MONITORING BIRD POPULATIONS ON NATIONAL FOREST LANDS: SUPERIOR NATIONAL FOREST, 1993

A summary report submitted to:

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INTRODUCTION

A habitat specific bird monitoring program was established on the Superior National Forest in 1991 (see Hanowski and Niemi 1991, 1993). The objectives of the program were: (1) to establish the physical layout of the monitoring program; (2) to monitor the abundance of indicator bird species specified by the Forest; (3) to monitor the abundance of common bird species on the Forest; and (4) to begin refining avian/habitat relationships used to assess forest management activities on breeding bird abundance and distribution. Additional goals for 1992 monitoring were: (1) to make statistical comparisons between 1991 and 1992 bird abundance; (2) to determine the power of statistical analyses in terms of detecting annual differences for a variety of community, guild, and species specific parameters; and (3) to explore similarities and differences in habitat data collected and the U.S. Forest Service forest types. Added objectives for 1993 were: (1) to analyze avian population trends detected after three years of monitoring; and (2) to reassign forest types based on field inspection of stands identified in 1992 as having questionable forest type classifications.

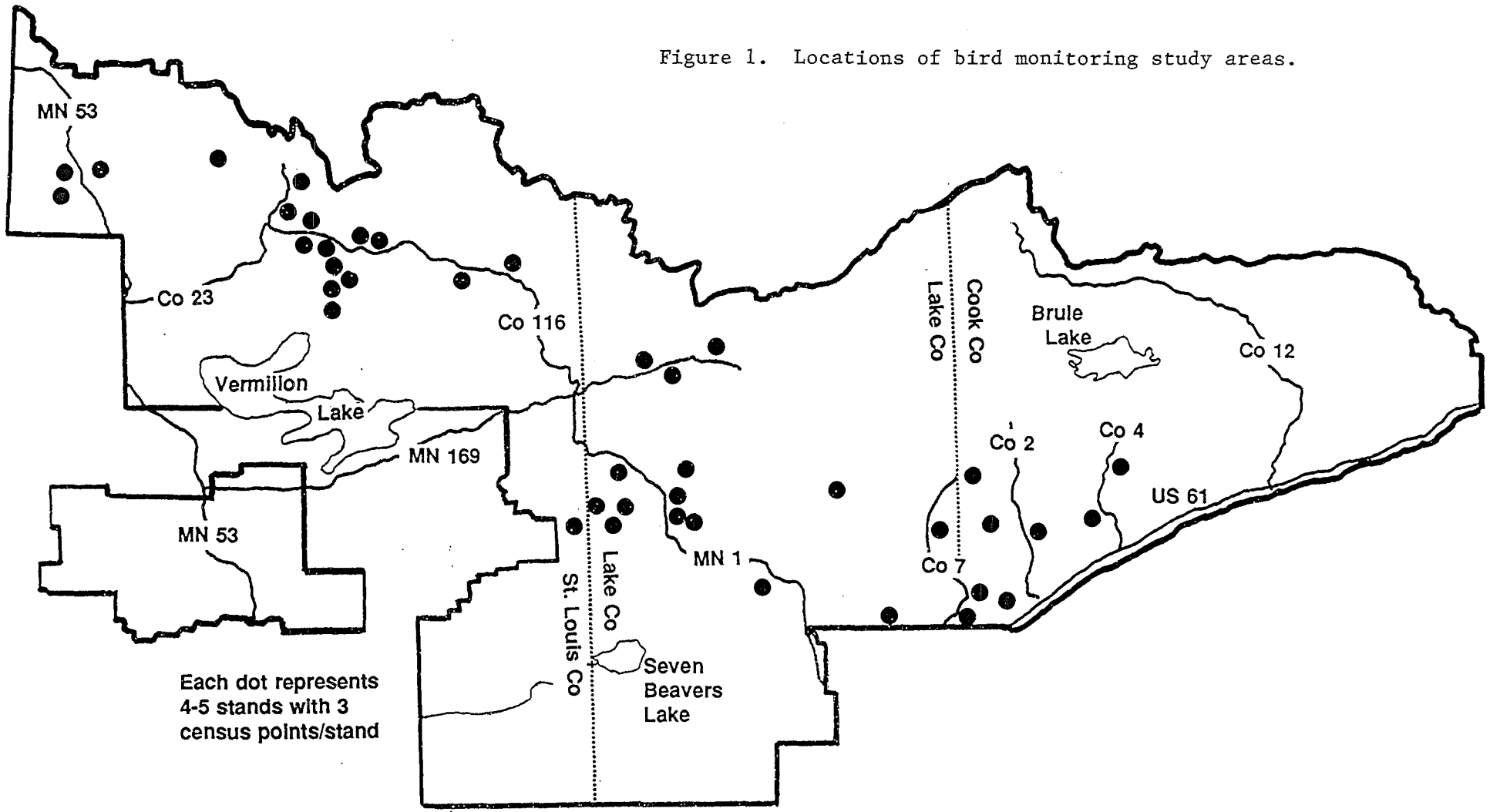
STUDY AREAS

A major goal in 1992 was to compare habitat data collected at each census point to forest cover types assigned by the Forest Service. We examined data collected at each census point in both 1991 and 1992, and identified points where major tree species (based on forest type) did not appear in our habitat data. For example, if a stand was classified as red pine, but red pine was not listed as one of the five tree species at all three points, the forest classification of the stand was considered to be "questionable". Stands that were clearly misclassified, or that had been harvested between 1991 and 1992, were reclassified into more appropriate forest types. In 1993 we continued to update forest classifications. As in previous years, points that had been harvested between field seasons were reclassified as regenerating. In addition, all stands that had been identified in 1992 as having questionable forest type classifications were field checked in 1993, and reclassified as necessary. This step was extremely important, and was necessary to complete before we could further analyze habitat associations of birds on the Forest. Stands and points where forest types were changed in 1993 are listed in Table 1. The reclassification of points and stands in 1993 caused some changes in the results we reported in 1992 (see results section below). General locations of sample areas are shown in Figure 1. See Hanowski and Niemi (1991) for a description of study area selection.

METHODS

Bird census. We censused three replicate points (each 10 minutes in duration) within each stand during a two week period in June using the point-count method (Reynolds et al. 1980, Hanowski and Niemi 1992). This is an excellent method for determining relative abundance of singing passerine species, but is inadequate for most raptors and waterfowl species. In addition, because only one census is conducted in June, this method probably underestimates relative densities of early nesting species (e.g., most permanent residents including woodpeckers and chickadees).

Figure 1. Locations of bird monitoring study areas.



SUPERIOR NATIONAL FOREST - Study Sites

Scale
20 mi.

Table 1. Stands and points on the Superior National Forest where forest types were changed in 1993.

District	Compart	Stand	NRRI Site	Old FS	New FS
9095	74	24	821	911	913
9095	74	24	822	911	913
9095	74	24	823	911	913
9095	74	37	827	11	113
9095	74	37	828	11	113
9095	74	37	829	11	113
9095	74	50	824	915	919
9095	74	50	825	915	919
9095	74	50	826	915	919
9095	90	21	803	163	173
9095	90	21	804	163	173
9095	90	21	805	163	173
9095	97	21	812	926	115
9095	97	21	813	926	115
9095	97	21	814	926	115
9095	101	44	483	916	911
9095	101	56	473	19	13
9095	101	56	474	19	13
9095	101	56	475	19	13
9096	42	10	641	919	39
9096	42	10	643	919	39
9096	42	11	650	13	16
9096	42	11	651	13	16
9096	42	11	652	13	16
9096	44	23	633	26	29
9096	44	23	634	26	29
9096	62	26	677	926	119
9096	62	32	674	19	926
9096	62	32	676	19	913
9096	62	42	683	926	119
9096	62	55	680	919	126
9096	79	16	620	22	12
9096	79	16	621	22	12
9096	79	16	622	22	22
9096	92	99	575	912	12
9096	92	99	576	912	12
9096	92	99	577	912	12

Table 1. Continued.

District	Compart	Stand	NRRI Site	Old FS	New FS
9096	204	14	740	912	913
9096	204	14	741	859	913
9096	204	14	742	859	913
9097	47	44	845	926	116
9097	47	44	846	926	116
9097	47	44	847	926	116
9097	47	44	856	926	116
9097	66	13	536	912	916
9097	66	13	537	912	916
9097	66	13	538	912	916
9097	79	12	559	953	36
9097	79	12	560	913	36
9097	79	12	561	913	36
9097	79	21	557	953	36
9097	79	21	558	953	36
9097	79	21	562	953	36
9097	126	13	859	166	186
9097	126	13	863	166	186
9097	126	13	864	166	186
9097	126	15	860	926	13
9097	126	15	861	926	13
9097	126	15	862	926	13

Five trained observers (see observer training section below) conducted the censuses which were completed between 0.5 hours before sunrise and 4 hours after sunrise. Censuses were conducted only during good weather (e.g., wind < 15 mph and no precipitation). Types of stands censused (forest cover type) were stratified by time of morning. For example, we avoided sampling all upland pine stands early or late in the morning. Forest cover types censused were also stratified by observer; each observer sampled relatively the same number of stands in each forest type.

We recorded weather (cloud cover, temperature, and wind speed) and time of day the census was conducted. All birds heard or seen from the center point were recorded in a circle with estimates of their distance (up to 100 m) from the center point. Numbers of individuals observed for each species were summed for three, five, and ten minute periods (see Hanowski and Niemi 1991).

Observer training. Prior to the field season, tapes of bird songs were provided as a learning tool for all observers, and all were required to pass an identification test of 75 bird songs made by Cornell University's Laboratory of Ornithology. A standard for number of correct responses was established by giving the test to observers who were trained in identifying birds by sound, and who had four to five years of field experience. This was done to identify songs on the tape that were not good representations of songs heard in northern Minnesota. Based on results of trained observers, we set the standard for passing at 85% correct responses. Songs on the tape were grouped by habitat (e.g., upland deciduous, lowland conifer) to simulate field cues that would aid in song identification.

Observer field training was done in late-May. Observers were first instructed on the methods for recording data on the field sheets. Observers then conducted simultaneous counts (four mornings; 40 points) and were allowed to ask questions about unknown birds after each 10 minute count. Count information was compiled for each observer, and new observer data was compared to experienced observer data. Species lists and number of individuals recorded on the count by each observer were compared. Deviations from the average or species missed were noted on the field sheets and returned to each observer.

In addition to training and testing, all observers were required to have a hearing test to ensure that their hearing was within normal ranges for all frequencies (125 to 8000 hertz). Normal ranges were standards established by audiologists.

All of the observers who worked on the Superior National Forest during the 1993 field season had conducted bird censuses in previous years.

Habitat data. We collected information on habitat structure and plant species composition at the center of each point. We estimated canopy height in meters, and recorded the most abundant tree and shrub species (up to five each). Tree and shrub density was estimated and coded by abundance (see Hanowski and Niemi 1991). Percent deciduous component, and percent coverage of vegetation layers at the high canopy, subcanopy, understory, and ground levels were also estimated and coded. Codes were recorded for topography and special features (e.g., snags). These data will ultimately be used to identify habitat features that may be important to bird species within individual forest cover types and ages.

Tree size. We separated each forest cover type into three groups based on age of stand origin and stocking density. We used the Forest Service classification of tree size and stocking density for three classes: sapling, pole-sized, and saw-sized. This information was obtained from the VMIS database or from the compartment maps. We changed the tree size if, after field verification, the stand had changed since the database or compartment map had been updated (e.g., especially regenerating stands). A number of the 1993 changes in forest type (Table 1) reflect changes in

stocking density, or tree size (e.g., from sapling to pole-size).

Data management. All data were entered into a Paradox file directly from the field data sheets. Several checks were made of the data file by someone other than the person who entered the data. After the data files were checked, information on birds within a stand was grouped (i.e., three points). Stands in which we were unable to place three points were not included in the summary file. In addition, we assigned each bird species into groups (guilds) based on habitat association, migration strategy, feeding method and substrate, and nest location (see Hanowski and Niemi 1991).

Density calculations. We calculated relative abundance values for four indicator species specified by the Forest. Numbers of territorial males per 40 acres were calculated by summing numbers of individuals for each species at three points within each stand. We determined the area of each sample (point count) based on a radius of 100 m for most species. We used a smaller radius of 75 m for the Brown Creeper because we were not confident that we could detect this species beyond 75 m. A priority for work in subsequent years is to determine detection limits for a variety of species. A relative abundance value for each indicator species on the forest can be calculated by multiplying the relative index value of a species within each habitat type by the total amount of that habitat on the forest. Because we have presented relative abundance as number of territorial males/40 acres, these values must then be divided by 40 to establish number of males on the forest. Relative index for each species within each forest type and tree size (e.g., pole-sized) can be summed to determine total numbers of territorial males in all cover types.

The relative index calculations should be used with caution. They are not meant to be interpreted as an absolute density for the Forest. Rather, they should be viewed as base values with which future monitoring data can be compared to determine whether the relative number of individuals observed in each cover type tends to be decreasing, increasing, or unchanged. More importantly, as these data are coupled with forest change, they will allow an approximate measure of the effects of these changes on a forest-wide basis.

Statistical methods. An unbalanced, repeated measures analysis of variance (ANOVA) was used to test for differences in bird abundance over the course of the monitoring program. The model allowed us to include stands even if a value was missing for one or more years, for example, if a site was not found in any given year, or if a census was not completed due to inclement weather. A repeated measures test is relevant when several measurements are taken on each experimental unit (e.g., multiple years), and the measurements are correlated. The test accounts for correlations among the dependent variables while testing for treatment effects. The most powerful repeated measures model has an assumption of "compound symmetry of the covariance matrix" (BMDP Statistical Software Manual 1992). This means that bird abundances are assumed to have the same variance in each year, and the

correlation between any two years is assumed to be the same as the correlation between any other two years. Because our data would not meet this assumption, we selected a model that required no assumptions about the structure of the covariance matrix (BMDP Statistical Software Manual 1992). This test used the method of maximum likelihood to obtain estimates of the regression and covariance parameters. The tested hypothesis was that of "no change over time". Therefore, P-values < 0.05 indicate a significant change in abundance over the course of the three years of monitoring. Pairwise comparisons between years were not conducted. All variables were examined for normality prior to statistical analyses (Sokal and Rohlf 1981), and were transformed when necessary (e.g., logarithmic or square root).

Data were examined separately for each species (all stands), providing that the species was observed on a minimum of 15 stands over the course of the monitoring program. Fifty-two species met this criterion, and were tested for statistical differences among years. Annual differences in abundance were also examined for mean number of species and individuals observed per stand, and for numbers of individuals within all guild types. The same model used for individual species was used for these tests.

In 1992 we calculated the power of statistical analyses using mean and variance data from 1991 and 1992. See Hanowski and Niemi (1993) for an explanation of these calculations. The power analysis was not repeated in 1993, but since degrees of freedom in the power formula (Hanowski and Niemi 1993) equal the number of years of monitoring - 1, an increase in the power to detect annual differences would be expected with the addition of another year of monitoring data.

RESULTS

Bird communities. The mean numbers of individuals and species recorded per stand were higher in 1993 than in either 1992 or 1991 (Appendix I). These represented significant changes ($P < 0.05$) over the course of the monitoring program. Altogether, 89 species were observed in 1993, compared with 88 species in 1992, and 78 species in 1991. Eight species were observed in 1993 only, 9 species in 1992 only, and 6 species in 1991 only (Appendix I). Most species that were observed in only one year were uncommon, and were observed on just one or two stands.

Individual species. Twenty-eight species differed significantly ($P < 0.05$) in abundance over the course of three years of monitoring (Appendix I). Two species decreased in abundance from 1991 to 1992, and also decreased from 1992 to 1993. These were the Red-eyed Vireo and the Mourning Warbler. Ten species increased in abundance in both time periods (Table 2). Sixteen species increased in abundance in one year and decreased in the other. Three of these species showed an increase in abundance in 1992 compared with 1991, but decreased in 1993 relative to 1992. These were the Cedar Waxwing, the American Redstart, and the Scarlet Tanager. Thirteen species decreased in 1992, but increased in 1993 (Table 3).

Table 2. Species that differed significantly (P < 0.05) over the course of the study, increasing in abundance in both 1992 and 1993 compared with 1991.

Yellow-bellied Flycatcher	Nashville Warbler
Black-capped Chickadee	Cape May Warbler
Winter Wren	Black-throated Green Warbler
Solitary Vireo	Northern Waterthrush
Tennessee Warbler	Rose-breasted Grosbeak

Table 3. Species that differed significantly (P < 0.05) in the course of three years of monitoring, decreasing in abundance in 1992 compared to 1991, and increasing in 1993 relative to 1992.

Least Flycatcher	Magnolia Warbler
Gray Jay	Yellow-rumped Warbler
Red-breasted Nuthatch	Blackburnian Warbler
Ruby-crowned Kinglet	Black-and-White Warbler
Veery	Ovenbird
American Robin	White-throated Sparrow
Northern Parula Warbler	

Bird guilds. Mean numbers of individuals per stand, standard error of the means, and P-values for those guilds tested for statistical significance are presented in Appendix II.

Bird abundance differed significantly ($P < 0.05$) within 6 of 10 habitat guilds (Figure 2) over the course of three years of monitoring. Five guilds increased in abundance in 1993 compared to 1992. Only the aquatic guild declined in 1993. Three of these guilds (the upland coniferous, upland mixed, and fields/meadows guilds) had shown significant declines in 1992 compared to 1991. The lowland conifer group increased in abundance in both 1992 and 1993 (Figure 2).

There were significant ($P < 0.05$) differences among years in bird abundance within 8 of 16 forage guilds (Figure 3). Seven of these groups increased in abundance in 1993 relative to 1992. Only fruit eating birds declined in 1993 (this guild had shown an increase in 1992 compared to 1991). Flycatchers and omnivores increased in abundance in both 1992 and 1993 (Figure 3).

Numbers of permanent residents, short-distance migrants, and long-distance migrants all differed significantly ($P < 0.05$) among years over the course of the monitoring program. All three migration guilds increased in abundance in 1993 compared to 1992 (Figure 4).

Number of males per stand within four nesting guilds (canopy, shrub, ground, and cavity nesters) differed significantly ($P < 0.05$) among years. These four guilds increased in abundance in 1993 compared to 1992. All four had decreased in 1992 relative to 1991. Nest parasites and platform nesters declined in 1993, but the change was not significant over the course of the study (Figure 5).

Indicator species. Forest type reclassification in 1993 (Table 1) resulted in some changes in the values we reported for indicator species in 1992 (Hanowski and Niemi 1993). In three instances (Brown Creeper, Swainson's Thrush, and Scarlet Tanager) the trend (e.g., increase or decrease in abundance) was unchanged, but the magnitude of the change, and the distribution of the species among habitats were altered. In the case of the Pine Warbler, we reported a slight increase in abundance in 1992 (Hanowski and Niemi 1993). However, after reclassifying stands in 1993, the Pine Warbler showed a decline from 1991 to 1992 (from 1046 to 604 males).

In 1993, two of the four indicator species increased in total numbers (Pine Warbler and Brown Creeper). The Pine Warbler increased from 604 males in 1992 to 935 males in 1993 (Figure 6), but was not abundant enough to test for statistical significance (see statistical methods section above). Pine Warblers were recorded in sapling jack pine, saw-sized red and white pine, and saw-sized aspen/birch (Figure 6).

The number of Brown Creepers increased 22% from 1992 to 1993 (from 13618 to 16605 males) (Figure 7). It increased in some habitat types and declined in others. The greatest increases were recorded in pole-sized balsam fir, black spruce, white cedar, and aspen/birch. The Brown Creeper also increased in abundance from 1991 to 1992 (see Hanowski and Niemi 1993), however, these increases were not statistically significant over the course of the monitoring program ($P = 0.493$).

In contrast, the number of Scarlet Tanagers did differ significantly ($P = 0.0085$) among years. It increased in total numbers from 1991 to 1992 (Hanowski and Niemi 1993), but declined in 1993 compared to 1992 (20%, from 5860 to 4679 males) (Figure 8). Decreases were noted in virtually all habitat types where it occurred except in mature balsam fir, maple, and aspen/birch.

Numbers of Swainson's Thrush also decreased from 1992 to 1993 (7% from 3932 to 3653 males) (Figure 9), but no significant difference was detected over the course of three years of monitoring ($P = 0.22$). Declines were recorded in some habitats, and increases in others.

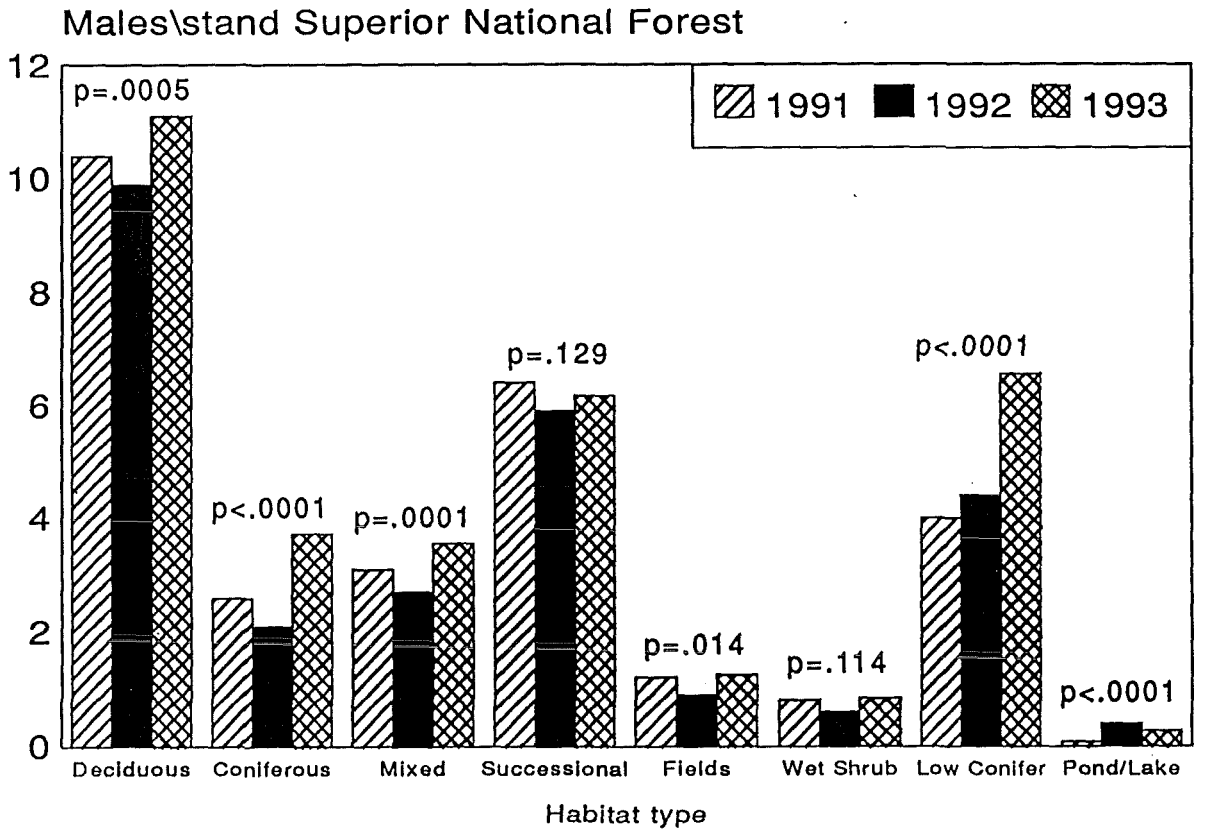


Figure 2. Relative abundance of birds observed/stand within eight habitat guilds on the Superior National Forest from 1991 to 1993. P-values are from repeated measures ANOVA (see text).

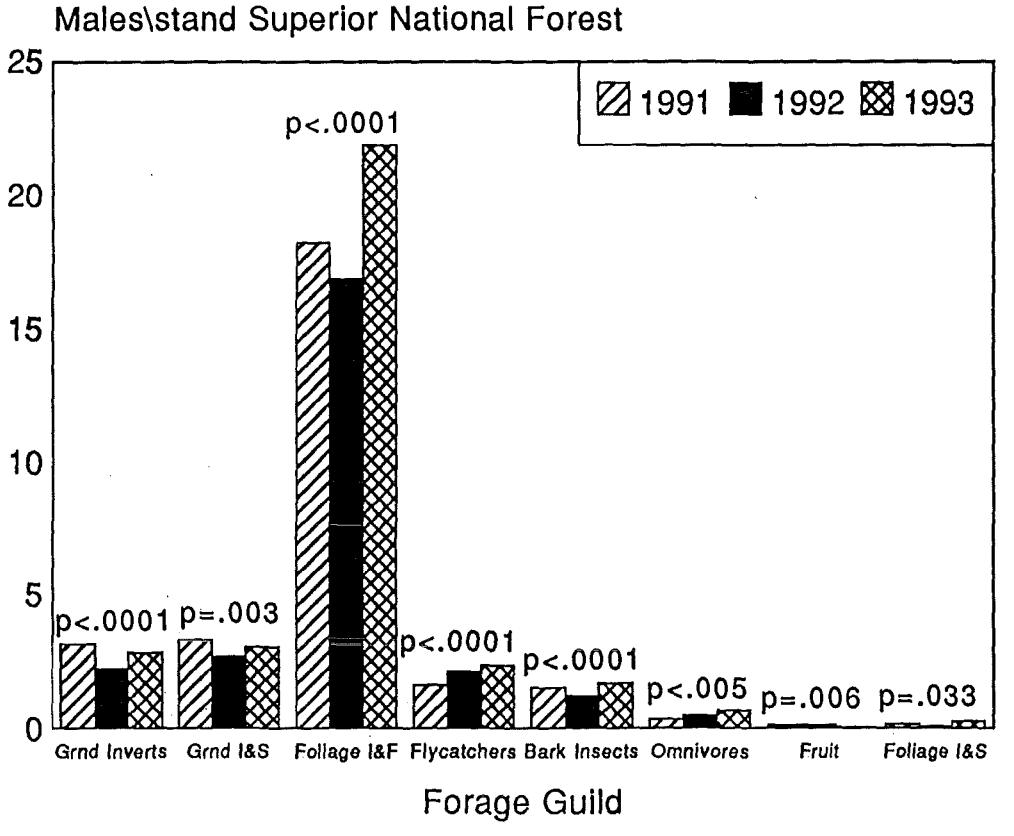


Figure 3. Relative abundance of birds observed/stand within eight forage guilds on the Superior National Forest from 1991 to 1993. P-values are from repeated measures ANOVA (see text).

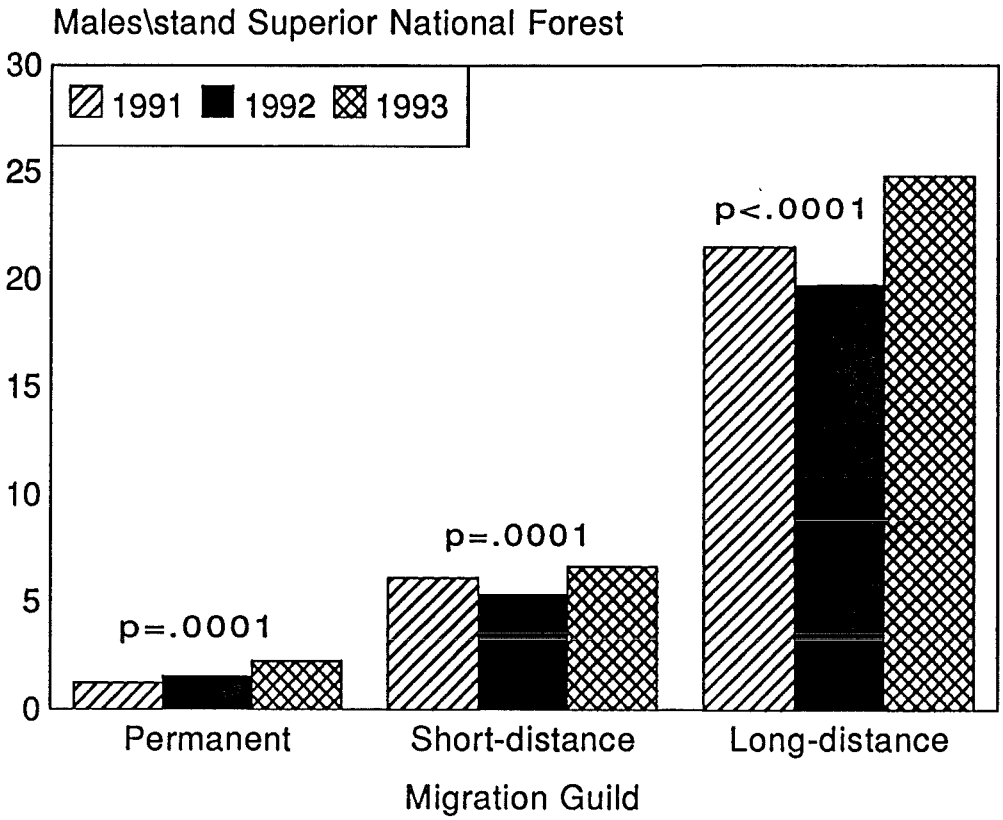


Figure 4. Relative abundance of birds observed/stand within three migration guilds on the Superior National Forest from 1991 to 1993. P-values are from repeated measures ANOVA (see text).

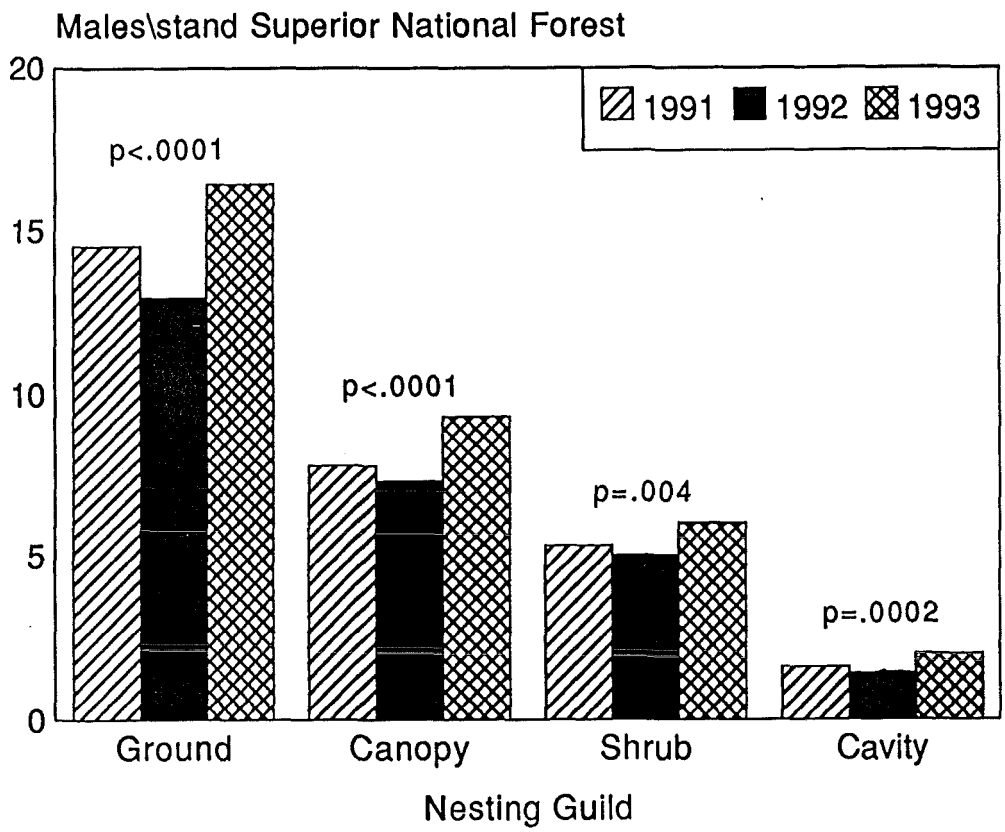


Figure 5. Relative abundance of birds observed/stand within four nesting guilds on the Superior National Forest from 1991 to 1993. P-values are from repeated measures ANOVA (see text).

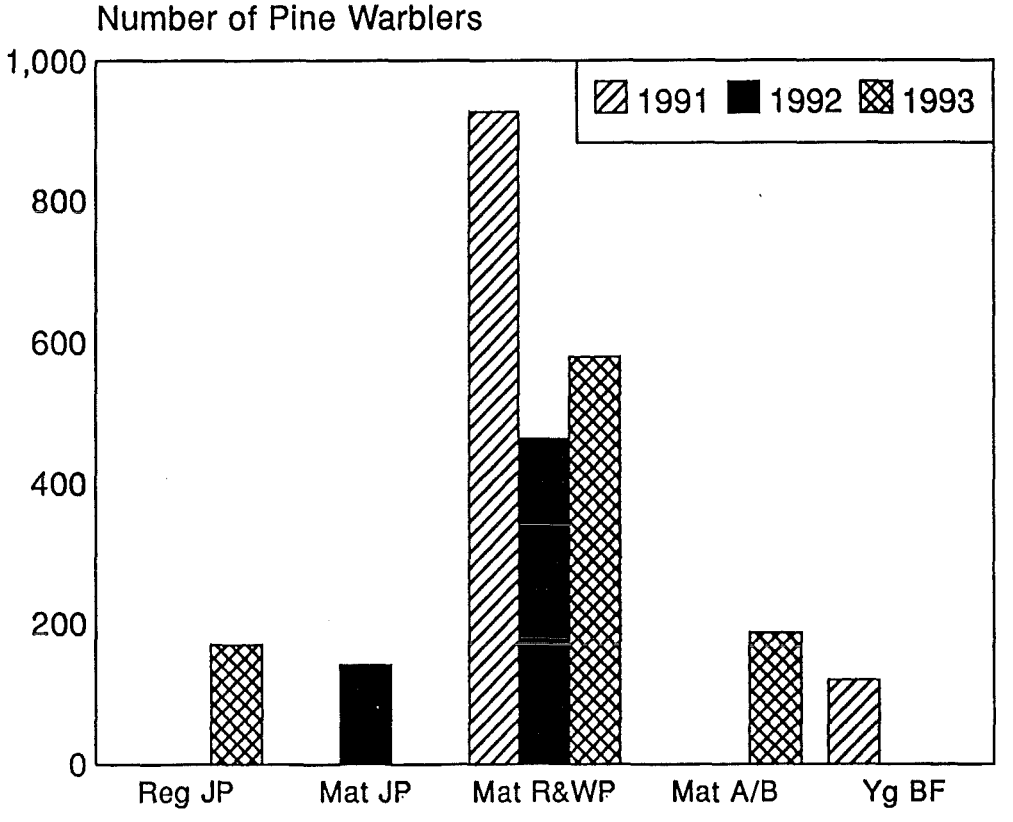


Figure 6. Number of Pine Warblers within habitat types on the Superior National Forest from 1991 to 1993. Reg JP=regenerating jack pine, Mat JP= mature jack pine, Mat R&WP=mature red and white pine, Mat A/B=mature aspen/birch, Yg BF= young balsam fir.

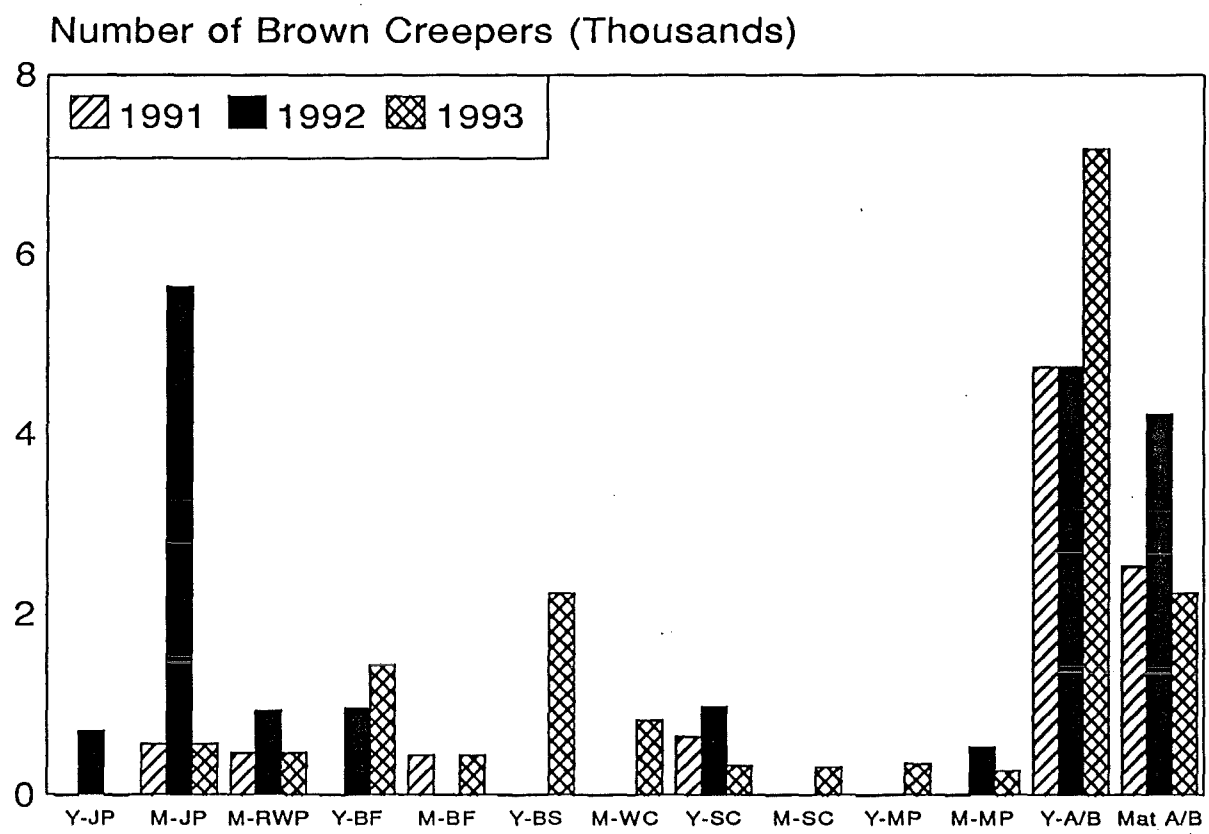


Figure 7. Number of Brown Creepers within habitat types on the Superior National Forest from 1991 to 1993. Y-JP=young jack pine, M-JP=mature jack pine, M-RWP= mature red and white pine, Y-BF=young balsam fir, M-BF=mature balsam fir, Y-BS=young black spruce, M-WC=mature white cedar, Y-SC=young swamp conifer, M-SC=mature swamp conifer, Y-MP=young maple, M-MP=mature maple, Y-A/B= young aspen/birch, M-A/B=mature aspen/birch.

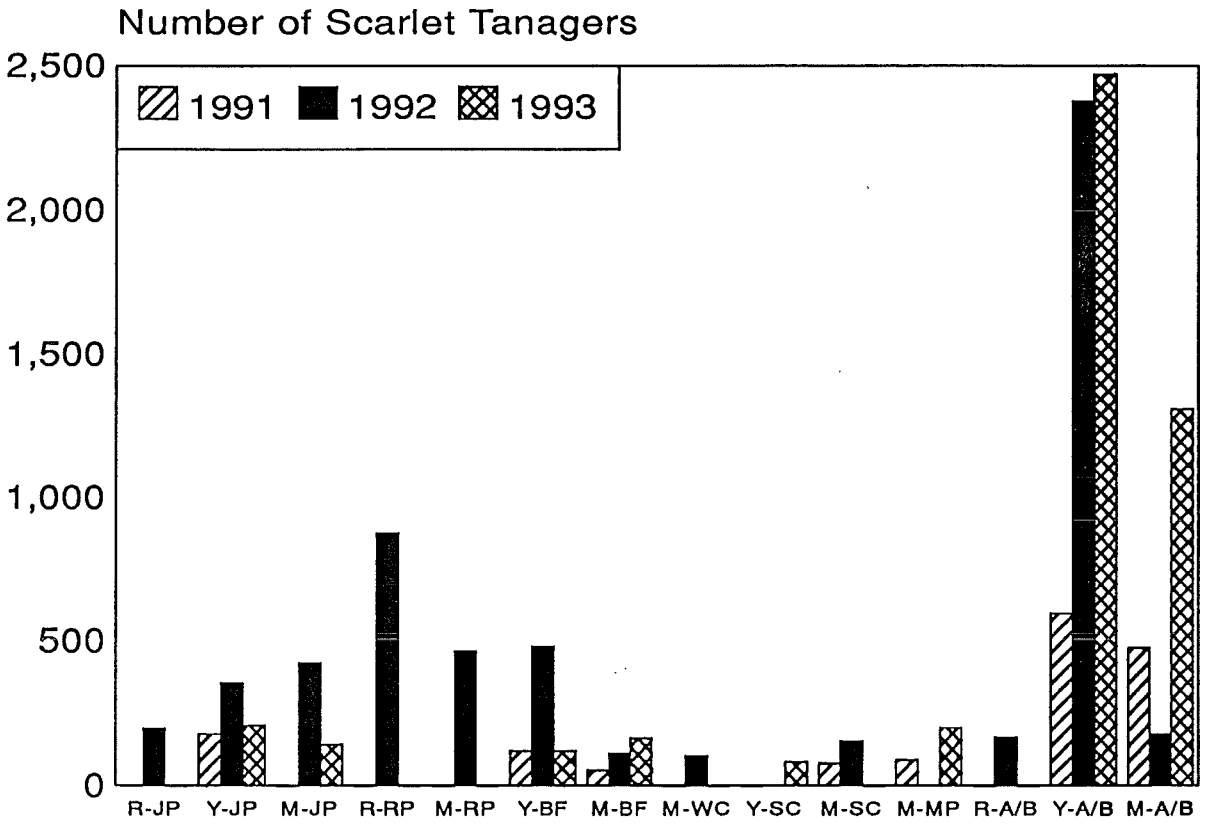


Figure 8. Number of Scarlet Tanagers within habitat types on the Superior National Forest from 1991 to 1993. R-JP=regenerating jack pine, Y-JP= young jack pine, M-JP=mature jack pine, R-RP=regenerating red and white pine, M-RP=mature red and white pine, Y-BF=young balsam fir, M-BF=mature balsam fir, M-WC=mature white cedar, Y-SC=young swamp conifer, M-SC=mature swamp conifer, M-MP= mature maple, R-A/B=regenerating aspen/birch, Y-A/B= young aspen/birch, M-A/B= mature aspen/birch.

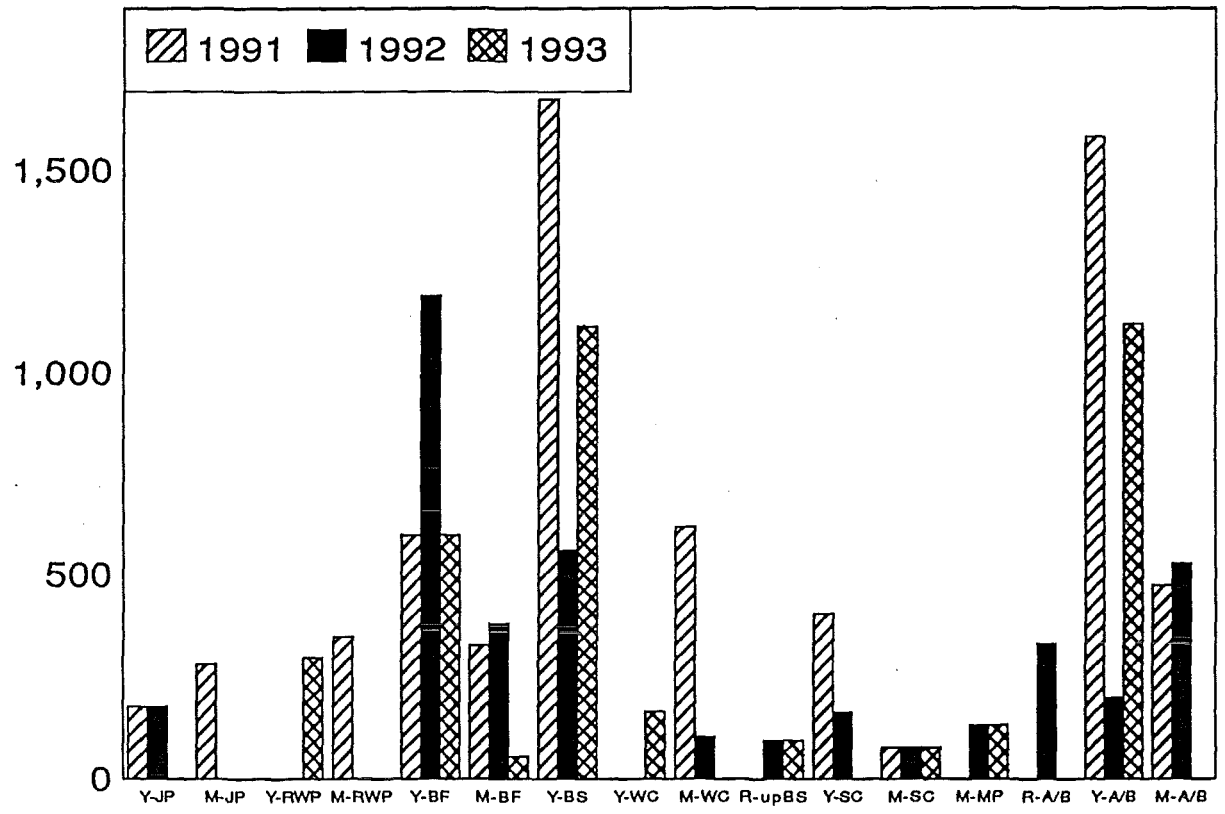


Figure 9. Number of Swainson's Thrush within habitat types from 1991 to 1993 on the Superior National Forest. Y-JP= young jack pine, M-JP=mature jack pine, Y-RWP=young red and white pine, M-RWP=mature red and white pine, Y-BF=young balsam fir, M-BF=mature balsam fir, Y-BS=young black spruce, Y-WC=young white cedar, M-WC=mature white cedar, R-upBS= regenerating upland black spruce, Y-SC=young swamp conifer, M-SC=mature swamp conifer, M-MP=mature maple, R-A/B=regenerating aspen/birch, Y-A/B= young aspen/birch, M-A/B=mature aspen/birch.

A word of caution is appropriate concerning the figures presented above for numbers of indicator species on the Forest. Available habitat (e.g., number of acres of different cover types) is very important in calculating these projections. The values presented here are based on 1991 estimates of amounts of different cover types on the Forest. Obviously, there have been changes since 1991 (e.g., harvesting). As we have said before, these values should not be interpreted as absolute densities for the Forest, but as base values with which future monitoring data can be compared.

Habitat associations. Relative abundance of individual species within habitat types is presented in Appendix III. Difference sized circles in the "bubble" plots represent ranges of abundance for each species.

DISCUSSION

Bird communities. We present relative indices of bird abundance for data gathered from 1991 through 1993, but caution that these data are best used for comparisons of annual variation within the Superior National Forest. Because the sample was allocated to cover types based on amount of that cover type on the Forest, we do not have equal sample sizes in each cover type. Differences in the number of stands sampled within each forest cover type (and age) have an affect on relative bird abundance values, especially number of species. For example, the number of species observed within a particular cover type is positively correlated with the area of that cover type (number of stands) that was censused. We would expect more species to be recorded in cover types that had more samples. There are statistical procedures that correct for species/area effects (e.g., rarefaction)(James and Rathbun 1981), and if we intended to compare data collected on the Superior National Forest to other areas it would be best to standardize these data. Again, we stress that the objective for the monitoring is to assess annual variation in relative terms for the Superior National Forest. Therefore, it is not necessary that we standardize the species counts because the comparison that we used to assess annual variation was based on a comparison of stands among years.

From 1991 to 1992, both total individuals and total species declined on the Superior National Forest, although the declines were not significant. By contrast, increases were observed for both these community parameters in 1993. Statistical tests indicated that the changes over time were significant. This pattern of increases in numbers of species and individuals was also observed on the Chippewa National Forest, and the changes over time were significant there as well (Montgomery et al. 1993). Total individuals and species recorded on the Chequamegon National Forest in Wisconsin, also increased from 1992 to 1993, but the increase was not significant (Hawrot et al. 1993). Annual differences in bird abundance are not unusual, and are likely due to a variety of factors including weather, and annual differences in song phenology (see Blake et al. 1992).

Individual species. In general, many more species increased in abundance from 1992 to 1993 than decreased. This pattern was evident on the Chippewa National Forest as well (Montgomery et al. 1993). On both Forests, many species which showed declines in 1992 relative to 1991, increased in abundance in 1993. Decreases in abundance were recorded in 1993 for a few species which had shown increases in 1992. Fluctuations in abundance of this sort are probably best viewed as normal annual variation (especially when based on only three years of monitoring data). Cold, wet, weather during the 1992 breeding season was likely a factor that contributed to the decreases that were recorded (Hanowski and Niemi 1993). Observer variation may also have been a factor affecting the 1992 results. Although every effort is made to ensure the quality and ability of observers conducting the censuses (see observer training section above), two new observers in 1992 consistently recorded fewer individuals and species than did the experienced observers.

Perhaps more noteworthy than species which exhibit annual fluctuation (which is not unusual) are species that show the same trend in both years, or the same trend on both the Superior and Chippewa National Forests. For example, the Nashville Warbler increased significantly in both years, on both Forests. It also increased on the Chequamegon National Forest from 1992 to 1993, although the increase was not statistically significant (Hawrot et al. 1993).

The Red-eyed Vireo declined in abundance on the Superior National Forest in 1992 compared to 1991, and also declined in 1993 relative to 1992. The change over time was significant. This species also declined slightly (but not significantly) on the Chequamegon National Forest (Hawrot et al. 1993). On the Chippewa National Forest, however, it declined in 1992, but increased in 1993 (Montgomery et al. 1993). These variations are difficult to explain.

A later than normal spring migration may have been a factor that contributed to some of the changes in bird abundance recorded on the Forest this year. During the first three or four days of censusing (1-4 June), observers noted that a number of apparent migrants were still moving through the Forest (e.g., Tennessee Warbler and Cape May Warbler), and that certain migrants, like the Red-eyed Vireo and Olive-sided Flycatcher were not present in normally expected numbers. This may partially account for increases recorded in 1993 for the usually uncommon Tennessee and Cape May Warblers. However, both these species increased on the Forest in 1992 as well, and anecdotal evidence (impressions of local birders) suggests that there were, in fact, more than normal numbers of both species present on the Forest during the 1993 breeding season. Both were recorded singing on several study sites sampled more intensively into July, 1993. Although late migrants have not been a problem during previous monitoring seasons, it may be advisable in the future to conduct the Superior National Forest censuses during the latter half of June.

Bird guilds. Increases in abundance were recorded in 1993 for almost all of the habitat guilds on the Forest. Similar increases were observed on the Chippewa and the Chequamegon National Forests (Montgomery et al. 1993, Hawrot et al. 1993). Most of these guilds had decreased in abundance on both the Superior and Chippewa National Forests from 1991 to 1992. The exception was the lowland conifer group which increased on both Forests in both time periods.

Except for fruit eating birds, all forage guilds that had sufficient numbers of individuals to test, increased in abundance on the Forest in 1993. On the Chippewa National Forest two forage guilds increased (seeds, foliage insects and fruit), and one guild declined (foliage insects and seeds)(Montgomery et al. 1993). On both Forests, the flycatchers increased in abundance in both 1992 and 1993. A significant increase in the number of flycatchers was also recorded on the Chequamegon National Forest in 1993 relative to 1992 (Hawrot et al. 1993).

All three migration guilds (permanent residents, short-distance, and long-distance migrants) increased in abundance on both the Superior and Chippewa National Forests in 1993 relative to 1992 (Montgomery et al. 1993). On the Chequamegon National Forest, permanent residents and long-distance migrants increased significantly in abundance from 1992 to 1993. Short-distance migrants also increased slightly, but not significantly (Hawrot et al. 1993).

Four nesting guilds (canopy, shrub, ground, and cavity) increased in abundance on the Forest in 1993 compared to 1992. These same four guilds also increased on the Chippewa National Forest in 1993 (Montgomery et al. 1993). Ground nesters and canopy nesters increased significantly on the Chequamegon National Forest in 1993, but shrub and cavity nesters declined (also significantly) (Hawrot et al. 1993).

Indicator species. Although there was an increase in 1993 in the numbers of Pine Warblers and Brown Creepers recorded on the Forest, no significant differences in abundance were detected over the course of the monitoring program. Significant differences among years were recorded on the Chippewa National Forest, however. Both the Pine Warbler and the Brown Creeper declined there from 1991 to 1992, and increased from 1992 to 1993 (Montgomery et al. 1993). On the Chequamegon National Forest, both species declined from 1992 to 1993, but not significantly (Hawrot et al. 1993).

Differences in numbers of Scarlet Tanagers recorded on the Forest were significant among years. The Scarlet Tanager increased in abundance from 1991 to 1992, but declined from 1992 to 1993. It also increased on the Chippewa National Forest in 1992, and declined in 1993, but the differences were not significant (Montgomery et al. 1993). A slight, but not significant, decrease was recorded in 1993 on the Chequamegon National Forest as well (Hawrot et al. 1993). Numbers of Swainson's Thrush declined on the Superior National Forest in both 1992 and 1993, but the

declines were not significant. It increased slightly, but not significantly, on both the Superior and Chequamegon National Forests (Montgomery et al. 1993, Hawrot et al. 1993). Again, it is difficult to interpret these changes based on trends from three years of data.

Power of statistical analyses. Percent difference detectable for individual species is dependent primarily on the relative abundance of the species on the Forest. For example, the Red-eyed Vireo, Nashville Warbler, Ovenbird, and White-throated Sparrow are the most abundant birds on the Forest, and we were able to detect a 10% change in abundance between years for these species. These species also occur over a wide range of habitat types. A 25% difference was detectable for a variety of species including woodpeckers (1), flycatchers (1), nuthatches (1), warblers (10), sparrows (1), thrushes (3), grosbeaks (1), kinglets (1), creepers (1), and wrens (1). The power of statistical analyses for detecting differences in abundance decreases for less common species like the Gray Jay (100% change), and it is not realistic to detect differences for species that are observed on only a few stands. It is possible to detect a 25% change for about one fourth of the species that we have observed on our point counts with two years of monitoring data (see Hanowski and Niemi 1993 for further description of power analyses). Although the power of statistical analyses was not recalculated using three years of monitoring data, an increase in the power to detect annual differences would be expected with the addition of another year of data.

Summary. A habitat specific bird monitoring program was established on the Superior National Forest in 1991. The program was designed to assess annual changes in bird abundance, and to attribute changes in numbers to habitat changes on the forest, or to natural fluctuations in bird numbers. Data collected from 1991 to 1993 have provided information on annual variation among guilds and individual species, and on relative densities of species within representative cover types on the Forest. The next step is to link habitat data and forest type to determine critical habitat needs on a species specific basis. This information can be used to aid forest management by providing information to establish harvesting and regenerating guidelines for individual forest cover types. Based on previous power analyses, we feel that a sufficient sample size is in place to detect a magnitude of difference in abundance adequate for most forest songbirds, including many neotropical migrants.

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Appendix I. Mean and standard error for number of birds/stand observed on the Superior National Forest from 1991 to 1993. P-values are shown for species that were tested for significant change over time.

	1991		1992		1993		
	Mean	SE	Mean	SE	Mean	SE	P-value
Total individuals	30.21	0.66	28.36	0.73	34.67	0.71	0.0000
Total number species	13.25	0.31	12.41	0.33	15.45	0.31	0.0000
Common Loon			0.01	0.01			
American Bittern			0.01	0.01	0.03	0.02	
Great Blue Heron					0.01	0.01	
Wood Duck	0.01	0.01					
Blue-winged Teal					0.01	0.01	
Broad-winged Hawk	0.03	0.01	0.02	0.01	0.02	0.01	
American Kestrel					0.01	0.01	
Spruce Grouse			0.01	0.01			
Ruffed Grouse	0.16	0.04	0.16	0.04	0.18	0.04	0.9075
Sora			0.01	0.01			
Common Snipe	0.01	0.01	0.01	0.01	0.01	0.01	
American Woodcock			0.01	0.01			
Black-billed Cuckoo	0.02	0.01	0.08	0.03	0.01	0.01	
Yellow-billed Cuckoo	0.01	0.01					
Barred Owl			0.01	0.01			
Great Gray Owl	0.01	0.01					
Boreal Owl	0.01	0.01					
Northern Saw-whet Owl	0.01	0.01					
Common Nighthawk			0.01	0.01	0.02	0.01	
Ruby-throated Hummingbird	0.01	0.01	0.04	0.02	0.04	0.02	
Belted Kingfisher	0.01	0.01	0.01	0.01			
Yellow-bellied Sapsucker	0.24	0.04	0.29	0.05	0.32	0.04	0.1639
Downy Woodpecker	0.03	0.02	0.06	0.02	0.05	0.02	0.4733
Hairy Woodpecker	0.11	0.03	0.09	0.03	0.05	0.02	0.1457
Northern Flicker	0.08	0.02	0.12	0.03	0.16	0.03	0.0741
Pileated Woodpecker	0.05	0.02	0.04	0.02	0.05	0.02	0.8463
Olive-sided Flycatcher	0.09	0.03	0.06	0.03	0.03	0.01	0.1239
Eastern Wood-Pewee	0.27	0.06	0.20	0.06	0.16	0.05	0.0603
Yellow-bellied Flycatcher	0.21	0.05	0.46	0.07	0.75	0.09	0.0000
Alder Flycatcher	0.19	0.05	0.20	0.05	0.19	0.05	0.9911
Least Flycatcher	0.66	0.11	0.60	0.12	0.69	0.11	0.0331
Eastern Phoebe	0.01	0.01	0.01	0.01			
Great Crested Flycatcher	0.02	0.01	0.05	0.02	0.05	0.02	

Appendix I. continued.

	1991		1992		1993		
	Mean	SE	Mean	SE	Mean	SE	P-value
Eastern Kingbird	0.01	0.01	0.02	0.01	0.03	0.02	
Tree Swallow					0.01	0.01	
Gray Jay	0.07	0.02	0.06	0.02	0.25	0.05	0.0020
Blue Jay	0.25	0.04	0.35	0.05	0.39	0.06	0.1733
American Crow			0.01	0.01	0.01	0.01	
Common Raven	0.01	0.01	0.03	0.02	0.01	0.01	
Black-capped Chickadee	0.11	0.03	0.13	0.03	0.38	0.06	0.0001
Boreal Chickadee	0.01	0.01			0.01	0.01	
Red-breasted Nuthatch	0.21	0.04	0.12	0.04	0.40	0.06	0.0001
White-breasted Nuthatch			0.06	0.02	0.03	0.02	
Brown Creeper	0.11	0.03	0.15	0.03	0.17	0.04	0.4926
House Wren	0.01	0.01	0.01	0.01	0.01	0.01	
Winter Wren	0.49	0.06	0.61	0.08	0.83	0.09	0.0021
Sedge Wren	0.03	0.02	0.01	0.01	0.01	0.01	
Marsh Wren			0.01	0.01			
Golden-crowned Kinglet	0.24	0.04	0.26	0.06	0.31	0.05	0.4300
Ruby-crowned Kinglet	0.06	0.02	0.05	0.02	0.15	0.04	0.0465
Eastern Bluebird	0.01	0.01					
Veery	1.69	0.15	1.03	0.11	1.39	0.12	0.0000
Gray-cheeked Thrush					0.01	0.01	
Swainson's Thrush	0.25	0.05	0.20	0.05	0.13	0.03	0.2198
Hermit Thrush	0.43	0.07	0.35	0.06	0.44	0.06	0.3989
Wood Thrush			0.02	0.01	0.01	0.01	
American Robin	0.66	0.08	0.45	0.06	0.64	0.08	0.0339
Gray Catbird			0.01	0.01			
Brown Thrasher			0.01	0.01	0.01	0.01	
Cedar Waxwing	0.06	0.02	0.26	0.06	0.11	0.04	0.0057
Solitary Vireo	0.04	0.02	0.06	0.02	0.19	0.04	0.0025
Yellow-throated Vireo			0.01	0.01	0.01	0.01	
Red-eyed Vireo	2.50	0.12	1.87	0.13	1.79	0.14	0.0000
Golden-winged Warbler	0.11	0.04	0.06	0.03	0.07	0.03	0.3255
Tennessee Warbler			0.03	0.02	0.54	0.10	0.0000
Nashville Warbler	2.59	0.17	2.63	0.19	3.38	0.20	0.0000
Northern Parula	0.32	0.05	0.25	0.05	0.49	0.07	0.0002

Appendix I. continued.

	1991		1992		1993		
	Mean	SE	Mean	SE	Mean	SE	P-value
Yellow Warbler	0.01	0.01	0.04	0.03	0.01	0.01	
Chestnut-sided Warbler	2.30	0.17	2.01	0.17	2.50	0.23	0.0769
Magnolia Warbler	0.54	0.07	0.47	0.07	1.00	0.10	0.0000
Cape May Warbler	0.01	0.01	0.06	0.02	0.10	0.03	0.0015
Black-throated Blue Warbler	0.03	0.02	0.08	0.03	0.06	0.03	0.1304
Yellow-rumped Warbler	0.28	0.06	0.13	0.04	0.32	0.06	0.0026
Black-throated Green Warbler	0.60	0.08	0.68	0.10	0.99	0.11	0.0004
Blackburnian Warbler	0.77	0.09	0.58	0.08	0.85	0.10	0.0122
Pine Warbler	0.06	0.02	0.03	0.01	0.05	0.02	
Palm Warbler			0.01	0.01	0.04	0.02	
Bay-breasted Warbler			0.01	0.01			
Black-and-white Warbler	0.97	0.08	0.63	0.07	0.92	0.07	0.0007
American Redstart	0.09	0.03	0.47	0.08	0.44	0.07	0.0000
Ovenbird	4.03	0.20	3.84	0.20	4.51	0.22	0.0010
Northern Waterthrush			0.04	0.02	0.11	0.03	0.0014
Connecticut Warbler	0.07	0.03	0.05	0.03	0.08	0.04	
Mourning Warbler	1.28	0.11	1.01	0.12	0.93	0.10	0.0133
Common Yellowthroat	0.48	0.08	0.31	0.06	0.46	0.09	0.0800
Wilson's Warbler					0.01	0.01	
Canada Warbler	0.67	0.08	0.74	0.09	0.72	0.09	0.8818
Scarlet Tanager	0.09	0.02	0.25	0.05	0.18	0.04	0.0085
Rose-breasted Grosbeak	0.41	0.06	0.46	0.07	0.77	0.09	0.0001
Indigo Bunting	0.04	0.03			0.01	0.01	
Chipping Sparrow	0.30	0.05	0.30	0.05	0.29	0.05	0.9957
Vesper Sparrow					0.01	0.01	
Song Sparrow	0.30	0.07	0.27	0.06	0.30	0.06	0.4813
Lincoln's Sparrow	0.04	0.02	0.03	0.02	0.05	0.02	
Swamp Sparrow	0.07	0.02	0.04	0.02	0.13	0.04	0.0678
White-throated Sparrow	2.41	0.15	1.92	0.15	2.18	0.16	0.0034
Dark-eyed Junco	0.01	0.01	0.03	0.02			
Red-winged blackbird	0.09	0.03	0.03	0.01	0.04	0.02	
Rusty Blackbird			0.03	0.03			
Brewer's Blackbird					0.03	0.02	
Common Grackle			0.03	0.02	0.01	0.01	
Brown-headed Cowbird	0.06	0.02	0.02	0.01	0.01	0.01	

Appendix I. continued.

	1991		1992		1993		
	Mean	SE	Mean	SE	Mean	SE	P-value
Northern Oriole	0.01	0.01			0.01	0.01	
Purple Finch	0.09	0.02	0.05	0.02	0.12	0.03	0.1311
Pine Siskin					0.06	0.02	
American Goldfinch	0.02	0.01	0.01	0.01	0.03	0.02	
Evening Grosbeak	0.09	0.04	0.06	0.02	0.18	0.05	0.1044
Unidentified non-passerine	0.92	0.08	1.22	0.11	0.77	0.09	
Unidentified sparrow			0.01	0.01			
Unidentified thrush			0.01	0.01	0.01	0.01	
Unidentified woodpecker	0.57	0.07	0.23	0.05	0.36	0.06	
Unidentified vireo			0.02	0.01			
Unidentified warbler			0.47	0.10	0.01	0.01	
Unidentified passerine			0.02	0.01			

Appendix II. Mean and standard error for number of birds/stand for guilds on the Superior National Forest from 1991 to 1993. P-values are shown for those guilds tested for significant change over time.

	1991		1992		1993		
	Mean	SE	Mean	SE	Mean	SE	P-value
Forage							
Aquatic vertebrates	0.01	0.01	0.03	0.02	0.04	0.02	
Predator	0.04	0.02	0.03	0.01	0.03	0.01	
Vegetation	0.16	0.04	0.17	0.04	0.18	0.04	
Omnivores	0.33	0.05	0.48	0.07	0.66	0.09	0.0045
Ground invert, ins & fruit	3.10	0.18	2.20	0.15	2.79	0.17	0.0000
Seeds	0.11	0.03	0.06	0.02	0.15	0.04	0.0930
Ground insects and seeds	3.30	0.22	2.68	0.21	3.03	0.23	0.0028
Foliage insects & fruit	18.16	0.41	16.85	0.47	21.88	0.46	0.0000
Aerial insects			0.01	0.01	0.03	0.02	
Flycatchers	1.57	0.16	2.07	0.18	2.34	0.17	0.0000
Fruit	0.06	0.02	0.26	0.06	0.11	0.04	0.0057
Foliage insects & seeds	0.13	0.05	0.06	0.02	0.25	0.05	0.0033
Bark insects	1.48	0.11	1.15	0.09	1.68	0.11	0.0000
Nectar and sap	0.25	0.04	0.33	0.05	0.36	0.05	0.0708
Aquatic vegetation	0.01	0.01			0.01	0.01	
Aquatic invertebrates	0.01	0.01	0.01	0.01	0.01	0.01	
Habitat							
Deciduous	10.51	0.40	9.63	0.40	11.10	0.44	0.0005
Coniferous	2.53	0.19	2.10	0.19	3.72	0.25	0.0000
Mixed decid-conifers	3.16	0.18	2.74	0.19	3.56	0.20	0.0001
Early successional	6.30	0.35	5.57	0.34	6.16	0.38	0.1294
Fields & meadows	1.19	0.14	0.92	0.12	1.25	0.15	0.0138
Shrub swamp	0.75	0.11	0.61	0.12	0.83	0.13	0.1138
Urban	0.01	0.01	0.01	0.01	0.01	0.01	
Open wetlands	0.12	0.03	0.06	0.02	0.05	0.02	
Ponds,lakes,rivers,&stream	0.09	0.03	0.40	0.07	0.28	0.05	0.0000
Lowland coniferous	4.06	0.22	4.35	0.30	6.55	0.33	0.0000
Migration							
Permanent	1.18	0.10	1.45	0.13	2.15	0.17	0.0001
Short-distance	6.08	0.31	5.27	0.29	6.61	0.35	0.0000
Long-distance	21.47	0.49	19.67	0.59	24.77	0.55	0.0000

Appendix II. continued.

	1991		1992		1993		
	Mean	SE	Mean	SE	Mean	SE	P-value
Nests							
Ground	14.52	0.40	12.94	0.42	16.43	0.44	0.0000
Canopy or canopy vegetatio	7.81	0.31	7.29	0.32	9.34	0.35	0.0000
Subcanopy or shrub	5.33	0.32	5.00	0.31	6.04	0.37	0.0038
Cavity, hole or bank	1.57	0.13	1.35	0.12	2.06	0.16	0.0002
Ledge or platform	0.01	0.01	0.01	0.01			
Nest parasite	0.06	0.02	0.02	0.01	0.01	0.01	

Appendix III. Relative abundance of birds in nine habitat types in the Superior National Forest. Values for circle sizes (see legend) were determined from 1991, 1992 and 1993 counts (mean values). Habitat type are regenerating (regen), semi-open lowland conifer (SO Low Con), closed canopy lowland conifer (CC Low Con), and young and old pine, mixed, and deciduous. Young includes pole-sized and old, saw-sized stands.

	Regen	SO Low Con	CC Low Con	Yng Pine	Old Pine	Yng Mix	Old Mix	Yng Decid	Old Decid
Common Loon								·	
American Bittern	·								
Great Blue Heron	·							·	
Wood Duck								·	
Blue-winged Teal								·	
Broad-winged Hawk					·	·		·	
Spruce Grouse	·								
Ruffed Grouse	●	●	●	●	·	●	●	●	●
Sora				·					
Common Snipe	·								
American Woodcock					·				
Black-billed Cuckoo	·			·		·	·	·	
Yellow-billed Cuckoo	·								
Barred Owl					·				
Great Gray Owl									·
Boreal Owl									·
Northern Saw-whet Owl	·								
Common Nighthawk	·								
Ruby-throated Hummingbird	·				·	·		·	·
Belted Kingfisher	·							·	

Mean number birds/stand · - 0.01 - 0.0 • - 0.05 - 0.10 • - 0.11 - 0.24 ● - 0.25 - 0.64 ● - > 0.64

	Regen	SO Low Con	CC Low Con	Yng Pine	Old Pine	Yng Mix	Old Mix	Yng Decid	Old Decid
Yellow-bellied Sapsucker	●	●	●	•	●	●	●	●	●
Downy Woodpecker	•	●	•		•	•		•	•
Hairy Woodpecker	●		•	•	●	•		•	•
Northern Flicker	●	•	•	•	•	•	•	●	•
Pileated Woodpecker	•			•	•	•	•	•	•
Olive-sided Flycatcher	●	●			•	•	•	•	•
Eastern Wood-Pewee	•				●			●	●
Yellow-bellied Flycatcher	●	●	●	●	●	●	●	•	●
Alder Flycatcher	●	●	•	•	•	•		•	•
Least Flycatcher	●	●	●	●	●	●	●	●	●
Eastern Phoebe	•							•	•
Great Crested Flycatcher	•	•				•	•	•	•
Eastern Kingbird	•				•			•	•
Tree Swallow	•							•	
Gray Jay	●	●	•	•	●	•	•	●	•
Blue Jay	●	●	•	●	●	●	●	●	●
American Crow								•	
Common Raven					•	•		•	•
Black-capped Chickadee	●	●	●		•	●	●	●	●
Boreal Chickadee		•	•						

	Regen	SO Low Con	CC Low Con	Yng Pine	Old Pine	Yng Mix	Old Mix	Yng Decid	Old Decid
Red-breasted Nuthatch	•	●	●	●	●	●	●	●	●
White-breasted Nuthatch				•	•		•	•	•
Brown Creeper		●	●	•	●	●	●	●	●
House Wren	•				•			•	
Winter Wren	●	●	●	●	●	●	●	●	●
Sedge Wren	•					•		•	•
Marsh Wren	•								
Golden-crowned Kinglet	•	●	●	●	●	●	●	●	•
Ruby-crowned Kinglet	•	●	●	●	●	•	•	•	•
Eastern Bluebird	•								
Veery	●	●	●	●	●	●	●	●	●
Gray-cheeked Thrush						•			
Swainson's Thrush	•	●	●	●	●	●	●	●	●
Hermit Thrush	●	●	●	●	●	●	●	●	●
Wood Thrush		•							•
American Robin	●	●	●	●	●	●	●	●	●
Gray Catbird								•	
Brown Thrasher	•						•		
Cedar Waxwing	●	●	•	•	●	●	•	•	●

	Regen	SO Low Con	CC Low Con	Yng Pine	Old Pine	Yng Mix	Old Mix	Yng Decid	Old Decid
Solitary Vireo	·	●	●	●	●	·	·	·	·
Yellow-throated Vireo	·								
Red-eyed Vireo	●	●	●	●	●	●	●	●	●
Golden-winged Warbler	●				·			·	·
Tennessee Warbler	●	●	●	·	·	●	●	·	·
Nashville Warbler	●	●	●	●	●	●	●	●	●
Northern Parula	●	●	●	●	●	●	●	●	●
Yellow Warbler	·					·		·	·
Chestnut-sided Warbler	●	●	●	●	●	●	●	●	●
Magnolia Warbler	●	●	●	●	●	●	●	●	●
Cape May Warbler		·	·	●		●	●	·	·
Black-throated Blue Warbler					·	·	●	·	·
Yellow-rumped Warbler	●	●	●	●	●	●	●	●	·
Black-throated Green Warbler	●	●	●	●	●	●	●	●	●
Blackburnian Warbler	·	●	●	●	●	●	●	●	●
Pine Warbler	·				●	·			·
Palm Warbler	·				·	·			
Bay-breasted Warbler		·							

	Regen	SO Low Con	CC Low Con	Yng Pine	Old Pine	Yng Mix	Old Mix	Yng Decid	Old Decid
Black-and-white Warbler	●	●	●	●	●	●	●	●	●
American Redstart	●	●	●	●	●	●	●	●	●
Ovenbird	●	●	●	●	●	●	●	●	●
Northern Waterthrush	·	●	●	·	·	·	·	·	·
Connecticut Warbler	·	●			●	·	·		·
Mourning Warbler	●	●	·	●	●	●	●	●	●
Common Yellowthroat	●	●	·	●	●	●	●	●	●
Wilson's Warbler	·					·			
Canada Warbler	●	●	●	●	●	●	●	●	●
Scarlet Tanager	·	·	●	●	●	●	●	●	●
Rose-breasted Grosbeak	●	●	·	●	●	●	●	●	●
Indigo Bunting					·				·
Chipping Sparrow	●	●	·	●	●	·	●	●	●
Vesper Sparrow	·								
Song Sparrow	●	·	·	·	·	·		●	●
Lincoln's Sparrow	·	●		·		·		·	
Swamp Sparrow	●	·	·	·	·	●	·	·	
White-throated Sparrow	●	●	●	●	●	●	●	●	●

	Regen	SO Low Con	CC Low Con	Yng Pine	Old Pine	Yng Mix	Old Mix	Yng Decid	Old Decid
Dark-eyed Junco	·	·			·				
Red-winged blackbird	·			·	·			●	·
Common Grackle	·		·					·	
Brown-headed Cowbird	·							·	·
Northern Oriole							·		·
Purple Finch	·	·	●	●	·	●	·	·	·
Pine Siskin	·	●	·		·		·	·	
American Goldfinch	·		·						·
Evening Grosbeak	·	●	●	·	·	●	·	·	·

Mean number birds/stand · - 0.01 - 0.0 · - 0.05 - 0.10 • - 0.11 - 0.24 ● - 0.25 - 0.64 ● - > 0.64