AN INVESTIGATION OF SHARP-TAILED GROUSE (*TYMPANUCHUS PHASIANELLUS*) IN NORTHEASTERN PRINCE EDWARD ISLAND

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Abstract

This study investigated aspects of the ecology of the sharp-tailed grouse (*Tympanuchus phasianellus),* an exotic gallinaceous bird, on a landscape spatial scale. The study evaluated limiting factors of three requirements for population integrity and survival: the availability of lek sites, landscape level suitability including nesting/brood cover, and winter food supply. The study took place in northeastern Prince Edward Island (PEI). The overall objective of this project was to determine if there is a self sustaining population of sharp-tailed grouse on the Island.

The study methods included two principle elements: a Geographic Information Systems (GIS) analysis of habitat requirements, and field surveys during the courtship season and critical winter period. The GIS analysis identified sharp-tailed grouse habitat based on published habitat metrics. The field program consisted of 1) lek identification using courtship vocalizations and visual observations to locate leks; 2) lek surveys to determine the number of territorial males per lek and to estimate population size, and 3) track, scat and visual observations to determine winter habitat use.

During the study four leks were found. The number of displaying male sharp-tailed grouse observed ranged from 3 to 27. Three of the four leks were associated with commercial blueberry growing areas. The GIS analysis showed that there were many potential lek sites in northeastern PEI but areas capable of supporting sharp-tailed grouse were limited by of the amount of forest. Winter habitat is not likely limiting grouse populations. Based on the observations of this study, the sharp-tailed grouse population is unlikely to be self-sustaining over a long period.

Acknowledgements

This project proved to be both challenging and incredibly rewarding. Much of it was a relatively solitary, unconventional journey. Watching sharp-tailed grouse display on a dancing ground is a truly fascinating experience.

This project would not have been possible without the support of many people. First among them would be my wife Krista and children, Grace, Noah, and William. Two of whom were born during this project.

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Chapter 1.
Introduction and Literature Review

1.1 Introduction

Prince Edward Island is juxtaposed in the acquired range for many exotic bird species (Erskine 1992), and contains a unique combination of climate, geology, soil, topography, flora and fauna. Species capable of colonizing must have aerial or water mobility greater than the width of the Northumberland Strait, the ability to migrate on ice flows, or the ability to exploit human transportation.

Prince Edward Island contains significantly disturbed land. In 1900 a mere 31 % of land remained forested (PEI DAF 2003). Desire for game species combined with limited habitat for native game led to a keen interest in exotic introductions (Heyland 1965, Smith 1978). Smith (1978) reinforced this attitude six decades after the first documented introduction of ring-necked pheasants *(Phasianus colchicus)* by saying that if the goal is to produce better hunting it is more advantageous to find new, adaptable game bird species than to restore disturbed habitat.

1.2 Game Bird Introductions

1.2.1 Types of introduced game bird species

Population responses of introduced species vary. An early classification assembled by Leopold (1933) based on game birds describes six generalized categories of responses: 1) dispersal failure, where the birds dispersed and did not breed; 2) straggling failure, where they initially bred but gradually disappeared; 3) colonial establishment, where they survived and did not spread; 4) artificial establishment where they survived with the aid of restocking; 5) recessive establishment where there is a population boom, then bust and stabilization; 6) establishment where the birds are fully integrated into the new ecosystem.

Cassey *et al.* (2005) tested five hypotheses concerning why introductions of exotic avian species had varying degrees of success on oceanic islands. They concluded that the number of individuals introduced and the number of exotic mammalian predators were both significant predictors of success. They concluded that introductions were more likely to succeed when the number of individuals introduced was larger (greater than 100 as compared to 0-10 and 11-100) and that introductions were more likely to fail where more species of exotic mammalian predators existed. Sol et al. (2002) studied 69 bird species throughout the world and determined that successful species had relatively larger brain sizes and showed a higher degree of foraging innovation in their native range than less successful species.

1.2.2 Impacts of introduced game birds

Bump (1951) suggested that no species can succeed without causing some change in plant and animal associations. For many introductions, impacts on native species and habitat have been documented. In the case of game birds, concern for negative impacts has been overshadowed by the immense popularity of introduced species for sport hunting (Kimmel 1988). Threats to native species are competition, predation, disease, parasitism, hybridization, and habitat alteration. Leopold (1933) indicated that ring-necked pheasants kill prairie chickens (*Tympanuchus* sp.). A record of a ruffed grouse (*Bonasa umbellus*) x pheasant hybrid was found in New York in 1930 (Bump *et al.* 1947). Ring-necked pheasants have been shown to parasitize nests of the lesser prairie chicken (*Tympanuchus pallidicinctus*) in Kansas (Hagen *et al.* 2002); as well American woodcock (*Scolopax minor)*, ruffed grouse, gray partridge (*Perdix perdix*), prairie chicken and various ducks (Kimmel 1988). Nest parasitism impacts the host species by lowering hatching success, increasing predation and, if the incubation times are coincident, causing hen hosts to abandon their nests to follow hatched pheasant chicks (Kimmel 1988).

Introduced game birds can assume ecological niches previously held by endangered or extinct birds. In the high elevation Hawaiian shrub land, Cole *et al.* (1995) suggested that pheasants and chukar partridge (*Alectoris chukar)* are likely exploiting a vacant ecological niche and may be providing valuable benefit by dispersing native shrub seeds in degraded ecosystems.

1.2.3 Game bird introductions to Prince Edward Island

Prince Edward Island has a history of trial and failure with exotic game birds. Gray partridge, ring-necked pheasant, sharp-tailed grouse, bobwhite quail (*Colinus virginianus*), and chukar partridge have been introduced (Rodd 1949). Four hundred bobwhite quail were released in 1947 but did not survive. A limited number of chukar partridge were released in 1947 and were reported to be thriving through one breeding season. Ten pairs of sharp-tailed grouse were obtained from Western Canada in 1946. Only half of these animals were released alive due to poor condition upon arrival. An additional release of 30 birds occurred a short time later and reports of an established population were promising (Rodd 1949).

Gray partridge and ring-necked pheasant have commanded most of the attention. Both have a long history of release efforts and characteristic population fluctuations. Gray partridge have become established at low but stable densities (MacQuarrie and Guignion 1969, Dibblee 2006). Erskine (1992) estimated a population of 1000 breeding pairs of gray partridge and 100 breeding pairs of ring-necked pheasant based on data collected for the Maritime Breeding Bird Atlas.

1.2.4 Gray partridge

Gray partridge were introduced in 1927 when ten pairs were released near Charlottetown (Tufts 1939, Heyland 1965) and reached a reported population in excess of 200,000 (Heyland 1965).

Heyland (1965) concluded that severe winter weather was the cause of the massive decline in both gray partridge and ring-necked pheasant populations, discounting the roles of predators, disease, poisoning, and lack of habitat. Another factor implicated to a lesser degree was hunting. Conversion of woodland to small agricultural fields in the late 19^{th} and early 20^{th} centuries provided desirable habitat, but later changes in farming practices reduced the area of cultivation, increased mechanization and the use of chemicals. This was reported to negatively impact both species but was unlikely to result in such a decline. Changing agricultural practices in Europe, including the application of herbicides limiting weed growth and insecticides limiting food for gray partridge chicks, have been linked to the decline in gray partridge (Marshall et al. 2003). Other factors implicated in the European decline of gray partridge seem similar to descriptions of the changes in farming practices on PEI. These include less spring tillage, increased field size, decrease in manure stored around farms, decrease in waste grain, more efficient equipment, and the removal of hedgerows.

MacQuarrie and Guignion (1969) reported that gray partridge were widely distributed, in low but stable populations. In the decades following this study, interest in the gray partridge resulted in numerous relocation attempts. Although up-to-date quantitative population data are not available for the gray partridge, it is clear that populations have not recovered to anywhere near the peak in 1948.

Severe nest predation may be suppressing growth of gray partridge (MacQuarrie and Guignion 1969). Tapper *et al.* (1996) clearly demonstrated that a seasonal reduction in predators significantly improves breeding success of gray partridge and results in higher fall numbers. Nack and Ribic (2005) used video to document cases of grassland bird nest depredation by cattle in Wisconsin that has implications for PEI. Gray partridge continue to exploit a niche on PEI, which presumably did not exist before extensive land clearing of the late 19^{th} and early 20^{th} centuries (Erskine 1992).

The gray partridge has a positive economic impact on PEI. It provides recreation for hunters during a limited fall season and is seen as a positive addition to the farm (MacQuarrie and Guignion 1969). Gray partridge also provide an aesthetic benefit to some wildlife viewers. Government and private programs have provided feed to help sustain them throughout the winter, demonstrating public interest and concern.

1.2.5 Pheasants

Considerable effort has been spent to establish a wild pheasant population on PEI and records indicate that more than 7000 birds have been released in 90 years. The historical record was summarized by Heyland (1965) and records of the Forests, Fish and Wildlife Division (Smith 1983) were added and believed to be accurate. In addition, the Souris Branch of the PEI Wildlife Federation has also released pheasants in eastern PEI (Smith 1983).

An effort was made to establish wild populations of the ring-necked pheasant and Japanese green pheasant (*Phasianus versicolor*) on PEI between 1969 and 1970 (Smith 1978). All introductions were unsuccessful as the birds were unsuited for local climatic conditions (Smith 1978). This experiment involved releasing birds raised in flight pens as well as the open field method where eggs are incubated by bantam hens. Smith (1978) recommended the open field method to create birds better suited for the wild. Birds did not disperse very far from the flight pens and were susceptible to human and avian predators (Smith 1978).

1.2.6 Sharp-tailed grouse

The Prince Edward Island Fish and Wildlife Division (PEI FW) introduced sharp-tailed grouse between 1987 and 1990 (Mullaly 1992, PEI FW 2006). Records indicate 42 birds from Manitoba and Saskatchewan were released at two sites in northeastern PEI (Appendix A). The majority of the birds came from the Clematis and Narcisse Wildlife Management Areas in the Inter-lake Region of Manitoba (Gillespie pers. comm., Ball pers. comm.). The birds were live captured and shipped by air to PEI. The initial release was in Clearsprings, Kings County on the northeastern shore of PEI (46.4695250, 62.3208504). A soft release method was used by conditioning the birds in a release pen (MacIntyre pers. comm.). This release was successful. In subsequent years birds were observed on a lek in Cable Head, Kings County (MacIntyre pers. comm.). The lek was a small grassy peninsula surrounded by shrubby cover dominated by bayberries (*Morella pensylvanica)*. Two additional releases took place in Cable Head (46.4632824, 62.6071759), in proximity to the lek (MacIntyre pers. comm.).

Since 1992, PEI FW has received reports suggesting that sharp-tailed grouse were reproducing in northeastern PEI and may have expanded their range westward into Queens County (Dibblee pers. comm.). Information about sharp-tailed grouse on PEI was limited and anecdotal and no effort to examine their status has been previously undertaken. This study represents the first effort to collect quantitative information regarding this exotic gallinaceous bird on PEI. In this study field research and Geographic Information Systems (GIS) models, using published information about sharp-tailed grouse, were combined to offer a thorough evaluation.

1.3 General Biology of Sharp-tailed Grouse

1.3.1 Courtship and breeding

Sharp-tailed grouse are polygynous, breeding on leks (dancing grounds) where males perform courtship displays for females who visit during the breeding season (Hamerstrom 1939). Dominant male sharp-tailed grouse establish central territories on the lek sites and do most of the breeding (Moyles and Boag 1981). Males with central territories have a higher survival rate than peripheral males or non-territorial males (Moyles and Boag 1981). Evans (1969) demonstrated that some males occupied virtually the same territory for at least two years. He noted that this would potentially reduce genetic variability in the progeny. Tsuji (1996) found evidence that females copulate only once during the breeding season.

1.3.2 Lek characteristics

Dancing grounds in Michigan averaged 180 to 400 m^2 (Ammann 1957). In Manitoba, leks occupied an average of 450 m^2, in an oval shape (Baydack 1988). The topography was flat to slightly mound shaped. The lek centre was greater than or equal to 0.5 m higher than the perimeter and the slope was less than or equal to 1 % (Baydack 1988). Baydack (1988) also found the average height of vegetation on leks in Manitoba was 10.4 cm. Sharp-tailed grouse showed a preference for elevated sites for its dancing grounds (Ammann 1957).

The area immediately surrounding the lek (lek site) was important. Gregg (1987) suggested that lek sites required an area of approximately 0.12 km^2 (193 m in radius), free from woody vegetation and that birds showed a preference for sites that contained dense grass cover within 180 m. Niemuth and Boyce (2004) determined leks were located on open sites which were an average of 306 m from forest cover. In Michigan, Ammann (1957) found that lek sites contained little or no woody vegetation and males abandoned dancing grounds when they became wooded. Pepper (1972) concluded that vegetation type was of no particular importance as long as the birds had a wide view of the surrounding area and that leks were not established on sites dominated by trees and shrubs. Lek sites appeared to be selected in order to maximize sound transmission of male courtship vocalizations and visibility for the detection of predators (Baydack 1988).

1.3.3 Landscape characteristics surrounding lek sites

Land use surrounding the lek was a critical factor for lek site selection (Niemuth and Boyce 2004, Hanowski *et al.* 2000). Typical sharp-tailed grouse habitat was level or slightly rolling (Amman 1957, Grange 1948). Baydack (1988) found that leks in Manitoba contained escape cover within 500 m, had suitable aspen (*Populus* sp.) perching sites within 400 m, and were 2200 m apart. Leks were less than 1600 m apart in the Nebraska sand hills (Johnsgard 1973). Leks had a clumped distribution in relation to suitable habitat (Niemuth and Boyce 2004). Distribution of leks in a low density population in east central North Dakota was related to residual herbaceous vegetation (Kirsch *et al.* 1973). Viability of sharp-tailed grouse populations in Wisconsin was related to the size of suitable habitat patches and how close the patches were to each other (Temple 1991).

Agricultural practices, including altering brush, were one of the leading causes in the reduction of sharp-tailed grouse range (Aldrich 1963). Sharp-tailed grouse could not survive on 100 % farmed land (Grange 1948). In an agricultural landscape, Kirsch et al. (1973) demonstrated that sharp-tailed grouse were dependant on retired farm land and male sharp-tailed grouse abandoned all lek sites when the adjacent retired farm land was ploughed. Kirsch *et al.* (1973) found that hay fields in isolation did not support sharp-tailed grouse, while Pepper (1972) concluded that a population forced to nest in hay/stubble had very low success (20 % of nests were successful) and would have difficulty maintaining itself. Mitchell (1984) also found that sharp-tailed grouse reproduction was severely limited in croplands. Ground cover was the most distinguishing feature of sharp-tailed grouse habitat in Michigan which included all plants and shrubs up to 0.9 m in height (Ammann 1957). Sharp-tailed grouse preferred cover dominated by shrubs and grass in Wisconsin (Gratson 1988). Gratson (1988) radio-collared 26 male and 13 female sharp-tailed grouse and found that sharp-tailed grouse spent the majority of their time in shrubs and grass during spring and summer.

An important lek characteristic in Saskatchewan was the amount of ungrazed or lightly grazed grass and shrub land within 1600 m of the site (Pepper (1972). Connelly *et al.* (1998) described all lands, including nest cover, within 2000 m of a lek to be critical. Brown (1966 in Prose 1987) also determined that dense herbaceous residual cover was related to the size of the lek and that females may have been choosing this cover for nest sites; therefore males were choosing lek sites in proximity to this cover type

Sharp-tailed grouse have relatively narrow habitat requirements and are sensitive to changes, particularly around lek sites. Ammann (1957) considered the spectrum of prairie grouse habitat to be from completely open land to 30 % closed canopy forest. He concluded that ideal areas contained 20-40 % woody cover and further specified that small clumps of trees were preferred over an even distribution. Forest patches near leks, however, negatively influenced preference (Niemuth and Boyce 2004).

The percent of aspen cover within 800 m of a lek was found to be important in the aspen parklands of Alberta (Moyles 1981). A decrease in displaying males was inversely related to the amount of aspen cover around the lek (Moyles 1981). Sharp-tailed grouse reached their greatest abundance when the landscape contained 25 – 50 % wooded cover in Wisconsin and did not tolerate over 75 % cover (Grange 1948).

Ammann (1957) provided a description of sharp-tailed grouse in Michigan where small, well defined openings (a few hectares) in an otherwise forested landscape may appear to contain the necessary requirements for sharp-tailed grouse but were not large enough. Patches of 4 – 20 ha may be occasionally used and may support the rearing of a brood. Ammann (1957) observed this situation many times, including several instances many kilometres from known occupied range but believed they added very little to the overall population and should not be considered as part of the range. Areas of 20 – 81 ha may be occupied if they contained above average cover; however he concluded that approximately 2.59 km^2 is the minimum area required provided it contained average cover and 10 km^2 or more would be required if the cover was poor. Ideal sharp-tailed habitat in 2.59 km^2 should contain 75 % open and 25 % in various stages of reforestation. Other studies of sharp-tailed grouse have given widely varying estimates as to the minimum area required. The minimum area of herbaceous vegetation required to maintain a stable population in Saskatchewan was 1.62 km^2 (Pepper 1972). In Wisconsin, Grange (1948) determined that 8 km^2 was required to maintain a population through high and low points in their cycle. Prose (1987) described the minimum area required to contain all life requirements for sharp-tailed grouse at 5.3 km^2. Niemuth and Boyce (2004) considered all land within 2.4 km of the lek to be important (approximately 18 km^2).

The home range of sharp-tailed grouse also varies between seasons and between sexes (Gratson 1988). In Wisconsin, the smallest home range occurs between May and August when cocks average less than 65 ha (Gratson 1988). The largest monthly home range of hens occurred during the pre-laying period in April and averaged 464 ha. He found that cocks feeding on natural foods ranged the widest (288 ha) during winter.

1.3.4 Nesting and brood cover

Females nest on the ground, producing 10-13 eggs that are incubated for 23-24 days by females alone. The brood disperses in 6-8 weeks after hatching (Harrison 1978). In an early study, Hamerstrom (1939) found that in Wisconsin nests occur almost exclusively in mixed plant species areas rather than pure stands.

Female sharp-tailed grouse choose nest sites and brood their young as far away from leks as possible (Gratson 1988). Pepper (1972) found nests to be located an average distance of 900 m from leks with a maximum distance of 1600 m. Connelly *et al.* (1998) indicated that the maximum distance between a lek to a nest was 2200 m. Niemuth and Boyce (2004) found a mean distance to nests from known lek of 980 m. One plausible hypothesis for this is that male courtship display attracts predators.

Vegetation height is a critical parameter for nesting. Pepper (1972) found that ideal height is greater than 0.3 m and that the majority of nesting occurred in native grass/shrub and tame hay, though some nests were found in grain stubble. Nests in grazed pastures were unsuccessful. Suitable nest cover limited the size of the sharp-tailed grouse population in Saskatchewan (Pepper 1972). In the absence of adequate grass cover, females nested in brushy draws that severely limited success (2 of 11) due to predation (Pepper 1972).

Ideal brood habitat in Wisconsin was characterized by Hamerstrom (1963) as containing both grass and shrub components with the shrub being the most important. The majority of broods were found in open cover, rather than wooded and included cultivated lands such as hay, as well as grass and shrub complexes (Hamerstrom 1963). Brood habitat should contain no more than 10 to 15% forest, in patches (Hamerstrom 1963). In Michigan, Ammann (1957) determined that brood habitat should not exceed 50 % woody cover.

1.3.5 Food

Leopold (1953) found that grouse can thrive on a winter diet of browse that other gallinaceous birds could not such as pheasants. He noted gross differences in the size of the intestines and caeca when compared with other birds. The caeca, believed to store microbes that aid in digestion, is more than twice as long in sharp-tailed grouse (49 cm) than ring-necked pheasant (20 cm) and almost 20 % longer than in ruffed grouse (40 cm) (Leopold 1953). Sharp-tailed grouse feed on a variety of insects, seeds, fruits, catkins and buds depending on availability (Connelly *et al.* 1998). In seasons other than winter, sharp-tailed grouse eat a variety of vegetation including the flower parts of dandelion (*Taraxacum* sp.) and buttercup (*Ranunculus* sp.) (Johnsgard 1973). Sharp-tailed grouse have a variety of food choices during fall and Johnsgard (1973) concluded that considerable variation depending on locally available foods should be expected. Sharp-tailed grouse also eat seeds and cultivated grains in agricultural areas and fruits from many shrubs (Johnsgard 1973).

The diet of sharp-tailed chicks consists primarily of insects including grasshoppers, spiders, ants and weevils for the first few weeks of life (Grange 1948). The most important food for chicks in Saskatchewan is grasshoppers (Pepper 1972).

Grange (1948) compared the food habitats of the sharp-tailed grouse to that of the ruffed grouse and concluded that considerable overlap exists between the winter range of sharp-tailed grouse and ruffed grouse and they have almost identical food requirements He found the difference in the rest of the year is because the sharp-tailed grouse favours more open habitats.

1.3.6 Predators and threats

Sharp-tailed grouse are ground nesting birds making them vulnerable to a variety of predators. Connelly *et al.* (1998) summarized the most common predators of sharp-tailed grouse which includes many animals common to PEI such as red fox (*Vulpes vulpes*), racoon (*Procyon lotor*), skunk (*Mephitis mephitis)* and coyote (*Canis latrans*). The majority of sharp-tailed grouse die from predation which impacts nesting, juvenile and adult survival (Schroeder and Baydack 2001). Connelly *et al.* (1998) also indicated that most winter mortality is likely due to avian predators. Nest success can be influenced by corvid density; Manzer and Hannon (2005) demonstrated that sharp-tailed grouse nests are eight times more likely to succeed in areas with lower corvid densities.

1.3.7 Threats to isolated populations

Sharp-tailed grouse are area sensitive and threatened when habitat patches are not large enough or close enough together (Temple 1991). Forest surrounding suitable sharp-tailed grouse habitat is a barrier to effective dispersal (Temple 1991). Temple (1991) concluded that in order for a population to be viable it required a spring breeding population of 280 birds (both sexes combined). These birds required a suitable area of at least 4000 hectares. He further concluded that to achieve a 95 % probability of persistence for 50 years that five of these subpopulations would be required.

Sharp-tailed grouse are vulnerable during the first two weeks after hatching and during fall dispersal (Hannon and Martin 2006). In Michigan the biggest threat facing sharp-tailed grouse was loss of habitat through forest planting (Ammann 1963). In the inter-lake region of Manitoba, where the majority of the PEI sharp-tailed grouse originated, uncontrolled aspen succession was believed to negatively impact sharp-tailed grouse (Ball pers. comm.). Niemuth and Boyce (2004) supported the conclusion of Grange (1948) that sharp-tailed grouse cannot survive in small colonies outside the connected range.

Westemeir *et al.* (1998) studied a geographically isolated population of prairie chickens in Illinois. Illinois has undergone a decline in prairie chickens and in 1994 an estimated 46 birds remained in only two isolated populations. They found significant differences in reproductive fitness, hatching, and egg success, between 1963 and 1991. They also compared genetic variation with samples from larger populations. The Illinois population had the lowest genetic diversity, having the lowest mean heterozygosity and 30 % lower allele diversity. Several of the alleles present in the larger populations were absent from the Illinois populations but did exist before the 1970's. Westemeir *et al.* (1998) determined that the Illinois population would have been extirpated without the introduction of birds from more stable, genetically diverse populations. After 271 birds were transplanted a significant increase in fertility and nest success were observed. This increase was determined to have been related to characteristics of the birds themselves and not environmental factors.

1.3.8 Comparable range

Land with sharp-tailed grouse in northeastern PEI is more closely related to areas within Michigan and Wisconsin than those of the prairies. A classification of grouse habitat in Canada by Aldrich (1963) includes Prince Edward Island with both Michigan and Wisconsin as part of the northern hardwood-conifer ecological climax type. While sharp-tailed grouse on PEI originated in Manitoba and Saskatchewan (Dibblee pers. comm.), it is more logical to give more weight to habitat associations from the more similar eastern regions of North America.

1.3.9 Translocations and introduction attempts

In the United States there have been at least 14 documented attempts to establish or re-establish sharp-tailed grouse populations since 1950 (Connelly *et al.* 1998, Snyder *et al* 1999, Applegate 1997). An attempt to introduce sharp-tailed grouse to Maine failed. This introduction targeted large blueberry barrens. It was believed to have failed because the climate was not appropriate (too much precipitation), the birds were in poor condition and an adequate number was not released (Applegate 1997). Successful introductions were reported in Kansas, Iowa, Washington, Oregon and Idaho, while unsuccessful attempts were made in Montana, Utah, Washington, Wisconsin, Colorado (2), Illinois, and Oregon. No documented introduction attempts to other areas in Canada were found.

1.4 Using Geographic Information Systems to model wildlife habitat.

Johnson *et al.* (2006) used GIS to analyze habitat for the lesser prairie chicken (*Tympanuchus pallidicinctus*) in south-eastern New Mexico. They concluded that GIS analysis in combination with population data can provide a valuable tool for conservation and management of this species. Niemuth (2003) developed a suitability model for prairie chicken and applied it to a digital land cover dataset for Wisconsin. He created a spatially explicit map predicting suitability for unoccupied range. Critical components of his model building were choosing the appropriate scale and the potential to use multiple spatial scales representing different landscape characteristics as well as local features such as disturbance or development. He also cautioned against the pitfalls of using a model developed in a different area because it may not account for regional differences.

Hanowski *et al.* (2000) studied landscape composition surrounding used and unused sharp-tailed grouse leks at 200, 500 and 1000 m. The main differences occurred at 500 and 1000 m and that inactive leks contained a higher proportion of upland forest and brush and active leks had a higher proportion of native grasses. No differences were found between active and inactive leks at the site level (200 m).

Rickers *et al.* (1995) demonstrated the implementation of a habitat suitability model through GIS for ruffed grouse. In particular they discussed the creation of a proximity-based model. They considered the use of GIS to be a technique adaptable to different management scenarios, which also possesses the ability to compile and standardize inventory data. Two relevant and important points were that 1) GIS can facilitate the creation of data products that contain no means of assessing error and 2) that most wildlife models must conform to existing resource inventories.

Niemuth and Boyce (2004) used logistic regression in GIS to develop a probability map for sharp-tailed grouse in Wisconsin. In their model distance from forest edge and amount of grass and shrub in the surrounding landscape were consistent predictors of lek presence. Areas with fewer forested patches within 800 m had a higher probability of containing a lek. They concluded that 800 m was the most appropriate distance to create a probability map. Niemuth and Boyce (2004) used multiple linear regression and found a significant relationship between the number of males attending lek sites and the percentage of nest cover (grass and shrubs) within 1200 m.

Ramsey *et al.* (1999) used both GIS and Remote Sensing to map potential habitat for sharp-tailed grouse. This model focused on nesting/brood rearing habitat with the intention of identifying sites for re-introduction. Specific data layers used included vegetation type, land use, elevation, slope, and human disturbances. Homer et al. (1993) also used remote sensing, specifically with Landsat Thematic Mapper Satellite data to create a GIS model for winter habitat of sage grouse (*Centrocercus urophasianus*) with the intent of extrapolating a validated model to unsampled areas. They contended that an important implication of this research is that GIS and remote sensing can be taken beyond habitat classification and be used to integrate specific fine-scale habitat selection with broad remote sensing habitat assessments.

1.5 Study Objective

The principle objective of this study was to determine the status of sharp-tailed grouse and sharp-tailed grouse habitat on PEI. More specifically the objectives were to:

- Find all sharp-tailed grouse dancing grounds in northeastern PEI and count the number of displaying male sharp-tailed grouse on each.
- Identify potential dancing grounds in northeastern PEI based on published requirements using a Geographic Information Systems (GIS) model.
- Determine the amount and distribution of potentially suitable area for sharp-tailed grouse including nest and brood cover using a GIS model.
- Determine whether sharp-tailed grouse are occupying the same basic range in winter as they do during the breeding season.
- Determine the percentage of the landscape containing two tree species (white birch and poplar) used as a proxy for sharp-tailed grouse winter food.

Meeting these objectives enabled the determination of occupied range and relative abundance of sharp-tailed grouse within the study area and was used to determine if the sharp-tailed grouse population could sustain a harvest from hunting.

Chapter 2.
Sharp-tailed grouse dancing grounds in northeastern
Prince Edward Island

2.1 Introduction

Sharp-tailed grouse have persisted on PEI for over 20 years yet little is known about their current status on the island. Curiosity from wildlife groups and the hunting community created a need for an investigation of their population numbers and breeding activity.

The sharp-tailed grouse is a prairie grouse, preferring open land to sparsely treed cover (Connelly *et al.* 1998, Ammann 1957, Grange 1948). Sharp-tailed grouse range from the Great Lake states north and west to Alaska and south to Colorado; however the southern and eastern populations have declined significantly (Connelly *et al.* 1998).

The lek, where male sharp-tailed grouse gather to perform a courtship display, is a critical part of the reproductive ecology of these birds (Connelly *et al.* 1998) and males demonstrate faithfulness to lekking areas, returning year after year (Ammann 1957, Giesen and Connelly 1993). Males arrive on the lek to establish territories 30 to 40 minutes before sunrise and display for 2.0 to 2.5 hours (Hamerstrom 1939, Marshall and Jensen 1937, Pepper 1972). Moyles and Boag (1981) also found that activity peaked in April and early May on clear, calm mornings. A behavioural change occurs in territorial males around the beginning of April when lek attendance becomes regular 30 minutes before sunrise (Moyles and Boag 1981). In Saskatchewan, damp windy weather and disturbance by humans or natural predators limits dancing activity (Pepper 1972). Reproduction can be limited when lekking birds are disturbed by human presence on the lek site (Baydack and Hein 1987).

The lek is typically higher than the surrounding 500 m, and has unrestricted visibility in all directions (Baydack 1988, Pepper 1972). Leks in Michigan contain no woody cover or only sparse trees or shrubs (Ammann 1957). Ammann (1957) described dancing grounds to be located in the most open part of the habitat, on a knoll or level ground and a good distance from dense brush or forest. Pepper (1972) determined that lek vocalizations can be detected at distances greater than 1600 m if conditions are optimal.

Surveying known leks is a technique used to estimate grouse populations (Amman 1957, Grange 1948, Cannon and Knopf 1981, Giesen and Connelly 1993). A typical dancing ground has between 8 and 12 males (Johnsgard 1973). The sex ratio for sharp-tailed grouse is not significantly different than 1:1 (Connelly *et al.* 1998). Spring population of male sharp-tailed grouse ranged from 1.3 to 1.97 males/ km^2 in Saskatchewan (Pepper 1972). Not all males visit the lek, a non-territorial, non-breeding, male population segment may exist equivalent to the territorial population (Rippin and Boag 1974).

The objective of this study was to locate sharp-tailed grouse leks in northeastern PEI. The lek is an essential component in the life history of the sharp-tailed grouse and presents the best opportunity to locate and observe the birds.

2.2 Materials and methods

2.2.1 Study area

The study area, in northeastern Prince Edward Island, Canada, was 408 km^2 in size. It was bounded by the south and west at 46.3188, 63.0187 and bounded by the north and east at 46.4836, 61.9723 (Figure 1). The northern boundary of the study area reaches the Gulf of St. Lawrence. This area was believed to include the majority of occupied sharp-tailed grouse range on PEI.

This investigation consisted of two activities: searching for leks and counting displaying males on leks. All field surveys used the following equipment: 8x35 Bushnell Binoculars, a Garmin e-trex GPS unit, a Bushnell 20x-60x spotting scope and tripod, a Canon 4MP digital camera, and local maps.

2.2.2 Finding sharp-tailed grouse leks

Initial lek searches were conducted in areas of frequent grouse observation. A relief map was used to identify local high points. A plan was developed to travel within sight/sound of these locations to see if sharp-tailed grouse had established a lek.

In the spring of 2008 a road based survey was undertaken. This survey followed accepted technique to detect sharp-tailed grouse leks (Quinn 1970, Larson 2005, Cannon and Knopf 1981, Ball pers. comm.). Survey routes were designed using GIS and provincial road network to determine the number of routes required to sample the entire area. The survey routes were approximately 15-20 km long. The stop interval was 1000 m and each of 227 stops consisted of 3 minutes of silent listening. The routes were conducted between 30 minutes before sunrise until 2 hours after sunrise.

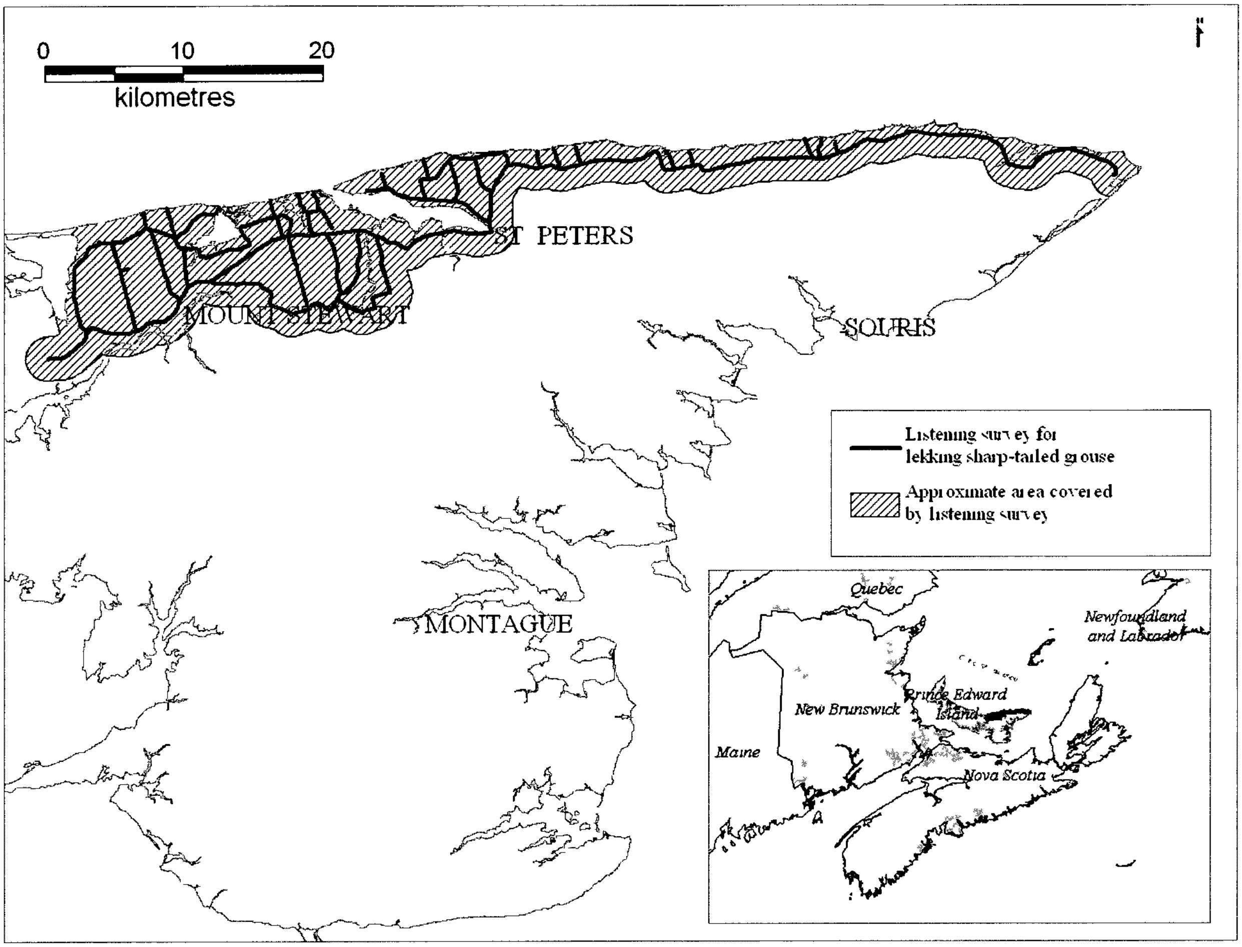

Figure 1. Listening survey for displaying sharp-tailed grouse in northeastern PEI.

The wind could not exceed 25 kph and no precipitation was tolerated. The survey was designed to cover the entire study area so that all leks would be found. In order to provide complete coverage of the study area, a number of routes were walked where driving was not possible. Additional walking surveys of continuous listening/observation were conducted totalling 30 km. The estimated survey coverage was 365 km^2 (based on an average hearing distance of 1.6 km under favourable conditions).

2.2.3 Lek Counts

Lek counts consisted of observations of the lek to count all displaying males present. Three leks were visited twice during the spring 2007. Four leks were visited at least twice during the spring 2008. Observation distances ranged from 100 m to 300 m and were chosen so the birds would not be disturbed.

A total population estimate was calculated for the study area and assumed that all leks were identified, a 1:1 sex ratio existed and that all males visited a lek. Spring density of male sharp-tailed grouse was calculated for the area surrounding each lek using three methods. The first used Gratson's (1988) spring cock home range estimate of 348 ha. The second used a larger area calculated using Niemuth and Boyce's (2004) distance of 1600 m that males travel from the lek site. The third used an estimate of contiguous open land surrounding the lek site taken from provincial GIS data.

2.2.4 Land use surrounding leks and characteristics of lek sites

MapInfo GIS and ArcGIS were used to determine characteristics surrounding the leks using the 2000 Corporate Land Use Inventory (CLUI) and various GIS datasets.

Global Positioning Systems (GPS) locations and/or transcribed field observations were used to create points representing each lek. Characteristics identified included: distance from forest, distance from any trees, distance from white birch and poplar, distance from buildings, distance from other leks, distance from nearest release point, size of lek, and height of vegetation on the lek.

In order to relate the number of sharp-tailed grouse observed to current land use, the Corporate Land Use Inventory 2000 (CLUI) was updated. This was accomplished using oblique photographs obtained on habitat assessment flights taken June 2007 and September 2008. This ensured an accurate depiction of the habitat surrounding the leks.

Land use surrounding leks was compared to random points in the landscape at various spatial scales. The CLUI was reclassified into broad categories, with meaningful biological interpretation for sharp-tailed grouse (Table 1). A grid covering the study area was created and a random number generator was used to randomly select 30 locations in the landscape. The leks and random points were buffered at 800 m, 1000 m, 1200 m, 1600 m and 2400 m (buffer areas). Summary statistics were calculated including the amount of each habitat class in each buffer area. The amount of each cover type was compared using nonparametric statistics because of low sample size. The 2000 data were used because updates were not practical for landscape surrounding the random points.

Table 1. Land use reclassification of CLUI to relevant categories for sharp-tailed grouse and percent of each category in the study area.

Description	CLUI dominant cover type	Percent of Study Area
Forest	All forested polygons including forested wetlands	50
Shrub/Grass	All polygons having grass or shrub as dominant class as well as agricultural classes having perennial cover such as pasture.	22
Agriculture	All polygons being actively cropped where the soil is likely to be exposed for some period throughout the year	18
Wetland	All non-forested wetlands	5
Developed	All developed lands including residential, recreational and commercial	4
Hedgerow	Polygons representing hedgerows.	1

2.3 Results

2.3.1 Sharp-tailed grouse leks on Prince Edward Island

Field results, including lek counts, were obtained over two years. Four leks were found during the study (Figure 2). Three of these leks were found in 2007 but the specific locations of only two were confirmed. The third lek location and the presence of one other were discovered in 2008.

All four leks were over 100 m from any trees and over 200 m from any forested stand (Table 2). The two largest leks were over 0.5 km from buildings while the smaller leks were less than 0.5 km from buildings. All were less than 0.4 km from stands of white birch or poplar. Vegetation on two of the leks was dominated by blueberries, another was a cutover shrub stand and the fourth was a cut hay field. In all cases the vegetation was less than 0.3 m and it had been manually altered (cut) during the study.

The estimated spring population of sharp-tailed grouse in the study area was 98 birds. The largest number of male sharp-tailed grouse observed displaying was 27 at Anderson Road in 2008, and the smallest was three at St. Peters in 2008 (Figure 3). The number of male sharp-tailed grouse was greatest when the amount of shrub/grass within 1 km of the lek was high (Figure 3). Of the six land use categories evaluated, only the amount of shrub/grass within 1 km of a lek site showed this relationship. Density estimates ranged from 0.9 to 7.8 territorial male sharp-tailed grouse per sq. km using Gratson's (1988) estimate of home range (Table 3).

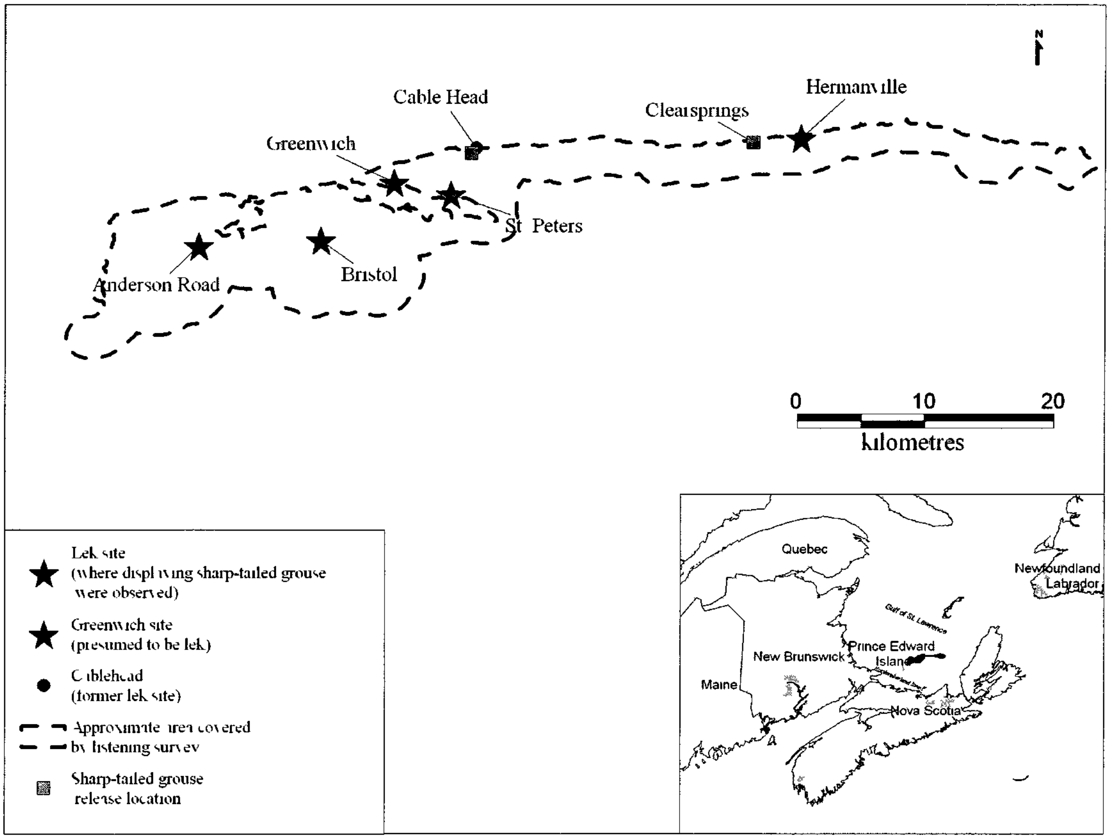

Figure 2. Sharp-tailed grouse leks in Prince Edward Island, 2007-2008. Also represented is an inactive lek, a possible fifth lek, the approximate area covered by the listening survey in 2008, and the original release locations.

Table 2. Selected characteristics of sharp-tailed grouse lek sites in Prince Edward Island.

Lek Characteristics	Anderson Road	Bristol	St. Peters	Hermanville
Height of vegetation	< .3 m	< .3 m	< .2 m	< .1 m
Approximate size	2000 m^2	320 m^2	N/A	N/A
Distance to nearest trees	125 m	210 m	150 m	230 m
Distance to closed canopy forest	610 m	450 m	520 m	230 m
Distance to buildings	1130 m	510 m	320 m	180 m
Distance from white birch/poplar	310 m	210 m	390 m	230 m
Distance from nearest known lek site	9.5 km	7.5 km	7.5 km	27.6 km
Distance from nearest release point	22.4 km	13.6 km	3.6 km	3.8 km

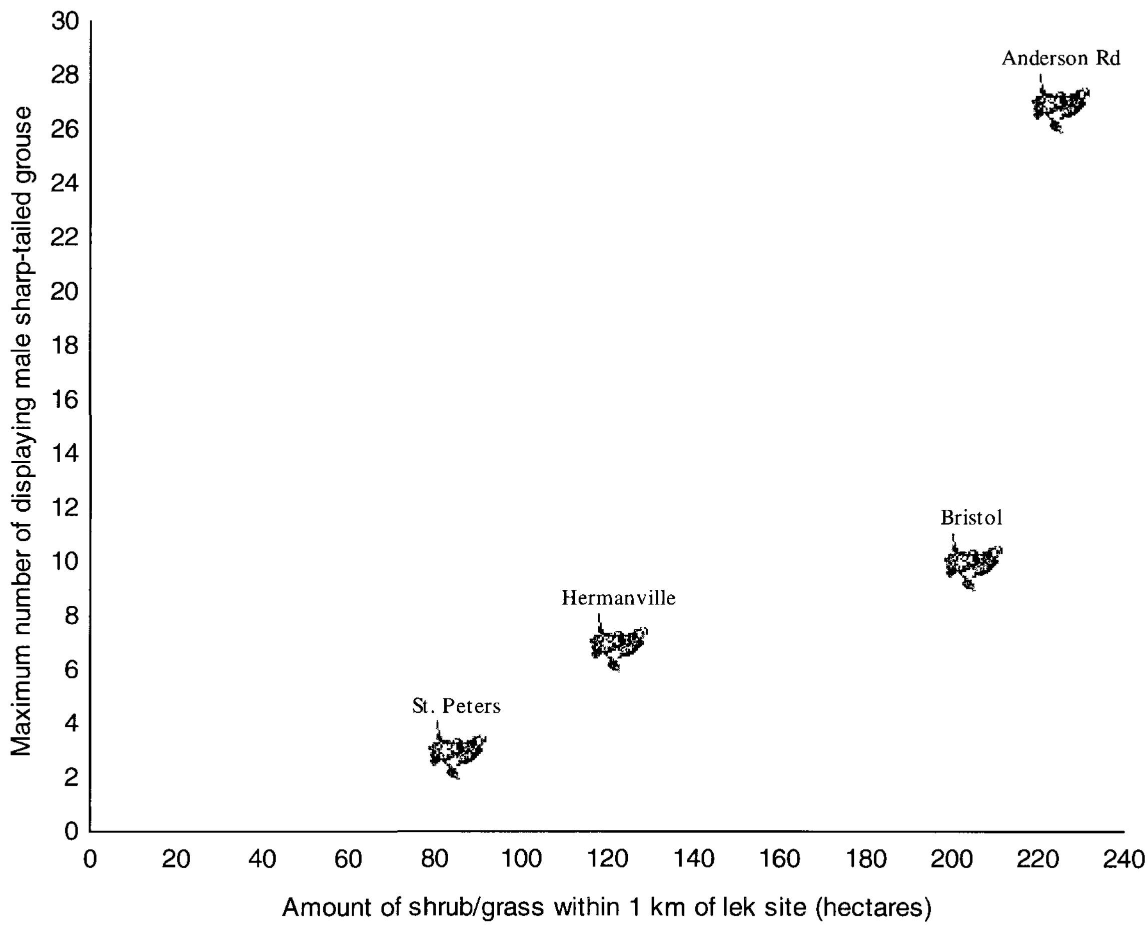

Figure 3. The number of male sharp-tailed grouse related to the amount of shrub/grass within 1 km of lek sites.

Table 3. Estimated spring densities of territorial male sharp-tailed grouse using three estimating methods.

Lek site (year)	Maximum males/lek	Continuous open land (km^2)	Density (males/ km^2) using home range 3.48 km^2 from Gratson (1988)	Density (males/ km^2) using home range 18 km^2 from Niemuth and Boyce (2004)	Density (males/ km^2) using continuous open land use estimate
Bristol (2007)	10	2.6	2.9	0.6	3.8
Bristol (2008)	10	2.6	2.9	0.6	3.8
Anderson Road (2007)	15	7.4	4.3	0.8	2.0
Anderson Road (2008)	27	7.4	7.8	1.5	3.6
Hermanville (2007)	4	3.8	1.1	0.2	1.1
Hermanville (2008)	7	3.8	2.0	0.4	1.8
St. Peters (2008)	3	3.4	0.9	0.2	0.9

2.3.2 Lek specific observations

Bristol

The first lek was found in a commercial blueberry growing area in Bristol. In 2006, the landowner reported that a sharp-tailed grouse had nested in a blueberry field. The initial search for the lek occurred on April 19th, 2007. The site was first visited at 6:30 am. The lek was detected within 30 minutes by visual observation of sharp-tailed grouse in a blueberry field (Figure 4a). Sharp-tailed grouse were observed displaying at 7:10 am from a distance of 250 m. Vocalizations such as clucking and cooing was heard and birds were observed tail rattling, joisting and jumping (Appendix 3). The display was continuous as numerous birds were observed entering and leaving the lek site. In 2007, a maximum of 24 sharp-tailed grouse were observed in close proximity to the lek site on a single visit (Table 4). The maximum number of males observed displaying in 2007 on an individual visit was 10.

In 2008 the site was visited three times during April and May. A maximum of ten sharp-tailed grouse were observed in proximity to the lek and a maximum count of ten displaying males were observed (Table 4). The occupied site appeared to be oval in configuration with a group of four males in the centre.

The site included a grass road/trail that bisects a large blueberry field (Figure 4b). It was on a knoll, the aspect was south and generally flat. It had at least 200 m visibility in all directions. Numerous grass patches were evident. Small white spruce trees (less than 30 cm) had been planted along the grassy road. The vegetation on the lek had recently been mowed (within one year) and was less than 10 cm in height and appeared to be uniform. During the two years this lek was visited, the height of blueberry plants

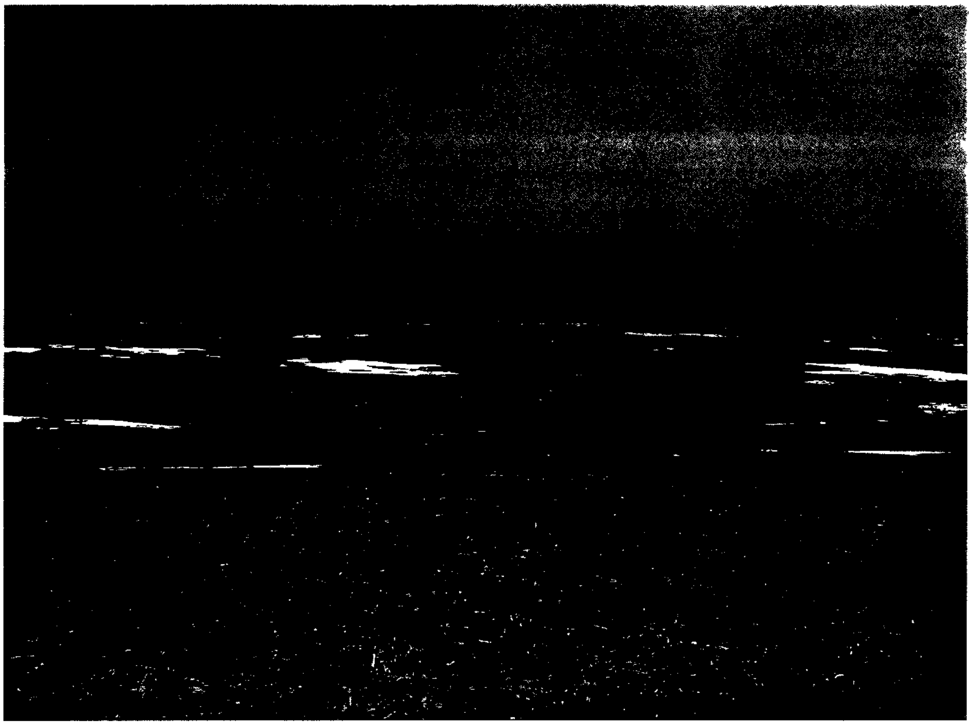

Figure 4a. Sharp-tailed grouse lek in commercial blueberry field in Bristol, view from south, April 2007.

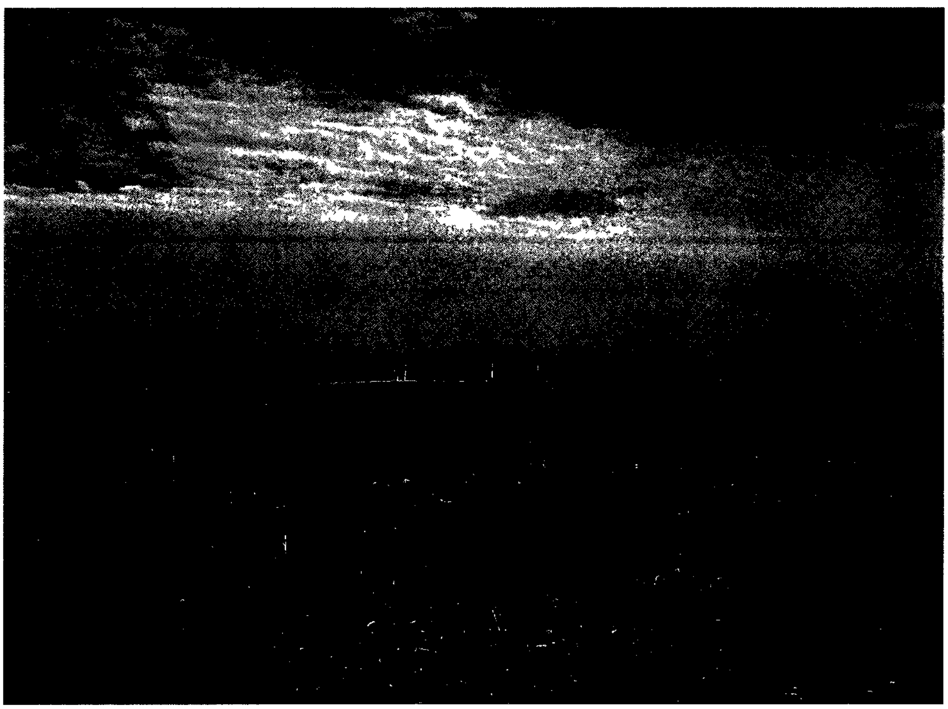

Figure 4b. Bristol lek site, road and bare patches evident, view from east.

Table 4. Observations from the Bristol lek.

Date	Observation point latitude	Observation point longitude	Observations	Total number of sharp-tailed grouse observed	Displaying males on lek
20-Apr-07	46.39983	62.76335	Observation of lek from west.	24	10
19-Apr-07	46.39983	62.76335	Original observation point for Bristol lek.	16	10
26-Apr-07	46.40189	62.76257	Observed displaying sharp-tailed grouse, took video from this point.	15	10
7-Apr-08	46.40209	62.76259	Observed Bristol lek site from west.	10	10
8-May-08	46.40236	62.75846	Observed Bristol lek site from east.	10	10
14-May-08	46.40236	62.75846	Observed Bristol lek site from east.	6	6

varied. It underwent manual treatment including mowing and chemical treatment (Roundup) to eliminate grass and other leafy vegetation. In 2008, the blueberry plants were in the crop year and had not been mowed (Figure 4b). Height was less than 30 cm but appeared to vary considerably as there were numerous bare patches evident (Figure 4b). The lek was 450 m from forest and 250 m from a 1 ha stand of poplar and a patch of black spruce trees less that 0.4 ha in size.

The Bristol lek provided the best opportunity to assess spring density. The boundaries of the available area appeared to be distinct being surrounded by closed forest on three sides (Figure 5a, b). Densities for this area ranged from 0.4 males/ km^2 to 2.9 males km^2 (Table 3). The Bristol lek was remote and it is unlikely that it would be disturbed during April under normal conditions. The closest road was seasonal and snow covered throughout this month in both years. Sharp-tailed grouse were observed displaying on this lek site in May when the road would normally be usable.

Anderson Road

A second lek was found on April 21st, 2007 in an 800 ha commercial blueberry growing area north of Mt. Stewart, PEI which is bisected by Anderson Rd. This road was not passable to vehicle traffic due to snow conditions. The first sounds of lekking grouse were heard at a distance of approximately 1000 m. The lek was on a ridge which has visibility in all directions and thus difficult to approach undetected. The aspect appeared to be south. The lek was in a blueberry field that had been recently mowed. The vegetation was less than 10 cm and appeared uniform in height (Figures 6a, b). The lek appeared to be void of blueberry plants in some areas. In addition to the birds observed

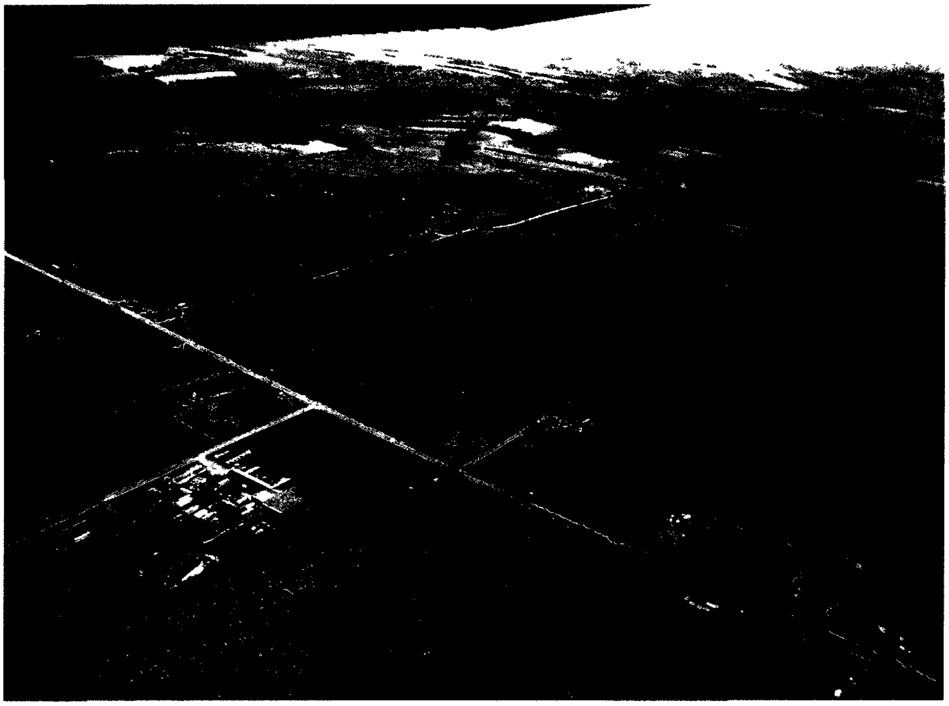

Figure 5a. Aerial view of landscape surrounding Bristol Lek site demonstrating isolation of large blueberry area, Sept. 2008. Arrow indicates lek.

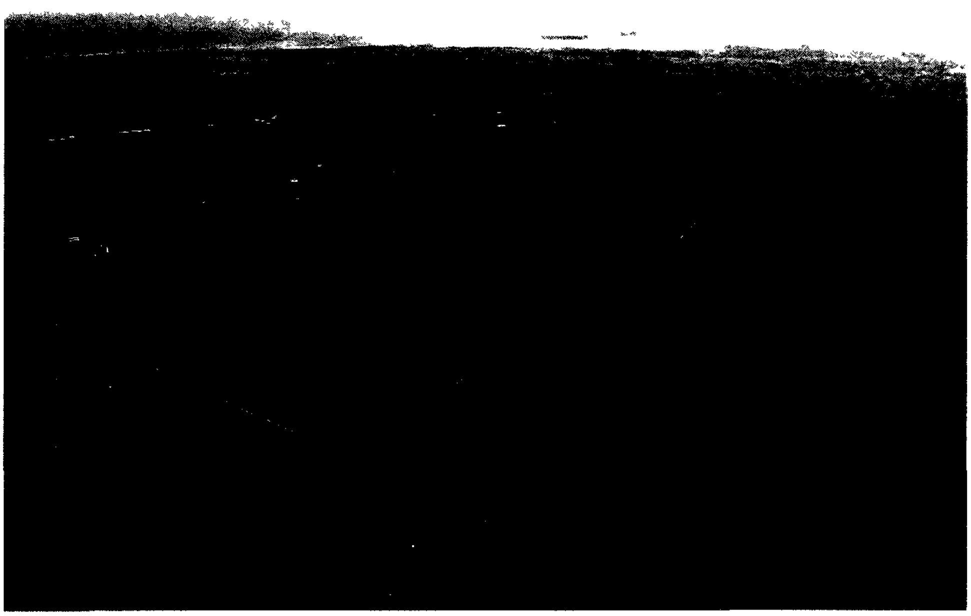

Figure 5b. Aerial view surrounding Bristol lek site, June 2007. Arrow indicates lek.

Figure 6a. Distant view of ridge containing Anderson Road lek in commercial blueberry field, view from southwest, April 2007.

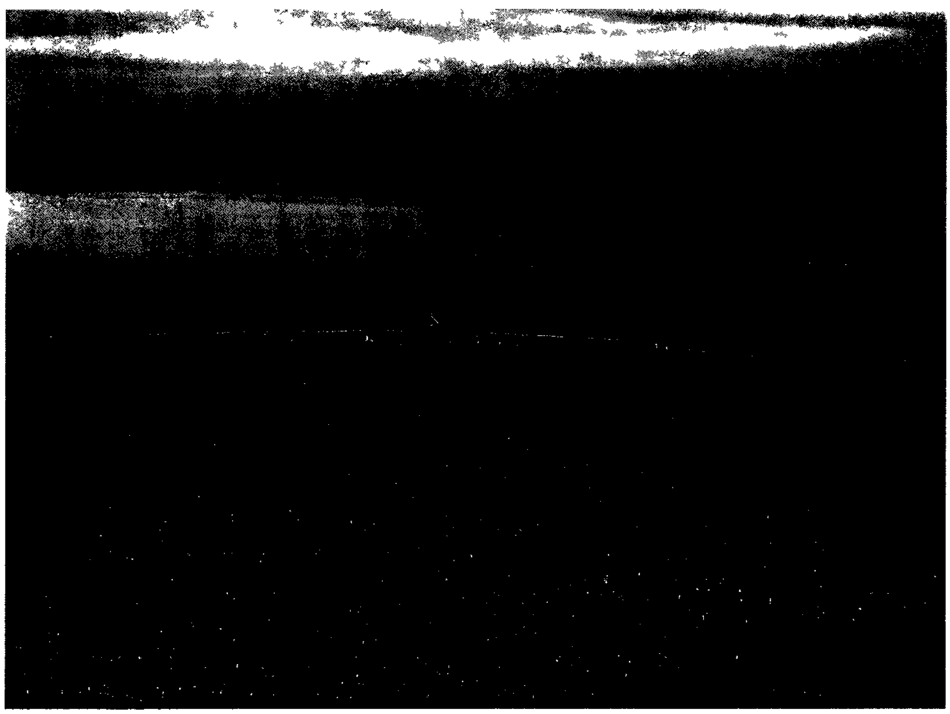

Figure 6b. Anderson Road Lek, view from north, May 2008.

on the lek, three separate sharp-tailed grouse were observed landing in harvest-year blueberry fields within 800 m of the lek. The lek was 610 m from forest. There were sparse conifer hedgerows within 200 m of the lek. Within 300 m there was a 3 ha stand of poplar. Over the two years of the study, vegetation was manually manipulated on this site by mowing. The site was flat, was located on a ridge, was higher than the surrounding area (Figures 6a, b) and was situated in a very isolated location (Figure 7): over one km from the nearest building and the nearest road was seasonal and not usable under normal conditions during April. During 2007 on an individual visit, a maximum of 17 total birds was observed near the lek site with a maximum of 15 displaying males. In 2008, a maximum of 35 sharp-tailed grouse was observed with a maximum of 27 displaying males (Table 5).

Hermanville

On April 25th, 2007 a lek was discovered in Hermanville. Birds were discovered in a small cleared area (Figures 8a, b). Birds were not observed displaying, however, a bright yellow/orange comb was seen. Birds stayed within 200 m after being inadvertently flushed from the site. Despite two visits to the area, the specific lek location could not be identified as the birds were not seen displaying in 2007. A maximum of seven male sharp-tailed grouse was observed displaying at the site in 2008 while a maximum of nine sharp-tailed grouse were seen in proximity to the lek site (Table 6).

Figure 7. Aerial view of Anderson Road lek site and surrounding area, Sept. 2008.

Table 5. Observations from the Anderson Road lek.

Date	Observation point latitude	Observation point longitude	Observations	Total number of sharp-tailed grouse observed	Displaying males on lek
6-May-08	46.39895	62.88574	Lek site, viewed from hedge.	35	27
21-Apr-08	46.39895	62.88574	Lek site, viewed from hedge.	23	21
15-May-07	46.39797	62.89	Observed birds on lek from road.	15	15
21-Apr-07	46.39637	62.8878	Observation point of lek.	17	14

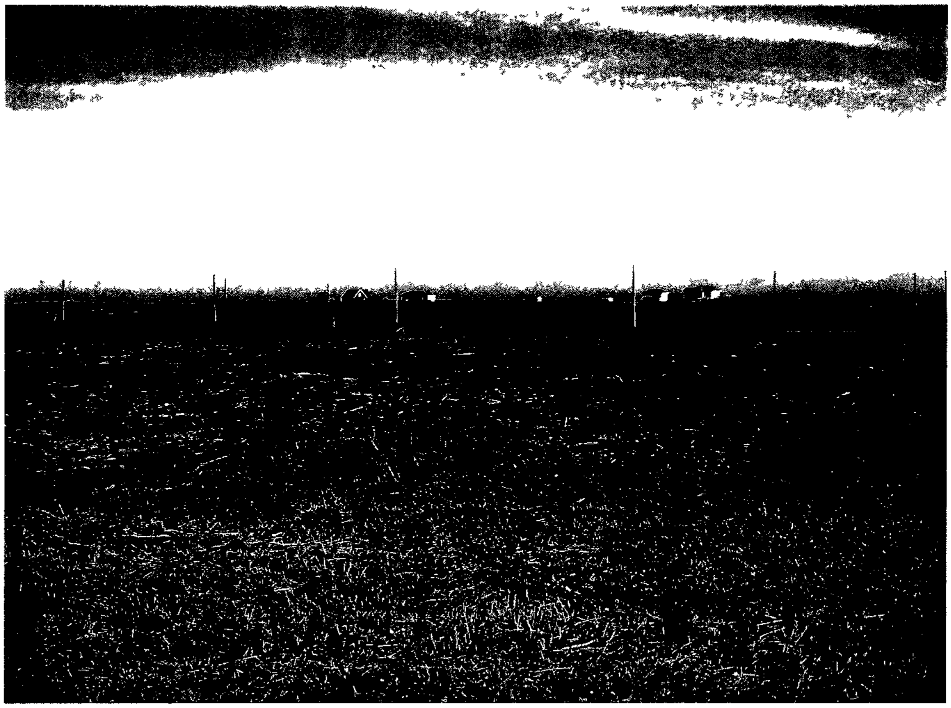

Figure 8a. Hermanville lek in foreground, view from east, May 2008. Power lines and seasonal cottages in background.

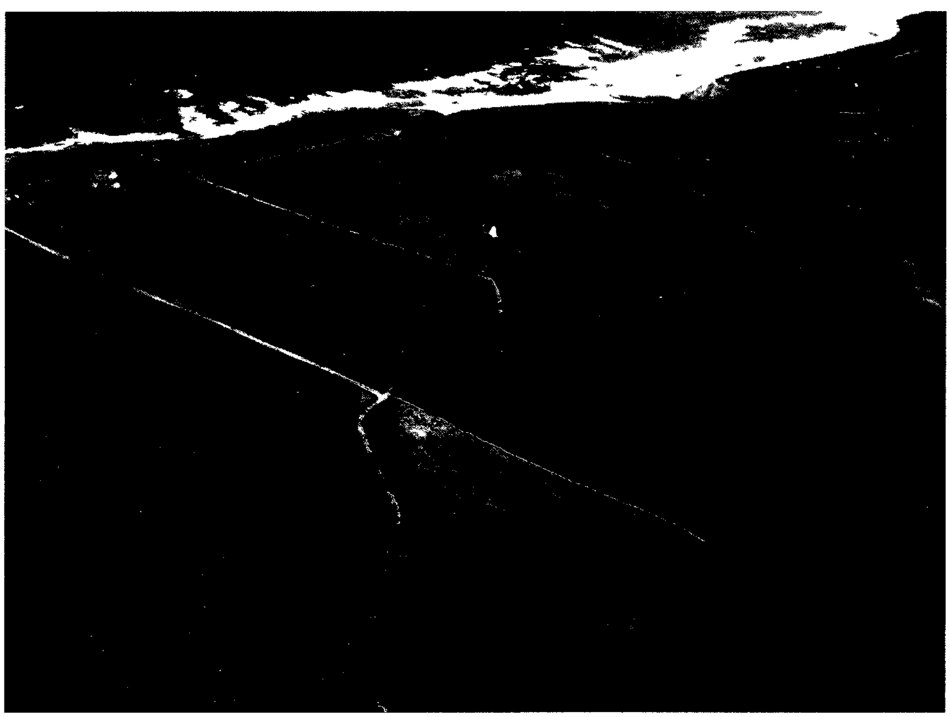

Figure 8b. Aerial view of Hermanville lek site, Sept. 2008, arrow indicates approximate location of lek.

Table 6. Observations from the Hermanville lek.

Date	Observation point Latitude	Observation point Longitude	Observations	Total number of sharp-tailed grouse observed	Displaying males on lek
18-Apr-08	46.47044	62.27257	Lek site in cutover area.	9	7
13-May-08	46.47094	62.27018	Lek is 117 m northwest of GPS point.	6	6
25-Apr-07	46.47292	62.27118	Observed 4 stgr grouse in cut over	4	0
11-May-07	46.47098	62.27025	Observed 4 stgr grouse in cut over	4	0

The Hermanville site had recently been cut (date unknown). In 2000, the cover type was interpreted to be 4 m tall alders and poplar. Remnant vegetation suggests that shrubs such as bayberry and pincherry were also present. This cutting provided a site to establish a lek in 2007 and 2008 however this benefit will be short lived. The lek was in an area under immediate threat from development including numerous new cottages. Survey stakes were observed on the site indicating impending development. The Hermanville lek was already in close proximity to a number of seasonal cottages. These cottages were vacant during early spring when sharp-tailed grouse were using the lek site however cottages were occupied in May. People travelling to and from these cottages would put them within 20 m of the lek. Also, a cottage was constructed within 100 m of the lek in 2008 after the courtship season.

St. Peters

The St. Peters lek was found during the road-based listening survey in 2008. It was visited twice in 2008. A maximum of three displaying males was observed with a maximum count of three sharp-tailed grouse in proximity to the lek (Table 7). The lek was in a hay stubble field (Figure 9a). During the second visit it was noted that the lek had been tilled since the previous visit (Figure 9b). One sharp-tailed grouse was observed and it did not display. The site is bounded by St. Peters Bay to the south and a paved road to the north (Figure 10).

The St. Peters site was the only lek discovered in an active agricultural area. The lek was in a large pasture field and not visible from the road. The site was within 300 m of a new 100-lot recreational cottage development. This large development had a road

Table 7. Observations from the St. Peters lek.

Date	Observation point latitude	Observation point longitude	Observations	Total number of sharp-tailed grouse observed	Displaying males on lek
20-Apr-08	46.4336	62.6316	3 males displaying 211m ENE from GPS point, used range finder for distance.	3	3
5-May-08	46.4337	62.6328	Lek site, tilling has occurred since previous visit.	1	0

Figure 9a. Ground view of St. Peters lek site, view from west, April 2008. Arrow indicates lek.

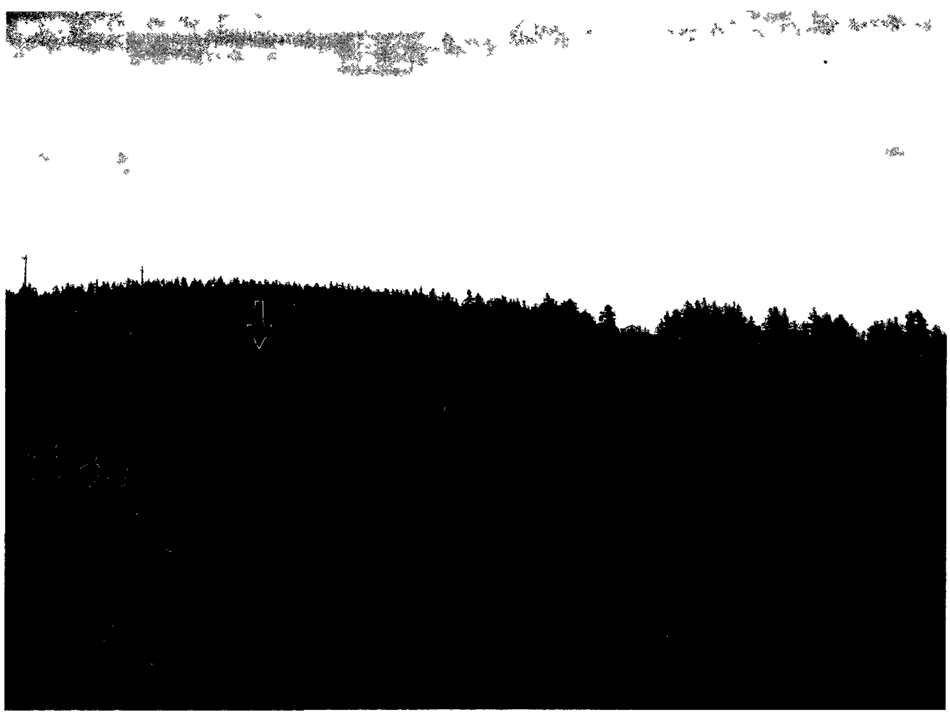

Figure 9b. Ground view of St. Peters lek site after disturbance, May 2008. Arrow indicates lek.

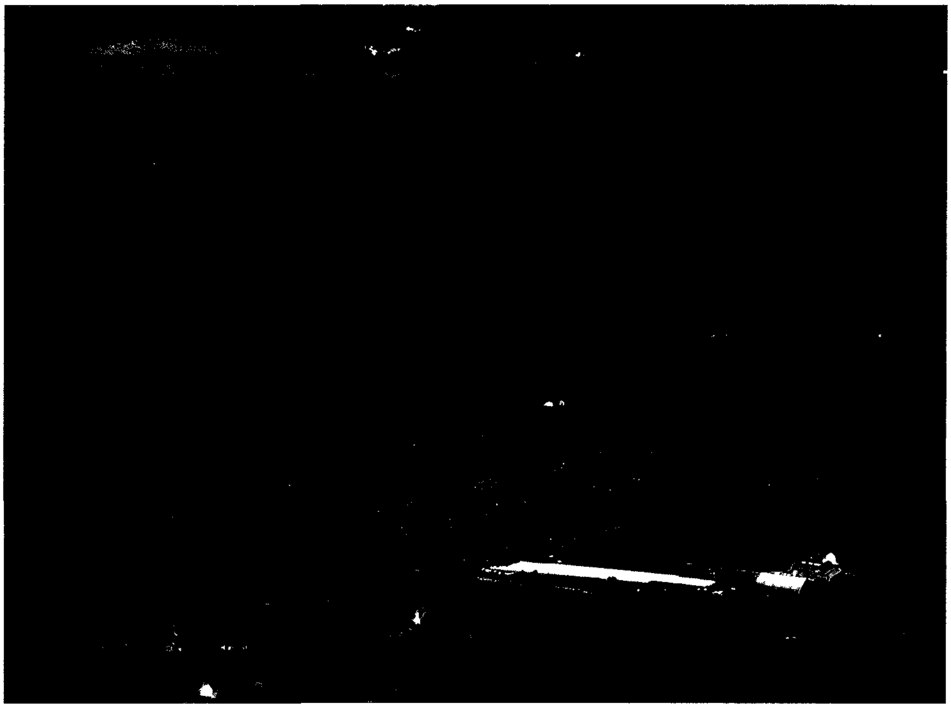

Figure 10. Aerial view of landscape surrounding St. Peters lek site, Sept. 2008. Arrow indicates lek.

network already built and one existing cottage. The remainder of the 24 ha property was retired farm land.

Greenwich

Sharp-tailed grouse were observed during autumn 2007 and spring 2008 in an abandoned field just outside Greenwich National Park (Figure 11). Birds were not observed displaying; however, two sharp-tailed grouse were seen leaving the same field on two occasions during the courtship season (Table 8). The site is adjacent to a larger area of abandoned farm land (Figure 11). The exact location of the lek was not determined. The justification for including it is based on circumstantial observations. It probably was not two females as sharp-tailed grouse are solitary nesters. It may have been two non-territorial males establishing a satellite lek peripheral to another, however, the only other lek discovered nearby was St. Peters with only three displaying males and 4.5 km away.

Cable Head

Four visits were made to a previously occupied lek in Cable Head. On April 25th, 2007 the site was visited at 6:00 am. A sharp-tailed grouse flushed from the road ditch 470 m from the site. No sharp-tailed grouse were observed on the lek or on any other visit to the area. Numerous cottages have been constructed in the area since the lek was occupied (Figure 12).

Figure 11. Habitat surrounding Greenwich site, Sept. 2008. Arrow indicates where birds were observed.

Table 8. Observations from the Greenwich site.

Date	Observation point latitude	Observation point longitude	Observations	Number of birds	Displaying birds on lek
31-Oct-07	46.4409	62.71159	Flushed 2 STGR from trail, 15 m east of this GPS.	2	0
31-Oct-07	46.44246	62.69004	Observed 2 STGR in flight, heading east to west.	2	0
8-Apr-08	46.4434	62.68608	In abandoned field near water, on return from Greenwich	2	0
5-May-08	46.44275	62.68863	In abandoned field near water, on return from Greenwich.	2	0

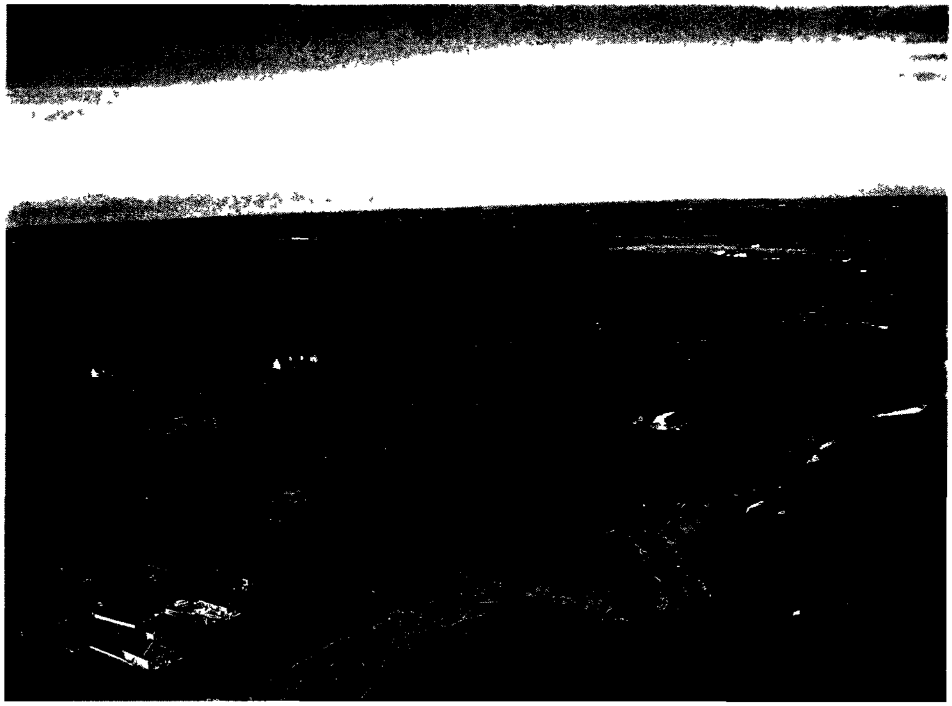

Figure 12. Aerial view of unoccupied site in Cable Head showing recreational development, Sept. 2008. Arrow indicates former lek.

St. Margarets

During the course of the study, reports of sharp-tailed grouse sightings from a coastal property in St. Margarets were investigated (Foulkes pers. comm.). A ground survey was conducted under favourable conditions (timing and weather). No sharp-tailed grouse were seen or heard. During the spring of 2008 a large area of open land existed but had no residual cover as it had either been ploughed the previous autumn or had been cropped with potatoes the previous summer.

2.3.3 Listening survey

One new lek was discovered at St. Peters during roadside listening surveys in spring 2008 (Figure 13). Sharp-tailed grouse were seen at the Greenwich site but were not observed displaying or heard.

Sharp-tailed grouse were confirmed on 8 of 227 survey locations. The Hermanville area (but not the lek) was independently discovered on this survey as a sharp-tailed grouse was observed in flight but the lek was not heard at that time. Areas surrounding the other known leks were surveyed and a lone sharp-tailed grouse was observed in a blueberry field on Anderson Road approximately 1300 m north of the lek. All other listening points were negative.

2.3.4 Land use surrounding lek sites

There was significantly more forested land within 800 m and 1000 m of random points on the landscape than surrounding leks (Mann-Whitney U-test, $p < 0.05$) (Figure 14). There was significantly more shrub/grass within 800 m of leks than at random landscape points (Mann-Whitney U-test, $p < 0.05$) (Figure 14). No significant differences

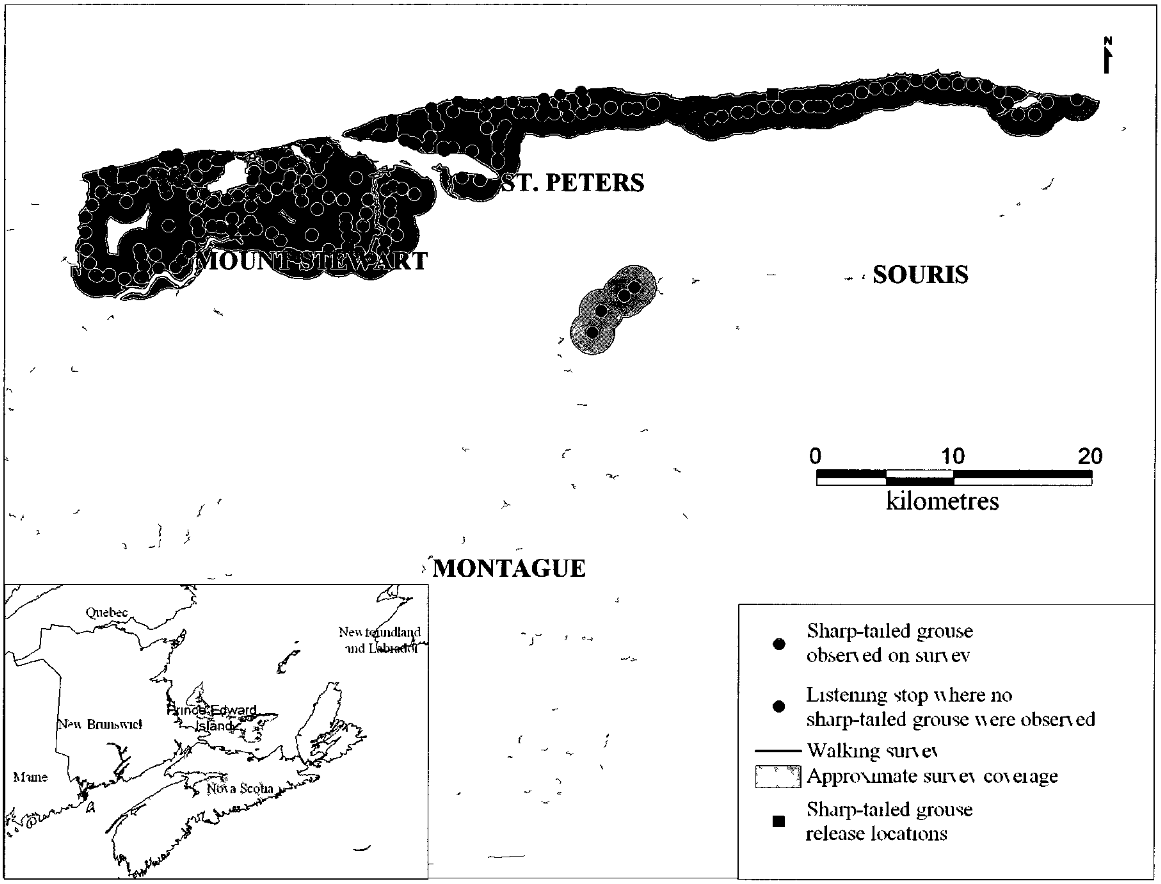

Figure 13. Map depicting locations of listening stops and confirmed observations during sharp-tailed grouse lek survey, spring 2008. Also represented are original release locations.

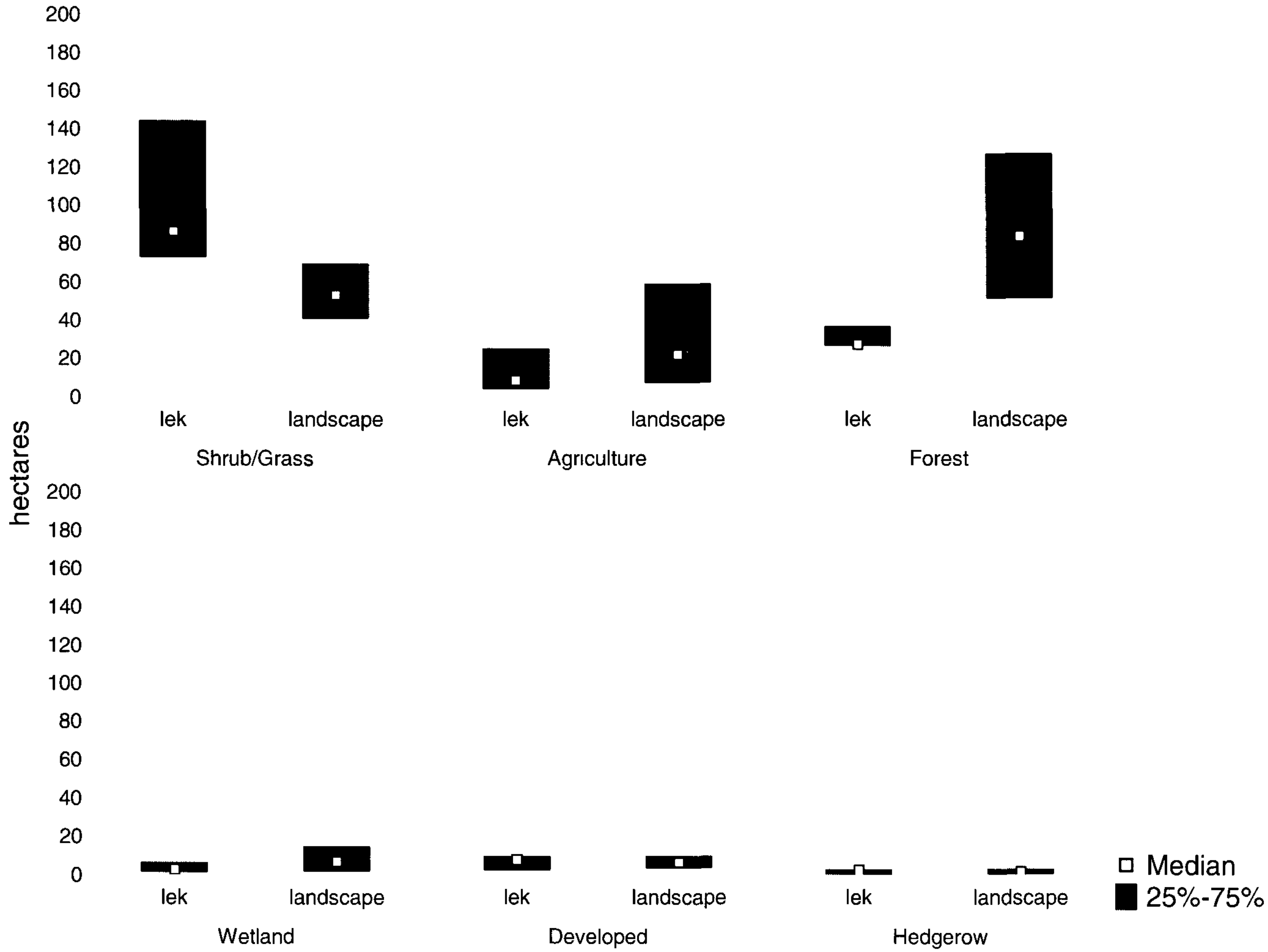

Figure 14. Classified land use within 800 m of leks (n=4) and random landscape points (n=30). Significant differences were found for shrub/grass and forest.

in land use were found between leks and random landscape points for 1600 m (Figure 15) or 2400 m (Figure 16) or for any other land use category.

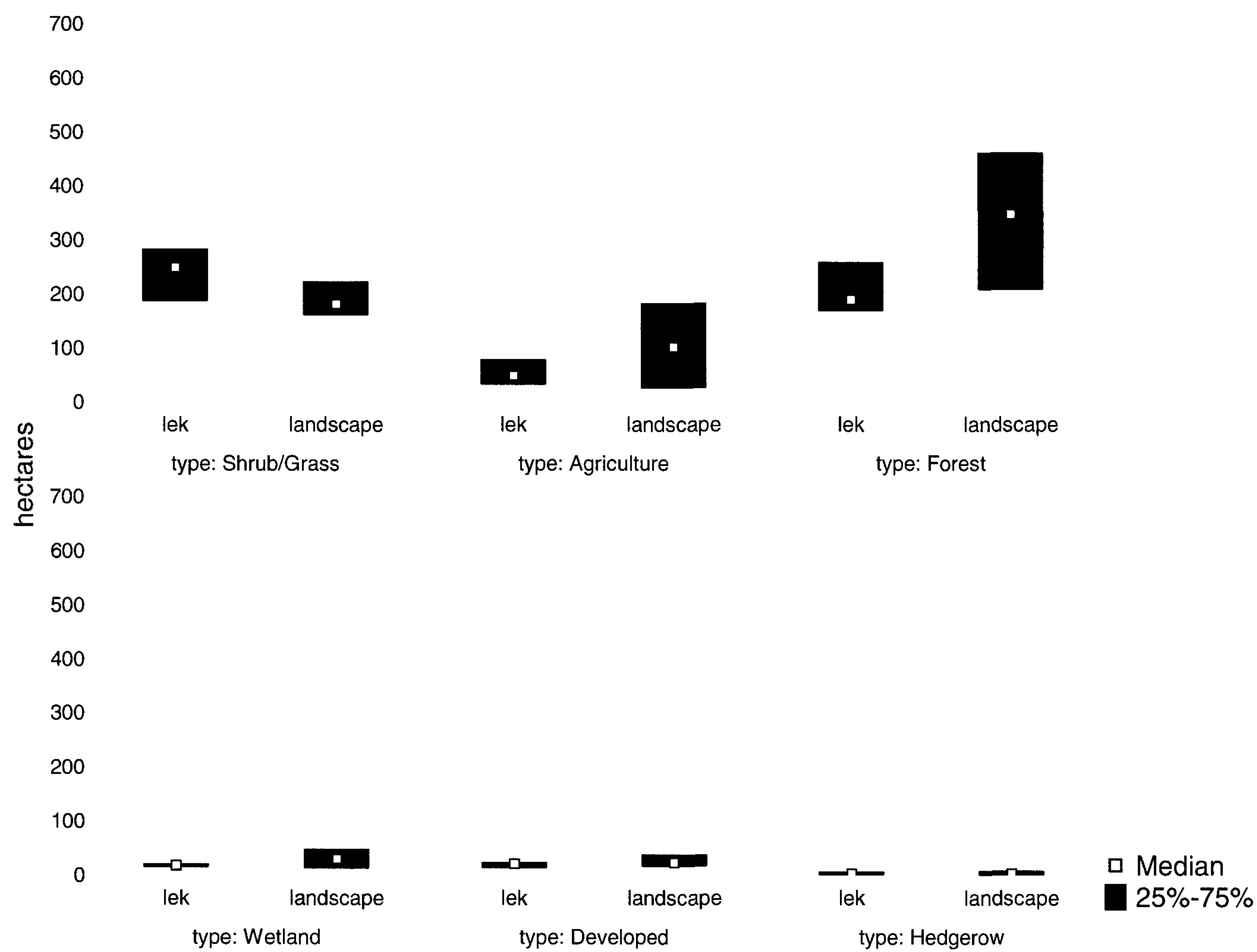

Figure 15. Classified land use within 1600 m of leks (n=4) and random landscape points (n=30).

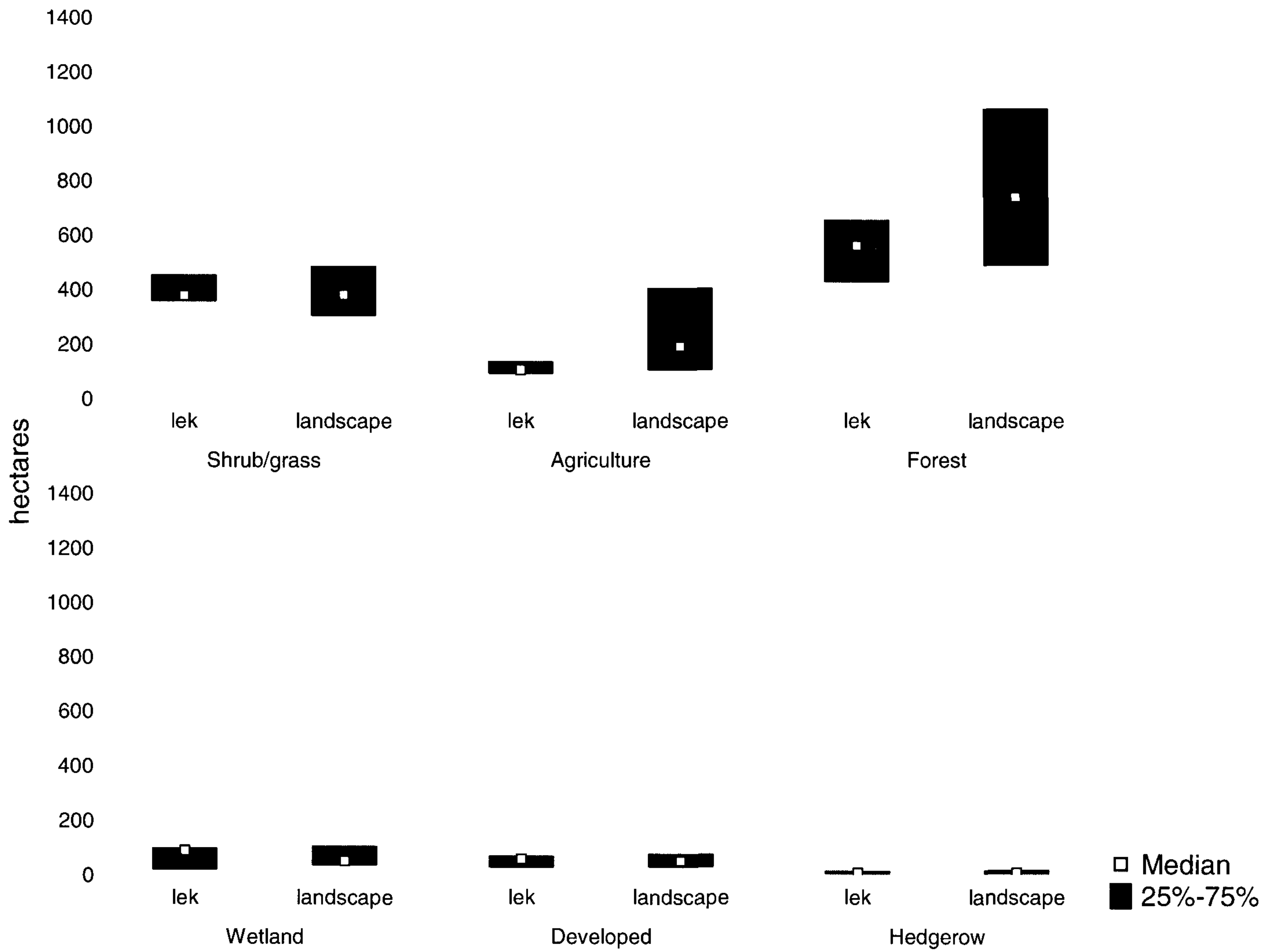

Figure 16. Classified land use within 2400 m of leks (n=4) and random landscape points (n=30).

2.4 Discussion

2.4.1 Sharp-tailed grouse leks, populations and local densities

The objective of this study was to locate sharp-tailed grouse leks. It was exciting and encouraging to encounter sharp-tailed grouse displaying on leks on PEI. Finding four leks (and a probable fifth) was a significant accomplishment. The number of displaying male sharp-tailed grouse varied widely despite the small number of leks. The most plausible explanation for this result is the quantity of suitable nest cover close to the site. The lek with the most male sharp-tailed grouse was surrounded by more shrub/grass than the others. The leks were compared and contrasted based on two factors; 1) the characteristics of the area immediately around the lek (lek site) and 2) the broader area around the lek (buffer area) analysed at various radii.

Many commonalities were found between the lek sites. The lek sites were void of trees and had visibility in all directions. All lek sites had been mowed or similarly altered. This probably benefited sharp-tailed grouse because they could detect approaching predators. This became apparent when trying to observe the displaying grouse undetected. It is believed that the reason sharp-tailed grouse were never observed displaying at the Greenwich site was because of its proximity to the road and the difficulty to get close without being heard or seen. The leks, while being disturbed by humans during the crop growing season, would not have people present on the site between the start of winter until the roads have dried following spring thaw.

The leks found in this study were geographically isolated from each other. The two largest leks were separated by 9.5 km and the lek at Hermanville is 28 km from the next closest site. Baydack (1988) determined the average distance between leks in

Manitoba to be 2.2 km and also considered perch sites for females between leks an important characteristic. Distance from other leks was determined to be a significant predictor of lek presence on the landscape (Baydack 1988, Niemuth and Boyce 2004) meaning that the probability of an area to contain a lek site was higher than by chance if there were other leks in the area. The implication was that leks are dependant on each other and that female sharp-tailed grouse benefit from having a choice of multiple leks to visit.

Each lek encountered in this study was unique. The dominant cover was not consistent across the lek sites. Two were blueberries, one was a shrub cutover and the other was a hay stubble field. This was consistent with Pepper (1972) who found that vegetation type was of no particular importance as long as the birds had a wide view.

2.4.2 Listening survey

The lek survey was extensive and survey conditions were ideal during much of the courtship season. A lek was discovered at St. Peters despite having only three male sharp-tail grouse displaying. The possibility that leks were undetected during the course of the survey cannot be discounted. It is possible that additional small (or large) leks existed and that the males were not displaying because they were absent during the survey or were disturbed by some unknown reason such as predators or people. Care was taken to ensure that listening surveys were conducted during favourable conditions. A number of potential problems detecting sharp-tailed grouse leks became apparent. Sound transmission is reduced in hilly topography, heavily treed areas, developed areas and many areas along the coast. On a given day, listening conditions can be favourable inland, but remnant surf can still hinder listening, even from considerable distances. Calm mornings on the north shore of PEI can still have noisy surf conditions, particularly if a northerly wind occurred the day before. This impacts both the sharp-tailed grouse surveyor and potentially the sharp-tailed grouse themselves. Their leks are typically situated to maximize sound transmission. It is not known what impact coastal noise could have on individual site suitability.

There are many possible disturbances that could cause sharp-tailed grouse to change behaviour during the courtship season. Disturbance was observed from humans as well as mammalian and avian predators. During one lek survey (Anderson Road 2008), a mature bald eagle flew over and all birds stopped displaying immediately. A crow flew over the same lek on the same morning and no behavioural change was observed (the sharp-tailed grouse continued to display). A red fox was observed within 200 m of a lek site and numerous coyote and fox tracks have been observed at various sites. Northern harrier (*Circus cyaneus*) were observed flying less than 20 m over areas believed to be occupied by sharp-tailed grouse.

2.4.3 Land use surrounding leks

Two interesting results differentiate the leks from the surrounding landscape. There is more shrub/grass in the 800 m surrounding the leks and there were fewer trees. This was consistent with Pepper (1972) who found that males established leks in proximity to suitable nest cover. This pattern was also seen at 1 km from the leks but not at 1.6 km or at 2.4 km. This is because sharp-tailed grouse choose a lek site that meets both micro and macro parameters. In order for a site to be suitable there must be sufficient nest cover in proximity to the lek. Females were determined to nest approximately 1000 m from leks (Gratson 1988). The lek attracts predators (likely away from nesting females); therefore females choose sites that are not immediately adjacent to the lek. The land use surrounding leks and random points show no differentiation at 2400 m. This was likely because sharp-tailed grouse are evaluating the suitability and establishing leks using a smaller radius.

Common cropping practices in PEI are not beneficial to sharp-tailed grouse. In 2004 the provincial government enacted legislation requiring a mandatory three year crop rotation. A typical three year rotation involves cropping potatoes the first year, followed by grain the second year and then hay or forage. Sharp-tailed grouse have very limited use for these lands during two of the three years. Potato and grain crops are planted in the spring, requiring the land to be manipulated and resulting in a direct conflict with sharp-tailed grouse nesting. The year of hay or forage could provide suitable nest and brood cover under ideal conditions. The harvested grain fields may be of some benefit to sharp-tailed grouse in the fall and early winter before they become covered in snow.

Coastal development poses a threat to the long term survival of sharp-tailed grouse in northeastern PEI. Areas consisting of low shrubs such as cranberries and bayberries are being destroyed for development. Most of the northeastern coastline is owned by non-residents presumably for recreational development. Numerous cottages now occupy much of the landscape in Cable Head, once believed to be the centre of sharp-tailed grouse activity (MacIntyre pers. comm.). This site is not being used as a lek site but may still hold desirable characteristics such as food or concealment. The most obvious explanation for the apparent abandonment of the Cable Head site is the new recreational development.

The two leks with the most displaying males in this study were both on commercial blueberry fields and surrounded by large areas of land also dominated by blueberry plants. Large amounts of forested land have been converted to blueberry production. Eighty two percent of blueberries in 2000 (estimated 2898 of the 3526 ha) were forested in 1990. Significant amounts of land continued to be cleared (Kelly pers. comm.).

The objective of this study was to locate sharp-tailed grouse leks. At least four sharp-tailed grouse leks were present in northeastern PEI in 2008. The leks were spread over approximately 50 km. Three of the leks were associated with commercial blueberry growing operations. The leks were found using auditory and visual methods and despite the low number of leks the method proved to be an effective way to locate lek sites and the number of leks was a reflection of the lack of available habitat. All sharp-tailed grouse observed were in open habitat types and there was more shrub/grass and less forest in the landscape surrounding leks than random points. In 2008, the spring sharp-tailed grouse population in northeastern PEI was approximately 98 birds, assuming all leks were identified. Densities calculated from suitable habitat surrounding lek sites ranged from 0.9 males/ km^2 (St. Peters) to 3.8 males/ km^2 (Bristol) in 2008.

Chapter 3.

Using Geographic Information Systems to determine sharp-tailed grouse habitat, including potential dancing ground sites, in northeastern Prince Edward Island.

3.1 Introduction

Geographic information system (GIS) combines computer hardware, software, and data to capture, store, manipulate and analyze information with a spatial (geographic) reference. Specific locations are represented by points in a GIS, points are connected to form lines and areas are represented by polygon features. A specific type of GIS uses a grid (raster) format to represent spatial information. Raster GIS uses fixed size pixels. It has a number of advantages over vector GIS in land classification and in processing speed. The nature of the data structure dictates that each pixel occupies a known location in the raster therefore calculations that depend on the relative position of other pixels can be readily accomplished.

Various functions/equations can be applied to raster data. Each pixel can be assigned a specific neighbourhood or region to further restrict or simplify the analyses. Attributes about these objects are stored in a digital database. Multiple layers of information can be combined in a vertical analysis to refine or improve a classification. GIS also provides the ability to perform analyses comparing spatial attributes, proximity and interspersion. Data can be analyzed at multiple spatial scales, from landscape level, to specific home range, animal or family group. GIS, when combined with statistical methods such as logistic regression analysis to map the probability of occurrence (Niemuth and Boyce 2004). It can also be used in combination with linear regression to visualize the strength of a particular land use association. These tools can be readily applied to wildlife habitat analysis as individuals of many species, such as sharp-tailed grouse, are known to occupy a home range with much of their life history linked to specific requirements.

Creating a geoprocessing model is a stepwise procedure where GIS functions are performed on one or multiple datasets and the output is carried forward as input in the next step in the process. The objective of the GIS analysis and geoprocessing model was to combine known life history parameters of sharp-tailed grouse from previous studies to determine potential suitable habitat.

In this study, two GIS models applied published habitat metrics to land use data to identify and categorize sharp-tailed grouse habitat. Model #1 is a predictive model used to identify potential lek sites. Model #2 is a capability model to identify areas/ranges capable of supporting sharp-tailed grouse. The difference in the approaches taken in Model #1 versus Model #2 is that the former assumes that the lek is the center of activity. Without a suitable site, sharp-tailed grouse would not occupy the range. The alternate is that without suitable nest/brood cover suitable lek sites are irrelevant.

3.2 Materials and methods

3.2.1 Study Area

The study area was located in northeastern PEI (Figure 17), was 1470 km^2 in area and bounded by the south and west at 46.2085, 63.1037 and bounded by the north and east at 46.4835, 61.9702. The northern boundary of the study area reached the Gulf of St. Lawrence. The majority of the western perimeter of the study area was bounded by Tracadie Bay or the Hillsborough River. The eastern boundary of the study area was the Northumberland Strait. The southern boundary of the study area was generally defined by Route 5. Over fifty percent of the study area was forested (Figure 18) with the remaining land divided between agriculture, shrub and grass land, and small amounts of wetland or developed land.

3.2.2 Geographic Information Systems, software and data

Software used for this study included ArcGIS version 9.2 (Environmental Systems Research Institute, Redlands California) including Spatial Analyst and Grid extensions. Attribute queries and map production were done using MapInfo Professional version 7.5 (MapInfo Corporation). A cell size of 20 m was chosen for the models in these analyses. In geoprocessing models cell size is a balance between the best possible resolution and the computational time required for the processing. It is likely that the study objectives could have been achieved using a larger cell size, however, it was decided to err on the side of caution to be sure that subtle land use details were preserved.

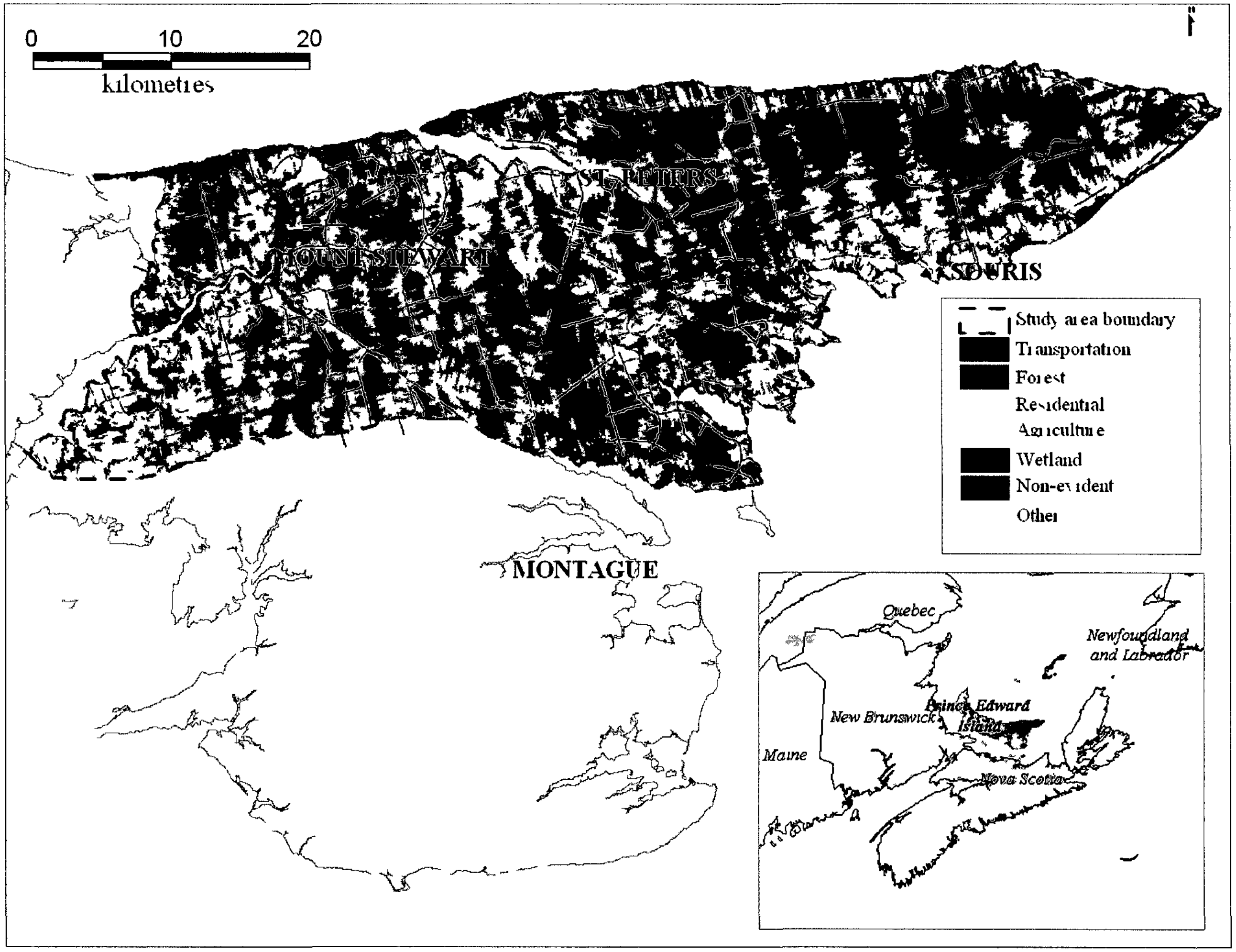

Figure 17. Map indicating study area boundary and distribution of major land use classes

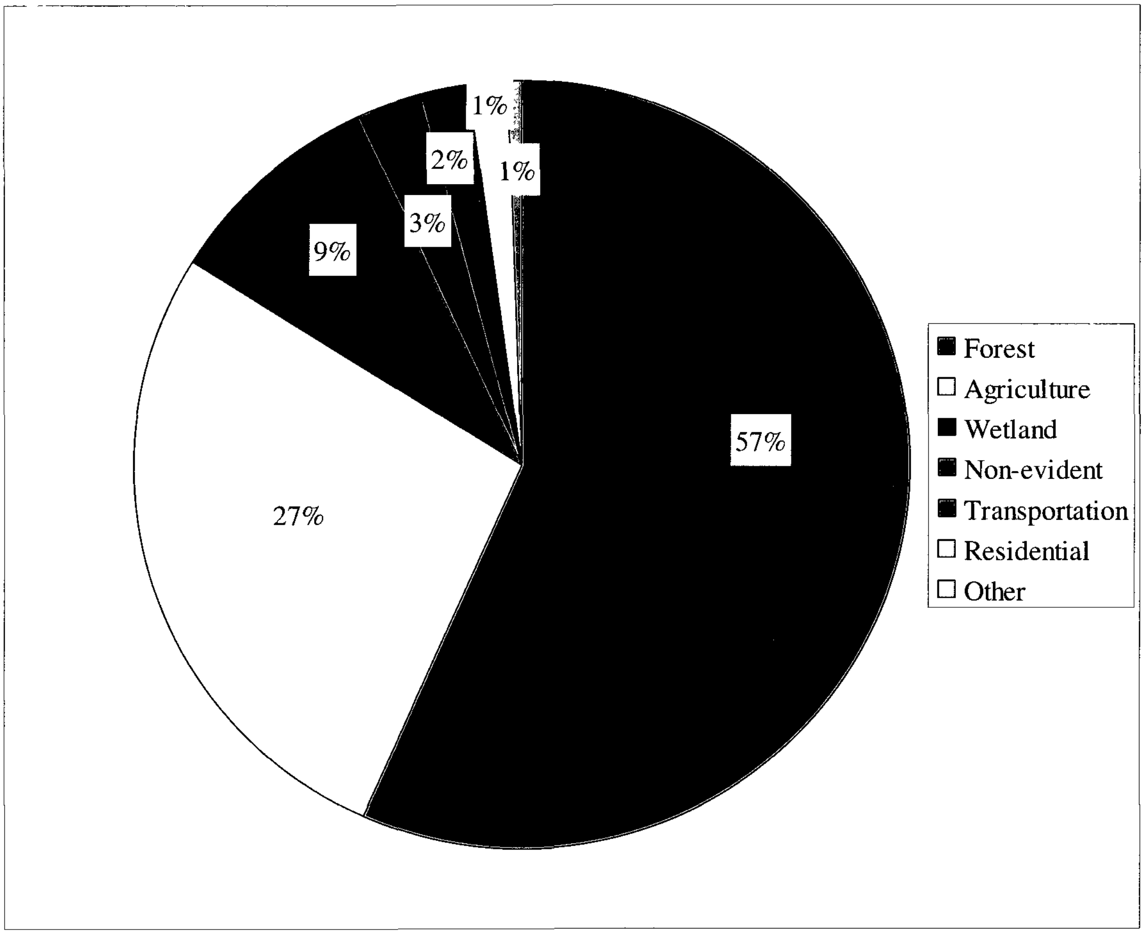

Figure 18. The proportion of each major land use category in the study area.

3.2.3 Data preparation

The Corporate Land Use Inventory 2000 (CLUI) consists of a GIS file (including database) created from a manual stereographic interpretation of colour infrared aerial photographs at 1:17,500 scale during the peak of the growing season, July 2000. The polygons were created by digitizing the interpretation into a GIS. Land use categories and cover types were designated for each distinct polygon and added as attributes to the CLUI database. The CLUI contained eleven broad land cover categories: agriculture, commercial, forestry, residential, industrial, institutional, recreational, transportation, urban, wetland and non-evident. Each land use category was further subdivided with 41 sub-use categories in total. This data layer was the base of the sharp-tailed grouse habitat assessment.

3.2.4 Geoprocessing Models

3.2.4.1 Model#1: Predicting lek site location

This model is based on the assumption that site specific features limit lek establishment. Such features can be represented using GIS and by interpreting land use information. A geoprocessing model was developed to find potential lek areas. These areas were further refined using landscape level characteristics. This procedure follows a similar methodology used by Hanowski *et al.* (2000), Niemuth (2003) and Niemuth and Boyce (2004) where logistic regression models were used to determine probability of lek occurrence on the landscape.

Collecting land use data for the entire province or even for a region like the north-east is likely cost prohibitive for most single species management projects. Thus, it is important to base these types of models on existing data.

The first step in the model was to select suitable land use types based on literature criteria that could realistically contain a lek (Figure 19). This file was created by querying the CLUI for open land with herbaceous ground cover in March, April and May. This included various land use categories: agriculture (pasture, hay land), non-evident (grass, shrub), wetland (meadow), residential (grass), commercial (grass), institutional (grass), forest (clear cut), industrial (grass), transportation (grass), urban (grass). Many of these categories may not provide suitable conditions for lek sites but were deemed to meet the basic criteria.

An important component of this model was the raster file depicting areas at least 200 m from forest in all directions. This file was created using the ArcGIS *focalmax* function. The purpose of the function was to find the highest value for each location on an input grid within 200 m circular neighbourhood. The corresponding value was sent to the output grid. If a forest pixel was identified, the output pixel was given a one; if no forest pixel was found in the processing neighbourhood, the pixel was given a zero. The result of this function was a raster depicting all pixels that were at least 200 m from forest. Additional limiting characteristics were considered. The site could not be on steep slopes, so any land having slopes greater than 5 % were removed. As human disturbance can disrupt lekking sharp-tailed grouse, all land within 200 m of a building was excluded.

Lek sites were further categorized based on landscape level predictors including the percent area of forest within 800 m, the amount of nest/brood cover within 1000 m

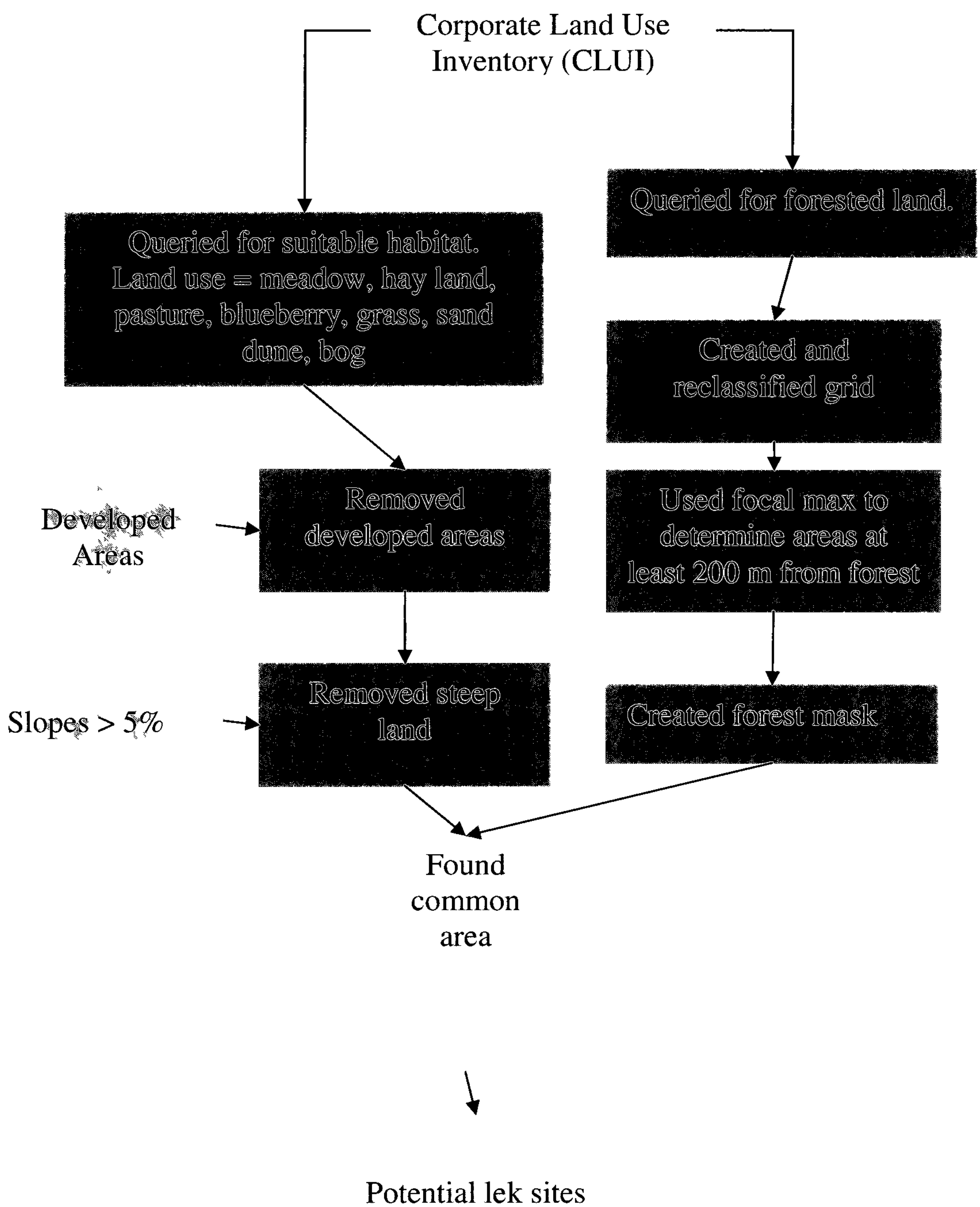

Figure 19. Geoprocessing model to identify potential lek sites, step 1.

and the percent of open land within 2400 m (Table 9, Figure 20). Each grid was reclassified to contain values between one and five with the value one representing the most suitable. The three grids were combined using a weighted overlay command; the nest/brood parameter was weighted at 50 %, increasing its influence on the output. The resulting grid contained values ranging from 2.5, meaning they met the criteria perfectly, to value of 11.5. The mean value was 5.3. The best 50 % of the sites were chosen as candidates for further analysis. The original lek potential grid was used to create the output polygons which were then aggregated.

3.2.4.2 Model #2: Habitat capability model for sharp-tailed grouse

A model was created to identify areas capable of supporting sharp-tailed grouse (Figure 21). The foundation of this model was that occupancy of sharp-tailed grouse in an area is dependant on landscape level predictors. The output was a raster surface depicting habitat capable of supporting sharp-tailed grouse. Conceptually, the two components of this method are similar to applying linear regression equations. The output of the model is the intersect point of the equation of the lines, or in spatial terms, the area of overlap.

The percentage of available habitat increased the number of sharp-tailed grouse (Pepper 1972) and, conversely, the percentage of unsuitable habitat reduced the number of male sharp-tailed grouse attending a lek (Moyles 1981). The appropriate radius was unknown for PEI so multiple radii were incorporated. A body of literature exists creating a solid foundation for the formulation of a draft model. Model #2 made the assumption that sharp-tailed grouse, given appropriate landscape composition would find a suitable lek site somewhere on the range and that it is the proportion of suitable cover types on the

Table 9. Reclassification of landscape characteristics from percent area to integer value ranging from 1 to 5, used to index potential lek sites where a score of 1 is the most desirable condition.

Nest and brood cover within 1000 m (percent)	Forest cover within 800 m (percent)	Open land within 2400 m (percent)	Score
0-10	greater than 50	0 – 10	5
10 - 20	30- 50	10 – 20	4
20-30	15-30	20 – 30	3
30 – 40	0-10	30 – 40	2
greater than 40	10 - 15	greater than 40	1

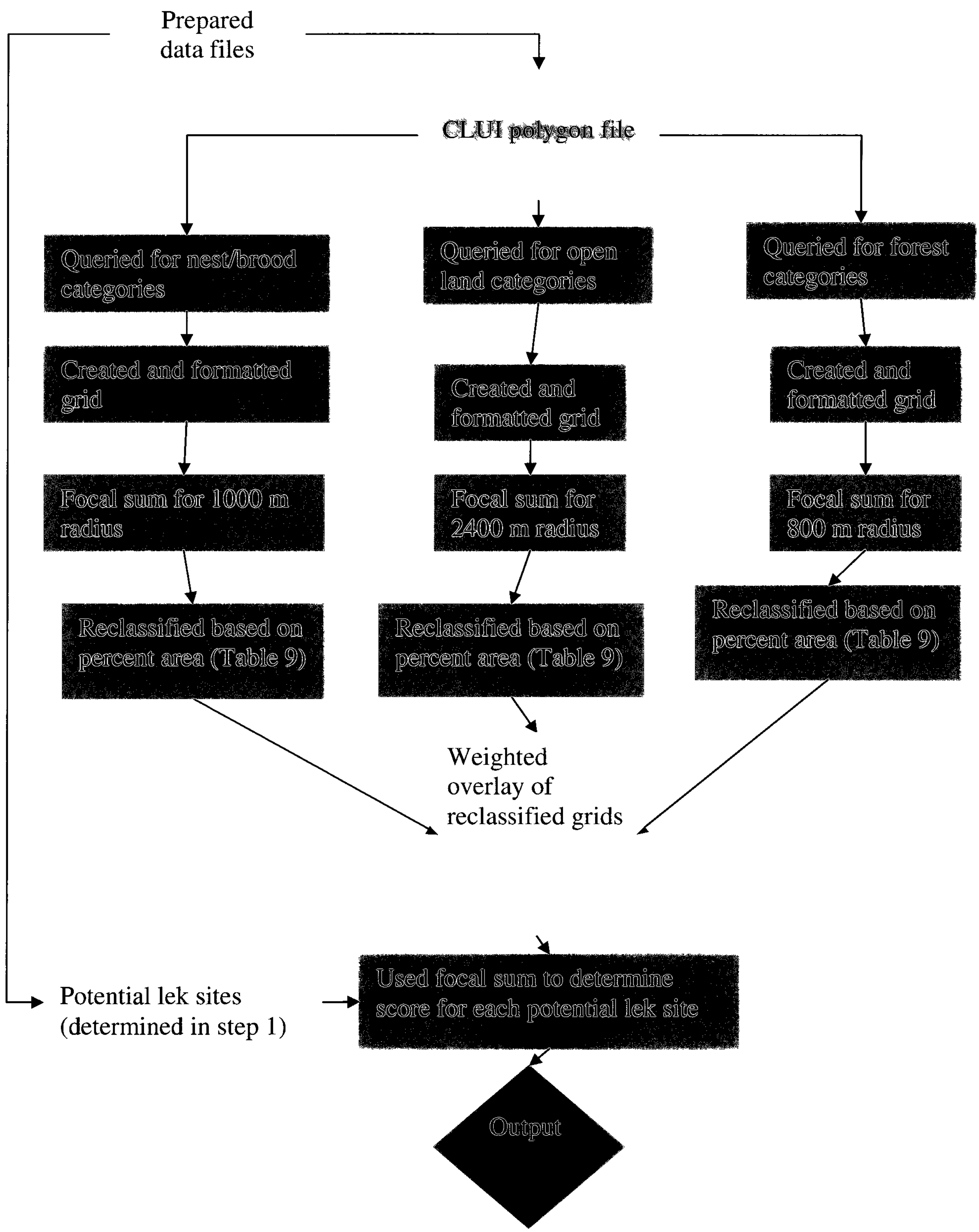

Figure 20. Geoprocessing model to identify potential lek sites, step 2.

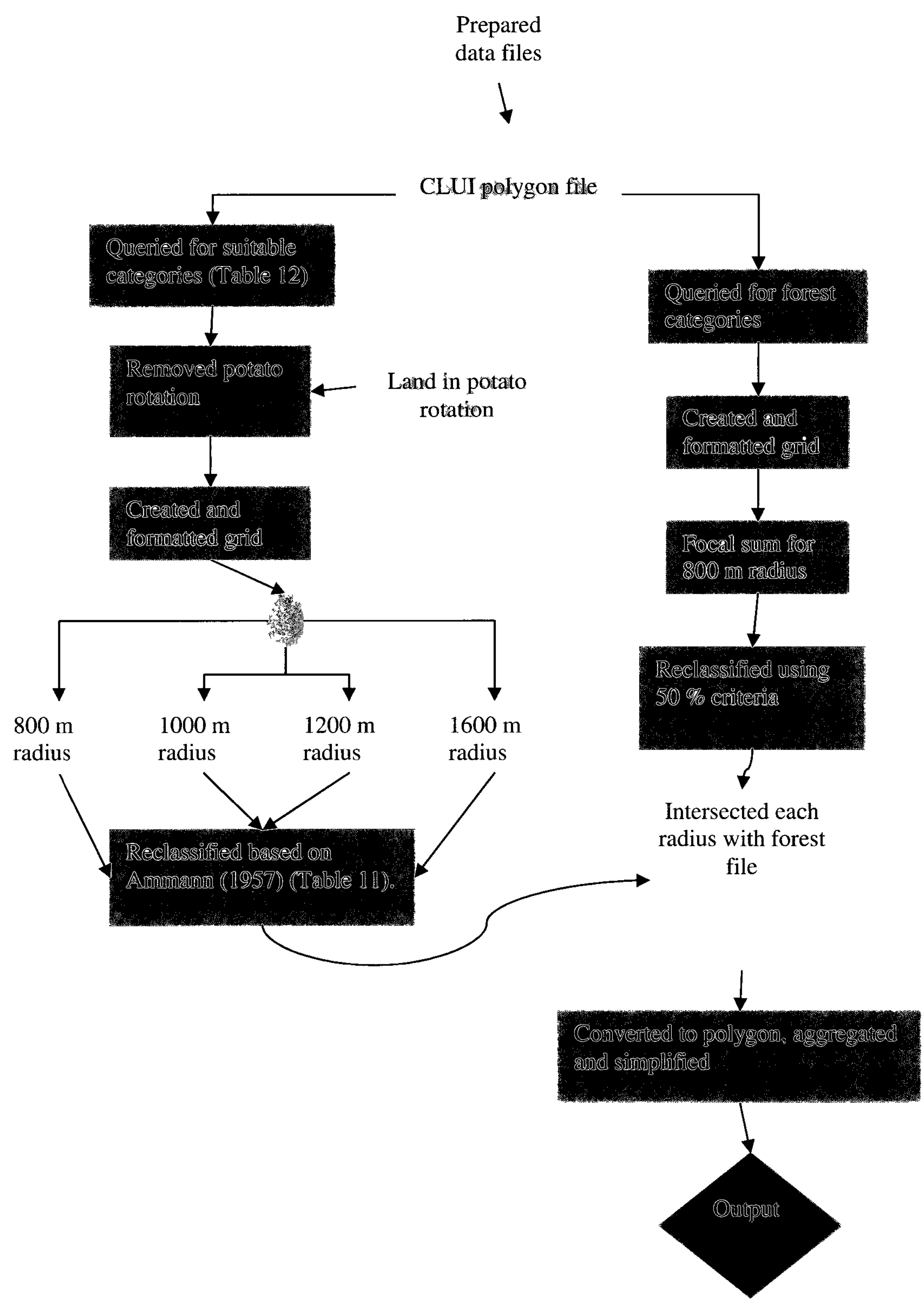

Figure 21. Geoprocessing model used to identify areas capable of supporting sharp-tailed grouse.

landscape that determine if a range would be occupied. This was supported by work of Hanowski *et al.* (2000) who indicated that even small changes in the proportion of suitable cover types will cause a lek to be unoccupied even though the site level characteristics may appear unchanged. This model was based on two accepted characteristics of sharp-tailed grouse habitat requirements. They required large open areas of herbaceous cover and habitats became unsuitable above 50 % forest cover (Ammann 1957). The model was not simply an inventory of suitable habitat. Landscape characteristics, including percentages of area required to support sharp-tailed grouse have been incorporated. The complexity in computation of this model was that the area surrounding each pixel was considered. Put into perspective, a radius of 120 pixels (2400 m) contains over 45,000, pixels and 18.1 km^2.

The amount of suitable habitat required could depend on many factors including the size of the contiguous range available or land use of the immediate surrounding area (Table 10). It could also depend on unknown factors. This model used a precautionary approach by broadly interpreting the suitability of potential land uses. This was intended to ensure that results can be interpreted with confidence that the capability predictions were liberal. These analyses used multiple spatial scales to incorporate variation from results of previous work.

Various authors have reported on the home range of sharp-tailed grouse. The issue for these analyses was to quantify the required minimum amount of suitable habitat within a range. Ammann (1957) provided the smallest estimate of minimum suitable habitat required to sustain sharp-tailed grouse in a predominantly forested landscape and provided the basis for model result classification (Table 11). The initial threshold, as

Table 10. Summary of reference metrics used to create habitat model and corresponding circular radius.

Description	Metric	Circular radius
The typical spring home range cocks (Gratson 1988)	348 +/- 11 ha	1000 to 1200 m
The typical spring home range hens (Gratson 1988)	604 +/- 111 ha	1200 to 1600 m
The average distance between lek sites in Manitoba (Baydack 1988) and Michigan (Ammann 1957)	2200, 2400 m	1100, 1200 m
The distance females travel from leks to nest (Pepper 1972)	900 m to 1600 m	900 m to 1600 m
The distance where the proportion of forest cover around lek sites is important (Moyles 1981)	800 m	800 m
Critical distance for lek probability (Niemuth and Boyce 2004)	800 m	800 m

Table 11. Reclassification of multi-scale neighbourhoods for sharp-tailed grouse suitability (adapted from Ammann 1957, Grange 1948).

Class	Suitable cover required (ha)	Percent of area required to achieve class at 800 m (201 ha)	Percent of area required to achieve class 1000 m (314 ha)	Percent of area required to achieve class at 1200 m (452 ha)	Percent of area required to achieve class at 1600 m (804 ha)	Percent of area required to achieve class at 1600 m (804 ha) (Grange 1948)
Absolute minimum	20	0-10%	0-15%	0 – 5%	0 – 2%	N/A
Not sustainable	20 - 81	10 – 40%	15-25%	5 – 20%	2 – 5%	0 – 25%
Suboptimal	81-259	40-100%	25 – 80%	20 – 60%	5 – 20%	25 – 50%
Optimal	**> 259**	**> 100%**	**> 80%**	**> 60%**	**> 20%**	**> 50%**

described by Ammann (1957) indicates that 80 ha with above average cover could support sharp-tailed grouse. During this study the quality of the cover could not practically be assessed therefore all suitable cover was assumed to be "above average". As the area increased the percentage of suitable cover required to support sharp-tailed grouse decreased: 40 % at 800 m, 20 % at 1200 m, 10 % at 1600 m. Potentially suitable sharp-tailed grouse habitat on PEI can be represented by land use classes in the CLUI (Table 12). Four potential areas were evaluated using circles of radius 800 m, 1000 m, 1200 m and 1600 m (Table 13). An alternate classification of minimum suitable area required to support sharp-tailed grouse was provided by Grange (1948). This was implemented at the 1600 m radius (Table 11).

The percent of forest cover was determined for a circular area of radius 800 m. For this analysis, closed forest represented forested land having an interpreted closed canopy greater than 25 %. Forest polygons were mapped in detail in the CLUI and this value was felt to be representative of a closed canopy forest (Kelly pers. comm.).

Table 12. Description of land use classes used to create map of potential sharp-tailed grouse areas and their corresponding codes from the CLUI database.

Land use	**Description**	**CLUI land use code**	**CLUI sub use and/or dominant cover type**
Non-evident land use	Abandoned land; typically shrubs or grass	NON	SHB, GRS
Pasture	Grazed and ungrazed pasture	AGR	PAS
Hay land	Excluding land in the potato rotation as mapped from Thematic Mapper (TM) satellite data composite for 1995-2000	AGR	HAY
Wetlands	Including areas dominated by meadow vegetation, shrub swamps and bogs.	WET	MDW, SSW, BOW
Blueberries and cranberries	Classified as an agricultural category in 2000.	AGR	BLB, CRN
Clear Cuts	Classified as a forest category in 2000.	FOR	CC
Other shrubs	Alders and pincherry < 4 m in height.	FOR	AL, PC
Sand Dunes	Sand dunes	WET	SDW

Table 13. Description of multi-scale processing neighbourhoods.

Radius(m)	Width in cells (20 m/cell)	Total number of cells	Area (km^2)
800	40	5025	2
1000	50	7845	3.1
1200	60	11289	4.5
1600	80	20081	8

3.3 Results

3.3.1 Potential lek sites.

Polygons created from step one of the model showed no obvious pattern of distribution (Figure 22). Potentially suitable sites were distributed throughout most of the study area with the exception of the northeastern coastline where there were fewer sites. The size of potential areas varied from a minimum of 450 sq. m. to 83 ha. Refining the model using landscape characteristics reduced the number of potential areas (Figure 23). The distribution of these areas appeared clumped with concentrations along the Hillsborough River Valley, St. Peters Bay, Souris and Bridgetown and there were large voids in the central part of the study area and in the northeast. Sites ranged in size from 450 m^2 to 83 ha.

3.3.2 Habitat capability models at multiple spatial scales

At each radius two results are presented. The first is the output of the habitat classification. The second is the output of the combined model including both the classified habitat and the restriction based on the percentage of forest within 800 m criteria.

Percent forest within 800 m

The majority of pixels in the study area had over 50 % forest within an 800 m radius (Figure 24). Areas with a low percentage of forest (less than 50 %) were mainly located near the coast and the estuaries.

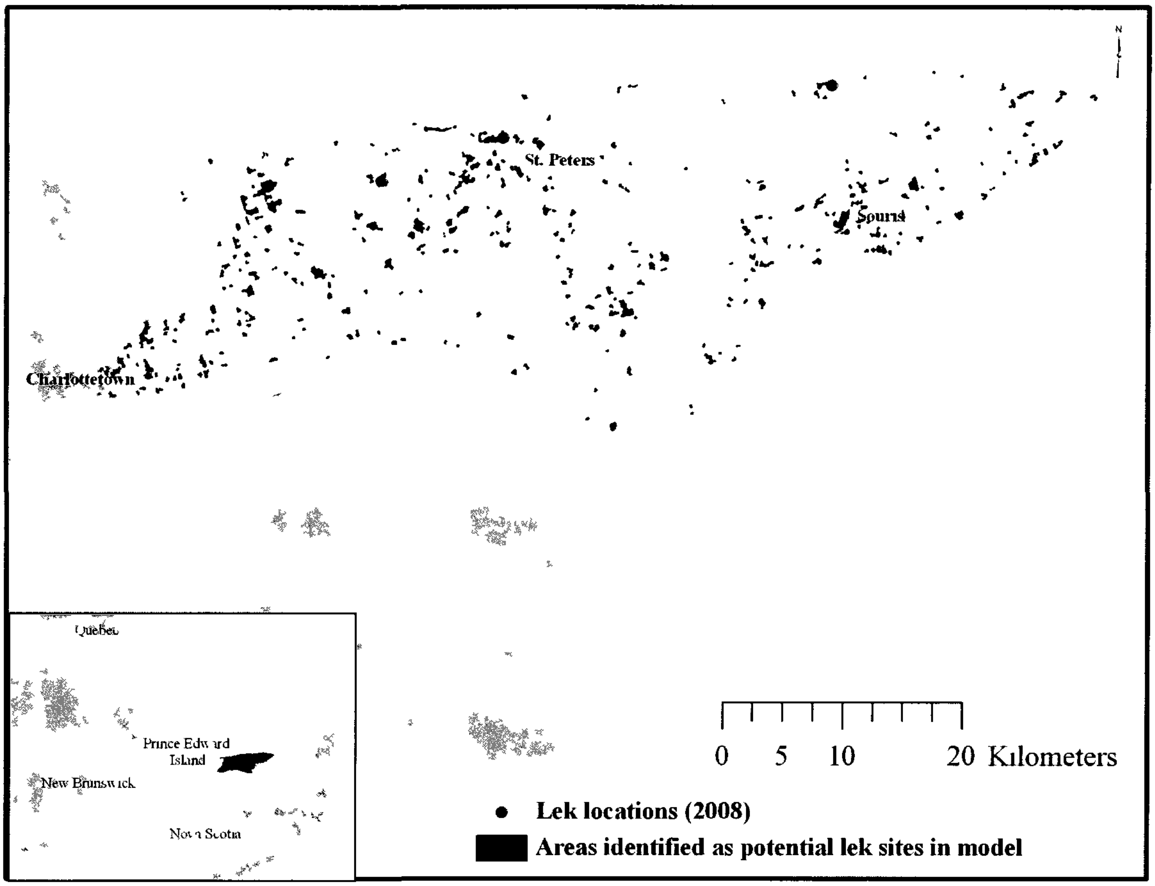

Figure 22. Polygons created from geoprocessing model depicting potential lek sites where potentially suitable lands were intersected with site level limiting factors including distance from forest, slope and distance from buildings. Also depicted are locations of leks found in 2008.

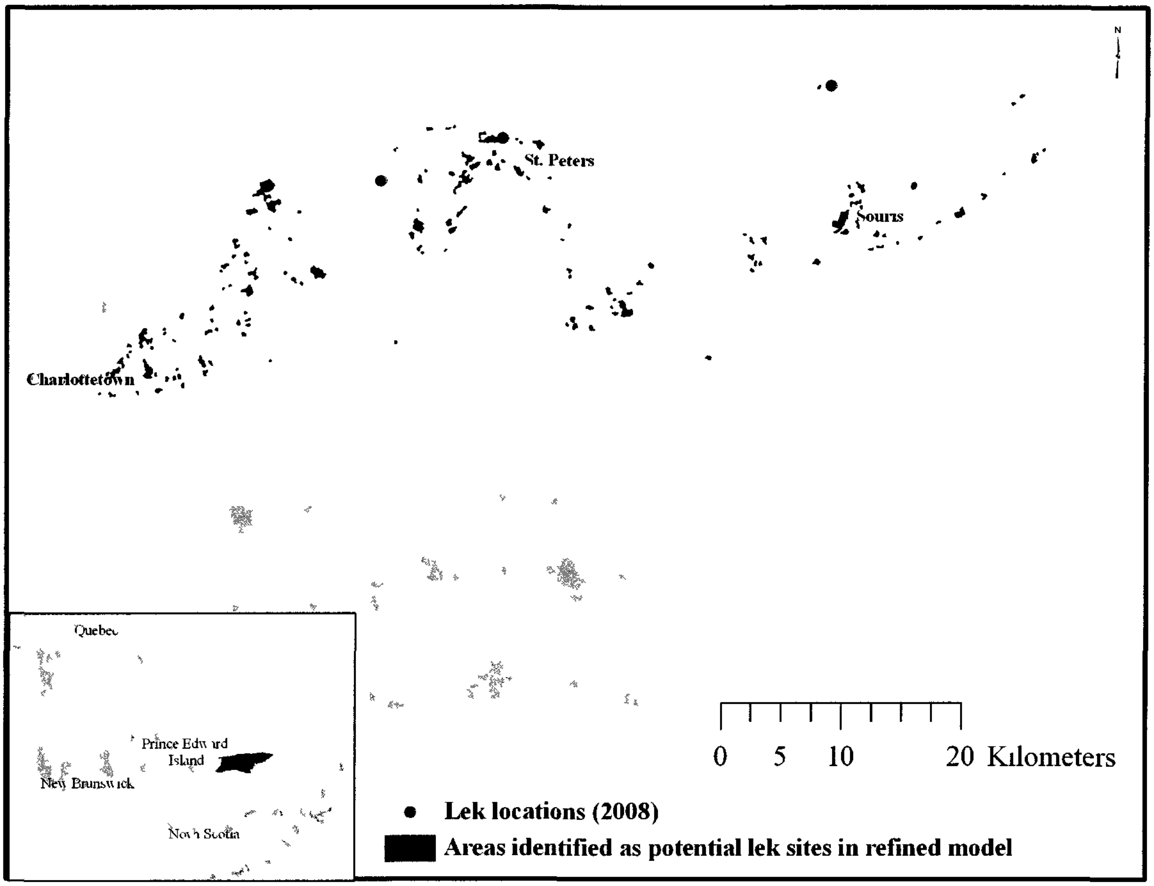

Figure 23. Polygons depicting potential lek sites, output from geoprocessing where previously determined potential lek sites were indexed using landscape level characteristics including percent forest within 800 m, amount of open land within 2400 m, and the amount of nest/brood cover within 1000 m. Also depicted are locations of leks in 2008.

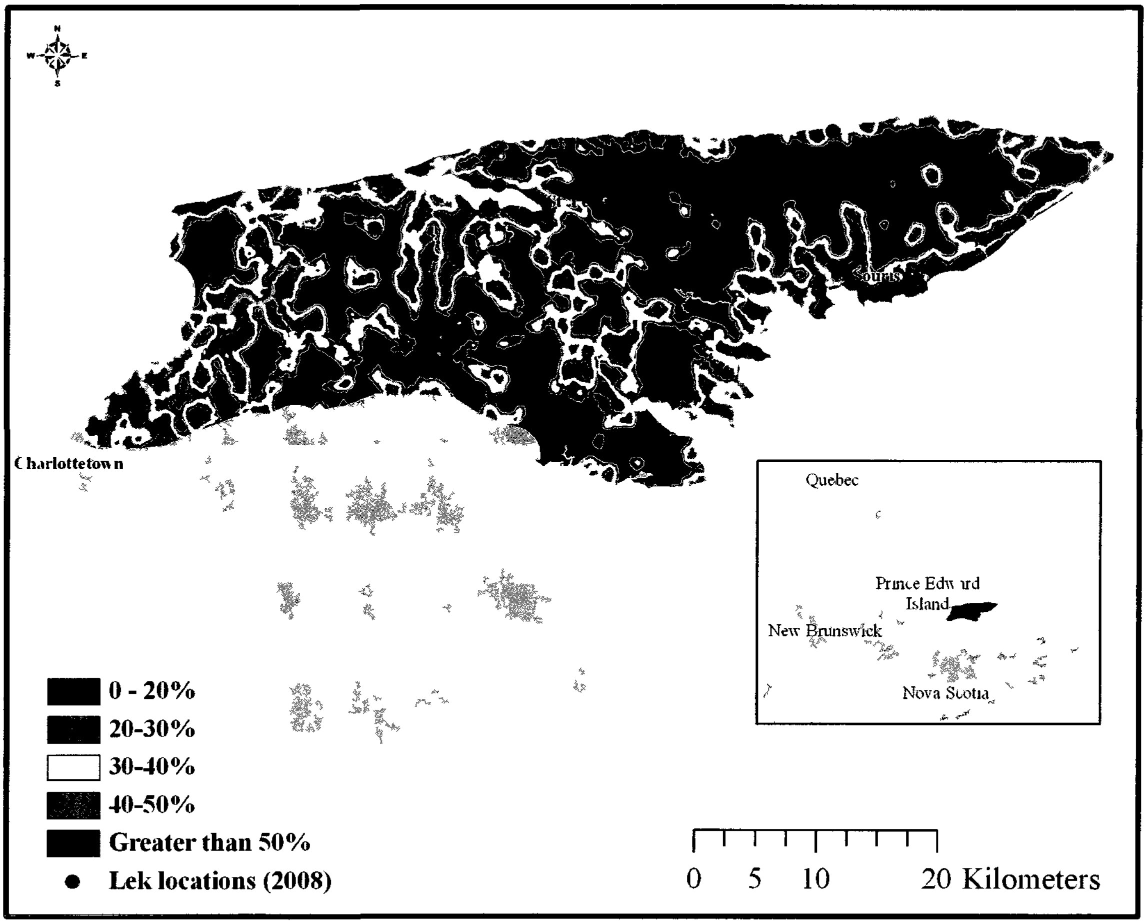

Figure 24. Thematic representation of the proportion of forest cover within 800 m from each grid cell. Also depicted are locations of leks in 2008

Habitat capability model 800 m radius

There were no areas that matched the optimum criteria. There were seven areas that contained greater than 60 % suitable land use within 800 m in the study area (Figure 25). These areas were not continuous but were spread throughout the study area. The two largest areas occurred in the northwest. The habitat capability model identified 97 areas (Figure 26). These areas ranged in size from 255 m^2 to 1294 ha. The areas appeared to be randomly distributed in the western portion of the study area but sparse in the east.

Habitat capability model 1000 m radius

There was one area that matched the optimum criteria which contained greater than 80 % suitable land use within 1000 m in the study area (Figure 27). This area was located in the western portion of the study area and was very small in size. A large proportion of the study area met the suboptimal criteria including much of the northeastern coastline. The habitat capability model identified 134 areas (Figure 28). These areas ranged in size from 255 m^2 to 3076 ha. The areas were randomly distributed in the western portion of the study area but are sparse in the east.

Habitat capability model 1200 m radius

There were two areas that matched the optimum criteria which contained greater than 40 % suitable land use within 1200 m in the study area (Figure 29). There was one large area and one small area; both were located in the western portion of the study area. A large proportion of the study area met the suboptimal criteria including much of the northeastern coastline. The habitat capability model identified 174 areas (Figure 30).

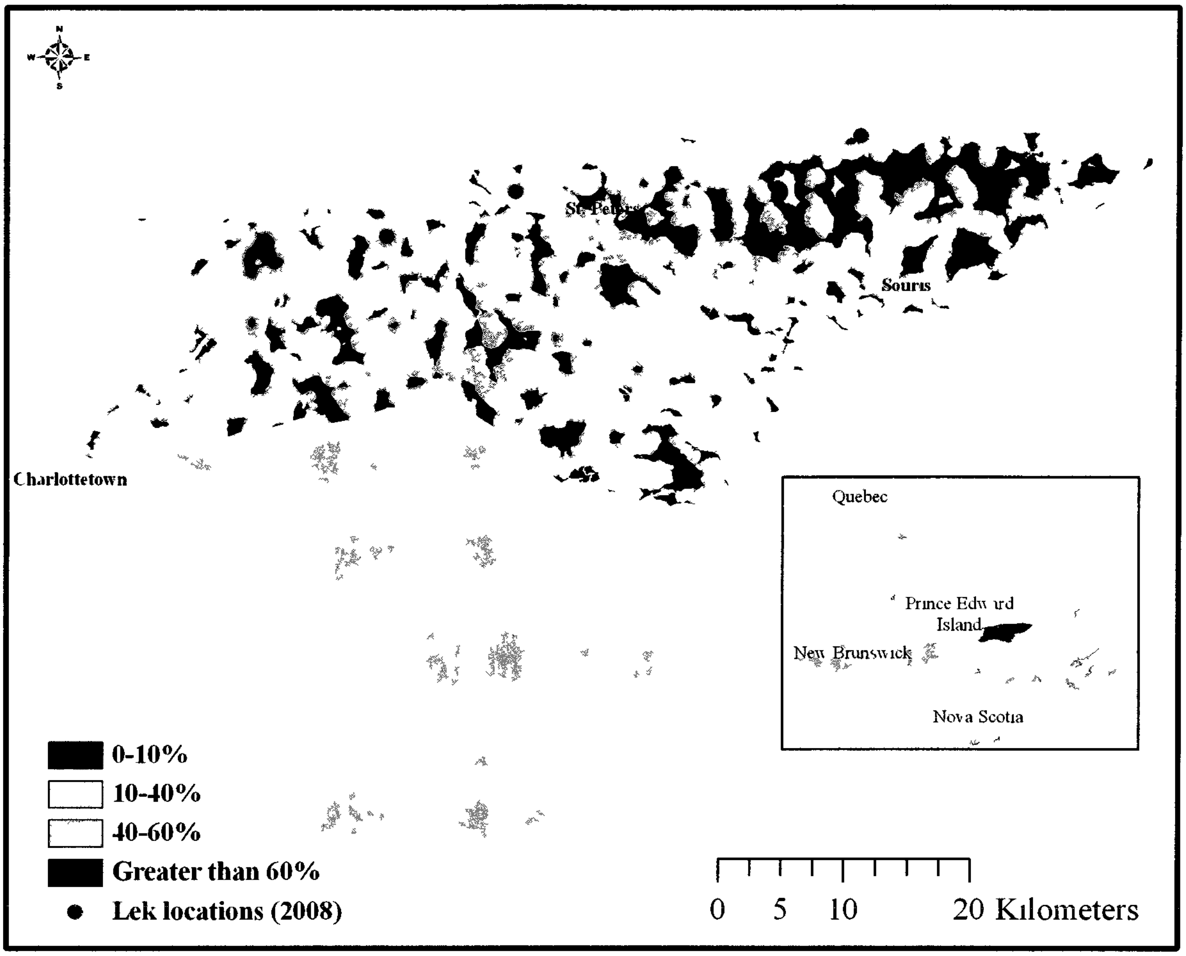

Figure 25. Thematic representation of the proportion of suitable habitat within 800 m of each grid cell, reclassified and coloured based on minimum area required to support sharp-tailed grouse. Also depicted are locations of leks in 2008

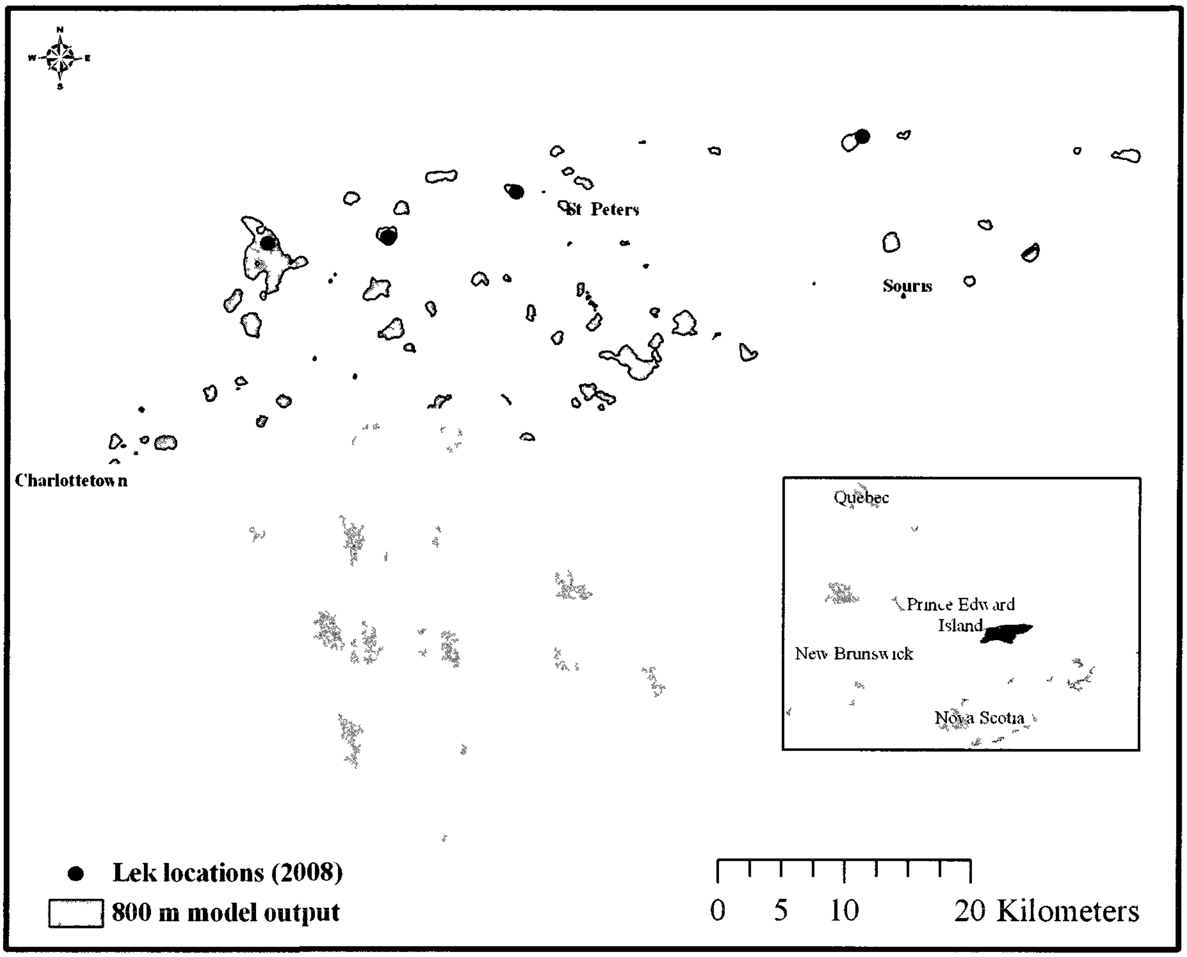

Figure 26. Polygons depicting optimum and suboptimum areas from habitat capability model that included potentially suitable land use within 800 m and restrictions based on the percentage of forest cover within 800 m.

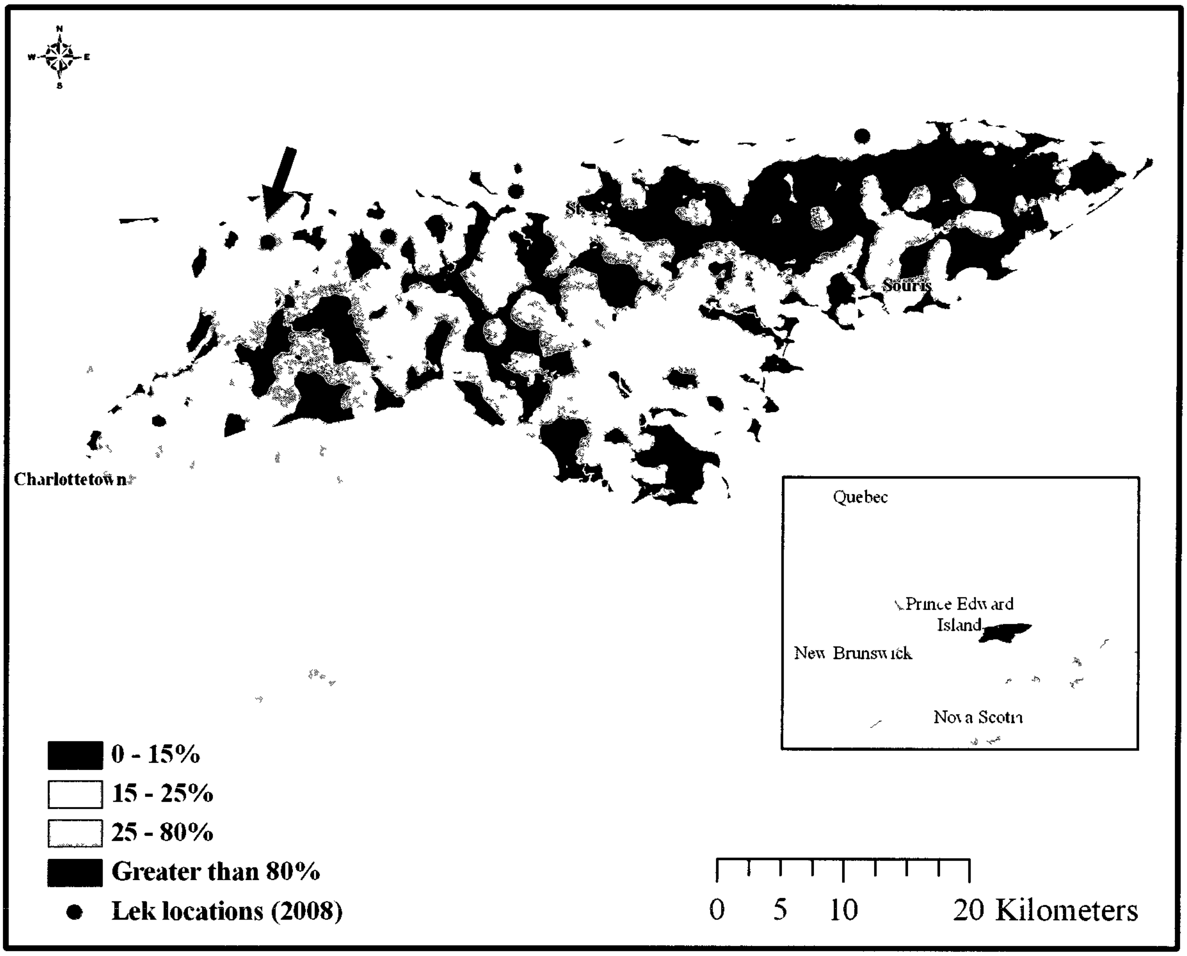

Figure 27. Thematic representation of the proportion of suitable habitat within 1000 m of each grid cell, reclassified and coloured based on the minimum area required to support sharp-tailed grouse. Arrow indicates only area that met optimum requirement. Also depicted are locations of leks in 2008

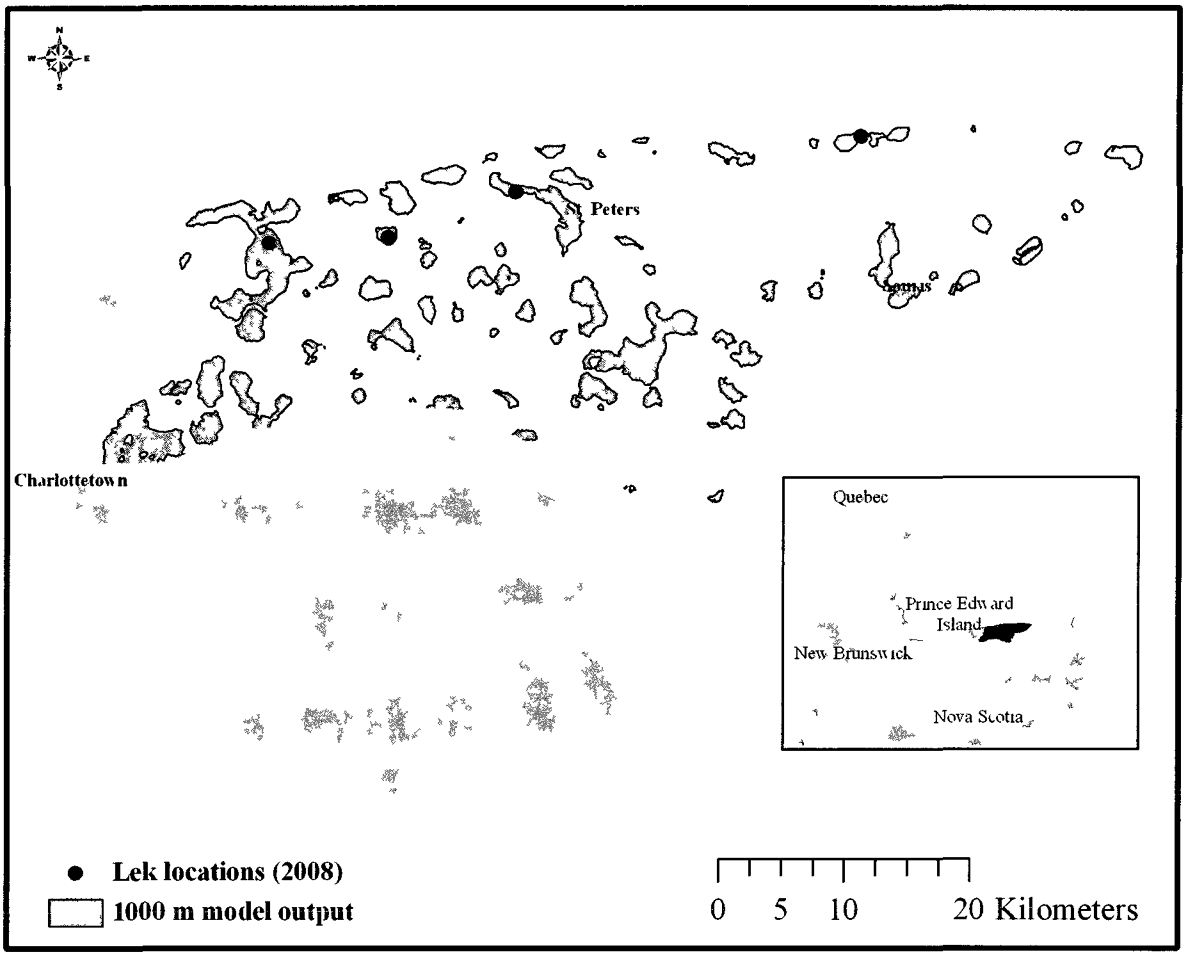

Figure 28. Polygons depicting optimum and suboptimum areas from habitat capability model that included potentially suitable land use within 1000 m and restrictions based on the percentage of forest cover within 800 m. Also depicted are locations of leks in 2008.

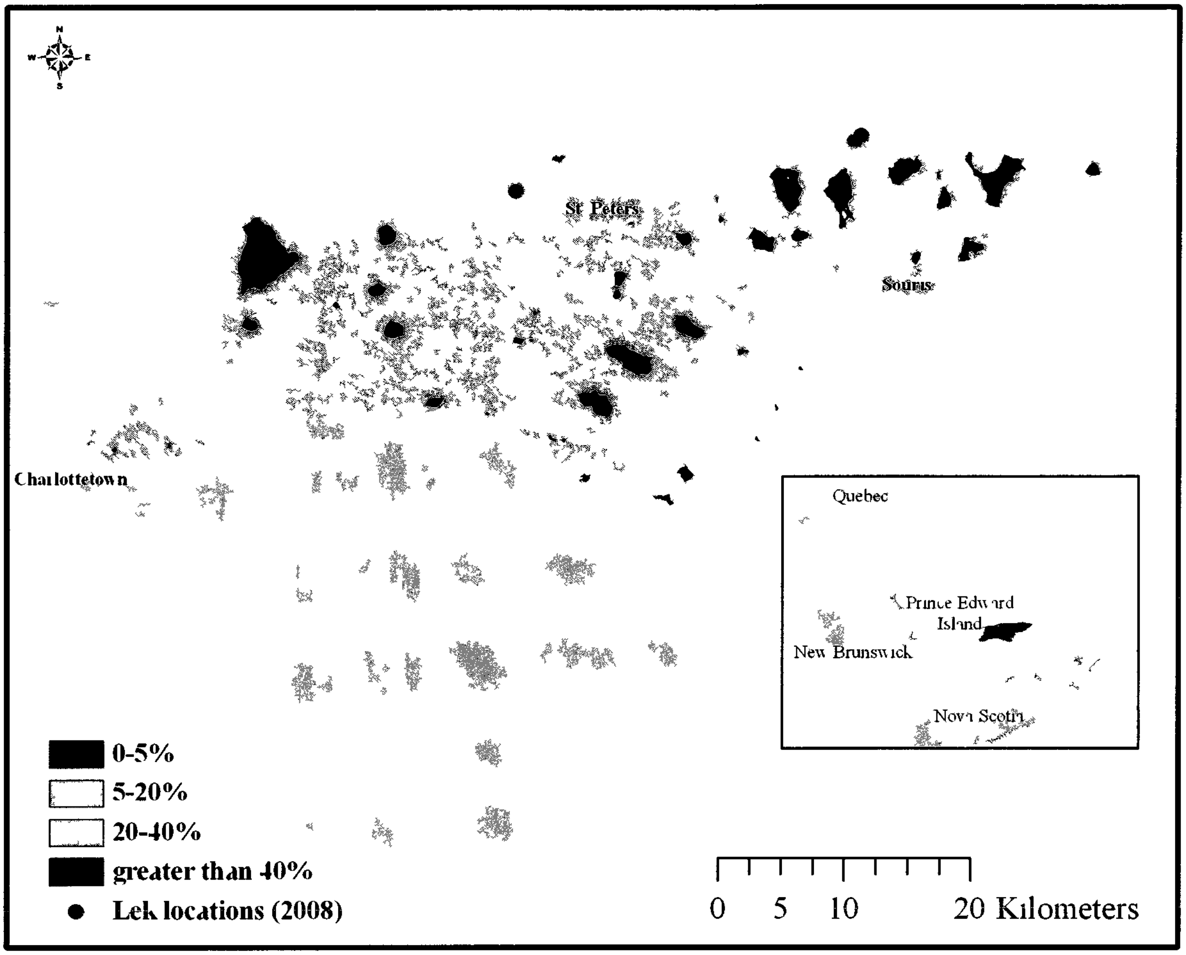

Figure 29. Thematic representation of the proportion of suitable habitat within 1200 m of each grid cell, reclassified and coloured based on minimum area required to support sharp-tailed grouse Also depicted are locations of leks in 2008

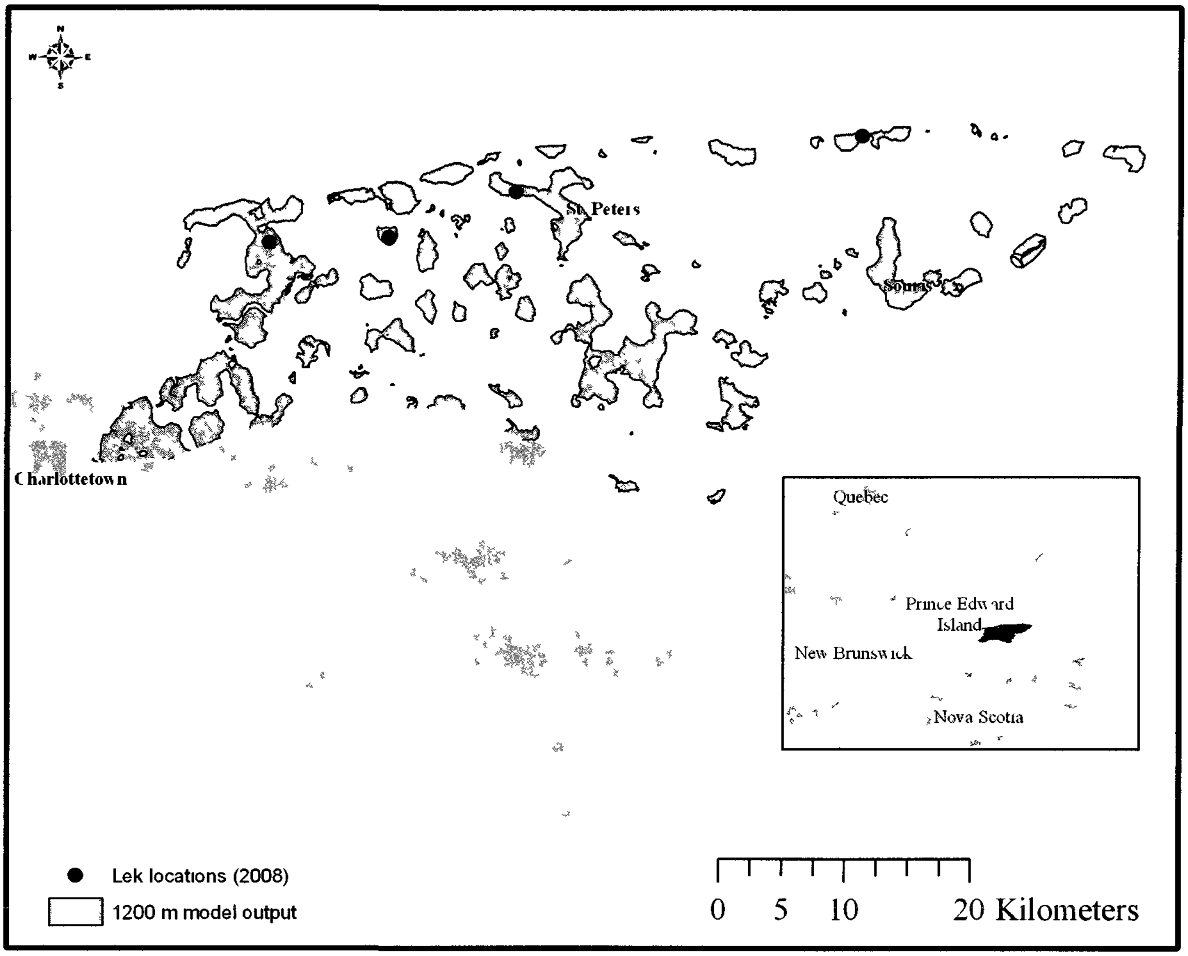

Figure 30. Polygons depicting optimum and suboptimum areas from habitat capability model that included potentially suitable land use within 1200 m and restrictions based on the percentage of forest cover within 800 m. Also depicted are locations of leks in 2008.

These areas range in size from 255 m^2 to 4828 ha. The areas were evenly distributed in the western portion of the study area but sparse in the east. One area greater than 4000 ha was identified. Two other areas greater than 3000 ha were also identified.

Habitat capability model 1600 m radius

There were many large areas that matched the optimum criteria which contained greater than 20 % suitable land use within 1600 m in the study area (Figure 31). The majority of the study area met the suboptimal criteria. There were only six areas, grouped in the northeast, which did not meet at least the suboptimal. The habitat capability model identified 164 areas (Figure 32), ranging in size from 255 m^2 to 9355 ha. Using Grange's (1948) requirements for suitable habitat produced one area. This area met the criteria of greater than 50 % suitable habitat within the 1600 m radius (Figure 33).

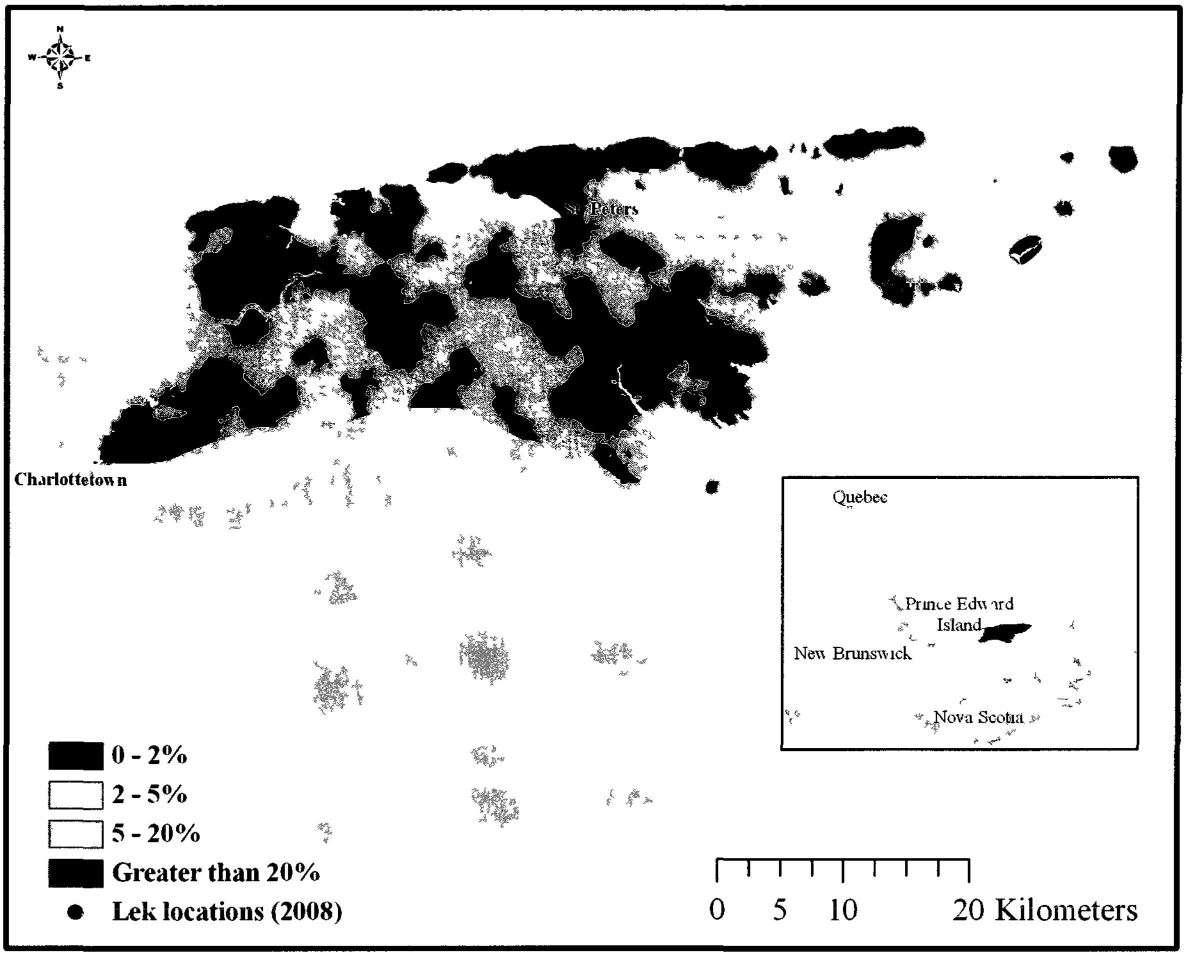

Figure 31. Thematic representation of the proportion of suitable habitat within 1600 m of each grid cell, reclassified and coloured based on minimum area required to support sharp-tailed grouse. Also depicted are locations of leks in 2008.

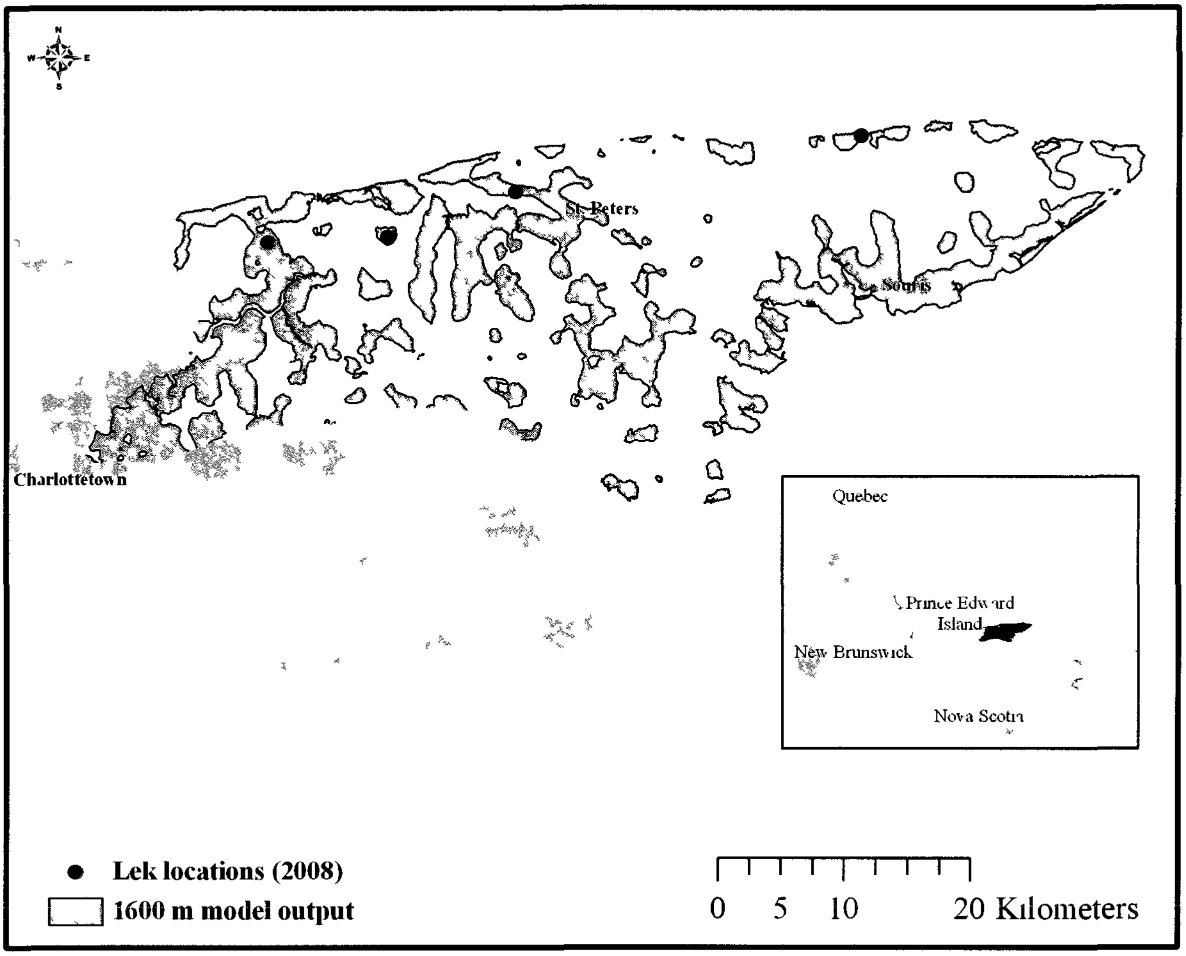

Figure 32. Polygons depicting optimum and suboptimum areas from habitat capability model that included potentially suitable land use within 1600 m and restrictions based on the percentage of forest cover within 800 m. Also depicted are locations of leks in 2008.

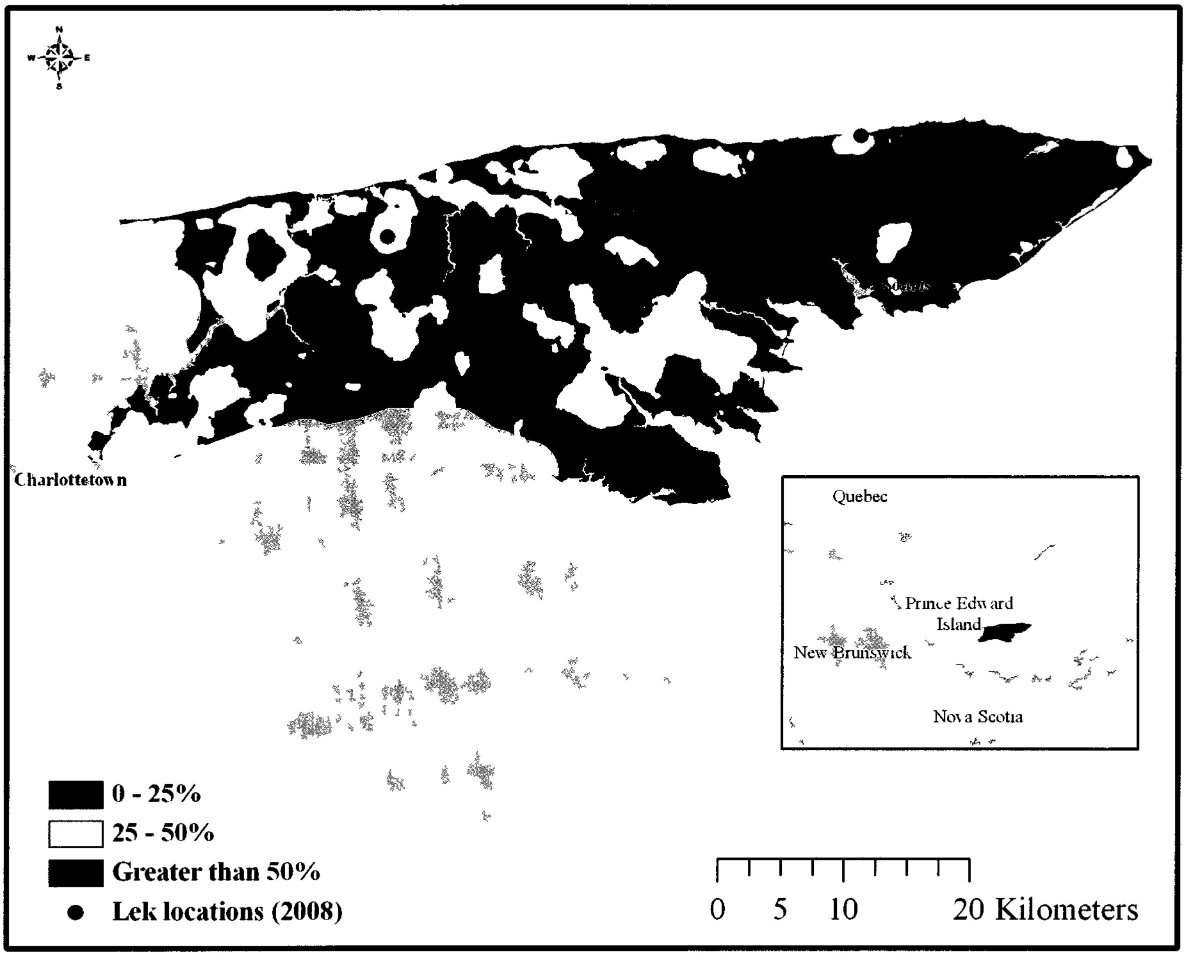

Figure 33. Percentage of suitable habitat required within 1600 m of each grid cell, based on description from Grange (1948). Also depicted are locations of leks in 2008.

3.4 Discussion

The objective of the analysis was to identify potential lek sites using site level characteristics, refined by landscape level characteristics through the development of a GIS model. A second objective was to identify areas potentially capable of supporting sharp-tailed grouse based on characteristics of the landscape at various spatial scales independent of potential lek sites using a GIS model.

3.4.1 Potential lek sites

Potentially suitable lek sites were characterized on site and landscape level factors. Site level factors included areas containing vegetation less than 30 cm tall, being at least 200 m from forest, and with less than five percent slope. Landscape factors included the amount of nest/brood cover in the surrounding 1000 m, the amount of open land in the surrounding 2400 m and areas with less that 50 % forest cover in the surrounding 800 m.

Model results show that there were many potential lek sites in northeastern PEI. This indicates that site level characteristics are not limiting lek establishment. This result was consistent with Hanowski *et al.* (2000) who were unable to develop a significant model at the lek site level (200 m radius). They modelled active and inactive leks and concluded that site level characteristics were not significantly different. They did however find differences at the other radii, indicating that landscape level characteristics are more important.

When landscape characteristics were factored into the model the picture seems clear. The distribution of potential sites was not uniform or random but appeared to be clumped. A large area in the northeast had no potential sites. A requirement to be 200 m from forest was probably the biggest limiting factor in this area as the region is heavily wooded. Areas with higher concentrations of potential lek sites included the known commercial blueberry areas and also included areas around denser human populations. These were probably associated with dairy farms. A particularly interesting result from the refined model was that only one area between Greenwich and North Lake was identified. This area did contain an active lek site in both years of this study.

The suitability of a site to be occupied as a lek must be influenced by the surrounding landscape. Many factors influence suitability of an area to support sharp-tailed grouse and only three were incorporated into this model.

Creating a broad potential lek site model is of little practical use without landscape level refinements. The preliminary model identified over 700 potential areas. This number seems unrealistic and is an impractical management tool. After the landscape refinement a more realistic number (204) was identified, and because many of these areas were grouped together the effective number of areas is small.

Using GIS data has some inherent limitations. When land use is homogeneous such as large agricultural fields or large forested stands the accuracy of air photo interpretation is unlikely to affect model results. Small heterogeneous polygons such as wetlands or land use types that are non-evident are more likely to produce misleading results. For example; a polygon classed as wetland with a dominant cover type of marsh, could also contain small areas of wet meadow suitable for lek establishment. Local topography may not be fully captured using available data. Contour data used to generate slope had a two metre interval. Sand dunes, or comparable areas with small hills may not be suitable for lek establishment but these may not be captured by the model. A 200 m distance from buildings was applied in this model. In reality, the local disturbance caused by each dwelling would vary depending on habits of the occupants. This variability could not be quantified. An example of this would be a dairy farm with an onsite residence. These sites could contain significant areas of pasture but daily events could disturb lekking grouse at distances considerably greater than 200 m.

Model results would probably change if different metrics had been chosen. The results of this model were likely liberal in their prediction of site suitability. An important feature of the model is the minimum distance from forest. Using the median distance to forest of 306 m found by Niemuth and Boyce (2004) would have reduced the number and size of potential areas.

3.4.2 Habitat capability model

The purpose of this model was to identify areas on the landscape capable of supporting viable sharp-tailed grouse populations. In general, the model showed that areas of optimal sharp-tailed grouse habitat are small, rare and disjointed. These characteristics pose a problem for the long term future of sharp-tailed grouse on PEI. The 1000 m model identified only one area, expanding to the 1200 m radius added only one additional area. At the 1600 m radius the percent forest within 800 m limits the inclusion of further areas. Expanding the radius beyond this distance would have no added value without expanding the radius at which the percent forest cover influences suitability.

The 800 m model provides the most interesting result and the best starting point for future research. The models incorporating wider radii give an increasingly general result. This is because they use a smaller threshold for suitability. Model results show that discrete areas become less apparent as the size of the sampling window increased. This is consistent with results from Niemuth and Boyce (2004) who found that landscape characteristics that differed between leks and unused points (amount of grass and shrub cover and less forest) decreased as they increased their sampling window. They found that predictive models created with 400 and 800 m fit their data better than larger sampling windows and that 800 m was the best radius to use because it was more biologically appropriate than the smaller radius and demonstrated a negative association with tree patches.

Lack of suitable breeding habitat appears to be the biggest threat to sharp-tailed grouse on PEI. The modelling process showed that PEI contains very shrub and grass habitat. In the study area, 57 % of the land was forest. When other unsuitable land uses were considered, 88 % of the study area was unavailable. Various authors, across much of the sharp-tail range, attribute re-forestation directly to the decline of sharp-tailed grouse populations. While northeastern PEI does contain small fields, juxtaposed in the forested landscape, sharp-tailed grouse require large contiguous blocks of open habitat. Thus, these isolated patches of seemingly good habitat have little practical value.

It has been speculated that lekking grouse may help to distract predators away from nest sites and that lekking grouse may act as sentinels alerting females to their presence. This was supported by evidence suggesting that females choose nest sites averaging 1 km from dancing grounds (Gratson 1988). This would add further support to the connection between lek sites and suitable nest cover and would suggest that the position or orientation of the nest cover was important. Nest cover adjacent to the lek site may not be as desirable because the advantage gained by using the lekking grouse to distract predators would be mitigated. This would also suggest that males, using nest cover to guide their lek site selection are also using a metric to assess suitability. To carry this thought further, it is quite likely that the available nesting habitat was not uniform in distribution nor was it comparable to western prairie landscapes. Sharp-tailed grouse on PEI have limited choice in available nest sites and certainly have to compromise this requirement.

These models have demonstrated that suitable areas of habitat do exist but are likely disconnected and separated by long distances. Some suitable habitat appears to be located near the coast while much of the interior is unsuitable and therefore unoccupied.

Sharp-tailed grouse occupy a large geographic area, including a wide range of latitudes and climatic conditions. Data used in these analyses were assimilated from previous work throughout the native range, with particular focus on the plains and prairie subspecies. The objective was to provide a model that would quantify potential available habitat. The model cannot, and is not intended, to be robust enough to account for anomalies or adaptations.

While this model was created for northeastern PEI, it could be easily extended to the entire province. Once validated by observational data it could be implemented similar to Niemuth (2003). He used a model developed on an occupied range to determine the probability of prairie chicken lek occurrence in an unoccupied range. While extending the model is technically possible, Prince Edward Island has active birding and hunting communities, in particular field hunting for geese and ducks. It is reasonable to assume that if sharp-tailed grouse were present in other regions, birds returning to lek sites would certainly overlap with hunters in the autumn or birders throughout the season. It is logical and reasonable to conclude that sharp-tailed grouse have not established themselves outside of northeastern PEI in appreciable numbers (Oakley pers. comm.).

Interestingly, all leks found during 2007 and 2008 appeared as potential leks sites in the output of the model (Figures 23, 26). A consideration when comparing model output to field data would be the time between the collection of the land cover data (2000) and the field observations (2008). It is clear that the landscape is dynamic as obvious change in land use could be noted between the two time periods. For example one of the leks (Hermanville) occurred on a site that was forested with 4 m alder in 2000 and would have been excluded from the lek potential model. Unfortunately, the majority of the changes would not favour sharp-tailed grouse nor would they likely add additional information to the model with two notable exceptions. Land clearing for blueberry production continues throughout PEI and it is speculated that the 2010 land cover inventory would provide a more accurate dataset to use with the field data collected as part of this study.

3.4.3 Limitations of models and the modelling procedure.

Limitations can be grouped based on whether they are related to interpretation of sharp-tailed grouse habitat requirements or if the limitation is related to the modelling procedure.

These models assumed that sharp-tailed grouse occupy certain land use classes. This assumption is based on information about the species from various studies throughout their native range. In reality, northeastern PEI is not a prairie landscape and the habitat types used in this model probably represent marginal sharp-tailed grouse habitat rather than the description of "above average" that would be required to meet Ammann's (1957) classification.

These models assigned value to the proportion of certain habitat types within a defined radius. This assumed that the distribution of the habitat within the range is not as important as its proportion. Alternatively, the size and distribution of patches could have been incorporated. It was felt that no value would be gained by adding complexity to the model without substantial justification. For example, it cannot be determined whether a 50 ha habitat patch would be more beneficial than two disjointed 25 ha habitat patches. It is probably a safe assumption that more suitable habitat is better; however further time spent on model refinements without a way to qualify the habitat was not warranted. An assumption made in the modelling process was that sharp-tailed grouse use the landscape in a uniform manner, radiating from a central point. In other words their home range is circular. Coastal areas, or areas bounded by forest cover may prevent this from happening.

This model gives comparable weight to two parameters (open land and percent forest cover) and gives additional weight to nest/brood cover. This may be under or over emphasizing the importance of the given parameter. The model is likely liberal in its estimate of suitable nest and brood cover. Two of the major components could vary considerably from year to year in their suitability (blueberry, hay land). Blueberry plants are perennial vines. The plant above ground is burnt or mowed typically every second year. The year following harvest, the plants are very short and would be unsuitable as nest or brood cover. Hay land may lack the structure required in April and May or may be ploughed or otherwise disturbed. Hay on PEI could be annual if it is part of a crop rotation or perennial if it is part of a livestock operation.

Other land uses may have limitations on suitability that may not have been captured by GIS. Sand dunes are sparsely vegetated and may or may not provide adequate concealment. Many of the coastal shrub lands have been impacted by recreational cottage development; this may not be fully captured by the GIS. Polygons containing "grass" as a land use were included as potential nest/brood cover. Many of these polygons would actually represent grassed lawns with limited potential for use by sharp-tailed grouse. Sharp-tailed grouse could be exploiting other land use types not accounted for in this model in unknown ways. Areas of shrub land could contain small openings capable of serving as lek sites but too small to be distinguished using aerial photography.

Another modelling approach used by Prose (1987) combined various limiting factors to create a suitability index. This approach could not have been applied directly in northeastern PEI. It is clear that suitable winter food is not limiting but it is unclear at which point the amount of winter food or percent forest cover would start to negatively impact sharp-tailed grouse during the rest of the year.

The objective of this study was to develop two GIS models that incorporate habitat criteria for sharp-tailed grouse. The first model identified locations that may be used as lek sites. It identified many potential leks sites, indicating that either site level characteristics are not limiting lek establishment or that there are other site level characteristics not considered in the model. The second model identified broad areas that may be capable of supporting sharp-tailed grouse. The model showed that there are only a small number of areas capable of supporting sharp-tailed grouse during the breeding season and these areas are not adjacent to each other. Overall, GIS proved to be a useful tool to thematically display results and these models may provide a foundation for future research.

Chapter 4.

Winter habitat use and an evaluation of the availability of winter food for sharp-tailed grouse in northeastern Prince Edward Island.

4.1 Introduction

The ability to survive the winter has severely limited introduced game birds in Prince Edward Island (Heyland 1965). Sharp-tailed grouse, however, appear to be well adapted to cold temperatures and snow and occupy a wide range of northern climates (Connelly *et al.* 1998). The presence of adequate snow cover is important as sharp-tailed grouse roost overnight in snow burrows rather than trees in winter (Grange 1948). Sharp-tailed grouse roost on top of the snow in shrubs when there is a crust preventing burrowing (Marshall and Jensen 1937). Dense cover is important to minimize heat loss from wind (Connelly *et al.* 1998). Gratson (1988) determined that grouse formed flocks when they were forced to roost in an exposed position and the flock was an anti-predator strategy. Sharp-tailed grouse did not flock when snow depth was greater than 18 cm and they could burrow (Gratson 1988).

Winter food and cover can be limiting factors for survival and to the suitability of an area to support sharp-tailed grouse (Prose 1987, Marks and Marks 1988). Prose (1987) used percent shrub cover and availability of residual grain to determine winter habitat suitability. In Idaho, areas that provided adequate food also provided thermal cover (Marks and Marks 1988). Winter food and cover were not limiting in Michigan (Ammann 1957). In addition, winter food was not believed to be limiting in Maine when it was evaluated for a sharp-tailed grouse introduction program (Applegate 1997).

The three main winter foods of sharp-tailed grouse in Wisconsin were white birch (*Betula papyrifera*) buds and catkins, trembling aspen *(Populus tremuloides)* (hereafter poplar) buds, and rose fruits (*Rosa* sp.*)* (Grange 1948). White birch catkins were considered to be their preferred winter food by Hamerstrom (1963). Schmidt (1936) also studied winter food requirements in Wisconsin and identified white birch catkins and twigs, bog birch (*Betula pumila)* buds, aspen buds, leatherleaf (*Chamaedaphne calyculata*) leaves and buds, buds from willows (*Salix* spp), cedar berries (*Thuja* sp.) and buds from cottonwoods (*Populus* sp.) to be staple food. Thomas (1984) found that 90 % of the sharp-tailed grouse diet in winter was made up of dwarf birch (*Betula glandulosa*) in Ontario. In order to be a quality bud supply, white birch and aspen should be at the edge of open habitat or in small discrete patches as dense large forest is normally avoided by sharp-tailed grouse (Schmidt 1936).

The sharp-tailed grouse has more variety in its winter diet than other species of grouse (Johnsgard 1973). Hawthorn (*Crataegus* sp.*)* fruit, buds of serviceberry (*Amelanchier* sp.*)* and choke cherry (*Prunus virginiana)* were important winter foods in Idaho and flock sizes were largest when hawthorn fruits were available (Marks and Marks 1988). Schmidt (1936) noted that when there is no snow cover, sharp-tailed grouse feed on a seeds from smartweed (*Polygonum pennsylvanicum* and *Polygonum hydropiper*), berries from wintergreen (*Gaultheria procumbens*) , snowberry (*Symphoricarpos albus*) and cranberry (*Vaccinium* sp.), and the leaves of alsike clover (*Trifolium hybridum)*, sweet clover (*Melilotus)*, alfalfa (*Medicago sativa)*, goldenrod (*Solidago* sp.*)*, strawberries (*Fragaria* sp.*)* and sheep sorrel (*Rumex acetosella)*. Evans and Dietz (1974) concluded that sharp-tailed grouse feeding exclusively on a hawthorn diet could maintain body weight. Schmidt (1936) indicated that all sharp-tails revert to a diet of browse even if other winter foods remain available.

The objective was to determine if winter food could be limiting sharp-tailed grouse in northeastern PEI. This objective was investigated in two parts. The first involved field visits to areas occupied by sharp-tailed grouse in the breeding season to observe and document evidence of winter habitat use. The second involved developing a GIS model to better understand the potential availability of winter food in northeastern PEI. The model used forested stands that contained mature white birch and poplar as a proxy for winter food. These species are the preferred winter food for sharp-tailed grouse, would be available under all snow conditions, unlike other potentially available foods. A practical assessment of the bud/catkin supply from individual stands containing white birch and poplar was not undertaken. For the purposes of this analysis an area without at least 10 % white birch and poplar within 1000 m would was considered limiting.

4.2 Materials and methods

4.2.1 Observing winter habitat use

Field surveys were conducted during January and February of 2007 and 2008. Surveys were restricted to areas believed to be occupied by sharp-tailed grouse during the breeding season based on previous reports or observations. Thus, not a random survey to determine magnitude of use. The intent was to observe grouse, their tracks and other evidence of their presence. This involved observing birds with a scope and/or binoculars while snowshoeing predetermined routes. Routes were designed to provide detailed searches along field boundaries, hedgerows and other suitable winter cover (Figure 34). Mature stands of white birch and poplar were identified on field maps for each area and visited for signs of sharp-tailed grouse. In addition, a limited number of grain fields were searched for grouse.

4.2.2 Determining available winter food using GIS.

A geoprocessing model was developed to determine the percentage of forested stands containing mature white birch and poplar (used as proxy for winter food) (Figure 35). A layer was created by querying the CLUI for forested stands which contained at least 10 % white birch or poplar with a stand height of at least 7 m. White birch begins to bear seed at about 15 years of age (Fowells 1965) and, on PEI, a 15 year old white birch tree is approximately 7 m in height (Huchinson pers. comm.). Poplar bears seed at approximately 10 years of age (Fowells 1965) and is also approximately 7 m in height (Huchinson pers. comm.). These data were converted to a raster format with a cell size of 20 m.

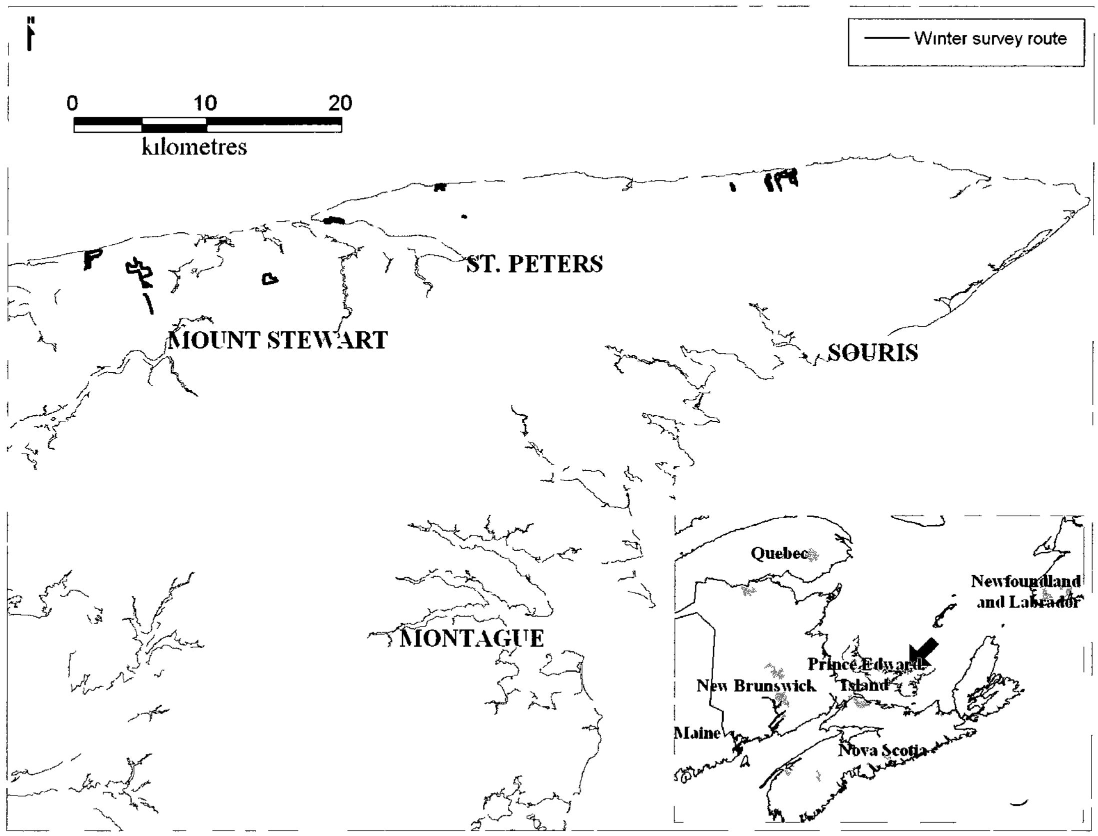

Figure 34. Map showing location of winter surveys for sharp-tailed grouse and their tracks and scat during 2007, 2008.

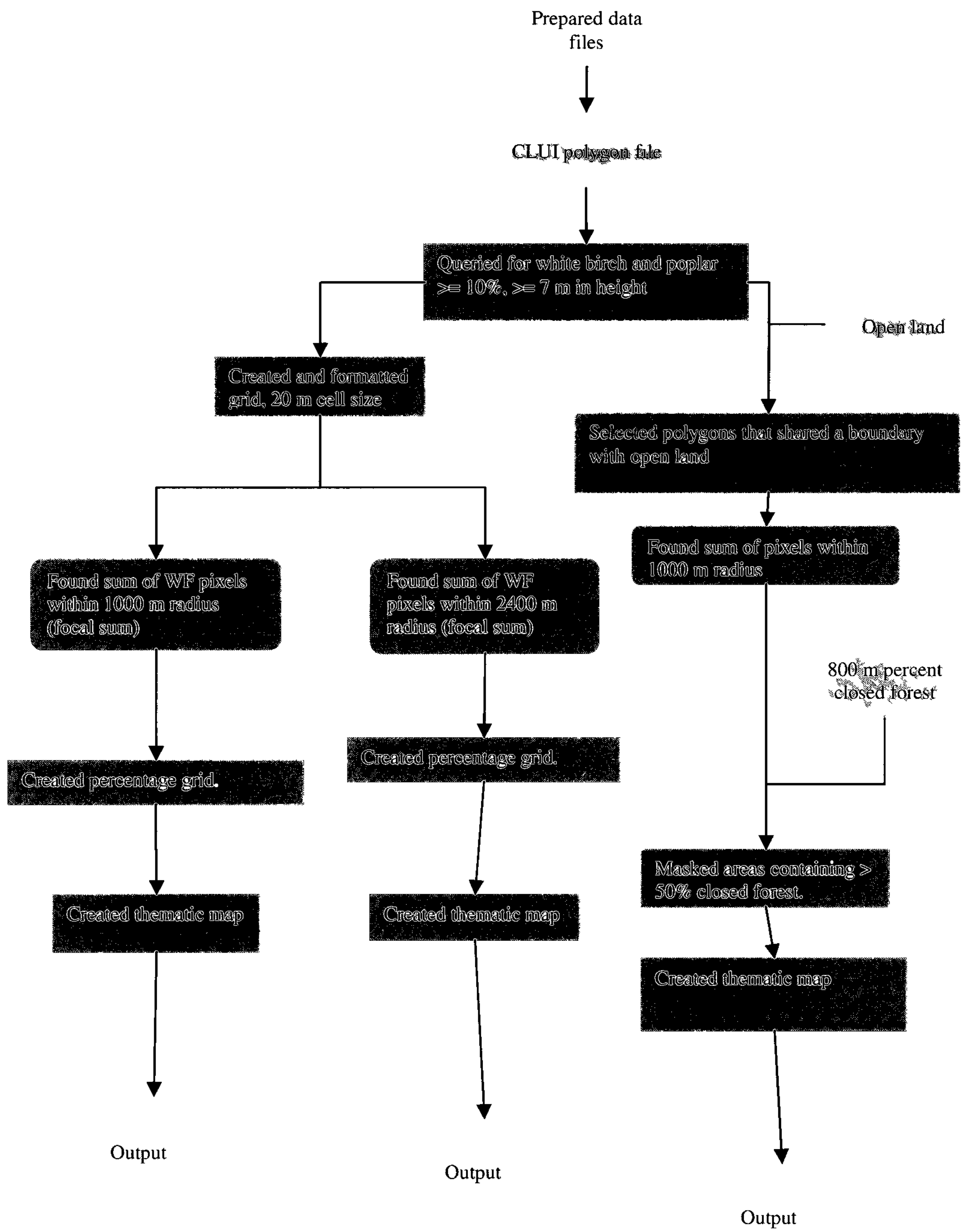

Figure 35. Geoprocessing model used to evaluate the percentage of white birch and poplar within 1000 m and 2400 m. The model also found the percentage of white birch and poplar adjacent to open land that was not part of an area containing more than 50% forest within 800 m.

The availability of winter food was considered for two radii. The minimum distance follows Gratson's (1988) estimate of winter range, approximately 1000 m. The wider radius was 2400 m and was chosen because it has been described as the distance considered critical around a lek site (Niemuth and Boyce 2004). The narrow radius was intended to identify areas capable of being a winter range independent of other characteristics such as a lek site. The wider radius was intended to identify areas where the winter range could overlap the range used in the other seasons.

This model was designed to produce three interpretable outputs. The first two were the percentage of winter food within 1000 m and 2400 m respectively. The third was a refined model, incorporating the potential accessibility of the food supply. This was done by removing forested stands that did not share a common boundary with open land types. In addition, areas not likely to be occupied by sharp-tailed grouse because of the percentage of closed canopy forest cover within 800 m were removed (previously identified in this study). This produced a thematic map showing the percentage of "available" winter food in areas "capable" of supporting sharp-tailed grouse.

These analyses considered each pixel as a focal point and used a neighbourhood processing function to determine the number (and therefore the proportion) of pixels classified as winter food (and available winter food) within the radii.

4.3 Results

4.3.1 Observed winter habitat use

Sharp-tailed grouse were visually observed on six occasions (Table 14) after a total of 44 km were surveyed. Flocks ranged in size from one to twelve. Tracks and scat from sharp-tailed grouse were observed on 15 other occasions (Table 15).

Sharp-tailed grouse were observed feeding in a white birch tree, a blueberry (*Vaccinium angustifolium)* field and grain stubble field. Tracks and partially consumed fruit provided evidence that sharp-tailed grouse were also feeding on cranberries. Bayberry (*Myrica pensylvanica)* seeds were observed in scat and evidence that sharp-tailed grouse were feeding on bayberries was observed in Hermanville. Pictures of evidence of sharp-tailed grouse feeding can be found in Appendix 2.

Snow burrows from sharp-tailed grouse were observed on multiple occasions (Figure 36a, b). Impressions in the snow and scat suggest that sharp-tailed grouse were seeking shelter in white spruce (*Picea glauca)* trees and a larch (*Larix laricina*) plantation on the edge of blueberry fields and in cattails (*Typha latifolia*) on the edge of a frozen wetland (Figure 37). Multiple tracks from sharp-tailed grouse were observed leaving a softwood thicket and walking into a snow covered blueberry field (Figure 38).

Sharp-tailed grouse were flushed or observed in flight on five occasions; on four of the five occasions, the birds initially flew over 500 m before landing. Vocalizations were heard, both from a single bird in flight and from flocks feeding and in flight. On one occasion a vocalization was heard at a distance of 300 m with wind speed of approximately 25 kph. While travelling by vehicle, nine sharp-tailed grouse were observed feeding in a grain field in Cable Head. Birds flushed from this field and flew

Table 14. Winter observations of sharp-tailed grouse.

Date	Location	Latitude	Longitude	Observation
21-Feb-07	Cable Head	46.4453	62.58	9 STGR observed feeding on ground in grain stubble
23-Jan-08	Bristol	46.4007	62.767	10 STGR feeding in one white birch tree, heard from distance of 380 m.
16-Feb-08	Anderson Rd	46.3901	62.888	3 STGR, saw and heard 1 STGR in flight and saw 2 others heading east over blueberry fields.
7-Feb-08	Hermanville	46.4721	62.273	1 STGR in flight, flying west to east.
21-Feb-08	Anderson Rd	46.4097	62.908	Observed 2 STGR in flight, flushed from ground near edge of field.
21-Feb-08	Anderson Rd	46.398	62.89	12 STGR feeding on ground in blueberry field, close to hedgerow.

Table 15. Winter observations of sharp-tailed grouse tracks and scat.

Date	Location	Longitude	Latitude	Description	Tracks	Scat
14-Feb-07	Big Pond	62.2612	46.4670	Edge of blueberry field under young spruce trees	Yes	Yes
14-Feb-07	Hermanville	62.2836	46.4693	Tracks under meteorological tower	Yes	No
21-Feb-07	Cable Head	62.6024	46.4668	Observed tracks and scat	Yes	Yes
21-Feb-07	Cable Head	62.6034	46.4649	Collected scat from frozen wetland	Yes	Yes
21-Feb-07	Big Pond	62.2610	46.4666	Tracks in hedgerow	Yes	Yes
21-Feb-07	Cable Head	62.5799	46.4453	Tracks in hedgerow	Yes	Yes
22-Oct-07	Bristol	62.7612	46.4018	Observed tracks in sand	Yes	No
23-Jan-08	Bristol	62.7607	46.4022	Tracks and scat on lek site	Yes	Yes
23-Jan-08	Bristol	62.7676	46.4040	Tracks and scat in hedge	Yes	Yes
7-Feb-08	Hermanville	62.2706	46.47	Tracks and scat observed in wild rose	Yes	Yes
7-Feb-08	Hermanville	62.2744	46.4663	Stand of young birch trees	Yes	Yes
16-Feb-08	Anderson Road	62.8883	46.3904	Multiple tracks and snow burrows. Tracks extending into blueberry fields. No tracks beyond 5m into cover.	Yes	Yes
21-Feb-08	Anderson Road	62.9074	46.4097	Tracks on edge of blueberry field, extending 5m into woods.	Yes	Yes
21-Feb-08	Anderson Road	62.8923	46.3991	Multiple sets of tracks (7) leading from edge of spruce plantation into blueberry field.	Yes	Yes
21-Feb-08	Anderson Road	62.8901	46.3979	Tracks and scat in hedge (birch) extending toward lek site.	Yes	Yes

Figure 36a. Snow burrow with scat found in larch plantation on edge of large blueberry field, Anderson Road winter 2008.

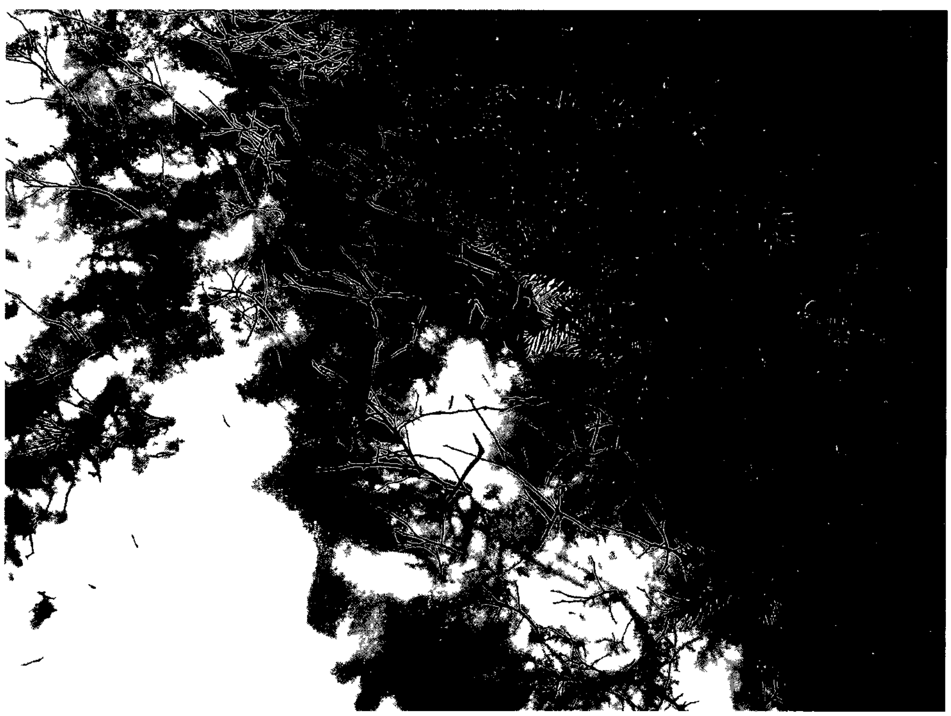

Figure 36b. Depression in snow and scat left by sharp-tailed grouse seeking shelter in white spruce hedge on edge of blueberry field, Hermanville winter 2007.

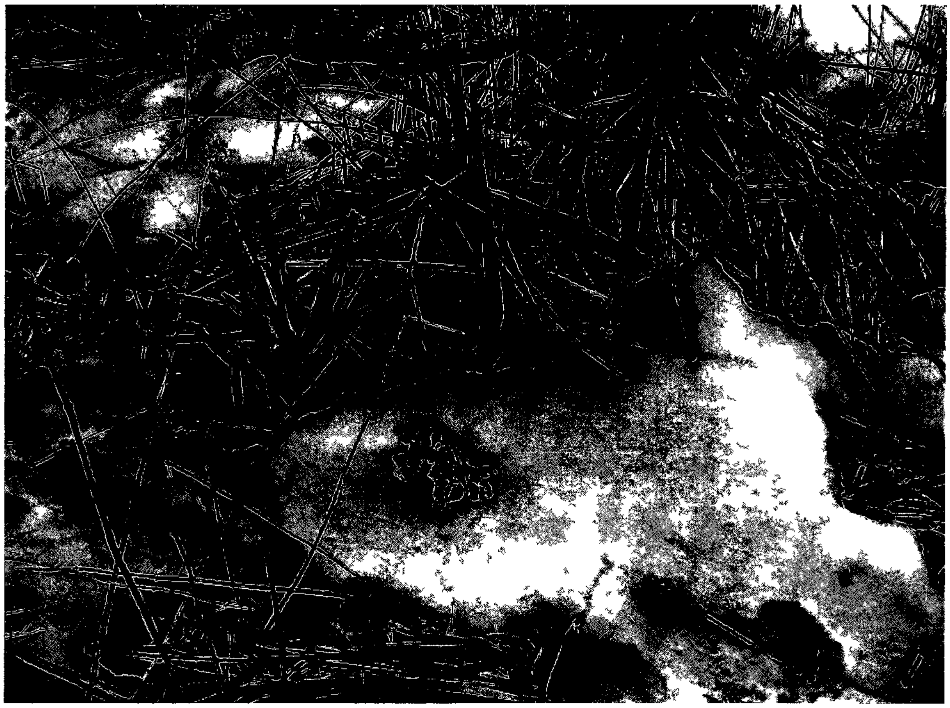

Figure 37. Depression in snow and scat left by sharp-tailed grouse on frozen wetland, Cable Head 2007.

Figure 38. Tracks from multiple sharp-tailed grouse leaving snow burrows and walking into snow covered blueberry fields, Anderson Road February 2008.

toward the open in a south easterly direction, over a road in a tight flock. The birds were vocalizing while flying.

Evidence that sharp-tailed grouse are visiting leks during winter was found in Bristol and Anderson Road (Figure 39). No evidence of activity was found on the Hermanville lek.

4.3.2 GIS model of white birch and poplar

In the entire study area there were only three sites that were not within 1000 m of a preferred winter food source. These were located on the tip of the sand spit in Tracadie, the easterly point of the Greenwich sand spit and a developed area in the town of Souris. All points in the study area were within 2400 m of winter food.

Model output shows that the majority of the northeastern portion of the study area contained greater than 50 % winter food within 1000 m (Figure 40). It is a gradient from a large high percentage area in the center to a peripheral band along the coastline which contained less than 10 % (Figure 40). Virtually all pixels contain 10 % winter food within the 2400 m radius (Figure 41). There are two large two large areas, one in the central portion and another covering most of the northeastern portion that have at least 40 %. The refined winter model follows a pattern of low percentage in most coastal areas and high percentage inland (Figure 42).

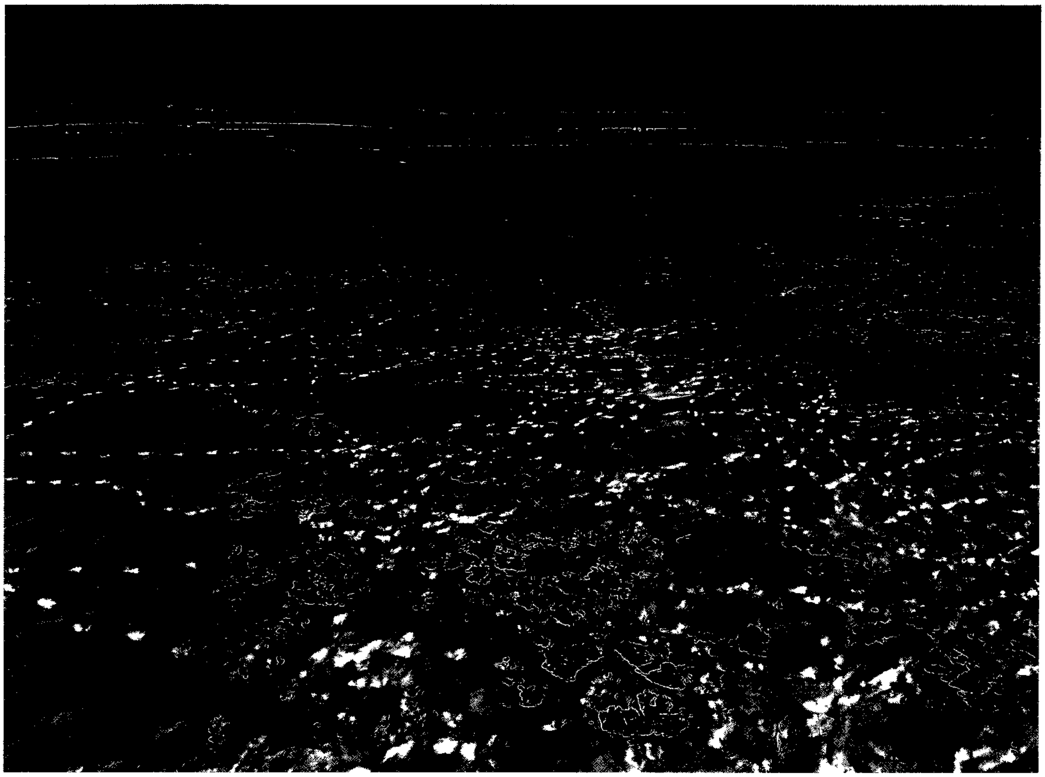

Figure 39. Tracks from sharp-tailed grouse on Anderson Road lek, February 2008.

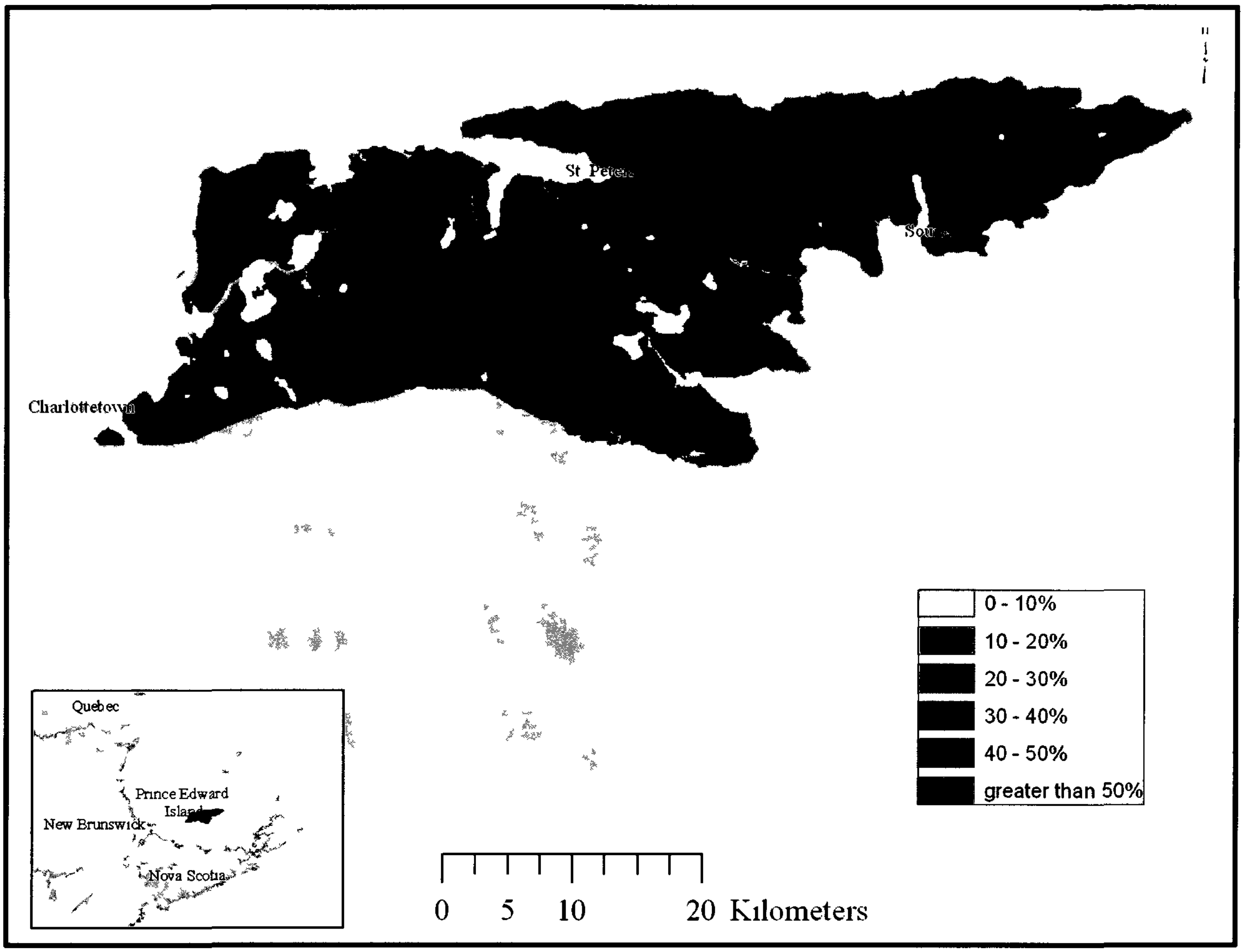

Figure 40. Percentage of white birch and poplar within 1000 m of each pixel.

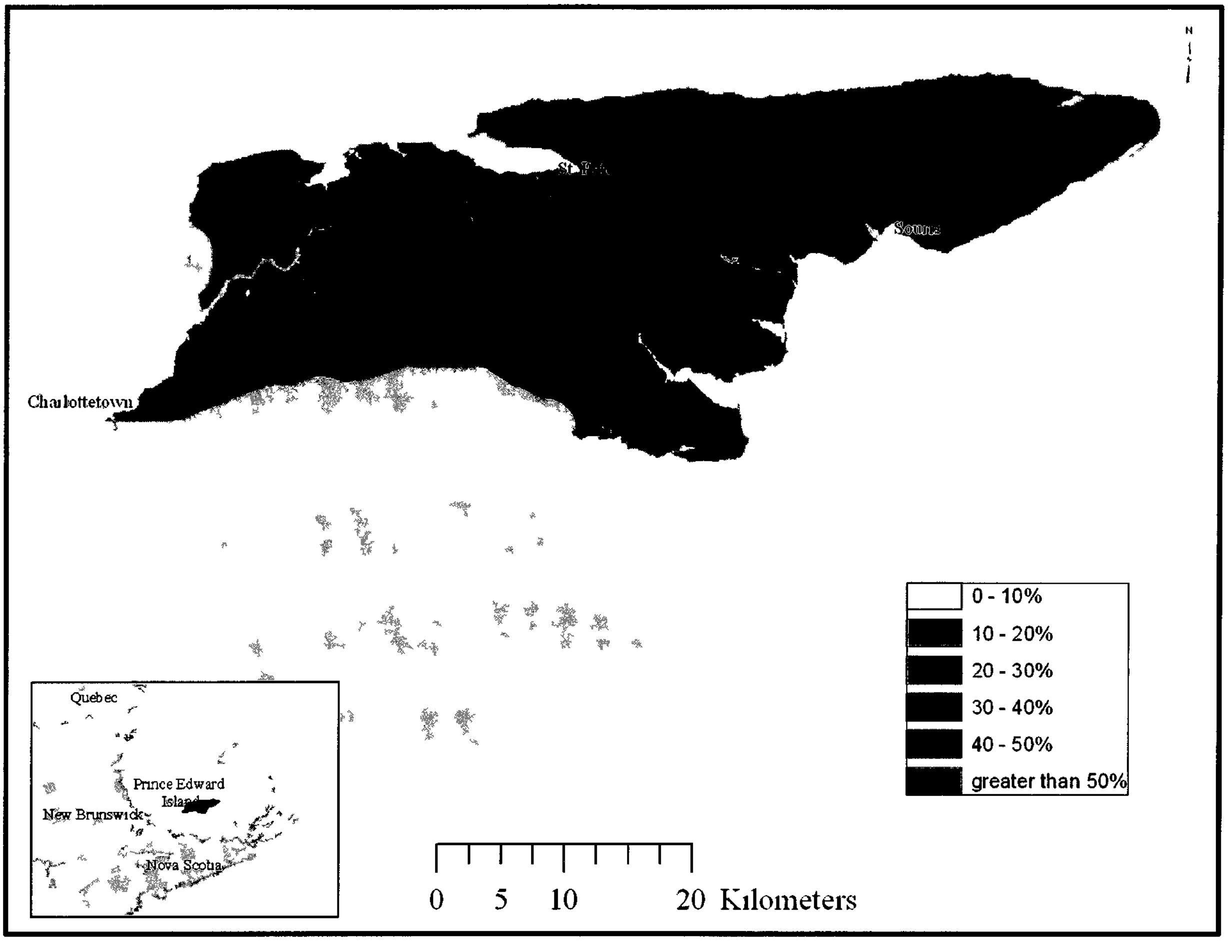

Figure 41. Percentage of white birch and poplar within 2400 m of each pixel.

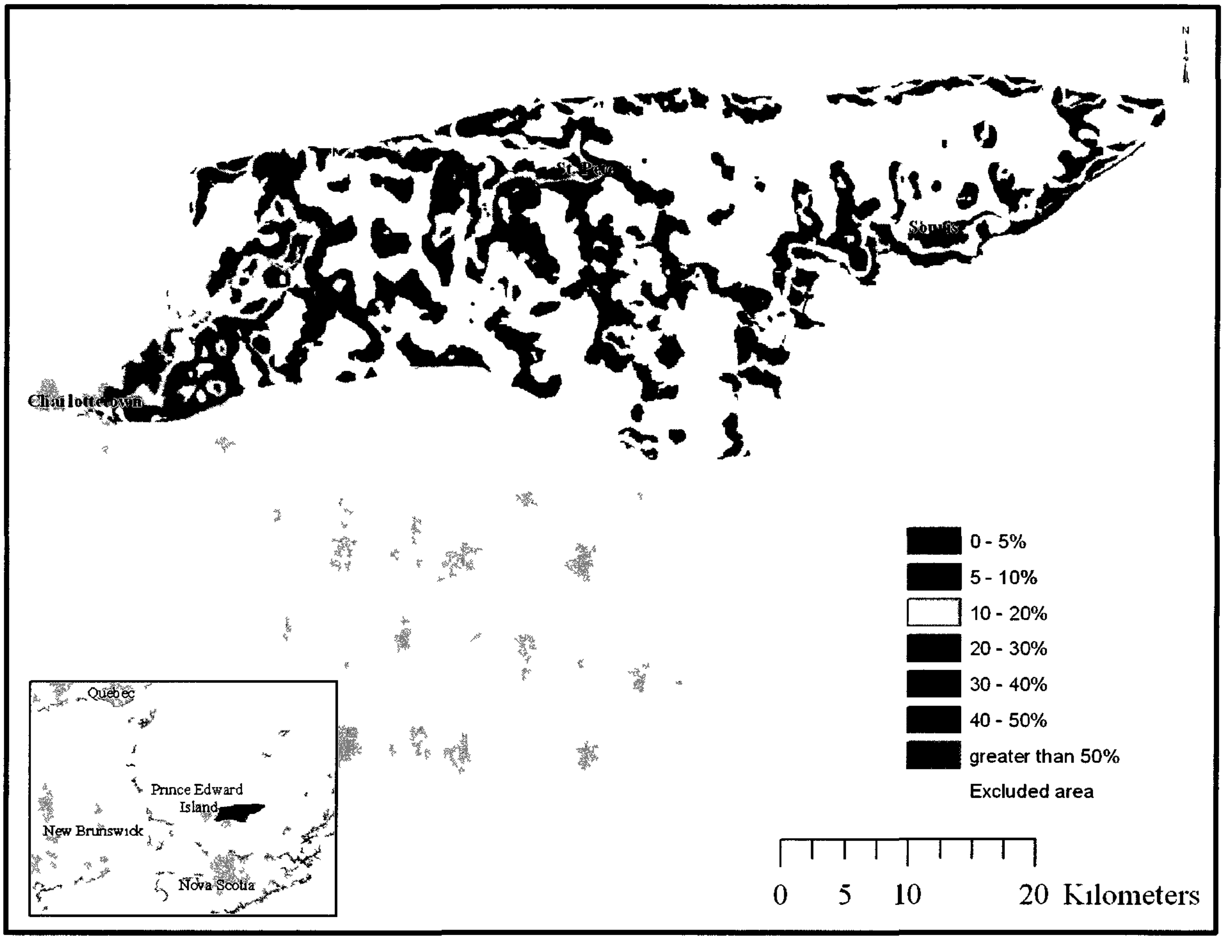

Figure 42. Percentage of accessible white birch and poplar within 1000 m of each pixel, excluding areas that have more than 50 % forest within 800 m.

4.4 Discussion

The objective of this analysis was to determine if sharp-tailed grouse are occupying the same area during winter as they did during the breeding season and to determine if winter food could be limiting in northeastern PEI.

Two tree species capable of providing winter food for sharp-tailed grouse occur in abundance in northeastern PEI. In addition, other suitable winter foods such as fruit from wild rose, and hawthorn would be available under most snow conditions. Residual agricultural crops such as grain and blueberries are also available throughout much of the winter. The landscapes where winter food and cover are limiting sharp-tailed grouse in other studies such as described by Prose (1987) are probably not comparable to northeastern PEI. However, if the entire province was considered, the predominantly agricultural areas in eastern Prince and western Queen's counties might contain this limitation.

4.4.1 Winter habitat use

Sharp-tailed grouse were observed on multiple occasions as winter surveys proved effective when conditions were favourable. A major limiting factor was snow conditions conducive with track observation. These surveys required fresh snow and low wind.

Evidence of sharp-tailed grouse on lek sites in winter is contrary to findings of Marks and Marks (1988) who determined males stopped visiting leks once they were snow covered. It suggests that in at least two cases, birds are using the same basic range for two of their critical requirements and that at least some sharp-tailed grouse are remaining in proximity to the lek site in winter. This is intuitive as much of the land use surrounding the lek sites consists of closed canopy softwood forest, believed to be unsuitable for sharp-tailed grouse. It is still possible, however, that other individuals or groups of birds are occupying other areas during winter. Sharp-tailed grouse would not have to vacate their spring and summer range in search of winter food.

4.4.2 GIS model of white birch and poplar

The winter food model showed that two trees species which provide the preferred winter food for sharp-tailed grouse are abundant in most areas of northeastern PEI. Only a small number of coastal areas did not contain at least 10 % white birch and poplar within 1000 m. In general, there are no areas without access to winter food but probably many that are unsuitable because they have too much limiting closed canopy forest. Determining the ideal threshold for percent winter food was beyond the scope of this study but is assumed to be quite low. Prose (1987) compiled information that determined an area could support sharp-tailed grouse with only one percent shrub cover but closer to ten percent was ideal. These studies need to be put in context because they refer to prairie landscape where forest is absent and the shrub cover is providing both food and cover.

The peripheral band indicating a low percentage of winter food along the coast is deceiving because a circular neighbourhood was used. The model takes into consideration all pixels that would include large areas of water. For example if a minimum threshold of 10 % was applied, many coastal areas would be excluded in this model but included if only the land area was considered. This is based on an assumption of a circular range.

Another important consideration is that these models assessed winter food for only two preferred foods: white birch and poplar. Many other foods capable of sustaining sharp-tailed grouse in winter occur in abundance in northeastern PEI such as pincherry and mountain ash. However, incorporating additional foods into the model would be redundant and provide no added value. Without data to qualify individual stands as food supply it must remain a general tool.

The refined winter model is speculative and without a suitable range of values or threshold it is difficult to interpret. It is reasonable to assume that areas with a smaller percentage of winter food are more likely to provide year round sharp-tailed grouse habitat. When the results of this model are compared with actual field observations it is clear that drawing firm conclusions from this model are not possible.

The field survey did not follow a statistically valid sample design. Surveying winter habitat had practical limitations including weather and timing. In addition, the ability to detect the target species was an issue. Another winter survey technique used in Manitoba included low level flying with the intent of flushing flocks of sharp-tailed grouse from cover (Ball pers. comm.). This method was deemed impractical. The line transect method was also considered however was not implemented because of the level of effort required.

Winter observations showed that at least in some cases sharp-tailed grouse were occupying the same area in the winter as they were in the breeding season. The GIS model clearly demonstrated that two preferred foods, white birch and poplar, occurred throughout northeastern PEI.

Chapter 5.
Summary and Management Implications

5.1 Introduction

The objective of this study was to learn more about sharp-tailed grouse and the capacity of PEI to support sharp-tailed grouse. From the results of this investigation it is clear that sharp-tailed grouse have survived, reproduced and expanded their range independent of additional stocking efforts since 1990. However, it is also clear that north-eastern PEI contains limited sharp-tailed grouse habitat particularly during the nesting season. Sharp-tailed grouse require large areas of open land and perennial or residual cover to meet basic life needs. Prince Edward Island can best be described as a mosaic or patchwork of discrete land use types, most of which are not used by sharp-tailed grouse. Winter food supply was not believed to be limiting and it is reasonable to assume that, in most of the area studied, the high proportion of forest cover is limiting sharp-tailed grouse expansion.

This investigation found no areas meeting the minimum area requirement of 4000 ha suggested by Temple (1991) nor was evidence found to suggest the areas currently occupied by sharp-tailed grouse on PEI meet his minimum spring population requirement of 280 birds. Temple (1991) suggested that to have a significant probability of survival, five large populated areas are required. This is unlikely to be the case for PEI and thus there can be no confidence that the sharp-tailed grouse population is viable over the long term. One of any number of foreseeable events such as reforestation of blueberry land, coastal development, or abandonment of pasture in favour of crop production could have negative consequences, let alone those that are unforeseen.

This study cannot discount the possibility that large areas under cultivation could provide a benefit to sharp-tailed grouse in certain years or field configurations. However, the timing of key life requirements such as lekking and nesting are in direct conflict with the timing of land preparation and planting for potatoes, grain and other crops. In addition, while hay fields may provide adequate nest conditions at the onset, the timing of hay cutting may pose additional problems for newly hatched broods. Three of the leks observed were in close proximity to areas under commercial blueberry production. Blueberry fields, in the year of harvest may satisfy a number of requirements: food, cover, nest and lek sites. Blueberry fields that have been manipulated following harvest (either mowed or burnt) provide no benefit as cover and nest sites are no longer available. Further conversion of land to blueberries, particularly in large connected areas, would certainly provide benefit to sharp-tailed grouse and could benefit the population.

Many of the conclusions are based on limited field observations and carry with them certain limitations. The field program was restricted by time, largely because of weather conditions. Winter field surveys could only be conducted when suitable snow conditions made it likely that evidence would be collected if it existed. Detecting lek sites and counting displaying males was limited to weather conditions conducive to sound transmission and visibility. In addition, the peak of male sharp-tailed grouse activity on leks sites occurs between ½ hour before sunrise and 2 hours after. This limited the number of routes that could be sampled.

Managing land on PEI specifically for sharp-tailed grouse would require deforestation and maintaining the land use in an early succession stage. The general management practices used by commercial blueberry growers appear to favour the type of land use and active management required by sharp-tailed grouse.

Land conversion on the scale required to produce a viable sharp-tailed grouse population would be detrimental to many native wildlife species such as red squirrel (*Tamiasciurus hudsonicus*), snowshoe hare (*Lepus americanus)*, and many species of forest dependant birds, amphibians and reptiles. In addition, many provincial and federal programs (such as Alternate Land Use Services and the Provincial Forest program) are designed to reforest retired farmland.

The information gathered as a result of this study can be put to immediate practical use for wildlife management on PEI. The methods used to quantify available habitat for sharp-tailed grouse can be easily adapted to ring-necked pheasant, gray partridge and the eastern wild turkey all of which have been or proposed to be introduced or transferred to other areas of the province. This approach is a course filter, allowing the wildlife manager to visualize potential available habitat on a landscape scale. This could be important for guiding decisions on new introductions or risk assessment for exotic species. In addition, the wildlife manager can use the results of this study to make specific management decisions related to sharp-tailed grouse on PEI.

5.2 Prince Edward Island's capacity to support a hunting season.

Sharp-tailed grouse are large, relatively conspicuous birds that prefer open areas. As such, it is the opinion of the author that these characteristics have led to the misconception that the sharp-tailed grouse population is higher than it actual is. While this study is far from exhaustive, it is clear that sharp-tailed grouse habitat requirements are very specific and the amount of suitable habitat on PEI is limited. Suitable areas are restricted in both number and distribution.

Sharp-tailed grouse are under immediate threat on PEI. A downturn in the blueberry industry would probably eliminate the sharp-tailed grouse population in a matter of years by removing a large component of potentially suitable habitat. Even a relatively minor change in the management practices such as planting of hedgerows or trees would be detrimental. Lek sites are also under threat. Of the four confirmed lek sites, one has a newly built cottage in close proximity, one was tilled during the courtship season and another has numerous conifer trees planted on or near it.

Most sharp-tailed grouse, if hatched successfully, are not surviving to enter the breeding population. Sharp-tailed grouse have high reproductive potential with an average clutch size of approximately twelve eggs (Ammann 1957). Two plausible scenarios are that juvenile sharp-tailed grouse are dispersing into unsuitable habitat and eventually dying without reproducing, or that nest success is low or both. Numerous reports of single birds have occurred in places such as Brackley, Glenfinnan, Vernon, Panmure Island which generally supports the first but probably a combination of both are occurring.

Sharp-tailed grouse populations on PEI are probably under long term threat because of low genetic variability. It is plausible that all sharp-tailed grouse currently on PEI are descendants of very few male birds since the initial release included only 25 males. On a lek, only birds occupying central territories usually have the opportunity to mate.

The opening of a fall hunting season would present an immediate threat to the overall population. Temple (1991) found that hunting can negatively impact short term viability of sharp-tailed grouse populations. Large leks are conspicuous and without some form of buffer zone or protective measure, hunters could easily target territorial males because they also establish and maintain territories in the fall (Evans 1969). Sharp-tailed grouse are particularly sensitive to human presence around the lek therefore disturbing any of the leks for an extended period of time may cause the birds to abandon the site altogether.

Sharp-tailed grouse are currently protected by the provincial Wildlife Conservation Act. Whether to hunt or even protect sharp-tailed grouse on PEI is a philosophical rather than a management question. This study can not provide the required scientific evidence to justify even a limited sharp-tailed grouse hunting season at this time.

5.3 Management Recommendations

If the goal is to develop and maintain a sharp-tailed grouse population on PEI that is viable in the long-term, the following management measures are recommended.

- Sharp-tailed grouse are linked to commercial blueberry growing areas so any effort to manage should initially focus on these areas.
- Sharp-tailed grouse are under threat from coastal development and this threat should be mitigated.
- Sharp-tailed grouse require intensive land management. Two options for PEI are clearing forested land in large blocks (4000 ha) or abandoning existing agricultural land and maintaining both in an early succession state.

- A viable sharp-tailed grouse population may require more genetic diversity. Genetic diversity should be assessed and augmented by additional releases if required.
- At the current estimated population level, a hunting season is not recommended. This could be re-evaluated if habitat conditions change drastically.

5.4 Further Study

Before proceeding with any active management, additional information is required. Sharp-tailed grouse are exploiting commercial blueberry fields on PEI. The impact of sharp-tailed grouse on these areas was beyond the scope of these analyses but could be investigated. They are using blueberry fields for a number of activities including lekking, nesting and feeding. Additional topics of interest include the success rate of nests in these fields and the impact of human disturbance. In addition, chemical treatments are applied to control pests (insecticides) and undesirable plant species (herbicides). Both of these treatments could impact sharp-tailed grouse life cycle as sharp-tailed grouse chicks feed on insects and juveniles and adults on various parts of leafy plants. Large areas of land have been converted to blueberry production since 2000. The land use inventory will be updated in 2010. This will be a good opportunity to revisit the model and determine if available habitat has increased or decreased and identify any areas large enough to support sharp-tailed grouse.

Another question that remained unanswered is whether or not the leks found in this study are connected by smaller satellite leks or large undetected leks in between. Do sharp-tailed grouse exist on PEI as a metapopulation, effectively isolated from each other with limited exchange of genetic material from dispersing birds? Two observations lead to the impression that the birds around each lek are geographically isolated from the birds around the other leks. The three largest areas are surrounded by considerable distances of forest. In addition, the Anderson Road area appeared large enough to support multiple leks while only one large lek was found. The genetic diversity of sharp-tailed grouse on PEI could be compared to samples from their native range to see if diversity has been lost.

Climate may play an important role in the difference in nest success or survival of chicks. A failed introduction attempted in Maine was partially attributed to a greater amount of precipitation than the native range (Applegate 1997). The climographs for various western sharp-tailed grouse areas could be analyzed and compared. Specific references will be required to determine what, if any, impact a difference in climatic conditions would have on the suitability of PEI to support sharp-tailed grouse.

Chapter 6.
Literature cited

Aldrich, J.W. 1963. Geographic orientation of American Tetraonidae. Journal of Wildlife Management 27: 529-544.

Ammann. G.A. 1957. The Prairie Grouse of Michigan. Department of Conservation, Lansing, 200 pp.

Ammann, G.A. 1963. Status and management of sharp-tailed grouse in Michigan. Journal of Wildlife Management 27: 802-809.

Applegate, R.D. 1997. Introductions of sharp-tailed grouse into Maine. Northeastern Naturalist 4: 105-110.

Ball, G. Personal communication. Wetlands Specialist, Manitoba Conservation.

Baydack, R. K., and Hein D. A. 1987. Tolerance of sharp-tailed grouse to lek disturbance. Wildlife Society Bulletin 15: 535-539.

Baydack, R. K. 1988. Characteristics of sharp-tailed grouse, *Tympanuchus Phasianellus*, leks in the parklands of Manitoba. Canadian Field-Naturalist 102: 39-44.

Brown, R.L. 1966. Response of sharp-tail breeding populations to annual changes in residual grassland cover. Proc. Annu. Conf. West. Assoc. State Game and Fish Comm. 46: 219-222.

Bump, G., Darrow, W., Edminster, F.C. and Crissey, W.F. 1947. The Ruffed Grouse - Life History, Propagation, Management. New York State Legislature, 915 pp.

Bump, G. 1951. Game introductions - when, where, how. Transactions of the North American Wildlife Conference 16: 316-325.

Bump, G. 1963. Status of the foreign game introduction program. Transactions of the North American Wildlife and Natural Resources Conference 28: 240-247.

Cannon, R.W., and Knopf, F.L. 1981. Lek numbers as a trend index to prairie grouse populations. Journal of Wildlife Management 45: 776-778.

Cassey P, Blackburn, T.M., Duncan, R.P. and Gaston, K.J. 2005. Causes of exotic bird establishment across oceanic islands. Proceedings: Biological Sciences 272: 2059-2063.

Cole F. R., Loope, L. L., Medeiros, A.C., Raikes, J.A. and Wood, C.S. 1995. Conservation implications of introduced game birds in high-elevation Hawaiian shrubland. Conservation Biology 9: 306-313.

Connelly, J.W., Gratson, M.W. and Reese, K.P. 1998. Sharp-tailed Grouse (*Tympanuchus Phasianellus*). In A. Poole and F. Gill, editors, The Birds of North America, No. 354. The Birds of North America, Inc., Philadelphia, PA.

Dibblee, R.L. 2006. PEI Game Survey 2005-2006. PEI Environment, Energy and Forestry, Charlottetown, 6 pp.

Dibblee, R.L. Personal communication. Wildlife Biologist, P.E.I. Department of Environment, Energy and Forestry.

Erskine, A.J. 1992. Atlas of the Maritime Breeding Birds of the Maritime Provinces. Nova Scotia Museum, Halifax, 270 pp.

Evans, R.M. 1969. Territorial stability in Sharp-tailed Grouse. Wilson Bulletin 81: 75-78.

Evans, K.E., and Dietz, D.R. 1974. Nutritional energetics of sharp-tailed grouse during winter. Journal of Wildlife Management 38: 622-629.

Foulkes, S. Personal Communication. Birder, St. Margarets. PEI.

Fowells, H.A. 1965. Silvics of Forest Trees of the United States. U.S. Department of Agriculture. Washington, D.C. 762 pp.

Giesen, K.M. and Connelly, I.W. 1993. Guidelines for management of Columbian Sharp-tailed Grouse habitats. Wildlife Society Bulletin 21: 325-333.

Gillespie, M. Personal Communication. Wildlife Biologist, Manitoba Conservation.

Grange, W.B. 1948. Wisconsin Grouse Problems. Wisconsin Conservation Department. Madison. 318 pp.

Gratson, M.W. 1988. Spatial patterns, movements, and cover selection by sharp-tailed grouse. Pages 158–192. *in* Bergerud, A. T. and M. W. Gratson, editors. Adaptive strategies and population ecology of northern grouse. University of Minnesota. Minneapolis, USA. 419 pp.

Gregg, L. 1987. Recommendations for a program of sharptail habitat preservation in Wisconsin. Research Report 141, Wisconsin Department of Natural Resources, Madison, Wisconsin, USA.

Hagen, C.A., Jamison, B.E., Robel, R.J. and Appelgate, R.D. 2002. Ring-necked pheasant parasitism of lesser prairie-chicken nests in Kansas. Wilson Bulletin 114: 522-524.

Hamerstrom, F.N. 1939. A study of Wisconsin's Prairie Chickens and Sharp-tailed Grouse. Wilson Bulletin 51: 105-120.

Hamerstrom, F. N., Jr. 1963. Sharptail brood habitat in Wisconsin's northern pine barrens. Journal of Wildlife Management 27: 792-802.

Hannon, S.J. and Martin, K. 2006. Ecology of juvenile grouse during the transition to adulthood. Journal of Zoology 269: 422-433.

Hanowski, J.M., Christian, D.P. and Niemi, G.J. 2000. Landscape requirements of prairie sharp-tailed grouse *Tympanuchus phasianellus campestris* in Minnesota, USA. Wildlife Biology 6: 257-263.

Harrison, C. 1978. A Field Guide to Nests, Eggs and Nestlings of North American Birds. Collins. Toronto. 625 pp.

Heyland, J.D. 1965. The decline of grey partridge *Perdix perdix* and ring-necked pheasant *Phasianus colchicus* on Prince Edward Island, 1955-61. Canadian Wildlife Service, Ottawa.

Homer, C.G., Edwards JR, T.C., Ramsey R.D. and Price K.P. 1993. Use of remote sensing methods in modeling sage grouse winter habitat. Journal of Wildlife Management 57: 78-84.

Hutchinson, P.J., Personal communication, Inventory Forester, PEI Department of Environment, Energy and Forestry.

Johnsgard, P.A. 1973. Grouse and Quails of North America. University of Nebraska Press. Lincoln. 553 pp.

Johnson, K., Neville, T., and Neville, P. 2006. GIS habitat analysis for lesser prairie-chickens in southeastern New Mexico. BMC Ecology 6. 20 pp.

Kelly, G. Personal communication, Forest Technician, PEI Department of Environment, Energy and Forestry.

Kimmel, R.O. 1988. Pages 253-265 In Hallet, D.L., Edwards, W.R., Burger, G.V. (editors.), Pheasants: Symptoms of Wildlife Problems on Agricultural Lands. North Central Section of The Wildlife Society, Bloomington, IN. 345 pp.

Kirsch, L.M., Klett, A.T. and Miller, H.W. 1973. Land use and prairie grouse relationships in North Dakota. Journal of Wildlife Management 37: 449-453.

Larson, M. 2005. Ruffed grouse and sharp-tailed grouse surveys in Minnesota during spring 2005. Minnesota Department of Natural Resources, Grand Rapids, Minnesota, USA.

Leopold, A. 1933. Game Management. Charles Scribner's Sons. N.Y. 481 pp.

Leopold, A.S. 1953: Intestinal morphology of gallinaceous birds in relation to food habits. Journal of Wildlife Management 17: 197-203.

MacIntyre, G. Personal communication. Conservation Officer, Prince Edward Island Fish and Wildlife Division.

MacQuarrie, I.G., and Guignion, D. 1969. Gray partridge on Prince Edward Island - studies on distribution and abundance in relation to environment. Department of Biology, University of Prince Edward Island, Charlottetown.

Manzer, D.L. and Hannon, S.J. 2005: Relating grouse nest success and corvid density to habitat: a multi-scale approach. Journal of Wildlife Management 69: 110-123.

Marks, J. S. and Marks, V. S. 1988. Winter habitat use by Columbian Sharp-tailed Grouse in western Idaho. Journal of Wildlife Management 52:743-746.

Marshall, E.J.P., Brown, V.K., Boatman, N.D., Lutman, P.J.W., Squire, G.R., and Ward, L.K. 2003. The role of weeds in supporting biological diversity within crop fields. Weed Research 43: 77-89.

Marshall, W. H., and Jensen, M. S. 1937. Winter and spring studies of the sharp-tailed grouse in Utah. Journal of Wildlife Management 1: 87-99.

Mitchell, J. 1984. Managing grouse: looking to the future. Nebraskaland 62: 10-13.

Moyles, D.L.J. 1981. Seasonal and daily use of plant communities by Sharp-tailed Grouse (*Pedioecetes phasianellus*) in the parklands of Alberta. Canadian Field Naturalist 95: 287-291.

Moyles, D.L.J. and Boag, D.A.. 1981. Where, when, and how male sharp-tailed grouse establish territories on arenas. Canadian Journal of Zoology 59: 1576-1581.

Mullally, D. 1992. Field survey Prince Edward Island sharp-tailed grouse March 1991-January 1992. Report to Fish and Wildlife Branch, P.E.I. Department of Environment. 5 pp.

Nack, J.L., and Ribic, C.A. 2005. Apparent predation by cattle at grassland bird nests. Wilson Bulletin 117: 56-62.

Niemuth, N.D. 2003. Identifying landscapes for greater prairie chicken translocation using habitat models and GIS: a case study. Wildlife Society Bulletin 31: 145-155.

Niemuth, N.D. and Boyce, M. S. 2004. Influence of landscape composition on sharp-tailed grouse lek location and attendance in Wisconsin pine barrens. Ecoscience 11: 209-217.

Oakley, D. Personal communication. Instructor, Wildlife Resources Program, Holland College, Charlottetown, Prince Edward Island.

PEI DAF 2003, Corporate Land Use Inventory for Prince Edward Island, Department of Agriculture and Forestry. Charlottetown, Prince Edward Island.

PEI FW 2006, Compiled records from the Forests, Fish and Wildlife Division. Department of Environment, Energy and Forestry. Charlottetown, Prince Edward Island.

Pepper, G.W. 1972. The ecology of Sharp-tailed Grouse during spring and summer in the aspen parklands of Saskatchewan. Saskatchewan Department of Natural Resources. Regina, Saskatchewan. Wildlife Report Number One. 55 pp.

Prose, B.L. 1987. Habitat suitability index models: plains sharp-tailed grouse. U.S. Fish Wildlife Service. Biological Report 82(10.142). 31 pp.

Quinn, R.J. 1970. Spring survey of sharp-tailed grouse and cock pheasant. Wildlife Branch. Department of Natural Resources. Regina, Saskatchewan.

Ramsey, R.D., Black, T.A., Edgley, E., and Yorgason, N. 1999. Use of GIS and Remote sensing to map potential Columbian sharp-tailed Grouse Habitat in southern Idaho. A final report to the USDI/BLM, Malad field Station, Idaho.

Rickers, J.R.; Queen, L.P. and Arthaud, G.J. 1995. A proximity-based approach to assessing habitat. Landscape Ecology 10: 309-321.

Rippin, A.B. and Boag, D.A. 1974. Recruitment to populations of male sharp-tailed grouse. Journal of Wildlife Management 38: 616-621.

Rodd, 1949. A letter from the director of Fisheries, P.E.I. Department of Industry and Natural Resources, Charlottetown, Prince Edward Island.

Schmidt, F. J. 1936. Winter food of the sharp-tailed grouse and pinnated grouse in Wisconsin. Wilson Bulletin 48: 181-204.

Schroeder, M.A. and Baydack, R.K. 2001. Predation and the management of prairie grouse. Wildlife Society Bulletin 29: 24-32.

Smith, H.A. 1978. An experimental introduction of the Japanese green pheasant (*Phasianus versicolor robustipes* delacour) into Prince Edward Island. Thesis for Masters of Science. Acadia University, Wolfville. 148 pp.

Smith, H.A 1983. Memorandum from the Director of the Fish and Wildlife Division. Prince Edward Island Department of Community Affairs, Charlottetown.

Snyder, J.W., Pelren, E.C., and Crawford, J.A. 1999. Translocation histories of prairie grouse in the United States. Wildlife Society Bulletin 27: 428-432.

Sol, D., Timmermans, S. and Lefebvre, L. 2002. Behavioural flexibility and invasion success in birds. Animal Behavior 63: 495-502.

Tapper, S.C., Potts, G.R., and Brockless, M.H. 1996. The effect of an experimental reduction in predation pressure on the breeding success and population of gray partridge *Perdix perdix*. Journal of Applied Ecology 33: 965-978.

Temple, S.A. 1991. Population viability analysis of a Sharp-tailed Grouse metapopulation in Wisconsin. Pages 750-758 in Wildlife 2001: Populations. McCullough and Barrett editors. Elsevier Applied Science Publishers Ltd. New York, N.Y. 1164 pp.

Thomas, V.G. 1984. Winter diet and intestinal proportions of rock and willow ptarmigan and sharp-tailed grouse in Ontario. Canadian Journal of Zoology 62: 2258-2263.

Tsuji, L.J.S. 1996. Do female sharp-tailed grouse, *Tympanuchus phasianellus*, copulate only once during a breeding season? Canadian Field-Naturalist 110: 535-536.

Tufts, R.W. 1939. Hungarian partridge in Prince Edward Island. Canadian Field Naturalist 53: 122.

Westemeier, R.L., Brawn, J.D., Simpson, S.A., Esker, T.L., Jansen, R.W., Walk, J.W., Kershner, E.L., Bouzat, J.L. and Paige, K.N. 1998. Tracking the long-term decline and recovery of an isolated population. Science 282: 1695-1698.

Appendix A.

Summary of numbers of sharp-tailed grouse released on PEI

Table A.1. Summary of numbers of sharp-tailed grouse captured and released on PEI.

Year	Origin	Date	# of Birds	Sexes	# Released Alive
1987	Manitoba	April 14	4	2 ♂♂; 2 ♀♀	3
1987	Manitoba	April 15	6	6 ♂♂	4
1987	Manitoba	April 21	2	1 ♂; 1 ♀	2
1987	Manitoba	April 22	6	5 ♂♂; 1 ♀	6
1987	Manitoba	April 23	8	1 ♂; 7 ♀♀	3 (5 killed by dog)
1987	Manitoba	April 29	2	1 ♂; 1 ♀	2
1988	Manitoba	April 21	4	4 ♂♂	4
1988	Saskatchewan	April 7	8	3 ♂♂; 5 ♀♀	8
1988	Saskatchewan	April 8	2	1 ♂; 1 ♀	2
1989	Manitoba	April 19	4	2 ♂♂; 2 ♀♀	4
1990	Manitoba	March 25	4	1 ♂; 3 ♀♀	4

Appendix B.
Photos of lekking sharp-tailed grouse

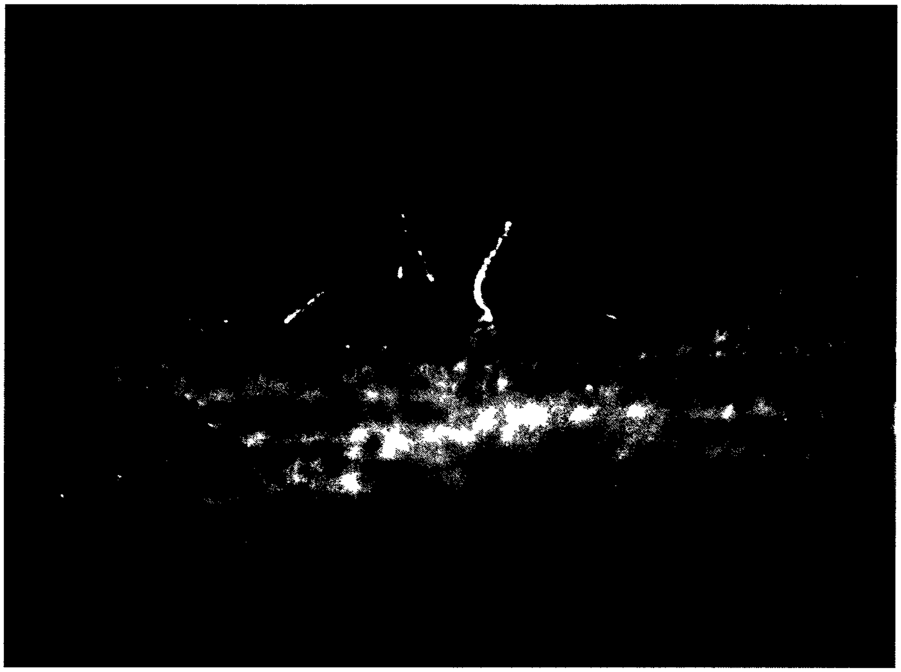

Figure B.1 Sharp-tailed displaying on lek in Bristol, view from west, April 2007, D. Oakley photo.

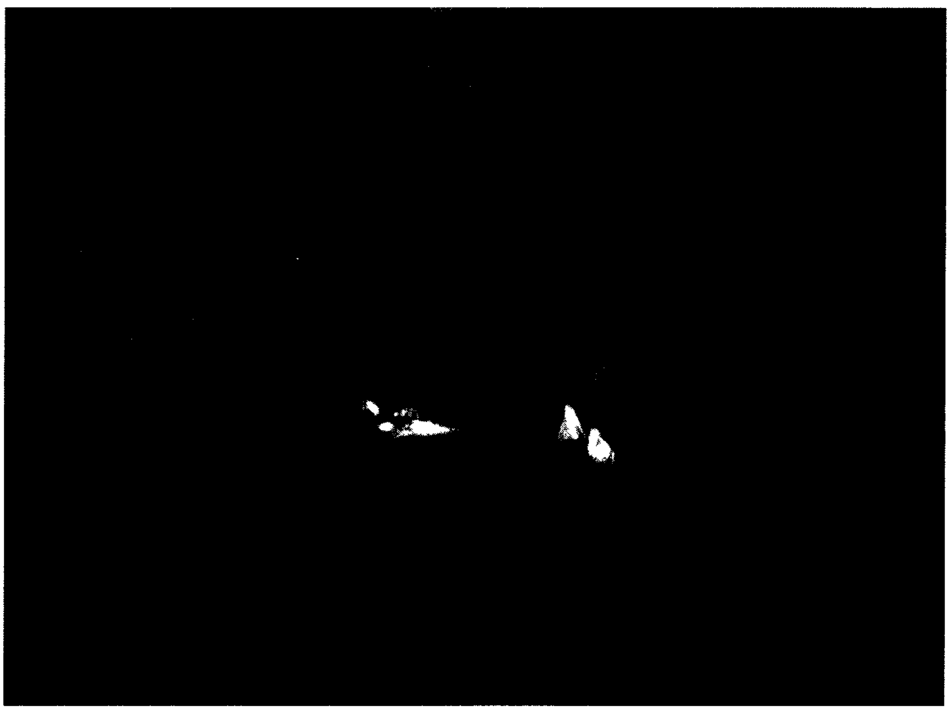

Figure B.2 Sharp-tailed grouse displaying on Bristol Lek site, view from east, May 2008.

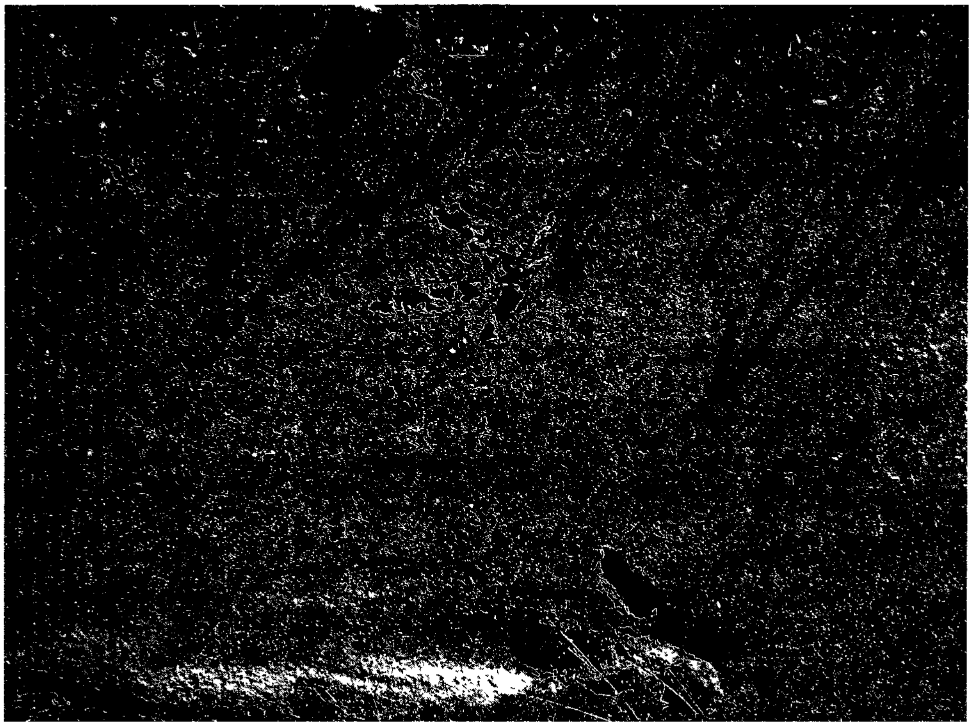

Figure B.3 Sharp-tailed grouse track near Bristol Lek site, Oct. 2007.

Figure B.4 Three male sharp-tailed grouse displaying on Bristol Lek site, view from east, May 2008.

Figure B.5 Sharp-tailed grouse displaying on Bristol Lek site, view from west, April 2007, D. Oakley photo.

Figure B.6 Sharp-tailed grouse flushed into tree, Bristol, April 2007.

Figure B.7 Sharp-tailed grouse displaying on Anderson Road lek, view from north.

Figure B.8 Sharp-tailed grouse on Hermanville lek, view from east.

Figure B.9 Sharp-tailed grouse in flight leaving Greenwich site.

Appendix C.
Photos depicting sharp-tailed grouse feeding observations

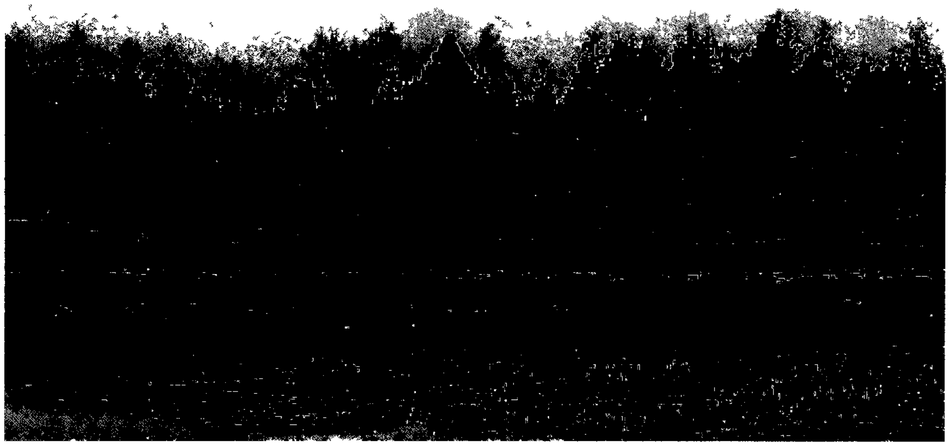

Figure C.1. Sharp-tailed grouse feeding in a harvested grain field, Cable Head winter 2007.

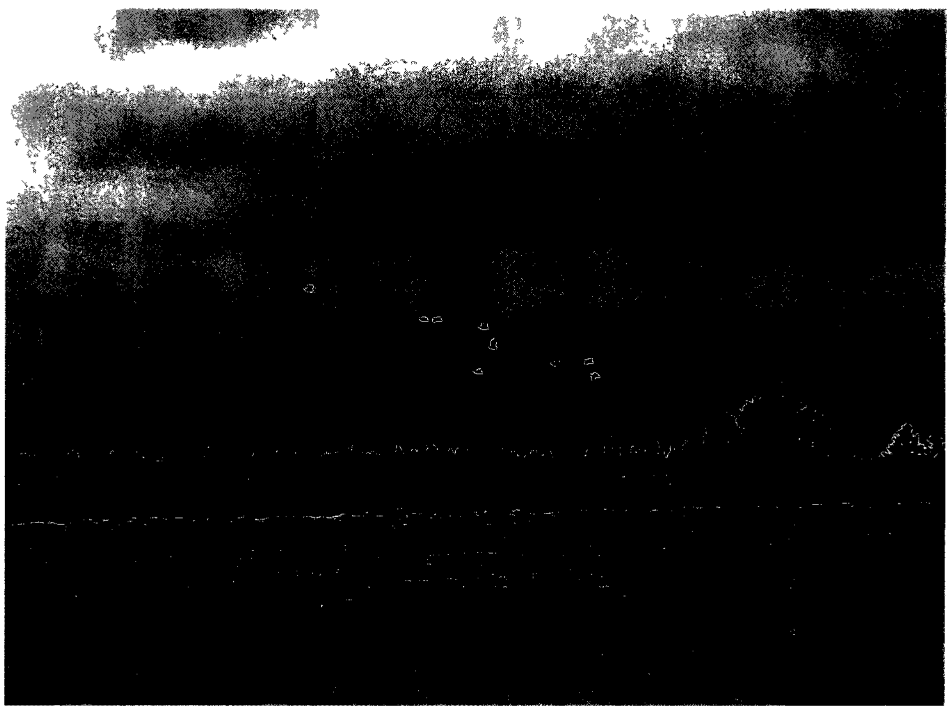

Figure C.2. Sharp-tailed grouse in flight, leaving a grain field in Cable Head, winter 2007.

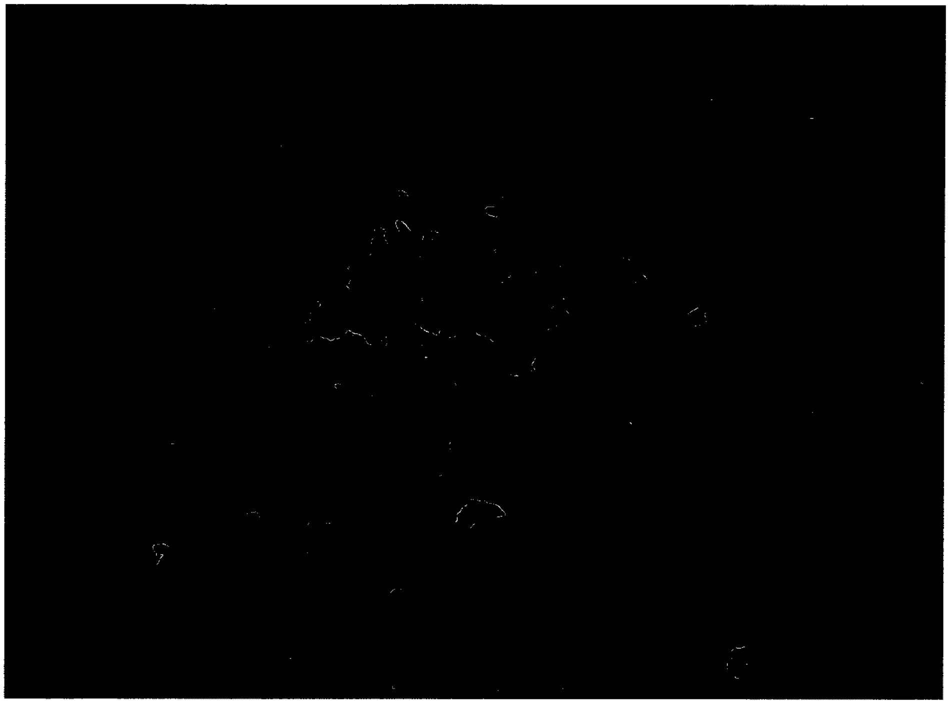

Figure C.3. Evidence that sharp-tailed grouse had been digging in snow, apparently feeding on plant material at Bristol lek site, winter 2008.

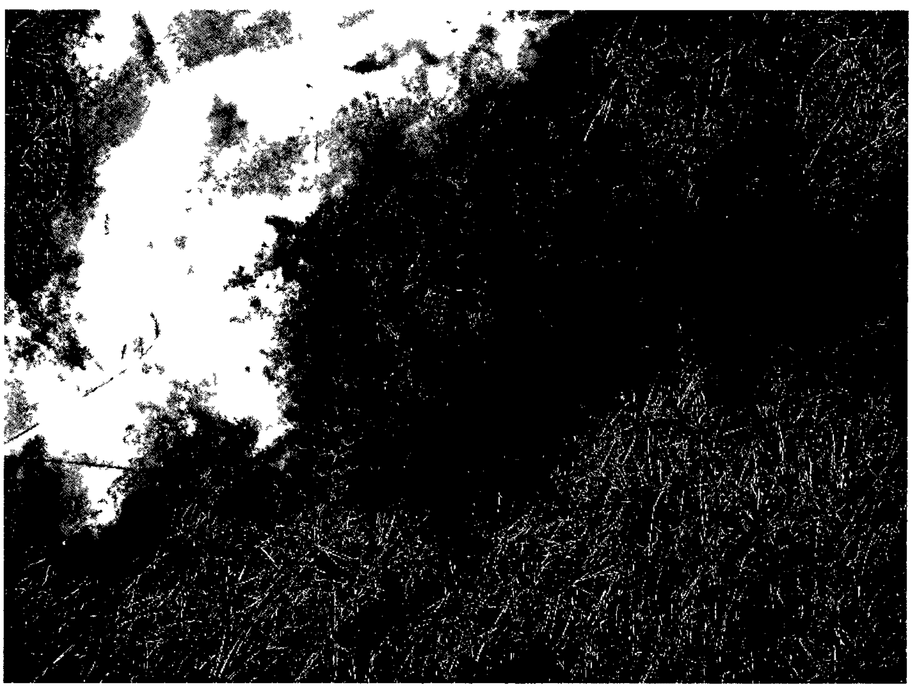

Figure C.4. Sharp-tailed grouse tracks and evidence of feeding on cranberries in Cable Head, winter 2007.

Figure C.5. Evidence of sharp-tailed grouse feeding on bayberries in Hermanville, winter 2008.