High Ruffed Grouse (*Bonasa umbellus*) Relative Abundance in a Transitional, Early-Successional Habitat

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Abstract

I recorded and examined ruffed grouse (*Bonasa umbellus*) flush data across upland hardwoods, lowland coniferous, and transitional habitats within the Adirondack State Park, New York. The flush data was recorded throughout September, 2011. Study site areas were accounted for to establish a flush per hectare rate. Contrary to my hypothesis the transitional habitat produced significantly more flushes (x^2, $p<0.0001$) than the hardwoods and coniferous habitats. Lowland (conifer + transitional) and upland flush per hour rates were compared to a mean central Adirondack rate. I was unable to establish a significant conclusion from this comparison. A habitat suitability index indicated that stem density and the absence of aspen (*Populus tremuloides, Populus gradidentata*) appeared to be the limiting factors within the hardwoods habitat. Unanimous upland stem density suitability index values (SIV3) of zero resulted in an upland fall to spring cover value (FSCOV) of zero. If stem density was suitable throughout the upland habitat the quality of grouse cover would have increased significantly (FSCOV=0.9). However, aspen would have to be established to create quality grouse habitat with adequate cover and forage. Therefore, I concluded that as the upland forest stand ages and stem density increases, grouse densities are also likely to increase.

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Table of Contents

Abstract ii

Acknowledgements iii

List of Figures and Tables vi

Introduction 1

Literature Review 6

- General Effects of Habitat on Fitness 6
- Range and Distribution 7
- Habitat Use and Evaluation 9
- Nutritional Requirements of Ruffed Grouse 13
- Fitness Indices of Grouse 16
- Trapping 17
- Sexing and Aging 19
- Marking 20

Field Methods 21

- Site Description 21
- Vegetation Measurements 26
- Grouse Population Estimates 26

Analytical Methods 29

- Grouse Populations 29
- Vegetation Analysis 30

Results 34

Discussion 38

Literature Cited 42

List of Figures and Tables

Tables

Table 1: Age and Sex Characteristics of Ruffed Grouse Plumage (Pyle et al. 2008)……………………………………………………………………………………..……20

Table 2: Calculated equivalent stem density coefficient for conifers (βV2), suitability index for total equivalent stem density (SIV3), suitability index for average height of woody stems (SIV4), suitability index for percent conifer (SIV5), fall to spring cover suitability index (FSCOV) per plot……………………………………………………………………….……………………34

Table 3: Flushes, area (hectare), and flushes per hectare of the upland, transitional, and conifer study areas…………………………………………………………………………..36

Table 4: Percent variance in flush per hectare rates attributed to habitat type (DF=1)……………………………………………………………………………………………36

Figures

Figure 1: Figure 1: General location of study habitats within the Adirondack Park, New York……………………………………………………………………………………..…..23

Figure 2: Site map of the upland study habitat within Franklin County, New York..…………………………………………………………………………………………24

Figure 3: Site map of the lowland study habitat within Franklin County, New York……………………………………………………………………………………………...25

Figure 4: Coefficient for equivalent stem density equation as determined by average lowest-branch conifer height (Cade and Sousa 1985)………………………..…………31

Figure 5: Suitability index (SIV3) for total equivalent stem density, in thousands of stems per hectare (Cade and Sousa 1985)……………………………………...…………32

Figure 6: Suitability index (SIV4) for average woody stem height (Cade and Sousa 1985)…………………………………………………………………………………………..32

Figure 7: Suitability index (SIV5) for percent conifer as determined by equation 2 (DOI:FWS 1985)………………………………………………………………………….33

Figure 8: Mean Central Adirondack, Upland, and Lowland Flush per hour rates. Error bars report standard deviation……………………………………………………………...37

Introduction

Wildlife management practices attempt to not only harbor life but create and sustain healthy populations of game and nongame species. Habitat type and quality is a key ecological factor in the health, fitness, and survivability of all types of life. While some habitats may be suitable for an organism to survive in, they may not rear an individual of great health or fitness (Rosenzweig 1981). Fitness is used to describe the viability of an organism to pass on its genes to the next generation. To reproduce, an organism must reach sexual maturity and make it to breeding season. In boreal and sub-boreal forests, one of the great limiting factors of this process for avian species is the individual's ability to survive the harsh winters by relying on fat storages and the few nutrients that are available (Bednekoff and Houston1994).

Ruffed grouse (*Bonasa umbellus*) are important game birds with an extensive distribution across the north woods of North America. Ruffed grouse are distributed from the northeast Atlantic coast west to Alaska and south through the Rocky and Appalachian mountain chains south to northern Georgia. Grouse can survive in a wide variety of habitats (both deciduous hardwoods, and coniferous boreal forest), but generally prefer early successional hardwoods with dense vegetative undergrowth (Tirpak et al 2007).

Ruffed grouse are primarily solitary birds with males drumming, most often in the morning, to advertise their presence to females and establish their territory with neighboring males (Edminster 1947). While female grouse are not territorial, males defend a patch of land about 2.3 ha; females generally have overlapping home ranges of 2-10 ha (Atwater and Schnell 1989).

While water is essential to sustain a healthy population, ruffed grouse are not limited to areas with open water. Grouse can obtain water from snow, dew, soft fruits, succulent vegetation, and insects along with open water (Edminster 1947). Cover habitat is also essential to guard grouse from avian predators. Coniferous forest provide thick overhead cover year round while deciduous cover is absent in the winter. Grouse survival decreases with an increase in tree height, due to an increase ease of predation by avian predators (Gullion and Marshall 1968). In mixed forest, conifer patches are commonly used as escape cover when the bird is flushed (Marshall 1946). Cover and shelter requirements shift with the seasons and weather. High winds and/or cold limit birds to hardwood and coniferous forest patches and keep them from open brush land. A key factor in the territory of a male is a drumming platform which is typically composed of a fallen log. The platforms must be 30 to 35 centimeters above the ground with unobstructed visibility. It must also contain a “guard object” for security nearby which is generally a stump or another fallen tree.

Except through the Appalachian mountain range, the diet and therefore the distribution of the ruffed grouse is heavily tied to aspen (*Populus tremuloides, P. grandidentata*). Aspen provide thick cover and male, staminate trees are a staple of their diet (Bump 1947, Atwater and Schnell 1989, McGowan 1973, Thompson and Fritzell 1989). Fall foods of the ruffed grouse are composed of persistent fruits, hard mass of oaks (*Quercus spps.*) and beech (*Fagus* *grandifolia*), and various seeds. The fall diet of grouse is much more varied than their winter diet. When snowfall occurs in the winter a shift occurs to the consumption of buds, catkins, and twigs of aspen, cherry (*Prunus spp.*), birch (*Betula spp.*), hornbeam (*Carpinus caroliniana*), and apple (*Malus spp.*). Primary spring and summer foods consist of various fruits, invertebrates, leaves, flowers, and seeds (Edminster 1947, McGowan 1973). While aspen plays a primary role in the diet of grouse they cannot rely exclusively on it. Coniferyl benzoate is a toxin found in aspen species that causes decreased food intake and increased water excretion with high levels of intake (Jakubas et al. 1993). Grit is required by grouse to help in the gizzard's role of their digestive process. Grit is usually composed of gravel and small stones. Due to variations in diet grit is most needed in winter when it is the hardest to acquire (Edminster 1947).

In northern temperate forest there is a large contrast in vegetation between lowland and upland forest. Lowland forest are generally wet and boggy consisting of thick stands of various conifers. Black spruce (*Picea mariana*), balsam fir (*Abies balsamea*), and tamarack (*Larix laricina*) are the predominant tree species while the ground is generally covered with sphagnum moss (Gullion and Marshall 1968). The understory is generally composed of labrador-tea (*Ledum groenlandicum*), leather-leaf (*Chamaedaphne calycullta*), pale laurel (*Kalmia polifolia*), sheep laurel (*Kalmia angustifoliaI*), willows (*Salix spp.*), speckled alder (*Alnus incana*), and highbush cranberry (*Viburnum trilobum*) (Gullion and Marshall 1968). Upland forests tend to be drier with open water consolidated to streams instead of pools and bogs found in lowland forest. The canopy of upland forests consist of trembling and bigtooth aspen, paper birch (*Betula papyrifera*), american beech (*Fagus grandifolia*), red maple (*Acer rubrum*), sugar maple (*Acer saccharum*), red pine (*Pinus resinosa*), and white pine (*Pinus strobus*). The understory consists of blueberries (*Vaccinium spp.*), blackberries and rasberries (*Rubus spp.*), bush honeysuckle (*Diervilla lonicera*), and wild sarsaparilla (*Aralia nudicaulis*). These two forest types are fairly easy to delineate, but may tightly coexist. It is not uncommon for islands of upland vegetation to be found within a lowland forest (Gullion and Marshal 1968).

I intended to investigate how habitat type and quality affected the fitness, health (determined by weights provided by Bump et al. 1947), and abundance of ruffed grouse in New York, within the Adirondack State Park. Within a boreal forest in Michigan, Gullion and Marshall (1968) determined that ruffed grouse survival was longest in hardwoods forests devoid of conifers. Due to differences in cover and available vegetation I hypothesized that the upland forest consisting of various hardwoods would produce a heavier and therefore presumably more fit grouse than the lowland coniferous forest that I investigated. Due to unsuccessful trapping, my goal was instead to determine the relative abundance of ruffed grouse across an upland forest, transitional zone, coniferous forest, and lowland habitat (comprising the transitional zone and coniferous forest). My goal also was to investigate the possibility of habitat selection across these cover types.

Upland areas, within the Adirondacks, generally contain hardwood tree species, as opposed to lowland areas that usually contain several conifer species (tamarack, black spruce, balsam fir) (Bump et al. 1947). These hardwood species, especially aspen, provide quality grouse forage (Bump et al. 1947, Atwater and Shnell 1989, Edminster 1947, Gullion and Marshall 1968, Svoboda and Gullion 1972, Berner and Gysel 1969, Fearer and Stauffer 2003, Giroux et al. 2007). Due to greater forage availability as well as Gullion and Marshall's (1968) finding that grouse survivability was highest in hardwoods, I hypothesized that the upland forest would have a higher relative abundance of grouse.

Species may select a habitat that is more likely to allow for their survival over another. Habitat selection is a function of location and environmental influences (Rosenzweig 1981). Habitat selection is determined when a habitat is used significantly more than it was available on the landscape (Rosenzweig 1981). I hypothesized that grouse would select for the upland habitat.

Grouse populations can be managed by altering habitat components, especially vegetative cover (Berner and Gysel 1969). The findings of this study should be used by game and land managers to improve grouse habitats within the Adirondack Park. Improving grouse habitats may in turn allow for higher and healthier grouse populations. Although I expect the findings of this study to be similar to those of other ruffed grouse studies, this study may produce new findings, unique to the Adirondack region.

Literature Review

Ruffed grouse (*Bonasa umbellus*) are an important game bird species of northern North American forest (Atwater and Schnell 1989). They are the most widespread North American member of the Tetraonidae family (grouse and ptarmigan) and are of the order *Galliformes*, which also includes turkeys, chachalacas, quail, and pheasants (Edminster 1947). Ruffed grouse are the only North American member of the *Bonasa* genus with two Eurasian cousins constituting the rest of the genera (Atwater and Schnell 1989). The name *Bonasa* makes reference to bison alluding to the bellow of the male's drumming. The specific epithet, *umbellus*, is Latin for umbrella, describing the neck ruff that males commonly display (Edminster 1947). Regionally, the ruffed grouse has many colloquial names and may be referred to locally (northeast U.S.) as partridge (Bump et al. 1947).

The topics that will be discussed in detail in this review are: general effects of habitat on fitness, range and distribution, grouse habitat use and scientific evaluation, nutrition, trapping, and sexing and aging of grouse.

General Effects of Habitat on Fitness

Appropriate habitat selection is a substantial and most likely life determining "decision" by an individual. Habitat selection is a function of location and environmental influences that are imposed upon an individual. Species may be considered generalist/opportunist (fine-grained) or a specialist (coarse-grained) (Rosenzweig 1981). Generalists are defined as having equal fitness in differing patches; specialist will have a higher fitness in one patch opposed to another. A fine-grained species, or opportunist, will use available resources in the proportion to which they exist; coarse-grained species will use resources in a proportion different to which they exist, and therefore tend to be specialist (Rosenzweig 1981). Hypothetically, if two coexisting species specialize on a resource, only the more specialized species will continue to exist and will be found throughout the resource range (MacArthur and Levins 1964). Interspecific competition is a main cause in the differing of niches, be they different habitats, food preference, or physiology (Svardson 1949). Specialization in one resource guarantees a less effective utilization of a different resource. A specialist who is twice as fit in a patch as a generalist will eventually replace the generalist (Rosenzweig 1981). Specialized species are more likely to occur in a patch in which they specialize. This may be due to actual habitat selection of the individual or a function of out competing other species. Habitat selection by a specialist is abandoned as population density passes a critical point and fitness is equal across differing habitats (Rosenzweig 1981).

Range and Distribution

Ruffed grouse have a greater distribution than any other North American Tetraonid. They prefer transitional hardwoods and boreal forest and can be found coast to coast spanning 34° of latitude, more than any other non-migratory game bird (Bump et al. 1947). They range from the northeast, west to Alaska, and can be found through the Rocky and Appalachian mountain chains as far south as

Georgia (Bump et al. 1947, Edminster 1947, Atwater and Schnell 1989). A limiting agent within its range is cover and is a primary reason why it is not found on the Great Plains (Bump et al. 1947). Aspen (*Populus spp.*) has proved to be an important factor in the distribution of ruffed grouse. Except in their Appalachian range, where the winters are milder, grouse rely heavily on aspen as a winter food source. This relationship is so strong that one can hypothesize the presence of ruffed grouse in an area according to the presence of aspen. Within this area aspen is not only a food source but also provides cover from avian predators (Bump et al. 1947, Edminster 1947, Stauffer et al. 2007). Stauffer et al. (2007) stated that "… (aspen) is the most important component of ruffed grouse habitat". Grouse are able to survive outside the range of aspen, in the Appalachian region, due to much milder winters and the availability of rhododendron (*Rhododendron spp.*) and mountain laurel (*Kalmia latifolia*) as cover. However, it is believed that the Appalachian region offers less cover from avian predators and lower quality forage (Stauffer et al. 2007).

Ruffed grouse species are composed of twelve distinct subspecies spatially separated. Subspecies vary by color, body size and weight, foot shape, and tarsus length (Pyle et al. 2008). Within the Adirondack Park only one subspecies is present, the St. Lawrence (Canada) Ruffed Grouse (*Bonasa umbellus togata*). *Bonasa umbellus togata* is found throughout New England, north through Ontario, Quebec, and New Brunswick, and west to Wisconsin (Atwater and Schnell 1989). This subspecies is described as mostly gray phase. Compared to the other predominant east coast subspecies *Bonasa umbellus*

umbellus, which can be found in southern New York, *Bonasa umbellus togata* is generally darker, larger, and heavier (Pyle et al. 2008, Atwater and Schnell 1989).

Except for the salt marshes of Long Island and the alpine areas of the Adirondack Region, New York was once a vast expanse of prime grouse habitat. Grouse can still be found throughout the state but do not venture into open areas such as farm fields (Bump et al. 1947). In 2005, ruffed grouse could be found throughout the state with the most sightings occurring in the Adirondack region. In the same year, there was also a single confirmed sighting on Long Island (NYSDEC 2005).

Habitat Use and Evaluation

While describing grouse utilization of habitat in New York, Bump et al. (1947) said grouse were most abundant "in those localities where settlement has opened up the forest and where mixed cover is found but where agriculture or other utilization by man has not been intensive". Areas such as abandoned farms provide prime, early-successional habitat within New York. Power lines, access roads, and logging trails also function to provide openings within a forested habitat (Berner and Gysel 1969). Historically, these early-successional habitats were created by fire, wind, beavers (*Castor canadensis*), and flooding. These factors can now be controlled or minimalized. This results in a decline in the creation of early-successional habitat (DeGraaf and Yamasaki 2003).

Broods are less capable of dealing with poor habitat than adults (Berner and Gysel 1969). Quality brood habitat provides substantial cover but also allows chicks to move around easily (Jones et al. 2008). If available, broods will use dense, early-successional stands that are 11-20 years old and 1.5-7.0 m tall (Giroux et al. 2007). Vegetative species diversity is an important characteristic. Grouse prefer upland habitats but will frequent lowland sites during the fall, winter, and spring (Berner and Gysel 1969).

Ruffed grouse are non-migratory, spending the entirety of their life within a given “activity center” (Bump et al. 1947, Fearer and Stauffer 2003). Hens are not territorial and encompass a home range within their habitat large enough to meet their nutritional and cover needs (Bump et al. 1947, Fearer and Stauffer 2003). These home ranges are overlapping, and change with seasonal needs but may average 2-12 ha depending on habitat quality, landscape components, social interactions, and microhabitat characteristics (Atwater and Schnell 1989, Fearer and Stauffer 2003). Males display territoriality within the immediate range of their drumming log and will spend the majority of their life within 250 meters of the log. Their home range, or activity center, is generally about 4 ha in suitable habitat (Atwater and Scnell 1989). Most birds live out their life within 1.5 km of where they are hatched and rarely ever venture more than 8 km away (Atwater and Schnell 1989).

The drumming log, in a male’s territory, is a keystone resource that defines his territory. Most males are able to locate a suitable drumming site within 600 meters of the brood range they occupied as a chick (Berner and Gysel

1969). The drumming log is located at the center of a male's territory (Zimmerman and Gutiérrez 2008). Males tend to visit and use one drumming log throughout their life, a prolonged absence from the site usually indicates that the bird is deceased. In the rare case that a male does decided to change his drumming site he usually finds an adequate site within 100 meters of the previous log (Gullion and Marshall 1968). Gullion and Marshall (1968) said that mature aspens near to the log and a tradition of occupancy are the two main factors in drum site selection. They found that grouse will stay at a site even if the vegetation around the log is drastically altered, with the exception of aspen. If a new male replaces a successor that was killed on the site by a raptor, generally a goshawk (*Accipter gentillis*), his future will most likely be short, goshawks learn to visit drumming sites (Gullion and Marshall 1968). Gullion (1972) established four factors that make a site suitable: (1) The site must be 30-35cm above the ground with an unobstructed view; (2) a guard object, such as a stump, must be present for the bird to use as cover, if need be; (3) There should be dense growth 3-4 meters from the log reaching at least a meter above the log height; (4) there must be mature male aspen within sight of the log. In areas such as the Adirondacks where boulders are present; the boulders, along with ledges may suffice for a drumming stage (Bump et al. 1947).

Cover from predators is the most important dynamic of both the male and female's domain (Bump et al. 1947). Raptor kills, mostly by goshawks, are the leading cause of mortality amongst grouse (Hewitt et al. 2001). Gullion and Marshall (1968) found, during a study in Minnesota, that 208 out of 243 (80%)

grouse were killed by raptors. Grouse cover's primary function is to shield them from avian attacks. Quality grouse brood habitats are forest openings with a substantial amount of shrub stems. Broods are rarely found far from these habitats (Dessecker and Mcauley 2001; Jones et al. 2008). Grouse survival is best in hard woods devoid of high conifers (Gullion and Marshall 1968). Still, if low conifers are present, grouse will fly to them for cover if flushed (Marshall 1946). Grouse survivability decreases drastically in areas where tall pines are present, these trees allow for many perches to be used by Goshawks. Gullion and Marshall (1968) found that 29/100 grouse survived a year in a pine dominated forest, while 50/100 survived a year in a hardwoods forest. Conifers such as spruce (*Picea spp.*) and balsam fir (*Abies balsamea*) do not alter grouse survival rates (Gullion and Marshall 1968). Of the two color morphs gray-phase birds survived, on average, 5 months longer than red-phase birds. However, the survivability of gray-phase birds in conifers was drastically lower than those of the hardwoods; red-phase birds did not show this same occurrence. Survivability of females is not drastically different from that of males (Gullion and Marshall 1968).

During the winter grouse roost under snow cover and in eastern red cedars (*Juniperus virginina*) (Bump et al. 1947, Thompson and Fretzell 1989). Zimmerman et al. (2008) found that grouse survivability is higher during cold, snowy winters than cold, snowless winters.

A Habitat Suitability Index for grouse (Cade and Sousa 1985) measures ecological factors on a 0-1 scale with 1 being optimal habitat. It accounts for cover from both avian and terrestrial predators as well as the specie's primary food source, aspen (Atwater and Schell 1989). This HSI measures average mature male aspen density, lowest branch height of conifers, total equivalent stem density, height of woody stems, and percent conifers.

Flush data from around New York State is collected through the state's cooperator ruffed grouse and American woodcock hunting log with the help of volunteer hunters. This study determined that on average hunters flushed 0.63 grouse per hour in the central Adirondacks during the 2010-2011 hunting season (NYSDEC 2011).

Nutritional Requirements of Ruffed Grouse

Grouse are omnivores throughout their life, but rely mostly on plant material during adulthood. Due to rapid growth, during the first two weeks of a chick's life animal protein is consumed very heavily, mostly in the form of insects. The most common insects consumed in New York are: ants, beetles, and caterpillars (Bump et al. 1947). By the end of the summer, late August, hatch year birds consume the same diet as adult birds. While adults are still considered omnivores, their diet is significantly different than that of chicks. Plant material constitutes the overwhelming majority of their diet (98.9% annually) while animal consumption is minimal (1.1% annually). Summer is the peak time of insect consumption due to their availability, but adult consumption is minimal with insects comprising only one-twenty-fifth (4%) of the adult bird's summer diet (Bump et al. 1947).

Throughout the spring, summer, and fall grouse are generalists in terms of plant consumption and are known to eat 334 species throughout their range (Bump et al. 1947). Most species consumed are pioneer and early transitional plants with shrubs and trees providing forages for the bulk of their diet. These species are most present three to five years after substantial timber harvest and are not usually found in dense forest. The most commonly consumed plants in New York are: aspen, cherry (*Prunus spp.*), birches (*Betula spp.*), raspberries (*Rubus idaeus*), blackberries (*Rubus allegheniensis*), hop-hornbeams (*Ostrya virginiana*), and thorn-apples (*Datura stramonium*) (Bump et al. 1947). Primary vegetative spring and summer foods consist of fruits, leaves, flowers, and seeds (Edminster 1947, McGowan 1973). With a change in available vegetation comes a dietary shift for the birds. Fall foods consist mostly of persistent fruits, hard mass of oaks (*Quercus spp.*) and beech (*Fagus grandifolia*), and various seeds (Edminster 1947, McGowan 1973). Leaves of broadleaved evergreens may also be consumed in the fall. Mountain laurel is consumed in the bird's southern range but is absent within the Adirondack region. Locally, partridgeberry (*Mitchella repens*), hawkweed (*Hieracium spp.*), and wood sorrel (*Oxalis montana*) may be consumed prior to heavy snowfall (Bump et al. 1947). Tanney and Hutchison (2010) found 20% of grouse crops in northwestern Ontario contained fungal fruiting bodies. They determined that grouse prefer mushroom gills over other parts of the fruiting body, because they are highest in nutrition and easiest to consume. Fungi may play a significant role in grouse diets throughout the fall, when other foods are harder to find (Tanney and Hutchison 2010). In the

Adirondacks, winter means snow and a drastic dietary shift for ruffed grouse due to available forage (McGowan 1973). Throughout the winter grouse consume buds, catkins, and twigs of aspen, cherry, birch, hornbeam (*Carpinus caroliniana*), and apples (*Malus spp.*) (Edminster 1947, McGowan 1973). During a study of Alaskan ruffed grouse (*Bonasa umbellus yukonensis*) McGowan (1973) found that the bird's diet was more varied through the fall than the winter. Still, with the reduction of diet variation only 30% of birds had crops containing a single food type.

The role of aspen species (*Populus tremuloides, P. grandidentata*), in the winter diet of grouse, cannot be overstated. Aspen provide thick cover for the birds and male buds are a staple of the grouse's diet. These buds emerge in early summer, after the leaves, and are persistent throughout the winter until they are shed in May (Svoboda and Gullion 1972). Aspen buds may account for 66% of the bird's winter diet (Jakubas et al. 1993). Aspen buds do not come without some downfall and cannot compose the entirety of their diet. Aspen buds contain a toxin, Coniferyl Benzoate (CB), which may be detrimental to grouse health. High levels of CB have been associated with decreased food intake and increased water excretion in ruffed grouse (Jakubas et al. 1993). Most aspen buds contain about 1% drymass CB; as little as 1.8% CB may be "deleterious" to ruffed grouse health, although they will consume buds containing 2.5-4.5% CB if nothing else is present (Jakubas et al. 1993). Jakubas et al. (1993) speculated that grouse may utilize aspen of lower CB levels over aspen with higher CB levels.

Open water availability does not seem to limit grouse distribution. While they require water to survive they are not tied to areas where open water is present, and may obtain water through a variety of resources. Grouse may acquire water from snow, dew, soft fruits, succulent vegetation, and insects (Edminster 1947).

Fitness Indices of Grouse

Bump et al. (1947) described body weight as a “major yardstick of (grouse) health. Body weight is affected by environmental factors such as food, weather, and shelter and will vary will vary between region, seasons, and years. Grouse require 78 calories a day to maintain their body weight (Bump et al. 1947). Heavier/stronger individuals will display levels of dominance over lighter/weaker individuals. Weights vary naturally across seasons due to environmental and physiological conditions which must be countered. For both sexes, grouse are heaviest in late fall (November-December). During this period New York males average 651 grams while females average 587 g. Males lose weight throughout spring and summer and are lightest in mid-August, averaging 604 g. Females lose weight quicker through the winter and spring and are lightest in mid-June, averaging 587 g (Bump et al. 1947). Body weight can be categorized into three levels: a zone of good health, a danger zone, and a critical zone. The zone of good health is what the average grouse should weigh and varies across regions, seasons, and sexes. Weights in the danger zone show that an individual is being stressed either by environmental factors or disease/parasites. Grouse that reach the critical zone can be expected to die soon. Once this zone is reached it is nearly impossible for an individual to regain health (Bump et al. 1947). These weights are displayed in Appendix 1, reprinted from a study of New York ruffed grouse by Gardiner Bump (1947).

Trapping

The mirror trap targets male grouse on drumming logs. The lily-pad style trap is not gender specific, but commonly captures hens and their attending broods (Dorney and Mattison 1956).

The mirror trap capitalizes on the male's aggressive nature and territoriality over his drumming site. The trap is a single-door, treadle-triggered box trap, intended for a live and safe capture of the bird. The trap should measure approximately 30 cm high x 25 cm wide x 58 cm long (Dorney and Mattison 1956). The trap should be wrapped in burlap to minimize injuries, which are usually superficial and not life threatening, and to protect the bird from inclement weather (Gullion 1965). The trap should be placed 1-2 meters to the east or south from an active drumming site. The mirror trap is "baited" with a mirror which should entice a territorial male to evacuate the "intruder" and lure them into the trap. The trap should be covered with conifer boughs to hide the trap from wary grouse and to protect the captured bird from predators. Grouse generally do not attempt to fly when in the trap unless it begins to rain or snow, for this reason trapping should not be attempted in inclement weather or in temperatures below -18°C. Trap success is usually highest in the spring on the second morning after a storm when the temperature is between -2 and 3°C (Gullion 1965). Traps should be set at dusk or after dark as to not frighten the local male, and should be checked daily.

Gullion (1965) stated that is “possible to trap virtually every grouse” with a lily-pad trap. This is the easiest and most effective means of trapping large numbers of grouse. This style trap is most successful in August and September when grouse are congregated in large broods (Dorney and Mattison 1956). The trap consists of 5 main parts: the central cage, end cages, holding cage, guide, and leads. The central cage is approximately 180 x 130 x 50 cm and constructed of wire mesh or chicken wire. The entrance to the trap should be 7 cm wide to allow enough room for the bird to enter but not exit. At each entrance a 50 cm high lead should be run at a perpendicular angle for approximately 20 meters (Liscinskey and Bailey 1955). At the central cage the lead has a 7 cm wide opening on each side. The leads and cages should all be supported using stakes (Dorney and Mattison 1956). A funnel should be used at each entrance of the cage to confine the entrapped bird. The funnel should be constructed using a 30 x 97 cm rectangle of one inch poultry netting. It should be supported using a 20 x 40 cm frame constructed with a ½ x 1” wood strip. The opening of the funnel needs to be 15 cm high and 7.5 cm wide (Gullion 1965). The top of the cages should be wire mesh and covered in boughs to protect from avian predators. Within the center cage a guide should be set the height of the cage to direct the birds to the holding cage. There are two types of holding cages the bob-type and the ramp cage. I will use the ramp cage due to its ease of use and transportation

(Dorney and Mattison 1956). The ramp cage is made of soft wire mesh. Birds walk up a ramp and through a cone, falling into a smaller holding pen. The cone for the ramp cage should be 15 cm in diameter (Dorney and Mattison 1956). At the end of each guide should be a cage in the style of the center cage, 1-1.5 m in diameter, to capture any birds diverted around the trap. Implementation of these end traps increased trapping success by 16% (Chambers and English 1958). Within the cages and along the leads the sod and leaves should be cleared to bare soil, which itself attracts grouse. In the fall traps should be set in brushy areas with dense undergrowth. Traps should be set under low hanging balsam fir, spruce, and pine boughs in the winter (Gullion 1965). Bait should be applied along the leads and in the cages, and can increase trap success by a factor of four (Dorney and Mattison 1956). Gullion (1961) dyed corn orange, red, blue, and purple resulting in a great success rate. Corn is a foreign food source to grouse, dying it resembles natural berries; once dyed, the corn should be stored frozen to retain its round shape (Gullion 1961).

Sexing and Aging

Ruffed grouse are sexed and aged primarily through examination of their plumage. Table 1 (Pyle et al. 2008) outlines plumage characteristics specific to sex and age class.

Table 1: Age and sex characteristics of ruffed grouse (*Bonasa umbellus*) plumage (Pyle et al. 2008)

Age/Sex Class	Ornamental Neck Feathers	Rump Feathers	Central Rectrices	Outer Rectrices
HY-Female	Short	1 Dot	Missing or indistinct sub terminal band	Narrow and rounded
HY-Male	Long	2-3 Dots	Partial to full sub terminal band	Moderately broad and rounded
AHY-Female	Short	1 Dot	Indistinct sub terminal band	Moderately narrow and truncate
AHY-Male	Long	2-3 Dots	Full sub terminal band	Broad and truncate

Marking

Grouse are usually banded using aluminum tarsus bands. The bands come in numeric order and are purchased from National Band and Tag Co. in units of 100; they are sex discriminate. The bands should be placed on the tarsus so that they can freely move up and down. They should also have the ability to turn around the tarsus. If the band is able to slip over the toe of the grouse it is too loose. Size 5 (♀) or 6 (♂) bands should be used for ruffed grouse. Bands are first opened using banding pliers. They are then fitted around the tarsus and crimped so that the ends are tight and flush. When done properly the bands should be round and not ovate (Giles 1969, Addy et al. 1956).

Field Methods

Site Description

This study measured ruffed grouse relative abundance across two distinct northern, temperate habitats; one habitat was a lowland coniferous forest (Figure 2) while the other was an upland mixed hardwood forest (Figure 3). Both locations were in northern New York within the Adirondack State Park, in Franklin County on private land (Figure 1). The lowland coniferous forest was located at 44° 25’ 31”N, 74° 09’ 12”W. The lowland forest was comprised mainly of balsam fir (*Abies balsamea*) with a moist to saturated soil covered in sphagnum moss. Other vegetative species within the lowland forest include: tamarack (*Larix laricina*), red spruce (*Picea rubens*), black spruce (*Picea mariana*), balsam poplar (*Populus balsamifera*), speckled alder (*Alnus incana*), and yellow birch (*Betula alleghaniensis*). The lowland site also contained a transitional area between the conifer swamp and an upland field. This transitional area contained quaking aspen (*Populus tremuloides*) and bigtooth aspen (*Populus grandidentata*). The upland mixed hardwood forest was located at 44° 26’ 48”N, 74° 10’ 38”W. The upland forest was comprised mostly of maples (*Acer spp.*), American beech (*Fagus grandifolia*), paper birch (*Betula papyrifera*), red spruce (*Picea rubens*), and white pine (*Pinus strobus*) with an understory consisting of blueberries (*Vaccinium spp.*), blackberry (*Rubus allegheniensis*), raspberry (*Rubus ideaus*), and wild sarsaparilla (*Aralia nudicaulis*). The upland site was harvested 3 to 4 years ago, while the lowland site was harvested approximately 20 years ago.

The two study areas were both roughly 32.4 ha (80 acres) each and were approximately 3.06 km (1.9 miles) apart.

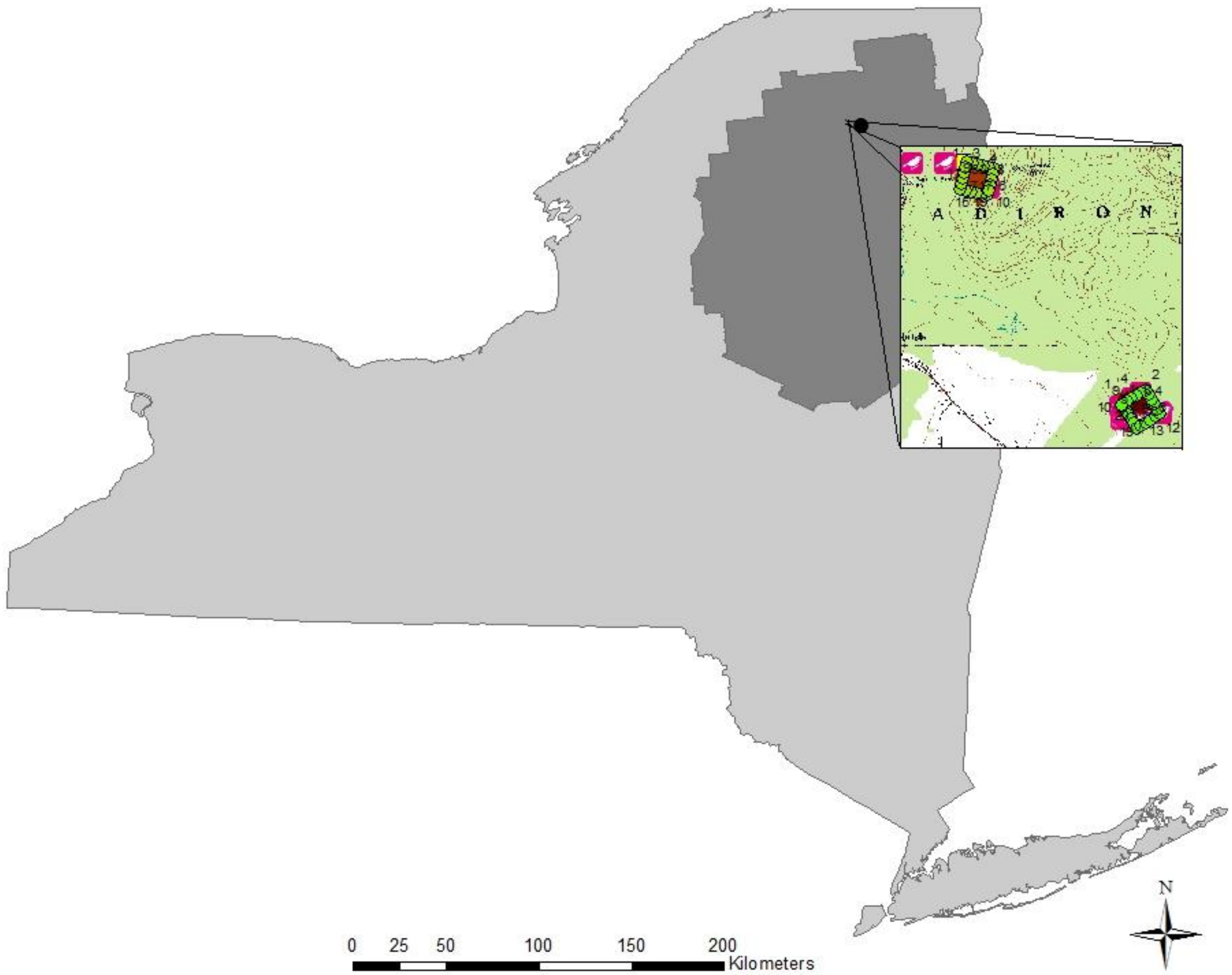

Figure 1: General location of study habitats within the Adirondack Park, New York. GIS data was acquired from Cornell University Geospatial Information Repository (CUGIR).

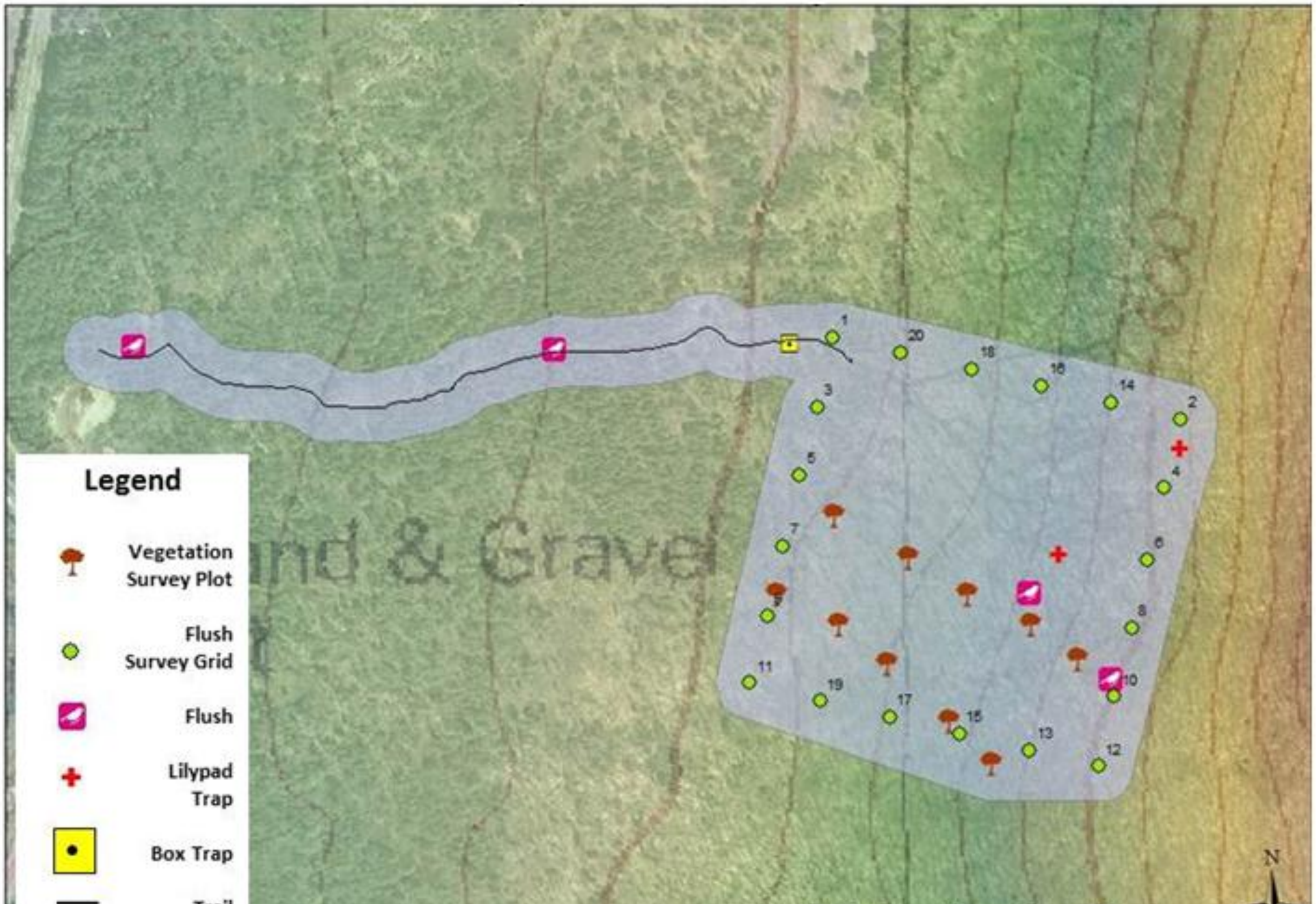

Figure 2: Site map of the upland study habitat within Franklin County, New York. GIS data was acquired from Cornell University Geospatial Information Repository (CUGIR).

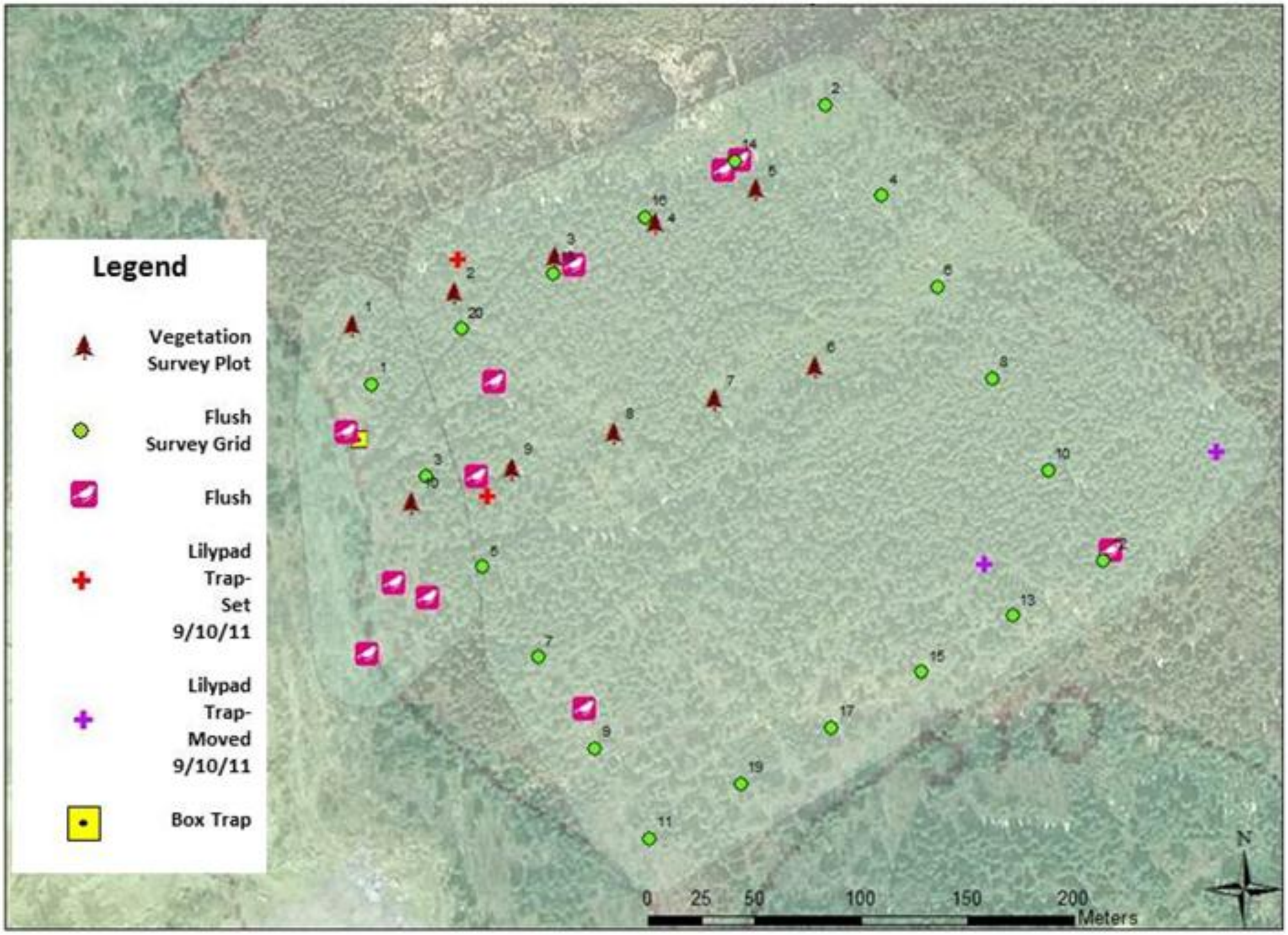

Figure 3: Site map of the lowland study habitat within Franklin County, New York. GIS data was acquired from Cornell University Geospatial Information Repository (CUGIR).

Vegetation Measurements

To determine vegetative habitat in relation to predicted good grouse habitat I used the USFWS Habitat Suitability Index (HSI) (Cade and Sousa 1985). The HSI incorporated measurements of the density of mature male aspens, lowest branch height of conifers, stem density, woody stem height, and percent conifers. In each study area I ran two, 200 m, parallel transects, with 10 m radius plots placed 50 m apart. One-hundred meters separated the two transects, 3140 m^2 were therefore surveyed in each study area; this was approximately 1% of each study area. Vegetation was measured during the last week of September and the first week of October. The number of mature (flowering) male aspen and total woody stems were counted per plot and converted to density per hectare. Average lowest conifer branch and woody stem height was calculated per plot using random subsampling. If the height was greater than I could physically measure I employed a calibrated rangefinder. Percent conifer was calculated per each plot using the quantity of deciduous stems and conifer stems; it was then extrapolated for the whole study area.

Grouse Population Estimates

I set lilypad style walk in traps, and box traps. The llilypad style traps consisted of a central cage, netting leads, an internal guide, a holding cage, and two smaller cages at the end of each lead. The central cage was 50 cm tall, and approximately 2 m in diameter. There were four openings total, two on each side of the trap that were split by the netting leads. The openings were exactly 7 cm wide which Dorney and Mattison (1956) found to be narrow enough for the birds to squeeze through without allowing them to escape. Each end cage was the same height and approximately 1.5 m in diameter, with two openings separated by the lead. A guide was used inside the central cage to direct captured grouse into a ramp-cage style holding pen as described in Dorney and Mattison (1956). Each trapping cage and the holding pen were covered in limbs to decrease the likely hood of flush injuries. Two netting leads ran 20 m from the central cage dissecting any travel corridor that the grouse may have been using. The leaf litter was cleared within the cages and along the leads as Dorney and Mattison (1956) found bare ground attracted ruffed grouse. The traps were baited with red grapes and corn.

The box traps were used to target solitary individuals. I used a single door, Tomahawk model 108 trap measuring 32x10x12" (Tomahawk Live Traps, Hazelhurst, WI). The traps were baited with whole corn and sliced red grapes. The traps were covered with foliated limbs and boughs to decrease likelihood of predation and increase trapping success. I employed two lilypad traps and one box traps per study area. They were not set in a predetermined pattern; instead they were set where grouse activity was the highest as indicated by scat and tracks. Trapping was conducted during the month of September, 2011. Trapping began September 1 and finished September 22. Traps were checked daily. Traps within the lowland study area were moved once halfway through the trapping session.

I planned to tag captured grouse using model 1242 sizes 5(♀)-6(♂) National Band aluminum tarsus bands. Bands were to be crimped using model 12 and 14 applicators (National Band and Tag Company, Newport, KY).The mass of captured grouse were to be recorded using a spring scale. Grouse were to be contained during the banding and measuring process with a drawstring on a cloth sack. Wing chord was to be measured by a 300 mm wing chord ruler (Avinet). Sex was to be determined using the rump feather dot method as described by Bump et al. (1947). Age was to be determined using the central retrice shape and subterminal band method as described by Bump et al. (1947).

Data concerning grouse flush frequency and location was collected throughout the study. Flush data was collected throughout the trapping period and during vegetation analysis fieldwork on the flush per hour basis. Time spent in each site was documented along with the number of grouse flushes. If a secondary flush was believed to be the same bird, the second flush was not counted. Flush data was also collected, during the last week of September, using 12, 250 m transects per study area. The transects were 50 m apart and in a grid pattern. Flushes that occurred during this survey were also included in the flush per hour data.

Analytical Methods

Grouse Populations

Fitness index was to be calculated as a function of body mass divided by wing chord length and measured in grams per millimeter (g/mm). A regression test would have tested my hypothesis that the upland forest would produce fitter grouse. I had planned to report the average fitness index of each study area per age and sex class, along with standard deviation. Grouse per health zone (Bump et al. 1947) per study area was to be determined to measure general health. Abundance was to be calculated using Chapman's equation.

To determine if there was habitat selection, flushes per habitat was analyzed. GIS was employed to determine the active area of each study site. A 25 meter area was buffered around all active areas within each study site (used trails, vegetation plots, traps, flush locations, and flush transects). The area of the smallest possible polygon to include all points and buffers was calculated. The lowland site was delineated into true coniferous, lowland forest, and a mixed transitional zone. Flushes were categorized to their respected geographic zone. Flushes per hectare were calculated using the hectarage established through GIS. A chi-squared test determined if grouse choose one habitat compared to the others. The expected value used in the chi-squared test was calculated as the proportion of flushes to the area of the habitat. A chi-squared test was used to calculate the significance of differences in flush per hectare rates between the transitional zone and the lowland forest; as well as the difference between the transitional zone, the lowland forest, and the upland forest.

Flush per hour data was compared to an average flush per hour rate (0.9) for the Adirondack region provided by Cooperator Ruffed Grouse and American Woodcock Hunting Log (CRGAWHL) (2011). A comparison was made by finding the percent difference between the observed rate and the expected rate, provided by the CRGAWHL (2011), using the following equation.

Equation 1: $$\left(\frac{|o-e|}{e}\right) * 100$$

Where: o = observed flush per hour rate

e = expected flush per hour rate

Vegetation Analysis

Vegetative measurements were collected using 10 meter radius plots and converted to hectares. An HSI value was then assigned in accordance to the measured variable. Average lowest-branch height of conifers was used to determine a coefficient used in a secondary equation to determine total equivalent stem density. Average lowest-branch height is nearly linearly and negatively correlated with the equivalent stem density coefficient for conifers (βV2) (Figure 4).

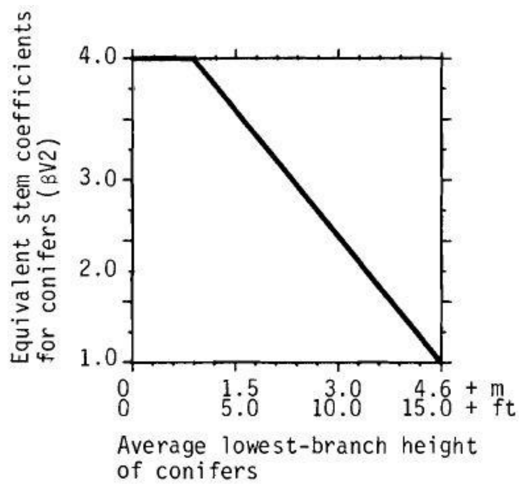

Figure 4: Coefficient for equivalent stem density equation as determined by average lowest-branch conifer height (Cade and Sousa 1985).

Total equivalent stem density (TESD) was determined as

Equation 2: $$\mathrm{TESD} = \mathrm{d} + 0.25\mathrm{s} + \beta\mathrm{V2c}$$

Where d = number of deciduous trees/ha

s = number of deciduous shrubs/ha

c = number of coniferous trees/ha

βV2 = equivalent stem density coefficient for conifers

The suitability index (SIV3) for total equivalent stem density, in thousands of stems per hectare is displayed in the following figure (Figure 5).

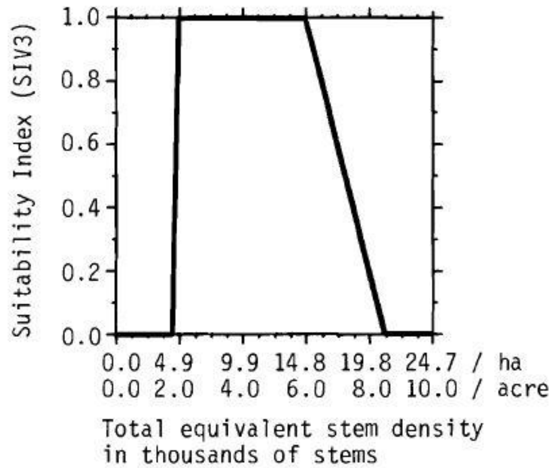

Figure 5: Suitability index (SIV3) for total equivalent stem density, in thousands of stems per hectare (Cade and Sousa 1985).

Suitability index (SIV4) for woody stem height as determined by the average height of woody stems per plot (Figure 6)

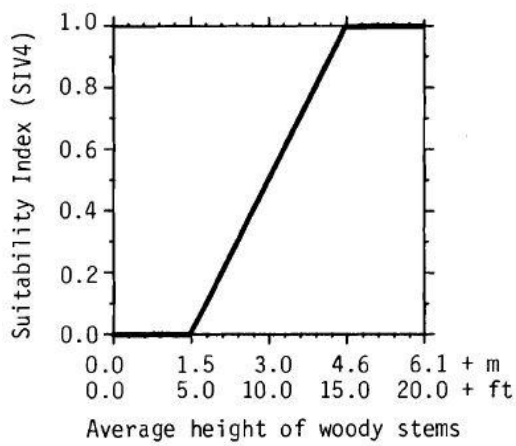

Figure 6: Suitability index (SIV4) for average woody stem height (Cade and Sousa 1985).

The suitability index (SIV5) determined by percent conifer was calculated as

Equation 3: $$\mathrm{SIV5} = \left[\left(3 \text{ x } \frac{\mathrm{c}}{\mathrm{c+d}}\right) + 1\right]^{-1}$$

Where: c = number of conifer trees/ha

d = number of deciduous trees/ha

Figure 7 shows the assigned suitability index (SIV5) for percent conifer as determined by the previous equation (Cade and Sousa 1985).

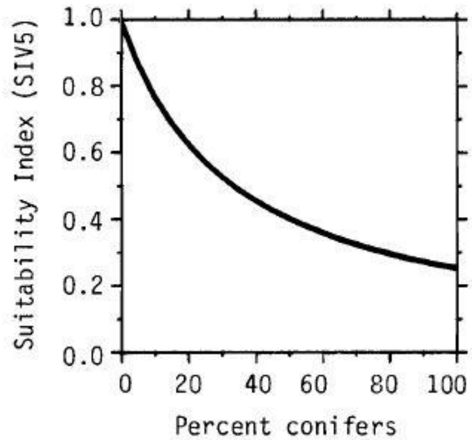

Figure 7: Suitability index (SIV5) for percent conifer as determined by equation 2 (Cade and Sousa 1985).

A total fall to spring cover suitability index (FSCOV) per plot was calculated as

Equation 4: $$\text{FSCOV} = \text{SIV3 x SIV4 x SIV5}$$

This equation returned an index (0-1) per plot. The ten per plot indexes were then averaged for an average fall to spring cover suitability index for the entire study area.

Results

The upland habitat had a resulting fall to spring cover value (FSCOV) of 0; the lowland habitat had a FSCOV of 0.19 (Table 2).

Table 2: Calculated equivalent stem density coefficient for conifers (βV2), suitability index for total equivalent stem density (SIV3), suitability index for average height of woody stems (SIV4), suitability index for percent conifer (SIV5), fall to spring cover suitability index (FSCOV) per plot. Mean fall to spring cover suitability index (FSCOV) per habitat. Standard Deviation*

Lowland Site

Plot	**βV2**	**SIV3**	**SIV4**	**SIV5**	**FSCOV**
1	1	0	1	0.25	0.00
2	1	1	1	0.25	0.25
3	1	0	1	0.25	0.00
4	1	0	1	0.25	0.00
5	2	1	1	0.25	0.25
6	4	1	1	0.25	0.25
7	1	1	1	0.25	0.25
8	4	1	1	0.26	0.26
9	3.25	1	1	0.27	0.27
10	3.25	1	1	0.35	0.35
S.D.*	1.33	0.48	0.00	0.03	0.13

Mean FSCOV: 0.19

Upland Site

Plot	**βV2**	**SIV3**	**SIV4**	**SIV5**	**FSCOV**
1	3.5	0	1	0.56	0
2	4	0	1	0.62	0
3	4	0	1	1.00	0
4	4	0	1	1.00	0
5	4	0	1	1.00	0
6	4	0	1	1.00	0
7	4	0	1	0.95	0
8	4	0	1	1.00	0
9	4	0	1	0.93	0
10	4	0	1	0.91	0
S.D.*	0.16	0.00	0.00	0.17	0.00

Mean FSCOV: 0

Trapping was not a success although I experimented with different trapping locations, within the lowland site, and different baits. Although corn was dispersed every time the trap was visited, it was consistently missing by the next visit. I speculate that rodents and small passerines were responsible for most of the consumption of the corn. It was also apparent that game animals were visiting my trap locations. Whitetail deer (*Odocoileus virginianus*) and wild turkey (*Meleagris gallopavo silvestris*) sign was occasionally seen throughout the trap area. On one occasion a lilypad trap was mangled by a black bear (*Ursus americanus*). The bear was positively identified by scat. On several occasions grouse were flushed within 20 meters of baited traps. Two white-throated sparrows (*Zonotrichia albicollis*) were caught in a lilypad trap within the upland site. The lowland box trap caught a snowshoe hare (*Lepus americanus*), and the upland box trap caught a raccoon (*Procyon lotor*). Sliced red grapes were also used as bait. As with corn they were consistently consumed within a 24 hour period. It was evident from teeth marks left in several grapes that *Peromycus spp.* were consuming the grapes. On several occasions box traps were set off, with their bait missing, without a successful capture. If other species besides *Peromyscus spp*. were setting off the trap, they had to be small enough to escape through the 1 x 1/2 inch wire mesh.

Since birds were not captured during the survey, mass, wing chord, and fitness were not calculated. Flushes, area, and flushes per hectare of each study area are displayed in Table 3. Flushes varied significantly between the three habitat types (x^2, $p<0.0001$). Flushes also varied significantly when habitats were analyzed in pairs (Table 4).

Table 3: Flushes, area (hectare), and flushes per hectare of the upland, transitional, and conifer study areas.

	Upland	Transitional	Conifer
Flushes	4	6	7
Area (ha)	11.8	1.3	9.8
Flushes per hectare	0.34	4.60	0.72

Table 4: P-values determined via chi-squared tests of significance in paired flush per hectare rates (df=1).

	Transitional	Conifer	Lowland (Transitional + Conifer)
Upland	p<0.0001	p=0.2184	p=0.0201
Transitional		p=0.0001	

The upland habitat had a flush per hour rate of 0.30; the lowland had a rate of 0.96. The mean Central Adirondack rate from 2010-2011 was 0.63 flushes per hour. The lowland habitat had the highest flush per hour rate likely signifying a higher relative abundance. Analysis of flush per hour data showed that although there may be a difference between flush rates recorded at the upland and lowland site and the mean, central Adirondack flush rate determined by the New York Division of Fish, Wildlife and Marine Resources (2011), the standard deviation of the rates was too high to make a strong conclusion.

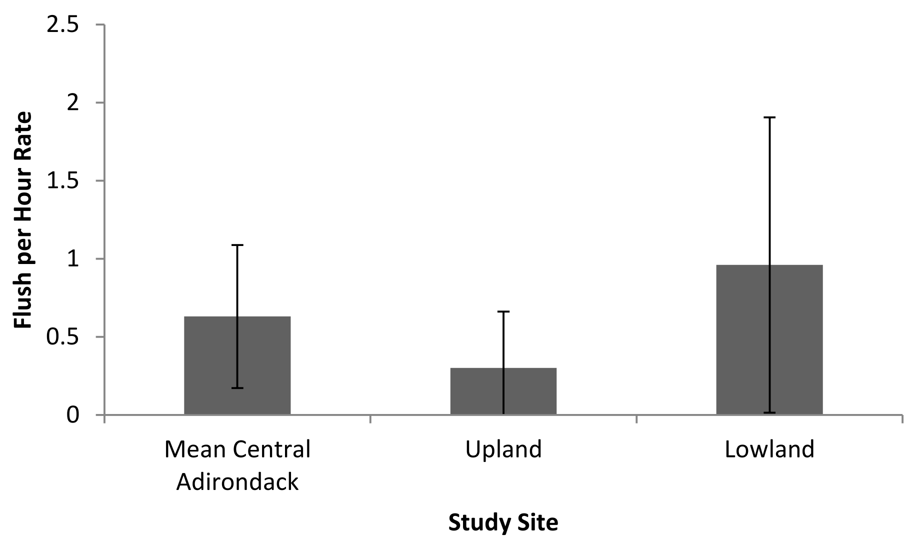

Figure 8: Mean central Adirondack, upland, and lowland flush per hour rates. Error bars report standard deviation.

Discussion

With this study I was unable to support my hypothesis that the upland forest would harbor grouse with a higher fitness than the lowland forest. I was also unable to support my hypothesis that the upland forest would show a higher relative abundance than the lowland forest.

Fall to spring cover values (FSCOV), as calculated by the Habitat Suitability Index Models: Ruffed Grouse Report (Cade and Sousa 1985), were lower than I had expected. Across the upland site, stem density was the limiting factor that kept the site from receiving a higher FSCOV (FSCOV=0). If equivalent stem density was above 153.93 stems per plot (4,900/ hectare), for each plot, the FSCOV would have been 0.9. In fact, if the stem density had been at or above this level for just half the plots the FSCOV would have been at the very least 0.42. Instead most plots had about one-quarter the stem density needed to receive a viable cover value. Percent conifer was the leading factor that equated to a poor FSCOV for the lowland site. Within the lowland site, plots that had high enough stem density to have a viable cover value generally had low FSCOV due to the high percent of conifers within the plot.

It is apparent, from the chi-squared test, that the transitional area produced significantly more flushes per hectare than any other habitat. Contrasting the transitional and upland, the transitional and conifer, and all three habitats a p-value of 0.0001 established that there was a 99.99% probability of a significant difference in flush per hectare rates. This probability of significance, of a higher flush per hectare rate, illustrates a likely selection of the transitional habitat by grouse. Contrasting the lowland and upland habitats there was a 97.99% probability (p=0.0201) that there was a significant difference in the flush per hectare rates. This probability of significance shows that there was a likely preference for the lowland site over the upland site by grouse. This preference may be due to differences in stem densities as indicated by the fall to spring cover values. Contrasting the conifer and upland sites there was a 78.16% probability (p=0.2184) that there was a significant difference in the flush per hectare rates. This probability of significance indicates that while grouse may prefer the conifer habitat over the upland habitat, the difference in preference is not significant.

I believe that if the upland forest had not had timber harvested 3 to 4 years prior, the relative abundance of grouse within the forest would have been higher. Stem density was the limiting factor for FSCOV and presumably adversely affected the grouse population due to a lower quality of available cover. Quaking aspen (*Populus trembuloides*) and bigtooth aspen (*P. grandidentata*) buds and stems play a substantial role in ruffed grouse diet. Neither species were present within the upland forest. Still, aspen trees were present at the lowland site within the transitional zone. Balsam poplar (*P. balsamifera*) was also present throughout the lowland forest, but grouse are only able to consume balsam poplar buds in the spring, when they are without resinous scales (Svoboda and Gullion 1972).

Early successional habitat was historically created naturally via fire, wind, beavers, and flooding (DeGraff and Yamasaki 2003). These factors have generally been restrained by society, thus limiting the creation of early successional habitat. However, neither of my study areas had strong restraints against them. Through location and topography beavers and flooding will probably cause any future creation of early-successional habitat at the lowland site. Wind is the most likely means of early-successional habitat creation at the upland site.

Today, early successional habitat, and in turn quality grouse habitat, may be managed for (DeGraff and Yamasaki 2003). Forest should undergo timber harvest once every ten to twenty years to continue the creation quality grouse habitat (Desseck and McAuley 2001, Fearer and Stauffer 2003). Even-aged silviculture practices (clearcut, seed tree, shelterwood) produce the best grouse habitat (Desseck and McAuley 2001, Fearer and Stauffer 2003, Giroux et al. 2007, Thompson and Frtizell 1989).There should be a close proximity between young and old aspen trees (Berner and Gysel 1969). Clearings should be one-third to one-half shrubs with dense shrub boarders. The rest of the clearing should be tree saplings (Berner and Gysel 1969). Prescribed burns may be used to increase the amount of herbaceous vegetation and improve the habitat for broods. Prescribed burns should be applied prior to grouse nesting (mid-April) (Jones et al. 2008).

I would conclude that if the upland forest had a higher stem density, reflecting a non-recently harvested forest, and had trembling and bigtooth aspen present, it is likely to have harbored a higher abundance of grouse relative to the lowland forest. I would also conclude that the upland grouse population will likely increase as stem density increases. To improve the quality of the upland habitat, for grouse, I would recommend any aspen trees that sprout not be harvested during the next timber harvest. I would also leave any eastern red cedars, to provide protected roost sites during the winter.

Literature Cited

Addy, CE. (1956). *Guide to waterfowl banding*. Maryland: US Fish and Wildlife Service.

Atwater, S., & Schnell, J. (1989). *Ruffed grouse*. Harrisburg, PA: Stackpole Books.

Bednekoff, P., & Houston, A. (1994). Optimizing fat reserves over the entire winter: A dynamic model. Oikos, 71(3), 408-415.

Berner, A., & Gysel, L. W. (1969). Habitat analysis and management considerations for ruffed grouse for a multiple use area in Michigan. *Journal of Wildlife Management*, *33*(4), 769-777.

Breeding Bird 2000-2005 Atlas. New York State Department of Environmental Conservation. Retrieved October 30, 2011, from http://www.dec.ny.gov/cfmx/extapps/bba/bbaMaps.cfm?bndcode=RUGR&year=2000

Bump, G., & New York (State) Conservation Dept. (1947). *The ruffed grouse: Life history, propagation, management.* Albany.

Cade, B.S., & Sousa, P.J. 1985. *Habitat suitability index models: Ruffed grouse.* U.S. Fish & Wildlife Service Biological Report. 82(10.86).

Chambers, R., & English, P. (1958). Modifications of ruffed grouse traps. *Journal of Wildlife Management*, *22*(2), 200-202.

DeGraaf, R. M., & Yamasaki, M. (2003). Options for managing early-successional forest and shrubland bird habitats in the northeastern United States. *Forest Ecology and Management*, 185, 179-191.

Dessecker, D., & McAuley, D. (2001). Importance of early successional habitat to ruffed grouse and American woodcock. *Wildlife Society Bulletin*, 29(2), 456-465.

Dorney, R., & Mattison, H. (1956). Trapping techniques for ruffed grouse. *Journal of Wildlife Management*, *20*(1), 47-50.

Edminster, F. C. (1947). *The ruffed grouse: its life story, ecology and management*. New York: Macmillan.

Fearer, T. M., & Stauffer, D. F. (2003). Relationship of ruffed grouse (*Bonasa umbellus*) home range size to landscape characteristics. *The American Midland Naturalist*, 150, 104-114

Giroux, W., Blanchette, P., Bourgeois, J., & Cabana, G. (2007). Ruffed grouse brood habitat in mixed softwood-hardwood nordic-temperate forests, Quebec, Canada. *Journal of Wildlife Management*, 71(1), 87-95.

Gullion, G. (1961). A technique for winter trapping of ruffed grouse. *Journal of Wildlife Management*, *25*(4), 428-430.

Gullion, G. (1965). Improvements in methods for trapping and marking ruffed grouse. *Journal of Wildlife Management*, *29*(1), 109-116.

Gullion, G., & Marshall, W. (1968). Survival of ruffed grouse in a boreal forest. *The Living Bird*,117-143.

Hewitt, D. G., Keppie, D. M., & Stauffer, D. F. (2001). Predation effects on forest grouse recruitment. *Wildlife Society Bulletin*, 29(1), 16-23.

Jakubas, W., Karasov, W., & Guglielmo, C. (1993). Ruffed grouse tolerance and biotransformation of the plant secondary metabolite coniferyl benzoate. *The Condor*, *95*, 625-640.

Jones, B. C., Kleitch, J. L., Harper, C. A., & Buehler, D. A. (2008). Ruffed grouse brood habitat use in a mixed hardwood forest: Implications for forest management in the Appalachians. *Forest Ecology and Management*, 225, 3580-3588.

Liscinsky, S., & Bailey, W. (1955). A modified shorebird trap for capturing woodcock and grouse. *Journal of Wildlife Management*, *19*, 405-408.

MacArthur, Robert, and Richard Levins. (1964). Competition, habitat selection, and character displacement in a patch environment. *Zoology,* 51, 1207-1210.

Marshall, W. (1946). Cover preferences, seasonal movements, and food habits of Richardson's grouse and ruffed grouse in southern Idaho. *The Wilson Bulletin*, *58*(1), 42-52.

McGowan, J. (1973). Fall and winter foods of ruffed grouse in the interior Alaska. *The Auk*, *90*, 636-640.

NYS Department of Environmental Conservation, Division of Fish, Wildlife and Marine Resources. (2011). Cooperator ruffed grouse & American woodcock hunting log. Retrieved from http://www.dec.ny.gov/docs/wildlife_pdf/grouselogreport10.pdf

Pyle, P., Howell S., Ruck, S., and DeSante, D. *Identification Guide to North American Birds* . Bolinas (Calif.): Slate Creek Press, 2008.

Rosenzweig, M. (1981) A theory of habitat selection. *Ecology 62*(2), 327-335.

Svardson, G. (1949) Competition and habitat selection in birds. *Oikos 1*(2), 156-174.

Svoboda, F., & Gullion, G. (1972). Preferential use of aspen by ruffed grouse in northern Minnesota. *Journal of Wildlife Management*, 36(4), 1166-1179.

Tanney, J., & Hutchison, L. (2010). A brief survey of mycophangy in ruffed grouse, *Bonasa umbellus*, from northwestern Ontario. *The Canadian Field-Naturalist*, 125, 72-73

Thompson F. R., & Fritzell, E. K. (1989). Habitat use, home range, and survival of territorial male ruffed grouse. *Journal of Wildlife Management*, 53(1), 15-21.

Tirpak, J, Giuliano, W., & Miller, C. (2008) Ruffed grouse brood habitat selection at multiple scales in Pennsylvania: implications for survival. *Canadian Journal of Zoology 86*, 329-337.

Zimmerman, G., & Gutiérrez, R. (2008). Ruffed grouse *Bonasa umbellus* habitat selection in a spatially complex forest: Evidence for spatial constraints on patch selection. *Ibis*, 150, 746-75

Zimmerman, G. S., Horton, R. R., Dessecker, D. R., & Gutiérrez, R. J. (2008). New insight to old hypotheses: Ruffed grouse population cycles. *The Wilson Journal of Ornithology*, 120(2), 239-247.