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Ecology of Martens in Southeast Alaska

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FEDERAL AID
RESEARCH FINAL REPORT

PROJECT TITLE: Ecology of Martens in Southeast Alaska

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PROJECT NR: 7.16

WORK LOCATION: Southeast AlaskaSTATE: Alaska

PERIOD: 1 July 1990–30 June 2001

I. STATEMENT OF PROJECT NEED

Please reference the Project Statement

II. REVIEW OF PRIOR RESEARCH AND STUDIES IN PROGRESS

Please reference the Project Statement.

III. SUMMARY OF WORK COMPLETED ON JOBS IDENTIFIED IN ANNUAL PLAN DURING GRANT W-27-4, JULY 1, 2000—JUNE 30, 2001

JOB 1: HABITAT USE.

PROGRESS. Consulted with biometrician on alternative analysis methods. Updated GIS data files. Participated in discussions with personnel from other land management agencies on improving mapped habitats using other physiographic attributes.

JOB 9: SCIENTIFIC MEETING AND WORKSHOPS.

PROGRESS. None attended. Poor health prevented out-of-town travel.

JOB 10: REPORTS AND SCIENTIFIC PAPERS.

PROGRESS. Prepared or contributed to the following manuscripts: Flynn (2001); Flynn and Schumacher (2001); Schumacher et al. in review; Stone et al. in review; Flynn and Ben-David in prep.

IV. **SEGMENT COSTS:** $34.5

V. ADDITIONAL FEDERAL AID-FUNDED WORK NOT DESCRIBED ABOVE THAT WAS ACCOMPLISHED ON THIS PROJECT DURING THIS SEGMENT

None.

VI. CUMULATIVE PROGRESS ON PROJECT OBJECTIVES

OBJECTIVE 1. Determine seasonal habitat use and selection patterns of a sample of martens living in logged and unlogged landscapes. Habitat selection will be analyzed at the microsite, stand, and landscape level. Habitat use and selection observed during the winter season will be compared with summer.

PROGRESS. This objective was successfully completed and the results were previously reported (Flynn and Schumacher 1999*a*, Flynn and Schumacher 1999*b*, Schumacher 1999, Schumacher et al. In review). During the study, we captured 311 martens (197 males and 114 females) a total of 1971 times. Of the captured animals, we put radio collars on 183 individual martens (100 males and 83 females). The radiocollared martens were relocated 3422 times from small aircraft. On the primary study areas, we located 137 radiocollared martens (86 males and 51 females) 2978 times to determine habitat use at the stand and landscape levels. From 1994–1998, we located 29 dens (15 natal, 14 maternal) used by 13 individual female martens. We also located 52 resting sites (32 summer, 20 winter) used by 21 martens. These data provided information on microsite habitat use.

OBJECTIVE 2: Determine the composition of habitats within the northeast Chichagof Island study area.

PROGRESS. This objective was successfully completed and the results were previously reported (Flynn and Schumacher 1999*a*, Flynn and Schumacher 1999*b*). We obtained GIS coverages of all habitats available for northeast Chichagof Island. These coverages were edited to update clearcuts, logging roads, and correct stream locations. Because of problems with the accuracy of the USDA Forest Service's timber-type map, we used a landcover map developed from LANDSAT TM satellite imagery to delineate marten habitats. The size/structure type was developed to distinguish forest stands by their density of trees by size class and to separate stands with multistoried canopies from singlestoried. For the study, we field sampled 65 stratified, random locations and 67 sites centered on marten dens or resting sites. The data were analyzed and the results presented.

OBJECTIVE 3: Evaluate the interagency habitat capability model.

PROGRESS. Data for this objective were collected and analyses completed. For the Tongass Land Management Plan, a group of interagency biologists developed a habitat capability model for martens in Southeast. We investigated 3 approaches to modeling and evaluating habitat capability.

We worked with Dr. Winston Smith, USDA Forestry Sciences Lab, to incorporate a degree of spatial explicitness in the habitat capability model by including an adjacency factor. We also worked with Dr. Richard Schneider, University of Alberta, to adapt his spatially explicit marten population model (Schneider 1997) for our study area. Finally, we compared the habitat selection data collected during this study with the values in the original habitat capability model.

OBJECTIVE 4. Determine the demographic characteristics of marten populations on northeast Chichagof Island.

PROGRESS. This objective was successfully completed and the results were previously reported (Flynn 1993, Flynn and Schumacher 1994, Flynn and Schumacher 1995, Flynn and Schumacher 1996, Flynn and Schumacher 1997, Flynn and Schumacher 1999*a*, Flynn and Schumacher 1999*b*, Flynn and Schumacher 2000, Flynn and Schumacher 2001). We estimated marten abundance on a portion of northeast Chichagof Island, Southeast Alaska using mark-recapture methods in combination with radiotelemetry. The procedures also provided useful information on population sex and age structure. Although population numbers were small, we were able to obtain 13 useful abundance estimates during 1992–1998.

OBJECTIVE 5. Determine marten movement and spatial patterns on northeast Chichagof Island.

PROGRESS. The data for this objective was collected successfully and some of the results were previously reported (Flynn 1991, Flynn 1993, Hickey et al. 1999, Flynn and Schumacher 1999*a*). Altogether, we captured and tagged 311 martens (197 males and 114 females) on northeast Chichagof Island. Of these animals, we radiocollared 183 (100 males and 83 females) and relocated them 3422 times from small aircraft to study short-term and long-term movement patterns. Also, we retrieved 127 tags from animals that had been trapped or died from other causes. We modeled home range areas for resident adult females to examine spatial relationships.

OBJECTIVE 6. Determine the abundance of small mammal prey within the Chichagof Island study area.

PROGRESS. This objective was successfully completed and the results were previously reported (Flynn 1993, Flynn and Schumacher 1994, Flynn and Schumacher 1995, Flynn and Schumacher 1996, Flynn and Schumacher 1997, Flynn and Schumacher 1999*a*, Flynn and Schumacher 1999*b*). Each year since

1990, we have trapped permanent transects at Salt Lake Bay and/or Game Creek to monitor trends in small mammal numbers.

OBJECTIVE 7. Determine the winter diet of martens on northeast Chichagof Island.

PROGRESS. This objective was successfully completed and the results were published (Ben-David et al. 1997). We investigated seasonal and annual changes in diets of martens in response to the changing abundance of small rodents (*Peromyscus keeni*, and *Microtus longicaudus*) on Chichagof Island, Southeast Alaska, using stable isotope analysis. We hypothesized that martens would feed primarily on small rodents during years with high abundance of these prey species, whereas during years of low abundance of prey, martens would switch to feed primarily on the seasonally available carcasses of salmon.

OBJECTIVE 8. Evaluate whether the skull size criteria developed by Magoun et al. (1988) correctly classify southeast martens by sex and age.

PROGRESS. Substantial data for this objective were successfully collected and important results presented. Magoun et al. (1988) presented criteria to determine the sex and age class of marten carcasses based on measurements of skull length and the development of the temporal muscle. We measured skulls from 3119 marten carcasses and compared them with the criteria in Magoun et al. (1988).

VII. DISCUSSION OF METHODS AND FINDINGS BY OBJECTIVES

Objective 1. Determine seasonal habitat use and selection patterns of a sample of martens living in logged and unlogged landscapes. Habitat selection will be analyzed at the microsite, stand, and landscape level. Habitat use and selection observed during the winter season will be compared with summer.

During the study, we captured 311 martens (197 males and 114 females) a total of 1971 times. Of the captured animals, we put radio collars on 183 individual martens (100 males and 83 females). The radiocollared martens were relocated 3422 times from small aircraft. On the primary study areas, we located 137 radiocollared martens (86 males and 51 females) 2978 times to determine habitat use at the stand and landscape levels. During 1994–1998, we located 29 dens (15 natal, 14 maternal) used by 13 individual female martens. We also located 52 resting sites (32 summer, 20 winter) used by 21 martens. These data provided information on microsite habitat use.

Natal dens usually were in cavities within the boles of trees or snags or inside hard logs. Maternal dens most often were in cavities beneath the roots of trees or snags or inside hard logs. Natal and maternal dens differed in the types of structures used and the height of the den chamber above ground. Seven of 15 natal dens were in elevated sites within the boles of trees or snags. Only 3 natal dens were in root cavities, and a single marten used all of those dens. In contrast, 8 of 14 maternal dens were in root cavities. Hollow logs were used at 5 natal dens and 5 maternal dens. Mean height above ground was significantly higher at natal dens ($\bar{x}$ = 3.3 m) than at maternal dens ($\bar{x}$ = 0.4 m) (F = 7.98 df = 1,27, p = 0.01).

During summer, martens rested in root cavities at 11 of 32 sites and within the boles of trees, snags, or stumps at 10 sites. They also rested in hollow logs at 5 sites, and on 4 occasions adult males rested on the ground in dense vegetation exclusive of a woody structure. In winter, martens always rested inside a woody structure. Thirteen of 20 winter resting sites were in root cavities, but martens also used cavities within the boles of trees or snags at 6 sites. We never found martens resting in hollow logs during winter. Martens rested in similar structures year round but relied more heavily on root cavities during winter.

Martens used larger diameter and less decayed structures at dens than at resting sites. Such structures were much larger in diameter than like structures in the study area, and most contained a cavity caused by decay that was used by the marten. Martens exhibited little selection for habitat surrounding dens and resting sites.

On northeast Chichagof Island, martens primarily used forested habitats (82%). They made little use of shrub fields (7.5%), recent clearcuts (6.8%), or sparsely vegetated habitats (4.2%). Among forested habitats, the medium/MS (28.6%) habitat had the greatest use followed by large/MS (18.9%) and intermediate/MS (18.5%). Small/MS (12.4%) and singlestoried habitats (3.0%) had limited use. Based on radiotelemetry, martens showed the greatest selection for large/MS (selection ratio = 1.39) and medium/MS habitats (selection ratio = 1.30). The mean selection ratios of these 2 habitats were not significantly different from each other, but both were significantly greater than any other habitat. Intermediate/MS stands (1.11) were selected less than the larger-sized habitats, but more than small/MS (0.72), singlestoried (0.81), and nonforested sites (shrub = 0.20 and sparsely vegetated = 0.30). The largest difference in selection ratios was observed during the winter season. Habitats with larger-sized trees showed greater selection. For more details, see Flynn and Schumacher (1999*b*).

OBJECTIVE 2: Determine the composition of habitats within the northeast Chichagof Island study area.

We obtained GIS coverages of all habitats available for northeast Chichagof Island. These coverages were edited to update clearcuts, logging roads, and correct stream locations. Because of problems with the accuracy of the USDA Forest Service's timber-type map, we decided to use a landcover map developed from LANDSAT TM satellite imagery to delineate marten habitats. We chose the size/structure map developed from LANDSAT TM imagery by Pacific Meridian Resources to define marten habitats. We selected the size/structure map for the analysis and further evaluation because we believed this map best represented the structural features of the forest. The size/structure type was developed to distinguish forest stands by their density of trees by size class and to separate stands with multistoried canopies from singlestoried. For the study, we field sampled 65 stratified, random locations and 67 sites centered on marten dens or resting sites. Because of the selection criteria, each random polygon contained only 1 type of size/structure pixel. However, the marten den/rest sites always contained several pixel types (2 to 7). For 65 random sites, the field label exactly matched the map label 55 times (85%). For only forest strata, the exact match was 78% (32 of 41). In each of the mismatches, the labels differed by only 1 size class. We found the poorest accuracy within the medium/MS (exact = 63%) and intermediate/MS (exact = 67%) strata. These strata appeared to be the most variable and difficult to map accurately. Additional plots are needed in these types to better determine whether they are "good" landcover types. The nonforest and small/MS strata were nearly 100% accurate. The LANDSAT TM procedures appeared to map these types well. Our data indicated that mapping procedures used for the LANDSAT TM pilot project mapped larger (>1.2 ha), homogenous areas more accurately than heterogeneous areas. In addition, the polygon labeling rules for mixed-pixel areas need additional evaluation.

We considered the mean numbers of trees and snags per plot by size class as a measure of habitat structure. We did not separate the trees by species or report live trees and snags separately. Other habitat attributes were measured (i.e., stumps, logs and understory. These forest attributes all contribute to habitat quality for old-growth associated species. The means for the tree-class variables by landcover strata for the random sites were similar with the den/rest (*t*-tests, alpha = 0.05). Consequently, we combined the random and marten den/rest sites for the remainder of the analyses. The landcover strata were significantly different for tree-class variables (ANOVA, alpha = 0.05). Because of the numerous comparisons, we summarized the landcover strata that differed by tree-class variable. Generally, large/MS sites had more large trees and fewer intermediate and small trees. Medium/MS sites were well stocked with many trees of all size classes. Intermediate/MS sites were highly variable. Some sites had clumps of larger trees mixed with intermediate and small trees. Some intermediate/MS sites had only intermediate and smaller trees. Also, several of the intermediate/MS sites were misclassified; these sites added substantial variance to data for this stratum. Small/MS sites had few large trees and numerous small trees. Some of the differences were obvious. The nonforest stratum had few trees of any size and differed from most other forest strata for nearly all variables. The singlestoried sites we measured differed from all others because of the large number of intermediate and small trees present. Four of the singlestoried sites resulted from natural wind throw, three resulted from about 35-year-old clearcuts, and 1 was a misclassified small stand. The magnitude of the differences among means was large in some cases, but the differences were not statistically significant because of large variances or small sample sizes. The intermediate/MS strata was the most variable and not different from medium/MS or small/MS strata. The other multistory strata were different for at least 1 tree-class variable. Large/MS differed from medium/MS (fewer intermediate trees), Intermediate/MS (more large trees), and small/MS for 2 variables (more large trees, fewer small trees).

Medium/MS was also different from small/MS (more large and intermediate trees).

OBJECTIVE 3: Evaluate the interagency habitat capability model.

For the Tongass Land Management Plan, an interagency group of biologists developed a habitat capability model for martens in Southeast Alaska (Suring et al. 1993). The land managers envisioned that the habitat capability model would be used to evaluate effects of management alternatives on marten habitat. The initial model assigned relative values to landcover types based on best professional judgment (Suring et al. 1988). On the Tongass National Forest, the available mapped landcover types were derived from a timber-based classification. Timber-type classes were assumed to indicate degree of canopy closure, availability of snags, and presence of down and dead wood. The habitat capability model was revised slightly in 1995 (Flynn 1995) based on habitat selection data collected during the early phases of this study (Flynn 1991). Also, the definitions for the mapped habitat categories were changed. Subsequent to initial model development, the utility of the habitat capability model approach was questioned, primarily because habitat selection may not establish a cause-and-effect relationship with carrying capacity (DeGayner 1993). Also, the habitat capability model did not include spatially explicit relationships, and the input habitat map had accuracy problems.

Two other habitat-modeling approaches were investigated. We worked with Dr. Winston Smith, USDA Forestry Sciences Lab, to incorporate a degree of spatial explicitness in the habitat capability model by including an adjacency factor. A "moving window" weighted the habitat value for a cell by the composition of the surrounding cells. This approach assumed that the habitat value of a cell was influenced by the composition of the surrounding habitat. Several moving window sizes and compositional-spatial relationships were evaluated. We concluded that the mapped habitat had inadequate spatial accuracy to warrant a spatially explicit analysis at this time.

We also worked with Dr. Richard Schneider, University of Alberta, to adapt his spatially explicit marten population model (Schneider 1997) for our study area. The model used rules governing the behavior and physiology of individual martens. It incorporated demographic and environmental stochasticity. Spatial dynamics of the population were explicitly linked to a digital vegetation map. A model outcome was the probabilistic distribution of the population in the future depending on parameter values. We spent considerable time adapting the model to input digital vegetation maps for the study area. The model incorporated successional vegetative changes by inputting a new vegetation map after a set number of years. The model had many appealing attributes, but we felt that it needed additional refinements to adequately model marten populations on Chichagof Island. Also, we had difficulty converting the vegetative map data to a format required by the model.

The habitat selection data collected during this study were consistent with the values in the original habitat capability model. For this comparison, we took the computed habitat selection indices for all animals during the winter/spring season and scaled them to range from 0.0-1.0. To compute the selection indices, we used the landcover map derived from LANDSAT TM imagery (described above). Therefore, the habitat categories used to develop the selection indices were not an exact match with the habitat categories used in the habitat capability model derived from the USDA Forest Service's timber-type coverage. Thus, some error would be expected. We developed the following cross-reference between the mapped landcover categories: large/multistory = high timber strata, medium/multistory = medium timber strata, intermediate/multistory = low strata forest, small/multistory = unproductive forest, and shrub and sparsely vegetated = nonforest.

Generally, the 95% confidence intervals (CIs) for the observed marten selection indices overlapped with most of the values in the original model. The poorest fit was for the singlestoried category. The original model assigned a value of 0.1 to this habitat, but the observed scaled selection index was 0.49 (0.4–0.59). We suspect that the LANDSAT TM map included a wider range of singlestoried forest types than the original habitat model. Also, the original model gave no value to nonforest types, but these types had selection indices that did not include 0. We suspect that sometimes the martens used small patches of forest mapped as nonforest. In comparison to the modified model, habitat values for medium/MS, intermediate/MS, singlestoried, and clearcut habitats were outside of the 95% selection index CIs. We found no reasons to modify our earlier recommendations on beach zone and riparian habitats. The spatial resolution of our use data (100 m) did not allow adequate evaluation of riparian or beach zones. We suspect that riparian and beach habitats have no special value to martens beyond the intrinsic value of the vegetative cover. Also, our earlier recommendation on elevation in the habitat capability model appears valid. Only 5% of the radiotelemetry locations were above 880 m (1600 feet) in elevation, and about 32% of the locations were above 250 m. Thus, we recommended that the factor for elevations between 250–880 m be dropped from the marten habitat capability model for Southeast Alaska.

OBJECTIVE 4. Determine the demographic characteristics of marten populations on northeast Chichagof Island.

We estimated marten abundance on a portion of northeast Chichagof Island, Southeast Alaska using mark-recapture methods in combination with radiotelemetry. The procedures also provided useful information on population sex and age structure. Although population numbers were small, we were able to obtain 13 useful abundance estimates from 1992 to 1998 because of high recapture rates ($\bar{x}$ = 0.72). Poor weather hindered completion of some surveys. We found that marten numbers on the study area varied greatly over the period, ranging from a low of 12.5 martens in winter 1997 to a high of 45.4 during winter 1995. The annual trend was for decreasing numbers from summer 1991 to winter

1992, then increasing numbers to winter 1996. By winter 1997, numbers had dropped substantially and remained low through 1998. Marten numbers were always greater in the fall compared to the following winter, indicating mortality or emigration during the late fall/early winter period. Marten population numbers estimated by mark-recapture procedures were highly correlated with the total number of individuals captured during a 6-day trapping session. Thus, the total number of unique captures may provide a useful estimate of marten numbers without the expense of radiocollaring and tracking individuals. Sex ratios were lower at the beginning of the study, increased to a high during 1995–96, then decreased at the end of the study. Age structure showed a nearly opposite trend with mean age greater during the early and later surveys, but lowest from winter 1994 to fall 1995. We found that marten populations can be monitored successfully using mark-recapture procedures. Because of their high vulnerability to trapping, close monitoring of populations is important for sustained-yield management of the species.

Captured martens showed the expected sexual dimorphism with the mean mass of captured males 48.2% larger than females (% dimorphism), or a dimorphism ratio of 1.48 (male:female). The body mass of captured male martens averaged 1187 g (SD = 148) but varied from 880 to 1700 g. Females averaged 801 g (SD =93) but varied from 620 to 1000 g. Only 6.7% of the male captures overlapped with the range of female body masses, but 27.6% of the females overlapped with the male range. Thus, a few males (mostly juveniles) had very low body masses that greatly increased the lower range for males.

The average mass of juvenile females (777 g, SD = 88) was slightly smaller than adults (808 g, SD = 94; t = -2.12, df = 250, P =0.035). The average mass of juvenile males (1118g, SE = 10.9) was less compared to adults (1223 g, SE = 8.3) (t = -7.5, df = 447, P < 0.001). Juvenile males were significantly lighter in the summer/fall (1088 g, SE = 10.9) compared to the winter/spring (1205 g, SE = 8.3). By their first winter, juvenile males were similar in mass to adults (1205 to 1241 g, t = -1.5, df =148 P = 0.13). Juvenile females did not differ in mass between summer/fall (779 g) and winter/spring (774 g) (t = 0.203, df = 51 P = 0.84).

The body mass of some individual martens varied substantially among captures, often within a short time. The greatest range in mass for an individual male was 530 g and 270 g for a female. Adult martens showed sexual dimorphism with the mean mass of captured males 48.2% larger than females (% dimorphism). The body mass of captured male martens averaged 1187 g), varying from 880 to 1700 g. Females averaged 801 g, varying from 620 to 1000 g. The mean body mass of juvenile females (777 g) was only slightly less than adult females (808 g). Juvenile males were significantly lighter in the summer/fall (1088 g) compared to their body mass in winter/spring (1205 g). By their first winter, juvenile males were similar in mass to adults (1205 to 1241 g).

We used deviations from the body mass predicted by linear regressions between body mass and total body length as an index to body condition (BCI) in captured martens. First, the mean total length was computed for each animal with multiple captures. We assumed that individuals had reached their full length when first captured, and any subsequent differences in body length were attributed to measurement error. Because of strong sexual dimorphism, we computed regression equations for males and females separately (males: y = 2.6598x - 534.6, R^2 = 0.13; females: y = 2.002x -355.1, R^2 = 0.18). The residuals from the regression analyses ranged from -382 to 479 for males and -181 to 251 for females. In order to compare males and females, we scaled the residuals for each sex by dividing each by the largest value. Thus, we divided all the male residuals by 479 and the females by 251, resulting in a condition index for both sexes varying from -1 to 1.

For adults, mean body condition indices (BCIs) were lowest in fall and greatest in the summer for both males and females. In contrast, mean BCIs for juvenile males and females were lowest in the summer. For juvenile males, fall was the next lowest season and by winter/spring their values were similar to the adults. For juvenile females, mean BCIs were lower in the winter/spring and greatest in the fall. Mean BCIs varied significantly among years for adult males in the fall, adult males in the winter/spring, and adult females in the winter/spring. Adult martens consistently showed low body condition during 1991–1992 and 1996–1997, including fall and winter/spring seasons. Adult males were high in fall 1994–1995 and adult males and females were high in winter/spring 1997–1998. Adult females were also high in 1992–1993 winter/spring. Mean BCIs for juvenile males were always low and below zero in the fall ranging from a low of -0.32 in 1992–1993 to a high of -0.05 in 1994–1995.

Summer BCIs of females and rodent numbers explained 90% of the variation in marten fecundity. Marten fecundity was low during 1991–1992 and 1996–1997 (0.68 and 0.50 corpora lutea/adult female), years with low mean adult female BCI (0.07 and 0.22) and rodent numbers (5.3 and 8.6 captures/100 TN). Marten fecundity was near maximum in 1993–1994 and 1994–1995 (3.25 and 3.5 corpora lutea/adult female), years with high adult female mean BCI (0.45 and 0.51) and rodent numbers (9.1 and 26.0 captures/100 TN).

Beginning in fall 1992, we drew a 2- to 3-cc sample of blood from the jugular vein of most captured martens. We sent the clotted blood cells to Merav Ben-David, University of Alaska Fairbanks, for analysis of the stable isotopes of carbon (C) and nitrogen (N) (Ben-David et al. 1997). Serum samples were sent to Castelli's Lab, University of Alaska Fairbanks, to determine the levels of beta-hydroxybutyrate (BHBA), blood urea nitrogen (BUN), lactate, and glucose. We used discriminate function analyses to explore whether adult martens could be separated based on sex using these blood chemistry values. In the summer season, martens could be classified by sex based on only blood serum values (68% classification rate). Based on lower mean isotope values for N, female diets in the summer appeared at a lower tropic level than male diets. Female diets showed less individual variability (SDs of C and N larger for males). Also, females had lower BUN and higher lactate values.

Adult females in the fall were less different from adult males than during the summer. We observed the same trends, but the classification rate dropped to 57%. Fall females had lower mean C and N and BUN, but higher lactate. SDs for C and N were greater for males, indicating greater variability in diet. All females in the winter showed some difference from all males; there were similar trends for C & N but classification rate was at 68%. In winter all blood chemistry means were higher for males. Body condition index was not strongly correlated with other blood chemistry parameters. In winter, all blood chemistry means were higher for males. Body condition indices were not strongly correlated with any of the blood chemistry parameters.

We collected marten carcasses from trappers on Chichagof Island and northern Baranof Island to determine age structure and maximum fecundity. Corpora lutea counts indicated that age-specific fecundity rates differed by area and over time. Marten fecundity appears strongly influenced by female pregnancy rates and highly variable among areas and years (within the same area). Yearling female martens showed low fertility on all areas and years (0% to 20% pregnant). On northern Chichagof Island, the pregnancy rate of 2+-year-old females ranged from 36 to 88%. The mean number of corpora lutea per adult female (1+ year) ranged from 0.68 in 1991–92 to 3.47 in 1993–1994. The mean number of corpora lutea per pregnant female remained high for all years varying from 2.94 in 1991–1992 to 3.71 in 1993–1994. By monitoring the presence and number of corpora lutea in trapped females, recruitment for the next fall can be predicted.

Fecundity of adult females was estimated by the number of corpora lutea found in the ovaries of trapper-caught carcasses collected in the fall. We found that marten fecundity was positively correlated with the mean BCI of females in summer (r = 0.670, P = 0.05) and deer mouse numbers in the fall (r = 0.715, P = 0.036). Although fecundity was negatively correlated with marten numbers the previous winter (r = -0.431, P = 0.197), the correlation was not significant. In a multiple regression model, summer BCI of females and rodent numbers explained 90% of the variation in marten fecundity. Marten fecundity was low during 1991–1992 and 1996–1997 (0.68 and 0.50 corpora lutea/adult female), years with low mean adult female BCI (0.07 and 0.22) and rodent numbers (5.3 and 8.6 captures/100 TN). Marten fecundity was near maximum in 1993–1994 and 1994–1995 (3.25 and 3.5 corpora lutea/adult female), years with high adult female mean BCI (0.45 and 0.51) and rodent numbers (9.1 and 26.0 captures/100 TN).

Of the 310 tagged martens (196 males, 114 females), 176 (108 males, 68 females) were radiocollared and 134 (88 males, 46 females) were only eartagged. For martens captured on the Salt Lake Bay, we recorded 131 deaths (91 males, 40 females). Of these deaths, 100 (67 males, 33 females) had been radiocollared and 31 (24 males, 7 females) were only eartagged. We had 88 tagged martens (68 males, 20 females) reported as caught by trappers. Of the trapped animals, 61 martens had been radioed (46 males, 15 females) and 27 only eartagged (22 males, 5 females). Natural deaths were recorded for 34 martens (18 males, 16 females). These animals had all been radiocollared. We had 10 martens (6 males, 4 females) die from capture-related causes. Of these animals, 7 martens had gotten wet in the trap and probably died from exposure. Three martens fatally injured themselves while in the trap.

OBJECTIVE 5. Determine marten movement and spatial patterns on northeast Chichagof Island.

We captured and tagged 311 martens (197 males and 114 females) on northeast Chichagof Island. The 183 radiocollared martens (100 males and 83 females) were relocated 3422 times from small aircraft to study short-term and long-term movement patterns. Hickey et al. (1999) radiotracked 31 resident martens (18 males, 13 females) during the summer and fall to evaluate short-term movement patterns. We repeatedly located martens during aerial tracking sessions that lasted 1–36 h; we calculated 853 travel distances over 1–24 h.

No evidence was found to separate the travel data by males and females. Generally, distance traveled by martens increased as the time interval between locations increased. Given 0–1 h between locations, martens traveled 101–250 m most frequently and >95% of the movements were <1000 m. The combined median distance moved in 0–1 hours was 133 m, or a mean speed of 0.067 km/hr. Given 4–5 h to travel, martens moved a median of 501 m. For this time period, martens traveled 0 m, 1–100 m, 101–250 m, and 1501–2000 m in similar (0.10, 0.12, 0.12, and 0.10, respectively) proportions. Apparently, some martens rested for the entire period, some individuals rested for parts of the period, and some animals traveled for the entire period. Both males and females usually moved across their home ranges within a 24-hour period. Combining models of marten movements and passage rates of blueberry (*Vaccinium* spp.) seeds, martens were estimated to move 86% of ingested seeds >100 m and 56% >500 m. Some seeds (1%) would be moved about 3500 m.

Flynn (1991) found no differences between the mean maximum travel distances of 8 males (26.1 km) and 4 females (22.5 km) in 1990–91. For 122 known death locations, the mean minimum straight-line distance between original capture site and death locations was similar for males ($\bar{x}$ = 13.0 km, SE = 1.37) and females ($\bar{x}$ = 9.1 km, SE = 1.9). Although similar, the actual distances traveled were probably greater because martens seldom swim and the straight-line paths often crossed significant water bodies. For only trapped animals, the mean distance for males ($\bar{x}$ = 14.3 km, SE = 1.55) and females ($\bar{x}$ = 11.6 km, SE = 2.8) were also similar. Because most trapped animals were captured off the study area, the mean minimum distance traveled for trapped martens ($\bar{x}$ = 13.7 km, SE = 1.35) was significantly greater than for martens that died of natural causes ($\bar{x}$ = 7.1 km, SE = 1.7) (t = 2.67, df = 120, P = 0.009). In 1996 a female marten was trapped about 54 km away from her original capture location. The maximum distance for a male was 65 km. Thus, females appear capable of traveling similar distances as males.

We modeled home range areas for resident adult females using the 95% convex polygon approach. For this analysis, the locations for each resident adult female were grouped by biological year, and a separate home range was calculated for each animal-year combination with at least 10 locations (n = 36). These home ranges varied in size from 0.10 to 17.88 km^2 with a median size of 2.3 km^2. Within a year, female home ranges showed no overlap. Among years, home ranges for an individual female overlapped substantially.

OBJECTIVE 6. Determine the abundance of small mammal prey within the Chichagof Island study area.

Since 1990, we have trapped permanent transects at Salt Lake Bay and/or Game Creek to monitor trends in small mammal numbers. The catch rates for long-tailed voles (*Microtus longicaudus*) and Keen's deer mice (*Peromyscus keeni*) fluctuated greatly during the study. We captured only 3 tundra voles (*Microtus oeconomus*) during the study. These voles were caught opportunistically; none was captured on the transects. At Salt Lake Bay, vole captures ranged from 0 in 1992 and 1998 to 11.1 captures/100 trap nights in 1995. Deer mouse captures ranged from 1.6 captures/100 trap nights to a high of 18.9 in 1994. Although not perfectly correlated ($r = 0.55$), catch rates of voles and mice indicated a similar pattern in changing abundance. Also, catch rates among habitats and between study areas changed in a similar pattern. Rodent numbers were declining at the beginning of the study in 1990, declined to a low in fall 1992, increased to a high in fall 1994, and declined to a low in fall 1997.

Because rodent numbers, particularly vole numbers, changed sharply during the study, the availability of an important food for martens also changed dramatically over time.

OBJECTIVE 7. Determine the winter diet of martens on northeast Chichagof Island.

We investigated seasonal and annual changes in diets of martens in response to the changing abundance of small rodents (*Peromyscus keeni*, and *Microtus longicaudus*) on Chichagof Island, Southeast Alaska, using stable isotope analysis. We hypothesized that martens would feed primarily on small rodents during years with high abundance of these prey species, whereas during years of low abundance of prey, martens would switch to feed primarily on the seasonally available carcasses of salmon. We also hypothesized that home-range location on the landscape (i.e., access to salmon streams) would determine the type of food consumed by martens, and martens feeding on preferred prey would exhibit better body condition than those feeding on other foods. We live-captured 75 martens repeatedly from mid-February to mid-December 1992–1994. We also obtained marten carcasses from trappers during late autumn 1991 and 1992, from which we randomly subsampled 165 individuals. Using stable isotope ratios and a multiple source-mixing model, we inferred that salmon carcasses composed a large portion of the diet of martens in autumn during years of low abundance of rodents (1991 and 1992). When small rodents were available in high numbers (1993 and 1994), they composed the bulk of the diet of martens in autumn, despite salmon carcasses being equally available in all years. Selection for small rodents occurred only in seasons in which abundance of small rodents was low. Logistic regression revealed that individuals with access to salmon streams were more likely to incorporate salmon carcasses in their diet during years of low abundance of small rodents. Using stable isotope analysis on repeated samples from the same individuals, we explored some of the factors underlying feeding habits of individuals under variable ecological conditions. We were unable to demonstrate that body weights of live-captured male and female martens differed significantly between individuals feeding on marine-derived or terrestrial diets. Therefore, martens, as true generalist predators, switched to alternative prey when their principal food was not readily available on a seasonal or annual basis. Although salmon carcasses were not a preferred food for martens, they provided a suitable alternative to maintain body condition during years when small rodents were not readily available.

OBJECTIVE 8. Evaluate whether the skull size criteria developed by Magoun et al. (1988) correctly classifies southeast martens by sex and age.

Magoun et al. (1988) presented criteria to determine the sex and age class of marten carcasses based on measurements of skull length and the development of the temporal muscle. We measured skulls from 3119 marten carcasses. These measurements were made by a number of project staff, volunteers, and cooperators. Similar to Magoun et al. (1988), we could distinguish males from females using total skull length (males $\bar{x}$ = 85.3 mm, females $\bar{x}$ = 76.9 mm, t = 94.9, df = 2909, $P < 0.001$). A discriminant function, computed using skull length and zygomatic width, correctly classified 96.7% of the martens into the correct sex category.

For 2998 skulls, we extracted teeth and obtained cementum ages. Although not perfect, we considered cementum age as the most accurate method to determine an animal's true age. In terms of age class, we found the procedures of Magoun et al. (1988) adequate to distinguish age classes in Southeast Alaska for management purposes. For males classified as juvenile, we found 97% with a matching cementum age. For males classified as adult, 82.4% had cementum ages of 1 or greater. For females, the procedures provided a weaker match with cementum ages. For females classified as juvenile, we found 91.6% with a matching cementum age. For females classified as adult, 71.7% had cementum ages of 1 or greater. Marten cementum-aged as juveniles (age = 0) were sometimes misclassified as adults (males = 20.4%, females = 27.4%). Martens cementum-aged as adults (age = 1^+) were seldom classified as juveniles (males = 2.5%, females = 8.7%).

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VIII. MANAGEMENT IMPLICATIONS OF FINDINGS

This research project gathered substantial data on several aspects of marten ecology in Southeast Alaska. Information collected ranged from habitat relationships to demographics to diet. Because of the extensiveness of the research, the project took longer to complete than originally projected. Also, the amount of resources needed to complete the project's tasks was underestimated. In a dynamic environment, short-term studies may lead to inaccurate conclusions about systems. Marten populations fluctuated greatly during the study. Habitat relationships could not be understood in the absence of demographic data. A complex project takes time and resources. Only a longer-term study provided adequate insight for an understanding of marten ecology on Chichagof Island.

Through the collaboration of cooperators, the amount and quality of information was greatly enhanced. Four graduate students (2 MS and 2 Ph.D.) contributed to the research and produced thesis. The fieldwork was greatly facilitated by the assistance of US Forest Service staff, especially personnel on the Hoonah Ranger District. Many persons contributed specimens, provided laboratory analyses, or assisted with other aspects of the project. Without the assistance of these other parties, the research would have been less successful.

The scope of the project limited fieldwork to 1 geographic location - northeast Chichagof Island. Because of the biography of Southeast Alaska, each major island has a unique assemblage of flora and fauna. The results from this research were influenced by the environmental characteristics of Chichagof Island during the period of study. In particular, small mammal abundance was limited to a few species. Because small mammals form an important part of marten diets, their availability has a major effect on marten ecology. Thus, we recommend that similar demographic studies be done on other geographic regions of Southeast Alaska. In particular, Prince of Wales, Kuiu, Admiralty, and Wrangell island represent major land areas with unique assemblages of potential prey.

Marten remain a major issue for the primary land manager in the region - the US Forest Service. In the current land management plan, the conservation strategy for terrestrial wildlife was strongly influenced by the habitat requirements of martens. Several management standards and guidelines were incorporated to mitigate the negative effects of timber harvest on marten populations. The effectiveness of these management practices, including the conservation strategy and additional standards, needs evaluation. Because a major furbearing animal and greatly impacted by timber harvest, martens will remain a management issue in Southeast Alaska into the near future.

IX. Federal Aid Cumulative Project Costs

Multiyear Project Costs: $1047.3

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