Impacts of Ski Area Development on Montane Forest Birds

Progress Report

Christopher Rimmer and Kent McFarland
Vermont Institute of Natural Science
RR 2, Box 532
Woodstock, VT 05091

10 December 1998

The overall objective of this project is to investigate the use by montane forest birds of two existing ski areas in Vermont and to evaluate the impacts of ski area-related activities on avian breeding behavior and success. Intensive data collection has focused on Bicknell's Thrush *(Catharus bicknelli)*, a restricted specialist of the montane spruce-fir zone, and Blackpoll Warbler *(Dendroica striata)*. The project's findings will be used to formulate guidelines and recommendations to develop a conservation strategy for montane forest birds and their habitats in the northeastern United States. This progress report highlights project work completed between 1 April and 31 October 1998.

Study Areas: Four study plots were used in 1998, two each on Mt. Mansfield and Stratton Mountain. On Mt. Mansfield, an existing 20 hectare (50 acre) plot in the undeveloped Ranch Brook (RABR) watershed served as a control plot. Because of logistical difficulties, studies in the Nose Dive Pod area, the site of a planned major ski lift and trails expansion project on Mt. Mansfield, were discontinued. A new experimental plot was established in an existing developed area around the Octagon (OCTA), which encompasses a network of ski trails, ski lifts, a restaurant, a parking lot, and the Mt. Mansfield toll road. On Stratton Mountain, two 10 hectare (25 acre) plots established in 1997 were used in 1998. One plot is located on the north peak (STRB), in an area that is currently fragmented by ski area development, subject to summer recreational activities (mountain biking and hiking), and in which future construction of a 34,000 square foot year-round restaurant is planned. A second control plot (STRA) is situated on Stratton's south peak, which consists of undeveloped Green Mountain National Forest land bisected only by the Long Trail.

Baseline Avian Population Monitoring: Complete inventories of all breeding birds were conducted by territory mapping on the two Stratton Mountain plots in 1998. These data are currently being analyzed and compared both to similar data collected in 1997 and to 1998 radiotelemetry data (see below). For logistical reasons, territory mapping was discontinued on Mt. Mansfield in 1998. Two series of five 10-minute point counts were conducted twice on Mt. Mansfield, as part of long-term monitoring of montane forest bird populations at this site and throughout the northeastern United States.

Focused Demographic Studies: Intensive research on the breeding ecology and population dynamics of Bicknell's Thrush and Blackpoll Warbler was conducted on each plot. We attempted to capture and color band all known breeding individuals and juveniles, using both passive and active mist-netting. Nestlings were banded when possible. We obtained a combined total of 167 Bicknell's Thrush captures on Mt. Mansfield and Stratton Mountain in 1998 (Table 1). While a full demographic summary of these 167 captures is not yet possible, a substantial number of banded adults from previous years were captured,

including at least two individuals on Mt. Mansfield originally banded as nestlings. We are in the process of analyzing return and survival rates using the MARK computer program. Our database of 1998 Blackpoll Warbler captures is currently being computerized.

Table 1. Numbers of Bicknell's Thrush captures on Mt. Mansfield and Stratton Mountain in 1998 (RABR = Ranch Brook, OCTA = Octagon, STRA = Stratton South, STRB = Stratton North).

Plot	Male	Female	Unknown Sex	Nestling	Total
RABR	10	5			15
OCTA	19	11	1	7	38
STRA	18	1	1	3	23
STRB	46	17	13	15	91
Total	93	34	15	25	167

We located and monitored a total of 69 nests of 10 species on Mt. Mansfield and 105 nests of 12 species on Stratton Mountain in 1998 (Table 2). We are currently computerizing these data and will calculate Mayfield estimates of nesting success. We will then compare nesting parameters and reproductive success between ski areas and natural forests to provide insights into population dynamics of various species in the two disturbance regimes.

Table 2. Nests monitored on Mt. Mansfield and Stratton Mountain in 1998.

Species	RABR	OCTA	STRA	STRB	Total
American Robin		6		9	15
Bicknell's Thrush	5	3	1	8	17
Black-capped Chickadee				1	1
Blackpoll Warbler	11	12	8	15	46
Catharus sp.			1	1	2
Cedar Waxwing		4			4
Chipping Sparrow				6	6
Golden-crowned Kinglet	1				1
Hermit Thrush			1		1
Lincoln's Sparrow				2	2
Magnolia Warbler	1	2	8	6	17
Myrtle Warbler	5	4	6	6	21
Slate-colored Junco		3	4	2	9
Swainson's Thrush	3		3		6
White-throated Sparrow	4	5	7	8	24
Yellow-bellied Flycatcher			2		2
Total	30	39	41	64	164

Radiotelemetry of Bicknell's Thrush: We radio-tracked 23 adult thrushes (15 males, 8 females) on Mt. Mansfield and 18 individuals (12 males, 6 females) on Stratton Mountain in June and July of 1998. Each bird received a 0.9 g transmitter attached to the top of the two central rectrices near the base of the rachis with a strand of dental floss. Observations of thrushes in the field and with video-taped nest observations indicated no obvious adverse reactions to the transmitters. We used 3-element Yagi antennas and portable receivers to locate transmitters. Tracking on Mt. Mansfield was done via simultaneous triangulations by 3 observers, to minimize errors and maximize accuracy. On the Stratton ski area plot, triangulations generally were not necessary because the forest was fragmented into small islands. Instead, birds were located by "local" triangulations and close-range fixes by one or two observers quickly circling an island that contained a bird to pinpoint its location. Locations were marked directly on 1:4,000 scale base maps in the field and graded from 0 (point exact) to 3 (point accurate within 30 meters). Most points were graded as 10-20m accuracy.

Analysis of the 1998 telemetry data is underway. A base map created in AutoCAD from aerial photographs and ground surveys was obtained from Stratton Mountain ski resort and imported into ArcView 3.1. Radio telemetry, color band resights, and capture points were digitized for each bird. All data were analyzed using Movement 1.1, a program extension written for ArcView that aids with analysis of animal movement data, and the Spatial Analyst 1.1 extension.

Preliminary analysis of telemetry data from the Stratton ski area plot was presented as a poster at the Association of Field Ornithologists annual meeting in October (Figures 1 and 2). Briefly, results showed: 1) much larger utilization distributions (estimated home ranges) than would be expected on the basis of territory mapping data; 2) significant overlap of utilization distributions; 3) multiple males singing and calling in overlap areas; and 4) more than one nest site typically incorporated within each male's estimated home range (Figure 1). Through careful observations and video taping, we documented multiple males feeding nestlings at several nests, both on Stratton and Mansfield (see below).

Although much additional analysis of our radio telemetry data remains to be done, including comparisons between birds on control and experimental plots, one important preliminary finding is that spot-mapping may not closely approximate actual densities of Bicknell's Thrush. Our intensive radio telemetry suggests that spot-mapping is not appropriate for estimating home range size or density of this species, counter to our earlier published findings. Bicknell's Thrush exhibit a high amount of overlap between their home ranges, which is contradictory to the assumptions of spot-mapping. However, spot-mapping coupled with fixed kernel density estimates can be used to find "hot spots" of activity (Figure 2). It may be possible to correlate these "hot spots" to habitat variables and other environmental data to help determine important conservation areas and issues.

Artificial Nest Predation Experiments: We conducted experiments on both Mt. Mansfield and Stratton Mountain in 1998. Two hundred and fifty artificial wicker nests were divided equally between five separate treatments on each mountain: 1) along foot trails (n=50); 2) along ski trail edges adjacent to unfragmented forest (n=50); 3) along the edges of islands in ski trails (n=50); 4) in the middle of small (n=25) and large (n=25) islands in ski trails; and 5) in undisturbed, unfragmented forest. Each nest was supplied with two Bobwhite *(Colinus virgianus)* eggs and one clay egg, was placed in a situation that closely approximated actual Bicknell's Thrush nest locations, and was checked after one week. Nest predation experiments were conducted first on Stratton Mountain in mid-June, then on Mt. Mansfield during late June. We were unable to deploy automatic cameras at nests, due to funding constraints. We are in the process of analyzing data from these 500 artificial nests, and we will compare them to those data collected at natural nests.

Videography of Bicknell's Thrush Nests: We conducted videography at 5 Bicknell's Thrush nests on Stratton Mountain and 7 nests on Mt. Mansfield, using a Sony Hi8 Handycam recorder. All nests were video-taped during the nestling period, so that identities of attending adults could be documented. At each nest, the camera was mounted to a tripod within a distance of 3-5 meters, with as unobstructed a view as possible of the nest rim and nestlings, and with care taken not to disturb the brooding female or feeding adults. Taping was conducted in 2-4 hour segments, and the camera was typically moved among several nests per day. Although the quality and clarity of tapes varied, due to factors such as lighting, weather, camera position, partial vegetation obstruction, and routes of nest approach and departure by attending adults, a great deal of valuable footage was obtained. We identified color-banded adults at each nest through a combination of video tape analysis, visual observations, and mist-netting.

We obtained a total of 23 hours and 29 minutes of video footage from 5 nests on Stratton Mountain and 44 hours and 14 minutes of footage from 7 nests on Mt. Mansfield. We recorded a total of 372 visits by adult Bicknell's Thrushes to these 12 nests, an average of 31 visits per nest (range = 6-85; Table 3). Although further detailed examination of these tapes remains to be done, preliminary analysis indicates that at least 4 of the 5 video-taped Stratton nests (3 on STRB, 1 on STRA) were attended by two males (Table 4). At one of these, 3 different males may have been feeding nestlings. On Mt. Mansfield, at least 2 of the 3 video-taped nests on the ski area (OCTA) plot were attended by 2 males, and 3 of the 4 nests on the undisturbed (RABR) plot had 2 males in attendance (Table 5). Two adjacent RABR nests (ca. 75 m apart) were apparently attended by the same 2 males, with each being the "primary" (as defined by relative frequency of visits) male at one of the 2 nests. One of these males was video-taped feeding nestlings at both nests, while the other was observed feeding nestlings from one nest and marked fledglings from the other, strongly suggesting that he had attended both nests. Nests on the STRB plot, in both 1997 (STRB97.4 and 97.8) and 1998 (STRB98.2 and 98.3), provided further evidence that some male Bicknell's Thrushes attend multiple nests (Table 4). The male in 1997 (YO/LBX) may have exhibited sequential polygyny, as its 2 nests were not known to be simultaneously active; however, the 1998 male (DBY/LGX) was documented feeding nestlings at 2 simultaneously active nests.

Our radio telemetry data confirm that most male home ranges encompass multiple nest sites (see above), and we believe that this phenomenon may be more common than documented by our limited videography in 1998. Our use of only a single camera, combined with frequent inclement weather during June and July and our relative inexperience in using the technique, resulted in incomplete coverage. We believe that videography has great potential for elucidating the complex social structure and behavioral ecology of Bicknell's Thrush, and we plan to expand our use of the technique in 1999. A thorough understanding of the apparently variable mating system of Bicknell's Thrush will be a prerequisite for modeling the population viability of this species, and for developing meaningful conservation strategies.

We are further convinced, based on nearly 70 hours of footage, that videography causes minimal disturbance, and thus poses little risk, to nests. All of the video-taped nests on both mountains successfully fledged young, and in no cases did we detect any obvious signs of disturbance or intolerance by brooding or feeding adults to the cameras. On several occasions, brooding females remained on the nest during our several minutes of camera set-up. An added benefit of videography was in enabling some assessment of the effects of human disturbance. Although we have not yet quantified results, one nest within 2 meters of the Mt. Mansfield toll road experienced frequent vehicle and foot traffic at close range. These appeared to be almost completely ignored by the brooding female and did not appear to affect food deliveries by the adults. This nest fledged 4 young. We will examine tapes more closely to investigate the responses of adults and

chicks to human disturbances on both Mt. Mansfield and Stratton Mountain.

One suggestive result of our preliminary videography and nest observation work is that Bicknell's Thrush populations on Mt. Mansfield and Stratton Mountain may exhibit a male sex bias. Although analysis of our banding and recapture data is necessary to evaluate this hypothesis, if true, it raises some important and potentially troubling questions about the species' conservation status. If sex ratios are skewed towards males on the breeding grounds, this may indicate that females are experiencing reduced survival during the non-breeding phase of their annual cycle, either on the Caribbean wintering grounds or during migration, or both. VINS' field research in the Dominican Republic may soon be able to shed light on this. Briefly, our work to date suggests that "optimal" winter habitat consists of mature broadleaf montane forest, and we suspect that these habitats may be male-dominated. However, our distributional surveys have also documented that Bicknell's Thrushes occupy lower elevation, second-growth habitats in the Dominican Republic. If, as is known for other species of Nearctic-Neotropical migrants, males and females occupy different habitats and experience differential survival in those habitats, then female Bicknell's Thrushes might be inhabiting "lower quality" second growth habitats on the wintering grounds and experiencing higher mortality. This could explain, in part, a male sex bias on the breeding grounds. Because it is not possible to determine the sex of birds externally in winter, we do not yet have adequate demographic data to examine this. However, in November of 1998 we collected blood samples from 12 live Bicknell's Thrushes in the Bahoruco Mountains and will determine the sex of each sampled bird through laboratory analysis.

Much additional research and analysis of our existing data are necessary to evaluate this possible scenario, which remains purely speculative. Results obtained over the next few months should provide important preliminary insights on both winter and breeding season demographics, helping to guide future research and the development of conservation strategies.

Conservation Implications and Recommendations: Pending further analysis of our 1998 results, it is premature to provide concrete management recommendations. Two preliminary findings stand out, however: 1) based on radiotelemetry data, Bicknell's Thrushes appear to avoid areas within ski developments that are characterized by wide clearings ($\geq$ 50 m wide) (Figure 2). While thrushes readily cross narrow ski trails and other small artificial openings, home ranges generally do not encompass those trails and other openings $\geq$ 50 meters in width; 2) nesting Bicknell's Thrushes appear to be tolerant of a variety of human activities that may occur in close proximity to active nest sites. Evidence from videography and general observations suggests that motorized vehicle traffic, foot traffic, bicycle traffic, and human voices do not significantly disrupt thrush nesting behavior or adversely impact nesting success. It should be emphasized, however, that this result is based on a small sample of observations that have not yet been rigorously analyzed.

We believe that at least one additional field season of intensive research will be necessary to adequately evaluate the extent to which ski area-related activities and habitat fragmentation impact breeding bird populations. We will issue a preliminary set of recommendations based on our 1998 field data once analysis has been completed. A comprehensive report will be prepared after the 1999 field season.

Dissemination/Education: We initiated discussions regarding collaborative development of educational materials and interpretive displays at each ski area in 1998, and we expect to begin designing and assembling these in 1999. We regularly disseminated project information during the summer through informal discussions with hikers, birders, other recreationists, and summer camp groups. Our research was filmed by the Discovery Channel's Animal Planet "All Bird TV" program and aired on 4 and 5 December. We presented a poster paper titled "Home range overlap and movements by male Bicknell's Thrushes during

the breeding period: implications for spot-mapping" at the Association of Field Ornithologists annual meeting in October. Finally, we participated in the third annual meeting of the U.S.-Canadian Bicknell's Thrush study group in Montreal during September.

Project Activities Planned for 1999

1. Refinement of demographic and behavioral ecology studies on Mt. Mansfield and Stratton Mountain, incorporating expanded radio telemetry, videography, and nest monitoring. Increased emphasis will be devoted to Bicknell's Thrush, relatively less to Blackpoll Warbler and other species.
2. Continued assessment of differences between ski area (experimental) and undisturbed (control) plots on each mountain.
3. Development of a report summarizing conservation issues at each site and proposing management recommendations to balance ski area development and viability of montane breeding bird populations.
4. Non-destructive sampling of blood from adult and nestling Bicknell's Thrushes to investigate paternity, sexual system, and social structure (samples were successfully collected from 15 males, 7 females, 1 adult of unknown sex, 11 nestlings from 4 nests, and 1 fledgling on Stratton Mountain in 1998, with no obvious adverse effects on subsequent behavior or survival. These are being analyzed by collaborator and former VINS staff biologist James Goetz at SUNY Syracuse).
5. Cooperative development of educational and informational resource materials for display at both ski areas.
6. Organization of a scientific paper session focused on Bicknell's Thrush at the 1999 American Ornithologists' Union meeting in Ithaca, New York.

Acknowledgments: We are extremely grateful to our 1998 field staff for their countless hours of dedicated work. They include Jim Goetz, Tim Redman, Jim Tietz, Colleen Dwyer, Jeff Farrington, Val Stori, Mark Pickering, Kristin Covert, Laura Gould, Eric Kruger, and Gabriel Colbeck. Collen Dwyer deserves special thanks for assistance with analysis of the Stratton radio telemetry data. We are also grateful for invaluable logistic support received from the Stratton Corporation and the Mt. Mansfield Company. The Hanover Food Coop and Food For Thought in Stowe provided much-appreciated donations of food for our Stratton and Mansfield field crews, respectively. Finally, we thank the organizations that helped to fund our 1998 work, including the National Fish and Wildlife Foundation, the Conservation and Research Foundation, the Philanthropic Collaborative, Inc., the Stratton Corporation, the Vermont Monitoring Cooperative, and the U.S. Fish and Wildlife Service.

Table 3. Results of videography at Bicknell's Thrush nests on Mt. Mansfield (OCTA and RABR) and Stratton Mt. (STRB). Bold indicates female.

Nest Identification	Color Band	Number of Visits
OCTA 98.1	**DBR/PUX**	26
	PUX/PUR	5
	YBK/LBX	22
	Unknown	7
	Total	60
OCTA 98.2	**YLG/BKX**	13
	OBK/BKX	5
	YBD/DBX	7
	Unknown	4
	Total	29
OCTA 98.3	**RW/BKX**	54
	RX/LBLB	18
	Unknown	13
	Total	85
RABR 98.2	**BKY/BKX**	2
	Unknown	11
	Total	13
RABR 98.3	**BKY/BKX**	2
	OPU/BKX	1
	Unknown	13
	Total	16
RABR 98.4	**DBO/BKX**	24
	RR/LBX	6
	W-RX/LBO	16
	Total	46
RABR 98.5	**LGDB/LBX**	23
	BKO/RX	1
	Unknown	1
	Total	25
SSTRB 98.3	**YY/DBX**	9
	BKR/LGX	6
	DBY/LGX	3
	Unknown	6
	Total	24
STRB 98.5	**LBPI/LGX**	3
	Unknown	3
	Total	6
STRB 98.6	**BKLB/DBX**	8
	OBK/DBX	9
	Unknown	8
	Total	25
STRB 98.7	**PIDB/LBX**	14
	Unknown	5
	Total	19
STRB 98.8	**RW/LGX**	1
	WO/LGX	5
	YO/LBX	2
	Unknown	16
	Total	24
Grand Total		372

Table 4. Identities of adult Bicknell's Thrushes attending nests on Stratton Mt. In 1997 and 1998.

Nest ID	Female (age)	Male 1 (age)	Male 2 (age)	Male 3 (age)	Obs.(1997)/ Video (1998) Time (min)	Comments	Nest Outcome
STRB97.1	**RO/LBX (ASY)**	**OW/DBX (SY)**	**YR/WX (ASY)**		0	Second male observed with fledglings	Fledged 2
STRB97.4	**RW/LGX (ASY)**	**BKO/LGX (ASY)**	**YO/LBX (ASY)**		1418	observed from blind	Fledged 2
STRB97.5	**YDB/LGX (ASY)**	**LGY/LGX (ASY)**	**DBY/LGX (ASY)**		120	Nest on edge, observed from trial	Fledged 3
STRB97.7	**LBPI/LGX (ASY)**	**DBR/LBX (ASY)**			1126	2nd nest for female	Fledged 2
STRB97.8	**PIY/LGX (SY)**	**YO/LBX (ASY)**	**PUO/LGX (ASY)**		1836		Fledged 2
STRA98.1	**PIBK/OX (ASY)**	**LBO/LGX (ASY)**	**BKR/OX (ASY)**		0	all visual at nest	Fledged 3
STRA98.1					0	built and then abandoned	Failed during laying or building
STRA98.2	**YDB/LGX (ASY)**	**DBY/LGX (ASY)**			0		Fledged 2
STRA98.3	*YY/DBX (SY)*	***DBY/LGX (ASY)***	*BKR/LGX (TY)*		338		Fledged 3
STRA98.4	**BKLB/DBX (ASY)**				0	female ID not 100 confirmed	Depredated during incubation
STRA98.5	*LBPI/LGX (ASY)*	DBR/LGX (ASY)	OLB/LGX (ASY)	**OW/LGX (ASY)**	315	first two males captured at nest. Male 3 observed.	Fledged 1
STRA98.6	*BKLB/DBX (ASY)*	*OBK/DBX (ASY)*			371		Fledged 2
STRA98.7	***PIDB/LGX (ASY)***	*??/DBX*			241	unidentified adult came to nest with food while female brooding	Fledged 3
STRA98.8	***RW/LGX (ASY)***	*WO/LGX (ASY)*	*YO/LBX (ASY)*		143		Fledged 3
STRA98.9	**RR/OX (SY)**				0		Depredated- 2yng, 1 egg

Note: **Bold** = visual ID, *italics* = *video id*, normal = captured at nest

Table 5. Identities of adult Bicknell's Thrushes attending nests on Mt. Mansfield in 1997 and 1998

Nest ID		Male 1 (age)	Male 2 (age)	Obs.(1997)/Video (1998) Time (min)	Comments	Nest Outcome
RABR97.6	RY/DB-PIX (ASY)	**OPU/BKX (ASY)**		2326	from blind	
MANS97.6	**BKPI/RX (ASY)**			1231	from blind	lled
RABR 98.1	**OLG/PUX (ASY)**	LBY/PUX (ASY)		0	male 1 trapped and radio	Failed-- abandoned after
					tracked near nest	17 days of incubation
					male 2 seen feeding	Fledged 3
RABR98.2	*banded*	*BKY/BKX (ASY)*	**OPU/BKX (ASY)**		recently fledged color-	
					banded chicks.	
RABR 98.3	**LGDB/LGX (ASY)**	***OPU/BKX (ASY)***	*BKY/BKX (ASY)*	185		Probably fledged 3
RABR 98.4	*DBO/BKX (SY)*	*W-RX/LBO (ASY)*	*RR/LGX (ASY)*	361		Fledged 3
					filmed during incubation	Failed-- female
RABR98.5	**LGDB/LBX (ASY)**	**BKO/RX (ASY)**		207	only	abandoned shortly before
						chicks hatched, male tried
						alone then left
OCTA 98.1	*DBR/PUX (ASY)*	*YBK/LBX (ASY)*	*PUX/PUR (ASY)*	482		Fledged 4
OCTA 98.2	*YLG/BKX (ASY)*	*YDB/DBX (ASY)*	*OBK/BKX (ASY)*	337		Fledged 3
OCTA 98.3	*RW/BKX (ASY)*	*RX/LBLB (ASY)*		746		Fledged 3

Note: **Bold** = visual ID, *italics* = *video id*, normal = captured at nest

Figure 1

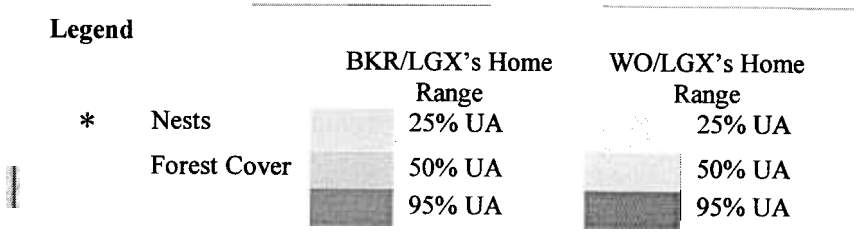
1997

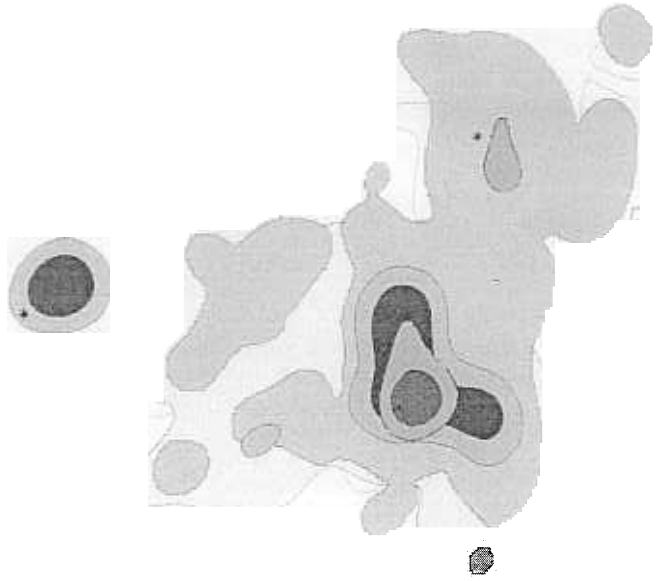
Color Bands	DBY/LGX	DBR/LBX	OLB/LGX	YDB/LBX	Mean	SD
Number of points	90	54	99	59		
Area (ha)	5.06	8.03	3.24	7.62	5.99	2.25

1998

Color Bands	YO/LBX	BKR/LGX	YDB/LBX	WO/LGX	PUPU/LGX	DBR/LBX	LGY/LGX	Mean	SD
Number of points	30	111	429	332	149	37	42		
Area (ha)	1.89	3.30	8.56	2.49	7.66	4.47	4.86	4.75	2.53

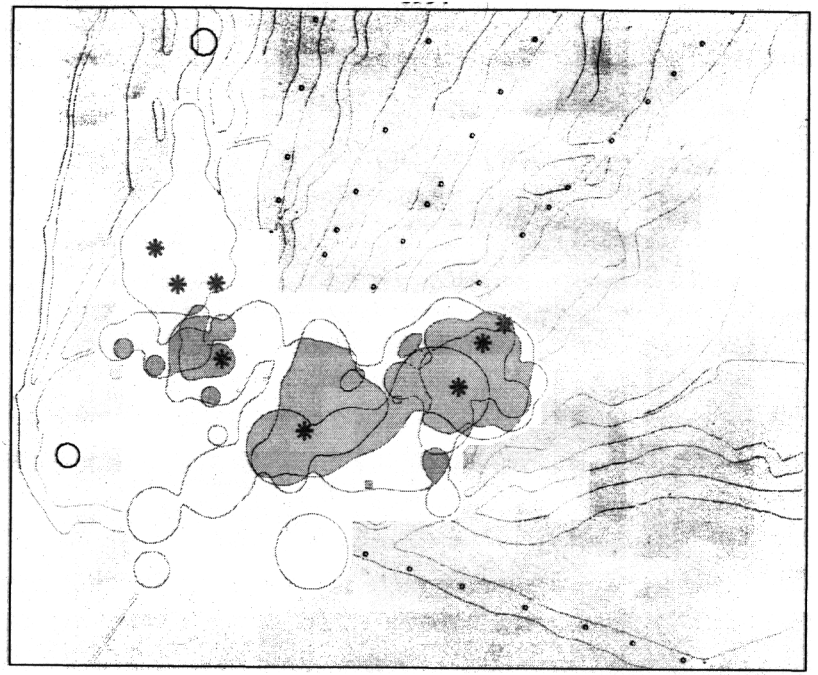
Home range estimates for male Bicknell's Thrush in 1997 and 1998.
A 95% probability estimate of the utilization area (UA) was calculated for each bird using a fixed kernel home range estimate as a grid coverage and a least squares cross validation to select a smoothing parameter (Silverman 1986, Worton 1989, Seaman and Powell 1996). The probability density estimates that were produced by fixed kernel methods may be directly interpreted as utilization distributions.

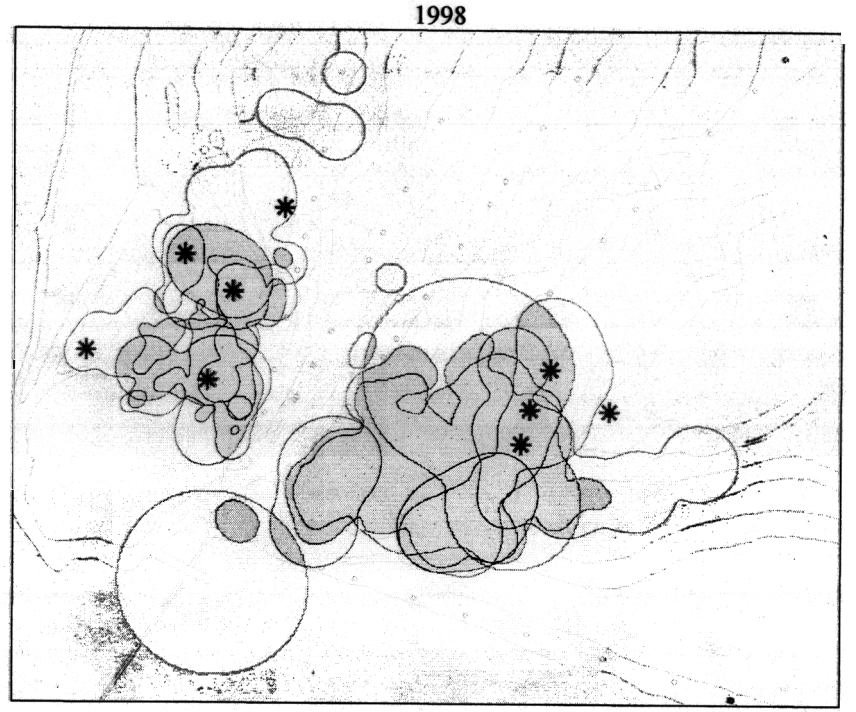




Home range estimates for two male Bicknell's Thrush in 1998.
To best illustrate home range size and overlap we chose two males with large location sample sizes in an area where we believe we discovered all nest sites. This amount of overlap of home ranges was typical for individuals on our study sites. Each male encompassed two nest sites (two different females). The second nest site was shared between each bird. In most cases individual high utilization areas correspond to nest locations.

Figure 2





Legend

Male 95% Utilization Areas (UA)

Male 95% UA Overlap

Overlap in home ranges between 7 radio tagged Bicknell's Thrush in 1997 and 11 radio tagged Bicknell's Thrush in 1998.

Fixed kernel home ranges with 95% utilization areas were calculated for each radio tagged trush. The blue region is the areas of overlap between 2 or more individual home ranges. Mpst areas contained more than 2 overlapped home ranges. Because all individuals were not radio tagged and some individuals had small location sample sizes, the overlap regions (map) and the number of individuals overlapped (table) represent a minimum estimate.

1997

Color Bands	Minimum Number Overlap
DBY/LGX	2
BKO/LGX	2
DBR/LGX	3
DBR/LBX	4
OLB/LGX	4
YDB/LBX	5
PUPU/LGX	4
Mean (+/- SD)	3.43 (1.13)

1998

Color Bands	Minimum Number Over5lap
BKO/LGX	5
OLB/LGX	5
YO/LBX	4
OW/DBX	5
BKR/LGX	5
YDB/LBX	8
LGR/DBX	5
WO/LGX	5
PUPU/LGX	5
DBR/LBX	5
LGY/LGX	4
Mean (+/- SD)	5.09 (1.04)