites. At relevé no.7 in the Lakeshore Campground a tent was erected in the peripheral area behind the gravelled section of the campsite, crushing many plants in this area. By the end of the season, users had increased the breadth of this area from 3.6 metres to 4.4 metres. Any further increase of this area was checked by two mature trees located on either side of the crushed area, and by dense vegetation at the back of this relevé.

A tent pitched at Lone Island Lake Campground on top of relevé no.12 effectively caused a large encroachment from the gravel pad. In September this disturbed area measured 3.4 metres long by 3.5 metres wide. In both relevés no.7 and 12, almost all of the existing vegetation under the tents had been damaged and only grasses and hardier species such as wild strawberry seem capable of tolerating this treatment.

Both of these examples indicate another aspect of the effects of campground design. In both the Lakeshore Campground and Lone Island Lake Campground, gravel pads were provided for each campsite. If there is room to put up a tent on the grassy periphery of the gravel pad, as in these two sample areas, then tent-campers will use this section, rather than the lumpier gravel surface. In revegetated areas such as that of Lone Island Lake Campground where red pine were planted to fill in the old logging road, a natural barrier to any artificial expansion of this site would have resulted by simply planting the trees closer to the gravel surface.

4.2.3 Vagrant Impacts

The final types of human impacts noted in the field were 'vagrant' impacts, these being acts of vandalism or other behaviour which causes damage to the natural environment of the park. These are summarized in Table 9 and show the variety of impacts which occurred between each consecutive field visit.

These impacts may appear somewhat redundant, but each contributes to the alteration of the area used by humans in a campground and its periphery. For example, the presence of axe marks, the removal of trees, branches or bark, and using trees to hang up camping gear or clotheslines, can scar individual trees and make them susceptible to disease which could eventually lead to the tree's death.

It was also found that storing equipment or moving picnic tables in to the area around the campsite causes damage to the ground cover, as well as the other layers of vegetation.

As predicted, the greatest numbers of impacts were noted in the Lakeshore Campground (Table 9) which is the oldest of the four campgrounds used in the study. This indicates that a combination of time and capacity use increases the amount of impact to the peripheral area of the campsite.

TABLE 9 - CHECKLIST OF VAGRANT IMPACTS OCCURRING IN THE SAMPLE RELEVÉS, WHITESHELL PROVINCIAL PARK

Field Sessions	June 1-2 to June 21-22				June 21-22 to July 12-13				July 12-13 to Aug. 2-3				Aug.2-3 to Aug. 23				Aug. 23 to Sept. 6-7			
Campgrounds*	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Vagrant Impacts																				
Axe cuts on mature trees						x							x				x			
Branches - broken off	x								x							x		x		
- removed by axe								x					x				x			
Tree culling - seedlings						x			x	x			x					x		
- mature trees																			x	
Removal of bark									x				x							
Using trees to hang gear or clotheslines					x							x								
Litter - garbage	x	x				x		x	x	x			x	x			x	x		
- wood (half-burned logs)	x													x						
Chopping and stacking firewood in the periphery					2															
Storing equipment in periphery (barbeques, picnic tables)					x				x							x				
TOTALS	3	1			4	3		2	5	2		1	5	2		2	3	3	1	

* Campgrounds Number 1 = Lakeshore
2 = Overflow
3 = Lone Island Lake
4 = Opapiskaw

CHAPTER FIVE

DISCUSSION OF THE PERIPHERAL DISTURBANCE STUDIES

An examination of the effects of campers' use on vegetation in the Whiteshell Provincial Park campgrounds has provided information useful in indicating the degree of disturbance occurring in the peripheral area of a campsite. These included:

a) the six indicator species which showed decreases in the number of individuals as a result of the impact of campers and/or the natural life cycle of the species,

b) the presence of new paths located beyond the campsites and leading into the previously undisturbed periphery,

c) the process of soil scuffing and erosion which took place on paths and in rock outcrop areas, and

d) the various vagrant impacts such as tree culling and branch removal which damaged the natural vegetation cover in the periphery.

The observation of these effects is an important finding for this thesis because it illustrates that recreational use is not being confined to the campsites themselves, but is spreading into the area beyond and between campsites. Long-term effects of this impact can result in deterioration in the peripheral area and represents an encroachment on more and more of the natural environment of the park.

One of the beneficial aspects of disturbance in the peripheral area is that use of this space opens up the natural forest canopy and the addition of light at ground level can stimulate growth of a number of species. This effect was found in the present study by comparing numbers of species in the control plots to those found in the sample relevés. Table 10 shows that disturbance in all four campgrounds had a significant effect on increasing species diversity. For example, the Lakeshore Campground had forty-five species in the sample relevés and only five species in the control plot. Lone Island Lake Campground contained twenty-nine more species than its control plot, the Overflow Campground had twenty-three more species and Opapiskaw Campground had twenty-seven more species. Differences in the numbers of species found in the tree layer could be attributed to revegetation schemes or to natural succession, but the diversity in ground cover is a result of the addition of light and changes in habitat conditions resulting from the presence of the campground.

This diversity of ground cover species was also noted by Hoffman et al., 1975 in the Rushing River Provincial Park study (Fig. 15). These researchers found that there was a gradient of decreasing impact from the campsite into the peripheral area, with the zone nearest to the gravel pad (Zone A, Fig. 15) being barren of vegetation cover. Zone B would contain 'weedy' or more resistant species and as impact decreased, natural vegetation would again dominate. This diagram, therefore, represents conditions for the Rushing River ecosystem where recreational impact has been intensive. According to the results of the present study, even the intensively used Lakeshore Campground contained a mixture of ground level and tree species directly adjacent to the gravel pad, as in relevé no.1. Therefore, Zone B would likely replace the bare soil of Zone A in this campground.

TABLE 10 : INCREASE IN SPECIES DIVERSITY SHOWN BY COMPARING SPECIES IN THE CONTROL PLOTS WITH THE SAMPLE RELEVÉS*

Campground	Stratum	Control Plot	Sample Plot	Difference
Lakeshore	Tree	2	4	+2
	Shrub	0	4	+4
	Herb	2	32	+30
	Moss & Lichen	1	5	+4
	Total	5	45	+40
Overflow	Tree	1	1	0
	Shrub	2	3	+1
	Herb	3	24	+21
	Moss & Lichen	0	1	+1
	Total	6	29	+23
Lone Island Lake	Tree	2	4	+2
	Shrub	0	5	+5
	Herb	3	24	+21
	Moss & Lichen	1	2	+1
	Total	6	35	+29
Opapiskaw	Tree	2	3	+1
	Shrub	0	4	+4
	Herb	4	20	+16
	Moss & Lichen	0	6	+6
	Total	6	33	+27

*Actual species lists are found in Appendices 3, 4, 5 and 6.

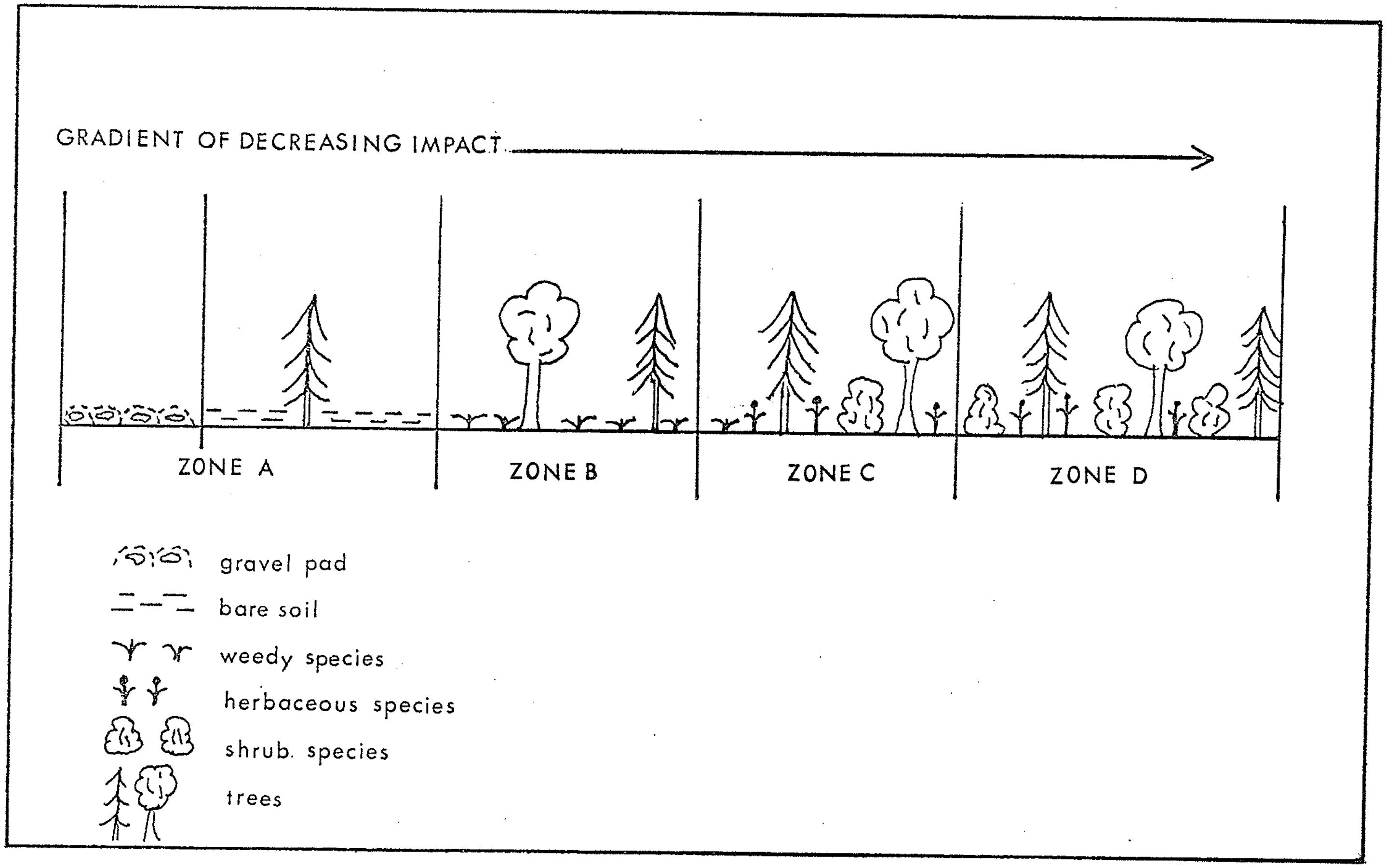

Fig. 15 Recreational impact on peripheral vegetation in Rushing River Provincial Park, Ontario. (after : Hoffman et al., 1975).

This discrepancy points to the fact that there are many factors responsible for the degree of disturbance occurring around campsites. For example, 'human disturbance' factors such as the number of years that a campground has been operating, and the intensity and type of use it has experienced can affect the amount of disturbance occurring there.

Most of the disturbance noted in this study took place in campgrounds which had experienced recreational use over a long period of time, specifically the Lakeshore Campground which was established in 1957 and Opapiskaw Campground, established in 1964. For example, of all of the vagrant impacts which were recorded in Table 9, the Lakeshore Campground contained the majority. This campground has experienced near capacity use for many years as was illustrated by the statistics of average occupancy in the campground for July and August (Table 1), and this intensity is reflected in the spread of impacts into the periphery of campsites. It is also important to note that many of the sharpest declines in the indicator species took place in the Lakeshore Campground, indicating that intensive use over the last twenty years has resulted in many impacts beyond the campsite margins.

Human disturbance factors are not the only factors responsible for the degree of deterioration that can result from the use of campgrounds. 'Environmental' factors such as soil type, soil depth, the amount of vegetation cover, and the drainage also contribute to the degree of disturbance that can occur in a natural environment. Some ecosystems contain well-developed soil profiles, have good drainage and are able to support dense vegetation growth, and are termed 'hardy' ecosystems for the purposes of this study. The opposite type of ecosystem would be a 'fragile' one, and is here defined as an ecosystem of thin soil cover, with poor drainage and only capable of supporting a sparse cover of vegetation. Using these criteria, the Lakeshore Campground could be termed a hardy ecosystem in comparison to the shallow soil cover and bedrock outcrops of the more fragile ecosystem found at Opapiskaw Campground. This can be illustrated by the following example. One person walking on the thin protective soil layer of a rock outcrop in Opapiskaw may loosen the edges of the soil and expose it to erosion by wind and rain. On a hardier ecosystem of grass or other vegetation cover, such as the Lakeshore Campground, one person may have little noticeable effect on the ecosystem. This idea has been supported by the work of Willard and Marr (1970) who studied an alpine-tundra landscape and found that concentrated walking in this fragile ecosystem was responsible for reducing the vegetation cover, eliminating certain lichen species, and actually destroying some ecosystems in as little as two weeks.

The final type of factors that can influence the degree of disturbance occurring in the peripheral areas of campgrounds are 'planning and design' factors. The amount of use a natural area can support has been discussed in Chapter One as its carrying capacity. It would be of great benefit to park planners if the carrying capacity of each type of ecosystem was known. Due to the complexity of the make-up of each type, this information is very difficult to determine. Often the carrying capacity is simply implied by the number of campsites decided upon by park planners in the initial stages of campground design. This important decision is usually based on a combination of factors, such as: the demand for a number of new campsites in an area, economic constraints for the development, and the capability of an area to support a campground. Often the emphasis is placed on the first two factors and the natural environment receives little, or insufficient consideration. Capacities based on demand for new campsites are not always the best measure of carrying capacity, and the result is often physical deterioration of the natural environment.

Design factors are also responsible for the environmental deterioration that occurs in the periphery of campsites. Some authors feel that much of the indiscriminant trampling and damage that occurs in campgrounds can be avoided by designing campgrounds with such features as : trails that go where people want to walk; natural or artificial barriers; and tables, washrooms and other facilities arranged in careful relation to each other (Tocher et al., 1965).

In conclusion, the interrelationships between the human disturbance, environmental and planning and design factors are responsible for the degree of disturbance occurring in the peripheral areas of campsites, and these can be summarized by the simple diagram shown in Fig. 16. The following chapter uses an example of a new campground at Black Lake in Nopiming Provincial Park to predict how these factors can influence the amount of disturbance occurring in the campground's periphery.

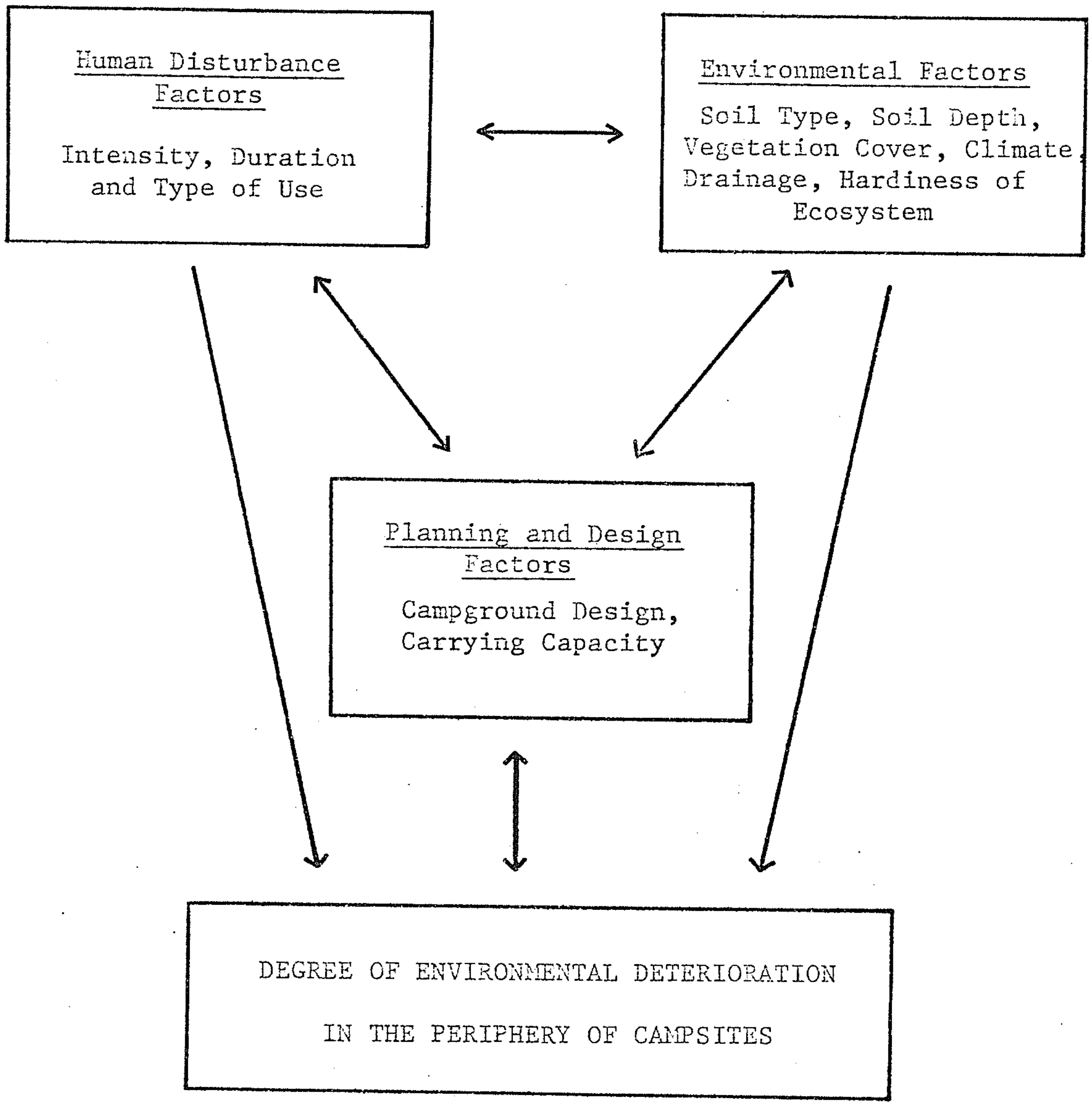

Fig. 16 Factors influencing the degree of environmental deterioration occurring in the periphery of campgrounds. The effects of campground use on the periphery of campsites is a function of the human disturbance, environmental, and planning and design factors listed above. For example, a high intensity of use over a short period of time will have more severe effects in a 'fragile' environment than the same intensity and duration of use in a 'hardier' environment.

CHAPTER SIX

APPLICATION OF THE APPROACH TO PARK PLANNING - THE CASE OF BLACK LAKE CAMPGROUND

The purpose of this chapter is to analyze how the physical environment and the design of a campground can influence the disturbance to the natural environment by using the example of a newly constructed campground at Black Lake in Nopiming Provincial Park, whose location is shown in Fig. 2. Since this campground was not opened for recreational use until June, 1978 the human disturbance factors of intensity and duration of use are as yet unknown. This, then, provides the opportunity to closely examine how the other two factors can influence future disturbance to the peripheral areas of campsites at Black Lake.

6.1 Environmental Considerations at Black Lake Campground

The natural environment at Black Lake Campground will be a strong factor in influencing the amount of deterioration that will result from use of the campground. The dominant tree layer of mature jack pine is closely spaced and thus allows little light to penetrate to ground level. Needle litter and moss provide most of the ground cover, but herbaceous species such as wild strawberry, bunchberry, vineleaf petasites and leatherleaf are also found in more open areas. Results from the study in the Whiteshell Provincial Park have shown that disturbance often increases the number of species making up the ground cover, and it can therefore be predicted that the construction of the campground and the effects of disturbance by campers will promote the growth of a more diverse vegetation layer at ground level. Since several of these species are similar to the indicators of disturbance discussed in Chapter Four, specifically wild strawberry and bunchberry, monitoring the growth or decline of these species in the peripheral areas could be useful to give indications of the degree of disturbance which might occur here.

Another element of Black Lake's environment that will affect the amount of deterioration is that of its thin soil. For example, Test Hole No.1, located at the western edge of the campground (Fig. 17) indicates that the soil depth to bedrock is 1.83 metres, and in the eastern edge at Test Hole No.6, the depth is only 0.31 metres (Manitoba, 1977A). Disturbance in and around campsites in the areas that have thinnest soils will promote a loss of ground cover and result in soil erosion similar to that found in Opapiskaw Campground (Fig. 14). Thus, with a shallow layer of sandy, well-drained soil overlying bedrock which outcrops in many places, and with a dense vegetation cover of one mature species, Black Lake Campground is set in a very fragile environment.

The amount and rate of deterioration that will result from human use of this ecosystem will depend on the intensity of use experienced there. A high intensity over a short period of time would be expected to produce a great amount of environmental deterioration in the campground. A lower intensity of use would not cause as much deterioration, and the effects of disturbance could likely be sustained over a longer period of time before the natural environment would show obvious signs of deterioration. Without knowledge of actual usage, these predictions cannot be very specific. However, certain features of the campground's design provide insight into how and where the

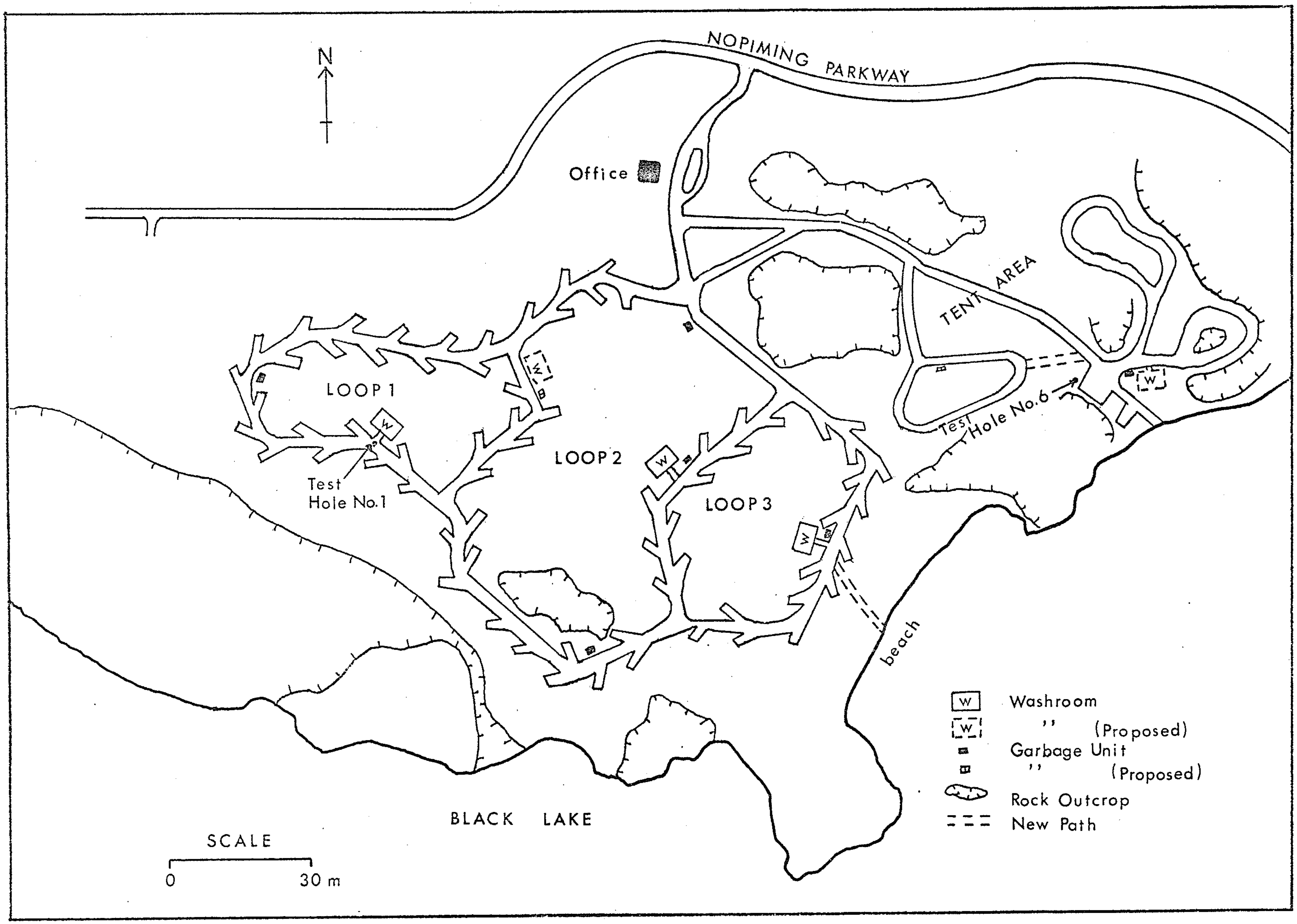

Fig. 17 Design of Black Lake Campground. (after Manitoba, 1977A)

effects of disturbance will be felt in this campground, and these will now be discussed.

6.2 Features of the Campground's Design and Some Predictions of the Effects of Campground Use on the Natural Environment of Black Lake Campground

The site selected for the campground at Black Lake has several advantages. It is situated on Black Lake with potential areas for two beaches and a boat ramp. It has good access to the Nopiming Parkway, the only road through the park at this time, and provides a central node for the further development of the park.

Figure 17 shows a representation of the layout of the campground as it was recently constructed. Two areas are provided for camping, the main area designed for tent and trailer camping, and the eastern section for tents only. The main area has three features :

i) one-way roads which are 3.7 metres wide as opposed to the two-way roads which are 6.7 metres wide. These are designed to cut traffic flow in front of the campsites and thus allow more privacy and reduce noise;

ii) gravel spurs on each campsite in a wedge shape to accomodate trailer door swings. These are located at a 45 degree angle to the roadway to allow easier backing onto the sites; and

iii) primitive facilities, i.e. non-modern washrooms and water taps located at three central locations, and seven bear-proof garbage units. No electricity or water is provided at the sites.

The tenting area does not feature designated camping sites as yet, but will allow approximately four sites per loop. One washroom and garbage unit will be provided in this area.

Several aspects of this design suggest implications for impact that could be expected in the periphery of campsites and thus, require further elaboration.

6.2.1 Loop Design

The loop design is probably the most economical and efficient way of making use of this parcel of land. One of the advantages stated for this design is that "loops or portions may be closed off for regeneration" if necessary (Manitoba, 1977A). In theory this idea is appealing, but in reality, a jack pine stand would take more than fifty years to regenerate if conditions were favourable, and it is highly unlikely that a significant portion of this campground would be closed for that length of time for re-planting.

Another aspect of the loop design was studied by Hoffman et al. (1975) who found that campsites located in loops are often the most degraded sites in the campground because of their "overlapping impact zones". A study of the zone of disturbance around campsites in Rushing River Provincial Park found that the average diameter of high impact areas was thirteen to twenty metres if traffic was not constrained by barriers (James et al., 1976). They suggested that a buffer zone of ground vegetation between adjacent campsites could be maintained if the minimum distance between sites was about thirty metres. Most of the campsites in Black Lake are approximately thirty metres apart, but in the intersections and corners of the loops, the location of the sites causes several overlapping impact zones (Fig. 17). Since the Rushing River study was done in an ecosystem similar to that of Black Lake, it would be advisable to maintain at least thirty metre spacing between sites. The Rushing River study also suggested that campsites experiencing higher use, for example near the beach or near facilities, should be wider apart. The idea of wider spacing may have particular significance to the natural environment of Black Lake where the mature jack pine are established on shallow, sandy soils. By constructing the campground in a previously closed forest canopy, an artificial wind tunnel effect is often created, and this phenomenon known as windthrow could result in the toppling over of trees rooted on shallow soils or where root systems were undercut during construction of the campground. Windthrow of trees is a common occurrence at Rushing River, especially in the jack pine community studied by Hoffman et al. (1975). During one windstorm in August, 1973 they report 300 to 400 trees fell. This, then should be another consideration for the spacing of campsites in this type of ecosystem.

6.2.2 Gravel Pads for Each Campsite

The actual campsites were field-checked during the construction phase by the Landscape Architect, and in this way, mature trees were left to form natural barriers around the sites. Each spur was gravelled, which provides a hard surface for trailers but is not as ideal for pitching a tent. With a spongy ground cover of needles and moss around most sites, and little in the way of a natural vegetation barrier to prevent use, it is very likely that tents will be set up in the peripheral area around campsites. This could result in a loss of the protective litter layer around the sites, and would hasten the process of erosion. This process was observed in the Lakeshore Campground in relevé no.7 and in Lone Island Lake Campground in relevé no.12, where the results of pitching tents in the periphery had killed many ground species and exposed the soil. In a fragile environment such as that of Black Lake, the removal of even needle litter and moss in the periphery of the campsites could have a noticeable effect on the natural environment by promoting soil erosion. It has been found that pine litter accumulation to a depth of only 1.3 centimetres can halt soil movement and control surface runoff (McClurkin, 1970). Therefore, in Black Lake it is important to confine users to their own sites and direct their movements within the campground to protect the existing ground cover.

6.2.3 The Tenting Area

The tent area is located amidst five rock outcrops (Fig. 17). At Test Hole no.6 the soil depth was only 0.31 metres, indicating that this is a potentially fragile part of the campground. The effects of human impact there are likely to be very similar to the findings in Opapiskaw Campground in relevé no.20, the rock outcrop. Decreases in cover here were attributed to the combined effects of trampling and scuffing of the soil cover which loosened the edges, and promoted erosion on the surface by wind and precipitation. When the rock becomes exposed in this way, the process is accelerated because the bare surface is no longer able to absorb the precipitation, and allows runoff to undercut soil and vegetation left on the outcrop. The tent area of the campground , even though it is exposed to the lake, will be an attractive area for tent users, and should be managed with extreme caution. A number of "bald hills" in this area would not be disirable aesthetically and would contradict the park's policy of preservation and conservation. Therefore, camping use in this area should be watched carefully. If the sites are found to be deteriorating rapidly, then the loop design will prove advantageous for closing off one or all three of these loops to camping.

6.2.4 Location of Facilities

One of the reasons impacts occur in areas between and around campsites is that people require access to facilities. There are three washroom and water taps located in the campground (Fig. 17). Due to the lack of undergrowth, these facilities will be clearly visible to campers in many parts of the loop. People take the shortest, most direct route to their destination (Scott-Williams, 1967) and with little in the way of a vegetation barrier to confine their movement, radial paths may be expected to develop (Fig. 18). Hopefully, by locating the washrooms near the roadway and not in the centre of the loops, this path development may be minimized and this may be aided by the addition of two more washrooms in the campground. One should be located at the western edge of Loop 2 to provide access to users in this part of the campground, and one should be established in the tenting area (see Fig. 17 for the changes). On Black Lake's ground cover of needle litter and moss, it would not take a long time or intensive use of the area before the soil would be exposed to erosion. It is thus important to direct movements within the campground where possible. By providing more facilities, the distance

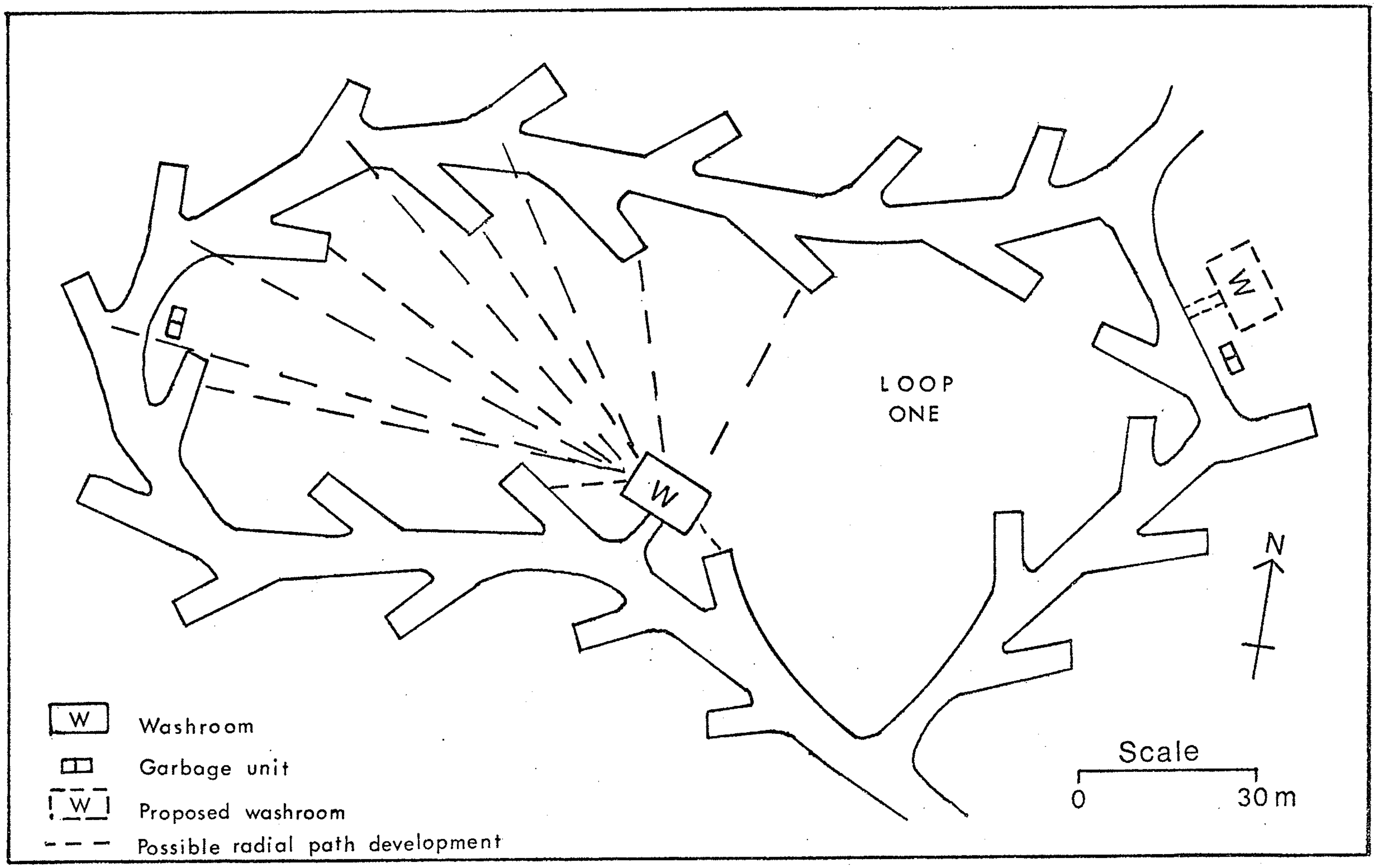

Fig. 18 Radial path development in Black Lake Campground. With little undergrowth to block the view of the facilities or inhibit movement, paths similar to the locations sketched above may be expected to develop.

needed to travel by each camper will be minimized and may lessen the chances of radial path development. Another change that would aid this movement is for the park's personnel to construct at least two more access paths with durable surfaces, such as sand or gravel. These are located on Fig. 17 with dotted lines, one providing access to the facilities on Loop 4, and one at the beach, providing both access to the beach from the campground and from the beach to the facilities. A final change to the design should be the addition of two more garbage units in the tenting area, so that campers would not have to travel great distances to deposit their litter.

6.3 Conclusions Regarding Black Lake Campground

The example of Black Lake Campground illustrates how the elements of the campground's design and the type of natural environment in an area can have a bearing on the spread of disturbance into the peripheral zone of campsites. Any disturbance of a natural area will have an effect on an ecosystem, and even a low intensity of use in a fragile environment such as Black Lake can be expected to cause significant changes to that environment.

The numerous outcrops found in the area provided obstacles to the campground design. A plan which originally called for 150 campsites (Manitoba, 1975B) had to be reduced to sixty-nine sites in the main camping area, and approximately twelve in the tenting area, for a total of eighty-one sites. Information on soil depth was crucial to the development of the tenting area, and field-checking in the construction stages was needed to preserve the natural surroundings of the campground. In this way, the important role of ecological input into the planning stages of campground development was permitted.

A study of the impact of recreation on the jack pine species itself was undertaken by Monti et al. (1977) . The researchers found that there was increased root exposure with increasing duration and intensity of use. This was correlated with soil compaction and erosion with the result that trees were exposed to drought and to the effects of windthrow as a result of recreational use. They also found that the resins and waxes exuded from the trunk of jack pines following trunk scarring forms an effective barrier to infection (Monti et al., 1977). Thus, the dominant vegetation of Black Lake may be able to withstand recreational impact if it is not intensive. However, the effects of deterioration in the periphery should be observed over time so that the dominant tree cover is not the only vegetation remaining in the future. This could be facilitated by monitoring several indicator species, such as wild strawberry and bunchberry. The delicate covering on the bedrock outcrops can be easily disturbed by trampling, and in parts of the campground where outcrops may be crossed by people, particularly in the tent area, rapid deterioration may require the construction of vegetation or other types of barriers to direct movement within the campground.

Maintaining Black Lake Campground in a natural state is necessary to meet the aims of park policy. Here, a recreational opportunity will be provided for its users in an area which will be preserved in as near a natural state as possible. It is difficult to predict the amount of use that the campground will experience. Offering only primitive facilities to the user, it will not attract all types of campers, but because of capacity use in most other Whiteshell Provincial Park Campgrounds, it is expected that this new area will attract some of the campers who normally utilize the campgrounds further south.

In the long term, the intensity of use that the campground at Black Lake experiences will be the most important factor influencing the spread of disturbance into the peripheral area of the campsites. Observations of these impacts could be used by park planners and managers to indicate where problems of environmental deterioration are becoming most critical. For example if a number of paths are leading to the same destination, causing an artificial scarring on the ecosystem, then perhaps a more durable path could be effectively located to channel the movements of users. Often, observations will point to other solutions such as the provision of another garbage unit to lessen the problem of litter. It is therefore important to monitor the types of impacts that can occur in the peripheral area of the campsites, such as those described in Chapter Four, in order to find solutions which would curb the encroachment caused by human use of a natural area on the rest of the park.

Planning a recreational area in the midst of a provincial park involves trade-offs between a number of factors, but if the park is to truly "conserve and manage the flora and fauna therein" (Manitoba, 1972B) then it must be developed in a way that upholds this policy.

CHAPTER SEVEN

SUMMARY AND CONCLUSIONS

7.1 Summary

The primary purpose of this thesis has been to analyze the types of impacts occurring in the peripheral area of campsites in four campgrounds in the Whiteshell Provincial Park in order to examine the nature of the spread of human influence into this part of the natural environment. Using the relevé method of vegetation sampling, changes in numbers of individuals of six indicator species were monitored between June 1 and September 7, 1977. A pattern of decrease in numbers was observed for four of these species and was attributed to a combination of factors such as: the direct trampling of vegetation; changes in habitat conditions due to human disturbance in the relevés; and the natural life cycle of the species. Two other indicator species, meadow rose and wild strawberry, appeared to be able to tolerate disturbance, and this was indicated by their ability to grow new foliage at different times during the growing season after damage had been caused by the presence of campers.

These changes occurred over only one summer and one can anticipate that over a longer period of time, human disturbance can lead to the permanent removal of vegetation cover around campsites, which in turn promotes soil erosion and can affect both the overall appearance of the campground and the growth and vitality of species within its periphery. The problem has been recognized in a number of studies which have shown that intensively used camping areas are having severe effects on the condition of the natural environment (Magill and Nord, 1963; Dotzenko et al., 1967; Lesko and Robson, 1975). The problem of widespread environmental deterioration was also noted in several campgrounds in the Whiteshell Provincial Park where intensive use of campgrounds such as the Beach and Brereton Lake Campgrounds has led to the removal of ground cover around campsites and a lack of vegetation other than the dominant tree layer.

Changes in vegetation cover are not the only results of disturbance occurring in the peripheral area of campsites. Many other changes occurring in the Whiteshell Provincial Park were described in this study. For example, many paths developed as a result of people finding their own routes to a destination. Repetitive use of these paths destroys the vegetation cover and promotes soil erosion, and many were found to increase in width over the summer of 1977.

Another result of disturbance occurring in the peripheral area of campsites was the presence of large areas of crushed vegetation where tents had been erected. Examples of this were seen in the Lakeshore and Lone Island Lake Campgrounds in the present study. Repeated use of these areas also destroys the ground cover, promotes soil erosion and results in large areas of bare soil adjacent to campsites and spreading into the forest margin.

There was also considerable evidence of what may be termed vagrant impacts. These were defined as acts of vandalism or other behaviour which causes damage to the natural park environment and observations of these impacts in the Whiteshell Provincial Park included tree and branch cutting, bark removal and trunk scarring with knives or axes, storing equipment or firewood in the area around campsites, and the presence of litter.

The third objective of this study required the examination of factors responsible for the degree of disturbance found in the periphery, and these are summarized as :

1. Human Disturbance Factors : The duration of the campground's use, the intensity of use experienced, and the type of user can affect the amount of environmental deterioration occurring in the periphery of campsites. Older campgrounds experiencing capacity or near-capacity use often show the most signs of disturbance. For example, the Lakeshore Campground in the Whiteshell was the oldest used in the study, and showed more effects of human disturbance that did the more recently established campgrounds.
2. Environmental Factors : The physical characteristics of a campground's environment, such as the soil type, soil depth, vegetation cover, climate and drainage can influence the amount of disturbance. A hardier ecosystem can tolerate more intensive use for a longer period of time without showing signs of environmental deterioration, while a fragile ecosystem does not react in the same way. A soil erosion study in Opapiskaw Campground was used as an illustration of a fragile ecosystem, where a low intensity of use caused noticeable changes in the soil cover over only one season.
3. Planning and Design Factors : The design of the campground was shown to be an important factor in controlling disturbance to the peripheral area. By the effective location of trails, washrooms and other facilities, and by directing traffic flow

by the use of vegetation or other types of barriers, much of the trampling of ground cover and other impacts to the periphery can be avoided.

The combination of these factors were then applied to an analysis of the newly constructed campground at Black Lake in Nopiming Provincial Park. Black Lake was considered to be a fragile ecosystem due to its numerous rock outcrops, thin sandy soil layer and dominant vegetation cover of one mature species, jack pine. By analyzing elements of the campground design such as the loop structure, the location of facilities and the area provided for tents, several predictions were made about the extent and effects of impact that could be expected in this campground in the future. The following are some of these predictions.

1. Due to the fragile nature of Black Lake's physical environment it is expected that human disturbance will result in erosion of the soil and vegetation cover of the many rock outcrops in and around the campground.

2. The opening up of the forest canopy by campground construction and human disturbance will promote a more diverse ground cover.

3. Due to a lack of undergrowth, radial path development will take place within the loops.

4. Tent erection in the periphery could result in removal of the needle litter and moss cover, thereby promoting erosion.

The extent of the effects of disturbance at Black Lake will depend on the intensity of use experienced in the campground. It is suggested that the populations of certain vegetation species such as wild strawberry and bunchberry be monitored as indicators of the degree of disturbance occurring in the periphery. Other types of disturbance, such as the presence of areas devoid of vegetation, paths and vagrant impacts can also be monitored to indicate the extent of human influence occurring in this campground, so that permanent deterioration can be avoided.

7.2 Conclusions

The spread of human disturbance into the periphery of campsites in the Whiteshell Provincial Park has taken its toll on the natural environment. Over time as the sphere of human influence expands into more and more of the natural park environment, the three aims of park policy, namely conservation, preservation and recreation, begin to conflict. An effectively designed campground should therefore contain the activities of its users, and channel impact into desired areas. Often carrying capacities of campgrounds are exceeded and the result of too many people using the area is seen in the spread of disturbance into the forest margins. This spread can adversely influence the condition of the park environment in the future.

Setting the limits for the carrying capacity of a campground is a very important planning decision because the amount of use inferred by the provision of campsites has been shown to have important effects on the natural environment. Often the decision for the number of new campsites is based on demand and not on what the physical environment can support. The end result is reflected in the overused appearance of many campgrounds.

There is a need, therefore, for a type of classification scheme which could be used as a guide for determining the amount of recreational use an ecosystem can support before irreversible damage is done to that environment. This is a complex task, and has to consider such elements as the dominant vegetation cover of the area under study, its soil type and depth to bedrock, its drainage and its climate. By developing a scheme based on these factors, the hardiness of an ecosystem can be defined, and guidelines as to the carrying capacity of each ecosystem could be derived. In this way an effective campground design based on sound ecological information could be developed, rather than designing the campground to meet a demand for new campsites based on a forecast of predicted usage alone.

Many authors, such as Theberge (1976) have called for more ecological input into the planning stages of park development. As early as 1964 Wagar stated that :

> We still tend to think of recreation primarily in terms of access rather than as something to manage on a sustained basis.
>
> (Wagar, 1964)

Thus, the problem of environmental deterioration resulting from recreational use has been noticed for a long period of time, and probably due to the complexity of setting precise limits for the carrying capacity of the many different environmental types, no system that is widely applicable has been developed as yet.

In campgrounds were evidence of the spread of impacts presently can be found, several things can be done if it is desired to try and maintain the campground in as natural a state as possible.

The types of impacts occurring in the periphery of campgrounds discussed in this thesis can be used as indicators of the degree of disturbance occurring beyond the campsite. For example, the observation of paths located in the periphery can be analyzed to find out where they lead and why. In the Lakeshore Campground where many paths were scattered between Bay One and the amphitheatre (Fig. 3) the effective location of one durable path would be the suggested solution.

Other effects such as large areas of crushed vegetation where tents have been erected, or bare patches of soil caused by trampling and/or erosion may suggest other solutions such as the planting of vegetation barriers or the seeding of an area to promote a more durable grass cover. These types of solutions are not always feasible, or desired in many campgrounds, but are mentioned here as an illustration of ways in which these types of impacts *could* be useful to the management of natural areas at the present time, or for the future planning and design of camping areas. With more information on the natural environment in the early stages of campground planning, many of these repair tactics would be unnecessary. Design based on carrying capacity determined by a classification scheme such as the one described previously would insure an understanding of the site chosen for the campground. During the construction phase field checks are necessary so that the natural environment can be preserved around the campsites, and can thus assist in directing the way in which the campground will be used in the future. Also during field checking, areas unsuitable for camping, such as marshy areas can be avoided. Without the actual field observations, development of more fragile areas such as rock outcrops and areas of shallow soil may take place, and this may have irreversible effects on the appearance of the campground in the future.

Finally, if the policy aims of preservation, conservation and recreation are to be realized in parklands, then campground development must take place with a clear understanding of the role of human disturbance in this part of the natural environment in parks. It is hoped that this thesis has contributed knowledge to this end.

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APPENDICES

APPENDIX 1 - AUTHORITIES AND COMMON NAMES OF PLANT SPECIES MENTIONED IN THIS THESIS

Species	Common Name
Abies balsamea (L.) Mill.	Balsam fir
Acer spicatum Lam.	Mountain maple
Actaea rubra (Ait.) Willd.	Red baneberry
Alnus crispa (Ait.) Pursh	Green alder
Amelanchier sanguinea (Pursh) DC.	Roundleaf serviceberry
Apocynum androsaemifolium L.	Spreading dogbane
Aquilegia canadensis L.	Canada columbine
Aralia nudicaulis L.	Wild sarsaparilla
Betula papyrifera Marsh.	White birch
Chamaedaphne calyculata (L.) Moench	Leather-leaf
Cirsium arvense (L.) Scop.	Canada thistle
Cladonia rangiferina (L.) Web.	Reindeer-moss
Cornus canadensis L.	Bunchberry
C. stolonifera Michx.	Red-osier dogwood
Corylus cornuta Marsh.	Beaked hazel
Diervilla lonicera Mill.	Bush-honeysuckle
Equisetum sylvaticum L.	Woodland horsetail
Fragaria virginiana Duchesne	Wild strawberry
Gaultheria procumbens L.	Wintergreen
Geranium bicknellii Britt.	Bicknell geranium
Gramineae spp.	Grasses
Halenia deflexa (Sm.) Griseb.	Spurred gentian

...continued

APPENDIX 1 - CONTINUED

Species	Common Name
Hylocomium splendens (Hedw.) BSG.	Mountain fern moss
Lathyrus ochroleucus Hook.	Creamy peavine
Lilium philadelphicum L.	Wood lily
Linnaea borealis L.	Twinflower
Lycopodium clavatum L.	Running clubmoss
L. complanatum L.	Ground-cedar
L. obscurum L.	Ground-pine
Myrica gale L.	Sweet gale
Peltigera aphthosa (L.) Willd.	Spotted peltigera
Petasites palmatus (Ait.) Grey	Sweet petasites
P. vitifolius Greene	Vineleaf petasites
Picea glauca (Moench) Voss	White spruce
Pinus banksiana Lamb.	Jack pine
P. resinosa Ait.	Red pine
Polygonum cilinode Michx.	Fringed bindweed
Polytrichum juniperinum Hedw.	Juniper hair-cap moss
Populus balsamifera L.	Balsam poplar
P. tremuloides Michx.	Trembling aspen
Pteridium aquilinum (L.) Kuhn	Bracken fern
Rhytidiadelphus triquetrus (Hedw.) Warnst.	Shaggy moss
Ribes hirtellum Michx.	Bristly gooseberry
R. oxyacanthoides L.	Northern gooseberry
R. triste Pall.	Bitter currant
Rosa blanda Ait.	Meadow rose

...continued

APPENDIX 1 - CONTINUED

Species	Common Name
Rubus chamaemorus L.	Cloudberry
R. pubescens Raf.	Dwarf raspberry
R. strigosus Michx.	Wild red raspberry
Rumex mexicanus Meisn.	Narrow-leaved dock
Salix bebbiana Sarg.	Beaked willow
Sarracenia purpurea L.	Pitcher-plant
Selaginella rupestris (L.) Spring	Spikemoss
Smilacina stellata (L.) Desf.	Starry smilacina
S. trifolia (L.) Desf.	Threeleaf smilacina
Taraxacum officinale Weber	Dandelion
Vaccinium myrtilloides Michx.	Sour-top blueberry
Viburnum edule (Michx.) Raf.	Squashberry
V. rafinesquianum Schultes	Downy viburnum

APPENDIX 2 - CONSTANCY TABLE RESULTS FOR THE LAKESHORE, OVERFLOW, LONE ISLAND LAKE AND OPAPISKAW CAMPGROUNDS

Stratum	Species	Visits[1]	Lakeshore (7 Relevés)						Overflow (4 Relevés)						Lone Island Lake (3 Relevés)						Opapiskaw (4 Relevés)					
			1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Tree	*Abies balsamea*		6	6	6	6	6	6							1	1	1	1	1	1	2	2	2	2	2	2
	Betula papyrifera		2	2	2	2	2	2							2	2	2	2	2	2						
	Picea glauca																				2	2	2	2	2	2
	Pinus resinosa		1	1	1	1	1	1							1	1	1	1	1	1						
	Populus balsamifera		3	3	3	3	3	3							1	1	1	1	1	1						
	P. tremuloides								4	4	4	4	4	4							1	1	1	1	1	1
Shrub	*Abies balsamea*		6	6	6	7	7	7													1	1	1	1	1	1
	Alnus crispa														1	1	1	1	1	1						
	Apocynum androsaemifolium														1	1	1	1	1	1						
	Betula papyrifera																							1	1	1
	Corylus cornuta		1	2	2	2	2	2	2	2	2	2	2	2			1	1	1	1						
	Picea glauca				1	1	1	1							1	1	1	1	1	1						
	Populus balsamifera		1	1	0	0	0	1													1	1	1	1	1	1
	P. tremuloides								1	1	1	1	1	1							1	1	1	1	1	1
	Salix bebbiana														1	1	1	1	1	1						
	Viburnum rafinesquianum								1	1	1	1	1	1												

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[1]Visits refer to: 1 - June 1-2; 2 - June 21-22; 3 - July 12-13; 4 - Aug. 2-3; 5 - Aug. 23; and 6 - Sept. 6-7, 1977.

APPENDIX 2 - CONTINUED

Stratum	Species	Visits	Lakeshore (7 Relevés) 1	2	3	4	5	6	Overflow (4 Relevés) 1	2	3	4	5	6	Lone Island Lake (3 Relevés) 1	2	3	4	5	6	Opapiskaw (4 Relevés) 1	2	3	4	5	6
Herb	*Abies balsamea*		5	5	5	4	4	4							1	1	1	1	1	1	2	2	2	2	2	2
	Acer spicatum			1	1	1	1	1																		
	Actaea rubra				1	1	1	1																		
	Amelanchier sanguinea														2	2	2	2	2	2		1	1	1	1	1
	Apocynum androsaemifolium														3	3	3	3	3	1	1	1	1	1	1	0
	Aquilegia canadensis								1	1	1	1	1	1												
	Aralia nudicaulis		5	5	5	5	5	5	1	0	1	2	2	1	2	2	2	2	2	2	2	3	3	2	2	2
	Betula papyrifera		1	1	1	1	1	1										1	1	1	1	1	1	1	1	1
	Cirsium arvense								1	2	2	2	2	2												
	Cornus canadensis		6	6	6	6	6	6	1	1	1	1	1	1	3	2	2	2	3	3	1	1	1	1	1	1
	C. stolonifera		1	1	1	1	1	1	1	1	1	1	1	1												
	Corylus cornuta		1	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1
	Diervilla lonicera		3	3	3	3	3	3							1	1	1	1	1	1	2	2	2	2	2	2
	Equisetum sylvaticum		1	1	2	1	1	0	4	4	4	2	2	3	1	1	1	0	0	0						
	Fragaria virginiana		4	4	3	3	4	5	4	3	3	4	4	4	2	2	2	1	1	1	1	1	1	1	1	1
	Gaultheria procumbens														2	2	2	2	2	2						
	Geranium bicknellii																				2	2	2	1	1	0
	Gramineae		7	7	7	7	7	7	4	4	4	4	4	4	3	3	3	3	3	3	3	3	3	3	3	3
	Halenia deflexa																				1	1	1	0	0	0
	Lathyrus ochroleucus		2	2	3	4	3	4	3	4	4	4	4	3	2	2	2	2	2	0	1	1	1	1	1	1
	Lilium philadelphicum		1	3	3	2	2	2		2	2	2	2	2	1	2	2	2	2	0						
	Linnaea borealis		1	2	3	4	4	4																		
	Lycopodium clavatum			1	1	1	1	1																		
	L. complanatum		1	1	1	1	1	1							2	2	2	2	2	2						
	L. obscurum		2	2	2	3	3	3																		
	Myrica gale																				1	1	1	1	1	1
	Petasites palmatus		1	3	3	3	3	3	2	2	2	2	2	2												
	P. vitifolius		1	1	1	0	1	0										1	1	0						

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APPENDIX 2 - CONTINUED

Stratum	Species	Lakeshore (7 Relevés)						Overflow (4 Relevés)						Lone Island Lake (3 Relevés)						Opapiskaw (3 Relevés)					
	Visits	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Herb	*Picea glauca*							1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Pinus resinosa													1	1	1	1	1	1						
	Polygonum cilinode																			2	2	2	2	2	2
	Populus balsamifera	3	3	2	2	3	2																		
	P. tremuloides		1	1	1	1	1	1	2	2	3	2	2	1	1	1	1	1	1						
	Pteridium aquilinum							3	3	3	4	4	1	1	1	1	1	1	0						
	Ribes hirtellum		1	1	1	1	1													2	2	2	2	2	2
	R. oxyacanthoides							2	1	2	2	2	2												
	R. triste	1	1	1	0	0	1	1	1	1	1	1	1	2	2	2	2	2	2						
	Rosa blanda	3	5	5	5	5	5	3	4	4	4	4	4												
	Rubus chamaemorus										1	1	1												
	R. pubescens	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1						
	R. strigosus	2	2	2	2	2	2	2	2	2	2	2	2												
	Rumex mexicanus								1	1	1	1	0												
	Salix bebbiana													1	1	1	1	1	1						
	Sarracenia purpurea	1	3	3	3	3	3																		
	Smilacina stellata				1	1	0																		
	S. trifolia	4	4	4	4	4	0							3	2	2	2	2	0	3	3	3	3	2	1
	Taraxacum officinale	1	1	1	0	0	0													1	1	1	1	1	0
	Vaccinium myrtilloides		2	2	2	2	1							3	3	3	3	3	3	2	2	2	2	2	2
	Viburnum edule								1	1	1	1	1												
	V. rafinesquianum							2	2	2	2	2	2												
Moss and Lichen	*Cladonia rangiferina*			1	1	0	0									1	1	1	1	2	2	2	2	2	2
	Hylocomium splendens	3	4	4	4	4	4							1	1	1	1	1	1	2	2	2	2	2	2
	Peltigera aphthosa			1	1	1	1													1	1	1	1	1	1
	Polytrichum juniperinum	3	3	3	3	3	3							2	2	2	2	2	2	1	1	1	1	1	1
	Rhytidiadelphus triquetrus	2	4	6	6	6	6		1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1
	Selaginella rupestris																			4	4	4	4	4	4

APPENDIX 3 - SPECIES FOUND IN CONTROL AND SAMPLE RELEVÉS - LAKESHORE CAMPGROUND

Stratum	Control	Sample Relevés
Tree	*Abies balsamea*	*Abies balsamea*
Shrub		*A. balsamea*
Herb	*A. balsamea*	*A. balsamea*
Tree		*Betula papyrifera*
Herb		*B. papyrifera*
Herb		*Populus tremuloides*
Tree	*Populus balsamifera*	*P. balsamifera*
Shrub		*P. balsamifera*
Herb		*P. balsamifera*
Tree		*Pinus resinosa* (planted)
Shrub		*Picea glauca*
Shrub		*Corylus cornuta*
Herb		*C. cornuta*
"		*Lathyrus ochroleucus*
"	*Aralia nudicaulis*	*Aralia nudicaulis*
"		*Petasites vitifolius*
"		*P. palmatus*
"		*Fragaria virginiana*
"		*Rosa blanda*
"		*Smilacina trifolia*
"		*S. stellata*
"	*Cornus canadensis*	*Cornus canadensis*
"		*C. stolonifera*
"		Gramineae spp.
"		*Linnaea borealis*
"		*Diervilla lonicera*
"		*Lycopodium obscurum*
"		*L. complanatum*
"		*L. clavatum*
"		*Vaccinium myrtilloides*
"		*Equisetum sylvaticum*
"		*Lilium philadelphicum*
"		*Sarracenia purpurea*
"		*Rubus strigosus*
"		*R. pubescens*
"		*Ribes triste*
"		*R. hirtellum*
"		*Taraxacum officinale*
"		*Acer spicatum*
"		*Actaea rubra*
Moss	*Hylocomium splendens*	*Hylocomium splendens*
"		*Polytrichum juniperinum*
"		*Peltigera aphthosa*
"		*Cladonia rangiferina*
"		*Rhytidiadelphus triquetrus*

APPENDIX 4 - SPECIES FOUND IN CONTROL AND SAMPLE RELEVÉS - OVERFLOW CAMPGROUND

Stratum	Control	Sample Relevés
Tree	*Populus tremuloides*	*Populus tremuloides*
Shrub		*P. tremuloides*
Herb		*P. tremuloides*
"		*Picea glauca* (planted)
Shrub	*Corylus cornuta*	*Corylus cornuta*
Herb		*C. cornuta*
Shrub		*Viburnum rafinesquianum*
Herb		*V. rafinesquianum*
"		*V. edule*
"		*Lathyrus ochroleucus*
"		*Aralia nudicaulis*
"		*Petasites palmatus*
"		*Fragaria virginiana*
"		*Rosa blanda*
"		*Cornus canadensis*
"		*C. stolonifera*
"	Gramineae spp.	Gramineae spp.
"	*Equisetum sylvaticum*	*Equisetum sylvaticum*
"		*Lilium philadelphicum*
"		*Rubus strigosus*
"		*R. pubescens*
"		*R. chamaemorus*
"		*Ribes triste*
"		*R. oxyacanthoides*
"	*Pteridium aquilinum*	*Pteridium aquilinum*
"		*Aquilegia canadensis*
"		*Cirsium arvense*
"		*Rumex mexicanus*
Moss		*Rhytidiadelphus triquetrus*

APPENDIX 5 - SPECIES FOUND IN CONTROL AND SAMPLE RELEVÉS - LONE ISLAND LAKE CAMPGROUND

Stratum	Control	Sample Relevés
Tree	*Abies balsamea*	*Abies balsamea*
Herb		*A. balsamea*
Shrub		*Alnus crispa*
Herb		*Amelanchier samguinea*
Shrub		*Apocynum androsaemifolium*
Herb		*A. androsaemifolium*
"	*Aralia nudicaulis*	*Aralia nudicaulis*
Tree	*Betula papyrifera*	*Betula papyrifera*
Herb		*B. papyrifera*
Moss		*Cladonia rangiferina*
Herb		*Cornus canadensis*
"		*Corylus cornuta*
Shrub		*C. cornuta*
Herb		*Diervilla lonicera*
"		*Equisetum sylvaticum*
"		*Fragaria virginiana*
"		*Gaultheria procumbens*
"	Gramineae spp.	Gramineae spp.
"		*Lilium philadelphicum*
"	*Lycopodium complanatum*	*Lycopodium complanatum*
"		*Petasites vitifolius*
Shrub	*Picea glauca*	*Picea glauca*
Herb		*P. glauca*
Tree		*Pinus resinosa*(planted)
Herb		*P. resinosa*
Tree		*Populus balsamifera*
Herb		*P. tremuloides*
"		*Pteridium aquilinum*
Moss	*Rhytidiadelphus triquetrus*	*Rhytidiadelphus triquetrus*
Herb		*Rosa blanda*
"		*Rubus strigosus*
Shrub		*Salix bebbiana*
"		*S. bebbiana*
"		*Smilacina trifolia*
"		*Vaccinium myrtilloides*

APPENDIX 6 - SPECIES FOUND IN CONTROL AND SAMPLE RELEVÉS - OPAPISKAW CAMPGROUND

Stratum	Control	Sample Relevés
Tree	*Abies balsamea*	*Abies balsamea*
Shrub		*A. balsamea*
Herb		*A. balsamea*
"		*Amelanchier sanguinea*
"		*Apocynum androsaemifolium*
"		*Aralia nudicaulis*
Shrub		*Betula papyrifera*
Herb		*B. papyrifera*
Moss		*Cladonia rangiferina*
Herb	*Cornus canadensis*	*Cornus canadensis*
"		*Corylus cornuta*
"		*Diervilla lonicera*
"	*Fragaria virginiana*	*Fragaria virginiana*
"		*Geranium bicknellii*
"	Gramineae spp.	Gramineae spp.
"		*Halenia deflexa*
Moss		*Hylocomium splendens*
Herb		*Lathyrus ochroleucus*
"		*Myrica gale*
Moss		*Peltigera aphthosa*
Tree		*Picea glauca*
Herb		*P. glauca*
"		*Polygonum cilinode*
Shrub		*Populus balsamifera*
Tree	*Populus tremuloides*	*P. tremuloides*
Shrub		*P. tremuloides*
Moss		*Rhytidiadelphus triquetrus*
Herb		*Ribes oxyacanthoides*
Moss		*Selaginella rupestris*
Herb	*Smilacina trifolia*	*Smilacina trifolia*
"		*Taraxacum officinale*
"		*Vaccinium myrtilloides*