Sharp-tailed Grouse Habitat Revitalization in the Interlake Region of Manitoba

By

© Robert P. Berger

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ABSTRACT

Prairie sharp-tailed grouse (*Tympanuchus phasianellus campestris*) habitat was assessed surrounding twelve study leks in the Narcisse Wildlife Management Area (NWMA). Examination of 20 years of aerial photographic data revealed that 36% of the total prairie surrounding traditional leks was lost to aspen closed forest. Seven of the 12 study leks were abandoned during this period, three remained stable, and two new leks became active. In 1976, 13 leks were known to exist within the study area, but by 1986 only five remained. A reduction in the subpopulation of sharp-tailed grouse in the study area appeared to be related to this habitat change.

Four areas within the NWMA were selected for habitat manipulation. Traditional leks within the study area were used as models of shape, elevation and cover. Aspen forest on two historical leks and two other sites was cleared from the lek itself as well as on the periphery. Manipulation decreased aspen cover and increased grassland. This allowed grouse to use newly formed prairie-like habitat. Lek observations, flush counts and radio-tracking were used to monitor grouse use of these areas. Size, vegetation cover, and elevation of the four manipulated sites were compared to two control leks in the study area.

Habitat manipulation appeared to cause new leks to develop in spring 1987. An average of nine males were observed displaying at one manipulated site. In fall 1987 and spring 1988, an average of 12 males, dominated by adults, displayed at the site. One female was captured, and three other females were observed visiting this lek. At a second manipulated site, four males displayed in spring 1988. A third manipulated site had two broods use the area in spring through fall 1987. In spring 1988, on two occasions, 9 and 3 male grouse respectively, danced on this historical lek. The second historical lek was occupied by a single, displaying male throughout spring and summer of 1987 and 1988.

Recommendations for restoration of sharp-tailed grouse habitat include: 1) use of a bulldozer and mower in areas where other treatments such as controlled burns or herbicides are not feasible; 2) replacement leks should have prairie < 200 m and woody escape cover > 200 m from the lek center; 3) minimum size of open habitat should be 5.45 ha, although larger open areas are encouraged; and 4) habitat maintenance in the NWMA should occur once every five years, if the rate of aspen invasion continues to average two percent per year.

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Chapter I

GENERAL INTRODUCTION

1.1 INTRODUCTION

In Manitoba, continued habitat loss (the deterioration of the environment surrounding an individual organism or species) is the major factor affecting many wildlife populations (Whittaker et al. 1973, Manitoba Department of Natural Resources 1987). Efforts to reduce habitat loss and the need for wildlife species conservation, has resulted in purchase of lands in Manitoba for Wildlife Management Areas (WMAs). Wildlife Branch policy states that WMA's should be maintained for multiple public uses including aesthetic, scientific, recreational, educational and economic needs (Dixon 1979).

The Narcisse Wildlife Management Area (Figure 1.1), near Chatfield, Manitoba (50° 47'N, 97° 34'W) comprises 11,810 ha of land designated for both consumptive and non-consumptive uses (Dixon 1979). Bossenmaier and Vogel (1974) classified the NWMA as an aspen-parkland community. The NWMA's parkland is characteristic of broadleaf and mixed broadleaf-coniferous forests. Scattered among forested areas are hayfields, prairie, and swamplands, that provide

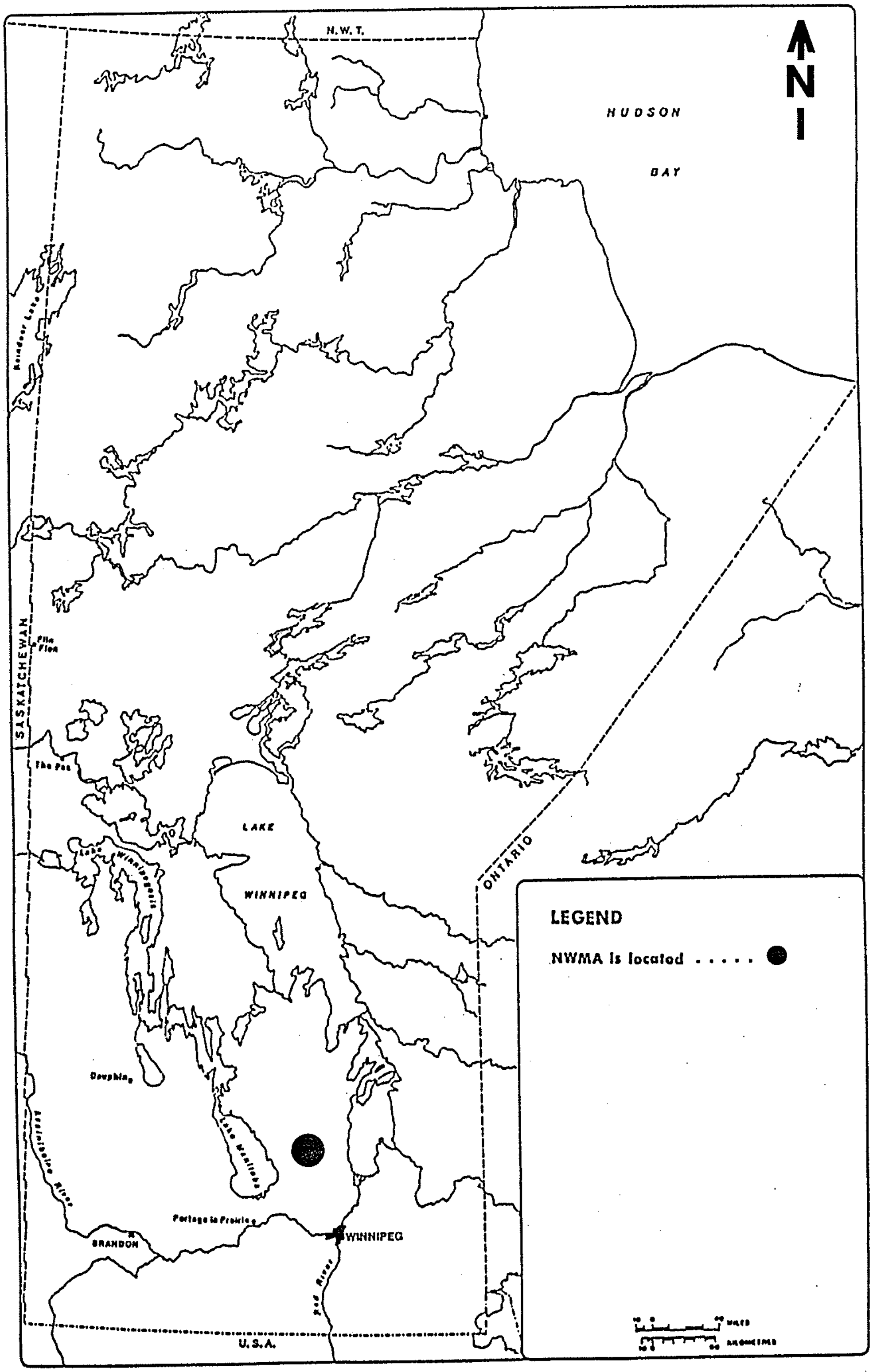

Figure 1.1: Location of the Narcisse Wildlife Management Area (50^{0} 47'N, 97^{0} 34'W) in Manitoba, Canada.

suitable habitat for many species including the prairie sharp-tailed grouse.

1.2 PROBLEM STATEMENT

Up until the mid 1970's, the diversity of the parkland within the NWMA had been maintained by natural, accidental and controlled fires, keeping the prairie relatively free of mixed wood, primarily trembling aspen (Populus tremuloides). However, fire prevention and suppression measures taken to minimize property damage and smoke nuisance in neighbouring communities, have allowed aspen to invade large areas of prairie (M. Gillespie, pers. comm.). If aspen succession continues, the diversity of the aspen-parkland will decrease, leaving habitat to wildlife species capable of surviving in a broadleaf forest.

Sharp-tailed grouse are common in the NWMA. Although aspen invasion may have increased winter forage and cover for sharp-tailed grouse, the availability of prairie needed for breeding, nesting and brood rearing activities has decreased. If succession continues under fire suppression, mature stands of aspen will replace young stands currently present in NWMA and prairie will disappear subsequently. Hamerstrom et al. (1961) note that a mature aspen forest represents suboptimal reproductive habitat for prairie sharp-tailed grouse.

1.3 OBJECTIVES

This study was designed to observe the association of aspen succession and sharp-tailed grouse subpopulation numbers, and secondly, to show what effects mechanical manipulation could have for the improvement of sharp-tailed grouse habitat.

Objectives of this research were:

1. to evaluate habitat change surrounding sharp-tailed grouse leks at the NWMA from 1965-1986 using remote sensing techniques.
2. to observe the association between habitat change, the number of sharp-tailed grouse and the total number of leks.
3. to assess the effects of bulldozing and mowing on traditional sharp-tailed grouse habitat and newly created areas.
4. to recommend techniques for the development and maintenance of sharp-tailed grouse habitat.

1.4 PRACTICUM FORMAT

The format of this practicum is a series of two papers (=chapters 3 and 4) to be submitted for publication. Pages were numbered consecutively throughout and there is a cumulative abstract, literature review, management recommendations and literature cited to satisfy University standards.

Chapter II

REVIEW OF THE LITERATURE

2.1 INTRODUCTION

Vegetation within a region is subject to change over time by the natural process of plant succession. Succession changes the diversity and abundance of plant species, concurrently affecting the composition and distribution of wildlife species within the community (Smith 1980). Wildlife must either have the ability to adapt to habitat change or move from that region to find acceptable habitat. In this case, habitat change may be regarded as a limiting factor to the wildlife population.

Prairie grouse are affected adversely by land use changes which alter their traditional habitat. (Hamerstrom *et al*. 1961, and Aldrich 1966). This is especially true for certain subspecies such as Columbian (*T.p. columbianus*), plains (*T.p. jamesi*), and prairie (*T.p. campestris*) sharp-tailed grouse, which are particularly vulnerable to land use impacts (Miller and Graul 1980, Kessler and Bosch 1982). Hamerstrom *et al*. (1961) stated that in some localities, populations of two subspecies of sharp-tailed grouse (*campestris* and *columbianus*) are in serious trouble.

The prairie sharp-tailed grouse has been extirpated from Illinois, Iowa, southern Wisconsin and southern Minnesota, although currently, prairie sharp-tailed grouse are abundant in Manitoba and Saskatchewan. An opinion survey of wildlife managers has predicted further distributional losses for prairie sharp-tailed grouse in six states and provinces. (Miller and Graul 1980). In Manitoba (Figure 2.1), the range is located to aspen parkland running through the central and southeastern portions of the province (Aldrich 1966).

2.2 ASPEN SUCCESSION

Seral communities replace one another until a climax community is achieved. The entire progression of seral stages (Figure 2.2) is called succession (Barbour et al. 1980). Aspen-dominated communities are characterized by the occurrence of aspen as both the dominant seral and climax tree species. Aspen has been regarded as a fire-induced successional species able to dominate sites until replaced conifers (DeByle and Winokur 1985).

An aspen community can be described by physical parameters of the aspen stand. Generally, there is a rich understory of herbaceous vegetation while aspen seedlings are absent by virtue of their shade intolerance. Aspen stands may be even or uneven-aged. Aspen may be affected by environmental influences such as fire, climate, history,

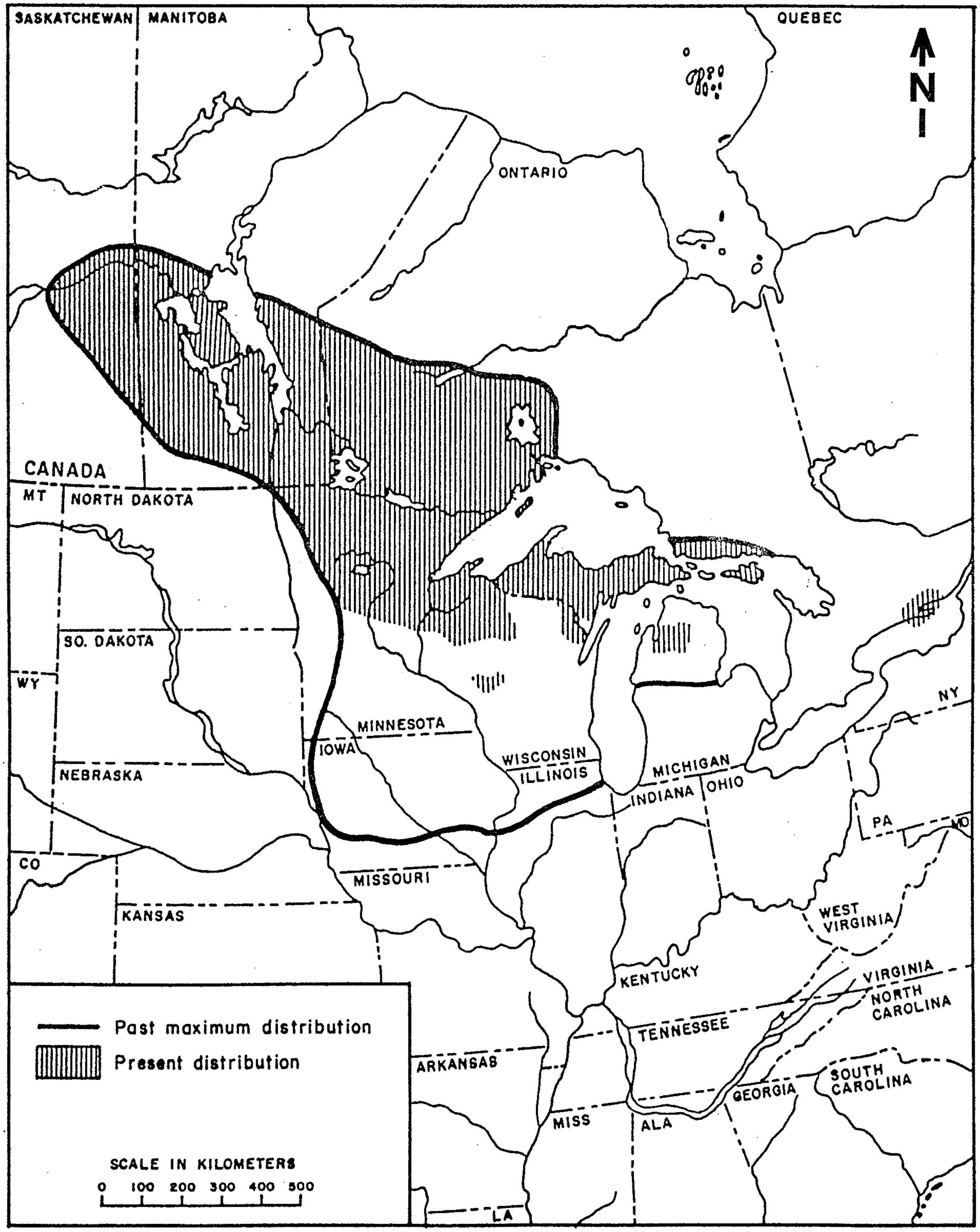

Figure 2.1: Past and present distribution of prairie sharp-tailed grouse in North America (Miller and Graul 1980).

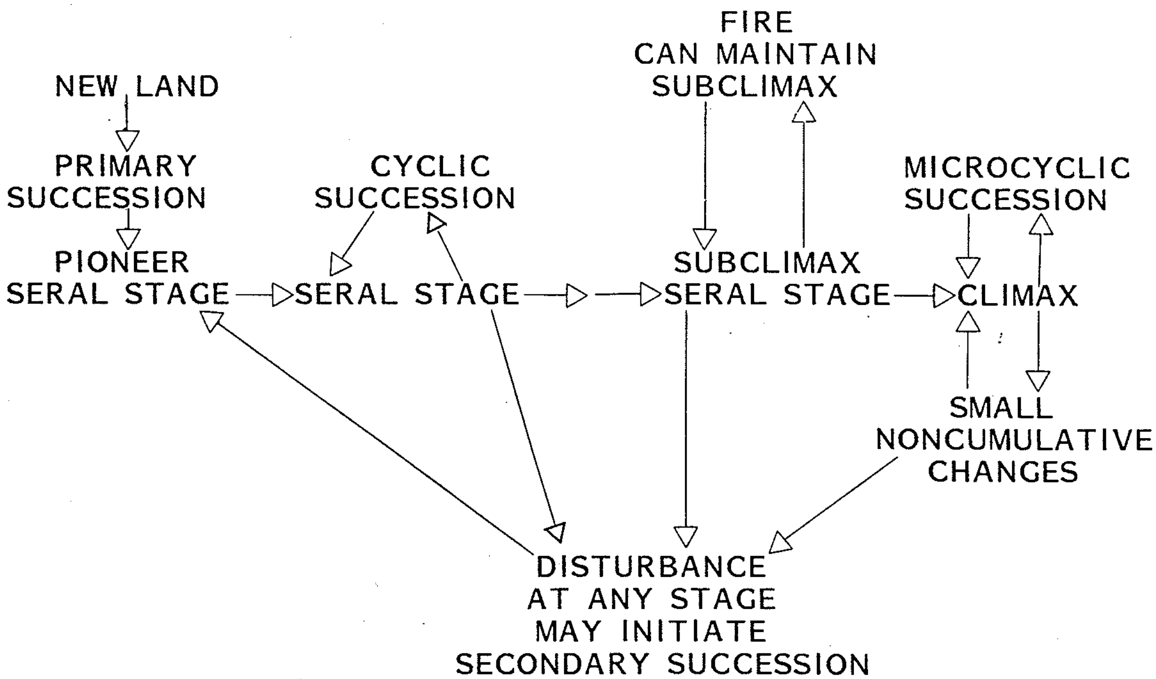

Figure 2.2: Diagrammatic pathway of different types of succession (Barbour et al. 1980).

soil or site quality, impacts of livestock and wildlife, disease, insects, and the presence of a coniferous seed source. However, an aspen stand is resilient. Vegetative growth occurs through the production of root suckers. When a tree is cut, burned, girdled or defoliated, suckering begins. Sucker production and growth continues as long as carbohydrate reserves remain. If the reserves are exhausted by repeated destruction of suckers (continued browsing, cutting, burning or herbicide application) suckering will be reduced. The production potential of an aspen stand which has been cut or burned is large (49,000 - 74,100 suckers/ha) but early self-thinning reduces final density (DeByle and Winokur 1985).

Although aspen produce seeds, suckering is the primary method of expanding into new areas. Bailey and Wroe (1974) have used aerial photography to monitor aspen invasion of prairie in a portion of Alberta parkland. In 1907, two groves of aspen were present in 40, one mile (1.6 km) transects. By 1966, aspen groves occurred in 35 of the transects and the rate of invasion was increasing. There was a correlation between aspen invasion into grassland and high growing season temperatures. The annual herb production decreased 80% to 90% under aspen.

Loucks (1970) noted that plant species diversity increases in temperate zones during early succession, but it decreases in late succession as the canopy closes and a few species dominate. Thus a periodic local disturbance which sets succession back to an earlier stage is required to maintain maximum diversity. Fire is such a disturbance. If fire suppression takes place, succession of species such as aspen will quickly consume prairie. In east-central Alberta, near Wainwright, aspen has expanded into the grassland community as a result of the suppression of large-scale burning over the last 12 years (Moyles 1981).

2.2.1 ASSOCIATION OF GROUSE AND HABITAT CONDITION

Sharp-tailed grouse are species of prairie-forest transition zones or parkland and show specific preferences for different plant communities at various times of the year. Pepper (1972) in Saskatchewan, Twedt (1974) in Nebraska and Ward (1984) in Idaho all found that unhindered visibility is characteristic of sharp-tailed grouse display sites.

Grassland and grassland-low shrub transition zones are selected throughout the year, with trees being used primarily in winter and spring. Marsh vegetation is sometimes used during winter. In summer, females with broods select grassland and grassland-low shrub transition zones during the day while males and females without broods select taller vegetation. Aspen is used for cover, roosting and as a winter food source (Evans 1968, Sexton 1979a and Gratson 1988).

Succession can have a negative affect on brood habitat and lek use. Ammann (1963) noted that many small, isolated colonies of Michigan sharp-tailed grouse disappeared in the late 1950's as a result of the encroachment of woody cover into forest openings. Hamerstrom et al. (1961) suggested that natural forest succession, fire protection, pine plantations and modern clean farming within farm communities have decreased the range of sharp-tailed grouse habitat.

As succession occurs, WMAs can be managed for sharp-tailed grouse habitat restoration. In order to maintain sharp-tailed grouse habitat, Minnesota Department of Natural Resources (1985) maintain certain proportions of open and brushland components. They achieve this through prescribed burning or mechanical treatments, such as shearing or hand-cutting brush on a lek, and logging trees near existing leks. These areas can be further enhanced by planting grasses desirable by sharp-tailed grouse. Habitat management for sharp-tailed grouse is carried out in a unit of habitat known as a block. Blocks of irregular size/shape may be manipulated by mechanical means to enhance particular types of vegetation growth. The Minnesota Department of Natural Resources (1985) recommends, where habitat exists rather uniformly in scattered but connected blocks, that blocks must be at least 0.5 $mile^2$ (1.3 km^2), and must be relatively free of woody vegetation. Some scattered brushland around leks (0.25 to 0.5 mile or 0.4 to 0.8 km away from lek center) satisfies sharp-tailed grouse needs for basic shelter, nesting, cover, and food in close proximity to the lek.

If prairie areas are reduced in size, number, or totally eliminated within the NWMA, a reduction of available breeding, nesting and brooding habitat for sharp-tailed grouse would be expected. Consequently, reductions in subpopulation abundance may occur due to: A) sharp-tailed grouse being forced to concentrate in remaining suitable habitats, which in turn may cause over-crowding and increased competition for space; B) sharp-tailed grouse dispersing or migrating from the study area in search of more suitable breeding, nesting and brooding cover; C) sharp-tailed grouse being out-competed for space and food by other species better adapted to aspen forest (Figure 2.3); and/or D) extirpation of sharp-tailed grouse within the study area through inadequate recruitment into the population. If any of these situations arise and if a smaller population size indirectly results from habitat deterioration, the NWMA's sharp-tailed grouse population will not provide the same use opportunities that the public currently enjoys.

Hamerstrom (1939) recognized that wildlife habitat management is planned regulation of plant succession. Without management, it is only a matter of time before succession proceeds beyond a stage favourable for booming, dancing, and ground nesting cover.

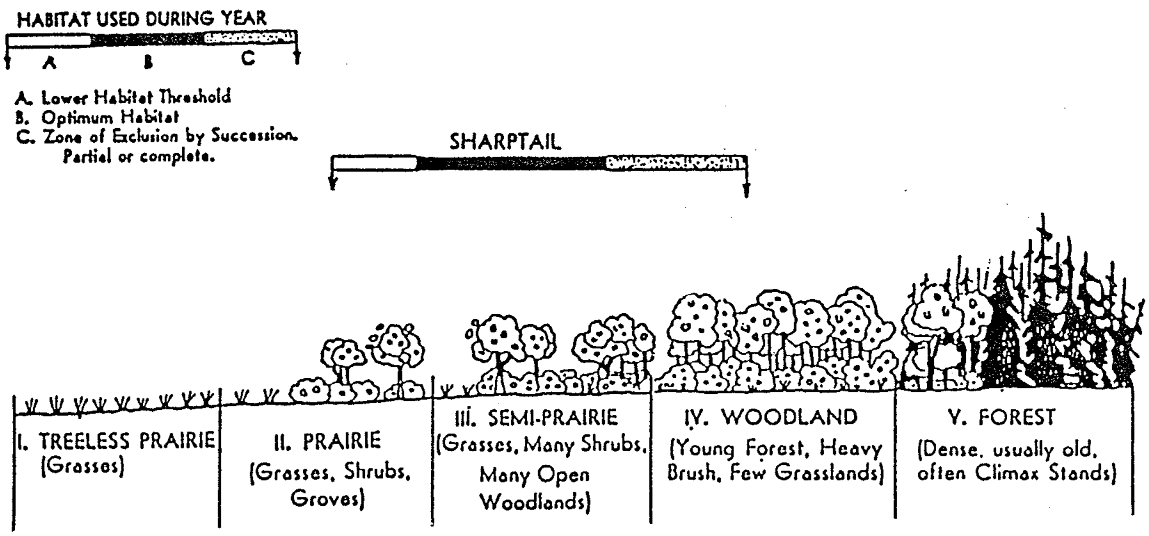

Figure 2.3: A Schematic representation of prairie sharp-tailed grouse tolerance to different community types (Berg et al. 1987a).

2.3 CHARACTERISTICS OF SHARP-TAILED GROUSE LEKS

A lek, also called a dancing ground or arena, is the communal display area where males congregate for the purpose of attracting and courting females, and to which females come for mating (Wilson 1975). Bradbury and Gibson (1983) suggested that lek site characteristics were so diverse that choice of a lek site was made through grouse behaviour rather than on the basis of habitat types present in the area. They cautioned that their models might be influenced by habitat suitability or other ecological determinants.

Numerous authors have described the physical attributes of leks. Ammann (1957) stated that leks are relatively open sites having low or sparse vegetation with topography varying from flat to slightly elevated above than the surrounding land. In northern Ontario, Hanson (1953) noted that sharp-tailed grouse leks were located on slightly elevated hummocks which enhanced visibility. Unhindered visibility is a general characteristic of prairie grouse leks (Pepper 1972). Kobriger (1965) found that 90% of the display grounds sampled were in areas mowed or winter-grazed by livestock. Sisson (1976) observed that mean vegetation height and density were lower on leks than on the surrounding terrain. In southwestern Manitoba, Baydack (1988) noted that leks were generally elevated (<1% slope), with a flat to undulating surrounding topography. Unhindered visibility, low spring vegetation heights on the leks, nearby escape cover (<500m) and nearby female perching sites were noted as important characteristics of the lek and surrounding area for plains sharp-tailed grouse.

2.3.1 FACTORS ASSOCIATED WITH LEKS

Evidence suggests that sharp-tailed grouse spend much of their life in close association with the habitat located within one kilometer of the lek. Hamerstrom and Hamerstrom (1951) noted that cover preferences for male sharp-tailed grouse in fall consisted of open, herbaceous cover. In late fall and winter, males moved to wooded thickets. In spring and summer males stayed close to leks. Brown (1961a) stated that the male sharp-tailed grouse feeding, loafing and roosting activities were confined to an area within 0.5 mile (0.8 km) radius of the lek.

Brown (1966a) stated that a relationship appeared to exist between the establishment of new sharp-tailed grouse leks and the estimated cover density. New grounds were established five times in his study area, following marked decreases in the sites' standing cover.

Rodgers (1985) established a lek for sharp-tailed grouse in Kansas. Transplanted birds were released on an artificial lek and during the spring of release, several cocks returned and displayed on the site for several weeks. Baydack (1986) attempted to move several leks in southwestern Manitoba. By using mechanical manipulation to create an alternate lek site, by placing decoys on the alternate site, and by disturbing the original dancing ground so that males could not congregate and display, he found that the alternate site was sometimes chosen. Call and Maser (1985) stated that sage grouse (*Centrocercus urophasianus*) leks may be created to replace traditional leks that have been destroyed by land use activities.

Ammann (1963) noted that controlled burns in Michigan may have been instrumental in boosting sharp-tailed grouse populations to unprecedented numbers in 1950. Anderson (1969) noted that a burn over greater prairie chicken (*Tympanuchus cupido pinnatus*) booming grounds did not reduce attendance.

2.4 CHARACTERISTICS OF NESTING HABITAT

Most sharptail nests are located within a few feet (one meter) of overhead cover (Ammann 1957). Evans (1968) noted that nests are usually found near a source of seeds, buds and berries since hens usually feed near the nest site. Kohn (1976) and Sexton (1979a) described vegetation surrounding nests in North Dakota and Manitoba and respectively noted that: regrowth, tame, and native vegetation were used most frequently by nesting females; vegetation height decreased as the distance from the nest increased; and nest sites had taller, denser shrub cover than randomly sampled vegetation. Kohn (1976), who studied plains sharp-tailed grouse in North Dakota, also suggested that hens nesting in a given habitat type were usually surrounded by additional vegetation of the same type. Nesting grouse in Nebraska preferred north slopes dominated by residual cover of grasses with an accumulation of plant litter (Sisson 1976).

Nest sites were usually located within 0.5 mile (0.8 km) of a lek (Evans 1968). Sexton (1979a) observed that 79% of females had summer home ranges occurring within one kilometer of their capture lek. Brown (1966b) observed a direct relationship between spatial distribution of nesting hens on relatively limited breeding ranges and the existence of density dependent nesting competition. Pepper (1972) concluded that sharp-tailed grouse nesting in native grass-shrub in Saskatchewan had 31% higher nesting success than sharptails nesting in hayland and cultivated fields.

Brown (1962) observed that brood movements with the hen occurred in association with native vegetation. Sites selected for brooding had relatively dense canopies of forbs and shrubs (Sisson 1976). Evans (1968) determined that 65% of sharp-tailed grouse broods occurred in mixed grass and shrub communities. In Wisconsin, 80% of prairie sharp-tailed grouse brood observations occurred in mixtures of grass and widely scattered trees or clumps of brush, cultivated lands or grasslands (Hamerstrom 1963). Kohn (1976), who studied plains sharp-tailed grouse in North Dakota, noted that woody plants were used more frequently by broods than nesting females. Moyles (1981) added that females with broods selected grassland-low shrub transition zones most frequently in his study area. Sexton (1979a) found that brood-rearing females in the NWMA, selected grassland or grass-shrub areas while broodless females used shrub and forest more often.

Kobriger (1965) who studied plains sharp-tailed grouse in Nebraska, stated that juvenile sharptails fed mainly on insects at 10 weeks of age, and at 12 weeks, diet shifted to 90% vegetable matter. In prairie regions, food preferences for broods during early weeks of life were found to be grasshoppers (Hillman and Jackson 1973). Newly hatched young traveled relatively short distances and required a high protein insect diet until seven weeks of age. Forbs support a more varied insect fauna than grasses, provide shade, provide water (in plant tissue), or collect dew, used by the chicks. Sisson (1976) stated that sharp-tailed grouse selected sites having early successional vegetation for feeding. These sites had relatively dense forb cover and sparse grass cover.

Pepper (1972) concluded that nesting and brooding habitat limited sharp-tailed grouse populations. Weather may also limit nesting and brooding success. Robel et al. (1972) suggested that a reduction in juvenile/adult age ratios coincided with the onset of severe winter weather. Cartwright (1944) stated that cold wet springs were detrimental during the nesting and brood rearing period. Conversely, in South Dakota, wet springs were considered favourable to grouse hatch where increased residual cover resulting from rainfall increased summer survival of broods (Hillman and Jackson 1973).

Chamrad and Dodd (1972) stated that controlled burns were a useful management tool for manipulating native vegetation for Attwater's prairie chicken (Tympanuchus cupido attwateri) in Texas. Fall burning produced an abundance of plant food (grass and forbs) for prairie chickens. Insect food supply improved after spring burns. Nesting habitat improved by the second season after a burn. Kirsch and Kruse (1972) showed that burning increased flowering, seed production, height and diversity of plants on grasslands and sharp-tailed grouse brood observations. Cannon and Knopf (1979) noted that prairie chickens may change the location of, or completely abandon a traditional site when grasses and forbs become too tall or dense. The best method for maintaining nesting and brood-rearing habitat is to conduct burns in late spring or early summer which results in improved nesting cover for subsequent seasons. Kruse and Piehl (1986), studying sharp-tailed grouse nesting in burn managed grasslands, suggest some adaptation to fire changed environments as most nests survived fire and hatched.

Westemeier (1972) also suggested that prescribed burns resulted in better quality prairie chicken habitat in Illinois during subsequent years.

2.5 POPULATION REGULATING MECHANISMS

The quality of habitat is the primary limiting factor to wildlife populations. If habitat is optimal or suboptimal in a region, other population regulating mechanisms affect wildlife in different ways. Interspecific and intraspecific competition for space, cover and food, and the predator-prey relationship increases, as habitat quality decreases. Competition emphasizes the role of habitat, and deemphasizes the importance of other hypotheses proposed for population regulation.

Two main 'schools of thought' exist concerning wildlife population regulating mechanisms: (1) the self regulation hypothesis, which emphasizes that intrinsic factors control population size and density, and (2) the environmental interaction hypothesis, which stresses the importance of extrinsic factors such as predation or climate (Keith 1974).

Intrinsic and extrinsic factors have also been suggested as a possible cause of population cycles. Cycles have been exhibited by snowshoe hares (Lepus americanus), voles (Microtus spp.), locusts (Locusta spp.), red grouse (Lagopus scoticus), ruffed grouse (Bonasa umbellus), sharp-tailed grouse, other species of grouse and mammals (Keith 1974, Wynne-Edwards 1978, and Krebs 1978). In Manitoba, fluctuations in numbers of grouse and hares were noted by early naturalists (Seton 1929, Criddle 1930). Keith (1974) noted that these fluctuations were cyclical in nature (e.g. three to four years for microtines and eight to 11 years for hares and grouse).

Chitty (1967) suggested that the sole mechanism behind population cycling was intrinsic, to the exclusion of all extrinsic factors. Lack (1966), on the other hand, stated that predation (an extrinsic factor) acts as (1) a selective force on species morphology, physiology and behaviour (2) a mediator of interspecific competition and thereby enhances community diversity and stability, and (3) a regulator of population abundance and distribution through regulatory and nonregulatory mechanisms. Climate has also been cited as an extrinsic factor associated with cycling (Wynne-Edwards 1978).

Keith (1974) suggested that predators do not initiate population decline during the cycle among lagomorphs. Hare-vegetation interaction initiate population decline and set the stage for predator-prey interaction, possibly lengthing the cycle. He also hypothesized that grouse populations changes (including sharp-tailed grouse) resulted from an increase in the rate of random contacts between predators and grouse. As grouse numbers increased and hare numbers decreased, predator hunting activity changed, explaining grouse decline solely by predation rates. He also acknowledged that grouse sometimes declined before hares, suggesting that some cycles could be explained by intrinsic factors, or extrinsic factors other than predation.

Bergerud (1988) suggested that extrinsic factors affect the number of breeding ruffed grouse in spring. He also stated that grouse regulate their numbers through spacing behaviour. As populations increase, space for breeding becomes limited and birds that cannot compete successfully have high mortality. Variables in the hypothesis are food supply and predation. The extrinsic environment or habitat shapes the evolution of behaviour and adaptive strategies. Pepper (1972) suggests that fluctuations of breeding populations of plains sharp-tailed grouse in Saskatchewan were ascribed to adverse weather conditions, hunting pressure and predation.

These theories suggest that as long as recruitment exceeds mortality, sharp-tailed grouse subpopulations, such as the one in the NWMA, will continue to exist within an area. However, recruitment may not exceed mortality if reproductive habitat is no longer available in adequate quality or quantity.

Chapter III

SHARP-TAILED GROUSE HABITAT CONDITION IN THE NARCISSE WILDLIFE MANAGEMENT AREA

3.1 INTRODUCTION

The prairie sharp-tailed grouse forms an integral part of the aspen parkland communities of North America. In Manitoba, attempts have been made to assess population size and condition province-wide since the mid-1940's (McWhorter 1962). The subpopulation of sharp-tailed grouse was censused in the NWMA from early to mid-1970, but not since then (Murray Gillespie, pers. comm.).

Baumgartner (1939), Ammann (1957), Hamerstrom and Hamerstrom (1951), Hamerstrom et al. (1961), Kobriger (1965), Brown (1961b, 1966b,c, 1967), Evans (1968), Pepper (1972), Hillman and Jackson (1973), Twedt (1974), Caldwell (1976), Kohn (1976), Sisson (1976), Sexton (1979a,b), Moyles (1981) and Baydack (1988) have found that sharp-tailed grouse required different portions of a plant community to fulfill different needs at different times during their life cycle. During the spring, summer and fall, prairie sharp-tailed grouse required areas of grass, shrub, and forest for breeding, nesting, brooding, feeding, loafing, and for escaping predators. In Wisconsin, Gratson (1988) noted that cocks and hens used grass-forb, and grass-shrub cover types during the spring, summer and fall most frequently, while shrub-marsh or sedge-meadow was used most frequently during winters. In Manitoba, winter cover is provided by thick forested areas and marshlands (M. Gillespie, pers. comm.). This study was initiated to determine, in part; A) the change of sharp-tailed grouse habitat in NWMA and B) to observe grouse response to habitat change.

3.2 DESCRIPTION OF THE STUDY AREA

A 20 km^2 area of NWMA was chosen for study (Figure 3.1). The NWMA was chosen since information on wildlife species, vegetation and habitat use was available from previous studies.

3.2.1 CLIMATE

The climate of the parkland around Narcisse is classified as sub-humid continental. January is the coldest month (mean -18.8°C) and July the hottest (mean 19.4°C). Extremes in temperature occur because of the continental nature of the climate. Precipitation averages 50 cm annually. Winds are predominantly northwesterly, although they vary seasonally (Weir 1960).

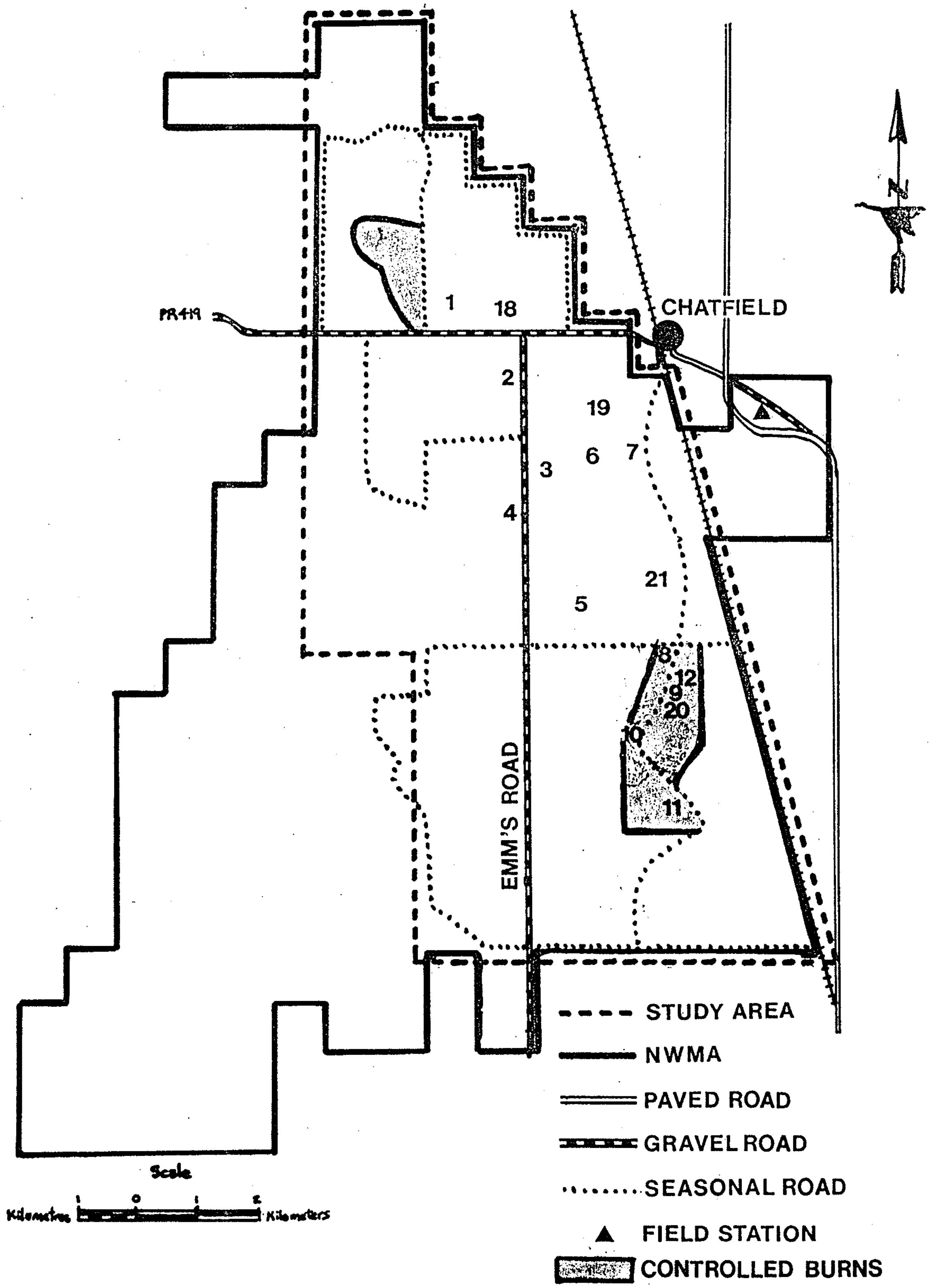

Figure 3.1: Study area within the Narcisse Wildlife Management Area (Numbers indicate locations of historic, stable and new leks).

3.2.2 TOPOGRAPHY AND SOILS

The land is a relatively flat to gently undulating glacial till plain. Bedrock is exposed in some areas, and the gentle swell and swale topography left by Lake Agassiz generally runs in a northwesterly direction. In most regions of the Interlake, glacial till covers the bedrock. Soil cover is generally thin, stony and high in lime. Soil types are classified as gray wooded, dark gray, peaty meadow or half bog soils (Pratt et al. 1961).

3.2.3 LAND USE AND VEGETATION IN NWMA

Agricultural settlement of the Narcisse-Chatfield area occurred in the early 1900's. Intensive settlement occurred during the post World War years, as land in the Narcisse-Chatfield area was given away to veterans and families. Settlement resulted in the establishment of livestock oriented subsistence farms. Prior to settlement, coniferous forests were prevelent in the Narcisse area (C. Dixon, pers. comm.). Coniferous forested areas are not usually used by sharp-tailed grouse (Berg et al. 1987a) and it is likely that few sharp-tailed grouse were present in the area during the time prior to settlement. The land was cleared for haying and the trees used for housing and fuel. The area was also subject to frequent wildfires, which occurred as farmers burned stubble on hayfields, and the fire escaped onto adjacent property. Clearing the land changed the area from coniferous forest and aspen parkland into primarily aspen parkland. Stoniness, low fertility and general droughtiness of the soils in the area resulted in chronic agricultural production problems and by 1968, few viable economic farm units remained (C. Dixon 1979).

Factors which kept the vegetative cover open during settlement were grazing and wildfire. I suggest that during this time, sharp-tailed grouse responded to the long-term change in habitat (i.e. forest to aspen parkland) and as a result, populated the area.

In 1963, the PFRA community pasture was established, and by 1965, 13,260 acres (5,300 ha) were open to cattle grazing. Originally, PFRA reserved 7,100 acres (2840 ha) west of the CNR railway track (i.e. within my study area) for additional community pasture. In 1968, these reserved lands were relinquished in favor of the establishment of the WMA. Grazing had a positive affect on sharptail numbers since it opens up extensive areas and creates prairie-like habitat. Between 1969 and 1975, extensive land appraisal and acquisition offers were made, thereby increasing the total acreage of NWMA (Dixon 1979).

Dixon (1979) stated that projects to improve deer habitat were undertaken in 1972, which involved clearing and disking trails, seeding old fields and establishing 850 acres (340 ha) of alfalfa (<u>Medicago sativa</u>), Alsike clover (<u>Trifolium</u>

hybridum) and wheatgrasses (Agropyron spp.). The increase of prairie-like habitat further enhanced the area for use by sharp-tailed grouse.

Two blocks of land in NWMA were designated as sharp-tailed grouse management areas. In spring 1972, a controlled burn was conducted (250 ha) approximately four kilometers south of Chatfield. This fire burned over leks 8, 9, 10, 11, and 12, thereby enhancing sharptail habitat. The second sharp-tailed grouse management area, three kilometers west of Chatfield and north of P.R. 419, was also burned (C. Dixon, pers. comm.).

Another major influence on the aspen parkland occurred in the summers of 1974 to 1976. The majority of aspen was defoliated by forest tent caterpillars, however the extent of defoliation was not recorded (Dixon 1979).

Rusch et al. (1978), Sexton (1979a) and Dixon (1979) presented a list of plant species commonly found in NWMA. The dominant tree species is trembling aspen. Other common tree species, shrubs, forbs and grasses are presented in Appendix A.

3.2.4 FIRE

Between 1900 and 1968, the cultivation of small acreages, limited clearing and fires were the major causes of habitat change in the NWMA. By keeping the prairie relatively free of aspen, this habitat complex was ideal for the prairie sharp-tailed grouse population around the NWMA from early to mid-1900's.

Districts started keeping fire reports for the NWMA in the 1960's (R. Cameron, pers. comm.). In 1967, a fire (contained to approximately 400 ha) burned just south of Chatfield. The habitat on leks 6, 7, and 19 burned at this time. In 1975, a fire burned over lek 2 and parts of lek 1 and 18. It was contained west of the central access road (Emm's road). In 1976, fire burned over lek 18 and lek 2. In March 1977, a large fire was contained to the west side of Emm's road. In 1980, two fires (approximately 400 ha) burned around the vicinity of lek 8 and leks 3, 6, 7 and 19. In 1981, a large fire burned over the area of lek 1 and lek 18, but it was contained north of PR 419. Finally, in spring 1988, 3/4 of the study area burned. Fire records indicate that a total of approximately 6000 ha burned, however burned areas were observed to be patchy in distribution. Control lek 18 (see chapter 4) did not burn, while the area around control lek 19 burned completely. Fire was contained adjacent to the south and east of manipulated lek 7 and south of lek 10. The areas immediately surrounding manipulated leks 20 and 21 did not burn (local fire district reports, NWMA 1967-1988). Refer to Table 3.1 for fire summaries.

TABLE 3.1

Fire summary for leks in the NWMA.

LEK	YEAR HABITAT BURNED
1	1975, 1981
2	1975, 1976
3	1977, 1980, 1988
5	1988
6	1967, 1980, 1988
7	1967, 1980, 1988 (Partial Burn)
8	1972
9	1972
10	1972
11	1972, 1988
12	1972
18	1975, 1976, 1981
19	1967, 1980, 1988

3.3 METHODS

Plant community conditions available in the NWMA from 1970 to 1986 were determined using remote sensing techniques. Sharp-tailed grouse response to vegetation change over this time period was assessed by using male numbers on leks as an indicator of subpopulation condition.

Color, and black and white aerial photographs of the NWMA (1965, 1975, and 1981) of varying quality were obtained from the Manitoba Remote Sensing Center. Photographic scale ranged from 1:8,000 to 1:15,000. In fall 1986 and 1987, additional photography was collected over the study area (scale 1:14,000).

Target areas for vegetation mapping were selected on the basis of current and historical occurrences of sharp-tailed grouse within specific blocks of habitat. A one kilometer radius surrounding the lek was designated for interpretation and mapping, based on sharptail preference for habitat immediately surrounding leks.

Aerial photographs were interpreted and mapped with a Bausch and Lomb Zoom Transfer Scope. Using the numerical vegetation classification system of Sexton and Dixon (1978), habitat types were labelled (Table 3.2), boundaries were delineated, and the map transferred to mylar. The resulting map was a pattern of habitat types, with the lek being located at the center of the map, and a circle (one

TABLE 3.2

Vegetation classification for the study area (Sexton and Dixon 1978).

<u>Primary Classes</u>

100 - Woodland
200 - Prairie
300 - Shrub
400 - Wetlands
500 - Agricultural

<u>Secondary Classes</u>

- 100 - Woodland
  - 110 - Deciduous
    - 111 - Closed (30%+ canopy)
    - 112 - Open (<30% canopy)
  - 120 - Coniferous
    - 121 - Closed (30%+ canopy)
    - 122 - Open (<30% canopy)
- 200 - Prairie
  - 210 - Dry or moist prairie
- 300 - Shrub
  - 310 - Dwarf aspen/birch (<3 meters)
  - 320 - Scrub (Saskatoon, snowberry etc. <1 meter)
  - 330 - Willow/alder
- 400 - Wetland
  - 410 - Marshes/bogs
- 500 - Agriculture
  - 510 - tame hay and field crops

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kilometer radius), forming the outside boundary. If a map was drawn to specification, the total area of one map would equal 3.14 km^2. The scale of each map varied because each series of aerial photographs had different scales. Over the 21 year mapping period, 12 different leks and their surrounding plant communities were mapped.

Areas were measured with a Calcomp 9100 Digitizer which converted habitat types on the cover map to numerical data. The scale of the map was measured and set using the scale bar method. Each segment of the cover map was converted to numerical form, tallied, and sorted. Total area of each habitat type was determined and its percentage cover calculated. An attempt was made to quantify sources of error from photographic interpretation and measurement. Samples of 5 different areas were drawn independently of one another, each area having a similar shape and size. These samples were pooled and weighted to find the pooled variance, and measurements were expressed as percent error or by $\pm$ km^2.

Aerial photography allows one to monitor habitat change, and measure habitat parameters including diversity, interspersion and juxtaposition of habitat types. Brown (1961b), Pepper (1972), Kirsch and Kruse (1972), Sisson (1976), Sexton and Dixon (1978) and Sexton (1979) used aerial photography to produce habitat cover maps of their study sites. Although remote sensing analysis is ideal for the production of habitat maps, the author should be aware of possible error. During the interpretive process, error is subject to the interpreter's ability to analyze the spectral images (Lillesand and Kiefer 1979, Boy and Rogers 1982). A second source of measurement error results from a combination of environmental, quantitative and mechanical inconsistencies (Estes and Thorley 1983). All sources of error should be accountable in the final evaluation of map accuracy.

The number of male sharp-tailed grouse present on leks was determined from counts (M. Gillespie and D. Sexton 1970-1988, unpubl. data). The method was adapted from Cannon and Knopf (1981) who used the maximum number of males recorded during the spring dancing period as the number present. If possible, 10 flush counts of male sharp-tailed grouse displaying on a lek in spring were averaged to establish the mean number of males using a lek for that year. If 10 counts were not available, all data points were averaged (at least two counts needed). Secondly, data on the total number of leks in the NWMA were recorded and plotted along with the percentage of cover types within the unit being analyzed. Trend analysis was used to examine the relationship between grouse numbers and habitat availability.

Pooled variance was used to estimate standard error for the habitat maps. A paired t-test comparison test was used to calculate individual habitat type differences between years. Each habitat type, derived from two independent interpretations over the same sampling year, was compared between sampling years, resulting in a t-value which was tested with one degree of freedom. Rates of community change were calculated and presented as dx/dt (where x is % of a given habitat and t is time).

3.4 RESULTS

Over the 21 years of study, at least 12 leks were active in the study area. Leks were categorized as either abandoned, recently established or stable. Habitat change is calculated between 1965 and 1986, or 1975 and 1986 unless specified otherwise.

3.4.1 ABANDONED LEKS

Different regions within NWMA had leks which were eventually abandoned. Six of the study leks (2, 3, 7, 8, 9, and 10) were abandoned between 1976 and 1986. In 1975, prairie occupied an average of 0.8 km^2 in total area surrounding leks while aspen closed forest averaged 1.4 km^2. By 1986, prairie had been reduced to an average of 0.2 km^2 while aspen had increased in total area to 2.1 km^2.

Aspen closed forest had a standard error of $\pm$ 0.31 km^2 averaged over all years considered, while prairie had $\pm$ 0.02 km^2. Standard error in mapping was calculated as $\pm$ 0.35 km^2 or 11.2% for all habitat types considered on each map.

Lek 2 (Figure 3.2) had one to seven males displaying each year between 1971 and 1977. Between 1978 and 1986, the lek was abandoned. Aspen and prairie surrounding the lek changed significantly ($P < 0.1$) between 1965 and 1975. In 1965, 1.0 km^2 of aspen closed forest and 1.3 km^2 of prairie was present. By 1975, 0.3 km^2 of prairie remained, as aspen increased to 2.4 km^2 of the total area mapped. By 1986, 80% of the total area was dominated by aspen closed forest.

Lek 3 (Figure 3.3) was active between 1971-1981. Number of males during this period ranged from nine to 18 each year. Between 1982 and 1986, the lek was abandoned. Aspen and prairie surrounding the lek changed significantly ($P < 0.05$) between 1965 and 1975. In 1965, 0.4 km^2 of aspen closed forest and 2.1 km^2 of prairie were present. By 1975, aspen closed forest (2.3 km^2) replaced the prairie (0.5 km^2). In 1986, 73% of the total area was dominated by aspen and only 8% of the total area remained prairie.

Lek 7 (Figure 3.4) was known to be active from 1971 to 1981, but between 1982 and 1986 males abandoned the site. Numbers of males ranged from 32 to 11 individuals each year before abandonment. Aspen closed forest changed from 1965 to 1986, but not significantly ($P > 0.1$). Prairie significantly changed ($P < 0.1$) from 1.5 to 0.4 km^2 in total area. Shrub cover increased in total area from 0.1 to 0.6 km^2. Aspen open and closed forest dominated the area in 1986, covering 61% of the area surrounding the historical

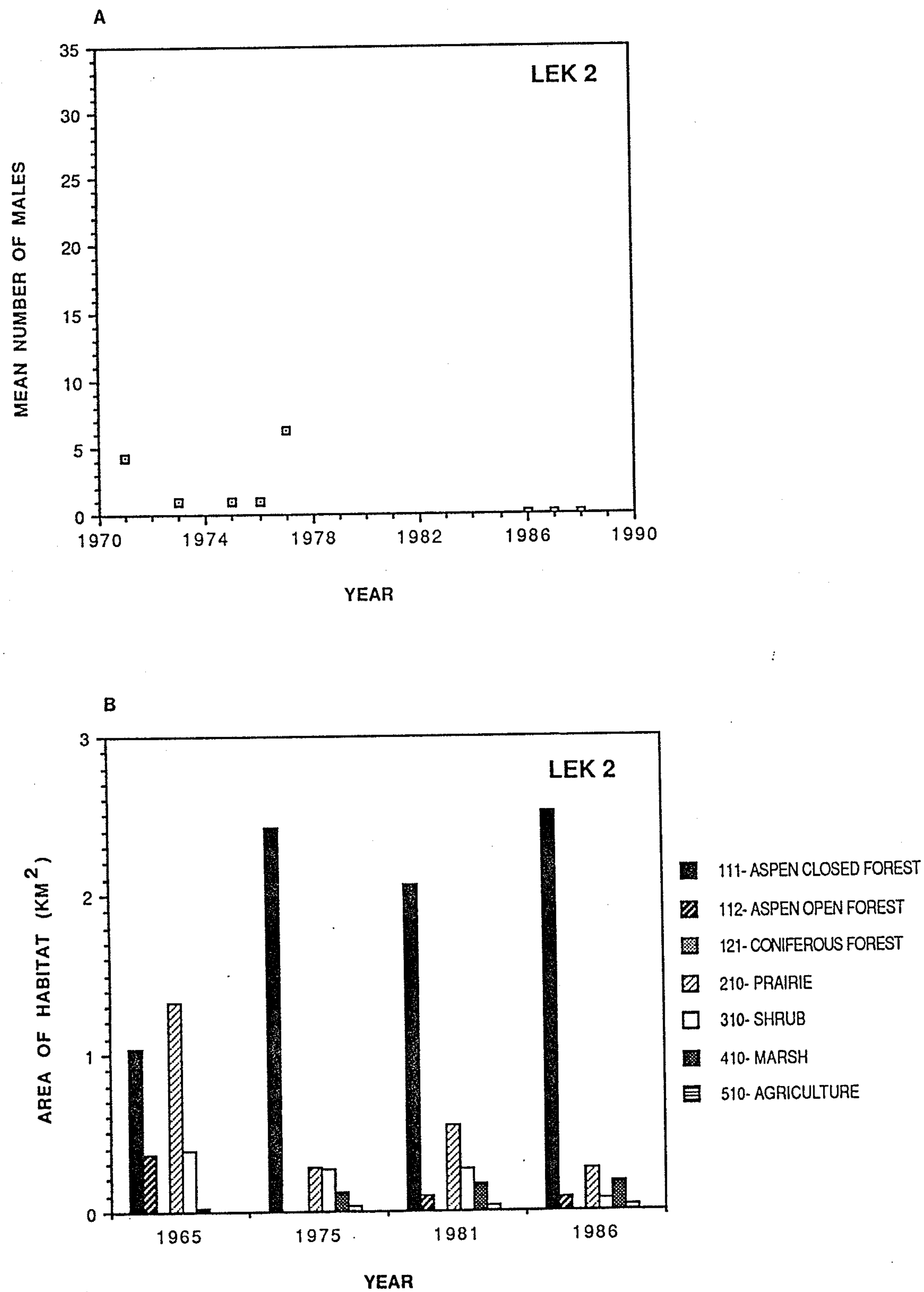
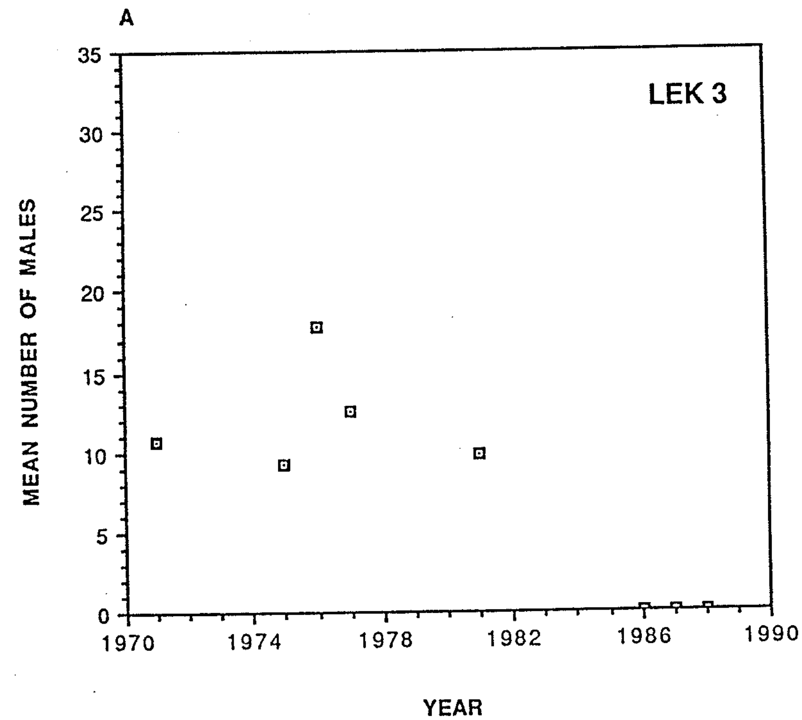


Figure 3.2: Numbers of male sharp-tailed grouse (A) and habitat area (B) from 1970-1988 on historic lek 2.



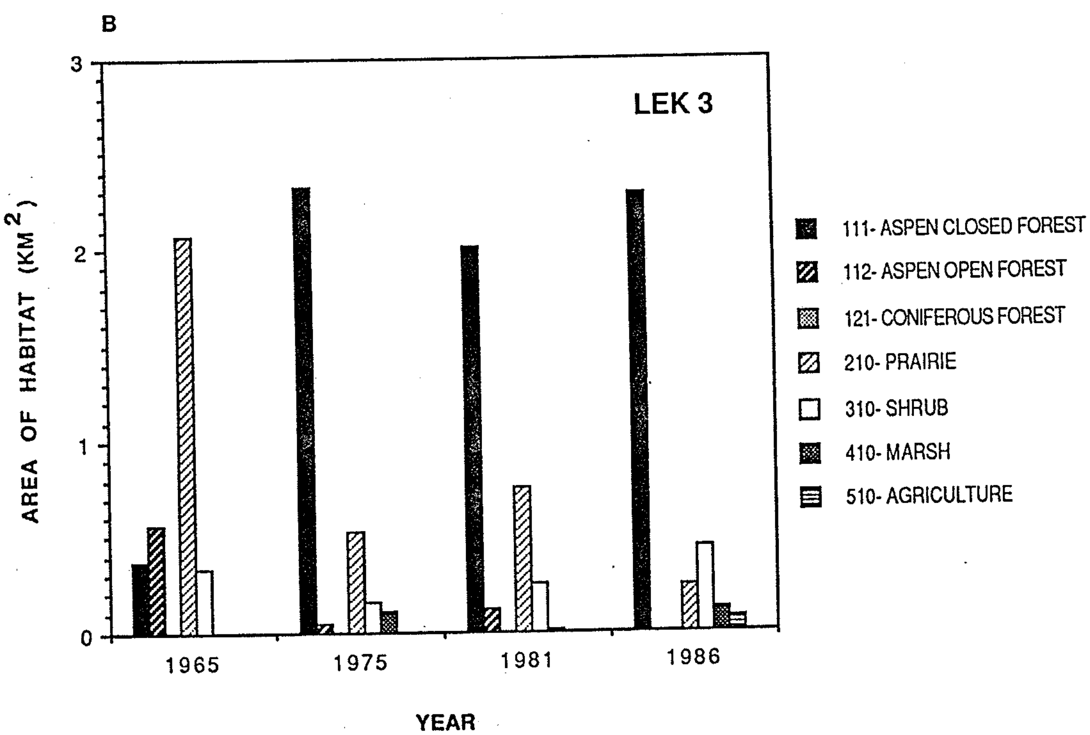


Figure 3.3: Numbers of male sharp-tailed grouse (A) and habitat area (B) from 1970-1988 on historic lek 3.

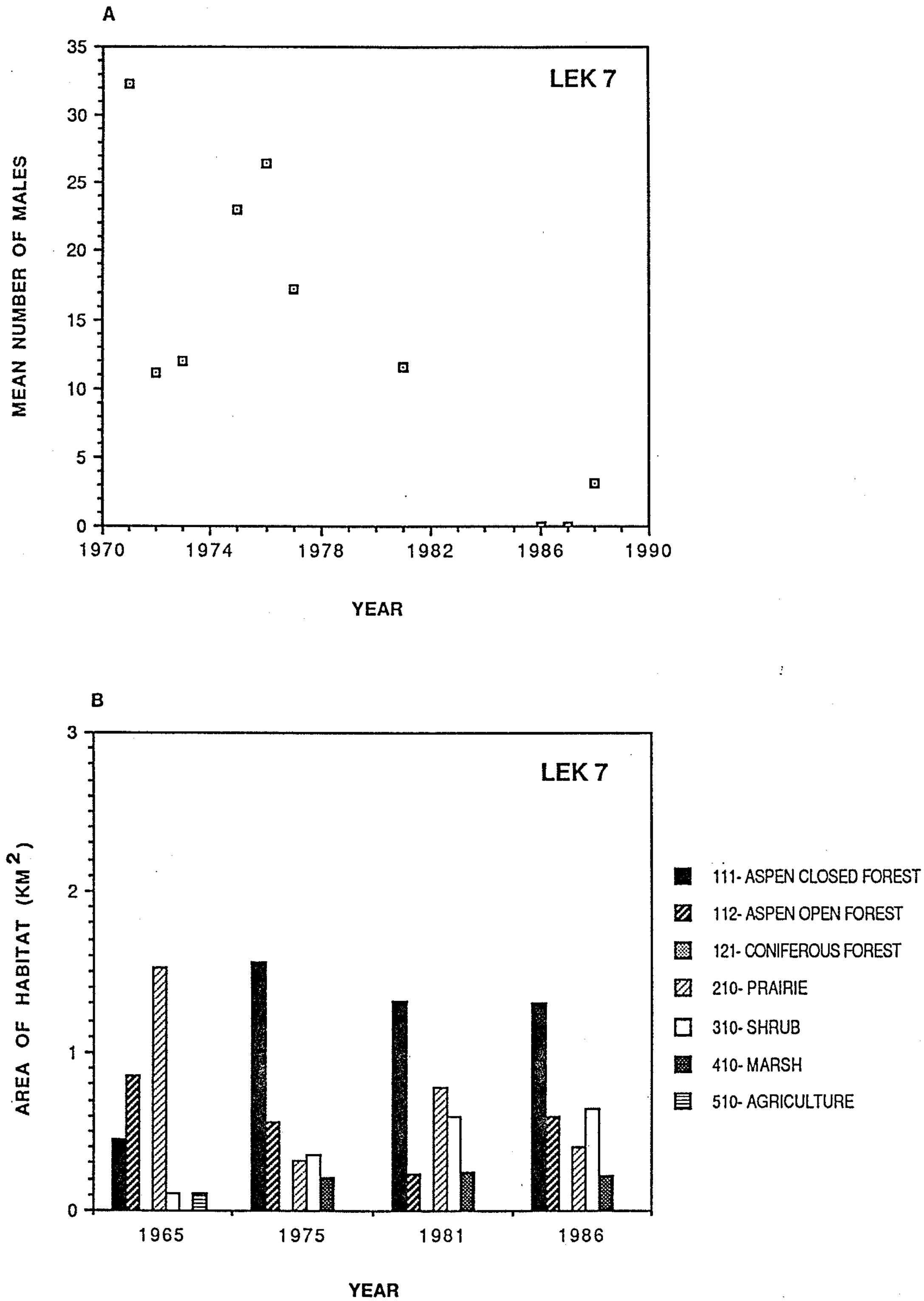


Figure 3.4: Numbers of male sharp-tailed grouse (A) and habitat area (B) from 1970-1988 on historic lek 7.

lek. In 1987, this site was subjected to habitat manipulation (see chapter 4).

Lek 8 (Figure 3.5) existed from at least 1970 to 1975, but by 1976 the lek was abandoned. Numbers of males ranged from 12 to 13 in 1970 and 1971, although by 1975 only one grouse remained. In 1965, 57% of the area was dominated by prairie. In 1975, 35% of the total area surrounding the lek was prairie, 30% aspen closed forest, 16% aspen open forest, and 19% shrub. By 1986, 81% of the total area was dominated by open and closed aspen forest. The loss of prairie was highly significant ($P < 0.05$) and the increase in aspen closed forest was also significant ($P < 0.1$) from 1965 to 1986.

Lek 9 (Figure 3.6) was known to exist between 1970 and 1975, but by 1976, male sharp-tailed grouse had abandoned the site. The number of males declined during this period, from 17 in 1970 to four in 1975. Habitat surrounding the lek also changed between 1965 and 1975. Total area of prairie was initially 1.8 km^2. In 1975, prairie had declined to 1.1 km^2 and by 1986 <0.1 km^2 of prairie remained, representing a significant loss of prairie ($P < 0.05$). Aspen closed forest increased from an initial 0.3 km^2 to 2.0 km^2 by 1986, a significant gain ($P < 0.1$).

Lek 10 (Figure 3.7) existed from at least 1970, and was abandoned between 1982 and 1986. Between 1970 and 1973, the

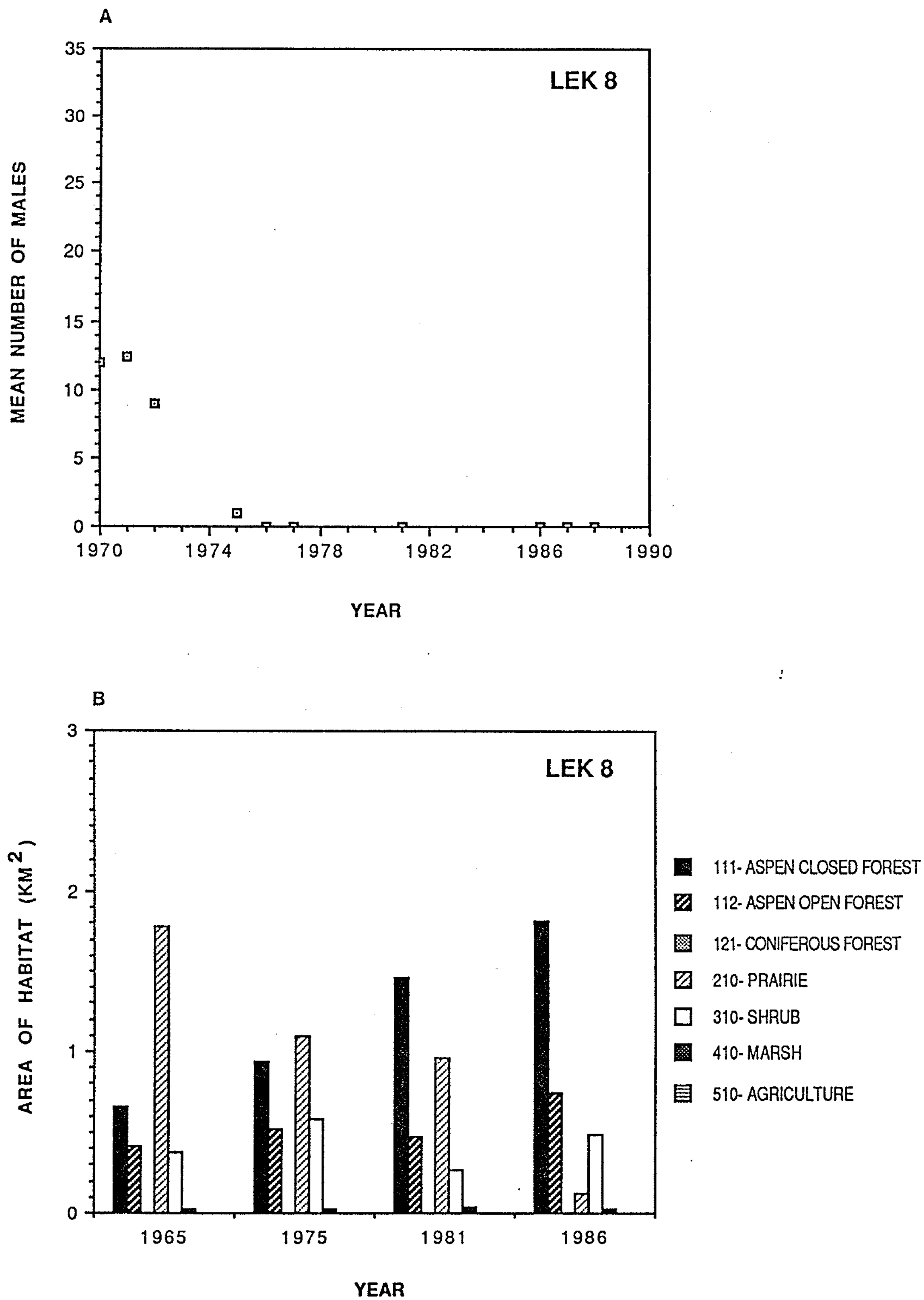


Figure 3.5: Numbers of male sharp-tailed grouse (A) and habitat area (B) from 1970-1988 on historic lek 8.

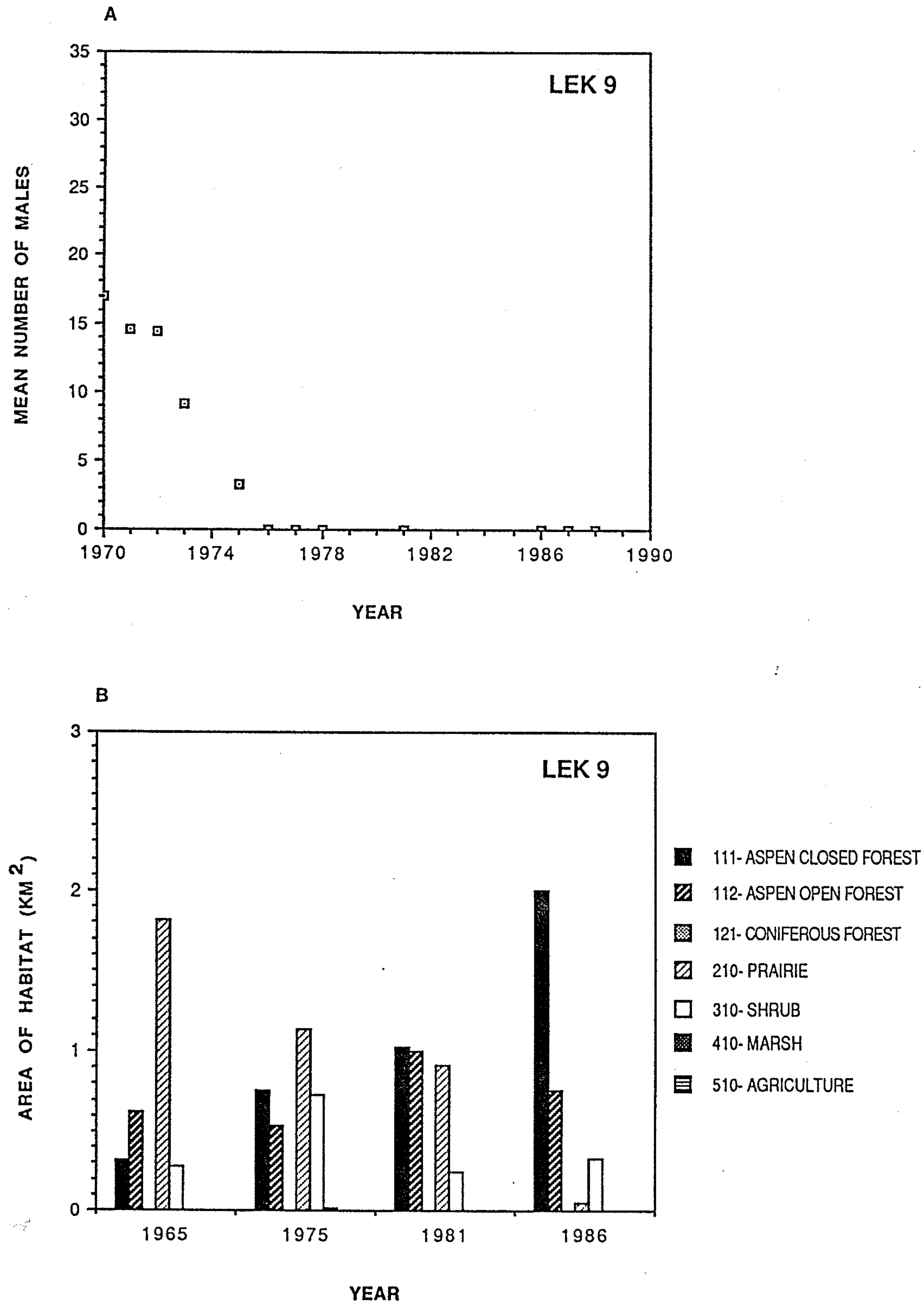
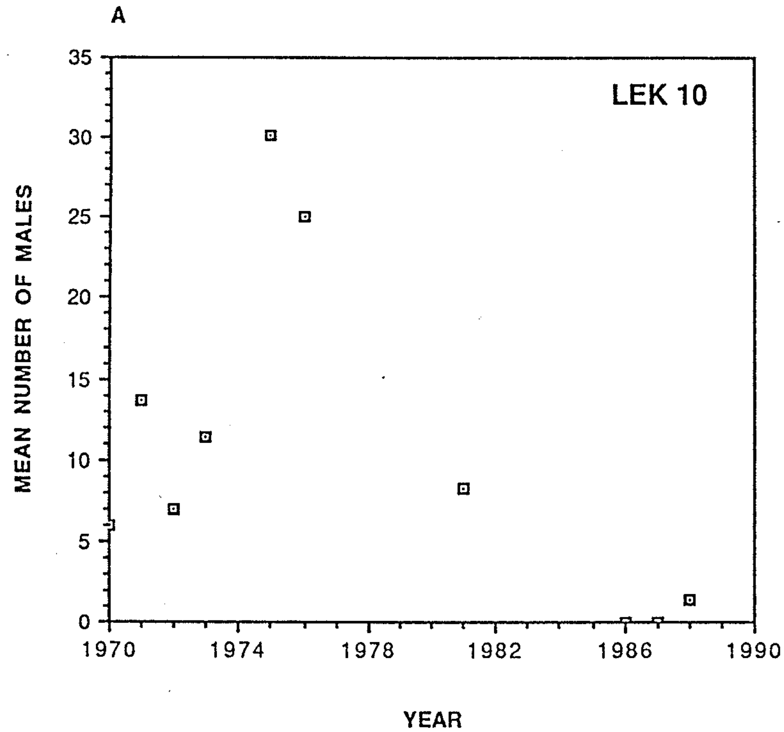


Figure 3.6: Numbers of male sharp-tailed grouse (A) and habitat area (B) from 1970-1988 on historic lek 9.



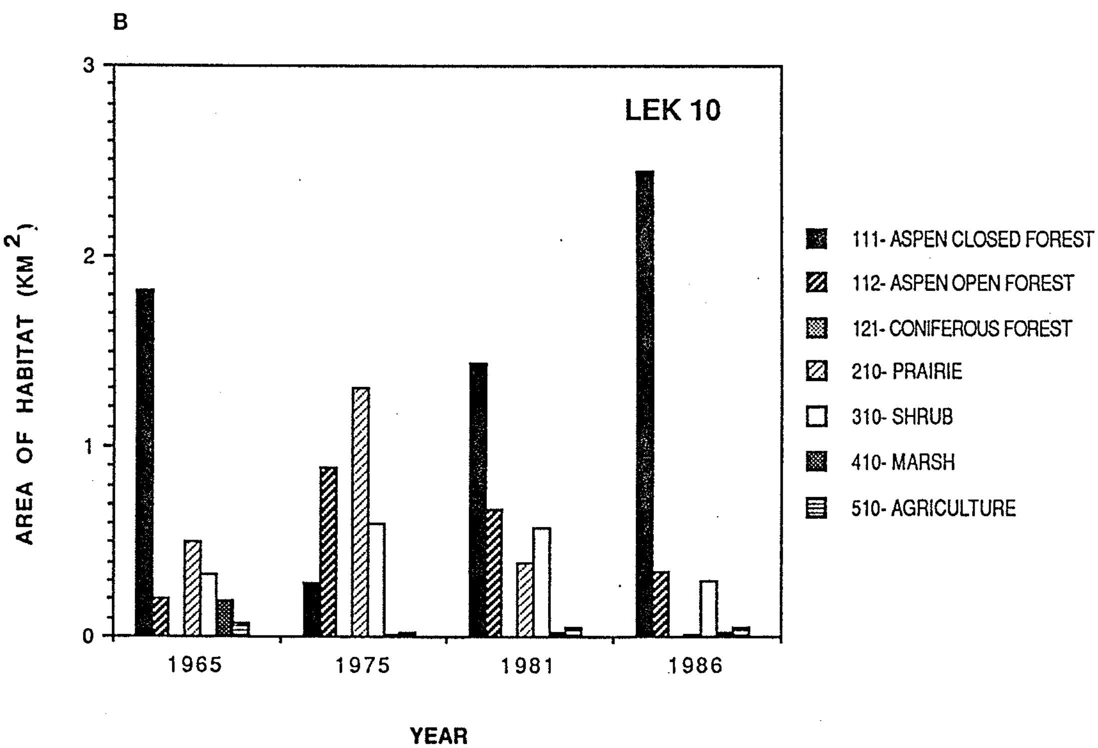


Figure 3.7: Numbers of male sharp-tailed grouse (A) and habitat area (B) from 1970-1988 on historic lek 10.

number of males on this lek ranged from six to 14. In 1975, male numbers tripled, and 30 birds were active. Leks 8 and 9, during the same time period, were abandoned. The habitat surrounding this lek in 1965 had 1.8 km^2 of aspen closed forest and 0.5 km^2 of prairie. In 1975, aspen closed forest decreased to 0.3 km^2 while prairie had increased to 1.3 km^2. By 1986, the types of plant communities surrounding the lek had shifted again. Less than 0.1 km^2 of prairie remained in this study block, (which did not represent a significant change ($P > 0.1$)) and more than 2.5 km^2 of aspen closed forest appeared (which did represent a significant change, $P < 0.05$) from 1965 to 1986. This abandoned lek was subjected to habitat manipulation (see chapter 4).

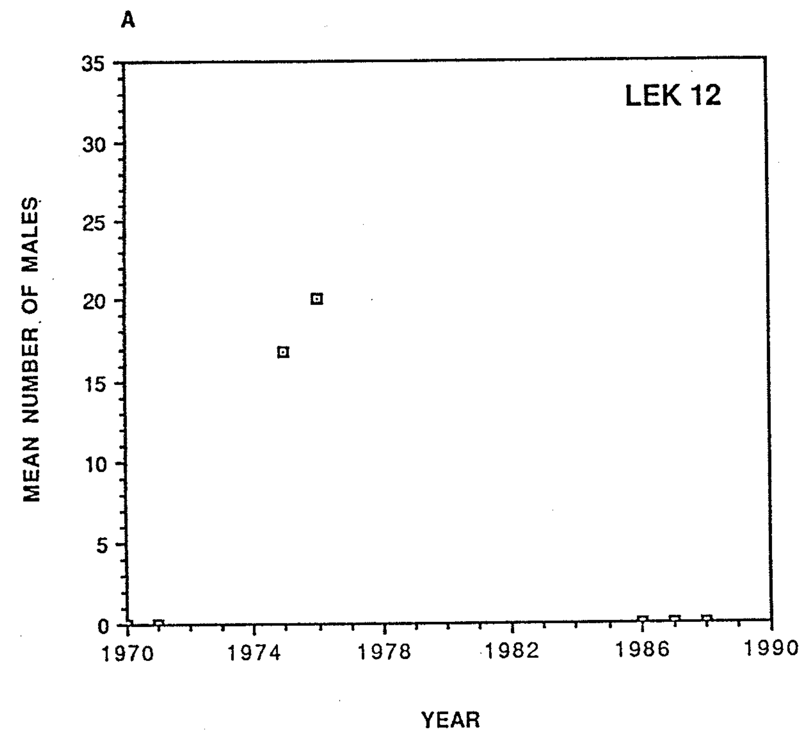
3.4.2 RECENTLY ESTABLISHED LEKS

Figures 3.8-3.10 represent three leks (12, 18 and 19) that were established after 1970, and appeared by a specific year. Leks 12, 18 and 19 were established between 1972 and 1985. In 1975, prairie occupied an average of 0.6 km^2 in total area surrounding these leks while aspen closed forest averaged 1.5 km^2. By 1981, prairie increased to 0.9 km^2 while aspen decreased to 1.0 km^2. The increase in prairie can be explained by the occurrence of fires, which burned over lek 12 in 1972, lek 18 in 1975, 1976 and 1981, and lek 19 in 1980.

Lek 12 (Figure 3.8) was not present in 1970 or 1971, but when discovered in 1975, had 16 grouse using it. The lek was abandoned between 1977 and 1986. From 1975 to 1986, aspen closed forest nearly tripled in area, increasing from 0.7 km^2 to 1.9 km^2, while prairie decreased from 1.1 to <0.1 km^2. Both the increase in aspen closed forest and the loss of prairie represent significant changes in the quantity of habitat ($P < 0.1$). By 1986, 85% of the habitat surrounding the historical lek was open and closed aspen forest.

Lek 18 (Figure 3.9) was not present between 1970 and 1978. Sometime between 1979 and 1986, the lek appeared with the number of active males ranging between 18 and 25. In 1975, 1.9 km^2 of closed aspen forest and only 0.2 km^2 of prairie existed. By 1986, closed aspen forest was reduced to 0.9 km^2 (significant change $P < 0.1$) while prairie increased by 0.7 km^2 ($P < 0.1$), to a total of 0.9 km^2.

Lek 19 (Figure 3.10) appeared between 1979 and 1986. Between eight and 21 males used the site from 1986 to 1988. In 1975, aspen closed forest occupied 1.8 km^2 of the total area surrounding the lek, but by 1986, this area was reduced to 0.8 km^2 (significant change $P < 0.1$). Aspen open forest and shrub increased in area from 0.2 to 1.0 km^2 and 0.4 to 0.7 km^2 respectively. Total area of prairie increased from 0.7 to 1.0 km^2 between 1975 and 1981. By 1986, prairie was reduced to 0.6 km^2. Both these changes were not significant ($P > 0.1$).



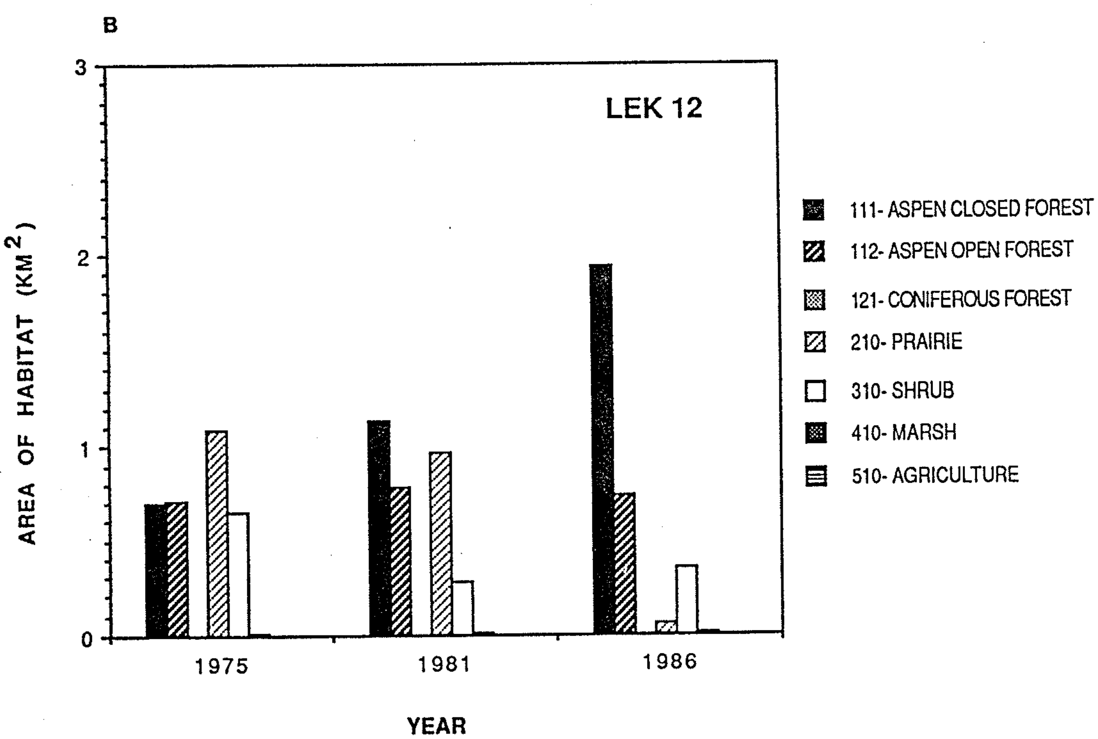


Figure 3.8: Numbers of male sharp-tailed grouse (A) and habitat area (B) from 1970-1988 on established lek 12.

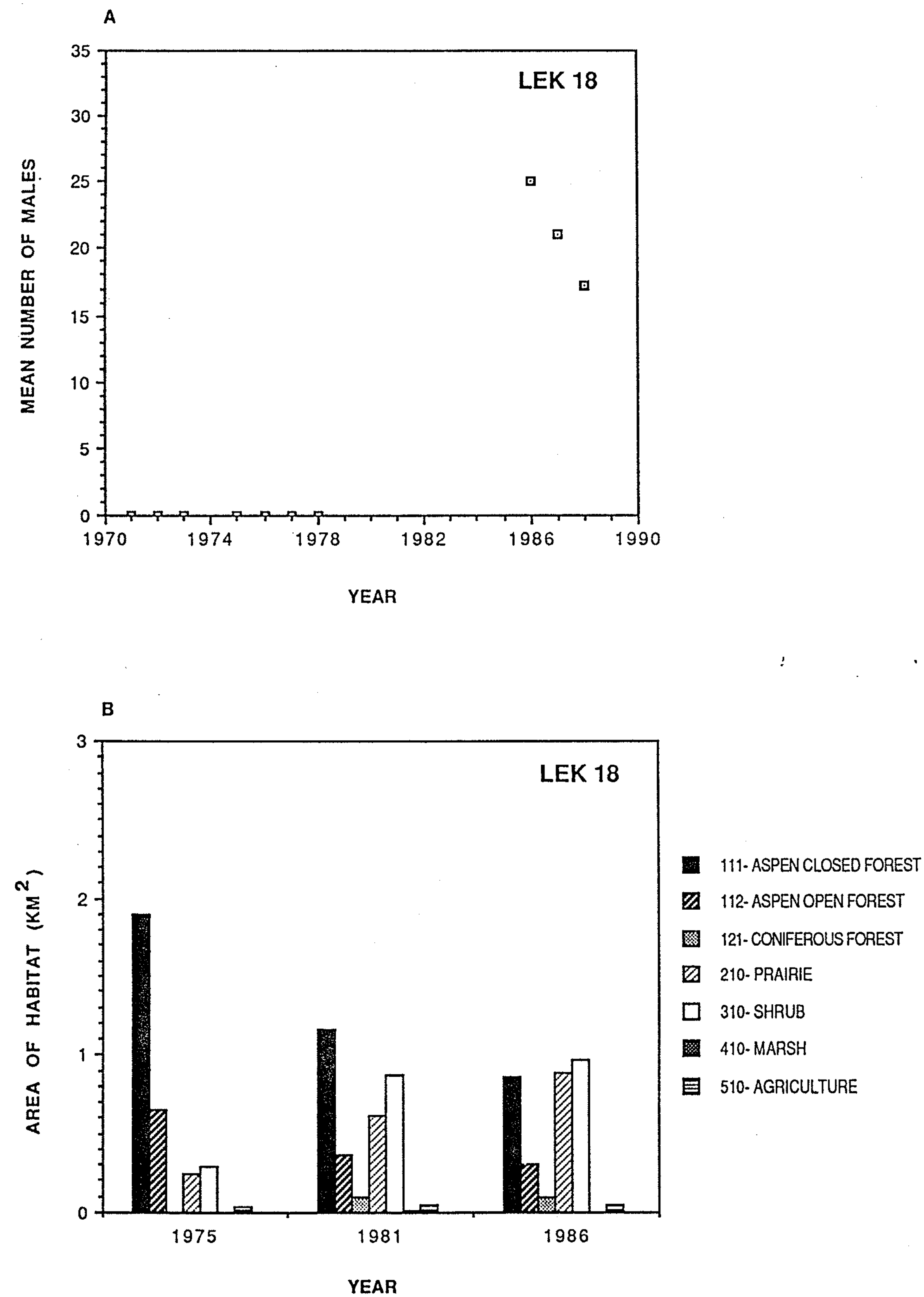


Figure 3.9: Numbers of male sharp-tailed grouse (A) and habitat area (B) from 1970-1988 on established lek 18.

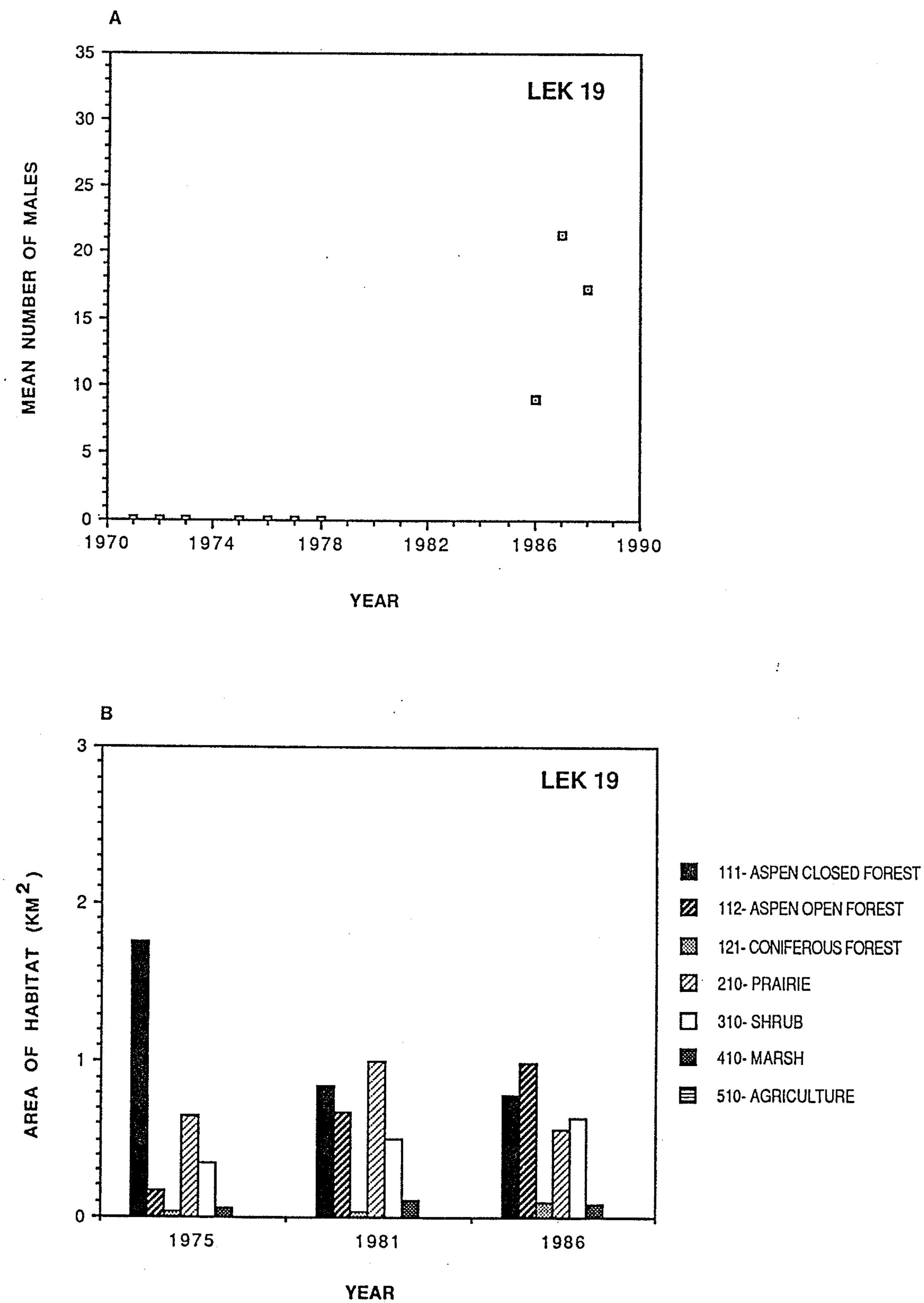


Figure 3.10: Numbers of male sharp-tailed grouse (A) and habitat area (B) from 1970-1988 on established lek 19.

3.4.3 STABLE LEKS

Figures 3.11-3.13 represent three leks (1, 5 and 11) that remained active over a 14 year period. Leks 1, 5 and 11 were established by 1971 and remained active until 1988. Lek 1 and 5 occurred on prairie-like areas (old agricultural fields). Aspen forest and prairie remained relatively constant surrounding lek 1, while aspen forest increased and prairie decreased around leks 5 and 11.

Lek 1 (Figure 3.11) was located in an agricultural field. The dimensions of the field remained relatively constant from 1965 to 1986. Numbers of grouse using this lek from 1971 to 1988 ranged from six to 13. The habitat surrounding the field changed slightly over time. From 1965 to 1981, closed aspen forest decreased, from 1.9 to 1.2 km^2. Prairie and shrub increased from 0.1 to 0.6 km^2 and 0.4 to 0.9 km^2 respectively. Aspen decrease and prairie increase were not significant ($P > 0.1$) for the change in habitat surrounding lek 1 from 1965 to 1986.

Lek 5 (Figure 3.12) was located in another agricultural field. Grouse numbers on the lek ranged from three to eight. In 1965, no agricultural field was present. Instead 1.7 km^2 of prairie and 0.7 km^2 of aspen open and closed forest existed in the immediate area. By 1975, prairie had been reduced to 0.2 km^2 and aspen open and closed forest surrounding the field had increased to 2.3 km^2 of the total

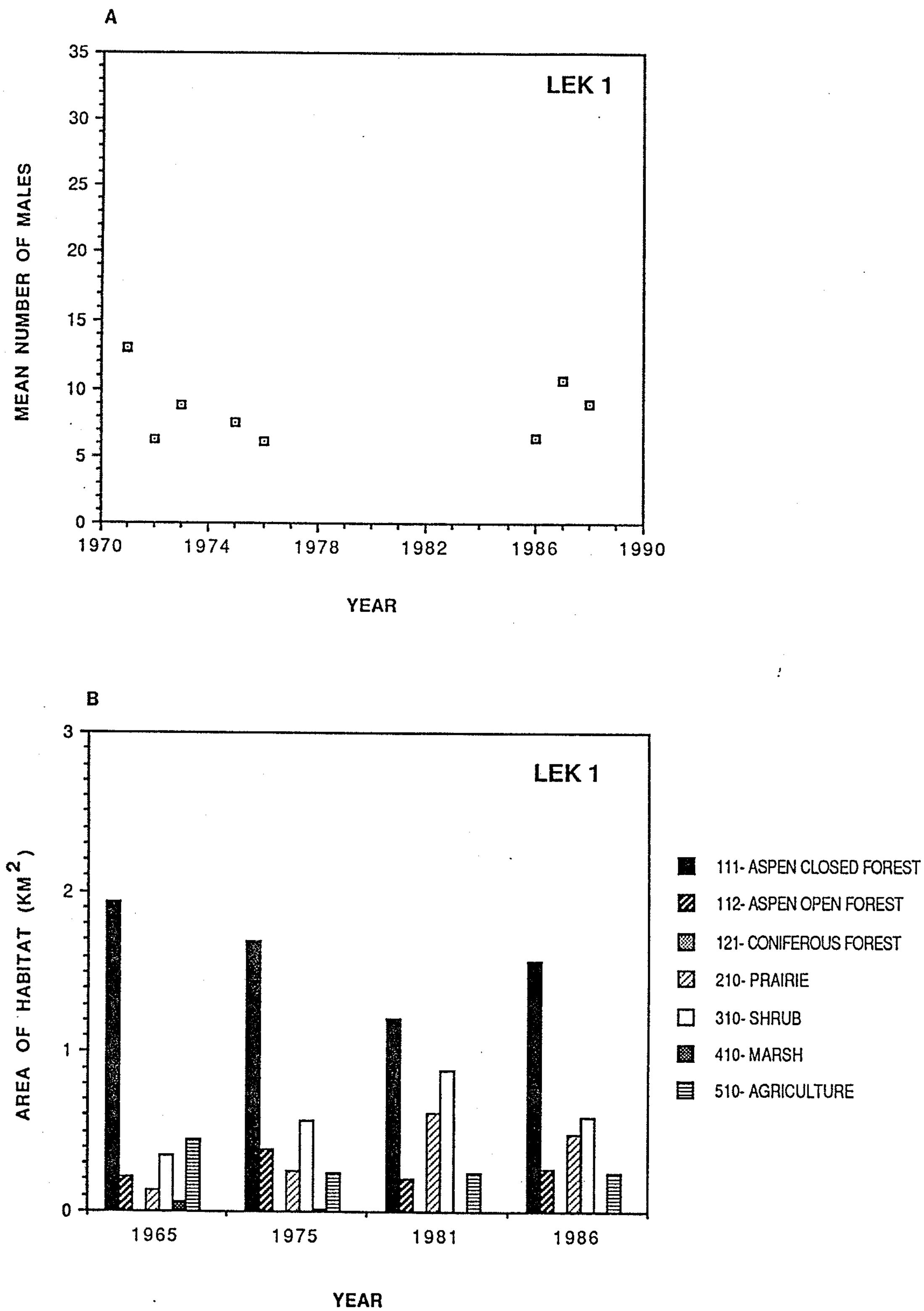
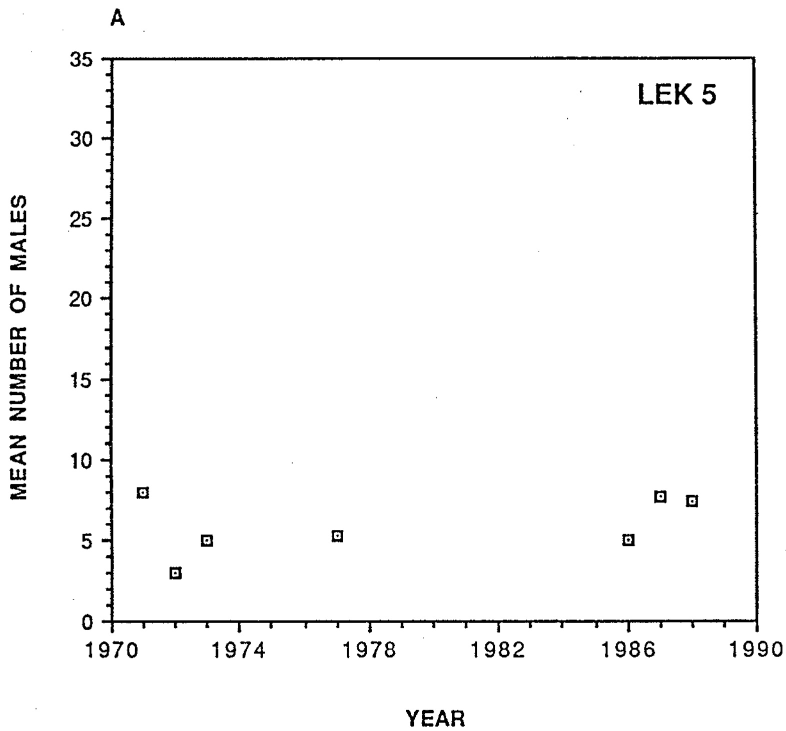


Figure 3.11: Numbers of male sharp-tailed grouse (A) and habitat area (B) from 1970-1988 on stable lek 1.



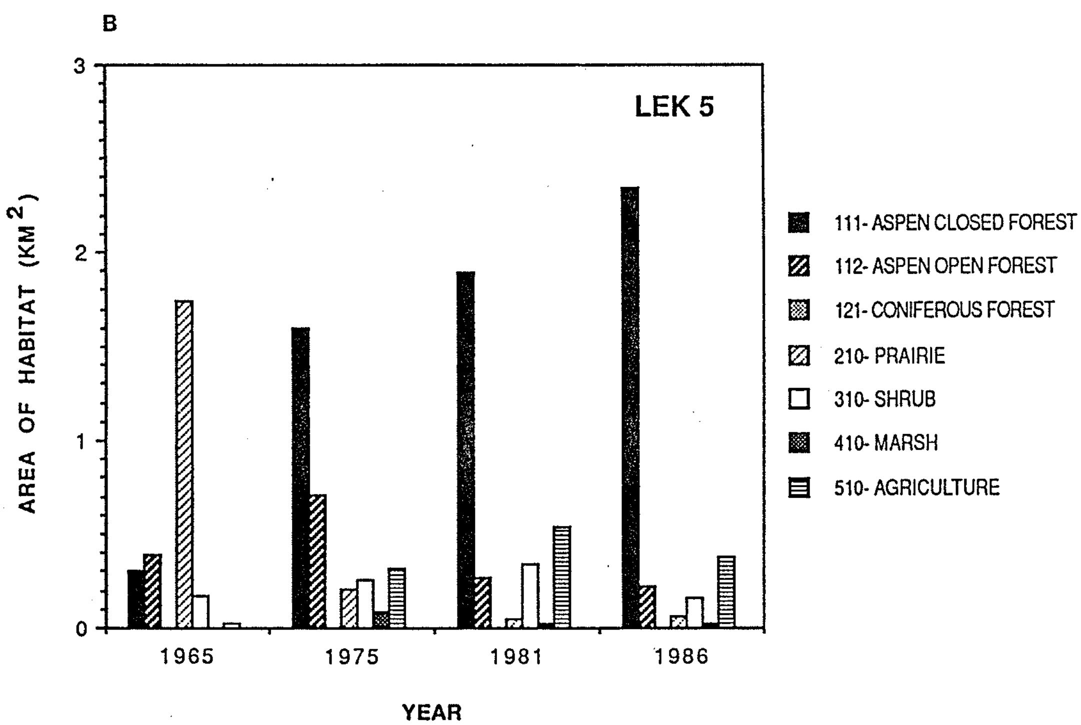


Figure 3.12: Numbers of male sharp-tailed grouse (A) and habitat area (B) from 1970-1988 on stable lek 5.

area surrounding the lek. In 1986, 2.6 km^2 of aspen open and closed forest were present, and < 0.1 km^2 of prairie remained. The overall increase in aspen closed forest and decrease in prairie were significant ($P < 0.05$) from 1965 to 1986.

Lek 11 (Figure 3.13) had males present between 1970 and 1988, ranging in number from one to 27. From 1975 to 1986 the habitat surrounding the lek changed dramatically. Aspen closed forest shifted from 0.4 to 2.3 km^2 (significant change $P < 0.1$) while prairie and shrub cover were reduced from 0.8 to < 0.1 km^2 ($P < 0.1$) and 0.8 to 0.4 km^2 respectively. A summary of change in habitat is indicated in Figure 3.14.

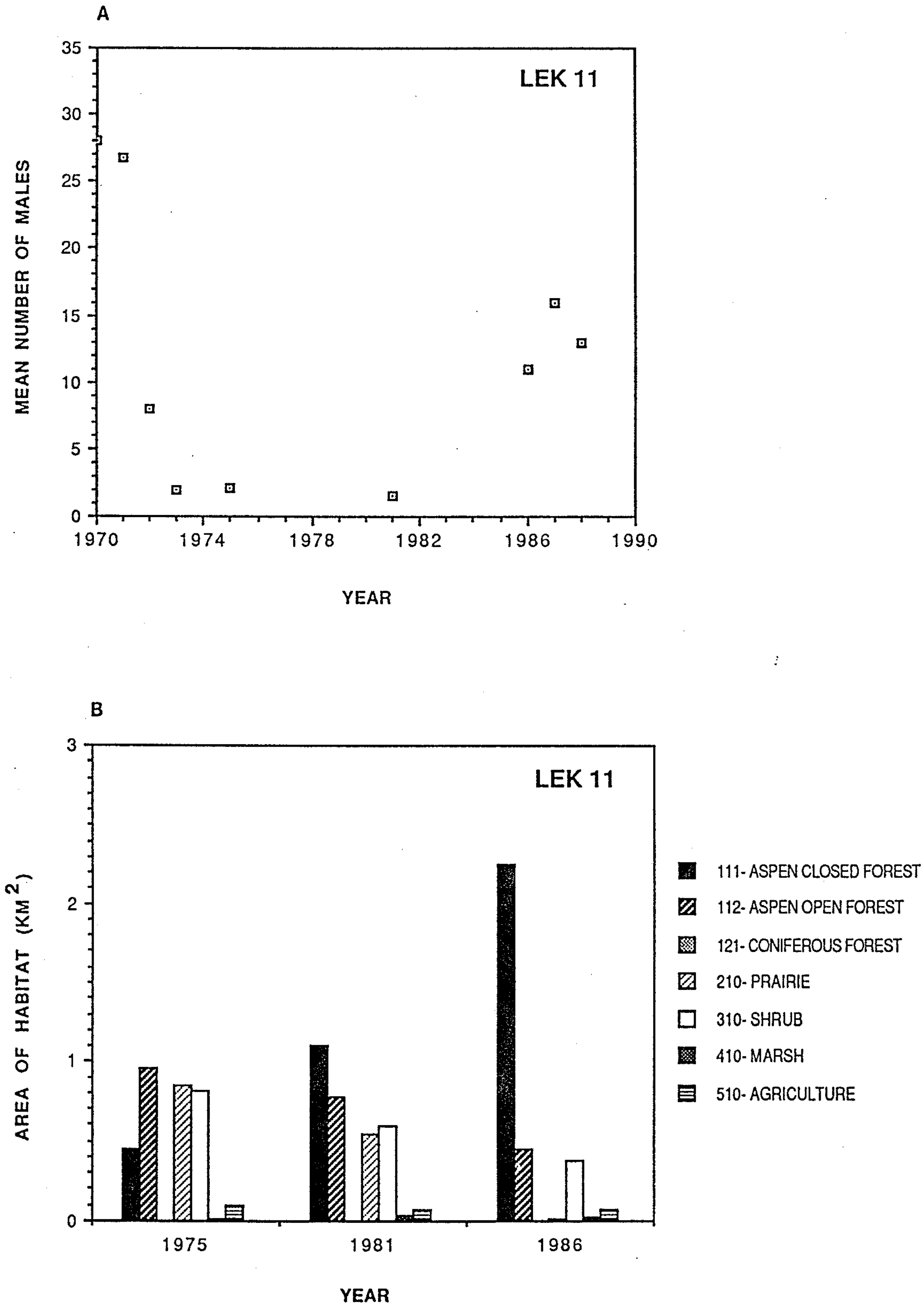
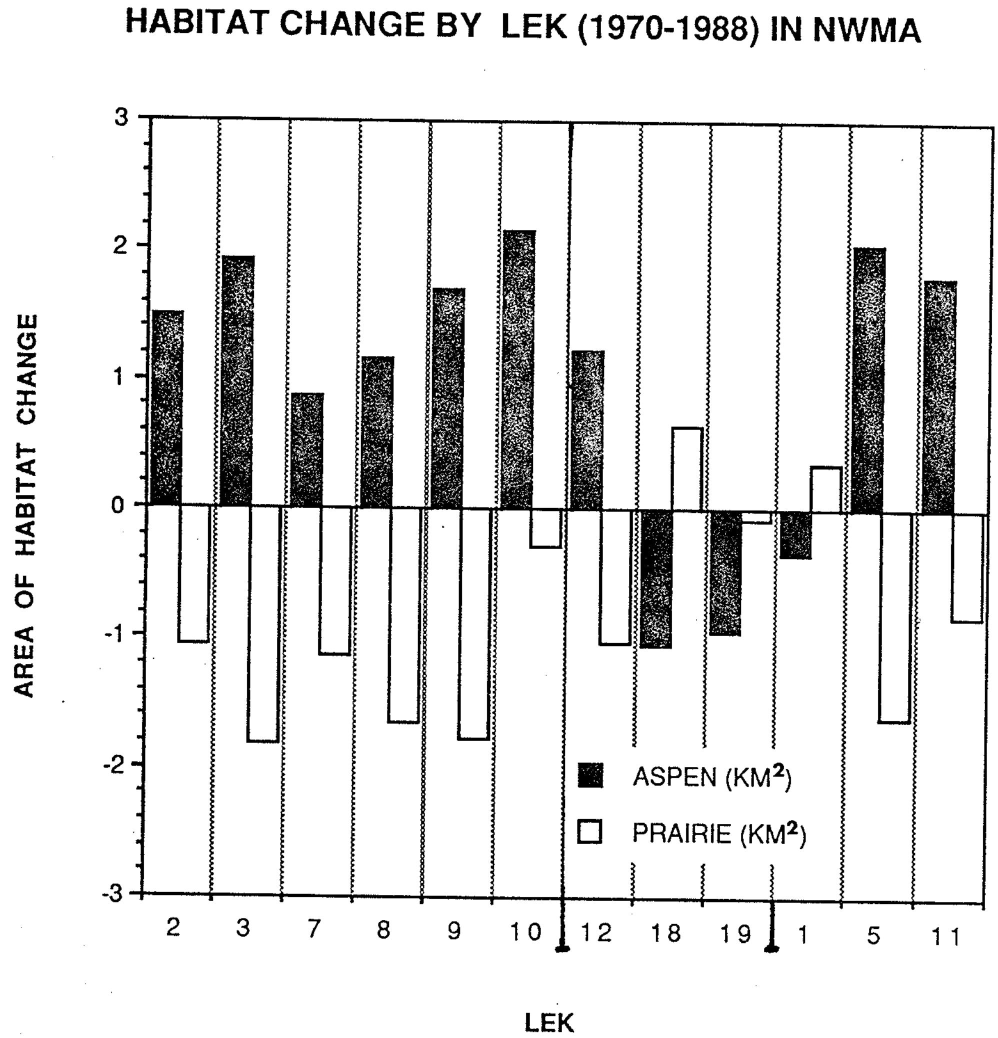


Figure 3.13: Numbers of male sharp-tailed grouse (A) and habitat area (B) from 1970-1988 on stable lek 11.



LEKS 2,3,7,8,9,10 - ABANDONED
LEKS 12,18,19 - RECENTLY ESTABLISHED
LEKS 1,5,11 - STABLE

Figure 3.14: Lek status and habitat change (1970-1988) in NWMA.

3.4.4 RATE OF VEGETATION CHANGE

From 1970 to 1988, six leks were abandoned, in all of which the total area of aspen closed forest increased and prairie decreased. Five leks had grouse begin to occupy the area after 1970, and were still present in 1988. Three of the five showed an aspen decrease and prairie increase. Two leks showed an aspen increase and prairie decrease.

Of the seven abandoned leks, the average rate of aspen increase was 0.06 km^2 or 4.5% per year. The mean rate of prairie decline was -0.06 km^2 (-4.5%) per year. Of the five leks which remained between 1970 and 1988, three showed an aspen decrease at a mean rate of -0.07 km^2 (-9.3%) per year and an increase in prairie of 0.02 km^2 (9.1%) per year. The two remaining leks had aspen increasing at a mean rate of 0.12 km^2 (9.1%) and prairie decreasing at a rate of -0.04 km^2 (-9.1%) per year. These two leks have remained stable since 1970 and 1971 respectively, up to 1988. The average of the total distribution of habitat types surrounding leks which were established, stable or abandoned is presented in Table 3.3.

Taking the difference between 1965 and 1986, aspen closed forest increased 36.2% in total area, aspen open forest increased 2.5%, prairie declined 37.5%, shrubs increased 2.3% and marsh decreased by 1.1% in the immediate area of all leks. There appears to be an inverse relationship between areas of aspen closed forest and of prairie.

TABLE 3.3

Total distribution of habitat types grouped by stages of use in NWMA, 1970-1986.

ABANDONED LEKS	LEKS PRIOR TO ABANDONMENT	STABLE LEKS
56% Aspen Closed Forest	43% Aspen Closed Forest	44% Aspen Closed Forest
14% Aspen Open Forest	12% Aspen Open Forest	15% Aspen Open Forest
15% Prairie and Prairie-like Areas *	28% Prairie and Prairie-like Areas	23% Prairie and Prairie-like Areas
12% Shrub	15% Shrub	17% Shrub
03% Marsh	02% Marsh	01% Marsh

* Prairie-like area means agricultural fields, abandoned hay fields etc.

3.4.5 CHANGE IN MALE NUMBERS ON LEKS

The mean number of male grouse on all leks was calculated by taking the total number of grouse on all leks during a single year and dividing it by the number of active leks (>2 males/lek) in that year. The trend (Figure 3.15) indicates that the mean number of grouse per lek varied between 1970 to 1986, but not significantly because of the large variation in the mean number of males. The total number of leks within the study area decreased from 12 to five (1976 to 1986). In 1987, seven active leks were observed and in 1988, a total of eight leks were found in the study area. The loss of one satellite lek and the gain of three new leks occurred in 1988. The three new leks were formed in manipulated areas (see chapter 4).

Leks 8 through 12 existed within three kilometers of each other. In 1970 and 1971, lek 8 had an average of 12 males. Leks 9, 10, and 11 had 15 to 17, six to 12 and 27 to 28 males respectively. Lek 12 did not exist during this time. From 1972 to 1974 the number of males occupying leks 8, 9, and 11 decreased. Lek 11 dropped from 27 to two males from spring 1971 to spring 1973. In 1975, lek 12 was recorded as active for the first time with 17 males displaying on it. The number of males on lek 10 increased from 11 to 30.

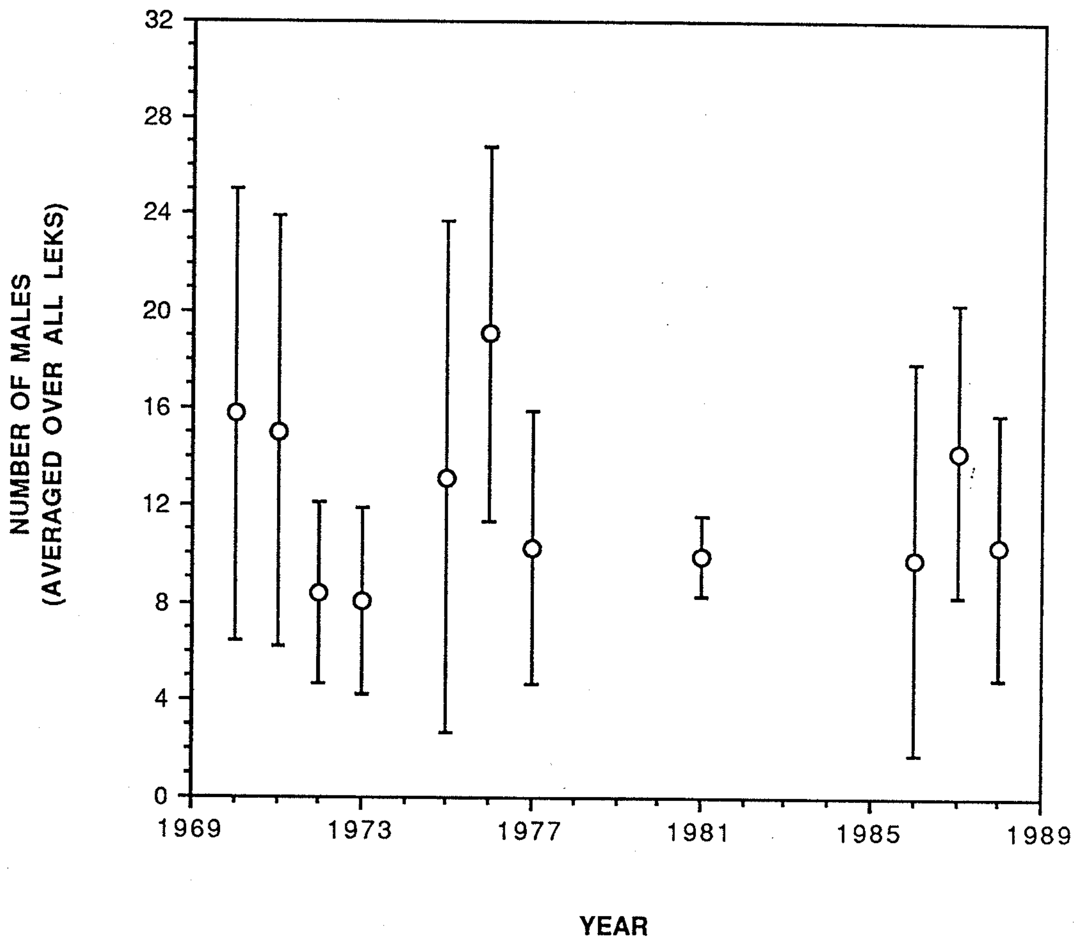


Figure 3.15: Average number of male sharp-tailed grouse per lek in NWMA from 1970-1988.

3.5 DISCUSSION

3.5.1 HABITAT CHANGE IN THE STUDY AREA

Some regions within the NWMA are undergoing aspen succession, changing from aspen parkland into aspen forest. The mean rate of aspen increase (0.06-0.12 km^2 or approximately 1.9% per year) was greater than rates reported in studies conducted on similar community types. Bailey and Wroe (1974) found that in a 59-year period of aspen change in the parklands of Alberta, the net increase in brush cover was 3.2%; while the annual rate of invasion averaged 0.05%. Johnston and Smoliak (1968) calculated the rate of brush invasion onto grassland as 0.75% per year in another study in Alberta.

The habitat distribution necessary to sustain a subpopulation of grouse within the traditional lek and surrounding plant community in the study area is approximated at no more than 44% aspen closed forest, and 15% aspen open forest. At least 23% prairie and prairie-like habitat, and 15 to 17% shrub is necessary for reproductive habitat. Prairie should be kept at the upper limit or greater if possible and at least one contiguous area of prairie >20 ha should be present. If sharp-tailed grouse habitat changes through succession, increasing aspen closed forest to above 56% and decreasing prairie to below 14%, sharp-tailed grouse will likely abandon the site.

Ammann (1957) found that sharp-tailed grouse in Michigan use an interspersion of cover types, including 6% forbs, 50% grass and woody cover, and 44% heavy wood cover with small grassy openings. This interspersion provides sharp-tailed grouse with breeding, nesting and brood rearing areas as well as with seasonal forage and cover requirements. The Minnesota Department of Natural Resources recommends that sharp-tailed grouse habitat be managed to include the following interspersion of cover types: 35% grass-legume, 15% small grain cropland, 7% sedge-marsh, 16% willow, 9% lowland brush and trees and 18% off-site aspen-birch. This is a higher percentage of grass cover than calculated for this study.

The trend of aspen increase and prairie decrease suggests that continued aspen succession at the rate observed will result in continued abandonment of traditional leks in NWMA. Lek 11 is an example of a stable dancing ground that is being threatened by advancing aspen. Caldwell (1976) corroborates the hypothesis that grouse abandon leks in aspen parklands of central Manitoba when the percentage of grasses within 0.8 km falls to less than 58%.

3.5.2 CHANGE IN SHARP-TAILED GROUSE NUMBERS

After examining the abandonment of traditional leks in the study area, I suggest that sharp-tailed grouse abandoned leks because habitat quality was decreasing as aspen forest invaded the prairie. Many authors have supported the conclusion that habitat deterioration causes declines in local populations (Hamerstrom et al. 1961, Ammann 1957, 1963, Aldrich 1966, Brown 1966a,c, 1967, Evans 1968, Anderson 1969, Miller and Graul 1980, Rogers 1985 and Berg et al. 1987a). In Alberta, Moyles (1981) noted the extent of trembling aspen cover around a lek was inversely correlated with the number of male sharp-tailed grouse observed on the lek and the total number of grouse recorded within 0.8 km of the lek. Pepper (1972) reported positive correlations between the number of summer-observed grouse and the amount of ungrazed native grass-shrub and tame haylands within 1.6 km of leks. He also observed a correlation between attendance of grouse on leks during spring display and the number of sharptails seen within 1.6 km of the lek in summer.

Some evidence suggests that male sharp-tailed grouse may shift to new locations after abandoning traditional leks. The total gain in males on leks 10 and 12 was 36 from 1975 to 1976, while the loss of grouse from leks 8, 9 and 11 was 41 from 1972 to 1975. The gains in males from the first set of leks approximates the loss from the second set. Leks 8 and 9 were abandoned shortly afterwards.

Twelve leks were present in 1976. By 1986, five leks remained in the study area. I suggest that when the mean number of males, the variation of male numbers between leks, and the total number of leks are the largest between years, the sharp-tailed grouse population within the study area has reached a peak in the cycle. Cannon and Knopf (1981) found that mean lek size was unrelated to the density of displaying males but that the number of greater prairie chicken leks was positively correlated with density. They also found that variability in average lek size increased as the density of displaying males increased. The increased variability in average lek size at higher population densities was attributed to the presence of a greater number of small, temporary leks. The number of smaller leks increased with density of displaying males, causing average lek size to decline as numbers of both displaying males and leks increased. Brown (1962) found that total number of leks in an area decreased while average number of cocks declined, whereas in the year prior, the total number of grounds decreased as average male attendance increased. Each case suggested variation with respect to mean number of males and the number of leks in any year.

The decline in the total number of leks, plus a slight decline in mean number of males per lek could be attributed to the 10 year cycle. The last peak in the population cycle for sharp-tailed grouse seemed to occur between 1975 and 1977 as supported by provincial harvest estimates (Manitoba Department of Natural Resources 1975). The 10 year cycling phenomenon suggests that the next peak in the cycle should have occurred between 1985 and 1987. Although the peak in the cycle did not occur between this time period, the subpopulation within the study area did increase in 1987 and 1988.

In the study area, subpopulation cycles may be discontinued if habitat deterioration continues. Ammann (1963) stated that cyclic tendencies seemed evident before the mid-1950's, but that sharp-tailed grouse populations no longer show recognizable cyclic behaviour in Michigan. He suggested that this phenomenon was a result of habitat deterioration.

Grouse did not form additional leks in the study area (1986 to 1988), except on manipulated sites (see chapter 4). Increases in the number of grouse on manipulated sites may be attributed to the revitalization of habitat. No other sites in the study area had a decrease in aspen and an increase in prairie.

The increase in the number of males on leks 10 and 12 was due probably to movement or dispersal of males from leks 8, 9 and 11. Grouse could have moved because of a decrease in breeding habitat quality in the three leks and a concurrent increase in quality (increase in prairie) in the latter two. A controlled burn occurred in 1972 around leks 8, 9, 10 and 12. If fire was patchy, and did not improve habitat quality on leks 8 or 9, this would provide an explaination for grouse dispersal.

Lek abandonment or new lek formation are partially explained by two behavioural models proposed by Bradbury and Gibson (1983), Gibson and Bradbury (1987) and Beehler and Foster (1988). The 'hotspot' model states that males should display at the point having the lowest cummulative distance to the activity centers of all females in the population. This model predicts that lek spacing will be positively correlated with the size of female home range, but that leks can be less than one home range diameter apart. Refering to the NWMA subpopulation, males may have moved to new leks because the activity centers for females changed. Change in female activity centers may have been a consequence of nest and brood habitat deterioration.

The 'hotshot' model is driven by (1) an increasing inequality in male mating success, produced by a combination of male-male dominance interactions plus conservative mate choice by females, and (2) the resulting association of novice and subdominant males with successful court holders. This model suggests that abandonment of smaller leks is due to behavioural rather than environmental cues. Abandoned leks were some of the largest leks in the study population and the Hotshot model does not account for the abandonment of large leks. A large lek complex suggests that a large inequality in male mating success and the association of novice and subdominant males already exists. The model suggests that these leks are most likely to persist in time, yet the study leks were abandoned. Therefore, the only qualifying factor to explain lek abandonment is the decrease in quality of breeding habitat. Bradbury and Gibson (1983) include an environmental component in the Hotspot model, which suggests that habitat suitability for the lek and the immediate area should be considered.

Alternative explanations for sharp-tailed grouse subpopulation change in my study area were hypotheses proposed by Chitty (1967), Lack (1966), Keith (1974) or Bergerud (1988). However, the underlying assumption in population regulation through intrinsic and extrinsic factors other than habitat quality, is that habitat has a maximum carrying capacity for wildlife. If habitat quality deteriorates (e.g. sharp-tailed grouse habitat in the study area), the threshold of habitat carrying capacity for the population will be reduced. Subsequently, both intrinsic and extrinsic factors which regulate wildlife populations, are limited, or are subject to the habitat itself.

3.5.3 COUNTING BIAS

Important trends of grouse numbers in the study area may have been obscured because subpopulation sampling was conducted only on leks. Other male grouse may have been part of a non-reproductive portion of the subpopulation that remained unsampled (Sexton 1979b). Unsampled grouse may also have been in the reproductive pool in a non-traditional sense by breeding off the lek. Sisson (1976) concluded that changes in spring population levels could, theoretically, be measured at certain population levels by counting numbers of displaying males on dancing grounds. However, variation in attendence due to changes in weather, time of day, and time of season make it difficult to obtain accurate counts. Brown (1965) and Rippin and Boag (1974) also suggest that when only estimates of total spring counts of males attending leks are used, the size of the total population is underestimated.

3.5.4 MODELLING OF GROUSE NUMBER AND HABITAT CHANGES

If grouse are abandoning leks because habitat is becoming unsuitable, and the study area loses more of its prairie to closed aspen forest, the total number of grouse should decline theoretically. More importantly, the abandoning of leks may also be an indicator of a decrease in the quality of nesting and brooding habitat. Females and juvenile grouse use prairie and shrub for a significant portion of the reproductive period. Aspen forest is used for cover during some times of day and season, but if insufficient prairie and shrub habitat exist, most recruits in a population cannot survive in the region. Increases in intraspecific competition, poorer quality food and cover, will decrease the fitness of individuals and increase mortality rates for the recruits. If females and broods do not have appropriate rearing habitat, they should abandon sites and move to preferred habitat types. Furthermore, if females do not find appropriate nesting habitat near leks, they should disperse to other locations and possibly mate elsewhere. Gibson and Bradbury (1987) suggest that if no females visit leks, males will be forced to abandon sites. Sharp-tailed grouse will either be forced to disperse to more suitable reproductive habitats, or adapt to a major community change. Baydack and Hein (1987) suggests that the latter is unlikely in the short term. Plains sharp-tailed grouse leks in southwestern Manitoba were not visited by females during lek disturbance studies in spring 1984 and 1985. Male sharp-tailed grouse did not abandon leks even though mating did not occur.

I suggest that annual change in the habitat quality may also cause an undetectable subpopulation change. Once habitat changes to some threshold limit, subpopulation change will be noticed. This change may also occur in a series of steps over several years before a response is observed. Examination of longer term habitat change and corresponding subpopulation change suggests that populations are affected by habitat quality. It may not be possible to examine trends within years due to seasonal variation within a subpopulation, but general trends can be examined between years.

A model (Figure 3.16) was developed to show that approximately every five years in the study area, management

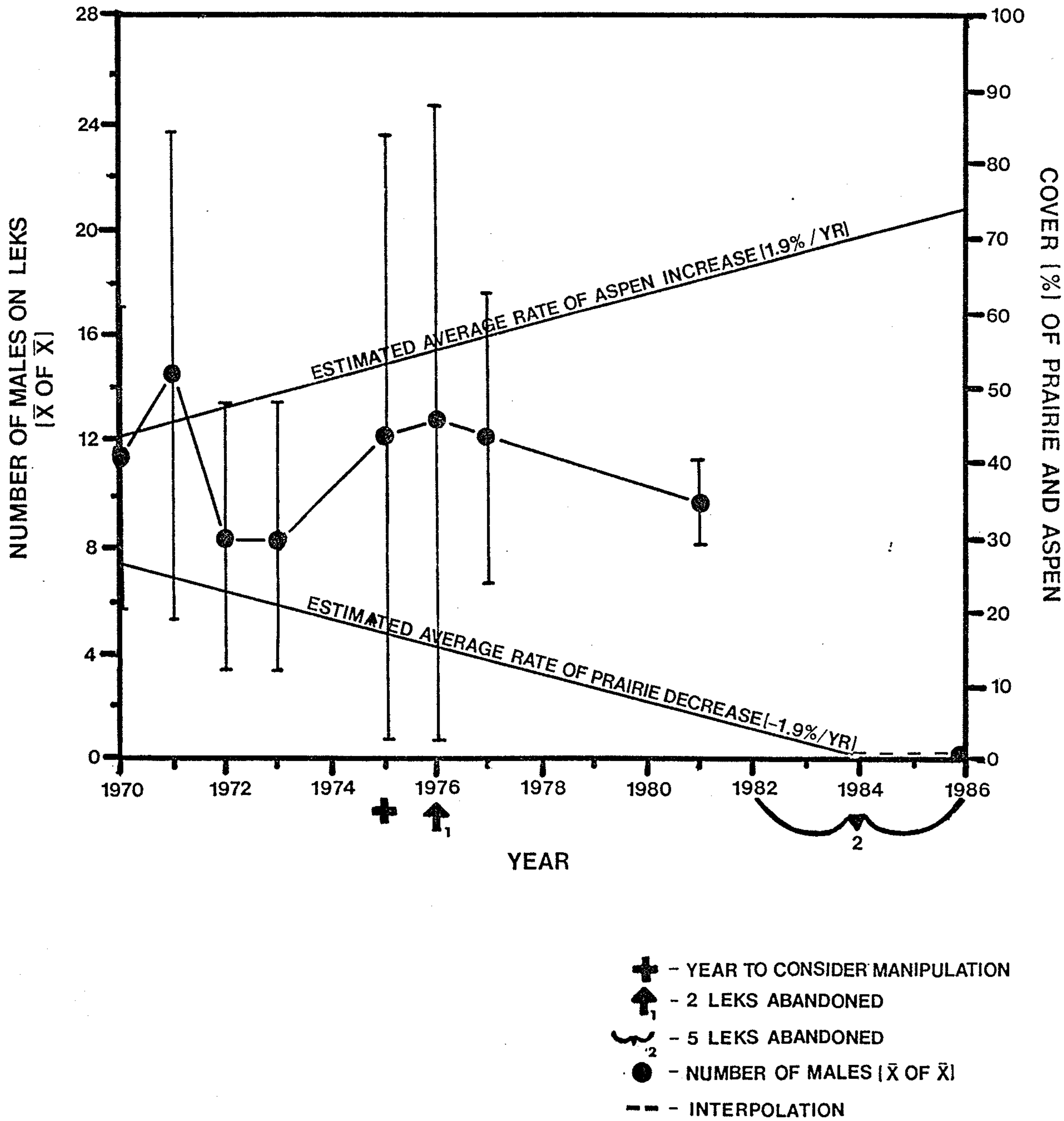


Figure 3.16: Model of the association between lek abandonment and cover values within 1.0 km radius of the lek.

is required to reverse the trend of aspen increase and prairie decrease. Factors underlying the model are: 1) that the aspen encroachment rate is 1.9% per year and loss of prairie is -1.9% per year, and 2) that aspen and prairie distribution within one kilometer of the lek are 43% and 27% respectively. I found that sharp-tailed grouse started abandoning leks when prairie decreased below 14%, and aspen increased above 56%. This suggested that prairie, within one kilometer of the lek, must be maintained above 14%. More open habitat would be beneficial because sharptails are known to inhabit areas with higher levels of prairie. The exact level when abandonment occurs needs to be determined with greater accuracy.

Brown (1967) proposed a breeding unit habitat index for quantitatively rating habitat characteristics of plains sharp-tailed grouse leks. This index was similar to my model and was based on the concept that habitat factors within the breeding range of the unit served to: 1) maintain a segment of the male cohort having traditional ties to the lek, and 2) to attract hens and young cocks making shifts in seasonal distribution. The multiple factor method relies on estimates of aerial distribution and stand density of shrubs, topographic features surrounding the lek, disturbance factors and a qualitative evaluation of grassland associations. My model differs since predictions of grouse subpopulation changes are made by examining habitat composition and rate of change within one kilometer of the lek. This model also recommends when habitat revitalization should occur to sustain the breeding population where Brown's model does not.

This study was not designed to determine the optimal distribution of prairie and aspen to sustain sharp-tailed grouse populations, but results did indicate the approximate level of distribution. Aspen regeneration and loss of prairie will occur at different rates in different regions. To manage sharptail habitat, the manager will have to determine past and present distributions of prairie and the rate of habitat change. Then a determination of the number of years (i.e. between years) needed for habitat maintenance can be made.

Chapter IV

SHARP-TAILED GROUSE HABITAT REVITALIZATION

4.1 INTRODUCTION

Habitat is the key to grouse management. Good quality grassland and brushy cover are essential for sharp-tailed grouse. Any factor or combination of factors, whether natural or man-made, which causes deterioration of native grassland over a large contiguous area, will have a profound effect on prairie grouse numbers. Nesting and brooding habitat cover are considered the foremost factor which most seriously limits the population (Hillman and Jackson 1973).

Sexton and Gillespie (1979) noted that changes in cover occurred on the NWMA after a fire reduced the height of vegetation, and caused grouse to move from a satellite lek back to a traditional lek. Kirsch and Kruse (1972) observed the establishment of four new leks on or near burned plots. Conversely, Sisson (1976) noted that changes in land use practices at sharp-tailed grouse courtship sites resulted in taller, denser vegetation, and caused the abandonment of sites within two to five years. Caldwell (1976) hypothesized that leks in aspen parkland in central Manitoba ceased to be used by grouse when the percentage of grassland within 0.8 km radius of the lek fell below 58%.

Characteristics of nesting and brooding habitat are also well documented in the literature (Ammann 1957, Kobriger 1965 Brown 1961a,b, 1962, 1965, 1966b, Evans 1968, Pepper 1972, Kohn 1976, Sisson 1976, Sexton 1979a, and Moyles 1981). Hillman and Jackson (1973) stated that nest sites were usually located within 1/2 mile (0.8 km) of a lek. Sexton (1979a) observed that 86% of females tracked to nesting locations nested less than one kilometer from the nearest lek. Evidence suggests that both male and female sharp-tailed grouse spend their life in association with the habitat located within one kilometer of the lek.

Sharp-tailed grouse habitat management should be concentrated within a one kilometer radius of an existing lek. Berg et al. (1987a) suggest that controlled burns, mowing, chaining brush, mechanical shearing, to a lesser extent herbicide application and hand cutting of trees, are standard management practices for maintaining sharp-tailed grouse habitat in Minnesota. Rotational grazing can also control succession. Ammann (1963) suggested that sharp-tailed grouse in Michigan decreased over a one year period by 9%, largely because of the loss in habitat. He found a combination of burning and herbicide spraying was found to be the most practical way of controlling woody vegetation. Other methods used were hand cutting of brush and trees, clearing of brush by discing or with a brush mower, and planting of herbaceous cover. McArdle (1977) observed that chaining promoted sharp-tailed grouse use of sagebrush-bunchgrass plant communities in Idaho. Grouse emmigrate into the area fairly soon after chaining, and later made substantial use of the area.

Berg et al. (1987b) stated that without fire, aspen parklands become a more homogeneous aspen-oak forest. Increased fire suppression and prevention has allowed succession to continue almost unabated in Minnesota. Largely as a result of succession, mosaics of open and brushland types have been converted to more homogeneous habitats supporting fewer and less diverse fauna and flora. The rate of succession is difficult to measure, but can be indexed from the rate of decline of indicator species such as sharp-tailed grouse.

This chapter describes the effects of bulldozing and mowing on traditional and newly created sharptail reproductive habitat. It also examines the effect habitat change has on subpopulation numbers of sharp-tailed grouse. I predicted that if new leks were formed on manipulated sites, male sharp-tailed grouse would be mostly juveniles.

4.2 METHODS

In spring and fall 1986, the study area within the NWMA was systematically searched for active leks and the locations were mapped. Flush counts of each dancing ground were made on a regular basis.

In fall 1986, aerial photographs were taken of the study area. These photographs aided reconnaissance of the area prior to choosing sites for habitat manipulation. Further reconnaissance of specific sites was conducted by snowmobile in early January 1987. Final site selection was based on the following criteria; A) whether or not the site was a historical dancing ground, B) degree of site workability (density and size of aspen and amount of exposed glacial till), C) degree of openness (whether or not stands of aspen were intermixed with prairie), D) site accessibility, and E) spatial relationships of site and traditional dancing grounds. In January 1987, four major sites (Figure 4.1) and one minor location (not listed) were cleared of standing aspen by a bulldozer. Stands of aspen were cleared using a linear strip method. Large trees were piled at the edge of a site to make mowing easier. Consideration was given to minimizing soil displacement and erosion risk by keeping the bulldozer blade raised above topsoil level. Each manipulated site was modelled after traditional leks to create habitat of similar shape and surrounding cover.

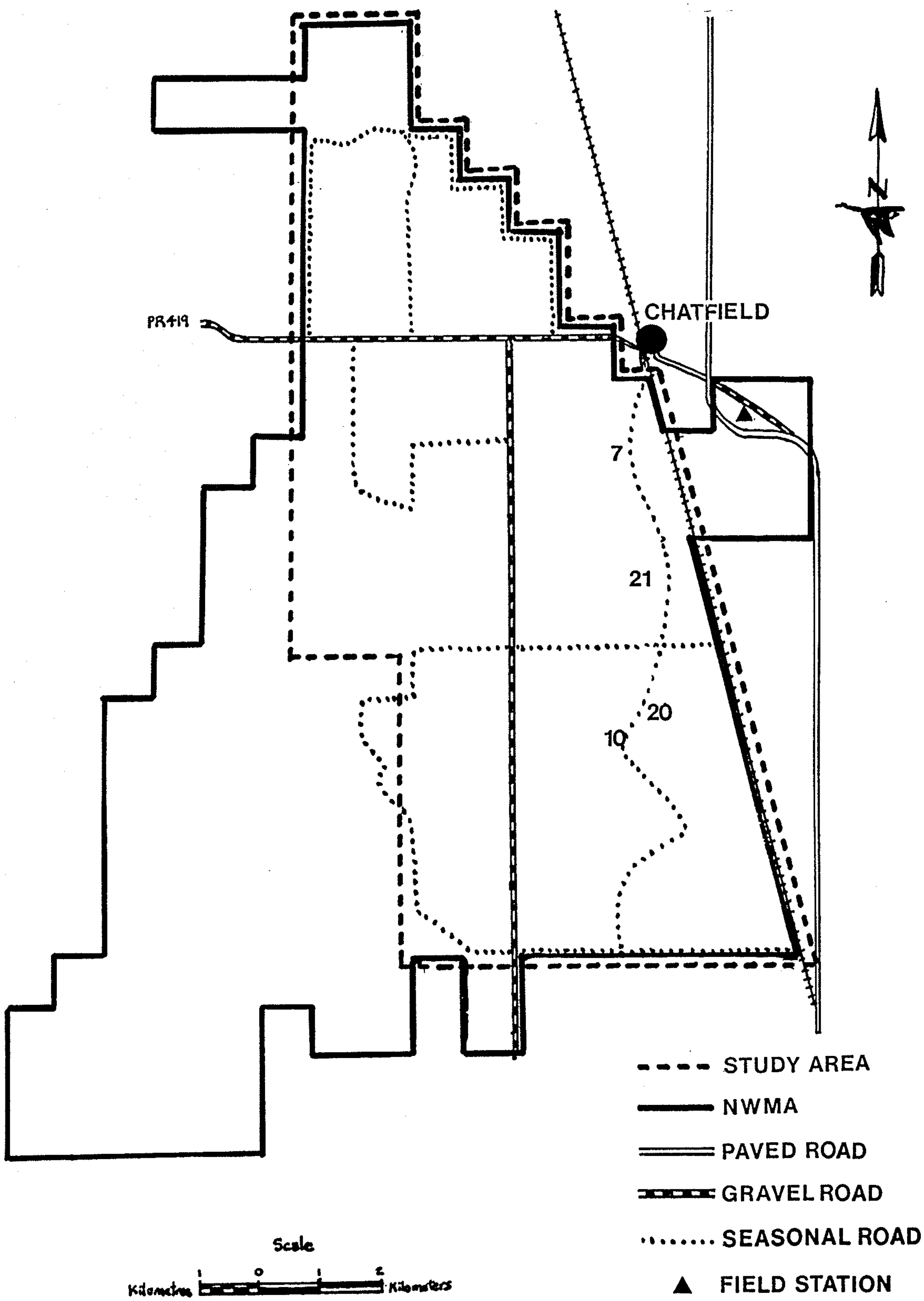
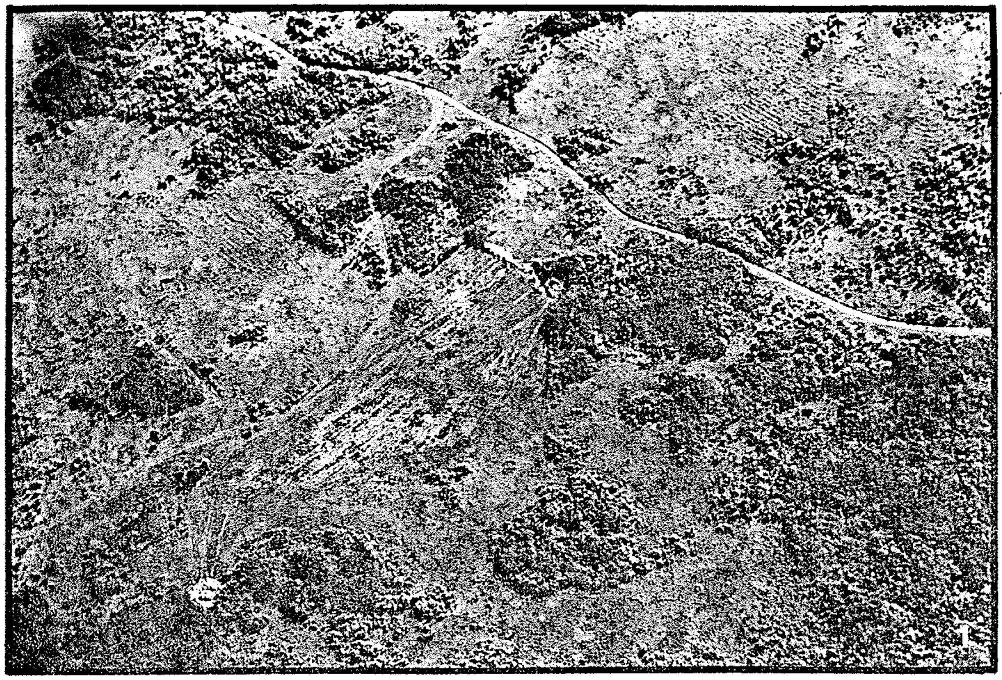


Figure 4.1: Location of the manipulated sites in the Narcisse Wildlife Management Area. Manipulated sites are renumbered by lek.

Manipulation of site 1 was conducted around historical lek 7. The total area cleared of standing aspen surrounding historical lek 7 was 3.65 ha. Site 2 was not known to have any lek activity from 1970 to 1986. Aspen was cleared to create 9.45 ha of prairie. A fireguard was built to completely encircle the area for future maintenance considerations. In 1988, site 2 was renamed lek 21. Site 3 manipulation was incompleted since difficulty was encountered clearing willow (Salix spp.). A fireguard was constructed in consideration of site completion and maintenance. Site 4 was also known not to have any leks between 1970 and 1986. The completed open area measured 5.45 ha, and in 1987 the site was renamed lek 20. Site 5 was constructed around historical lek 10. The final area clear of closed aspen forest was 3.28 ha. (Figure 4.2).

Between 7 and 28 July 1987, a tractor and brush mower was used to cut suckering aspen (Figure 4.3). Areas with high densities of rock and debris which could not be mowed, were trimmed with a hand-held brush saw.

During spring, summer and fall 1986 and 1987, and spring 1988, sharp-tailed grouse activity on traditional, historical and manipulated areas was monitored daily. Other wildlife species within manipulated sites were also noted (Appendix B).



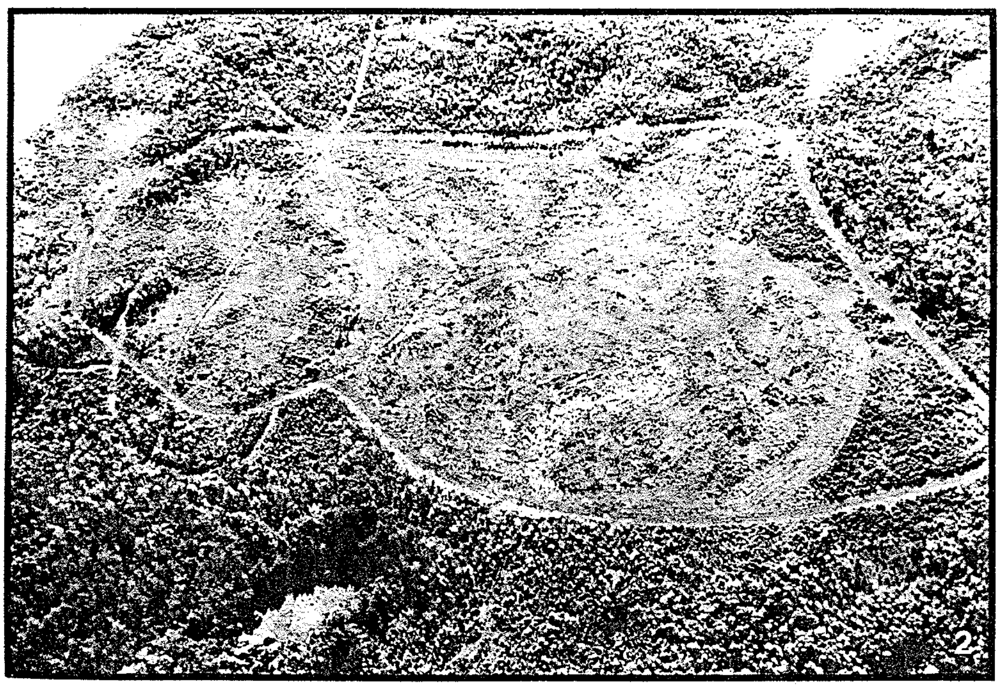
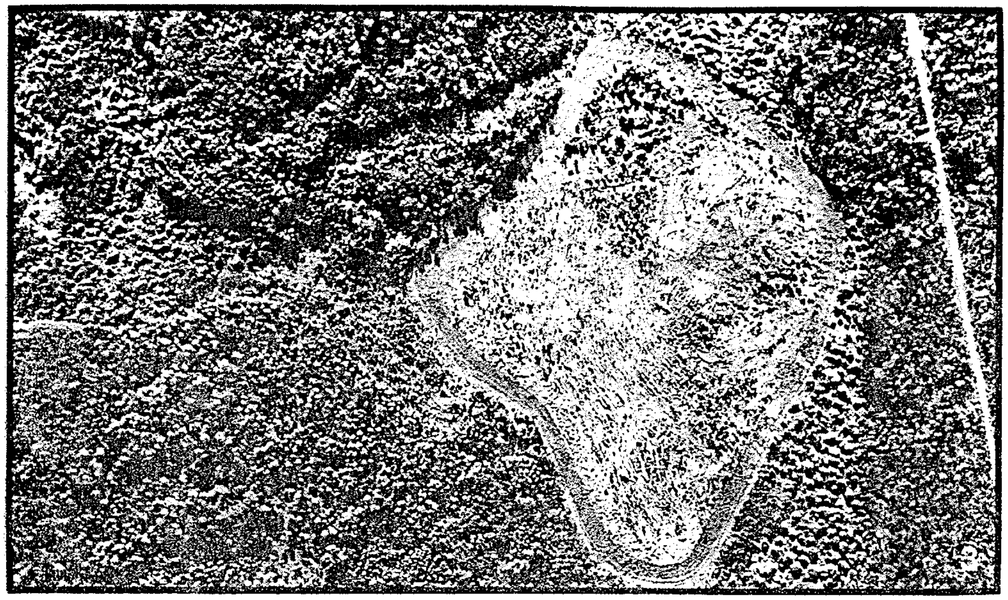


Figure 4.2: Aerial photographs of the five manipulated sites (in series: site 1 to site 5).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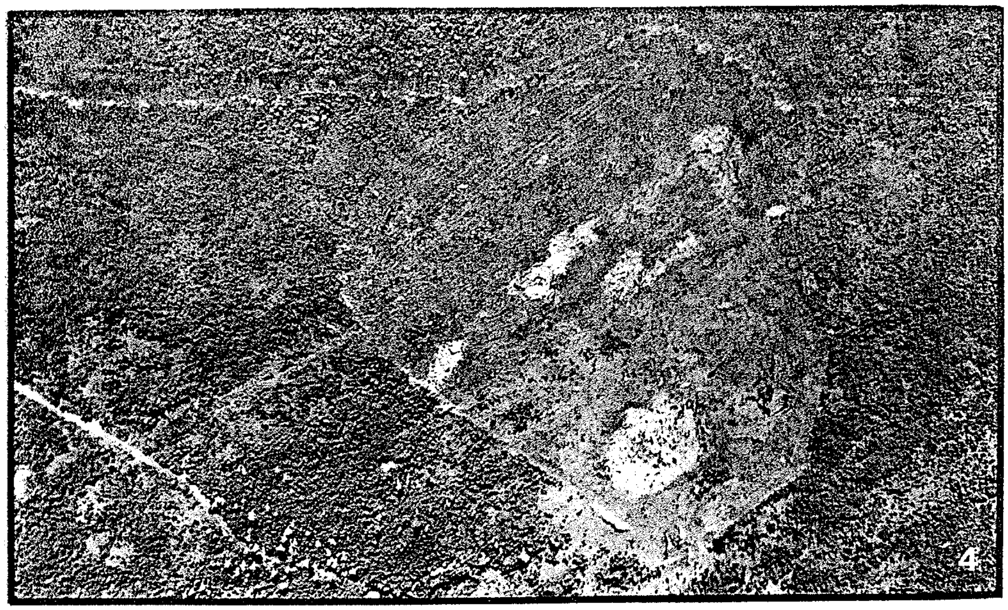
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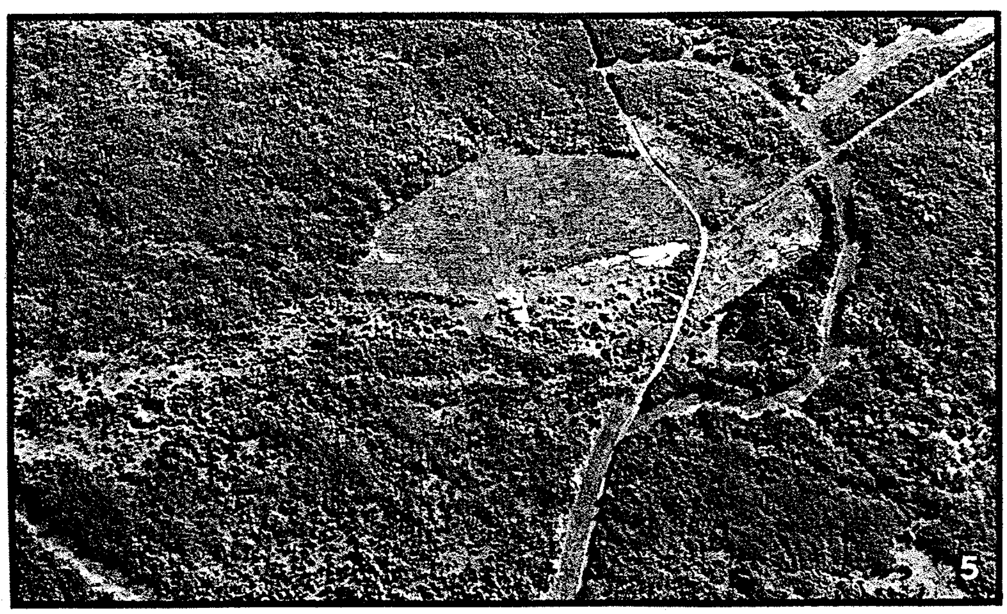
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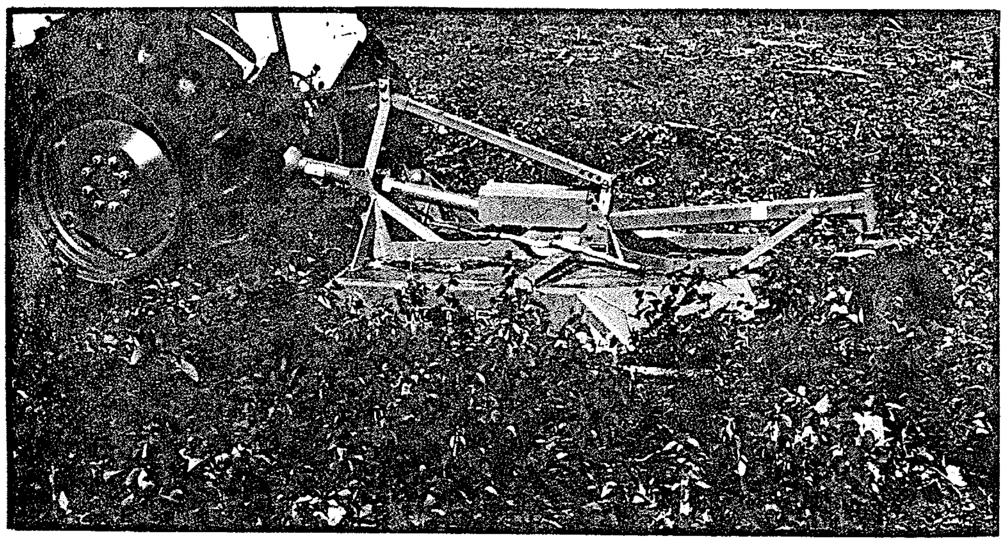


C

Figure 4.3: The effect of mowing on suckering aspen (A) bucket on tractor clearing heavy debris (B) mowing (C) comparison of mowed and unmowed aspen.

Male sharp-tailed grouse were captured in spring and fall 1987, and spring 1988. Two steel mesh traps (Baydack 1986) and six traps, constructed with welded wire mesh sides and cotton mesh tops, were used to trap grouse. The latter consisted of side panels (1.5 X 1.5 X 1.0 m) with 20 cm^2 openings of inverted steel mesh or woven wire funnels (Val Schawarock, pers. commun.). Woven wire leads (< 40 m) were extended from each opening.

An experimental remote controlled drop net was also used to trap grouse. Four solenoids mounted on moveable metal brackets were attached to four, 1.5 m aluminum poles. The poles were positioned over a sharptail territory on the lek and each corner of a cotton mesh net (6 X 6m) was attached to the arm of the solenoid with waxed dental floss. Solenoids were connected through a relay to a motorcycle battery. The relay was triggered by two modified walkie-talkies. One transmitted a signal from a remote location, the other received it and activated the relay. All four corners of the net were released simultaneously to drop the net and capture grouse.

On one occasion, a large non-remote controlled drop net (17 X 10m) was used to trap grouse (design followed Silvy and Morrow 1985).

Males were trapped and marked on leks adjacent to manipulated areas in order to monitor possible movement of males from traditional leks onto manipulated sites. At least 50% of males were banded on leks 5, 11, 18, and 20, while 24% of males were banded on lek 19. Male decoys and tape-recorded vocalizations were used to enhance trapping success. A total of 40 male (34 adults, six juveniles) and six female (all adults) sharp-tailed grouse was banded. Grouse were sexed and aged using crown and tail feather patterns (Henderson et al. 1967 and Wishart 1977) and primary shaft measurements (Caldwell 1976). Sequential aluminum leg bands and plastic color coded leg bands were used for individual identification (Appendix C). Thirteen solar-powered transmitters attached to ponchos (Amstrup 1980) were placed on grouse (six adult males, two juvenile males and five adult females) to monitor their movements. A yagi antenna and AVM receiver were used to relocate males and females. At least two mornings per week were set aside to observe grouse on leks. Banded and transmittered grouse were not recorded on leks because grouse did not visit any lek other than on the lek they were trapped.

Control leks 18 and 19 were selected along with the four treated (manipulated) sites (leks 7, 10, 20, and 21) for elevation, and vegetation species, density, and cover comparisons. During fall 1987 a systematic sampling technique was used. Six transect lines originating from 0^{o}N and spaced at 60^{o} intervals on each area radiated out from the lek center. Sampling intervals ranged from five to 25 meters.

Two sampling strata were used, one on the lek itself, the other an area up to 200 m from lek center. Visibility and cover were measured at sampling points using the density board technique (Jones 1968). Measurements were taken at 45^0 and 0^0 above horizontal. Measurements taken at 0^0 were not used because vegetation cover was too dense. Plant cover was also sampled using a modified Daubenmire (1959) method, and categorized as low (1-35%), medium (36-75%) or heavy (76-100%) cover. Elevation was measured at each site using a surveyors level and rod.

Data were analyzed using SAS (SAS Institute, Inc. 1982) on the University of Manitoba mainframe computer. Elevation graphics were plotted with SAS Graph. Jones cover board data were analyzed using trend analysis and presented in scatter plots.

Leks were compared based on Daubenmire cover values using minimum variance agglomerative hierarchial cluster analysis (Ward 1963). The analysis was performed using procedures CLUSTER and TREE (SAS Institute, Inc. 1985). Cluster analysis is a numerical method which achieves a classification of a set of 'n' individuals (leks). Hierarchical agglomerative clustering methods begin by fusing the two nearest individuals. In minimum variance clustering, subsequent fusions are based on minimizing the increase in total within-cluster sum of squares at each fusion. The method leads to even-sized, tight groups, and the results are plotted as a dendrogram (Orloci 1967).

In this study, cluster analysis is used to establish whether or not a difference existed between Daubenmire cover values on manipulated sites versus the control leks. If the groupings recognized by cluster analysis lead to a separation of quadrats from manipulated areas and control leks, this would suggest that differences in vegetation arise as a result of manipulation. Conversely, if groupings include both control leks and manipulated areas, this would indicate that vegetation is similar accross control leks and manipulated habitats.

4.3 RESULTS

Manipulation cleared, in total, approximately 22 ha of aspen and created 22 ha of prairie in four different locations. No other areas in the study area had prairie created during this time (1986 and 1987), therefore grouse likely used the most open sites (i.e. manipulated areas) suitable for reproduction within the region.

Plant cover and species density were similar in control leks and manipulated leks (Appendix D and E). Grass species, litter/ bare ground, and bearberry were the most prominent species. Manipulation did not seem to affect plant density or their corresponding Daubenmire cover values.

The most prominent species in the area surrounding leks included grasses, trembling aspen, bearberry, rose, bedstraw, other small forbs, and bare ground. Grasses and litter dominated in Daubenmire plant cover values (Appendix F and G). Manipulated sites and control leks had similar cover and plant species densities in the area surrounding them.

When plant cover was grouped into five general categories there was no difference between control and manipulated areas (Appendix H and I). This indicates that the bulldozing and mowing on the manipulated sites did not alter plant species cover of low vegetation. Plant species densities were also unaffected. It did however, change the cover and density of the shrub and tree categories, which was the primary purpose of the treatment. Plant cover for the area surrounding leks was dominated by the grass and forb categories. Jones cover board sampling indicated that control leks had higher shrub cover within 200 m of the lek than did manipulated areas. Lek 10 had the highest tree cover within 200 m of the lek.

Aspen growth from spring to fall 1987, in an area left unmowed on manipulated site 5, suggested that suckering aspen had the ability to grow approximately 1.0 m to 1.5 m in a single growing season within the study area.

4.3.1 DAUBENMIRE SAMPLES ON LEKS

Both control and manipulated areas could not be distinguished from each other by grouping plant cover on the lek. Manipulation did not change sites to look different from control leks. Quadrats within each grouping were indistinguishable, therefore vegetation types were not unique to particular leks. Leks could not be grouped on the basis of vegetation groups. Cluster analysis showed four groupings of cover. Litter and grass explained 74.5% of the variation in cover data between leks. Group 1 was dominated by high litter, while all other categories including grass spp., bearberry, bedstraw and unknown forbs were low relative to the litter/bare ground. Categories in group 2 were all low in cover. Group 3 had medium to high amounts of litter and medium grass cover, while group 4 was distinguished by medium cover values of bearberry (Appendix D).

Control leks and manipulated areas could not be distinguished from each other by grouping plant densities. Cluster results were plotted on a dendrogram (Appendix E). Grass spp. and bearberry explain 99.2% of the variation between leks. Three groups were recognized. Group 1 was variable, having low grass and low to high densities of bearberry. Group 2 was distinguished by high grass densities. Group 3 had the highest grass densities and high bearberry densities.

4.3.2 DAUBENMIRE SAMPLES OFF LEKS

Manipulated areas could not be distinguished from each other by groupings of plant cover off the lek. Control leks were similar to each other, but different from manipulated sites, distinguished by high bearberry cover values. Cluster analysis showed that 64.6% of the variation between leks was explained by litter and grass. A total of six different groups were recognized (Appendix F). The important species were represented by litter/bare ground, grass spp., trembling aspen, bearberry, rose spp., bedstraw and unknown forbs. Group 1 had low cover values for all species. Group 2 had a high cover value for bearberry, while all other species were low. Group 3 was dominated by trembling aspen. Groups 4, 5 and 6 had medium to high values of litter, but group 4 was distinguished by not having any bearberry and group 5, by not having aspen.

The area surrounding both control and manipulated sites did not appear to be different from each other with respect to plant densities. Grass and bearberry densities explained 98.2% of the variation between leks (Appendix G). Four groups of plant densities were recognized. Group 1 consisted of low to moderate grass densities in each quadrat. Group 2 was represented by moderate grass and high bearberry densities. Groups 3 and 4 had high grass densities.

4.3.3 PLANT COVER GENERALIZATIONS

Trends between leks using generalized cover values showed that control and manipulated leks could not be distinguished from each other using plant cover values. Plant cover was grouped into five categories: grass, forbs, shrubs, trees, and litter/ bare ground (Appendix H). The grass and forb categories explained 69.2% of the variation between leks. Five groups were recognized. Group 1 was represented by moderate cover values of forbs and litter. Group 2 was dominated by high forb cover, while group 3 had high grass cover. Group 4 had medium cover values of shrubs. Group 5 was distinctive because of high cover of litter and bare ground. All leks were characterized by high litter cover values. The majority of leks also had medium to high forb cover values and medium grass cover.

Both control leks had higher shrub cover values than manipulated sites. Lek 10 also had higher tree cover in the surrounding area than all other manipulated and control sites. Plant cover cluster results for the area surrounding the leks were plotted on a dendrogram (Appendix I). Grass and forbs categories explained 64.2% of the variation between areas. Six different groups were recognized. Groups 1, 4 and 6 had high litter and bare ground cover values. Group 2 was represented by high forbs and group 3 by high grass cover. Group 4 had moderate shrub cover. Groups 5 and 6 both had high tree cover values. The area surrounding each lek had high litter and forb cover, with moderate to high grass cover values.

4.3.4 JONES COVER BOARD SAMPLES ON LEKS

For fall 1987, trend analysis indicated that visual obstruction on the lek increased slightly from the center to the periphery of leks 18 and 19 (Appendix J). Manipulated areas 7, 10, 20 and 21 showed a different trend from the control leks. Cover stayed uniform from the lek center to the periphery on leks 7, 10 and 21. Manipulated lek 20 had cover decrease from lek center to lek edge (Appendices K and L).

4.3.5 JONES COVER BOARD SAMPLES OFF LEKS

Visual obstruction was sampled for the area surrounding each lek up to 200 m from the lek center. Lek 18 showed that maximum cover values increased by approximately 15%, up to 125 m from the lek center. By 150 m obstruction values reached 100% in some transects remained high. Lek 19 showed a similar trend. Maximum visual obstruction increased from 30 to 45%, measured from lek center up to 125 m. At 150 m, some values reached 100% and remained high between 150-200 m from the lek center (Appendix M). Lek 7 was similar to both leks. Obstruction values remained low between 0-20%, although four points were >60%. At 125 m from lek center, cover values reached 100% and remained high (Appendix N).

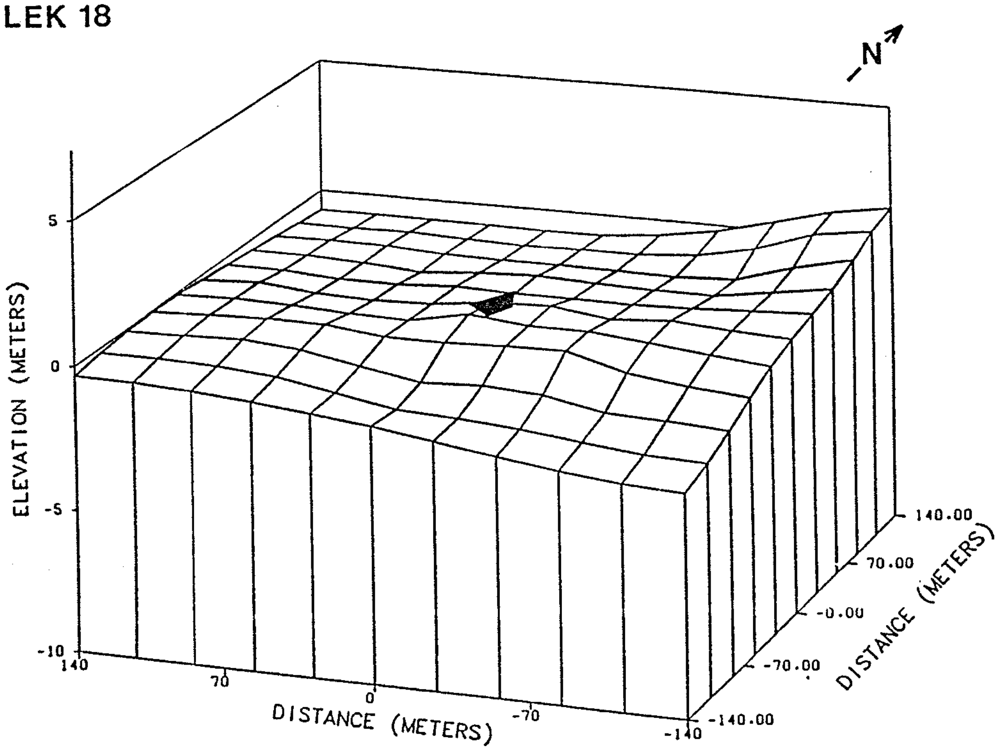
Leks 20 and 21 were also similar to control leks, however, values were more variable within 75 m of the lek (ranged from 0 to 80%). Between 100-200 m lek 20's visual obstruction values ranged between five and 100%, while lek 21 had higher values (25-100%) increasing from 100 to 200 m from the lek center (Appendices N and O). Lek 10 was not similar to control leks and other manipulated leks. Some values reached 70% by 75 m, and by 100 m, all values increased to 100% (Appendix O).

4.3.6 ELEVATION

Elevation for control leks 18 and 19 and manipulated areas 7, 10, 20 and 21 are plotted (Figure 4.4). The area within a 140 meter radius of leks 18, 19 and 7 had a slight drop in elevation from the lek center to its periphery. Lek elevations for manipulated leks 10, 20 and 21 appeared to differ from both control leks and manipulated lek 7 by having larger elevations differences, although this was not proven statistically. A two to three meter drop in elevation over the 140 m from the lek center represented a 1% to 2% drop in elevation.

A

LEK 18



B

LEK 19

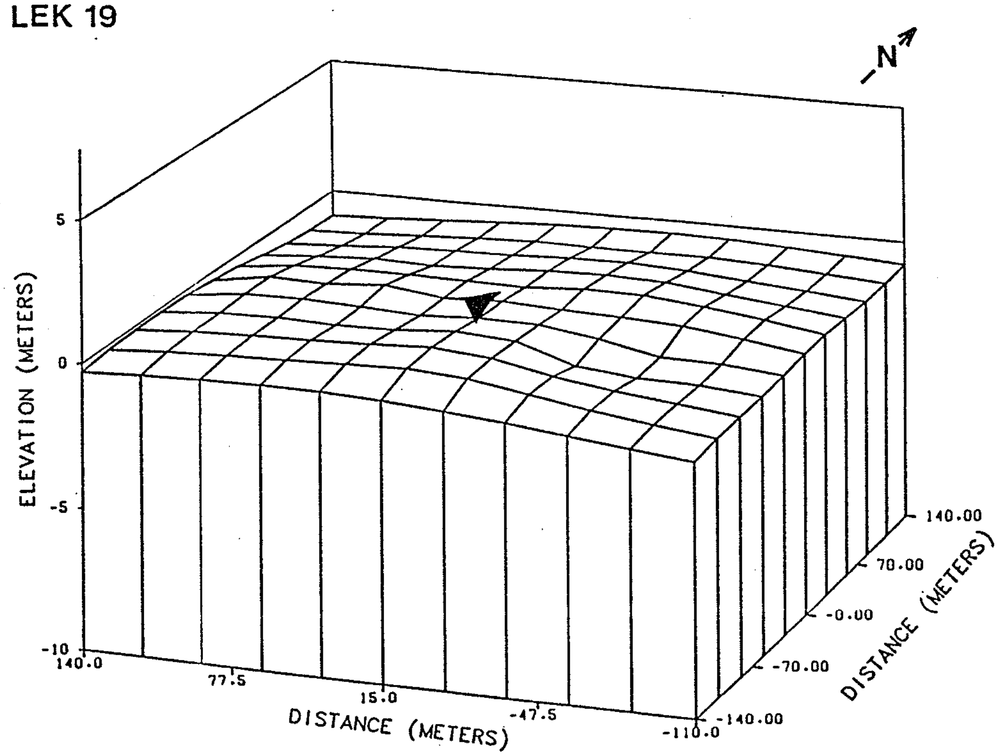
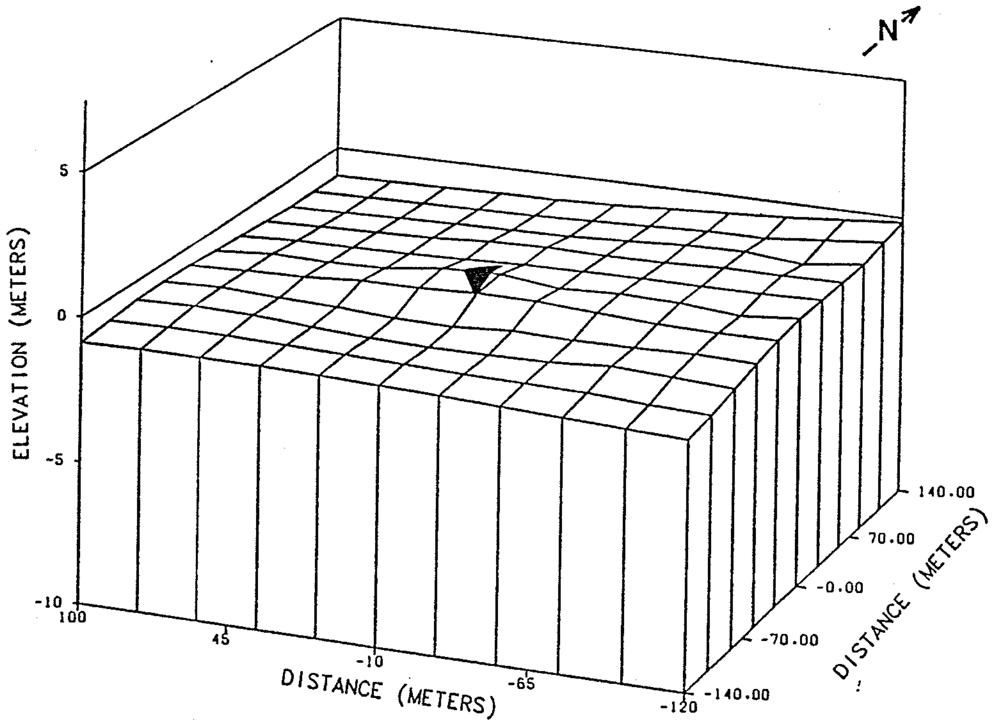


Figure 4.4: Elevations of control leks 18 and 19 (A,B) and manipulated leks 7,21,20 and 10 (C,D,E and F). Lek centers are designated by black polygons.

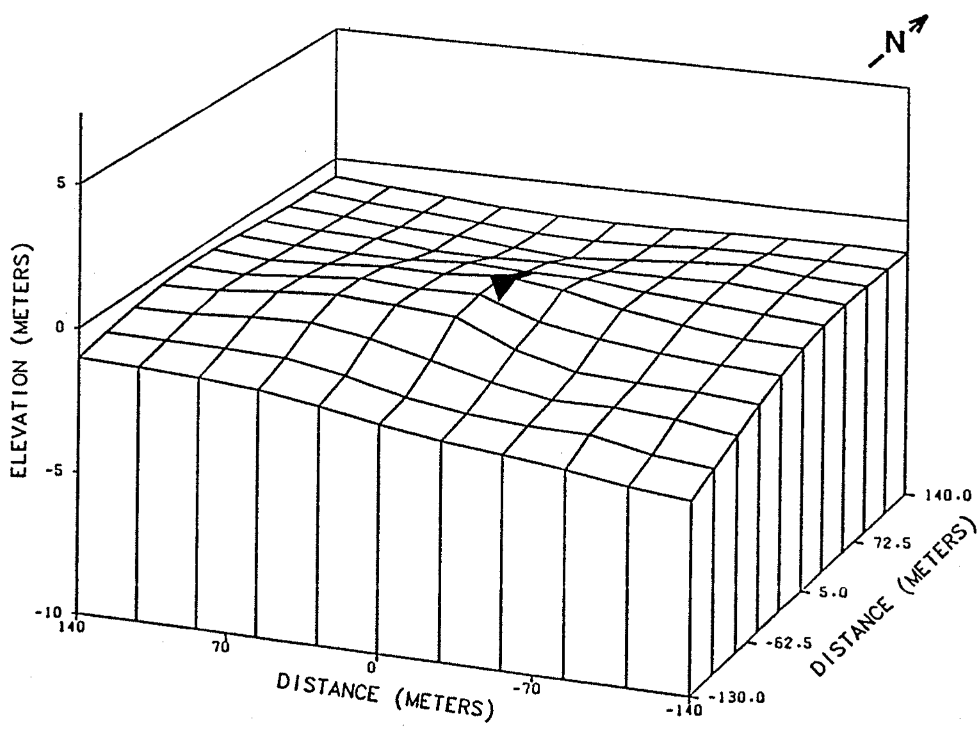
C

LEK 7



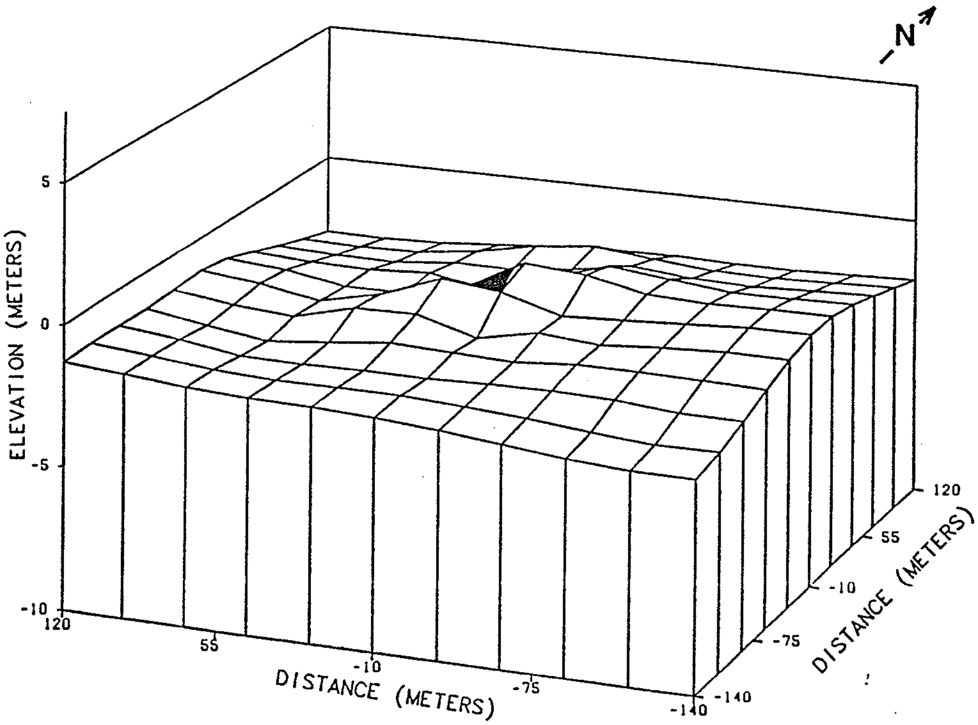
D

LEK 21



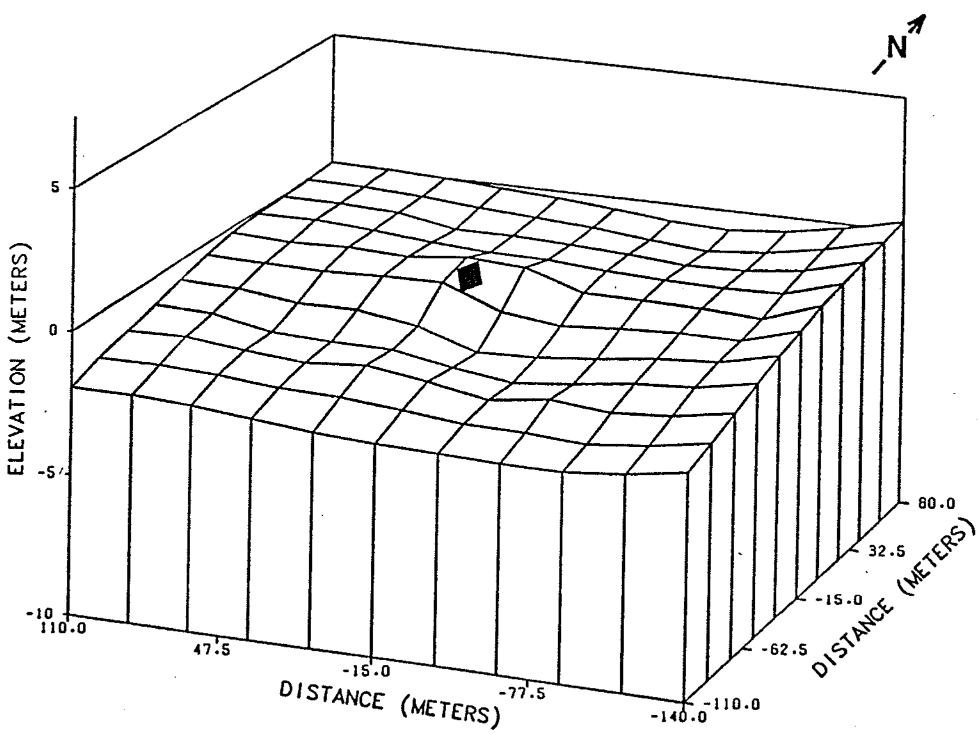
E

LEK 20



F

LEK 10



4.3.7 LEK ESTABLISHMENT AT MANIPULATED SITES

Observations showed that at least one of the four manipulated areas had males congregating and displaying for two consecutive years, whereas in the year prior to manipulation, no males were present. All four manipulated sites had males display on them for at least part of one spring period. Roosting and feeding activity was observed on all four sites. I observed brood activity on one of the four sites.

In spring 1987, an average of nine males displayed on a central hill within manipulated site 4, indicating a lek had been established. One adult female was trapped and banded. No copulations were observed. In fall 1987, males displayed, and in spring 1988, an average of 12 males displayed. On April 26 1988, 16 male grouse were observed on the ground, and at least three female grouse were perched in nearby trees. A total of eight adults and one juvenile male (Figure 4.5) were banded in 1987/88. The origin of the males was not established despite banding males and females on adjacent leks.

In spring 1987, no display activity was witnessed on historical lek 7 (manipulated site 1). Throughout summer 1987, however, two broods of sharp-tailed grouse (one brood of three and one brood of four plus the hen) used the area in and around lek 7. Broods were observed on several

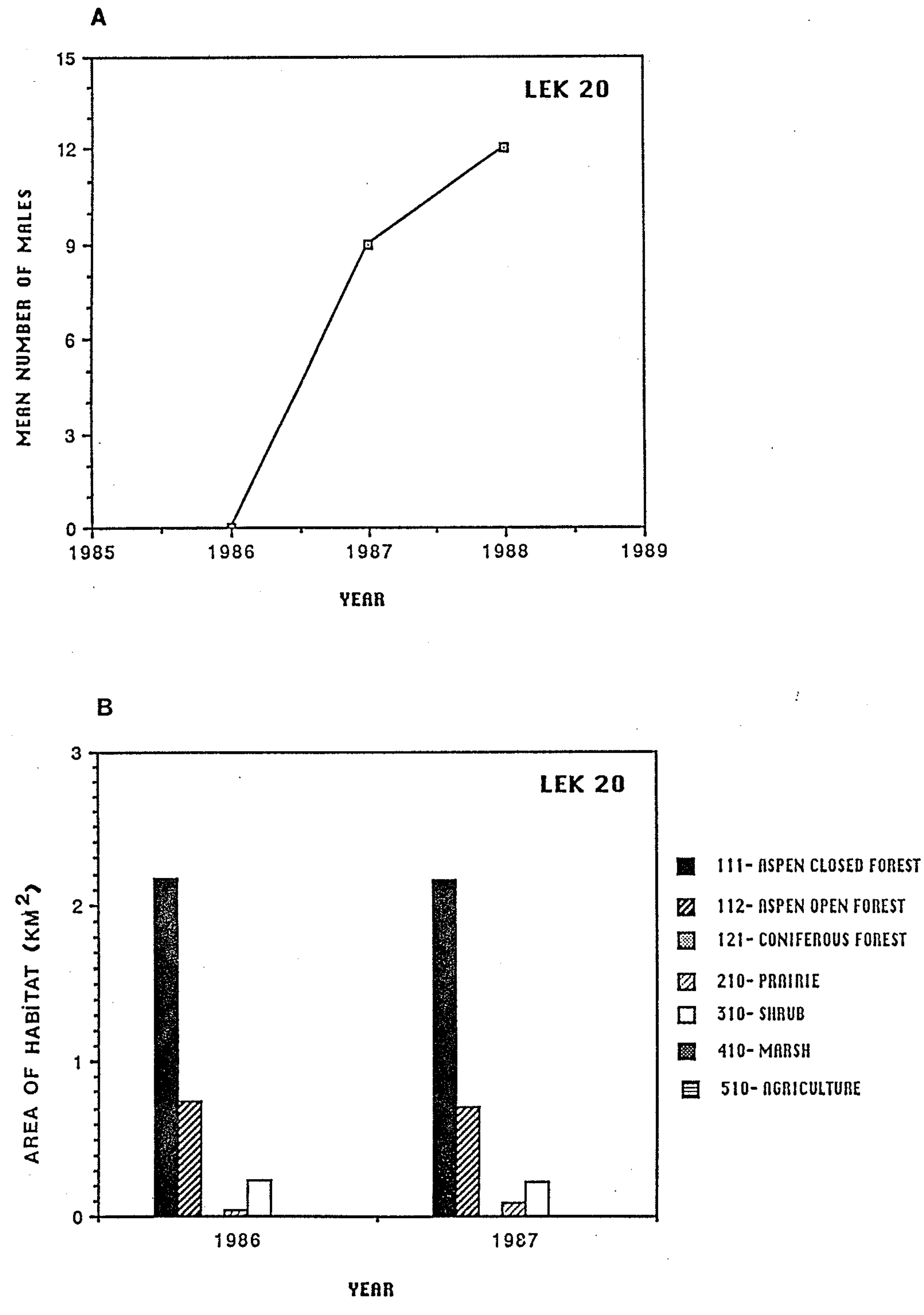


Figure 4.5: Numbers of male sharp-tailed grouse (A) and habitat change by manipulation (B) from 1986 to 1987.

occasions, feeding on insects and forbs growing underneath the aspen sucker canopy. On April 26 1988, nine males were observed displaying around historical lek 7. Males danced in a very unorganized fashion in comparison to behaviour on traditional leks. Territories held by males were very large and only one 'face-off' was witnessed. On one other occasion three males danced around the central hill (Figure 4.6). The origin of these males was never established.

Manipulated area 2 (lek 21) was known never to have had males aggregate on the site. In spring and summer 1987, several grouse were observed roosting and feeding on the fireguard. In spring 1988, a mean of four males was observed displaying in the manipulated area. On one occasion, six males displayed. Observations of these birds indicated that none were banded (Figure 4.7).

In manipulated area 5 (historical lek 10), one grouse roosted in a small brush throughout spring and summer 1987. In 1988, a lone sharp-tailed grouse male was observed displaying on two different occasions. Calls included "chilk's", "coo's" and "hoots." The 'aeroplane wing' display was also observed (Hjorth 1970). Although dancing activity occurred here, historical lek 10 could not be considered active because a lek requires more than one male (Figure 4.8).

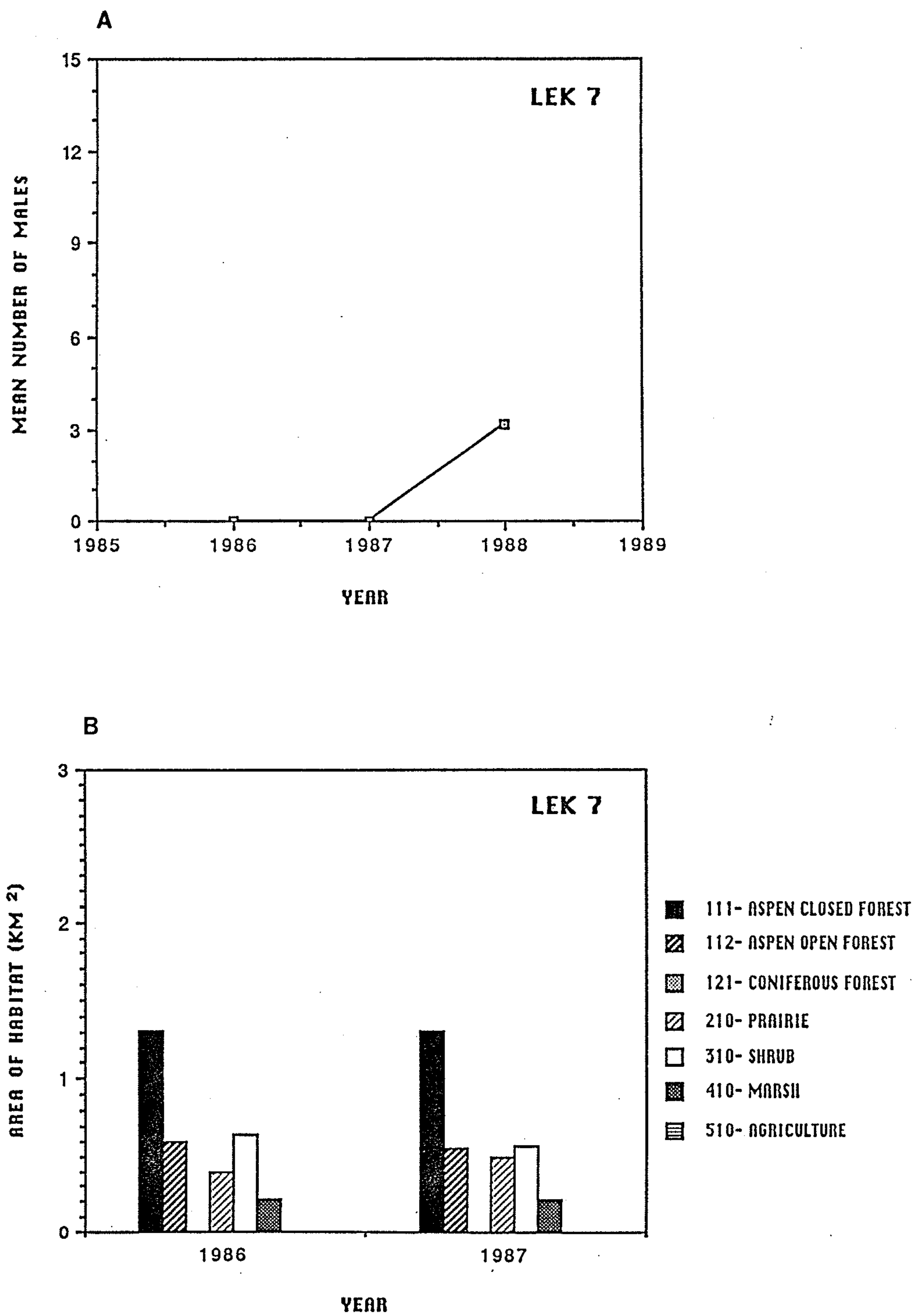


Figure 4.6: Numbers of male sharp-tailed grouse (A) and habitat change by manipulation (B) from 1986 to 1987.

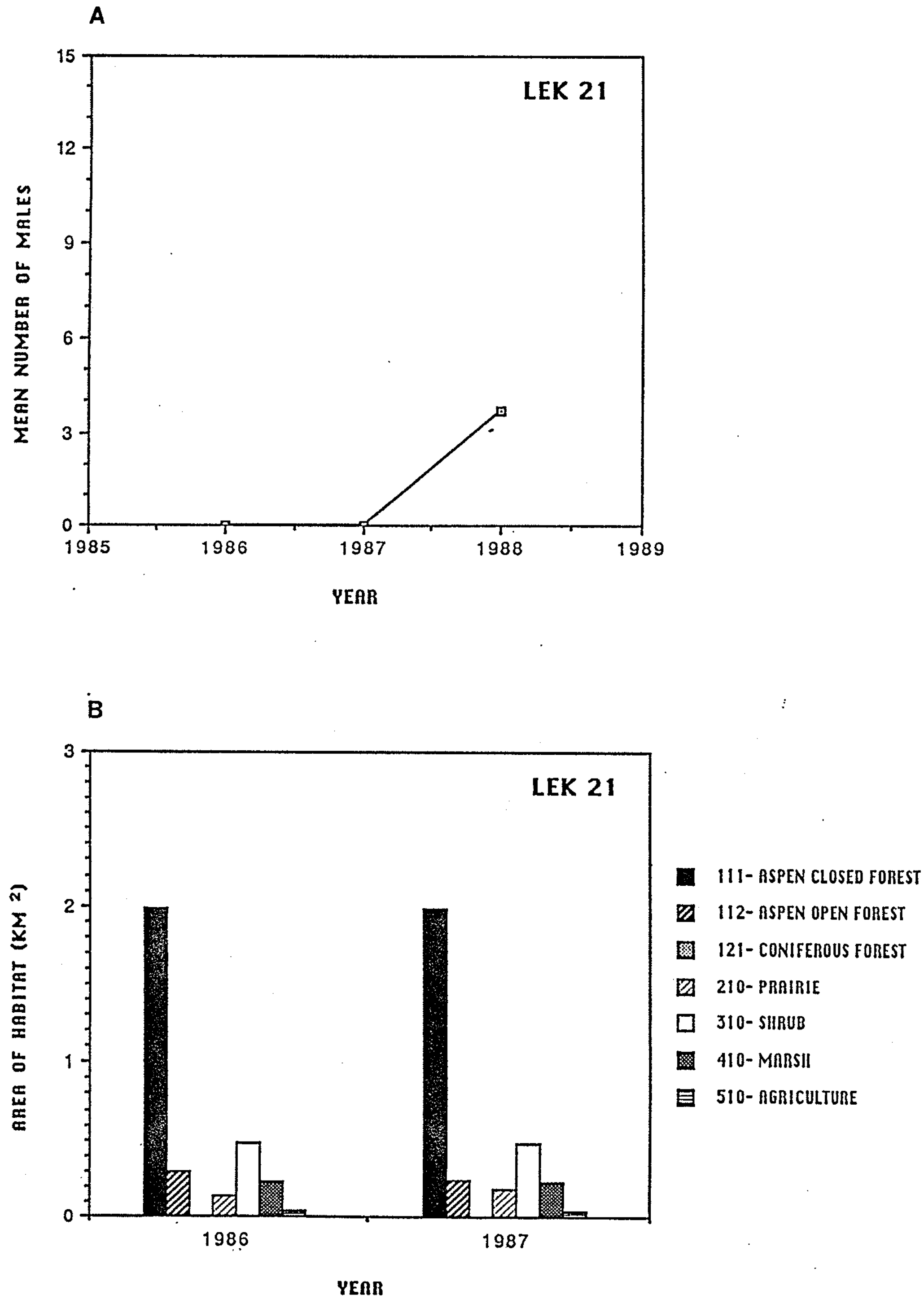


Figure 4.7: Numbers of male sharp-tailed grouse (A) and habitat change by manipulation (B) from 1986 to 1987.

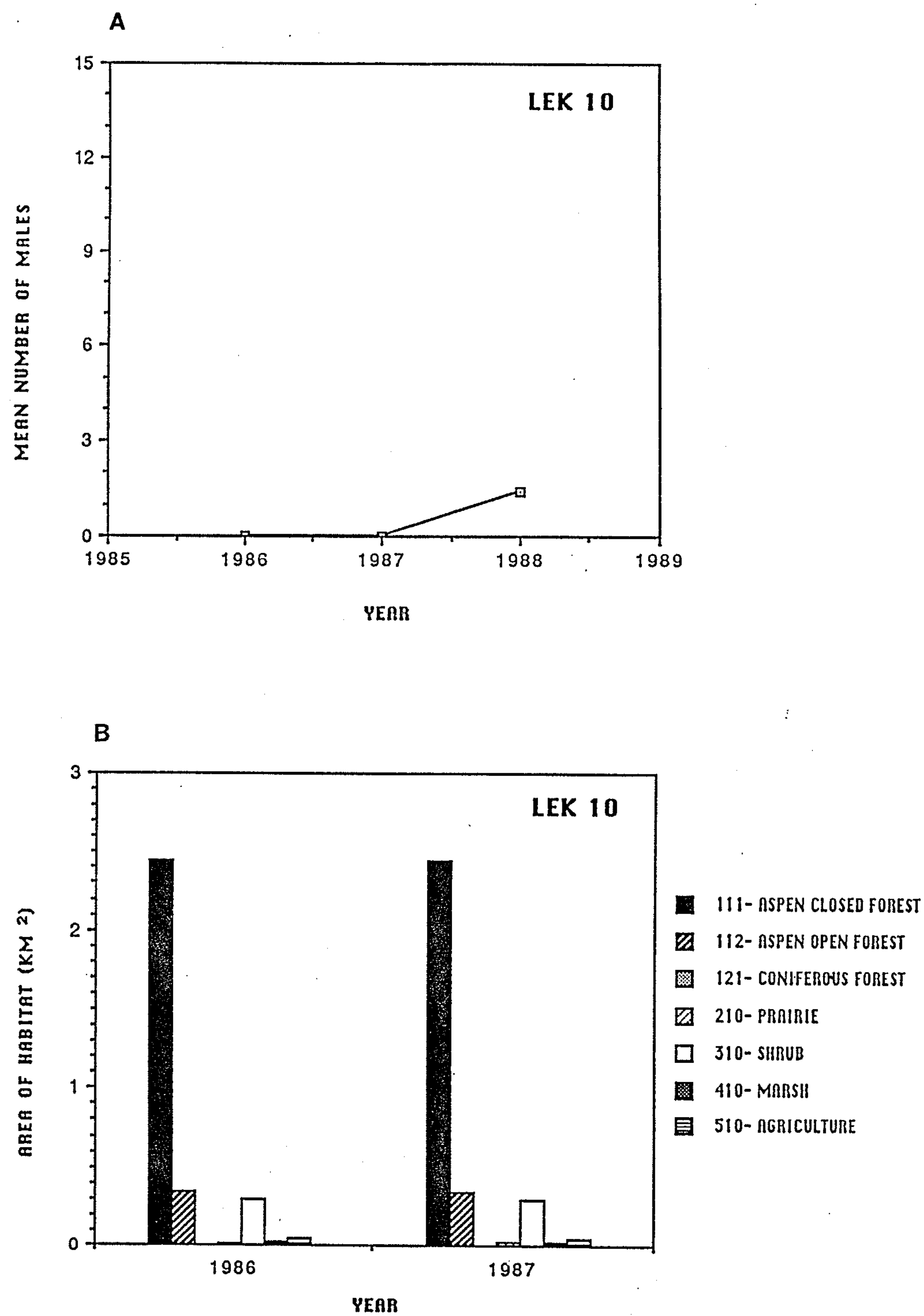


Figure 4.8: Numbers of male sharp-tailed grouse (A) and habitat change by manipulation (B) from 1986 to 1987.

4.4 DISCUSSION

4.4.1 COMPARISON OF MANIPULATED AREAS AND CONTROL LEKS

Bulldozing and mowing changed the cover and density of shrub and tree categories on manipulated sites but did not change the total area of prairie within a 1.0 km radius of a lek. However, clearing aspen forest usually created the largest open habitat suitable for reproductive purposes. This presented an opportunity for grouse to occupy these regions that were otherwise unavailable had revitalization not taken place. I found that the minimum size of open habitat (prairie) needed to entice grouse to display is 5.45 ha. I suggest that increasing cleared areas to at least 20 ha would likely increase the chance of male and female sharp-tailed grouse using the area. Minnesota Department of Natural Resources (1985) suggested that leks require an area of 0.13 mile (0.2 km) in diameter relatively free of woody vegetation. Brushland within 0.25-0.5 mile (0.4-0.8 km) of the lek satisfies grouse requirements for shelter, nesting cover and food.

Lek 10 probably had tree cover too close to the historical lek to be able to attract more males to display at this site. Three hectares clear of aspen forest was too small an area to attract more grouse. Pepper (1972) indicated that in general, heavy cover occured approximately 200 yds (180 m) from the lek, but this was quite variable from lek to lek as was the extent of cover at these distances. Kobriger (1965) stated that mowing of grasslands appears beneficial for maintenance of important foods such as clovers and possibly for maintenance of breeding grounds.

Visual obstruction values on control leks, sampled by the Jones (1968) cover board technique, increased from the lek center to the lek periphery. The manipulated sites differed from the control leks, by having uniform vertical cover values from lek center to lek edge, or cover decreasing towards the periphery. Bulldozing and mowing on or adjacent to the lek explains this phenomenon.

Visual obstruction values showed an interesting trend in the area surrounding the control leks. Cover remained low until 150 m from the lek center, then doubled or tripled in value. This phenomenon suggested that heavy cover such as shrubs or trees did not occur until at least 150 m from the lek center. All manipulated sites showed a slightly different trend. Heavier cover such as shrubs usually occurred 100 m from the lek center, suggesting that heavy cover was left standing too near each manipulated lek. Brush mowing in the future should eliminate most of the shrub and tree cover within a 150 m radius of lek center.

All manipulated sites were selected because the area contained at least one hill or slightly elevated area. Each surveyed site had a 1% to 2% drop in elevation except for manipulated lek 7, with <1%. Although the two control leks did not occur on sites with an appreciable elevation, Ammann (1957), Hanson (1953), Sisson (1976) and Baydack (1988) suggested that leks usually occur on elevated sites. Twedt (1974) noted a vertical rise of 2.75 m in elevation for leks in his study area. Ward (1984) suggested that percent slope accounted for 6% of the variation between leks and non-leks in his study area.

Habitat created for the lek and surrounding area needs adjustment time. Aspen suckers were appearing where aspen stands once stood. To change these areas back to prairie, maintenance techniques such as mowing or burning would have to continue. A method to deter aspen suckers from reappearing is needed to provide management guidelines on the optimal rate and time of treatments.

Growth rate of shrub cover, including aspen, rose, dwarf birch, buffaloberry, saskatoon and willow, was rapid on manipulated sites. Aspen suckers which were not mowed, initially grew approximately 1 m to 1.5 m in one season. Selective mowing should provide the shrub areas within the manipulated sites necessary for approach cover and female nesting cover.

Several dissimilarities were observed between control and manipulated sites such as heavy cover left standing too near manipulated leks. However, much similarity exists. The area surrounding leks was modified so that open grassland was present adjacent to the lek. Some shrub cover was left >100 m from lek center to create approach cover for males and nesting cover for females. Nearby escape cover usually occurred beyond 200 m. Most patches of prairie were left undisturbed to minimize the impact of manipulation on the area.

4.4.2 SHARP-TAILED GROUSE RESPONSE TO MANIPULATION

It was thought that revitalizing historical leks should encourage male sharp-tailed grouse to re-establish displaly populations more easily than on newly created sites. The underlying assumption was that since grouse had occupied a historical lek, some part of its attractive qualities should remain despite aspen succession. By manipulating the historical lek to restore prairie-like habitat, the area should be more attractive to grouse than an area never occupied by grouse. Exactly the opposite occurred as grouse initiated and established leks at sites where no grouse were known to have congregated prior to manipulation. Some display activity did occur on historical leks as well.

The size of the open area may also have played an important role in the establishment of leks on the manipulated sites. Leks 20 and 21 were the most open (5.45 ha and 9.45 ha respectively), and had the greatest response by males. Leks 7 and 10 were 3.65 and 3.28 ha each, the smallest of which attracted only a single male which infrequently displayed. Even though the area only attracted a single male, any response to manipulation was favoured since even a single male may have an opportunity to reproduce. Sexton (1979b) reported an off-lek copulation between a single male and female sharp-tailed grouse. Lek 7 attracted grouse on two occasions, yet it remains to be seen whether or not grouse will continue to be attracted to the site.

Grouse use of the manipulated sites can be explained by Brown's (1966a) observations. He stated that a relationship appeared to exist between the establishment of new breeding grounds and estimated cover density. In Montana, new leks occurred in five cases following marked improvements in the standing cover. In three instances, new grounds were established in stabilized cover areas rated as heavy. Without exception, the largest leks have been located in areas surrounded by extensive, heavy stands of residual herbage.

No movement of males was documented between traditional leks and manipulated sites. Banded males appeared to display only on the lek where they were trapped. I suggest that males from the 'floating population' established the new leks. This hypothesis was supported by Rippin and Boag (1974), who established that a population of non-territorial males existed. This population consisted of juvenile males which recruited onto a lek only after territorial males were removed. Non-breeding males and females are considered part of the floating population.

Initially it was thought that juvenile males would be the first grouse to use the newly created display areas. However, banding information from lek 20 indicated that adult males dominated the site. It is possible that this new lek was formed by relocation of adult and juvenile males where habitat was becoming unsuitable for display, or from a lek devoid of females. These events would force males to move (Bergerud 1988). The ages of males on other manipulated sites were unknown although it was possible that males were juvenile. On new leks, Brown (1966a,c) found that yearlings outnumbered adults 6:1 and 9:1. Adults dominated by a margin of 3:1 on traditional grounds prior to abandonment. Eng *et al*. (1979) observed that a new sage grouse lek was initially occupied by yearling males, which moved from a nearby traditional lek. Hens which visited the experimental lek were probably sub-adults as well, since lek visitation occurred one week after the peak visitation period. The only female captured at a new lek (lek 20, 1987) was an adult. Females were observed visiting this site but their age was unknown. The fact that other females visited the new lek suggested that this lek may survive.

Gratson (1988) stated that the establishment of one lek and the relocation of a second and third lek were associated with the spring location of females. Brown (1966a,c and

1967) suggested that standing cover at light densities could limit breeding distributions, but not in the presence of interspersed shrubs and rough topography; standing cover at high or greatly increased densities acts in the establishment or increase of breeding unit numbers.

Caldwell (1976) recommended a strategy for the persistence of leks. He found that small grounds persisted in poor habitat based on tradition. The frequency of fire in aspen parkland communities before settlement allowed males to take territories on a small lek in poor habitat; within a few years this area could be in an area of optimum nesting habitat and a lek where many copulations could take place. Thus breeding strategy of male sharp-tailed grouse probably evolved in an environment with relatively frequent fires and habitat change. Similarily, females first look for optimum nesting cover and then breed at the nearest lek. Alternatively, they might return to the lek where they previously bred and then search for adequate nesting cover. As habitat changes away from that optimum nesting cover, female nesting effort shifts to areas of better quality cover.

Another aim in revitalizing prairie around leks was to stimulate and allow females to rear young in these areas. At least two broods used the area surrounding lek 7. I suggest that nesting habitat seemed to be another limiting factor for sharp-tailed grouse in the study area. A management technique for increasing numbers of grouse is to improve nesting success by enhancing nesting and brood cover. Since these cover types are closely associated with lek habitat, another benefit is that males will also use the area for breeding purposes. Bergerud (1988) observed that lek relocation attempts have failed in the past largely because males do not vacate proven display grounds near nesting females. Females however, are more flexible and their pre-incubation range presents opportunities for exploration of nesting habitat (Sexton 1979a). If this is true, new lek locations in the study area may be located near nesting and brooding habitat. During years of increasing or peaking grouse numbers, it may be easier to create leks, since greater numbers of male sharp-tailed grouse (especially juveniles) are also looking for new display locations, as well as trying to gain territories on existing leks.

Chapter V

MANAGEMENT RECOMMENDATIONS

A strategy for the revitalization of sharp-tailed grouse habitat currently being lost to aspen succession was tested on an experimental basis in the NWMA. The method is an alternative when prescribed burning, herbicide application, or other techniques are not feasible for habitat maintenance. Although this study was experimental, application of the technique is practical and may be easily adapted to different plant communities and lekking species.

If aspen succession progresses at rapid rates and is thought to be a primary limiting factor to a grouse population, the following strategy may be used to reverse the trend, and enhance the density of sharp-tailed grouse.

5.1 GENERAL RECOMMENDATIONS

1. If aerial photographs of the area are available, the extent of habitat change should be verified. If no aerial photography is available, biologists familiar with the area should be consulted.

2. If mechanical manipulation is selected to reestablish habitat preferred by sharp-tailed grouse, predevelopment

work should include aerial photographic examination and ground truthing of suitable areas to determine the region(s) feasible for manipulation. Elimination of small stands of aspen (e.g. five hectares) within existing prairie areas is more practical than clearing large contiguous aspen stands (e.g. 40 hectares).

3. Creation of leks should be attempted after such factors as proximity of nesting, brood-rearing and wintering areas are considered.

4. Sharp-tailed grouse leks which are developed in aspen parkland should closely resemble traditional leks in the area, with respect to; elevation (approximately 1% slope), escape cover (> 200m from the proposed lek center), residual shrub cover (> 100m from the lek center), and open cover (prairie extending up to 200m from the lek center). The minimum recommended size of open habitat is 5.45 ha but openings of at least 20 ha of prairie is suggested.

5. Manipulation by bulldozing should take place in the coldest part of winter as frozen aspen trunks will shear off at the base. At warmer temperatures, aspen trunks are flexible, are bent rather than sheared and eventually spring back.

6. Shrub and tree growth on and within 200 m of the lek center should be eliminated. A brush mower is useful to maintain sites and eliminate suckering aspen. Mowing of

aspen in mid-July permits young grouse broods to take advantage of suckering aspen for cover. Also, by removing aspen in July, nutrient depletion of the aspen root system is considered to be maximal (R. Jones, pers. comm.).

7. Decoys and grouse vocalizations to attract grouse to the manipulated sites were not used in this study but may be necessary if no response is achieved.

5.2 NARCISSE WILDLIFE MANAGEMENT AREA RECOMMENDATIONS

1. The NWMA has lost much of grassland and grass-shrub habitat. Seven leks were abandoned in NWMA between 1970-1986 when prairie decreased from 27 to 14% and aspen increased from 43 to 56% of the total area within a one kilometer radius of the lek. The model was developed (Chapter III) which suggests approximately every 5 years, management to maintain a more optimal distribution of prairie and aspen must be done. Otherwise, sharp-tailed grouse will abandon leks. Frequency of fire and disturbance within the NWMA can alter this maintenance schedule.

2. Vegetation height should be maintained at < 10cm on the proposed lek site as recommended by Baydack (1988) unless grouse establish a lek. Mowing treatments on manipulated sites should continue (once per season) until aspen suckering has ceased. At least every five years, the lek and area within 200 m, should be checked for encroachment of aspen stands or heavy cover.

3. Further studies are encouraged to find the optimal time and size of treatments needed to restore prairie in the NWMA.

4. Consideration should be given for a large scale manipulation of habitat to revert large stands of aspen to grassland by the forementioned techniques or alternate methods.

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Appendix A

LIST OF COMMON PLANTS FOUND IN NWMA

TREES

trembling aspen (*Populus tremuloides*)
balsam poplar (*Populus balsamifera*)
white spruce (*Picea glauca*)
black spruce (*Picea mariana*)
bur oak (*Quercus macrocarpa*)
willow (*Salix* spp.)

SHRUBS

roses (*Rosa* spp.)
saskatoon (*Amelanchier alnifolia*)
chokecherry (*Prunus virginiana*)
shrubby cinquefoil (*Potentilla fruticosa*)
silverberry (*Elaeagnus commutata*)
Canada buffaloberry (*Shepherdia canadensis*)
western snowberry (*Symphoricarpos occidentalis*)
dwarf birch (*Betula glandulosa*)
red-osier dogwood (*Cornus stolonifera*)

FORBS

bearberry (*Arctostaphylos uva-ursi*)
three-flowered avens (*Geum triflorum*)
wild red raspberry (*Rubus idaeus*)
common bedstraw (*Galium boreale*)
lamb's-quarters (*Chenopodium album*)
asters (*Aster* spp.)

GRASSES

needle grasses (*Stipa* spp.)
june grass (*Koeleria cristata*)
wheatgrasses (*Agropyron* spp.)
blue grasses (*Poa* spp.)
big bluestem (*Andropogon gerardi*)
wild rye (*Elymus canadensis*)

MARSH SPECIES

cattails (*Typha* spp.)
common reed grass (*Phragmites communis*)
sedges (*Carex* spp.)
reed canary grass (*Phalaris arundinacea*)
bulrushes (*Scirpus acutus*, *S. validus* and *S. fluviatilis*)

Appendix B

OBSERVATIONS WITHIN MANIPULATED AREAS

A complete list of avian and mammalian species observed in revitalized areas

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AVIAN SPECIES

American Kestrel (*Falco sparverius*)
Red-tailed Hawk (*Buteo jamaicensis*)
Northern Harrier (*Circus cyaneus*)
Merlin (*Falco columbarius*)
Great Horned Owl (*Bubo virginianus*)
Sharp-tailed Grouse (*Tympanuchus phasianellus*)
Ruffed Grouse (*Bonasa umbellus*)
Whip-poor-will (*Caprimulgus vociferus*)
Downy Woodpecker (*Picoides pubescens*)
Eastern Bluebird (*Sialia sialis*)
Northern Flicker (*Colaptes auratus*)
Western Meadowlark (*Sturnella neglecta*)
Dark-eyed Junco (*Junco hyemalis*)
Brown Thrasher (*Toxostoma rufum*)
Upland Sandpiper (*Bartramia longicauda*)
American Robin (*Turdus migratorius*)
House Sparrow (*Passer domesticus*)
European Starling (*Sturnus vulgaris*)
Blue Jay (*Cyanocitta cristata*)
Common Grackle (*Quiscalus quiscula*)
Eastern Kingbird (*Tyrannus tyrannus*)
Brown-headed Cowbird (*Molothrus ater*)
Eastern Phoebe (*Sayornis phoebe*)
Harris' Sparrow (*Zonotrichia querula*)
Sandhill Crane (*Grus canadensis*)
Red-winged Blackbird (*Agelaius phoeniceus*)
Rufous-sided Towhee (*Pipilo erythrophthalmus*)
Tree Swallow (*Iridoprocne bicolor*)
Chipping Sparrow (*Spizella passerina*)
Yellow Warbler (*Dendroica petechia*)
Killdeer (*Charadrius vociferus*)
Common Snipe (*Capella gallinago*)
American Crow (*Corvus brachyrhynchos*)
Gray Catbird (*Dumetella carolinensis*)
American Goldfinch (*Carduelis tristis*)

MAMMALIAN SPECIES

White-tailed deer (*Odocoileus virginianus*)
Snowshoe Hare (*Lepus americanus*)
Red Fox (*Vulpes vulpes*)
Coyote (*Canis latrans*)
Vole (*Microtus spp.*)

Appendix C

SHARP-TAILED GROUSE BANDING INFORMATION

Alum. band	Color band	Trans. freq.	Age	Sex	Date banded	Lek
A-1880	R/Y/R		AHY	M	21-5-86	18
A-1881	R/B		AHY	M	5-4-87	18
A-1882	R/G	151.279	AHY	M	6-4-87	18
A-1883	R/B/Y		AHY	M	20-4-87	18
A-1884	R/G/Y		AHY	M	21-4-87	18
A-1885	R/B/B		AHY	M	21-4-87	18
A-1886	R/R		AHY	M	21-4-87	18
A-1887	R/Y/B		AHY	M	21-4-87	18
A-1888	Y/Y		AHY	M	22-4-87	19
A-1889	Y/B	150.951	AHY	F	22-4-87	19
A-1890	Y/G	150.918	AHY	M	22-4-87	19
A-1891	Y/B/R	151.387	AHY	F	23-4-87	19
A-1892	Y/W		AHY	M	22-4-87	19
A-1893	Y/W/R		AHY	M	23-4-87	19
A-1897	Y/R	150.997	AHY	F	22-4-87	19
A-1899	Y/G/R		AHY	M	23-4-87	19
62-1559	G/Y	150.904	AHY	F	24-4-87	11
62-1560	G/B		AHY	M	24-4-87	11
62-1561	G/W		AHY	M	24-4-87	11
62-1562	G/R		AHY	M	24-4-87	11
62-1563	G/G		AHY	M	24-4-87	11
62-1564	B/G		AHY	M	27-4-87	20
62-1565	B/W		AHY	M	27-4-87	20
62-1566	B/R		AHY	M	27-4-87	20
62-1567	B/Y	151.061	AHY	M	27-4-87	20
62-1568	B/B		AHY	F	27-4-87	20
62-1569	W/Y		AHY	M	30-4-87	5
62-1570	W/G		AHY	M	30-4-87	5
62-1571	W/R		HY	M	30-4-87	5
62-1572	W/G/Y	151.341	HY	M	4-5-87	5
62-1573	W/G/B		AHY	M	4-5-87	5
62-1574	W/G/R		AHY	M	6-5-87	5
62-1575	B/G/R	151.233	AHY	M	6-5-87	20
62-1577	B/Al/R/G		AHY	M	9-5-87	20
62-1578	G/Al/R/G		AHY	M	8-5-87	18
62-1579	G/Al/R/Y		HY	M	8-5-87	18
62-1580	G/Al/R/W		AHY	M	8-5-87	18
62-1581	B/B/G	151.219	AHY	M	9-5-87	20
62-1582	G/Al/R/B		HY	M	10-5-87	18
62-1583	R/Al/R/B		AHY	M	10-5-87	18
62-1584	R/Y/Y		AHY	M	21-5-86	18
62-1585	R/Al/R/Y		HY	M	11-5-87	18
62-1586	---	151.918	AHY	F	16-6-87	18
62-1591	B/Al/R/Y		AHY	M	13-9-87	18
62-1593	---	151.265	AHY	M	4-5-88	20
62-1594	---	151.432	HY	M	5-5-88	20

List of Fatalities

Alum. band	Age	Sex	Date banded	Date recovered	Cause of Death
A-1882	AHY	M	6-4-87	Fall-88	Hunting Mortality
A-1880	AHY	M	21-5-86	21-5-86	Retrap Mortality
A-1890	AHY	M	22-4-87	4-6-87	Raptor Mortality
A-1891	AHY	F	23-4-87	Fall-87	Hunting Mortality
62-1567	AHY	M	27-4-87	Fall-87	Hunting Mortality
62-1572	HY	M	4-5-87	Fall-87	Hunting Mortality
62-1575	AHY	M	6-5-87	4-5-88	Retrap Mortality
62-1581	AHY	M	9-5-87	Fall-87	Hunting Mortality
62-1584	AHY	M	21-5-86	Fall-88	Hunting Mortality
62-1586	AHY	F	16-6-87	4-5-88	Mammal Mortality

LEGEND

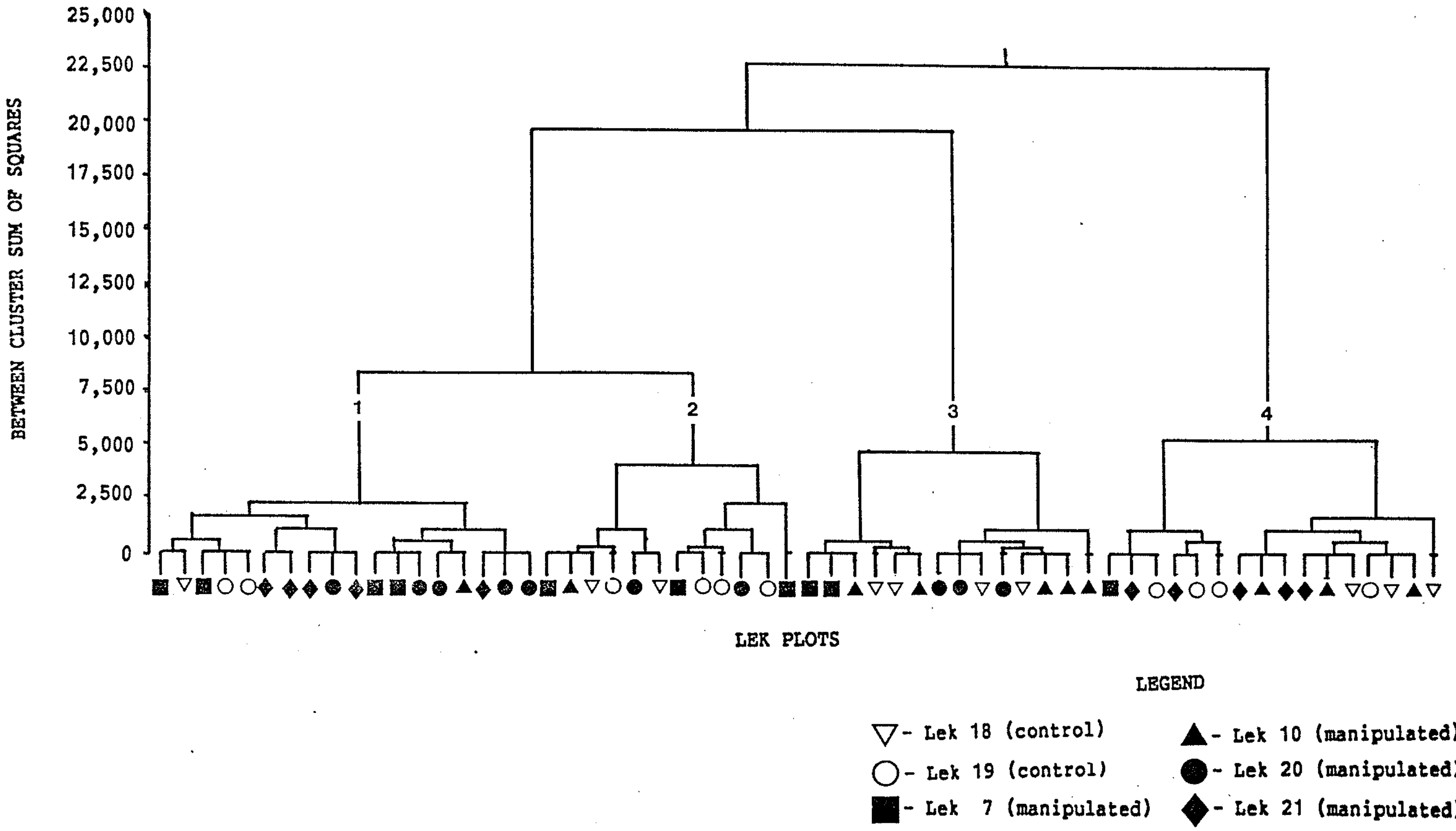
Color Band Combinations

R - Red	LEK 18
Y - YELLOW	LEK 19
G - GREEN	LEK 11
B - BLUE	LEK 20
W - WHITE	LEK 5
Al- ALUMINUM	

Appendix D

CLUSTER ANALYSIS OF PLANT SPECIES COVER VALUES ON LEKS

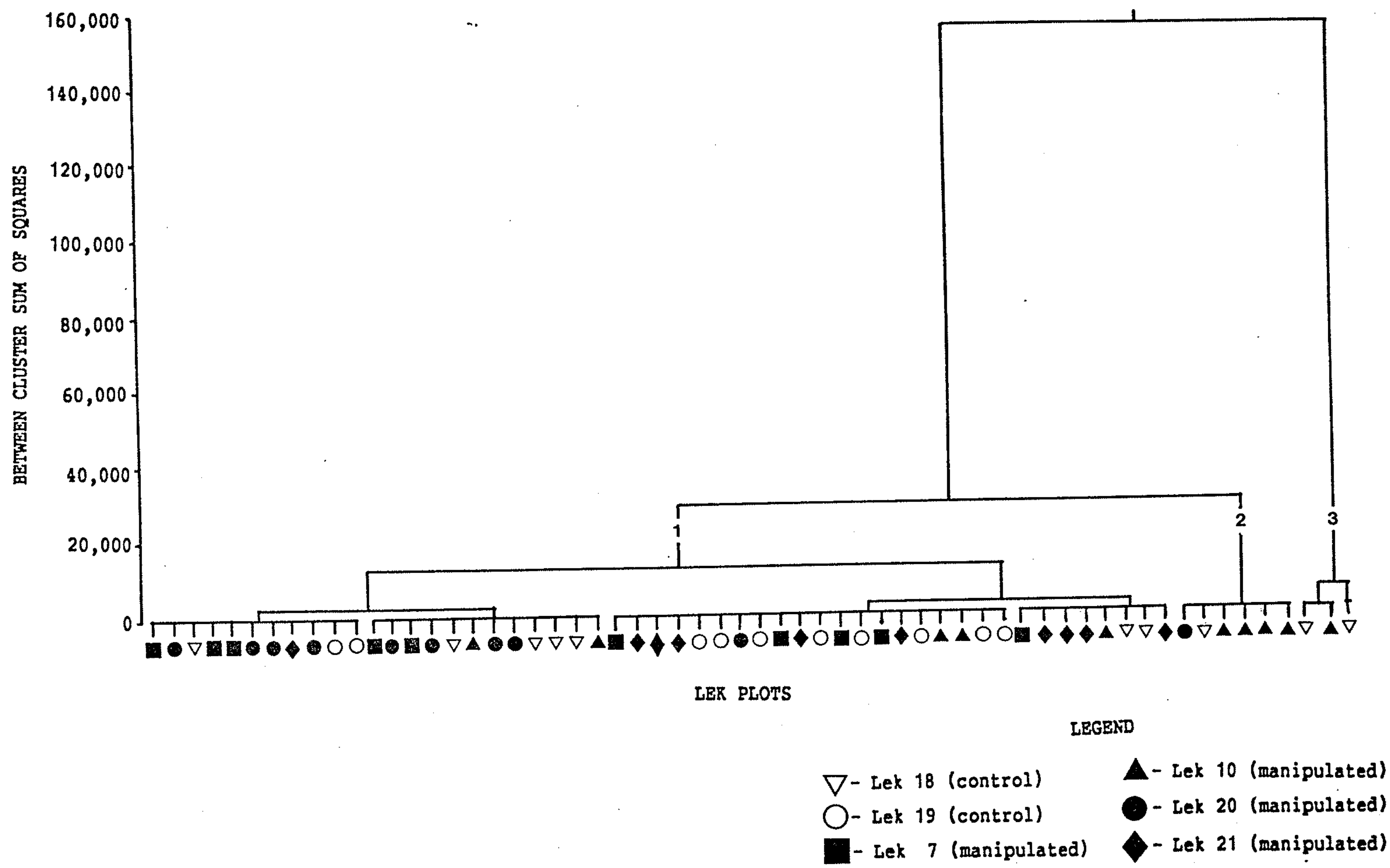
Wards Minimum Variance Cluster Analysis
of Plant Species Cover (on lek)



Appendix E

CLUSTER ANALYSIS OF PLANT SPECIES DENSITIES ON LEKS

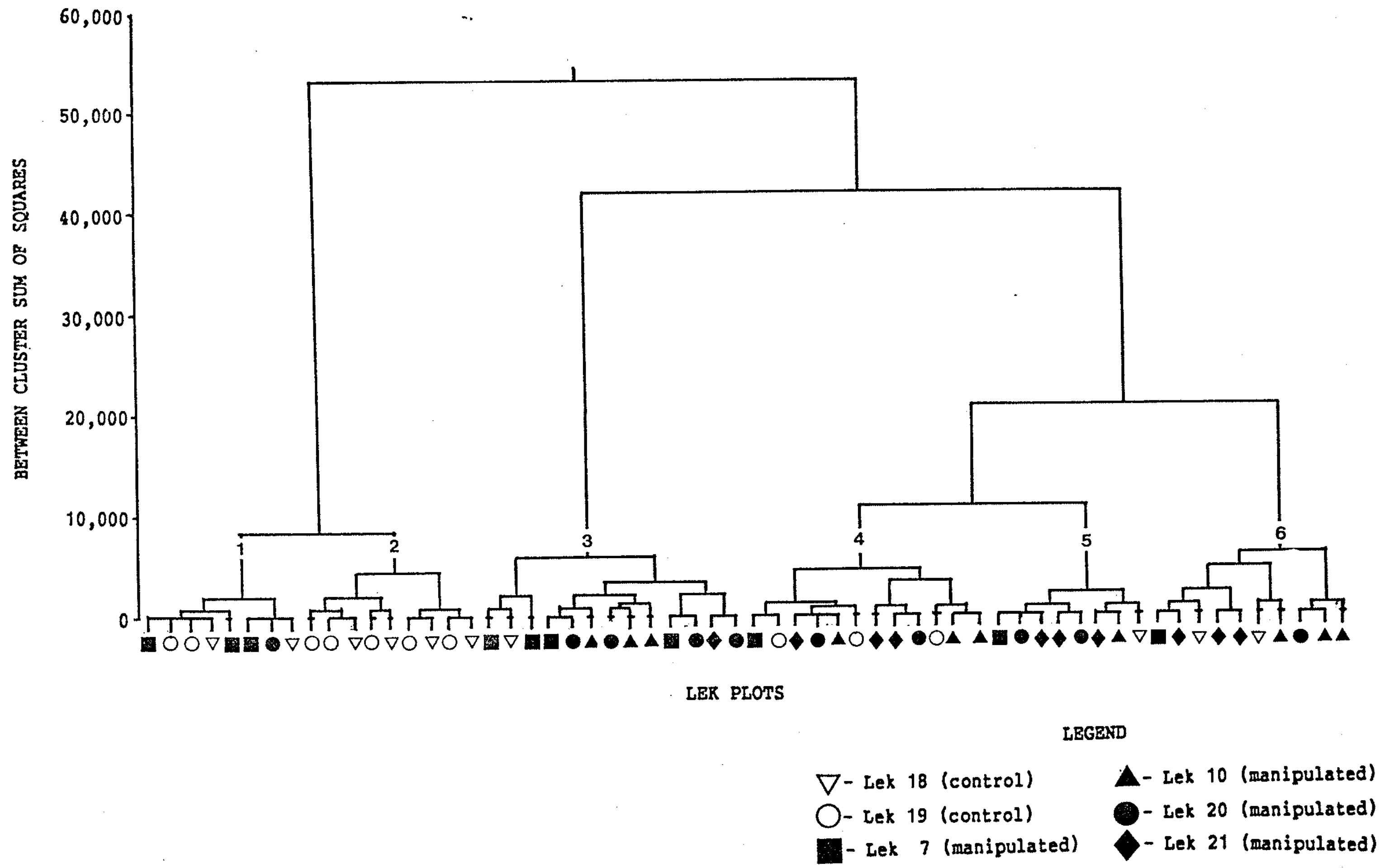
Wards Minimum Variance Cluster Analysis
of Plant Species Density (on lek)



Appendix F

CLUSTER ANALYSIS OF PLANT SPECIES COVER VALUES SURROUNDING LEKS

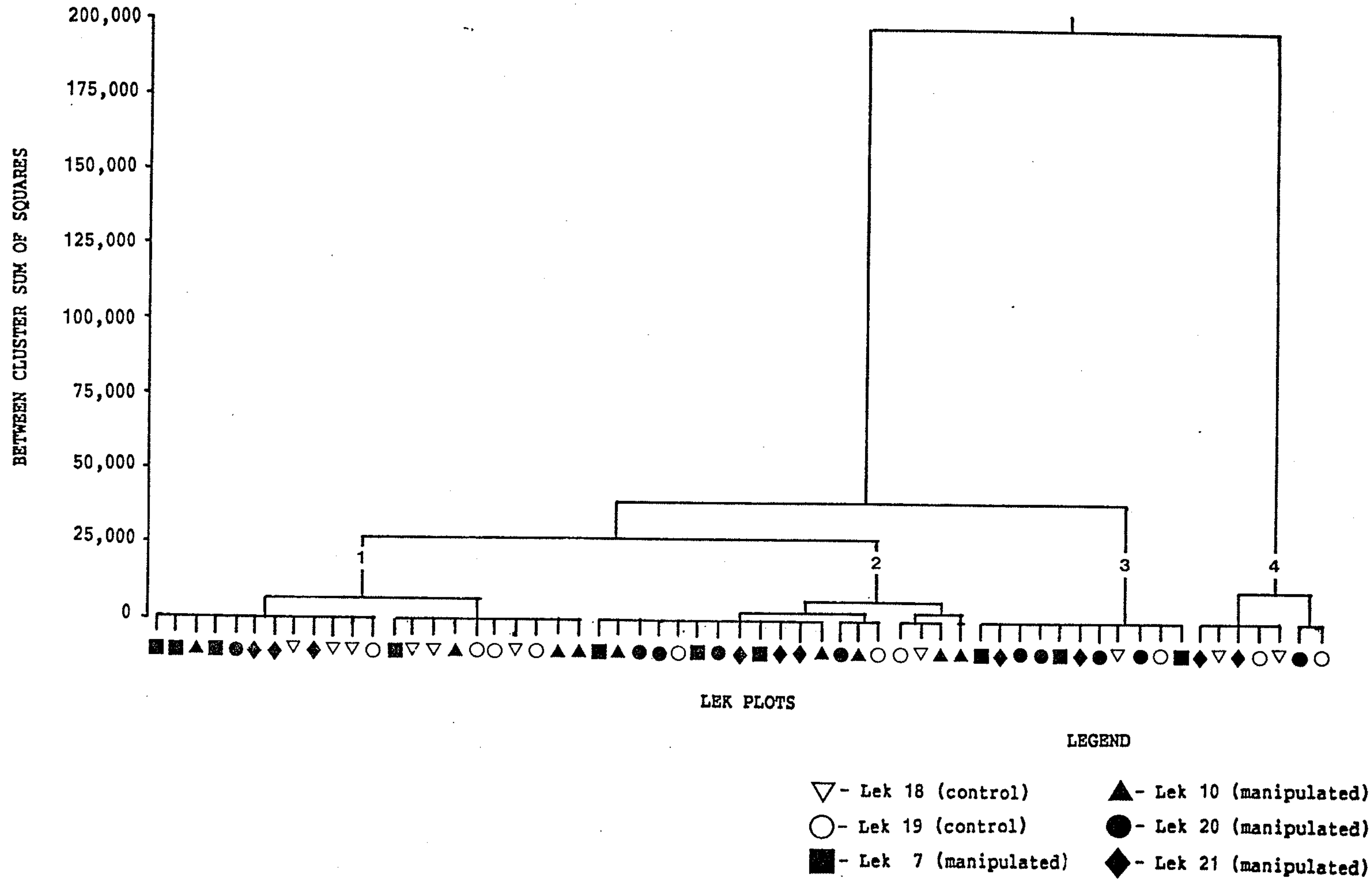
Wards Minimum Variance Cluster Analysis
of Plant Species Cover (in surrounding area)



Appendix G

CLUSTER ANALYSIS OF PLANT SPECIES DENSITIES SURROUNDING LEKS

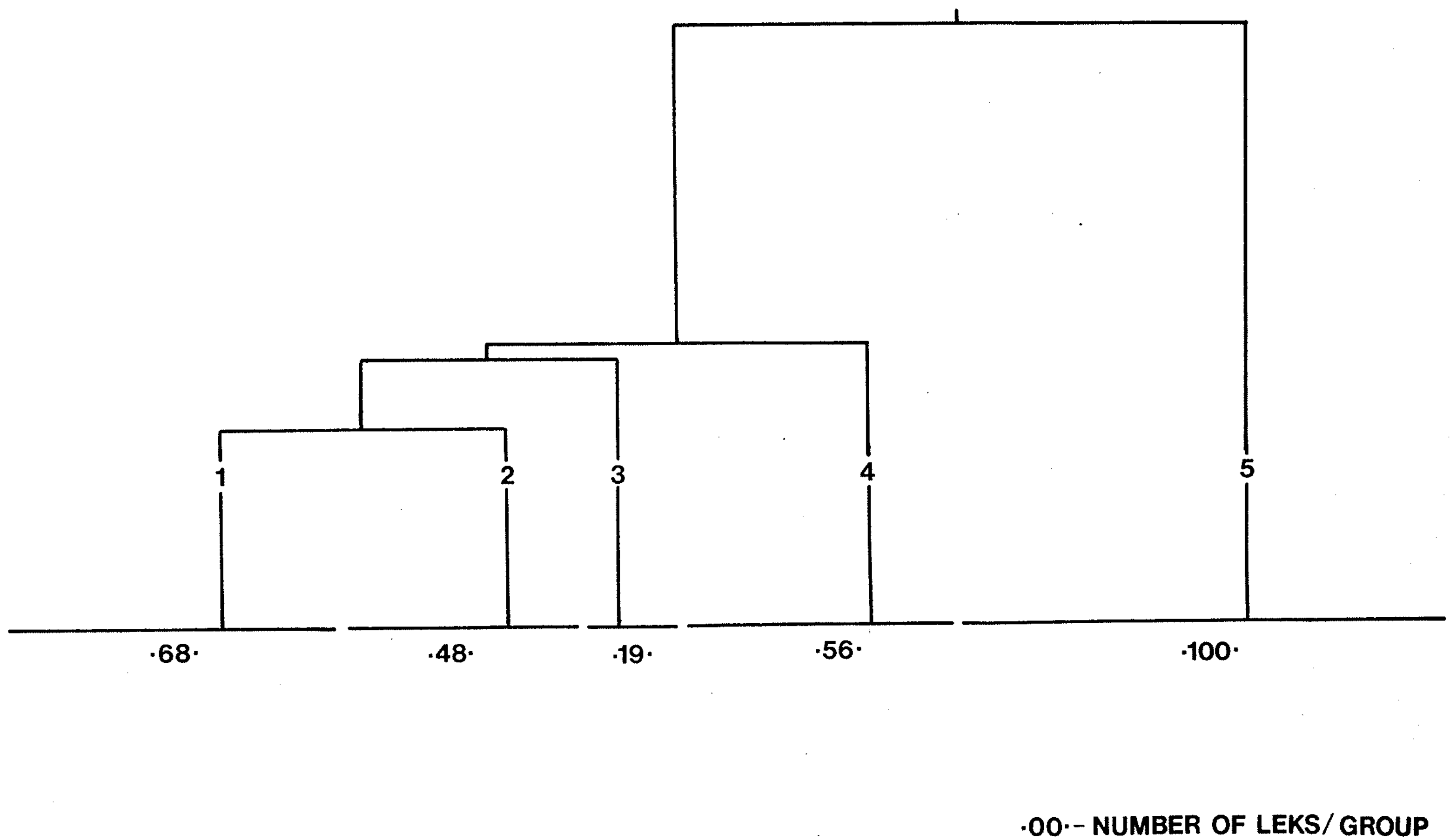
Wards Minimum Variance Cluster Analysis
of Plant Species Density (in surrounding area)



Appendix H

CLUSTER ANALYSIS FOR PLANT COVER GENERALIZATIONS ON LEKS

Wards Minimum Variance Cluster Analysis
of Daubenmire Plots (grouped species on lek)



LIST OF LEKS (LEFT TO RIGHT ON DENDROGRAM=COLUMN) BY GROUP

GROUP 1

LEK 10	LEK 19
LEK 19	LEK 19
LEK 21	LEK 20
LEK 21	LEK 10
LEK 19	LEK 7
LEK 21	LEK 7
LEK 21	LEK 18
LEK 10	LEK 7
LEK 10	LEK 7
LEK 20	LEK 10
LEK 21	LEK 21
LEK 7	LEK 7
LEK 18	LEK 10
LEK 7	LEK 10
LEK 20	LEK 20
LEK 18	LEK 10
LEK 21	LEK 10
LEK 21	LEK 19
LEK 21	LEK 7
LEK 21	LEK 20
LEK 10	LEK 7
LEK 10	LEK 7
LEK 20	LEK 10
LEK 21	LEK 7
LEK 10	LEK 7
LEK 10	
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LEK 18	
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LEK 21	
LEK 21	
LEK 18	
LEK 19	
LEK 21	
LEK 21	
LEK 19	

GROUP2

LEK 10	LEK 20
LEK 18	LEK 20
LEK 18	LEK 21
LEK 18	LEK 7
LEK 18	LEK 7
LEK 18	LEK 7
LEK 20	
LEK 7	
LEK 7	
LEK 10	
LEK 21	
LEK 21	
LEK 18	
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LEK 10	
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GROUP3

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GROUP4

LEK 10	LEK 20
LEK 10	LEK 20
LEK 21	LEK 21
LEK 10	LEK 19
LEK 18	LEK 20
LEK 19	LEK 19
LEK 10	LEK 7
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LEK 19	LEK 19
LEK 7	LEK 20
LEK 19	LEK 20
LEK 19	LEK 19
LEK 7	LEK 20
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LEK 19	
LEK 21	
LEK 19	
LEK 19	

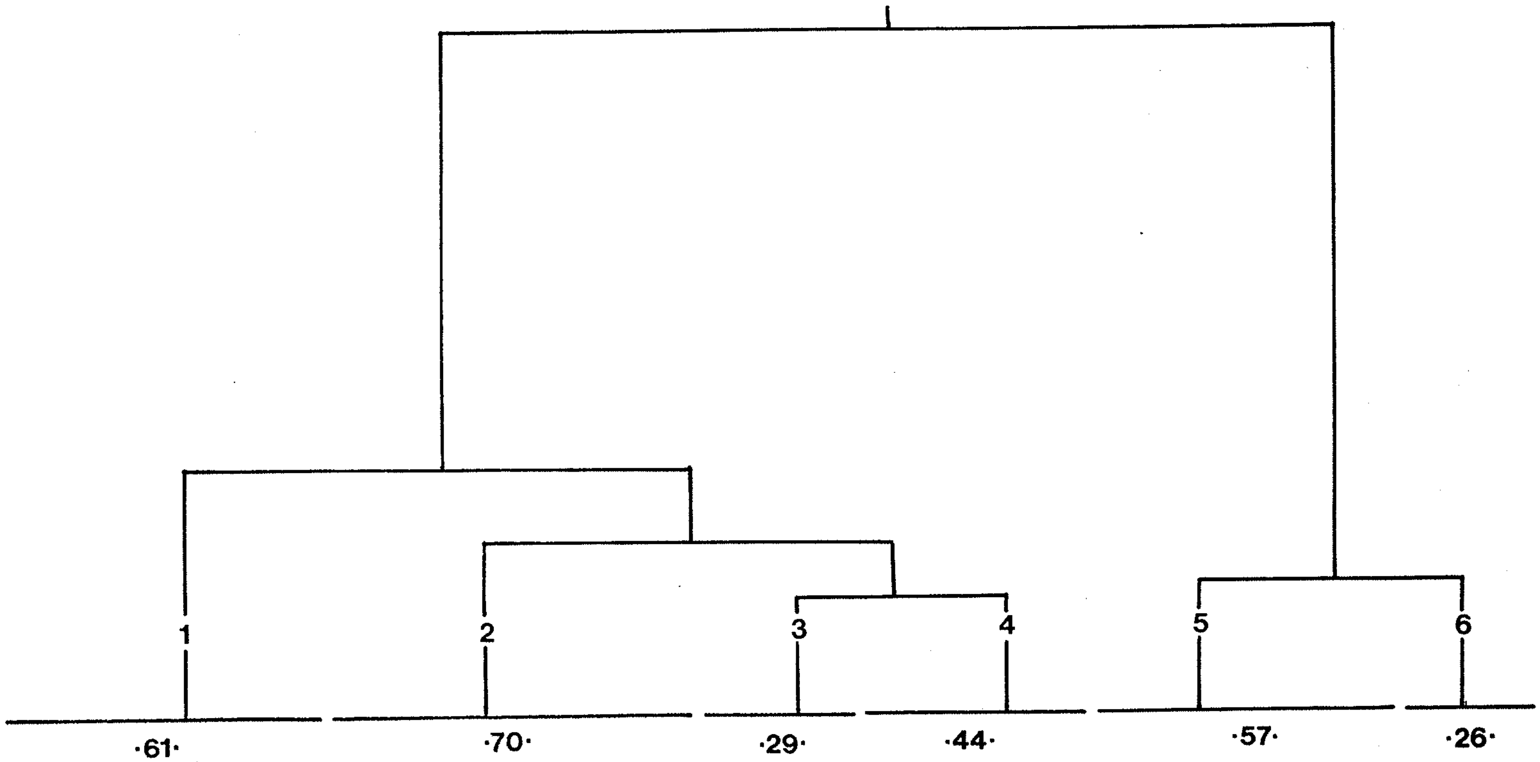
GROUP 5

LEK 10	LEK 10	LEK 20
LEK 10	LEK 18	LEK 10
LEK 21	LEK 10	LEK 20
LEK 20	LEK 10	LEK 10
LEK 20	LEK 10	LEK 18
LEK 21	LEK 21	LEK 20
LEK 7	LEK 21	LEK 18
LEK 10	LEK 10	LEK 18
LEK 21	LEK 19	LEK 18
LEK 21	LEK 18	LEK 10
LEK 7	LEK 18	LEK 19
LEK 10	LEK 19	LEK 7
LEK 18	LEK 10	LEK 18
LEK 20	LEK 10	LEK 18
LEK 7	LEK 18	LEK 19
LEK 10	LEK 18	LEK 20
LEK 18	LEK 18	
LEK 18	LEK 19	
LEK 18	LEK 20	
LEK 19	LEK 20	
LEK 19	LEK 21	
LEK 20	LEK 21	
LEK 21	LEK 7	
LEK 21	LEK 18	
LEK 21	LEK 20	
LEK 21	LEK 7	
LEK 21	LEK 19	
LEK 21	LEK 19	
LEK 21	LEK 20	
LEK 7	LEK 20	
LEK 7	LEK 20	
LEK 7	LEK 20	
LEK 18	LEK 20	
LEK 18	LEK 20	
LEK 19	LEK 20	
LEK 19	LEK 20	
LEK 21	LEK 7	
LEK 21	LEK 10	
LEK 21	LEK 20	
LEK 21	LEK 20	
LEK 10	LEK 10	
LEK 20	LEK 10	

Appendix I

CLUSTER ANALYSIS FOR PLANT COVER GENERALIZATIONS SURROUNDING LEKS

Wards Minimum Variance Cluster Analysis
of Daubenmire Plots (grouped species in surrounding area)



·00· – NUMBER OF LEKS/ GROUP

LIST OF LEKS (LEFT TO RIGHT ON DENDROGRAM=COLUMN) BY GROUP

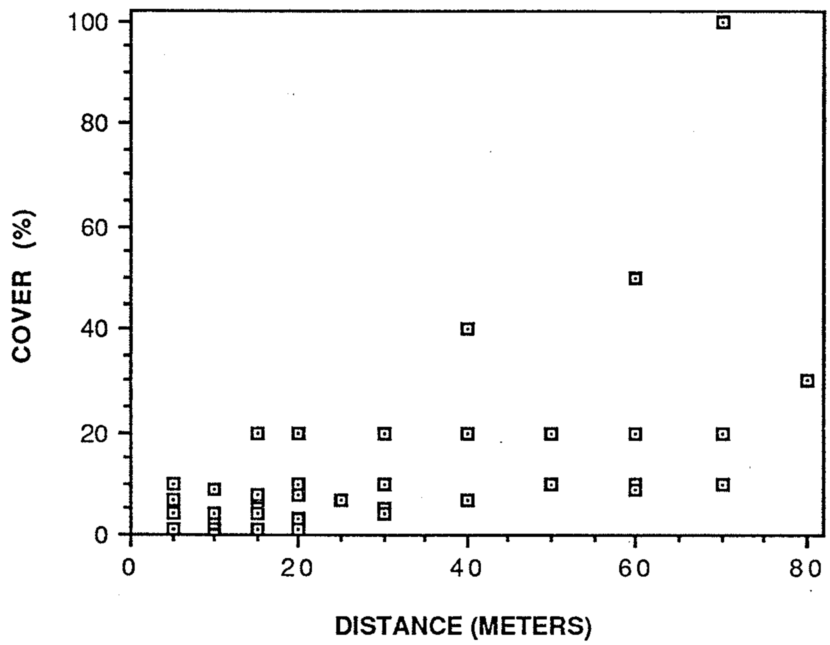
<u>GROUP 1</u>		<u>GROUP 2</u>		<u>GROUP 3</u>	<u>GROUP 4</u>	
LEK 10	LEK 20	LEK 10	LEK 19	LEK 10	LEK 18	LEK 18
LEK 21	LEK 21	LEK 7	LEK 20	LEK 18	LEK 18	LEK 18
LEK 20	LEK 21	LEK 18	LEK 20	LEK 18	LEK 19	
LEK 7	LEK 21	LEK 18	LEK 21	LEK 19	LEK 19	
LEK 19	LEK 7	LEK 18	LEK 20	LEK 18	LEK 19	
LEK 21	LEK 10	LEK 21	LEK 20	LEK 21	LEK 18	
LEK 21	LEK 18	LEK 18	LEK 21	LEK 18	LEK 19	
LEK 21	LEK 20	LEK 19	LEK 7	LEK 7	LEK 7	
LEK 21	LEK 20	LEK 20	LEK 19	LEK 20	LEK 19	
LEK 20	LEK 20	LEK 21	LEK 21	LEK 7	LEK 7	
LEK 20	LEK 21	LEK 19	LEK 21	LEK 10	LEK 19	
LEK 21	LEK 7	LEK 21	LEK 21	LEK 20	LEK 19	
LEK 21	LEK 10	LEK 21	LEK 18	LEK 7	LEK 19	
LEK 20	LEK 21	LEK 18	LEK 7	LEK 10	LEK 19	
LEK 21	LEK 10	LEK 18	LEK 20	LEK 7	LEK 21	
LEK 10	LEK 20	LEK 7	LEK 21	LEK 19	LEK 7	
LEK 18	LEK 7	LEK 20	LEK 21	LEK 21	LEK 7	
LEK 19	LEK 20	LEK 21	LEK 7	LEK 7	LEK 18	
LEK 10	LEK 20	LEK 7	LEK 20	LEK 7	LEK 18	
LEK 20		LEK 18	LEK 7	LEK 19	LEK 19	
LEK 7		LEK 18	LEK 7	LEK 20	LEK 19	
LEK 18		LEK 18	LEK 19	LEK 21	LEK 18	
LEK 18		LEK 18	LEK 20	LEK 7	LEK 18	
LEK 21		LEK 18	LEK 20	LEK 19	LEK 19	
LEK 20		LEK 18	LEK 21	LEK 21	LEK 18	
LEK 20		LEK 18	LEK 21	LEK 21	LEK 18	
LEK 18		LEK 18	LEK 20	LEK 7	LEK 18	
LEK 19		LEK 10		LEK 10	LEK 19	
LEK 19		LEK 19		LEK 10	LEK 18	
LEK 20		LEK 21		LEK 18	LEK 19	
LEK 20		LEK 7		LEK 18	LEK 19	
LEK 19		LEK 10		LEK 19	LEK 19	
LEK 19		LEK 20			LEK 19	
LEK 10		LEK 10			LEK 19	
LEK 19		LEK 7			LEK 18	
LEK 20		LEK 20			LEK 18	
LEK 20		LEK 21			LEK 18	
LEK 20		LEK 7			LEK 7	
LEK 20		LEK 21			LEK 7	
LEK 20		LEK 10			LEK 18	
LEK 20		LEK 21			LEK 19	
LEK 20		LEK 21			LEK 19	

GROUP 5		GROUP6
LEK 10	LEK 21	LEK 10
LEK 10	LEK 7	LEK 10
LEK 10	LEK 10	LEK 10
LEK 10	LEK 10	LEK 18
LEK 7	LEK 10	LEK 10
LEK 10	LEK 7	LEK 20
LEK 10	LEK 19	LEK 20
LEK 18	LEK 7	LEK 21
LEK 10	LEK 10	LEK 20
LEK 10	LEK 10	LEK 21
LEK 18	LEK 7	LEK 10
LEK 7	LEK 7	LEK 21
LEK 10	LEK 10	LEK 19
LEK 10	LEK 20	LEK 7
LEK 20	LEK 7	LEK 10
LEK 10		LEK 20
LEK 10		LEK 10
LEK 10		LEK 7
LEK 10		LEK 21
LEK 20		LEK 7
LEK 7		LEK 7
LEK 10		LEK 19
LEK 10		LEK 7
LEK 10		LEK 20
LEK 20		LEK 20
LEK 19		LEK 21
LEK 21		
LEK 7		
LEK 7		
LEK 7		
LEK 10		
LEK 7		
LEK 21		
LEK 19		
LEK 19		
LEK 19		
LEK 10		
LEK 19		
LEK 19		
LEK 19		
LEK 20		
LEK 21		

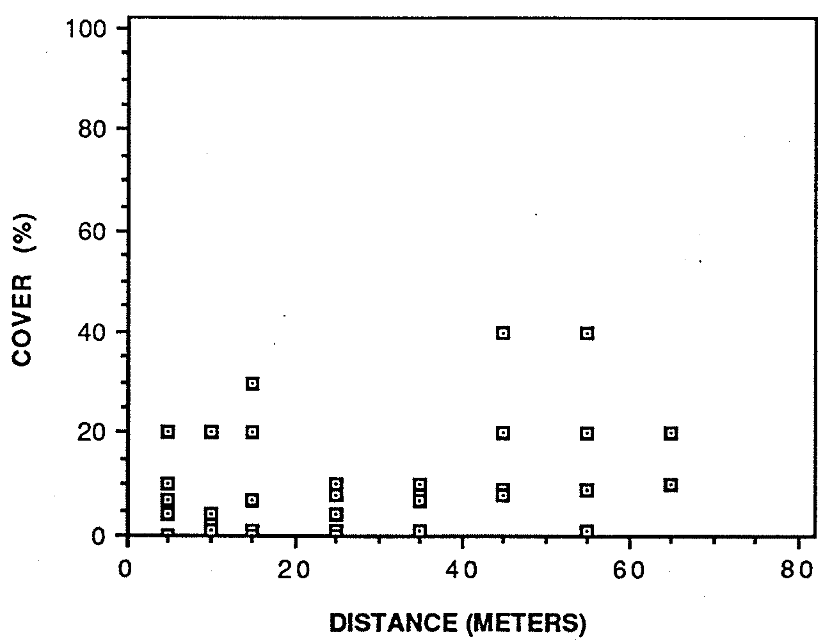
Appendix J

PLOT OF VISUAL OBSTRUCTION VALUES ON CONTROL LEKS 18 AND 19 FROM JONES COVER BOARD SAMPLES

A) VISUAL OBSTRUCTION VALUES ON LEK 18



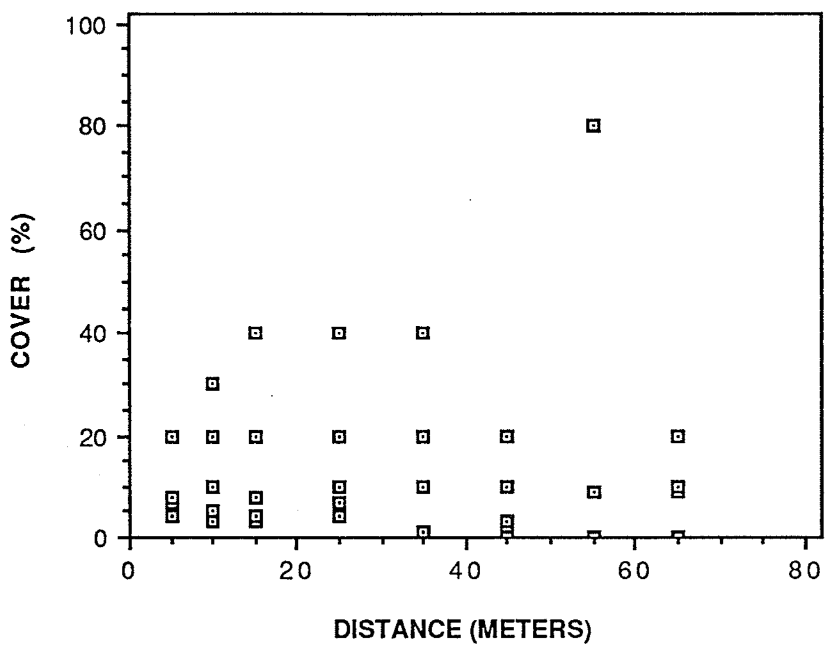
B) VISUAL OBSTRUCTION VALUES ON LEK 19



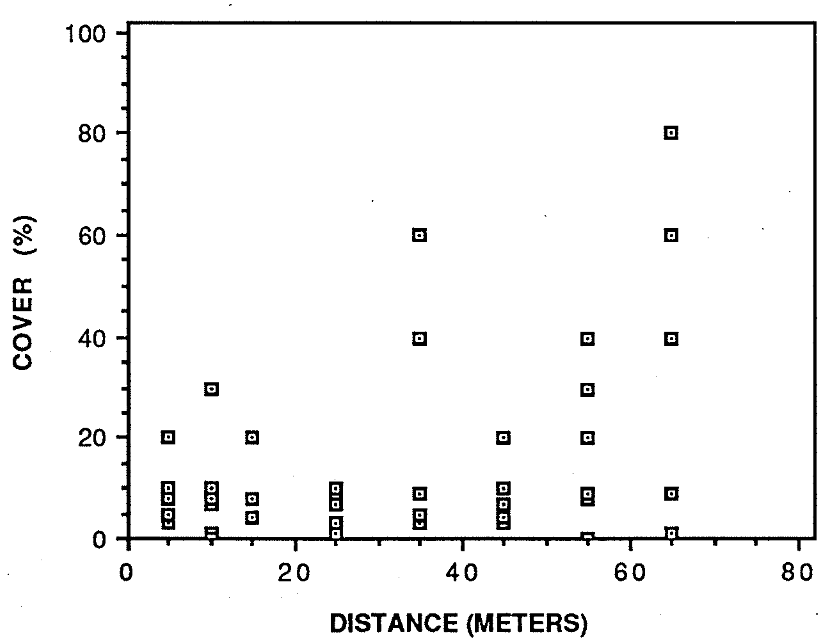
Appendix K

PLOT OF VISUAL OBSTRUCTION VALUES ON MANIPULATED AREAS 7 AND 10 FROM JONES COVER BOARD SAMPLES

C) VISUAL OBSTRUCTION VALUES ON LEK 7



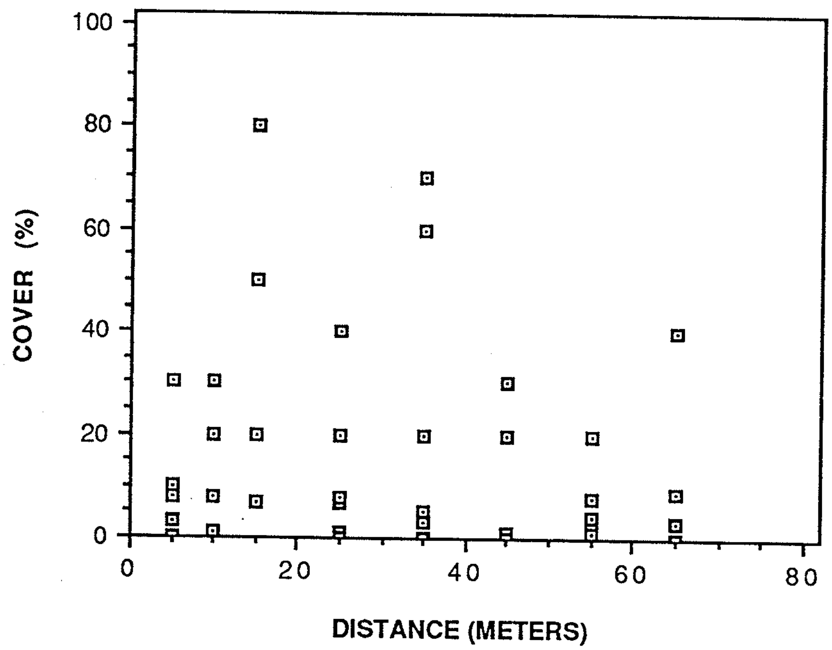
D) VISUAL OBSTRUCTION VALUES ON LEK 10



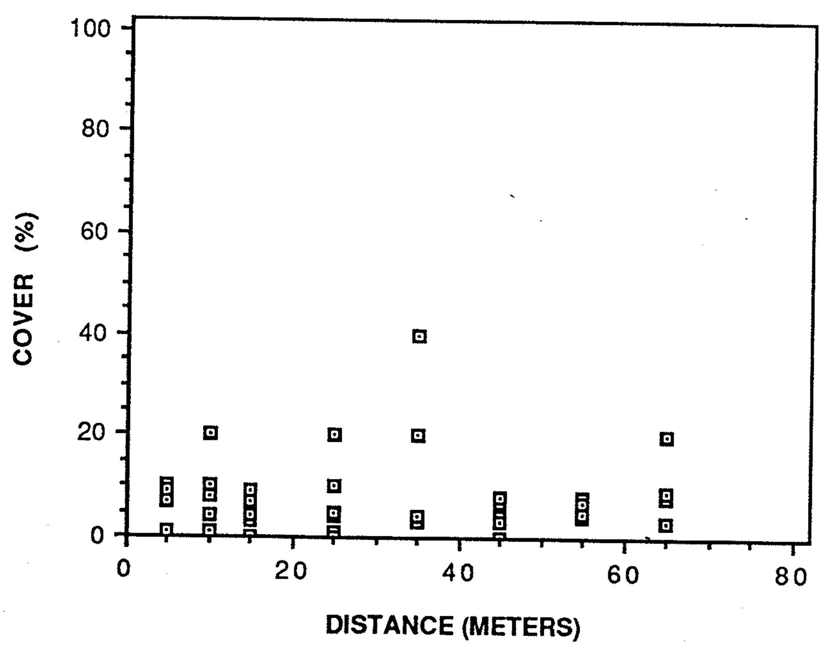
Appendix L

PLOT OF VISUAL OBSTRUCTION VALUES ON MANIPULATED AREAS 21 AND 20 FROM JONES COVER BOARD SAMPLES

E) VISUAL OBSTRUCTION VALUES ON LEK 20



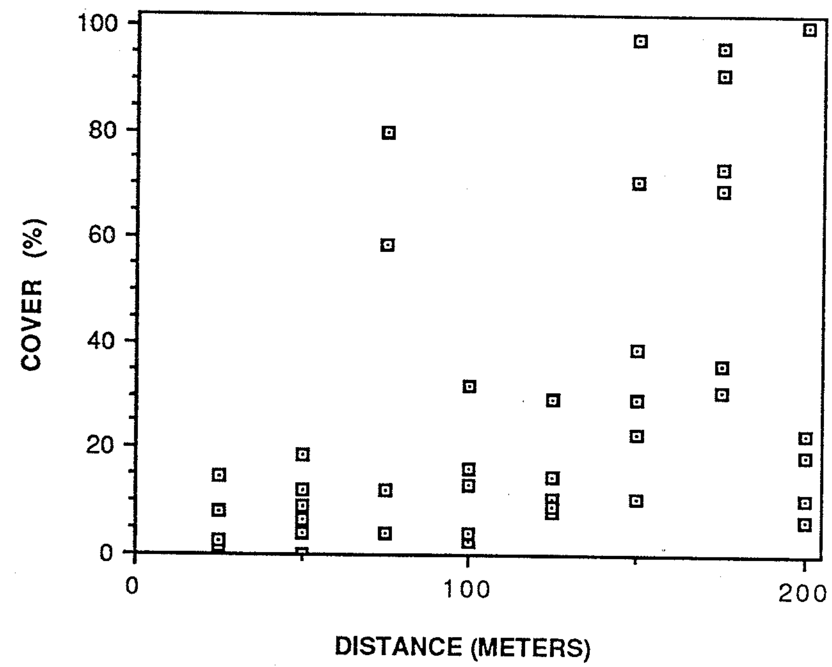
F) VISUAL OBSTRUCTION VALUES ON LEK 21



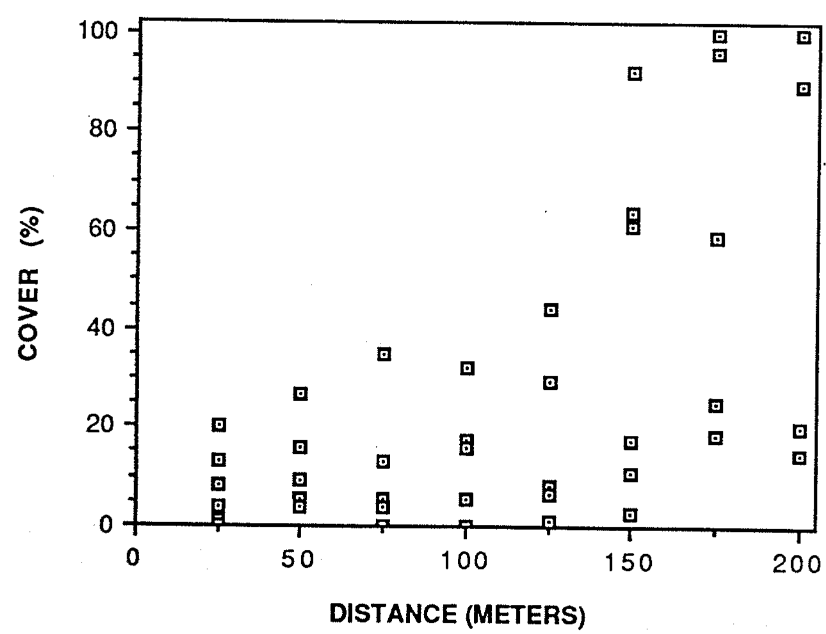
Appendix M

PLOT OF VISUAL OBSTRUCTION VALUES SURROUNDING CONTROL LEKS 18 AND 19 FROM JONES COVER BOARD SAMPLES

A) VISUAL OBSTRUCTION VALUES OFF LEK 18



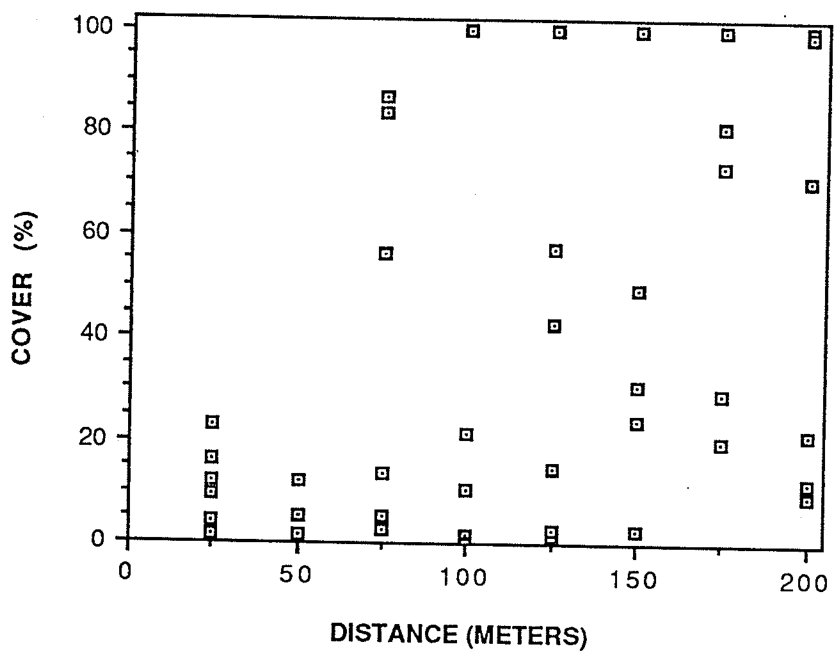
B) VISUAL OBSTRUCTION VALUES OFF LEK 19



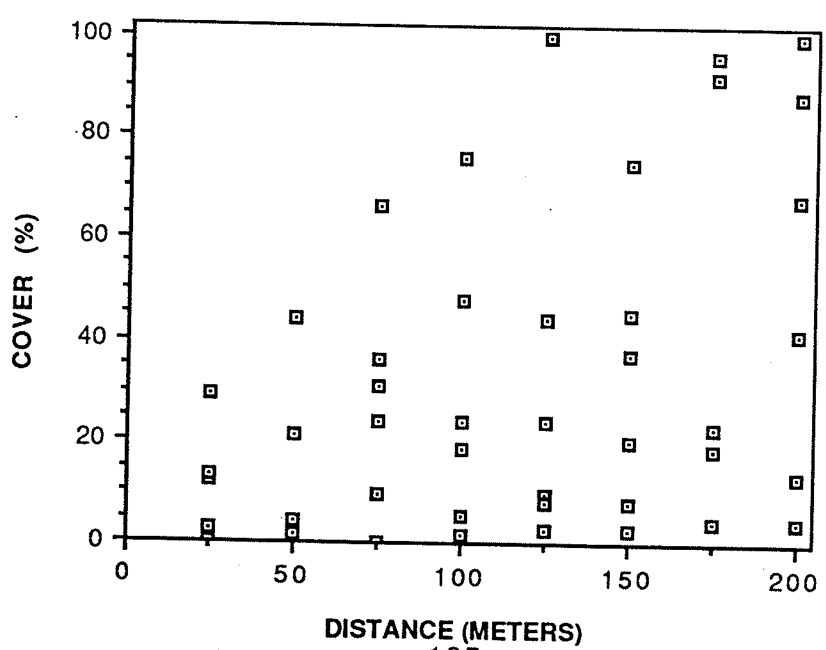
Appendix N

PLOT OF VISUAL OBSTRUCTION VALUES SURROUNDING MANIPULATED AREAS 7 AND 20 FROM JONES COVER BOARD SAMPLES

C) VISUAL OBSTRUCTION VALUES OFF LEK 7



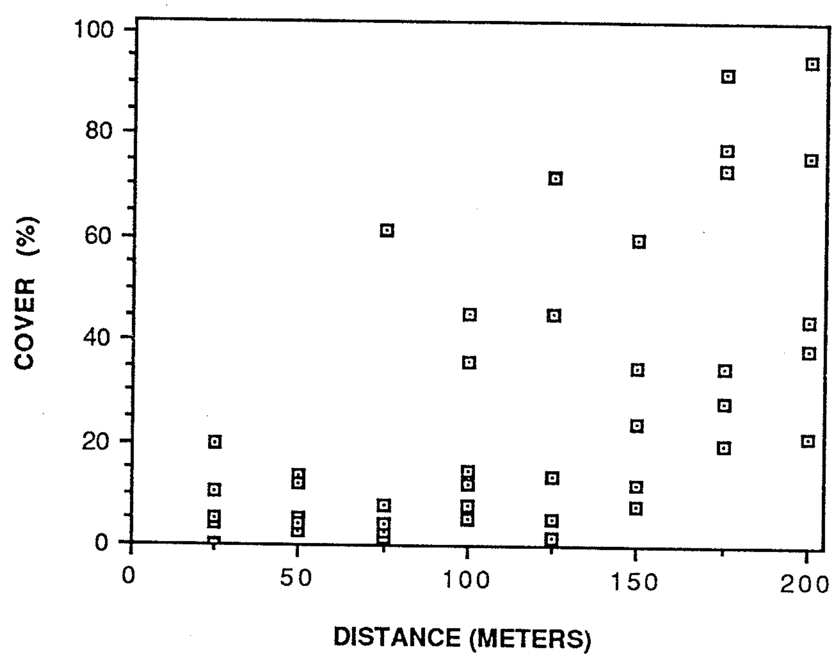
D) VISUAL OBSTRUCTION VALUES OFF LEK 20



Appendix O

PLOT OF VISUAL OBSTRUCTION VALUES SURROUNDING MANIPULATED AREAS 21 AND 10 FROM JONES COVER BOARD SAMPLES

E) VISUAL OBSTRUCTION VALUES OFF LEK 21



F) VISUAL OBSTRUCTION VALUES OFF LEK 10