168

RED SQUIRREL HABITAT USE:

POPULATION DEMOGRAPHICS IN DIFFERENT HABITATS AND THE EVALUATION OF A HABITAT MODEL

Matthew T. Wheatley
CW - 405 Biological Sciences Building
University of Alberta
Edmonton, Alberta, T6G 2E9

This is a joint effort of:

Foothills Model Forest,
the Canadian Circumpolar Institute, and the
University of Alberta

TABLE OF CONTENTS

LIST OF TABLES

Abstract: Commonplace in wildlife management is the idea that habitat herterogenaity affects species abundance and distribution. Intuitively, the occurrence and densities of a given species will be influenced by conditions related to successful reproduction and survival. These ideas become key in areas where single-species modelling has been chosen across heterogeneous landscapes for populations found in multiple habitat types (forest generalists). Relationships between habitat type and populations for forest generalists must be understood before the validity of a single-species model can be tested. This study investigates three populations of the North American red squirrel (*Tamiasciurus hudsonicus)* in different habitats in the same geographic location at the same time. Via live trapping methods, I document the demographics of these populations and relate the data to the animal's distribution and to specific assumptions inherit in single-species wildlife management regarding habitat suitability.

Introduction: Central to the study of animal ecology and the understanding of biodiversity is the usage an animal makes of its environment: specifically the kinds of food it consumes and the varieties of habitats it occupies[5]. Few would argue that habitat heterogeneity (landscape patterns), or the non-uniform spatial and temporal distribution of resources, affects species dynamics, abundance and distribution. Such landscape patterns are pervasive in nature and are known, or hypothesized to affect many animal populations and ecological processes[1,4,6,13,17,20,21]. Widely distributed organisms often utilize a variety of habitat types throughout their range (habitat generalists)[2]. However, a full understanding of the role of habitat heterogeneity requires an examination of demographic processes (movement, survival, reproduction, recruitment) in populations that assemble and become established in multiple habitats[14]. Recent attempts at forest resource management in Alberta have made efforts to include landscape patterns and wildlife populations as a top priority. To understand and conserve diversity in animal populations, we need to better understand the consequences of habitat heterogeneity in population dynamics.

It would appear clear that landscape patterns influence the numbers and distribution of many forest rodent species. Intuitively, the occurrence and densities of a given species will be influenced by conditions related to survival and successful reproduction[15]. When referring to generalist species (a single species found in multiple habitat types), there is the assumption that their populations will be more resilient to landscape alterations. I argue that we do not know enough about the interplay between habitat and generalist populations to make this assumption: relatively subtle but important relationships may exist between habitat heterogeneity and populations of generalists. In other words, how does habitat type alter or reinforce the dynamics of a population[16]? By becoming resident in a specific habitat, could the fate of an individual differ from those of animals in other habitats? For example, different habitats may allow for higher reproduction or survival for the same species than other habitats. Altering habitat heterogeneity across a region may have considerable impact on a generalist species in that region. This impact may extend into other species or ecosystem processes if the generalist is a common or important component in the wildlife community.

These concerns are keystone in the current attempts at landscape resource management and the conservation and understanding of biodiversity. The impact of landscape patterns on generalist species has received considerably less attention than that of specialist species considered endangered through anthropomorphic changes to the landscape (eg: loss of old growth). Managers need to understand habitat heterogeneity across the landscape, but they *must* be able to relate this to the animal populations found across the landscape. If we cannot do this, then we are missing a critical component in understanding the diversity of an area, especially when considering wildlife modelling. This requires population level research across a landscape. Data to address these issues for vertebrate species are uncommon at best. One way we can answer these questions is by comparing resident generalist populations in different habitat types in the same geographic location. This type of information becomes even more important when management of a species is required in an area containing several habitat types that may differ in quality for any given species.

One method that has been developed for predicting habitat quality for a single species is the Habitat Suitability Index (HSI)[27]. It is based on the premise that habitat suitability can be linked to individual habitat variables with primarily linear relationships, and that these variables can be combined into a meaningful index using a variety of variable weighting and averaging procedures[24]. However, for a generalist species with established populations in several habitat types, HSI type management breaks down under certain circumstances. First, if species relative abundance is a poor indicator of habitat quality, HSI modelling will not make accurate predictions over time[25]. Second, if there is no understanding of the relationship between habitats with respect to resource availability and reproductive success, a major component of predictive power is lost making HSI modelling almost pointless. If this type of management option is to be considered, these issues need to be addressed for the managed species. For generalist species, an understanding of habitat and population success must be made.

Territorial organisms often are used to study the relationship between environment and fitness. Because individuals in territorial populations have exclusive resources, it is easier to draw comparisons between environmental characteristics and individual growth, survival and reproductive success[12]. The North American red squirrel (*Tamiasciurus hudsonicus*) is a forest generalist throughout its range in Alberta[19]. These animals defend individual, non-overlapping territories (exclusive resources) and possession of a territory is critical to survival[11]. That is, members of adult populations are stationary, exhibit resident populations in multiple habitat types and do not move across habitat type. Furthermore, red squirrel populations form an important alternate prey base for secondary consumers such as great horned owls (*Bubo virginianus*), red-tailed hawks (*Buteo jamaicensis*), northern goshawks (*Accipiter gentilis*) and marten (*Martes americana*) among others (eg: Lynx). Given these characteristics, red squirrel populations are fitting for research directed towards generalist populations across habitat types. The study proposed herein directly addresses the demographics of red squirrel populations in three different habitat types in Alberta to better understand the diversity inherent *within* a generalist species.

Previous work on red squirrels in Alberta has focussed both on the population[7,8,18,22] and individual[3,10,11] level. Historically, population level work has overlooked two important areas. First, populations selected for study in the same geographic area (in Alberta) are commonly in habitat not known to be important for red squirrels (ie: aspen; aspen-black spruce; aspen-balsam poplar[7,18]) and we know that red squirrel populations are tied to a diversity of *conifer* tree species. Second, where data exists for resident populations in known important habitats (ie: white spruce, pine spp., conifer dominated areas in Alberta, B.C. and Yukon[8,10,23]) , there is extensive geographic variation and temporal variation between study sites. Hence, problems arise on how to interpret differences or similarities (ie: due to habitat, year, latitude, adaptations?). This study will compare populations across a habitat continuum from pure white spruce to mixed-wood habitats to pure lodgepole pine, in the *same* geographic location and will address issues pertaining to HSI modelling for the red squirrel and its distribution.

Objectives:

(1) To compare the demography of red squirrel populations in three different habitat types in the same geographic location.
(2) To relate population dynamics to red squirrel distribution and to HSI modelling, to suggest the possible validity of HSI management for this forest species.

Methods:

Three habitat types, known to be important for red squirrel habitat, have been chosen near Hinton, Alberta based on landscape abundance (lodgepole pine, white spruce-pine mix) and suggested biological importance to red squirrels (white spruce). Study grids have been set up and replicated in each habitat type (n= spruce-4, pine-5, mix wood-4; size range 10-27 ha) in spring, 1995 within about 100 Km^2 surrounding the townsite of Hinton and within the forest management area of Weldwood of Canada (Hinton division). Study areas are all located within the same natural region (see Study Locations below).

Squirrel populations have been live trapped using Tomohawk live traps (Tomohawk Live Trap Co., Tomohawk, WI)- at least 5 traps per hectare - and ear tagged with metal eartags (Monel Metal Eartag #1) for identification for the summer of 1995. Live trapping provides almost all of the data required to meet the above stated objectives (ie: handling each animal to obtain individual animal condition). Animal numbers and densities were obtained using live trapping in concert with call counts and intense visual observations on each study grid. Similar work will be replicated in the summer of 1996. Data recorded when live trapping animals are; sex, weight, reproductive condition, location, morphology measurements (jaw size, hind foot length), and territorial behavior upon release.

Study areas will be described via the collection of the following data; tree density, downed woody debris, canopy cover, dbh, tree species composition and cone availability.

Sampling Design: See "Methods" above.

Study Locations: Study areas are all located within about a 100 Km^2 area with the townsite of Hinton, Alberta at its center. The entire study region consists of foothills running northwest to southeast near the front range of the Rocky Mountains. Major river systems in the area include the

Athabasca River and the Gregg River. One third of the study areas (n=3/12) are north of the Athabasca River with the remainder south of the river. Specifically, on the south side of the river, study locations are located within a few kilometres of the Robb Road, Gregg River Road and the Bighorn Highway (Hwy 40 South to Cadomin, Alberta). North of the river, study locations are within 15 kilometres of Hinton on the Fish Creek Road and the "**A Road**". All access roads, save Hwy 40 South, are maintained by Weldwood of Canada, Hinton Division.

I selected study areas that were mature forest (80 - >100 years) that had not previously been logged. Sites were selected based on tree composition, patch size, access and stand age. Area of each study site varied based on patch size and/or the number of resident squirrels initially captured (initial goals were set at 15-25 animals per grid, grid size was set or increased to achieve these goals). Sites were all selected to be representative of common mature stands found throughout the area[26].

Lodgepole pine areas consist of at least 80% *Pinus contorta*, with understorey cover being alder (*Alnus crispa*), wild rye (*Elymus spp.*), Labrador tea (*Ledum spp.*) and mosses (*Ptilium spp., Sphagnum spp.*). Few white spruce (*Picea glauca*) are present in these area and, if so, occupy an understorey position. Lodgepole pine study sites are generally southwest facing on moderate to steep slopes of the foothills in the area. White spruce areas consist of at least 86% *Picea glauca*, with understorey cover being feather moss (*Hylocomium spp.*), common horsetail (*Equisetum spp.*) and some birch shrub (*Viburnum spp.*). Spruce study areas were generally flat with little variation in topography. Mixed-wood areas consist roughly of a 50:50 mix of spruce and pine trees with some deciduous species as well (see Table 1 below). Understorey vegetation varies within each site. Mixed areas are generally undulating terrain with some steep areas and some flat areas on every grid.

Table 1: Description of Study Areas (Tree Composition expressed as % white spruce : % lodgepole pine).

Habitat	Tree Composition
White Spruce	86:12 93:7 99:1 99:1 Mean = 94% Spruce
Mixed-Wood	49 SW:51 PL mix 59:41 58:42
Lodgepole Pine	17:83 12:80 (8% mixed) 4:94 8:92 5:95 Mean = 89% Pine

Table 1 describes tree composition for all of the study areas in a ratio of %white spruce : % pine. All areas fall within the above-mentioned tree composition for each stand type. Spruce areas that were less than 95% white spruce consisted mainly of deciduous trees (Aspen, *Populus tremuloides,* Balsam Poplar, *Populous balsamifera*) making up the final percentage of the area's composition.

Project Status, January 1, 1996: To date, all field work for the first field season has been completed. Outside funding has been perused for the summer of 1996 and, if denied, will be covered by Foothills Model Forest money. In any event, the red squirrel project will be completed on time with no major foreseeable setbacks to its status. **Note:** Not all data collected in 1995 are presented in this report. The data for this study are currently being worked and re-worked and, therefore, some information is not yet in a suitable form to be reported here at this time.

Results

Results are presented in tabular form with brief descriptions for each table. Text describing the results will follow each table.

Table 2: Squirrel Densities for Spring and Fall 1995 (data presented are; mean #squirrels/hectare, sd, n).

Forest Type	Spring Density	Fall Density
White Spruce	2.67, 0.10, 4	2.97, 0.24, 3
Mixed-Wood	1.48, 0.26, 3	No Data
Lodgepole Pine	1.24, 0.36, 5	1.35, 0.55, 3

Densities in spruce habitat were almost double that of pine and mixed-wood areas. Significant differences were detected for spruce when compared to all other areas. Lodgepole pine and mixed-wood areas did not differ. Densities for spruce were significantly different from pine and mixed habitats ($p<0.001$). Mixed and pine were not significantly different ($p=0.483$, ANOVA + Tukey's). This follows for both spring and fall seasons. Only small increases in density were detected in spruce and pine areas for the fall season. In general for the summer of 1995, a low numbers of juveniles established territories on the study sites (pers ob., data not shown here, in prep).

Table 3: Weights (Mean, SE, N). Average weights are taken from 3-5 day trapping sessions in May and August, 1995. Averages are controlled for pregnant females in spring and juveniles in fall.

HABITAT	SEX	SPRING	FALL
PINE	MALE	219.6, 2.6, 15	217.3, 6.8, 16
	FEMALE	218.7, 5.11, 16	205.7, 8.2, 14
SPRUCE	MALE	234.1, 3.0, 34	217.9, 3.7, 26
	FEMALE	214.5, 5.4, 29	198.3, 4.21, 30

There were no large differences in animal weight across habitat in general. In the spring, males in spruce were significantly larger than any other group however, their weights dropped over the summer to match those of pine squirrels. Spruce males tended to lose more weight over the summer months, pine males stayed relatively more stable. Significant Differences (t-test following ANOVA): *Between Habitats* - Spring males Pine vs Spring males Spruce ($p=0.006$). *Within Habitats* - Spring males Spruce vs Spring females Spruce ($p=0.002$); Fall males Spruce vs Fall females Spruce ($p=0.001$). All differences not reported here were not significant. Sample size was considered too small for mixed-wood areas to report weights broken down into male and female groups.

Table 4: Female reproduction broken down individually for each grid with sufficient data. TOTAL# = Total number of females trapped with sufficient data to address reproductive conditions, #DARK = The number of females (out of the total #) that have gone through estrous in the past (ie: have matured enough that they have been receptive to males before, dark nipples), #LAC/WN = The number of females, of those that were reproductively active, that lactated long enough to wean a litter (ie: at least 60 days - where the reproductive condition of the nipples could be monitored as a weaning female).

HABITAT	**GRID #**	**TOTAL #**	**# LAC/WN**	**# DARK**
SPRUCE	1	15	5 (38%)	13 (86%)
	2	20	3 (30%)	10 (50%)
	3	5	3 (60%)	5 (100%)
PINE	1	7	5 (71%)	7 (100%)
	2	13	8 (80%)	10 (77%)
	3	10	6 (75%)	8 (80%)
MIXED	1	7	2 (33%)	6 (85%)
	2	3	1 (33%)	3 (100%)
	3	5	2 (50%)	4 (80%)

Average % of females lactating long enough to wean (*all averages combined within habitat type*):

Spruce = 42% (sd=15)
Pine = 75% (sd=4.5)
Mix = 38% (sd=9.8)

There were no significant differences between spruce and mixed-wood areas with respect to female reproduction, and these were both significantly lower than pine areas (ANOVA, data arcsine transformed, p = 0.001). None of the areas differed with respect to the proportion of females that had been reproductively receptive in the past (ie: #Dark compared between habitats, p>0.05).

Table 5: Female reproduction all raw data combined within habitat type. Averages have been recalculated as a percentage of all females within a habitat all grids combined, not an average percent of females from different grids within habitats as above. ie: 39% of reproductively active females in all spruce areas lactated long enough to wean a litter (11/28). 70% of all females in spruce were post-estrous (28/40). Raw data was combined to increase sample size of females for each habitat type. Within habitat variation is presented above just below Table 4.

HABITAT	TOTAL #	# LAC/WN	# DARK
SPRUCE	40	11 (39%)	28 (70%)
PINE	30	20 (80%)	25 (83%)
MIXED	15	5 (36%)	14 (93%)

Table 6: Cone Crop: Cone counts were done in spruce and pine forests across entire study area.

SPRUCE CONES:
Average # cones per tree = 14 (SE = 1.54, n = 448)
Median = 1.0
Mode = 0

PINE CONES:
Average # NEW cones per tree = 55 (SE = 3.16, n = 321)
Mode = unknown, 57% of data set had counts > 50 cones per tree.

(G-test comparing spruce counts to pine counts was significant, $p<0.05$)

Data to address cone crop for years prior to this study have yet to be obtained from seed count data in the area.

Discussion: Cone crop data for 1995 suggests that the spruce areas are at a low in cone production. It is not uncommon for spruce forest to fluctuate with respect to cone crop and a low in cone numbers can potentially last for up to 3-4 years. Pine forests tended to have higher numbers of new cones as well as those left on the trees from previous years. All of these cones are available to the squirrels, newest cones being easiest to handle, as there are no other major seed predators in this system for cones that have not opened (ie: serotinous pine cones). The effect of cone crop from previous years, at this time, can only be hypothesized via reproductive success of the squirrels on the study area.

Densities differed for spruce areas when compared to all other habitat types. This was expected simply based on what has been found for spruce densities in other areas. However, pine and mixed-wood densities did not differ and were both almost half of those found in spruce. Perhaps the composition of pine and spruce in the mixed-wood areas was not sufficient enough in spruce areas to sustain higher densities than were found here. Trapping data in mixed-wood areas was not sufficient for the summer of 1995 to compare animals in mixed-wood areas who were on spruce and/or in pine territories. If the composition of spruce in an area has a direct influence on territory size and hence density, it would be interesting to look at the intensity of competition for both spruce and pine territories in mixed areas. Are spruce territories considered more valuable and, if so, could this be related back to density or an individual's success?

Animal weights were not consistent with what was predicted initially. From other studies where weight had been reported, squirrels in spruce habitat were significantly heavier than squirrels in pine areas. I only found this to be true for males in the spring. By fall, weights in the spruce area had dropped to values comparable to those in pine. This may be due to the poor cone crop in spruce areas. Going into the fall, in general, we should see animal weights increase. This did not happen. Comparatively, pine animals had more stable weights over the summer and did not lose as much mass going into the fall season. This could also be a reflection of the more stable cone resource in pine areas. Ultimately, this should be reflected in the following year's reproduction and survival for each area. This data, obviously, has not yet been collected.

Female reproduction tended to be higher in pine areas based on the proportion of females lactating long enough to wean litters in the summer of 1995. However, the proportion of females lactating needs to be related to the total number of females in an area AND survival as well. Some measure of juvenile recruitment would also supplement these data. Again, survival data has not yet been collected. These data need to be represented in terms of female abundance for any meaningful comparison to be made (ie: is 10% of 100 females in spruce the same as 75% of 20 females in pine with respect to the proportion of females breeding?). This has yet to be done in terms of survival as well.

Please note that this is an interim report and that, to date, the data are still being worked-up.

Acknowledgments: This study has been funded by The Foothills Model Forest and The Canadian Circumpolar Institute (Circumpolar/Boreal Alberta research Grant). In-kind support has been granted by The Canadian Forest Service, The Environmental Training Center, Hinton, Alberta, and Weldwood of Canada, Hinton Division.

LITERATURE CITED: 1. Addicott J.F., Aho J.M. et al. 1987. Oikos 49:340-346. 2. Alder G.H. and Wilson M.L. 1987. Ecology 68:1785-1796. 3. Becker C.D. 1992. Ph.D. Thesis, University of Alberta. 4. Huffaker C.B. 1958. Hilgardia 27:343-383. 5. Johnson D.H. 1980. Ecology 61: 65-71. 6. Kareiva P. 1982. Ecol. Monogr. 52:261-282. 7. Kemp G.A. and Keith L.B. 1970. Ecology 51:763-779. 8. Klenner W. 1991. J. Anim.Ecol. 60:971-978. 10. Larsen K.W. 1993. Ph.D. Thesis, University of Alberta. 11. Larsen K.W. and Boutin S. 1994. Ecology 75:214-223. 12. Larsen K.W. and Boutin S. 1995. Can.J.Zool. 73:1115-1122. 13. Levin S.A. and Paine R.T. 1974. Proc.Nat.Acad.Sci.U.S.A. 71:2744-2747. 14. Linzey A.V. and Kesner M.H. 1989. Can.J.Zool.

69:76-81. 15. Mazurkiewicz M. 1991. Acta Theriologica 36:207-227. 16. Rosenzweig M.L. 1991. Am.Nat. 137:S5-S28. 17. Roy L.D., Stelfox J.B. and Nolan J.W. 1995. *In:* Relationships between stand age, structure and biodiversity in aspen mixedwood forests in Alberta. Alberta Environment Centre, pp.159-186. 18. Rusch D.A. and Reeder W.G. 1979. Ecology 79:400-420. 19. Smith H.C. 1993. Alberta Mammals, Provincial Museum of Alberta Press, Edmonton, Alberta. 20. Spence J.R. 1983. J.Anim.Ecol. 52:497-512. 21. Southwood T.R.E. 1962. Biol.Rev. 37:171-214. 22. Sullivan T.P. and Sullivan D.S. 1982c. For.Chron.58:263-266. 23. Sullivan T.P. and Moses R. 1986. J.Wildl.Manage. 50:595-601. 24. Laymon S.A. and Barret R.H. 1986. in: Wildlife 2000: modelling habitat relationships of terrestrial vertebrates. Univ, Wisconsin Press, Madison WI, 470 pp. 25. Van Horne B. 1983. J.Wild.Manage. 47:893-901. 26. Corns I.G.W. and Annas R.M. 1986. Field guide to forest ecosystems of west-central alberta. Can.For.Serv., North For.Cent., Edmonton, Alberta. 27. USDI. 1981. Standards for the development of suitability index models. Ecological services manual 103. USDI Fish and wildlife service, Div. Ecol. Serv., Washington DC.