HABITAT USE AND REPRODUCTION OF FEMALE RING-NECKED PHEASANTS IN EASTERN KINGS COUNTY, NOVA SCOTIA

by

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In Memoriam

David Durell Sutton, 1953 - 1991. Good friend, keen conservationist and avid pheasant hunter.

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Abstract:

Public concern over the availability of habitat for ring-necked pheasants (Phasianus colchicus) prompted the Department of Natural Resources to initiate a habitat use study for these birds. During the winters of 1995 and 1996, 50 wild female ring-necked pheasants were live-trapped and fitted with necklace style radio collars in eastern Kings County, Nova Scotia. Hen locations were calculated from 18 February 1995 until 01 April 1996. Annual and seasonal habitat use was determined. Nesting activities were also documented. There was a significant difference in annual habitat use. Shrub was the most highly used cover type on an annual as well as a seasonal basis. Alders and grain were two habitat types out of ten that were used in different proportions throughout the day, possibly the result of morning and evening feeding in grain and increased use of alders during midday as a loafing area. Overall nesting success was 54%. Sixty per cent of juvenile and 75% of adult birds were successful at hatching a nest. Predators destroyed 33% of nests. Shrub had the highest number of successful nests/ha., followed by wetland, grass and grain. Later nests tended to be more successful. Success was negatively correlated with nesting home range size indicating hens occupying smaller home ranges were more reproductively fit. Suggestions are given regarding conserving shrub, wetland and grass habitats for pheasants and other farm wildlife.

Introduction:

Ring-necked pheasants, native to southern Asia, have been successfully introduced to temperate regions of Europe and North America, primarily as a game bird. Over much of its natural and introduced range pheasants are also raised domestically for food. Other successful introductions have occurred in Chile, the Hawaiian Islands, New Zealand, Tasmania, a few south Pacific islands, Flinders Island in Australia and on the South Australian mainland (Hill and Robertson 1988).

During the winter there is generally a segregation of the sexes, although family groups comprised of the adult female and her brood tend to remain together until breeding activity takes place in the spring. Pheasants have a rare type of breeding and mating system known as 'territorial harem defense polygyny'. Males establish and defend a territory while attempting to attract females for breeding (Hill and Robertson 1988). Females generally establish a nest off the males' territory where she alone incubates an average of 13 eggs (DNR unpublished data) for about 23 days (Dale 1956). Within hours of hatching the chicks leave the nest but stay with the adult female. For the first three weeks the young are almost entirely dependent on insects, after which their diet changes to include herbaceous vegetation as well. This family unit usually stays together until the following spring although there have been reports of broods seperating from the female after 60 days. The adult males take no part in brood rearing and remain generally segregated from the females and young. On occassion males may congregate with family groups during the winter.

Ring-necked pheasants were first introduced into Nova Scotia in 1856. Subsequent introductions followed but none were successful until they became established in 1936 in Kings County. Although self-sustaining, the original Annapolis Valley introductions were supplemented by further releases until the early 1960's. Following their successful introduction in the Annapolis Valley hundreds of pheasants were released into most parts of Nova Scotia between 1951 and 1960. Wherever agriculture and other land use practises provided adequate habitat small pockets of birds became established (van Nostrand 1963). The coastal areas of Digby, Yarmouth and Lunenburg counties also contain self-sustaining populations as do the agricultural areas of Hants, Halifax, Pictou, Colchester and Cumberland counties. Other small pockets of pheasants exist in the province. These are primarily the result of continued releases of small numbers of pheasants by individuals and wildlife clubs. These releases are unlikely to contribute significantly to the established populations that currently exist. Pheasants occur mainly in agricultural areas, with the greatest concentration and abundance of pheasants in Nova Scotia in the eastern Annapolis Valley (Sabean 1990).

Since their successful establishment in Nova Scotia, pheasants have been considered an important species by the public from both a consumptive and non-consumptive perspective. In 1943 a hunting season was opened for pheasants in Kings County. From 1948 to the present, the hunting season has expanded to include the remainder of the province (Sabean 1990).

In North America pheasants are associated primarily with productive soils which tend to be dominated by agriculture (Allen 1956). Being non-migratory pheasants have adapted to a diet of herbaceous vegetation and invertebrates during warmer months and weed seeds and waste grains from agricultural activities during colder seasons. In the northern extreme of their range (which includes southern Canada) pheasants are limited by severe weather in winter (Dale 1956). Without adequate shelter from the elements, survival of pheasants is lowered by severe weather conditions (Hill and Robertson 1988). Survival of hens and broods (Jarvis and Simpson 1978) and reproductive success are also factors in pheasant abundance (Boyd 1981). An adaptation that female pheasants possess to increase their survival is cryptic colouration. This lessens detection by predators during roosting and nesting. Pheasants have also adapted to feed primarily during the first and last hours of daylight and seek cover during most of the day. Adequate cover for nesting and predator avoidance is also essential and pheasants survive best in habitats where these conditions exist (Hill and Robertson 1988). The success of any organism is determined in large part by its habitat (Boyd 1981).

Habitat is defined as the area where a particular organism is normally found. All of the characteristics that together make up a specific habitat type dictate what organisms and how many of them can survive there. Some habitat types are able to support greater numbers of a particular animal than other areas (Allen 1962).

Different methods have been used to measure habitat use. Visual observations of marked and unmarked individuals, track and scat abundance, flushing of animals, hunter reports, animal density and radio telemetry have all been used to estimate habitat use (Hill and Robertson 1988). Measuring an animals use of its habitat is based on the number of times it is located in (i.e. uses) a given area.

Numerous authors have reported on inadequacies in pheasant habitat. Stokes (1954), Olsen (1977), Jarvis and Simpson (1978), Warner (1988), Gatti et al. (1989) and others have all commented on the importance of habitat and how modern clean farming techniques (i.e. harrowing to edge of ditch, more reliance on chemical herbicides and pesticides, less waste spaces, fall plow-down of corn and grain stubble) leave less and often degraded areas for pheasants. Diminishing in size and quality, these habitats are not able to support high numbers of pheasants or other farm wildlife (Owen 1986). Degradation or loss of high-use habitats may be a factor limiting pheasant abundance (Petersen et al. 1988). This is particularily the case for winter cover. MacMullin (1961) and others have stated that winter cover was lacking throughout most of the pheasants' North American range, primarily the result of the aforementioned clean farming practices.

Gates and Hale (1974), Olsen (1977), Jarvis and Simpson (1978), Penrod et al. (1986), Haensly et al. (1987), Warner (1988) and others have all commented on the importance of habitat for nesting and brood rearing by pheasants. Survival of hens and broods is considered important to maintain pheasant numbers (Jarvis and Simpson 1978).

Home range size is implicated as a factor in nesting success and survival of pheasants and their broods. Boyd (1981) noted that home range size increased as the number of nesting attempts to successfully raise a brood also increased. Warner (1984), Warner et al. (1984) and Hill (1985) all reported higher survival of pheasant broods as home range size decreased in area. Gatti et al. (1989) reported higher rates of survival in female pheasants that occupied small home ranges. Thompson and Fritzell (1989) noted a similar trend in male ruffed grouse (Bonasa umbellus) survival. Seasonal home range size can vary because of abundance or lack of essential habitat components (Whiteside and Guthery 1983). The larger an area a pheasant must occupy to satisfy its life requirements the greater the risk to those birds from exposure to predators, the elements or accidents (Warner 1988, Gatti et al. 1989).

In Kings County Nova Scotia, van Nostrand (1963) noted that a reduction in pheasant numbers occurred between 1958 and 1963 as a result of a general decline in habitat conditions brought about by changing agricultural practises. These changes included a reduction in the overall area of orchards, mowing of grass in orchards, increase in cutting of grass for silage and a reduction in grain production. Also in Kings County, Nova Scotia, McKay (1978) attributed an increase in pheasant numbers between 1965 and 1976 to an increase in the amount of available food for pheasants (mainly an increase in grain and corn production), favourable weather and moderate hunting pressure.

No research into actual pheasant habitat use has occurred in Nova Scotia. This lack of data on pheasant habitat use prompted the Department of Natural Resources (DNR) to initiate a habitat-use study. In order to maintain or protect the high-use habitats, they must first be identified. Once this is accomplished, steps can be taken to attempt to maintain these important areas. Not only pheasants but other farm wildlife will benefit from agricultural landscapes that are able to support abundant and diverse wildlife populations. Although studies from other areas identify habitats used by pheasants, the results are often dictated by what cover is locally available in those respective areas. Since the majority of these studies originate in the American midwest and elsewhere, habitat conditions are not always directly comparable to those in Nova Scotia. By studying local pheasants, a more accurate indication of actual covers used is possible.

The objective of this study was to identify high use habitats used by female pheasants in Kings County. Two methods were employed to identify these areas. Habitat use and nesting success by habitat type were both investigated. The amount of use that hen pheasants made of a particular habitat type would be considered a measure of its overall importance - the higher the use the more important that area is to female pheasants. High rates of nesting success would also be interpreted as another measure of habitat importance. These two measures would allow a ranking of habitats from the most to the least important. Successful nesting was considered as one measure of individual female pheasant fitness. Birds that occupied habitats where nesting success was higher than other areas were considered more fit (ie. contributed more to population continuation). Chick survival after hatching was not measured. Van Horne (1983) reported that birds with low fitness levels (ie. lower reproductive success rates) often occupy poor habitats.

I predict that female pheasants in this study occupy habitats that offered the greatest amount of cover for roosting, loafing and nesting activities. Food availability or easy access to feeding areas would also be important. I also predict that high use habitats would also sustain high levels of nesting and produce greater numbers of successful nests.

Study Area:

The Annapolis Valley in Nova Scotia (approximately 65° Longitude and 45° Latitude) lies at the northeastern extreme of the range of the ring-necked pheasant in North America (van Nostrand 1963). The valley is bounded on the north by a narrow escarpment known locally as the North Mountain (elevation aproximately 185 m.). The

South Mountain, a gradual incline of similar elevation forms the southern boundary (McKay 1978). The valley floor has an average elevation of approximately 60 m. and extends from Windsor in the east to Digby in the west. This region is underlain by red sandstone of the Triassic period which in turn is covered by shallow flats, tidal marshes, sands and clay. The climate is temperate and modified by both the North and South Mountain (Johnson 1969). Fairly evenly distributed throughout the year, the annual rainfall is approximately 100 mm and average annual snowfall is about 185 cm. The coldest month, February, has a mean temperature of -6° C while the warmest (July) has an average temperature of +19°C (Agriculture and Agri-food Canada 1996).

The fertile valley soils favour the most intensive agriculture in Nova Scotia. Dairy, beef, pork, poultry, fruit trees, various row crops such as potatoes, carrots, onions and beans, hay and grains are the major agricultural crops grown (van Nostrand 1963).

The actual delineation of the study area was based on the area occupied by the group of radio-collared pheasants studied. The study area encompasses three sites in eastern Kings County. Two occur on the valley floor (Sheffield Mills and Hillaton) and from April 21, 1995 to October 29, 1995, one bird used an area occurring in Glenmont on the North Mountain. See Figures 1-6 describing the Kings County Pheasant Study Area.

The boundaries of the study area were not defined until the investigation was nearly complete. The study area was delineated by including all areas that were currently being used and/or assumed the pheasants would use during the course of the study. Ten different habitat types were identified on the study area. These were based on vegetation species composition and physical structure. The DNR Forestry Division in Truro, N.S. conducted the air photo interpretation using 1992 aerial photography at a scale of 1:10,000. They also supplied the cover-typed maps. Ground checking was done by DNR staff at the Wildlife Division in Kentville, N.S. The habitat types include (in no specific order):

1) **Forest** - all areas containing trees ≥ 4 m. in height and with a crown closure ≥ 20%, including plantations. The more common and adundant species include spruce (Picea spp.), birches (Betula spp.), red oak (Quercus borealis), maples (Acer spp.) and poplars (Populus spp.).

2) **Grass** - all upland areas of predominately (> 50%) uncut grasses, including old fields, fallow lands, hay fields and pastures. Common species include timothy (Phleum pratense), couch (Agropyron repens), bent grass(Agrostis spp.) and weed species such as dandelion (Taraxacum officinale), chickweed (Stellaria spp.), wild carrot (Daucus carota) and clovers (Trifolium spp.).

3) **Alders** - all stands of predominately (> 50%) alders (Alnus rugosa) regardless of understory and usually occurring on poorly drained sites. Infrequently, clumps of

willow (Salix spp.) were interspersed throughout this vegetative type. Under the Nova Scotia Wetlands Database this habitat type is categorized as shrub swamp.

4) **Wetland** - all marshes, swamps, bogs and wetlands having no significant overstory, consisting of grasses and other herbaceous vegetation and being wet at least part of the year. Common plant species include reed canary grass (Phalaris arundinacea), broad-leaved cordgrass (Spartina pectinata), wooly scirpis (Scirpis cyperinus), blue-joint grass (Calamagrostis canadensis) and cattail (Typha latifolia). This habitat type is classified as sedge meadow under the Nova Scotia Wetlands Database.

5) **Grains** - all commercially grown grains including wheat, rye, barley and corn.

6) **Shrub** - all areas containing shrubs and bushes ≤ 4 m. high and usually having an herbaceous understory. The shrub category includes shade intolerant successional species such as white birch (Betula papyrifera), cherries (Prunus spp.), poplars, willow, hawthorn (Crataegus spp.) and speckled alder . The understory includes reed canary grass, wild rose (Rosa spp.), sedges (Carax spp.), brambles (Rubus spp.), goldenrods (Solidago spp.) and asters (Aster spp.).

7) **Row crops** - all commercially grown crops other than grains, including peas, carrots, onions and soya beans.

8) **Urban** - the area surrounding ($\leq$ 20 m) human habitation including residences, farmyards and includes government maintained roadways.

9) **Crop residue** - all agriculture fields before a crop is established ($\geq$ 10 cm in height) and/or what is left after harvesting, including plowed fields.

10) **Orchard** - all commercial orchards having predominately mowed grass as a ground cover.

The overall study area totalled 1569.1 hectares. Yearly and seasonal availability of the aforementioned habitat types are displayed in Table 1.

Materials and Methods:

Hen pheasants were captured between February 1995 and March 1996 using baited walk-in live-traps similar to ones described by Dietz et al. (1994). All birds captured were aged (juvenile or adults) by measuring the shaft diameter at the superior umbilicus of the proximal primary as described by Wishart (1969) and Greenberg et al. (1972). Weights were also taken. A radio-telemetry collar (necklace type, model MED-4, available from Lotek Engineering, Newmarket, Ontario) was attached to each bird. As well, a numbered leg-band was placed on each bird that offered a $10.00 reward for return of the bird and radio-collar. Collar weight (11.0 g) was approximately 1.7% of expected weights of hen pheasants (≥ 900 g) and is reported to have minimal effect on activity or survival (Johnson and Berner 1980; Warner and Etter 1983). The necklace collar design appears to have the least observable effect on galliforme survival or activity (Marcstrom et al. 1989; Small and Rusch 1985). A Telonics model TR2 receiver and a Telonics model RA-2A hand-held H-antenna were used to receive the signal from each transmitter (collar).

Each radio transmitter contained an activity switch. If the collar was motionless (i.e. dead bird or collar falls off onto ground) for ≥ 14 hours, the signal pulse changes from 40 beats per minute (bpm) to 80 bpm. For the first month all birds were monitored at least once every day and afterwards 3-4 times per week to detect any mortality and to take readings to determine hen locations. All dead birds were collected as soon as possible in an attempt to identify cause of death as evident by bite marks, faecal remains or tracks. Einarsen (1956) offers suggestions on determination of certain predator species by evidence in the field at the site of mortality. Birds that died within 5 days of collaring were excluded from habitat use analysis as suggested by Snyder (1985) and Penrod et al. (1986).

Monitoring of birds consisted of two different aspects. One was to listen to each individual frequency to determine if that bird was alive or not (depending on signal pulse rate). The other form of monitoring was to collect hen pheasant location information to determine habitat use. A number of locations were chosen on the study area that were easily recognizable from air photos such as road intersections and field edges. These spots became established listening stations and subsequently all pheasant locations were determined from these points. Universal Transverse Mercator (UTM) coordinates were calculated for all listening stations where readings were taken. One hundred and five such stations were used over the course of the study. The direction of the signal from the transmitter was determined based on signal strength. The strongest/loudest signal signified the direction of the transmitter. A compass bearing was taken of the direction of the signal. At a second station another bearing of the same signal was also taken. By triangulation the location of the radio-collared pheasant could be determined. To reduce errors in determining locations because of birds moving, simultaneous readings were taken whenever possible (Schmutz and White 1990) or length of time between bearings was kept to five minutes or less (Penrod et al. 1986, Leptich 1992). All stations were chosen so that bearings crossed at greater than 40° and less than 140° (Penrod et al. 1986). All bearings were recorded as azimuth, using a 20° West declination. Gathering of pheasant location data via triangulation was conducted from February 18, 1995 until April 1,1996. When an individual pheasant was located in a specific habitat , this was interpreted as that pheasant using that cover type.

As suggested by Saltz (1994), an attempt to determine the relative accuracy of the telemetry system being used was conducted. A series of tests were carried out in the field where the operator was not aware of the location of a transmitter and had to locate it from a known listening station (after Zimmerman et al. 1995). The actual location of the transmitter was determined after the observer had estimated it. Forty-seven such trials were carried out. The standard deviation of the errors (actual bearing to transmitter minus bearing estimated in field) was used in calculations to determine pheasant locations. The standard deviation of the bearing errors was used to calculate the transmitter location as well as creating an error ellipse (area) surrounding that point (Nams, 1990). The mean standard deviation of the bearing errors was $\pm 7.6^{\circ}$. All readings having an error ellipse $\geq$ 10 ha. were eliminated from both habitat use and home range calculations. Appendix 1 displays a number of statistics relevant to this study including the number of locations for each bird, number of locations deleted (area $\geq$ 10 ha.), and the mean, standard deviation and maximum areas of all error ellipses.

All monitoring of birds was done on a revolving schedule: sun-up to early morning, late morning, early afternoon, late afternoon, and evening to sundown. Over any given length of time there were approximately an equal number of observations during these time periods. Monitoring at different times of the day was balanced for different individuals across all seasons. This allowed monitoring of habitat use at different times of the day at different times of the year. Because pheasants are diurnal, readings were taken during these time periods.

Radio-collared hen pheasants were monitored for nesting activities during 2 seasons -

1995 and 1996. As suggested by Picozzi (1975), nests were located and marked inconspicuously or by general description alone to avoid detection by predators. When a bird appeared to be in the same location for two or more days it was assumed that she may be initiating a nesting attempt. Using the receiver to pinpoint the pheasants' location allowed nesting birds to be approached closely. All evidence of nesting was recorded for hens that flushed when the nest was approached. If the bird did not flush and the actual nest was not visible, the nest in question was visited again at a later date and eggs counted when the bird was determined by triangulation to be off her nest. These locations were recorded so the nests could be examined later for success or failure. A nest that hatched ≥ 1 egg was considered successful, all others that were depredated or abandoned were considered unsuccessful. The habitat type where the nest occurred was recorded. Depredation of nests was identified by all evidence on site. All nest destruction that was attributed to mammals was similar in apearance. The site of one destroyed nest contained raccoon fur. Although all destroyed nests could not positively be attributed to raccoons, the appearance of the nest remains was consistent with mammalian depredation as reported by Einarsen (1956) and Reardon (1951). Nests abandoned because of the observers were not included in nest success calculations. Over the two nesting seasons, 4 nests were discovered and subsequently abandoned by the next day. It was assumed that the researchers were responsible for these nest abandonments. In all four instances the eggs did not appear to be molested and the nest bowls were intact.

Hatch date was predicted using mean clutch size (mean = 13, n = 33) for Nova Scotia (DNR unpublished data) and incubation period of approximately 23 days (Dale 1956). This reduced the number of visits to each nest to one (or 2) times during laying and incubation, thereby reducing human disturbance that may have biased the outcome or risked alerting predators to the nest site (Strang 1980). Birds were never intentionally flushed from their nests. These precautions should have reduced any effects that searching should have on nest outcome (Evans and Wolfe 1967, Taylor 1991, Willis 1973, Galbraith 1987, O'Grady et al. 1996). Periodic monitoring of incubating hens (via radio telemetry) was done to determine if the particular nest in question was still active. Visiting the nest soon after the hatch date gave information on success or failure as evidenced by egg remains and nest site conditions (Einarsen 1956, Reardon 1951). When back-dating to determine laying and incubation schedules , 1.3 days per egg laid were used (Dale 1956).

Although nests were only visited one or two times during incubation, each could be monitored to determine if and when the hen was on the nest. Without the antenna attached, the receiver would pick up the signal from a transmitter from approximately 15 m. away. This allowed monitoring of nests on a regular basis without visiting the actual nest site. Each such visit was planned so as to not travel directly to and from the general nest area. The investigator would "swing by" along a circular path to avoid creating visual clues that might alert predators to the nest. When a hen was determined to be off the nest, her location was calculated via triangulation. This method allowed for determination of habitat use during the nesting season. Nests were located and monitored for outcome during the nesting seasons of both 1995 and 1996.

All location information (date, time, station, bearing) were recorded and entered into files on computer software FOXPROW 2.5 (Microsoft Corp. 1993). By using software LOCATE II (Nams 1990), UTM coordinates of bird locations were calculated. The DNR Forestry Division converted these UTM coordinates to Modified Transverse Mercator (MTM) which were then loaded into computer software ARCVIEW (Env. Systems Res. Inst. Inc. 1996). In ARCVIEW, this information was overlain onto a GIS cover-typed map of the study area (available from DNR Forestry Division). From this digitized map the area and habitat types of the study area were determined. Habitat use was calculated from the number of pheasant locations determined within each habitat type and by adjusting for the area of each habitat, the number of days during each season and the length of time that birds participated in the study.

In this study, seven seasons were identified for determining habitat use and are defined as follows:

Winter 95 - start of study to end of snow cover ≥ 1 week duration. (18/02/95 - 14/03/95).

Spring 95 - end of winter '95 to begining of nesting season (15/03/95 - variable for each bird).

Nesting 95 - begining of nest initiation (egg laying) to nest outcome determined. (variable for each bird).

Summer 95 - end of nesting season to begining of fall (1st killing frost). This coincides with brood rearing. (variable - 25/09/95).

Fall 95 - first killing frost to first complete snow cover ≥1 week duration. (26/09/95 - 30/11/95).

Winter 96 - 1st snow cover to end snow cover, similar to Winter 95 (12/01/95 - 15/03/96).

Spring 96 - end winter to end telemetry location determination. (16/03/96 - 01/04/96).

For habitat use analysis, both winter seasons were pooled as were both spring seasons. Weather data was supplied by Agriculture and Agri-Food Canada (1996).

Annual and seasonal home ranges were computed for all birds by use of software TIN, a sub-routine of ARCVIEW. A home range was considered to be the area that an individual bird occupied during a given time period. By joining the outermost points of the various bird locations, annual and seasonal home ranges were calculated using the 100% Minimum Convex Polygon method (Mohr 1947). The home ranges were the areas that the birds actually used. The entire area contained within the outermost points was considered as available for use (Mauser et al. 1994). All seasonal home ranges calculated contained ≥ 8 pheasant locations. The area of each habitat type within each annual and seasonal home range was calculated. The means of the annual and seasonal home ranges were calculated as was the area of each habitat type contained within these mean values. The mean home range values and their respective habitat areas were used in habitat use analysis.

All nesting information was also entered into files in FOXPROW. Hen identification (collar frequency and band number), date nest found, number of eggs, habitat type, general location description including identifying features and eventual nest outcome were the variables recorded.

Habitat use was measured as the number of adjusted locations/ha.*birdday. A birdday was defined as one bird participating in this study for one day. To calculate the number of locations/ha.*birdday involved a two step process. Shrub use during fall is used as an example. First, the total actual number of observed locations in shrub were divided by the mean fall home range area of shrub multiplied by the total number of birddays for the fall. This gave the actual number of locations/ha.*birdday for fall. Second, the actual number of locations/ha.*birdday for the fall were multiplied by the total number of observed locations for the fall divided by the total actual number of locations/ha.*birdday for the fall. This calculation yielded the adjusted number of locations/ha.*birdday for shrub during the fall (see Appendix 2). These adjustments accounted for the difference in length between seasons, the varying amounts of time that individual birds participated in the study and the differing use of habitat types. This allowed for within and between season comparisons. The seasonal home ranges for all birds were pooled during each season and the mean was used in calculating the adjusted number of locations/ha.*birdday. Twenty per cent of the largest and 20% of the smallest home ranges were excluded from calculations used to determine the mean home range sizes used in both seasonal and annual home range habitat use calculations. This 20% trimmed mean lessened the effect of outlier values (Dr. P. Farrell, pers. comm.). Swihart and Slade (1985) have raised concerns about statistically independent data and its effect on home range estimates. I used the minimum convex polygon method because it is not affected by lack of independence between successive observations (Swihart and Slade 1985).

Statistical analysis was performed on software SYSTAT for Windows, version 5.

To examine habitat use at different times, days were divided into 3 equal time periods. These ranged from approximately one hour before official sunrise to one hour after sunset and were dubbed morning, midday and evening respectively. Only one daily location/bird/time period was used in time of day habitat use analysis (Smith et al. 1982). Because of insufficient sample size daily use could only be analyzed on a yearly basis.

A two-tailed sign test (Mendenhall 1979) was used to compare the proportions of different habitats available in the winter study area with those used in the mean winter home range. This test was conducted to determine if there were differences between the proportion of habitats available during winter on the study area and what was actually used by the pheasants. Low numbers of other seasonal home ranges limited testing to winter only.

Chi-square goodness of fit (Kranzler and Moursund 1995) was used to test for differences in annual, seasonal and time of day habitat use. All tests were run at the 0.95 confidence level ($P < 0.05$). Habitats were ranked as to their relative importance based on use (adjusted number of locations/ha.*birdday) - the higher the use the higher that habitat was ranked. Higher ranked habitats were interpreted as being more important to hen pheasants in this study. Because of problems with assigning preference/avoidance inferences in resource utilization studies (Porter and Church 1987), this ranking only considers importance from the perspective of use.

Nesting success was similar between the two nesting seasons so the data were pooled for analysis. A few hens attempted more than one nest per season. This again raised the concern about lack of independence of data. All multiple nesters had one nest attempt randomly chosen to be included in nest analysis. Re-sampling was conducted seven times (7 trials) to ensure that all nest attempts were included at least once in nesting calculations. The number of nests per hectare and successful nests/ha. were calculated. Habitat types with a high number of successful nests/ha. were ranked more highly than areas with low success.

Spearman rank correlations were used to test for relationships between nesting variables such as success, nest initiation date, number of eggs laid, distance from the centre of the spring home range to the actual nest site, nesting season home range size, annual home range, nest site habitat and age of hens. The per cent of successful nests was also correlated with habitat use (ie. the adjusted number of locations/ha.*birdday). To ensure independence of data, re-sampling was conducted for seven trials. This was based on the constraint that all data would be included at least once in the analysis. The means for the Spearman correlations were calculated for all tests done.

Mann-Whitney U tests were used to detect differences between number of eggs laid, nest initiation date, annual home range size, nesting home range and distance between the centre of the nesting home range to the actual nest site. The dependent variables were successful versus unsuccessful nests, juvenile versus adult, first and subsequent nest attempts and nest success and habitat use.

Results:

Fifty hen pheasants were captured and radio-collared. This group was comprised of 22 juveniles, 27 adults and one of unknown age. A total of 2,306 locations were determined by radio telemetry and 2,066 of these locations were used in habitat use analysis (see Appendix 1). Five hens died within 5 days of capturing and no locations were determined for them.

Twenty-three female pheasant home ranges were used in winter habitat use calculations, 14 in spring, 10 in nesting, 10 in summer and 6 in fall. Grain and row crops were not available during winter or spring and crop residue was not available during the nesting season. Appendix 3 shows the number of birds that contributed seasonal home range data and the mean size and number of home ranges by season (before and after the 20% trimmed mean) that were used in habitat use analysis.

Habitat use:

There was a significant difference between the proportion of wetland habitat available during the winter season and actual wetland use in the mean winter home range ($z = -2.298$). Availability and use of the wetland habitat type were not equal. Significant differences also existed during winter between use and availability of shrub ($z = 3.971$), crop residue ($z = 4.394$), urban ($z = 4.808$) and forest ($z = 4.808$). Alders were available and used in equal proportions during winter ($z = -1.462$) as was the grass habitat ($z = -0.212$).

There was a significant difference in annual habitat use ($X^2 = 621.8$, 8 df, $P < 0.05$). The number of adjusted locations/ha.*birdday showed shrub to be the most highly used habitat type overall, followed by grain. There was no significant difference in use between forest and wetland ($X^2 = 0.860$, 1 df, $P > 0.05$). Together they were the next highest used habitat types. The next ranked habitats were wetland and alders (no difference in use, X^2= 1.85, 1 df, P > 0.05), grass and urban (no difference in use, X^2= 1.247, 1 df, P > 0.05), urban and row crops (no difference in use, X^2= 0.620, 1 df, P > 0.05), and row crops and crop residue (no difference in use, X^2= 2.40, 1 df, P > 0.05). Although orchard comprised 2.4% (38.5 ha) of the study area, no home ranges occurred that included any of this habitat type. Table 2 displays the mean annual and seasonal home range areas by habitat types and Table 3 displays the ranked order of annual habitat use.

The most highly used habitat type in winter was shrub followed by alders, wetland, forest and grass. Shrub also ranked first in spring, nesting, summer and fall. Table 4 displays the seasonal rankings assigned to each habitat type used. Where multiple habitat types have the same ranking, there is no statistical difference (P > 0.05) between their use.

Annual habitat use during three daily time periods was statistically different (X^2 = 311.8, 16 df, P > 0.05). However only alders and grain exhibited different amounts of use on a daily basis. Grass, wetland, shrub, row crops, crop residue, urban and forest all had no significant differences in use on a daily basis (see Table 5).

Nesting:

During the two nesting seasons, only 2 hens attempted a third nest. Both birds abandoned their second attempts because of the researchers. A total of four nests were abandoned because of the researchers and these nests were excluded from nesting success analysis.

Twenty-five of 46 nesting attempts (54%) successfully hatched one or more birds. Nine (60 %) juveniles (first year birds) and 15 (75 %) adults brought off successful nests. Twenty-five (69%) of all hens in this study successfully hatched a nest. Table 6 summarizes nesting success by age. Grain had 3 of 3 nests successful (100%) while 7 of 9 in wetland and 9 of 15 in grass successfully hatched. Table 7 displays nesting success by specific habitat type. However these measures of nesting success do not take into account the area that is potentially available for nesting. When considering overall area, shrub had the highest number of successful nests/ha. (56.3) followed by wetland (5.6) and grass with 5.2 successful nests/ha. Table 8 summarizes the results of nesting on a per hectare basis.

Thirty-three per cent of nests were destroyed by mammalian predators, likely raccoon (Procyon lotor) and skunk (Mephitis mephitis) (Table 9). Hay mowing accounted for 3 nest losses (7%) and one nest was lost to ravens (Corvus corax), one abandoned and one lost to unknown causes. A summary of the outcome of 46 nesting attempts is contained in Table 9.

The results of the Spearman correlations (mean values from 7 trials) show a weak positive correlation between nest initiation date and success. The later nests are initiated the more chance there is for success (r_s = 0.379). A negative relationship exists between three variables : number of eggs laid and the distance between the centre of spring home range and the nest site (r_s = -0.556); eggs laid and the size of the nesting home range (r_s = -0.531); and eggs laid and annual home range size (r_s = -0.668). This indicates that the number of eggs laid decreases with distance between the centre of the spring home range and the actual nest site, nesting home range size and annual home range size. Nest success negatively correlates with nesting home range size (r_s = - 0.477) indicating that smaller nesting home ranges have higher nesting success. There exists a positive correlation between nest date initiation and annual home range (r_s = 0.458) indicating that nest initiation begins later in larger annual home ranges. There also exists a positive correlation between nesting success and habitat use (r_s = 0.543) indicating that the high use habitats have higher rates of nesting success. There was no significant correlation between nesting success and age of the hen pheasant (r_s = 0.166).

There was a significant difference between date of nesting and successful (5 of 7 trials with Mann-Whitney U tests, u values range from 54.0 to 95.0, P-values from 0.005 to 0.043; mean = 142 [May 22], s.d. = 14.9) versus unsuccessful nests (mean = 135 [May 15], s.d. = 17.2). Successful nests tend to be initiated later. A significant difference was also detected between size of the nesting home range size and nesting success (4 of 7 trials, Mann-Whitney U tests, u values from 40.0 to 46.0, P-values from 0.037 to 0.048; mean = 6.9 ha., s.d. = 9.8 for successful nests) versus unsuccessful nests (mean = 11.5 ha., s.d. = 16.8). This indicates that the smaller nesting home ranges have more successful nests.

Discussion:

Porter and Church (1987) claim there are problems with study area delineation and that slight changes in boundaries can affect the proportional distribution of habitat types. This can yield misleading results when habitat use is calculated using study area availability of cover types. In the present study, availability and use of five habitat types were not equal during winter. I calculated habitat use based on what the pheasants actually did use. The annual and seasonal mean home ranges were used as a basis for calculations to determine habitat use.

Habitat use by wild female ring-necked pheasants on the Kings County Pheasant Study Area was not random. The hen pheasants studied used some habitats more than others. Habitat types were ranked as to their relative importance based on use and nesting success. This strategy has the advantage of employing two different methods to rank habitat importance.

Shrub appears to be a very important habitat type for pheasants in Kings County, Nova Scotia. The shrub areas in this study were characterized as having both a dense herbaceous ground cover and an overstory. Both characteristics provided cover throughout the year and especially during winter when this feature is essential for pheasant survival. Use of grain during the nesting season is also highly ranked possibly because it provides a relatively undisturbed habitat for brood rearing and nesting. Alders, wetland and grass also provide important cover at various times of the year. Other authors have reported high use of both grass and wetlands (Table 11).

There was a significant difference in habitat use on an annual basis. Pheasants probably used different habitats based on the amount of cover and food that each area provided. Overall, shrub had the highest use of all habitat types followed by grain. The present study ranked forest and wetland as third (no significant difference in their uses) and wetland and alders as being fourth in importance. Grass and urban were both ranked fifth overall followed by row crops. Crop residue was used the least.

There was also a significant difference in individual habitat use across all seasons. Winter habitat use was dominated by shrub. Van Nostrand (1963) suggests that shrubby or woody cover is important as winter cover for pheasants in Nova Scotia. Shrub use is followed by alders, wetland, forest and grass. There were no significant differences in their use and therefore all four were of equal importance. Wetland, forest, grass, urban and crop residue were all used in similar amounts and together make up the third or lowest ranked habitat type used. Row crops and grain were not present during winter.

During spring, shrub ranks as the number one habitat type in this study followed by alders. The number three ranking is shared equally by five cover types: forest, wetland, urban, crop residue and grass.

During the nesting season shrub again ranked highest in use followed by grain. Wetlands, forest, alders, grass and row crops all were used equally and were ranked third in importance. Urban had the lowest use of all habitat types during the nesting season. Crop residue was not used during this time.

Summer habitat use was dominated by shrub followed by a combination of wetlands, alders, row crops, grain and forest. Grass, urban and crop residue followed in ascending order of importance.

Shrub and forest were equally ranked as the most important fall habitat component in this study. Wetland and grass occupied the second ranked category along with alders and crop residue. Use of grain, urban and row crops followed in ascending order.

Although pheasants are associated primarily with agricultural landscapes, they seem able to successfully occupy a range of habitat types. This would account for the similar yet regional differences in habitat use reported by various authors. Playas in west Texas are comprised of a small water body surrounded by lush vegetation (Whiteside and Guthery 1983) similar to wetlands in Nova Scotia described in this study. However, related plant species and climate would be different although plant community structure appears similar. Basically the same holds true for grass and shrub habitats both identified earlier as important for pheasants. Forest use in Nova Scotia was also ranked highly. In Britain, pheasants use woodlands almost exclusively during winter (Hill and Ridley 1987). The British woodlands that are heavily used by pheasants are described as having a dense herbaceous ground cover, a well developed shrub layer and an overhead canopy. These are similar in structure to the forest areas used by pheasants in the present study. Overall it would appear that habitat structure is more important than the different plant species that make up any given habitat used by pheasants. From the findings of this study, dense ground cover and where available, an overstory, appear to provide optimum habitat for pheasants during all seasons.

Annual time of day habitat analysis revealed a significant difference in use. On an individual habitat basis, only alders and grain displayed annual differential use on a daily basis. Alders had higher than expected use during midday as did grain during morning and evening. Perhaps the high use of alders during midday can be attributed to the presence of overhead cover to prevent detection by predators and as shelter from the elements, particular in winter while birds are loafing (Gates 1970). Heavy use of grain during morning and evening may be the result of feeding, both after leaving a roost/loafing area or prior to entering one. Leptich (1992) found a similar pattern of hen pheasants using grains in southern Idaho.

One interesting finding from this study was the apparent lack of use of orchards. Van Nostrand (1963) noted that pheasant numbers had declined in Nova Scotia between 1951 and 1963. He cites early mowing of grass in orchards as one possible reason for this reduction of pheasant numbers. All orchards that occurred on the Kings County Pheasant Study Area were mowed and/or treated with herbicide to control growth of grasses. Providing little cover for concealment the orchard habitat category was used very little by hen pheasants in the present study (6 of 2,306 locations occurred in orchard as did one of 46 nesting attempts, which was unsuccessful).

Nesting success for this study was 54.3%. Different authors have reported pheasant nesting success ranging from 10.4% (Baxter and Wolfe 1973) to a high of 65.0% in Conservation Reserve Program (CRP) fields in Iowa (Patterson and Best 1996). Table 10 presents the summarized results of other nesting investigations reported in the literature. The level of nesting success observed in this investigation as well as the aforementioned studies is likely a result of local conditions at the time of investigation and may not be indicative of long term population trends. The level of nesting success is significant in identifying which habitats are more important to pheasants and which ones provide the greatest likelihood of successful nesting. Identifying the most important habitats potentially allows for their maintenance and protection.

From the 46 nests monitored, 15 (33%) were destroyed by mammalian predators, 3 (7%) were destroyed by mowing machines and 1 (2%) each were lost to avian predators, abandoned and unknown causes. In Iowa, Riley et al. (1994) reported 36% nest losses to mammalian predation. Forty-two per cent of nests studied in South Dakota (Leif 1994), 23.1% in Nebraska (Linder et al. 1960), 54.7% from Colorado (Snyder 1974) and 32% of pheasant nests occurring in Iowa CRP fields (Patterson and Best 1996) were destroyed by mammalian predators. All of these results can be attributed to local conditions at the time of the various studies. Some factors that contributed to the varying levels of nest predation reported in this and earlier studies include numbers and densities of mammalian predators present and the area of high quality habitat available that provides adequate concealment for nesting pheasants. Predator removal has proven to be very costly and also ineffective as soon as the practice is stopped (Chessness et al. 1968). Good nesting habitat in adequate supply will help to ensure hen pheasants can reproduce successfully and will mitigate the effects of nest predators. Dense ground cover is important. Residual vegetation allows nesting birds, especially the early ones, better concealment (Boyd 1981, Hanson 1970).

An evaluation of nesting habitat must take into account the number of nests initiated, the success of those nesting attempts and the availability of the different cover types. The shrub category again dominates as the most highly ranked habitat type having a calculated 56.3 successful nests/ha. followed by wetland (5.6 successful nests/ha.) and grass with 5.2 successful nests/ha. The value of grain is also demonstrated as an important nesting habitat (3.3 successful nests/ha.). Numerous other authors also recognize these habitat categories as critical for successful pheasant nesting. See Table

10 for a summary of nest site habitats that are considered important based on the results of other pheasant nesting studies.

The Spearman rank correlation for success and nest date ($r_s = 0.379$) suggests that later nests are marginally more successful than early ones. This is corroborated by the results of the Mann-Whitney U tests that showed a significant difference between success and nest date. Goransson and Loman (1986) suggest that an increase in vegetation height offers better concealment thereby reducing destruction by nest predators.

There were negative correlations between success and distance and success correlated with annual home range size. There was also a significant difference between success and nesting home range. These all indicate a higher rate of nest success associated with birds in smaller annual and nesting home ranges. Using nesting success as a measure of fitness, hens occupying smaller home ranges appear more reproductively able to contribute to the overall population. Boyd (1981) found that home range size (during the reproductive season) increased in size as the number of nesting attempts to produce a brood also rose.

There was no correlation between hen pheasant age and nesting success. The results of this study indicate that success is not related to age. Older females do not appear to be more experienced at using habitats that yield higher rates of nesting success. Nor does it appear that juvenile (first year breeders) are forced into poorer nesting areas.

In Kings County, Nova Scotia both habitat use and nesting success were highest in the shrub category. Providing both a dense ground cover as well as an overhead canopy, this habitat type is ranked as being the most important for pheasants. These two measures of ranking habitat importance corroborated each other. Grain, wetland and grass have also been shown to be important cover types based on measures of use and successful nesting.

The shrub, wetland, grass and grain habitats identified in this study have been shown to be important to pheasants in Kings County. These results corroborate research from numerous other areas. Any conservation programs aimed at pheasants in Nova Scotia must consider all of these crucial habitats.

Management Recommendations :

The first step towards effective pheasant management, identifying the actual areas of high-use habitats in Nova Scotia's most intensive agricultural region has been done. Identifying habitats in the remaining agricultural areas or at the very least a representative sample from these areas should be completed. Long term monitoring of habitat type and availability could alert wildlife managers of any loss or measurable degradation of these important pheasant covers. Should the number or area of high-use habitats diminish, a program similar to the Conservation Reserve Program such as done in the U.S. could provide an alternative in the form of undisturbed grassland that can provide both good nesting areas as well as winter cover. This would not only benefit pheasants but also other grassland nesting birds.

Shrub, grass and wetlands are more likely to be influenced by wildlife managers than is grain. Grain fields do provide a continuous, relatively undisturbed habitat until nesting is usually complete. However, grain production is at the whim of agricultural markets and usually beyond the control of wildlife managers. Wetlands already receive a substantial amount of legislative protection as well as promotion by government and non-government organizations (NGO's) locally such as Ducks Unlimited and the Eastern Habitat Joint Venture. Private conservation organizations should petition governments to protect or purchase these valuable wildlife areas. NGO's should approach private landowners with stewardship proposals to protect and conserve these essential habitats. Volunteer easements (restrictions on development) or land leasing are both strategies that will work to conserve these and other valuable wildlife habitat on privately owned agricultural lands.

One aspect of pheasant habitat use that was not addressed by this study is the juxtaposition of the various cover types. The spatial arrangement of habitats will affect pheasants. High quality cover must be located within close proximity to feeding areas. If individual areas become insular they may lose their value to pheasants. Further research is needed in Nova Scotia to determine if and when this condition happens.

For pheasants and other farm wildlife there appears to be some optimism for the future. The majority of land in the Annapolis Valley that has agriculture potential is currently being used as such. The more productive soils will be used more intensively and marginal areas (known to agriculturalists as unimproved areas) will likely be dropped from agricultural use as economic conditions make it unprofitable to farm these areas. These unimproved areas are likely to be dropped from agricultural activities outside the Annapolis Valley as well. Over the province as a whole there is more unimproved areas than there were five years ago and this trend is expected to continue into the future (A. Pick, pers. comm.). These unimproved areas have the potential for pheasant habitat.

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Table 1 : Yearly and seasonal availability of habitat types on the Kings County Pheasant Study Area : 1995-96.

	Annual[a]	Winter	Spring	Nesting	Summer	Fall
Habitat type	Ha. (%)	Ha. (%)	Ha. (%)	Ha. (%)	Ha. (%)	Ha. (%)
Alders	74.9 (4.8)	74.9 (4.8)	74.9 (4.8)	74.9 (4.8)	74.9 (4.8)	74.9 (4.8)
Grass	227.3 (14.5)	227.3 (14.5)	227.3 (14.5)	227.3 (14.5)	227.3 (14.5)	227.3 (14.5)
Wetland	82.3 (5.2)	82.3 (5.2)	82.3 (5.2)	82.3 (5.2)	82.3 (5.2)	82.3 (5.2)
Shrub	27.8 (1.8)	27.8 (1.8)	27.8 (1.8)	27.8 (1.8)	27.8 (1.8)	27.8 (1.8)
Grain	83.1 (5.3)	0	0	135.3 (8.6)	304.7 (19.4)	47.3 (3.0)
Row crops	80.6 (5.2)	0	0	359.9 (22.9)	159.8 (10.2)	15.8 (1.1)
Crop residue	405.3 (25.8)	569.1 (36.3)	569.1 (36.3)	73.9 (4.8)	104.6 (6.7)	506.0 (32.2)
Urban	176.8 (11.3)	176.8 (11.3)	176.8 (11.3)	176.8 (11.3)	176.8 (11.3)	176.8 (11.3)
Forest	372.5 (23.7)	372.5 (23.7)	372.5 (23.7)	372.5 (23.7)	372.5 (23.7)	372.5 (23.7)
Orchard	38.5 (2.4)	38.5 (2.4)	38.5 (2.4)	38.5 (2.4)	38.5 (2.4)	38.5 (2.4)
Total	1569.1 (100)	1569.1 (100)	1569.1 (100)	1569.1 (100)	1569.1 (100)	1569.1 (100)

[a] Adjusted because Row crops and Grain were not available during both winter and spring.

Table 2 : Mean (± s.d.) annual and seasonal home range area of habitat types on the Kings County Pheasant Study Area, 1995-96.

	Annual	Winter	Spring	Nesting	Summer	Fall
Habitat type	Ha. ± s.d. (%)	Ha. ± s.d. (%)	Ha. ± s.d. (%)	Ha. ± s.d. (%)	Ha. ± s.d. (%)	Ha.± s.d. (%)
Alders	0.762 ± 0.970 (8.4)	0.835 ± 0.830 (11.8)	1.164 ± 1.318 (8.6)	0.460 ± 0.602 (13.0)	0.130 ± 0.236 (1.5)	1.100 1.330 (7.1)
Grass	1.721 ± 1.636 (14.2)	0.533 ± 0.633 (7.5)	2.429 ± 1.482 (18.0)	1.180 ± 1.060 (33.4)	3.650 ± 1.301 (42.6)	2.300 2.082 (14.9)
Wetland	1.256 ± 1.421 (12.3)	1.370 ± 1.298 (19.3)	1.743 ± 1.463 (12.9)	0.330 ± 0.668 (9.3)	0.590 ± 1.505 (6.9)	2.333 1.565 (15.1)
Shrub	0.071 ± 0.180 (1.6)	0.043 ± 0.095 (0.6)	0.079 ± 0.131 (0.7)	0.010 ± 0.032 (0.4)	0.060 ± 0.135 (0.8)	0.283 0.467 (1.8)
Grain	0.904 ± 1.244 (10.8)	0	0	0.010 ± 0.032 (0.4)	0.980 ± 0.875 (11.4)	2.267 1.587 (14.6)
Row crops	0.785 ± 1.590 (13.8)	0	0	0.380 ± 0.605 (10.8)	0.910 ± 1.049 (10.6)	1.250 3.062 (8.1)
Crop residue	1.265 ± 1.699 (14.7)	1.083 ± 0.788 (15.2)	2.464 ± 2.566 (18.3)	0	1.050 ± 1.276 (12.3)	1.633 2.319 (10.5)
Urban	2.884 ± 2.275 (19.6)	2.996 ± 1.605 (42.2)	4.800 ± 2.588 (35.6)	1.050 ± 0.696 (29.6)	1.000 ± 0.927 (11.7)	4.183 2.610 (27.0)
Forest	0.324 ± 0.533 (4.6)	0.239 ± 0.343 (3.4)	0.793 ± 0.833 (5.9)	0.110 ± 0.191 (3.1)	0.190 ± 0.341 (2.2)	0.133 0.327 (0.9)
Orchard	0	0	0	0	0	0
Total	11.548 (100)	7.101 (100)	13.472 (100)	3.530 (100)	8.560 (100)	15.482 (100)

Table 3 : Ranking[a] of annual habitat use by 46 radio-collared hen pheasants in Kings County, Nova Scotia from 18 Feb. 1995 to 01 April 1996.

Rank	Habitat type(s)[b]	No. locations[c]
1	shrub	1184
2	grain	273
3	forest/wetland	121/107
4	wetland/alders	107/88
5	grass/urban	54/43
6	urban/row crops	43/36
7	row crops/crop residue	36/24

[a] Ranking based on use ie. number of adjusted locations / ha.*birdday. When 2 or more habitats are equally ranked, there is no significant difference in their use ($P > 0.05$).
[b] Orchard was not used.
[c] Based on adjustments made for home range availability and measured as number of adjusted locations / ha.*birdday. Locations refer to corresponding habitat types (ie. Rank # 3: forest = 121, wetland = 107).

Table 4 : Ranking[a] of seasonal home range habitat use by 46 radio-collared hen pheasants in Kings County, Nova Scotia from 18 Feb. 1995 to 01 April 1996.

Season	Rank	Habitat type(s)[b]	# Locations[c]
Winter[d]	1	shrub	447
	2	alders/wetland/forest/grass	37/27/26/25
	3	wetland/forest/grass/urban/crop residue	27/26/25/20/17
Spring[d]	1	shrub	358
	2	alders	41
	3	forest/wetland/urban/crop residue/grass	23/18/18/15/14
Nesting[e]	1	shrub	135
	2	grain	52
	3	wetland/forest/alders/grass/row crops	10/10/4/4/4
	4	alders/grass/row crops/urban	4/4/4/2
Summer	1	shrub	174
	2	wetlands/alders/row crops/grain/forest	53/42/41/40/38
	3	grass/urban	22/18
	4	urban/crop residue	18/5
Fall	1	shrub/forest	62/56
	2	alders/wetland/grass/crop residue	19/17/10/10
	3	grass/crop residue/grain/urban	10/10/8/8
	4	row crops	0

[a] Ranking based on use ie. number of locations / ha.*birdday. When 2 or more habitats are equally ranked there is no significant difference in their use ($P > 0.05$).
[b] Orchard was not used.
[c] Based on adjustments made for home range availability and measured as locations / ha.*birdday. Location numbers refer to corresponding habitat types (ie. Winter rank # 2: alders = 37, wetland = 27, forest = 26...).
[d] No availability of row crops or grain during winter or spring.
[e] No availability of crop residue during nesting.

Table 5: Adjusted number of locations/ha.*birdday based on home range use by habitat type and time of day for pheasants on the Kings County Pheasant Study Area during 1995-96.

Habitat	Morning	Midday	Evening	Total
Alders	26	40	24	90
Grass	17	18	20	55
Wetland	37	39	35	111
Shrub	451	416	306	1173
Grain	145	39	85	269
Row crops	10	15	12	37
Crop residue	8	8	8	24
Urban	14	17	15	46
Forest	48	33	44	125
Total	756	625	549	1930

Table 6 : Nesting success by age for 40 radio-collared hen pheasants in Kings County, Nova Scotia during 1995-96.

	Juvenile	Adult	Unk.	Total
# hens available to nest	17	22	1	40
# initial nest attempts	15	20	1	36[a]
# successful (%)	4 (27)	12 (60)	1 (100)	17 (47)
mean clutch size (n)	12.8 (8)	13.2 (9)	Unk.	13.0 (17)
# second attempts	6	2	0	8[b]
# successful (%)	5 (83)	2 (100)	—	7
mean clutch size (n) of 2nd attempt	11.3 (6)	10.5 (4)	—	11 (10)
# third attempts	0	2	0	2
# successful (%)	—	1 (50)	—	1 (50)
mean clutch size (n) of 3rd attempt	—	8 (1)	—	8 (1)
# hens hatching > 1 young (%)	9 (60)	15 (75)	1 (100)	25 (69)

[a] 2 Juv. and 2 Adult birds had no nesting attempts in 1995.
[b] 1 Juv. and 3 Adult nests (8%) abandoned because of researchers not included.

Table 7 : Pheasant nesting success by habitat types on the Kings County Pheasant Study Area : 1995 - 96.

Habitat type[a]	# nests[b]	# successful (%)
Grass	15	9 (56)
Alders	4	1 (25)
Wetland	9	7 (78)
Grain	3	3 (100)
Shrub	9	4 (44)
Rowcrop	2	1 (50)
Orchard	1	0 (0)
Urban	3	0 (0)
Total	46	25 (54)

[a] includes only those habitat types used for nesting.
[b] 4 nests abandoned because of researchers not included.

Table 8 : Mean annual home range, number of nests initiated, nests/ha., # successful nests and successful nests/ha. for hen pheasants in Kings Co., N.S. during 1995 and 1996.

Habitat	Annual H.R. (ha.)	No. nests	No. nests/ha.	No. succ. nests	succ. nests/ha.
Alders	0.762	4	5.2	1	1.3
Grass	1.721	15	8.7	9	5.2
Wetland	1.256	9	7.2	7	5.6
Shrub	0.071	9	126.8	4	56.3
Grain	0.904	3	3.3	3	3.3
Rowcrop	0.785	2	2.5	1	1.3
Urban	2.884	3	1.0	0	0
Total	9.959	45	4.5	25	2.5

Table 9 : Outcome of 46[a] nests by habitat type[b] for 40 radio-collared hen pheasants in Kings Co., N.S. during 1995 and 1996.

Habitat type	No. nests	No. success	Mammal predator	Avian Predator	Farm machine	Abandon	Unk. cause
Grass	15	9	3	1	2	0	0
Alders	4	1	2	0	0	1	0
Wetland	9	7	2	0	0	0	0
Grain	3	3	0	0	0	0	0
Shrub	9	4	5	0	0	0	0
Rowcrop	2	1	0	0	1	0	0
Urban	3	0	2	0	0	0	1
Orchard	1	0	1	0	0	0	0
Total	46	25 (54%)	15 (33%)	1 (2%)	3 (7%)	1 (2%)	1 (2%)

[a] 4 nests (8%) abandoned because of researchers not included.

[b] Only those habitats where nests occurred.

Table 10 : Summary of results of various pheasant nesting studies as reported by other researchers.

% nest success	Main habitat type used	Researcher(s)	Area	Date
65	grass	Patterson & Best	Iowa	1996
42	unknown	Leif	South Dakota	1994
43	grass waterways	Riley et al.	Iowa	1994
35	unharvested hay	Warner & Etter	Illinois	1989
59	green wheat	Snyder	Colorado	1984
56	old field	Boyd	New York	1981
31	field (retired cropland)	Dumke & Pils	Wisconsin	1979
30	wetlands/hayfields	Gates & Hale	Wisconsin	1975
23.8	hay	Olson & Flake	South Dakota	1975
23.5	roadsides	Snyder	Colorado	1974
10.4	alfalfa	Baxter & Wolfe	Nebraska	1973
15.1	alfalfa	Linder et al.	Nebraska	1960
12.5	alfalfa/wheat stubble	Robeson	New York	1957
45.4	weeds	Stokes	Ontario	1954

Table 11: Primary annual and seasonal pheasant habitat use as reported by various researchers.

TIME	PRIMARY HABITAT	RESEARCHER(S)	AREA	DATE
Annual	fallow grass	Penrod et al.	New york	1986
	playas	Whiteside & Guthery	Texas	1983
	wetlands	Gates & Hale	Wisconsin	1974
	shrub	Mills (this study)	Nova Scotia	1997
Winter	wetlands	Gates & Hale	Wisconsin	1974
	wetlands	Gates	Wisconsin	1970
	marshes	Gatti et al.	Wisconsin	1989
	ungrazed sagebrush	Leptich	Idaho	1992
	fallow grass	Penrod et al.	New York	1986
	playas	Whiteside & Guthery	Texas	1983
	woodlands	Hill & Ridley	Britain	1987
	shrub	Mills	Nova Scotia	1997
Spring	old fields	Boyd	New York	1981
	fallow grass	Penrod et al.	New York	1986
	wetlands	Gates & Hale	Wisconsin	1974
	wetlands	Gatti et al.	Wisconsin	1989
	grains/playas	Whiteside & Guthery	Texas	1983
	grains	Hill & Ridley	Britain	1987

	shrub	Mills	Nova Scotia	1997
Nesting	wetlands	Gates	Wisconsin	1970
	wetlands	Gates & Hale	Wisconsin	1974
	old fields/hay	Boyd	New York	1981
	fallow grass	Penrod et al.	New York	1986
	alfalfa/ditches/grains	Hanson & Progulske	South Dakota	1973
	playas/alfalfa/wheat	Whiteside & Guthery	Texas	1983
	shrub	Mills	Nova Scotia	1997
Summer	oats/hay	Warner	Illinois	1979
	grain	Gates & Hale	Wisconsin	1974
	grain	Hanson & Progulske	South Dakota	1973
	grain	Whiteside & Guthery	Texas	1983
	old fields	Boyd	New York	1981
	fallow grass	Penrod et al.	New York	1986
	weeds/grass/grain	Hill	Britain	1985
	shrub	Mills	Nova Scotia	1997
Fall	playas	Whiteside & Guthery	Texas	1983
	wetlands	Gates & Hale	Wisconsin	1974
	wetlands	Gatti et al.	Wisconsin	1989
	shrub	Mills	Nova Scotia	1997

Figure 1: Map of Nova Scotia showing relative location of the Kings County Pheasant Study Area.

Figure 2: Map of Kings County, N.S. showing the three study sites.

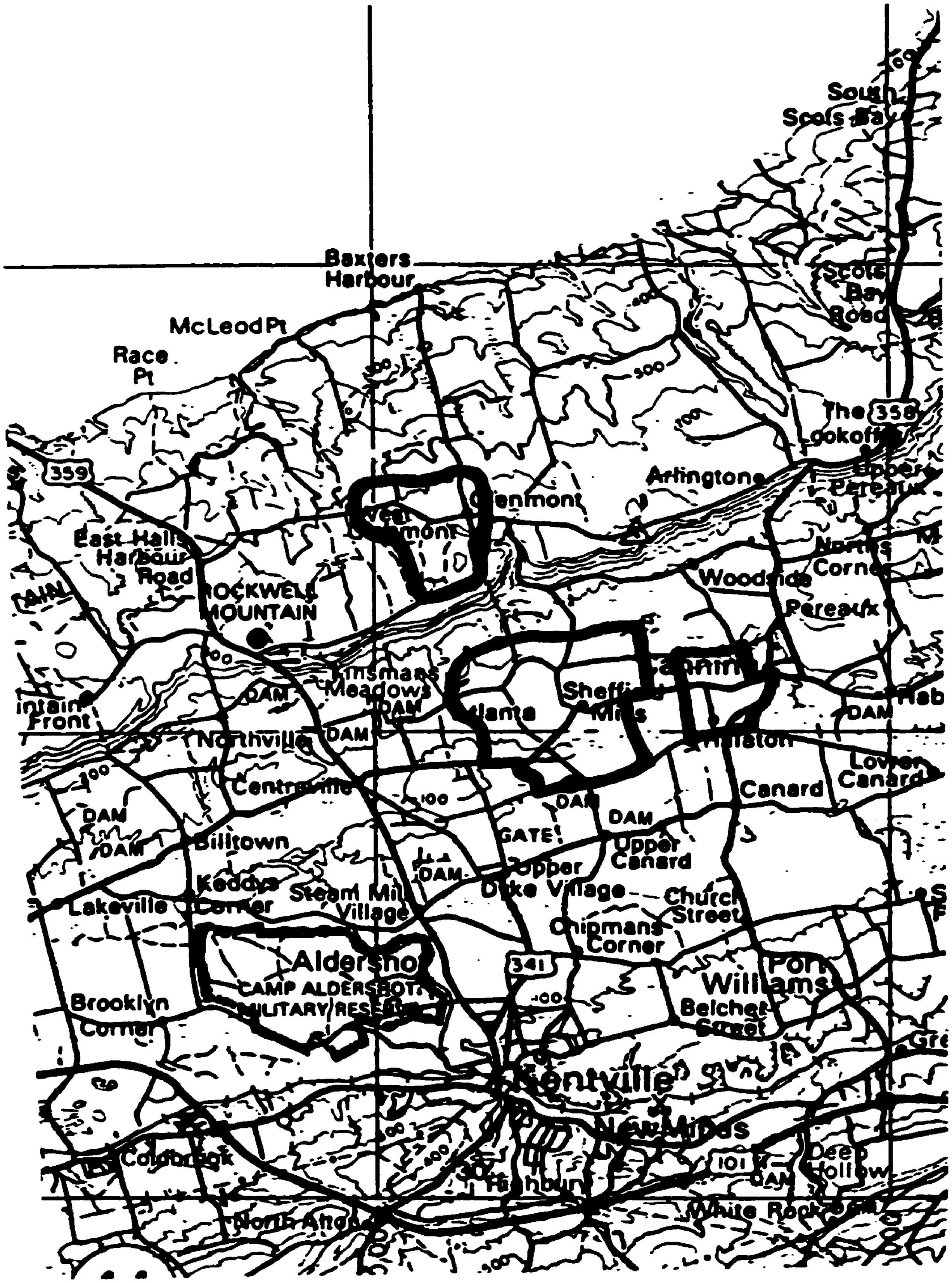
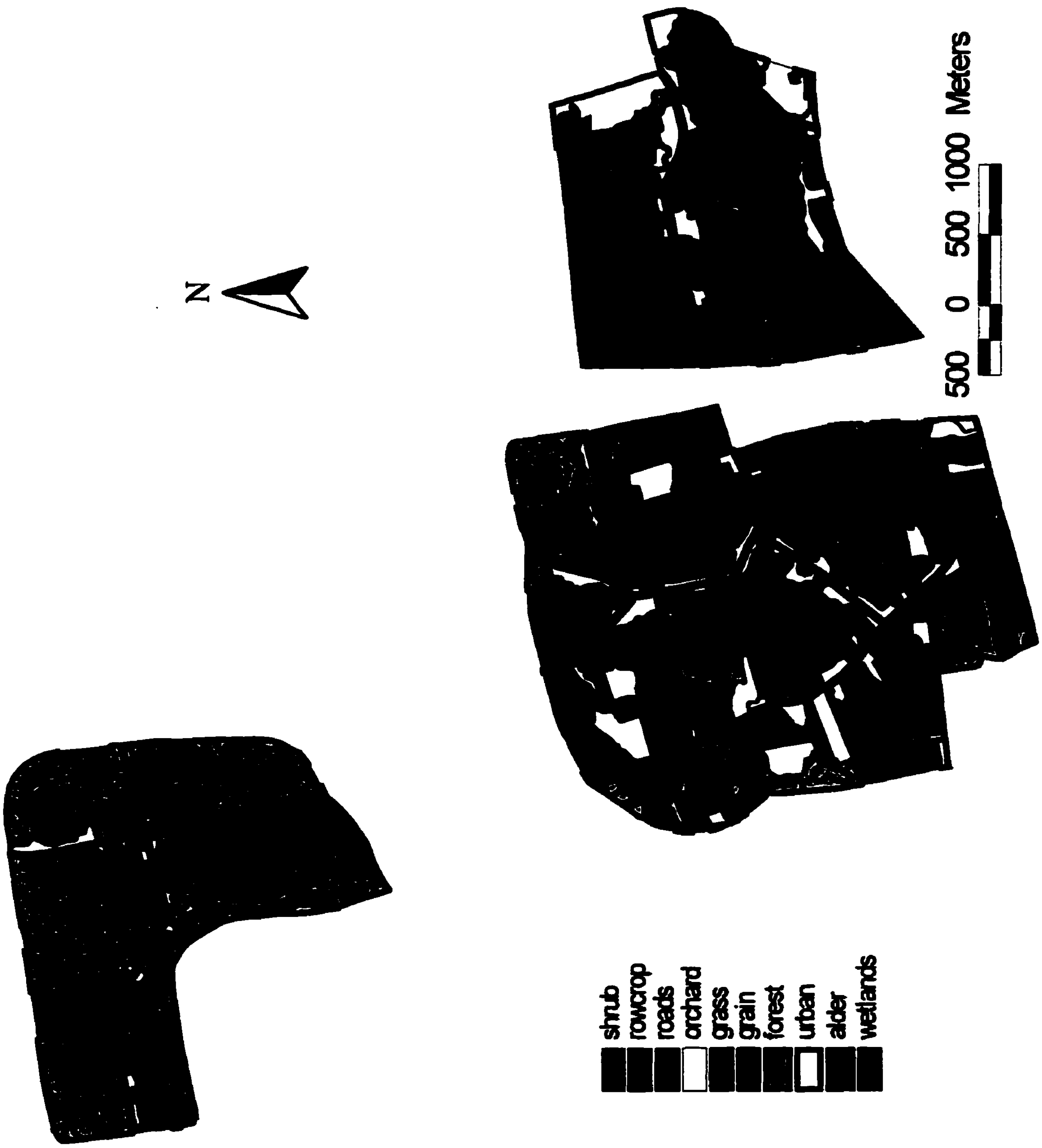


Figure 3: Map of the Kings County Pheasant Study Area showing habitat types* .



* When the study area was mapped, all agricultural areas were in use - therefore no crop residue cover type was delineated. As the grain and row crops categories were harvested the crop residue habitat came into being.

Figure 4: Map of Glenmont Study Site showing habitat types.

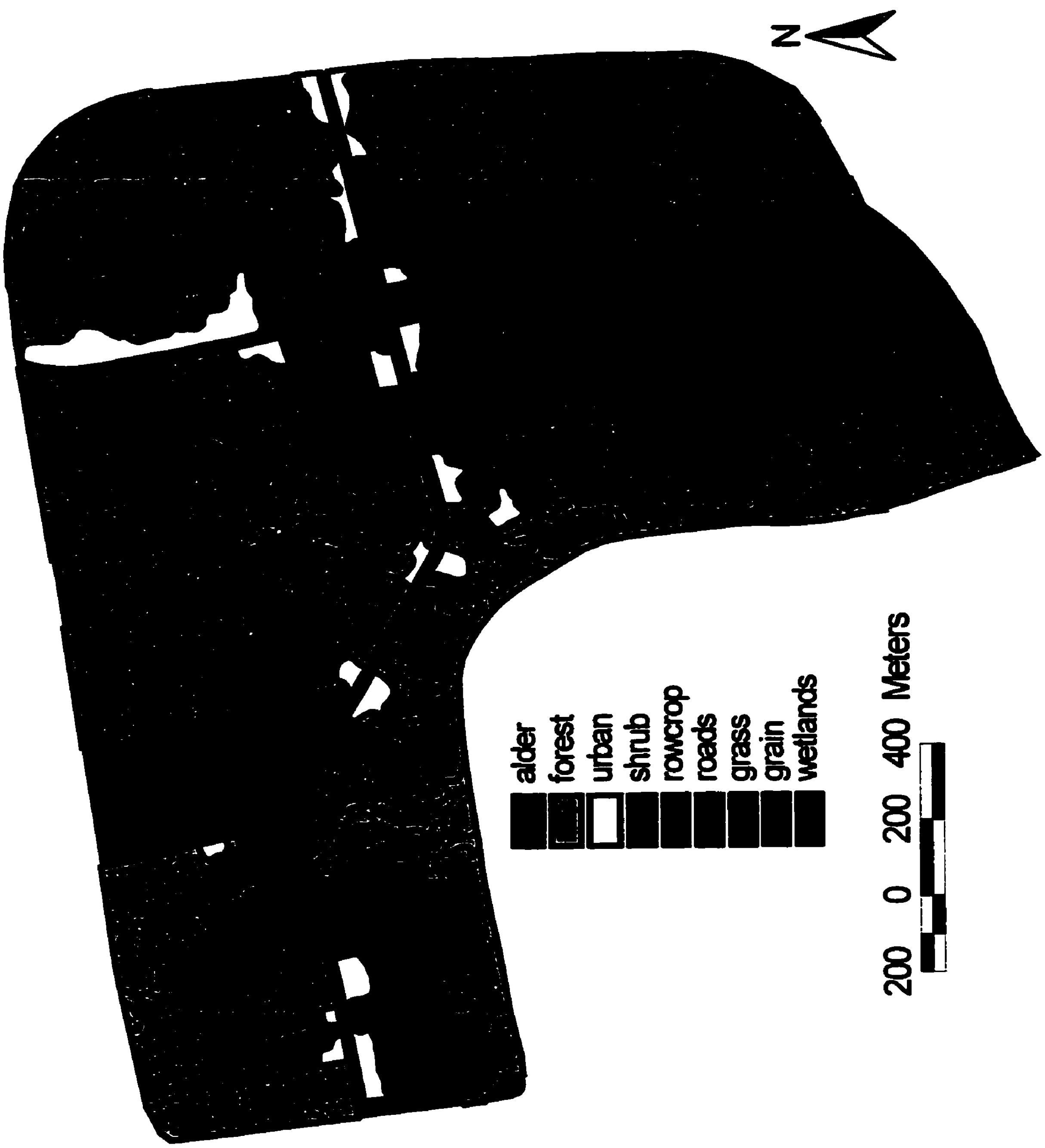


Figure 5: Map of Sheffield Mills Study Site showing habitat types.

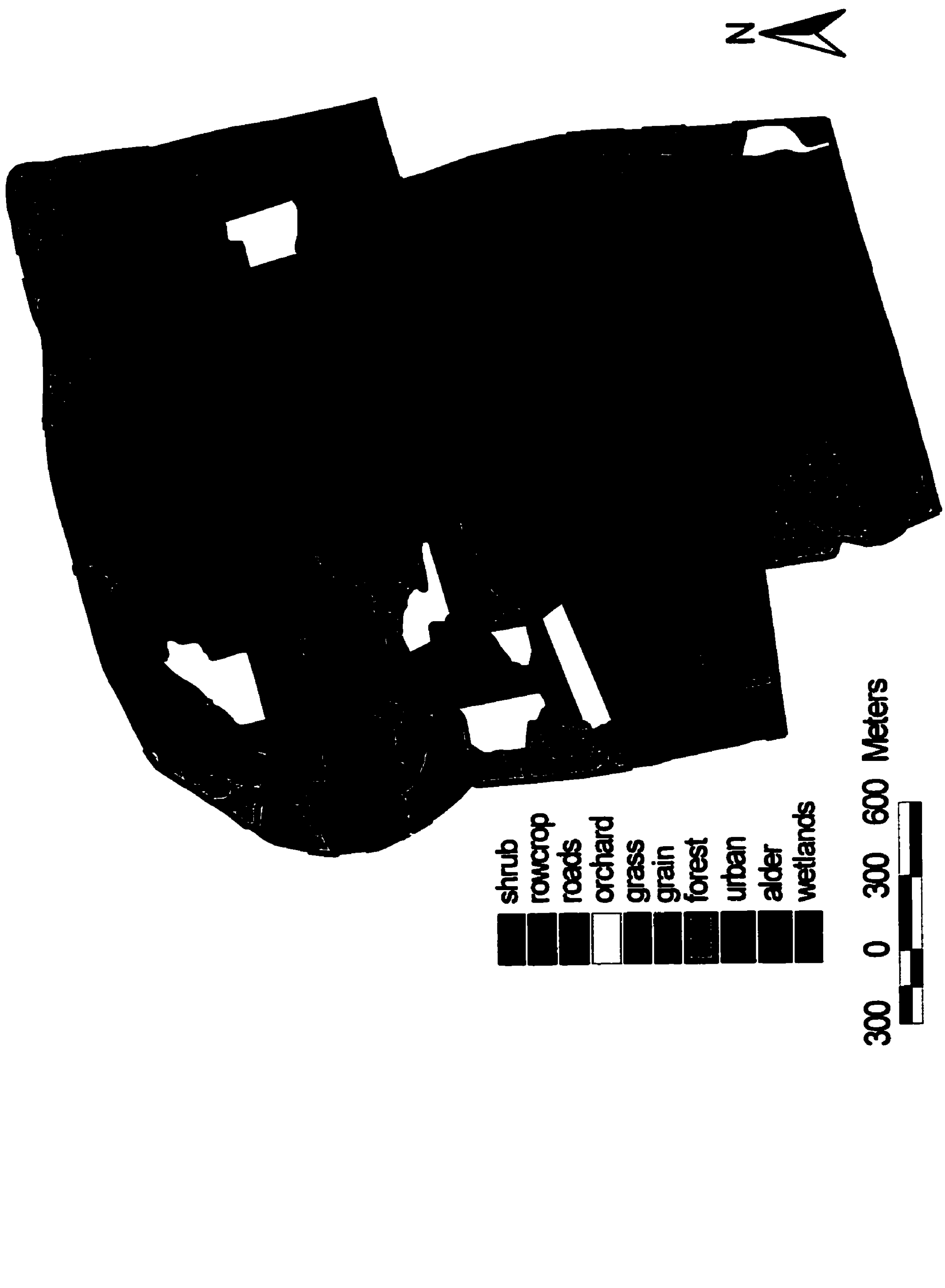
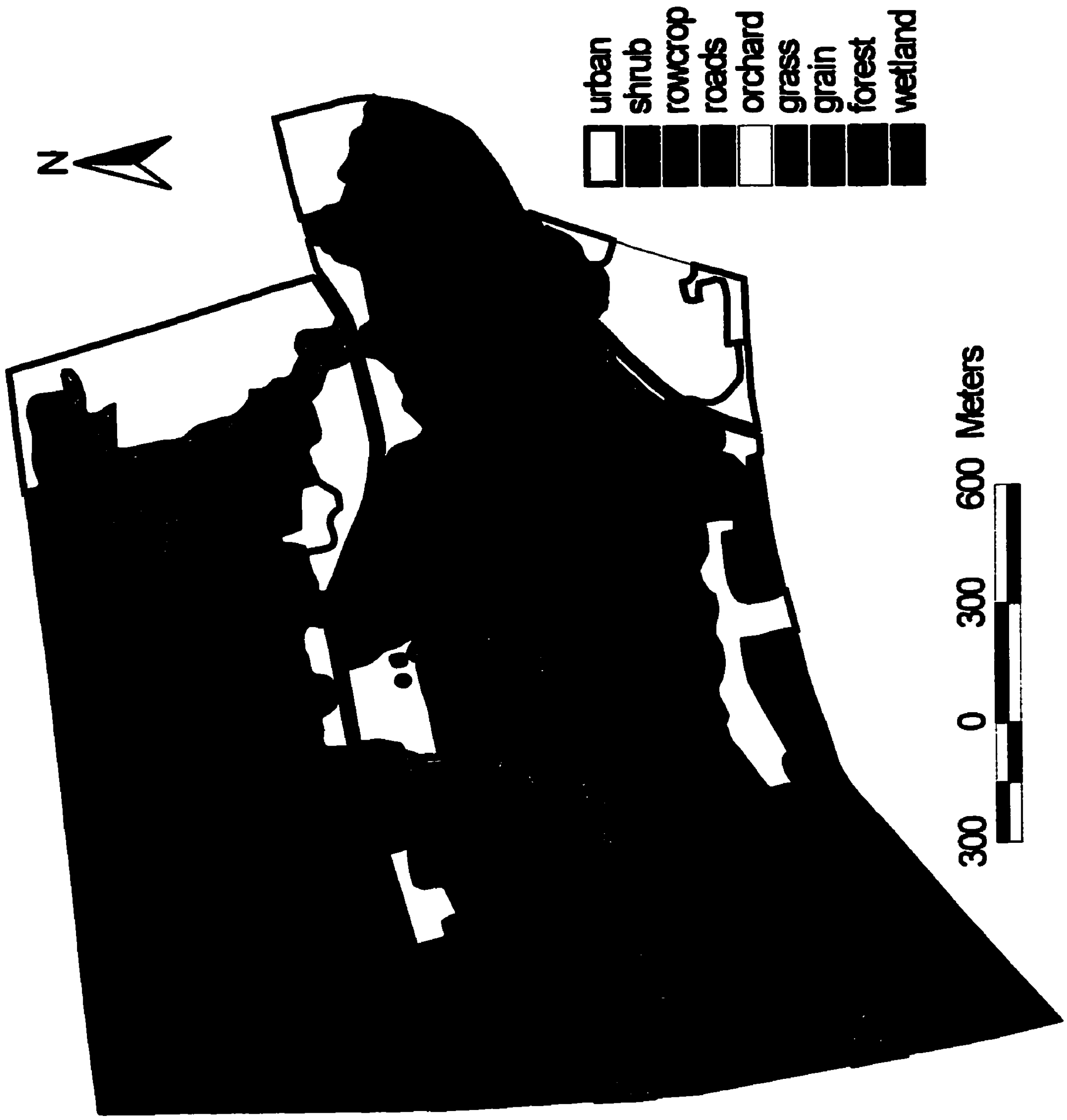


Figure 6: Map of Hillaton Study Site showing habitat types.



Appendix 1: Total locations, locations deleted, locations used, mean and standard deviation and largest error ellipses used in habitat use analysis for 45 radio-collared hen pheasants in Kings County, N.S.

Bird #	Total # locations	Number locations deleted [a]	Number locations used	Mean error ellipse (ha)	Std. dev.	Largest error (ha)
Phes1	33	7	26	2.0	2.1	6.9
Phes2	148	11	137	1.8	1.7	8.8
Phes4	76	28	48	3.4	2.5	9.3
Phes5	17	4	13	3.9	2.8	8.5
Phes6	146	16	130	2.0	1.8	9.6
Phes7	77	11	66	2.5	2.4	9.1
Phes8	142	18	124	1.8	2.0	9.6
Phes9	24	1	23	2.5	2.0	7.7
Phes10	21	3	18	2.0	1.6	5.8
Phes11	72	5	67	1.6	2.0	9.3
Phes12	162	7	155	2.0	1.5	8.3
Phes14	134	18	114	1.6	1.8	9.4
Phes15	84	6	78	2.6	2.1	9.7
Phes16	146	10	136	2.4	1.7	8.8
Phes17	46	3	43	2.3	2.3	9.5
Phes18	119	7	112	1.8	1.3	7.7
Phes19	73	6	67	2.0	1.6	8.2
Phes20	112	5	107	2.2	1.5	7.6
Phes21	126	17	109	4.0	2.1	9.3
Phes22	117	5	112	2.2	2.1	9.3
Phes23	3	0	3	0.8	0.7	1.8
Phes24	59	14	45	2.7	2.2	9.9
Phes25	13	2	11	3.8	2.1	8.3

Appendix 1 (continued):

Bird #	Total # locations	Number locations deleted	Number locations used	Mean error ellipse (ha)	Std. dev.	Largest error (ha)
Phes26	63	4	59	1.9	1.2	5.2
Phes27	45	3	42	1.8	1.4	6.8
Phes28	47	7	40	3.5	2.6	9.8
Phes29	28	2	26	2.8	2.3	7.4
Phes30	5	1	4	0.8	0.6	1.8
Phes32	15	2	13	0.8	0.3	1.5
Phes33	15	1	14	1.7	1.6	6.9
Phes34	16	0	16	1.1	1.0	4.7
Phes35	15	8	7	3.2	2.3	8.2
Phes36	14	1	13	1.3	1.1	3.6
Phes37	15	3	12	2.1	2.3	6.5
Phes38	15	0	15	1.2	0.8	2.8
Phes40	6	0	6	2.1	2.0	6.2
Phes41	5	0	5	0.6	0.2	0.8
Phes42	6	0	6	2.1	2.4	7.3
Phes43	8	0	8	1.4	1.4	4.7
Phes44	9	1	8	1.4	1.1	3.0
Phes45	8	0	8	1.5	0.7	3.0
Phes46	7	1	6	1.6	0.9	3.5
Phes47	8	0	8	1.0	0.9	2.4
Phes48	2	0	2	2.0	2.0	3.9
Phes49	4	0	4	2.2	2.6	6.7
Total	2306	236	2066	2.0	1.6	9.9

[a] Locations deleted that have error ellipse ≥ 10.0 ha.

Appendix 2: How to determine the adjusted number of locations/ha.*birdday:

Step 1:
actual observed # locations /(mean home range area * total # birddays) = actual # locations/ha.*birdday.

Step 2:
actual # locations/ha.*birdday * (total actual # observed locations / total actual # locations/ha.*birdday) = adjusted # locations/ha.*birdday.

Shrub use during fall as an example:

Habitat	Actual observed # locations	Mean fall home range (ha)	Actual observed locations/ha.*bird day	Adjusted # locations/ha.*bird day
Alders	23	1.1	0.03168	19
Grass	26	2.3	0.017128	10
Wetland	42	2.333	0.027277	17
Shrub	19	0.283	0.101724	62
Grain	20	2.267	0.013367	8
Row crops	0	1.25	0	0
Crop residue	18	1.633	0.016701	10
Urban	34	4.183	0.012315	8
Forest	8	0.133	0.091137	56
Total	190	15.482	0.311329	190

Total birddays during fall = 660.

Appendix 2 (continued):

Step 1:

actual observed # locations/ha.*birdday
= actual observed # locations / (mean home range area of shrub * total # birddays)
= 19 / (0.283 * 660)
= 0.101724 locations/ha.*birdday

Step 2:

adjusted # of locations/ha.*birdday
= actual observed # locations/ha.*birdday * (total actual # observed locations / total actual # locations/ha.*birdday)
= 0.101724 * (190 / 0.311329)
= 62 adjusted locations/ha.*birdday

Appendix 3 : Number of hen pheasants contributing home ranges by season.

Season	Total # H.R.'s	Total H.R.'s used[b]	No. Hens	Mean H.R. size (ha.)
Winter[a]	37	23	27	7.101
Spring	22	14	22	13.472
Nesting	16	10	16	3.350
Summer	16	10	16	8.560
Fall	10	6	10	15.482
Total	101	63	N.A.	11.548

[a] 10 hens had home ranges during both winter 95 and winter 96.
[b] after 20% trimmed mean.