Alaska Department of Fish and Game
Division of Wildlife Conservation
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Preparation of Manuscripts on Marten Ecology in Southeast Alaska

Rodney W. Flynn

Research Final Performance Report
1 July 2002–30 June 2004
Federal Aid in Wildlife Restoration
W-27-5 and W-33-2
Study 7.20

FEDERAL AID
FINAL RESEARCH REPORT

ALASKA DEPARTMENT OF FISH AND GAME
DIVISION OF WILDLIFE CONSERVATION
PO Box 25526
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PROJECT TITLE: Preparation of manuscripts on marten ecology in Southeast Alaska.

PRINCIPAL INVESTIGATOR: Rodney W. Flynn

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FEDERAL AID GRANT PROGRAM: Wildlife Restoration

GRANT AND SEGMENT NR: W-27-5 and W-33-2

PROJECT NUMBER: 7.20

WORK LOCATION: Douglas

STATE: Alaska

PERIOD: 1 July 2002–30 June 2004

I. PROBLEM OR NEED THAT PROMPTED THIS RESEARCH

A large amount of information had been collected on marten ecology in Southeast Alaska during previous studies. Much of this information had not been published and additional analyses were desirable.

II. REVIEW OF PRIOR RESEARCH AND STUDIES IN PROGRESS ON THE PROBLEM OR NEED

The data used in the project was collected during research completed from 1990 through 2001 (see Federal Aid in Wildlife Restoration Projects W-23-4, W-24-1, W-24-2, W-24-3, W-24-4, W-24-5, W-24-6, W-27-2, W-27-3, Job 7.16. and Appendices). Previous research focused on marten habitat selection and factors affection population dynamics. We live-trapped, collared and radiotracked martens to obtain data on macro- and micro-site habitat use. Habitat conditions were determined to provide a measure of habitat availabilities and structural characteristics. Through repeated live-trapping and mark-recapture analysis, we annually estimated marten abundance. Marten carcasses from trappers were evaluated for age, sex, body condition, and reproductive status. We determine marten diets and food selection using stable isotope analysis. We compared marten population demographics with diets and prey abundance.

III. APPROACHES USED AND FINDINGS RELATED TO THE OBJECTIVES AND TO PROBLEM OR NEED

OBJECTIVE 1: Analyze previously collected data on marten ecology.

New approaches and analyses recommended by peer reviewers were incorporated into the analyses of previously collected data. (See Appendices A-F).

OBJECTIVE 2: Prepare manuscript on marten habitat relationships.

Manuscript on marten denning and resting structures was revised based on peer comments. New multivariate analyses were incorporated and the revised manuscript was submitted for publication. A draft manuscript on marten macro-scale habitat selection was completed and prepared for review. (See Appendices A-B).

OBJECTIVE 3: Prepare manuscript on factors affecting marten abundance.

Four manuscripts were prepared and revised several times based on peer review comments. Additional analyses were completed and incorporated into the manuscripts. These manuscripts have been to peers for review. (See Appendices C-F).

IV. MANAGEMENT IMPLICATIONS

For each manuscript, the discussion or management implications sections have been attached.

V. SUMMARY OF WORK COMPLETED ON JOBS IDENTIFIED IN ANNUAL PLAN FOR LAST SEGMENT PERIOD ONLY

JOB 1: Additional analyses on previously collected data on marten ecology were completed. Also, new approaches and analyses recommended by peer reviewers were incorporated. (See Appendices A-F).

JOB 2: Manuscript on marten denning and resting structures was revised based on peer comments. New multivariate analyses were incorporated and the revised manuscript was submitted to a journal. A draft manuscript on marten macro-scale habitat selection was completed and prepared for review. (See Appendices A-B).

JOB 3: Four manuscripts on factors affecting marten abundance were prepared and revised several times based on peer review comments. Additional analyses were completed and incorporated into the manuscripts. These manuscripts have been sent to peers for review. (See Appendices C-F).

VI. ADDITIONAL FEDERAL AID-FUNDED WORK NOT DESCRIBED ABOVE THAT WAS ACCOMPLISHED ON THIS PROJECT DURING THE LAST SEGMENT PERIOD, IF NOT REPORTED PREVIOUSLY

None

VII. PUBLICATIONS

See Appendix F for a complete list of publications and reports regarding marten ecology by the authors since 1991.

VIII. RESEARCH EVALUATION AND RECOMMENDATIONS

The manuscripts will need additional revision based on peer comments. Each manuscript made recommendations on future research needs.

IX. PROJECT COSTS FROM LAST SEGMENT PERIOD ONLY

FEDERAL AID SHARE $46,904 STATE SHARE $15,635 = TOTAL $62,539

X. APPENDIX

XI. PREPARED BY:

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APPENDIX A

Selection of Denning and Resting Structures by American Martens in Southeast Alaska

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Abstract: To learn about which attributes influence selection of forest structures used by American martens (*Martes americana*), we studied woody structures used as reproductive dens and resting sites in partially logged temperate rainforest in Southeast Alaska. We investigated how denning structures differed from resting structures and used logistic regression to evaluate attributes that influenced selection of structures relative to their availability. Natal dens usually were within the boles of trees or snags, or inside hard logs. Maternal dens usually were in cavities beneath the roots of trees or snags, or inside hard logs. In summer and winter martens most often rested in root cavities. Structures used as dens were larger in diameter than resting structures, and dead wood used for denning was less decayed than dead wood used for resting. The probability of martens using live trees as dens increased with diameter and the presence of holes in the bole. The probability of structures being used for resting increased with diameter for trees, stumps, and with advanced stages of decay for snags and stumps. Our findings suggest that continually recruiting old, large-diameter woody structures is important for maintaining martens in managed forests.

MANAGEMENT IMPLICATIONS

The structures selected by martens for denning and resting commonly develop during late successional stages, likely in trees over 200 years of age. We found selection for these attributes even in a landscape dominated by old-growth forest, suggesting that structures suitable for denning and resting are uncommon. In stands regenerating from timber harvest these features may be absent or exist only as short-lived legacies of the old forest. Therefore, when management goals include providing timber for harvest and maintaining populations of martens in the same landscape we recommend retaining trees, snags, and CWD with large diameter, cavities, and a variety of decay classes for use as dens and resting sites. We also recommend that management plans ensure continued recruitment of such structures through time and that they be distributed throughout the landscape. One way to accomplish this goal is to change from clearcut harvesting to selective timber harvest strategies that retain a spectrum of tree sizes and ages in managed stands. Selective harvest strategies that retain canopy cover sufficient to prevent formation of a dense single-storied canopy of regenerating trees may also preserve habitat value for small mammal prey species within harvested units.

Our findings also directly relate to the conservation strategy for martens in the Tongass Forest Plan (U. S. Forest Service 1997). An element of that strategy is standards and guidelines designed to help mitigate the effects of timber harvest on martens. These guidelines state that depending on the proportion of a management area already harvested, in new timber harvest units 10-20 trees, 7 snags, and 7 logs per hectare 56-71 cm in diameter should be retained. Our findings indicate that retaining structures up to 71 cm in diameter would capture only about 38% of the structures used by martens on NCI, whereas retaining structures up to 90 cm in diameter would capture about 70% of structures used by martens. Martens on NCI did use smaller diameter structures, but because the relative roles of structure diameter and other attributes important to martens in selection of denning and resting structures remain uncertain, we recommend trees, snags, and logs retained for martens be >80 cm diameter, and on sites where a sufficient number of such structures are not available, retaining the largest structures present. This would ensure that large, old structures with the highest likelihood of having suitable features are retained.

Currently, most information on denning and resting structures used by martens comes from western North America. However, martens also inhabit central and eastern Canada and the northeastern United States where forests differ in composition, structure, and logging history from those in western North America. Information on denning and resting structures from those areas would provide greater insight into which criteria influence selection of these structures.

APPENDIX B

HABATAT SELECTION BY AMERICAN MARTENS ON NORTHEAST CHICHAGOF ISLAND, SOUTHEAST ALASKA, 1991-1997

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Abstract: We determined macro-scale habitat selection by American martens on northeast Chichagof Island during 1991-92 through 1997-98. We located 137 radiocollared martens (86 males and 51 females) 2,978 times to determine habitat selection at the stand and landscape levels. Martens showed the greatest selection among forested habitats during the winter followed by summer. During the fall, little selection was observed among forested habitats. Selection ratios for nonforest habitats were always small confirming a general avoidance of nonforest by martens. 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). Larger-sized stands contained a greater number of large woody structures, including live trees, snags, and logs. For most habitat categories, the 95% confidence intervals (CIs) for the observed marten selection indices overlapped with the values in the Interagency Habitat Capability Model indicating model parameters were reasonable. Clearcut logging, the predominant method of tree harvesting in western North America, will remove vertical structures important to martens, such as live trees and snags. Selective logging approaches that would retain significant vertical woody structure in a unit should be explored.

Key words: Chichagof Island, habitat selection, *Martes americana*, Southeast Alaska.

DISCUSSION

Habitat selection

We found that martens used mostly forested habitats (82%) and selected for larger-sized forest stands within a coastal temperate forest landscape. They made little use of the other available habitats, including shrub fields, recent clearcuts, or sparsely vegetated sites. Our findings were consistent with other marten habitat studies (Buskirk and Ruggiero 1994). Broadly, martens have been found to be limited to conifer-dominated forests, usually late-successional stands on mesic sites (Buskirk and Ruggiero 1994). Often, these forests contain abundant and complex physical structure. Given the entire North Pacific Coastal region is dominated by conifer forests and mesic conditions, our study explored whether martens selected habitats based on stand characteristics.

Martens showed the greatest selection for large and medium-sized MS stands. 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). Larger-sized stands in the temperate rainforest provide an abundance of woody structure, including live trees, snags, and logs, all in close proximity (Alaback and Juday. 1989, Schumacher 1999). Intermediate-sized stands often contained small patches of large boles within a generally smaller stand (Flynn and Schumacher 1999b, Schumacher 1999). Live trees in a larger old-growth stand frequently contain substantial decay, which resulted in numerous cavities. These woody structures provide excellent den and resting sites (Schumacher 1999) and cover from the wet weather and potential predators.

Martens showed the largest selection among forested habitats during the winter followed by summer. During the fall, little selection was observed among forested habitats. Selection ratios for nonforest habitats were always small confirming a general avoidance of nonforest by martens. During the colder temperatures of winter, martens may need to rest in cavities available in larger woody structures of large-sized stands (Schumacher 1999). Winter conditions in Southeast Alaska are often characterized by frequent rain and wet snow conditions. Large woody debris may provide important cover from the elements while traveling or hunting. Also, large conifer trees intercept snow (Kirchhoff and Schoen 1987), perhaps resulting in prey being more available under the canopy. Winter habitats selected by martens were similar to those of black-tailed deer (Schoen and Kirchhoff 1985). Martens may scavenge on deer carcasses in these habitats.

Habitat capability model

Generally, the 95% confidence intervals (CIs) for the observed marten selection indices overlapped with most of the values in the original habitat capability 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.

MANAGEMENT IMPLICATIONS

Martens selected for larger-sized, old-growth forest stands. Little use was recorded for small-sized stands or nonforest habitats. 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). Intermediate-sized stands often contained small patches of large boles within a generally smaller stand (Schumacher 1999). Large trees and CWD provide martens with several important life history requirements including cover from predators (Vernam 1987, Lindstrom et al. 1995), inclement weather while resting (Buskirk et al. 1989, Martin and Barrett 1991), denning (Hauptman 1979, Wynne and Sherburne 1984, Baker 1992, Ruggiero et al. 1998), or foraging (Corn and Raphael 1992). Adequate availability of structures for denning and resting is probably important for marten survival.

Clearcutting, the predominant method of tree harvesting in western North America (Franklin and Forman 1987, Vance 1990), structures important to martens, such as live trees and snags, are felled. Although an abundance of CWD may exist immediately after clearcutting, the amount and size of CWD will decline as the slash and residual CWD decay (Franklin and Waring 1980, Tritton 1980). Because all trees have been removed, new large CWD will not be recruited into the stand with a 100-year timber rotation. Martens generally avoid areas with little overhead cover (Buskirk and Ruggiero 1994), and abundant CWD in recent clearcuts probably is of little value to them. However, martens will use residual CWD in second-growth stands (Baker 1992), but how long these structures will remain useful to martens is unknown. Highly decayed CWD probably provides less value to martens (Wilbert 1992). New logs or snags of sufficient size to accommodate marten dens or resting sites may require over 200 years to grow (Harris 1984, Franklin et al. 1981). Currently planned 100-year timber rotation times on managed forests will not permit the formation of large CWD before the next cutting (USDA Forest Service 1997).

Leaving a substantial amount of vertical structure in the unit may retain habitat values for marten in a logged stand. Although little research has been done on selective logging approaches in Southeast Alaska (Deal 2001), new silvicultural systems that use partial cutting could provide a sustainable timber resource while maintaining some stand structural diversity (Deal et al. 2002). Unfortunately, we were unable to include any selectively logged stands in our study because very few existed in our study area. Additional research is needed to examine the impact of selective structure removal on marten habitat.

APPENDIX C

TEMPORAL CHANGES IN POPULATION DYNAMICS: IMPLICATIONS FOR ABUNDANCE ESTIMATION OF MARTENS

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Abstract: American marten (*Martes americana*) abundance has been difficult to determine because of their secretive nature. Increased human access and habitat changes from logging activities have created population management concerns. Reliable estimates of abundance are important for understanding the dynamics of a population. We estimated marten abundance and sex and age structure on a portion of northeast Chichagof Island, Southeast Alaska using mark-recapture methods in combination with radiotelemetry. Although population numbers were small, we were able to obtain 13 useful abundance estimates from 1992-1998 because of high recapture rates ($\bar{x}$ = 0.72). Poor weather hindered completion of some surveys. Estimated marten numbers varied greatly over the period, ranging from a low of 12.5 martens on the study area during winter 1997 to a high of 45.4 martens 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 with 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 radiocollaring and tracking individuals. Sex ratios changed during our study period with fewer males in the population during 1991-1994, more males from 1995-1996, and then fewer males again during 1997-1998. 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.

MANAGEMENT IMPLICATIONS

We found that marten population abundance could be monitored on certain areas using mark-recapture procedures. The study area would need to have good access, so the entire area could be trapped, and the traps checked daily. The study area would need to contain > 20 martens to meet minimum sample-size requirements. With the development of reliable regression equations, live trapping results without the radiocollaring may provide a reliable estimate of marten abundance.

All martens were quite vulnerable to trapping. We found that recapture rates were similar for males and females whether resident or transient. Recapture rates suggested that fur trappers could catch about 70% of an area's marten population within 5-6 days, including the resident adults. After the initial week of trapping, most captures would be new transient individuals moving through the area. In our area, the effective trapped area was a band within 1.6 km of the trap line. In areas with less restrictive topography, the effective trapping area may vary based on changing home-range size (Thompson and Colgan 1987). Again because of our topography, we frequently had transient martens moving into and through the area over time.

Marten population management in areas with easy human access can be difficult because of their high catchability (Clark et al. 1987, Strickland and Douglas 1987). Many authors (Archibald and Jessup 1984, Strickland 1994, Thompson and Colgan 1987, Buskirk 199X) have advocated the refugium concept for marten management. This approach has been promoted by several wildlife management agencies. Under the refugium concept, large untrapped areas function as population source areas; trapped areas function as sinks. Annually, juvenile martens disperse from the source areas and repopulate the sinks. Our data indicated that trapped areas could be major sinks and provide support for the refugium approach. Actually in years with high adult dispersal, a large proportion of the total population can be captured in the sinks (Flynn In prep).

We found marten abundance to vary greatly with time. Marten numbers can fluctuate greatly because of major changes in food availability (Weckwerth and Hawley 1962, Thompson and Colgan 1987). Thus, Thompson and Colgan (1987) recommended using a "tracking strategy" (Caughley 1977) for population management in addition to refugia. During years of declining and low numbers, marten trapping seasons would be restricted to reduce mortality. Preseason surveys could provide information for the following trapping season. If more lead time were required, late winter surveys would provide information for the following fall season. Specific management actions would need to consider the areas and quality of refugia available along with marten population trends.

Land management plans need to consider the potential impact of increased access on marten populations. Our data indicated that sink habitat can be easily created by increasing trapper access. In Southeast Alaska, logging roads provide easy access, especially if the roads are connected to communities. Planned management actions should evaluate the area and quality of existing refugia with the amount of sink habitat to be created. In our study area, we trapped an effective area of about 1.6 km on both sides of the trap line. If marten home ranges were larger, this sink zone would also be larger.

APPENDIX D

Determining Sex and Age of American Martens in the North Pacific Coast: Using Skull Length and Temporal Muscle Coalescence

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Abstract: Several methods have been employed to determine the sex and age of harvested American martens in North America. Most of these methods use skull characteristics. Because of their high vulnerability to trapping, close monitoring of marten populations is important for sustained-yield management. Managers have sought sexing and aging methods that are inexpensive, but still relatively reliable. During 1991-98, we collected 2,998 marten carcasses from trappers in Southeast Alaska and surrounding areas to examine relationships among certain skull characteristics and an animal's sex and age. Our specimens included animals from both the *americana* and *caurina* genetic clades. We found that using a dividing point of 81 mm for total skull length classified over 98% of the carcasses to the correct sex. We found that temporal muscle development could be used to classify many martens into the correct juvenile and adult age classes. For males, a dividing point of 28 mm in length of temporal muscle coalescence (LTMC) correctly classified about 90% of the carcasses into the correct age class. For females, a dividing point of 1.0 mm in the width between the temporal muscles (WBTM) correctly classified about 81% of the carcasses into juvenile and adult age classes. Unknown errors in cementum ages probably contributed to lower correct classification rates. Also, inconsistent measurement probably contributed to the observed errors. Based on the agreement with previous studies, large geographic area sampled, and genetic clades included, we concluded that the methods could probably be applied to most of western North America. Before deciding on a method, managers need to decide on the reliability needed and the funds available. To increase reliability of aging, cementum analysis should be used for males with a LTMC between 20-30 mm and females with WBTM < 2 mm and LTMC < 10 mm.

APPENDIX E

DIET, BODY CONDITION, AND REPRODUCTION IN AMERICAN MARTENS: THE ROLE OF ALTERNATIVE FOODS

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***Abstract*:** Reproductive performance in females for many mammals is reduced with diminishing resources. In addition, previous studies have established a positive relationship between body condition and reproductive performance in several species of mammals. Among small mustelids, with limited ability to accumulate fat reserves, optimization of food intake through diet selection may partially determine reproductive success of females. We investigated diet composition, body condition, and reproductive performance of female martens (*Martes americana*) during mating, pre-implantation, gestation and lactation in Southeast Alaska from 1991 to 1994 in relation to changes in numbers of small rodents. Stable isotope analysis of blood and muscle tissue was used to indicate the diet of 75 live-trapped martens, and 160 marten carcasses, and percentages of prey in the diet were calculated using a dual-isotope, multi-source mixing model. Reproductive status of female martens was established using counts of corpora lutea for carcasses and from blood progesterone levels for live females. Body condition was determined from weight and fat scores for carcasses, and from body weight for live females. Concurrently, we monitored abundance of small rodents in our study area. Our results suggest that although small rodents were preferred by martens, other alternative foods such as squirrels, birds, salmon carcasses, deer carcasses, and intertidal organisms allowed some female martens to maintain body condition and reproduce successfully even in years when preferred foods were not readily available.

Discussion

The percentages of reproductive female martens (age > 2 years) were low in both 1991 and 1992 (36% and 75%) during a period of low numbers of small rodent in our study area. Between 1991 and 1992, the proportion of reproductive female martens (age > 2 years) and the mean counts of corpora lutea of all reproductive females increased while the abundance of small rodents continued to decrease. While the increase in proportion of reproductive female martens between 1992 and 1993 corresponds to an increase in the abundance of small rodents, no change in the percent of small rodents in the diet of martens occurred between summer 1992 and summer 1993. We expected that the proportion of small rodents in the diet of martens would decrease during years of low abundance of this prey. Also, we expected the ovulation rate of female martens would change directly with changes in the abundance of small rodents. Thompson and Colgan (1987) reported lower ovulation rates in martens during years of food scarcity in Northcentral Ontario than in years with plentiful foods; however in their study area, all alternative prey declined simultaneously. Kartashov (1989) observed a large decrease in ovulation rates in sables in 1982 and 1983 but provided no information on food availability during the years of that study. The stable isotope analysis showed that martens relied on squirrels and birds in summer. During that season nestlings and juvenile squirrels are encountered at a higher rate and are easier to capture than voles or deer mice (Zielinski et al., 1983). Therefore, availability of squirrels and birds in summer may override the effect of low abundance of small rodents, and affect body condition and rates of ovulation in martens. Unfortunately, we have no data on the abundance of squirrels and birds in any year of our study.

In our study, the proportion of reproductive females 1 - 2 years old was significantly lower than the proportion of females > 2 years of age. Other studies (Strickland and Douglas 1987, Thompson and Colgan 1987) have reported a lower proportion of reproductive yearlings compared with older females. Younger females are more susceptible to a decline in abundance of small rodents as proposed by Mead (1994). Nonetheless, diet composition of martens in our study area did not vary with sex or age (Ben-David et al. in review *a*), suggesting that younger females were not subjected to different dietary pressures than older females. Whether other environmental pressures affect reproductive performance in younger females merits further investigation. The lack of females 1 - 2 years old from our 1993 and 1994 samples precluded drawing conclusions on the response of younger females to an increase in abundance of small rodents.

Studies on ovulation rates in the genus *Martes* as well as in other mustelids demonstrated an increase in corpora lutea counts with increasing age (Doktor et al. 1987, Kartashov 1989, King 1983, Shea et al. 1985). We were unable to detect differences in mean counts of corpora lutea between 1 - 2 years old females and females > 2 years. However, we found low ovulation in all females during 1991, and our sample size was small in 1992.

Martens in our study area principally fed on small rodents in autumn when those were available in high numbers (1993 and 1994), and to a lesser degree when abundance of small rodents was low (1991 and 1992). In autumn 1991 and 1992, salmon carcasses contributed substantially to the diet of martens. In early winter (preimplantation period), no differences could be detected in diets of reproductive and nonreproductive females. Also, body condition of reproductive and nonreproductive females was not significantly different, and no difference was detected between females that fed mainly on salmon carcasses and those that fed mainly on rodents. This finding does not support our hypotheses that females feeding on rodent prey would exhibit better body condition than those that fed mainly on salmon carcasses and that reproductive females will feed more heavily on the preferred rodent prey compared with nonreproductive females. These results suggest that although salmon carcasses are not a preferred food for martens (see also Ben-David et al. in review *a*), they are an alternate food suitable to sustain body condition for some females through the winter and may allow females to successfully implant even in years when small rodents are not readily available.

In spring, carcasses of winter-killed deer seemed to be an important component in the diet of martens, composing 34 and 43% of the diet in that season. Nagorsen et al. (1989) reported deer remains in 20% of gastrointestinal tracts of martens obtained from trappers in winter on Vancouver Island, British Columbia, suggesting that this food was important for insular populations of martens in the Pacific Northwest. In spring, marine-derived foods were less available to martens in our study area because the salmon runs end in mid- to late November. Nonetheless, some carcasses of salmon may remain available as they thaw from the snow on stream banks or because they were cached by martens (Henry et al., 1990) or other predators such as mink (Ben-David et al. in review *b*). Other possible marine-derived foods were intertidal organisms exposed at low tide. Fecal analysis (M. Ben-David and T. V. Schumacher, unpublished. data) showed remains of salmon and crab shells in marten scats collected in spring.

This observation could explain the occurrence of stable isotope signatures in marten tissues characteristic of marine-derived foods during spring. Others studies have shown that island-inhabiting martens fed on intertidal organisms in winter (Nagorsen et al. 1989, Nagorsen et al. 1991), as did other species of mustelids (Ben-David et al. 1996, Bowyer et al. 1994).

We suggest that alternative foods such as squirrels and birds in summer; salmon in autumn; and deer carcasses and salmon in winter and spring can provide female martens with adequate resources for all stages of reproduction especially during years of low abundance of small rodents. For example, one reproductive female (MR24) which fed largely on marine-derived foods in spring showed evidence of lactation when recaptured in July. Thompson and Colgan (1987) reported that few female martens produced young and lactated during periods of low abundance of mammalian prey. The availability of marine-derived foods to martens in our study area may reduce the effects of shortages in preferred foods during embryonic diapause, gestation, and lactation.

APPENDIX F

AGE STRUCTURE AND FECUNDITY OF MARTENS TRAPPED ON CHICHAGOF ISLAND, SOUTHEAST ALASKA, 1991-1997[1]

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Abstract: We determined sex and age ratios and potential fecundity of American marten carcasses collected from trappers on Chichagof Island during 1991-92 through 1997-98. We focused on the northeast portion Chichagof Island (NCI) because of the management concern there. The marten-trapping season was closed on NCI in 1990-91 because of a concern for overharvest during the previous 3 years. The total trapper catch, age ratios, and fecundity varied greatly during the study. After the trapping season reopened in 1991-92, the trapper catch ranged from 19 in 1993-94 to a high of 354 in 1996-97. We collected 1367 carcasses (824 males and 544 females) from all of Chichagof Island and 599 (365 males and 234 females) from NCI. For the carcasses from NCI, the ratio of adult males: adult females varied from 0.9 in 1997-98 to 2.8 in 1992-93. The juvenile: adult ratios varied from 0.3 in 1997-98 to 6.5 in 1993-94. Juvenile: adult female ratios varied from 0.6 in 1997-98 to 13.0 in 1993-94. Based on counts of corpora lutea, potential fecundity of trapped female martens varied from 0.46 corpora per adult female in 1996-97 to 3.50 in 1994-95. Fluctuating pregnancy rates caused most of the variation in fecundity. Pregnancy rates averaged 34% and were under 50% in most years (except 1993-94 and 1994-95). We found corpora lutea counts highly correlated with recruitment the following fall. Demographic information from trapper-caught carcasses can provide useful management information for marten populations. Juvenile: adult ratios provide an estimate of recruitment for the harvest year. Age structure provides additional insight on population dynamics over the past several years. The ovarian analysis provides a measure of potential recruitment for the next biological year.

DISCUSSION

The number of martens trapped on NCI varied greatly among years. This variation likely resulted from changes in the abundance of martens and changes in trapping effort. Marten numbers fluctuate in response to fur trapping and changing abundance of prey (Thompson and Colgan 1987, Flynn and Schumacher, in prep.). Although we did not document trapping effort, trappers indicated that in years when martens were abundant they usually expended more effort than during years when martens were scarce. We experienced good cooperation with trappers providing carcasses. Consequently, the percentages of the harvest that we collected remained similar, but the actual number of carcasses varied among years.

Fecundity (number of corpora lutea * pregnancy rate) was influenced more by pregnancy rate than by the number of corpora lutea per pregnant female. Overall, the number of corpora lutea per pregnant female changed little from year to year, varying from 2.9 to 3.6. However, pregnancy rates ranged from 13 to 73%.

The marten population on Chichagof Island periodically experienced near reproductive failure, i.e. 1991-92, 196-97, and 1997-98. Most studies have found high marten fecundity rates. Over 12 consecutive years, Strickland and Douglas (1987) reported that both pregnancy rates and numbers of corpora lutea in pregnant female martens in Ontario were stable, ranging from 91-100% and 3.19 - 3.53, respectively. Aune and Schladweiler (1997) reported pregnancy rates similar for 2 populations in Montana, ranging from 76-95% over 5 years, but a lower mean number of corpora (2.6) per adult female in the southwestern part of the state. Also in Ontario, Thompson and Colgan (1987) reported 2.74-3.46 corpora lutea in pregnant females. Thus, martens on NCI appeared to be less productive than most populations in North America.

Fecundity of female martens varied by age class. Although counts of corpora lutea for pregnant females did not differ by age class, pregnancy rate did vary with age. Only about 13% of yearling females were pregnant. Therefore, on Chichagof Island few yearling female martens breed and give birth. Also, yearling martens found to be pregnant may have been incorrectly aged. Females aged 2 (33%) or 3 (38%) had lower pregnancy rates than older females (45-73%), indicating that a female marten may not achieve full reproductive capability until older than 3 years of age.

Fecundity of martens on Chichagof Island varied through time and was often lower than reported elsewhere. During several years, the marten reproduction on NCI nearly failed completely. We found marten fecundity seldom within the range (2.3-3.5 corpora lutea per adult female) reported by Strickland and Douglas (1987) for a 12-year period in Ontario. They found pregnancy rates for adult females varying from 91-100% with an overall yearling pregnancy rate of 78% and a 93% rate for mature females ($\geq$2 years old). Also in Ontario Thompson and Colgan (1987) reported pregnancy rates for mature females to range from 50% - 72%. In contrast we found an overall pregnancy rate of 34% for adult females with average pregnancy rates of 13% for yearlings and 44% for mature females. Thompson and Colgan (1987) attributed reduced ovulation and pregnancy rates, especially among yearlings, to declining food resources. Our findings support the conclusions of Thompson and Colgan (1987) because changes in fecundity on Chichagof Island also appear related to changes in abundance of food resources, primarily due to natural fluctuations in abundance of long-tailed voles. Marten populations on Chichagof Island appear to have lower and more variable fecundity over time than populations elsewhere and that lower fecundity appears related to lower availability of prey. Therefore, managers should consider the availability of prey when setting trapping regulations.

The age structure of marten harvested on Chichagof Island likely reflected changing recruitment rates over time. We found a strong correlation between fecundity measured by corpora lutea counts with age ratios (juvenile: adult) the following year. Also, years with low mean age were correlated with age ratios in the harvest. Thus, counts of corpora lutea provide managers with a measure of possible recruitment for the following year. Because reproduction in martens has been linked to availability of prey (Thompson and Colgan 1987), monitoring prey abundance may provide some insight into productivity of the population and harvestable surplus during a given year.

When managing populations of martens, Strickland and Douglas (1987) recommended that to avoid overharvest of adult females, the ratio of juveniles: adult female be kept above 3:1. Higher juvenile: adult ratios likely reflect greater recruitment. During our study, juveniles: adult female ratios on NCI exceeded 3.0 only 3 times (1993-94, 1994-95, 1995-96), and the ratio was $\leq$1:1 in the remaining 4 years. However, ratios of sex or age groups in the harvest can be highly unstable when samples sizes are small. Therefore, when using ratios to inform management decisions, it is important to consider the sample size from which the ratio was calculated.

Demographic information from trapper-caught carcasses can provide useful management information for marten populations. Juvenile: adult ratios provide an estimate of recruitment for the harvest year. Age structure provides additional insight on population dynamics over the past several years. The ovarian analysis provides a measure of potential recruitment for the next biological year. If a commercial laboratory is available for tooth cementum ageing and ovarian analyses, the data collection procedures are relatively easy for the investigator to complete.

APPENDIX F

Publications and Reports

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