

Bald eagles of the San Luis Valley, Colorado : their winter ecology and spring migration
by Alan Robert Harmata

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Biological Sciences
Montana State University
© Copyright by Alan Robert Harmata (1984)

Abstract:
Approximately 100-300 bald eagles (Haliaeetus leucocephalus) winter in the San Luis Valley (SLV) of southcentral Colorado. Between January and mid-March 1980-1981, bald eagles were captured, measured, and plumage described. An aging protocol based on plumage, iris, and mandible coloration was developed. A sexing technique was developed based on 4 measurements. Morphological differences were related to resource partitioning between age classes and sexes and also migration differences between sexes of adults. Fifteen adult bald eagles were marked with tail-mounted transmitters to study winter ecology. Over 1300 hours of monitoring showed mean seasonal home range size was 310.7 km^2 . Single day movements typically covered only a small portion of the home range. Mean daily activity was 15.5% of daylight hours and monthly activity was negatively correlated with severe weather. Human activity within 150 m of an eagle perched in a tree or 760 m of an eagle on the ground usually elicited a flush response. Perch trees were usually near irrigation ditches surrounded by agricultural land. Foraging habitat consisted of areas of brushland/cropland interspersion. Habitat use shifted from upland to riparian areas as ice-out on rivers progressed. Roost site suitability appeared dependent on distance from human activity while roost site preference seemed dependent on proximity to food. Primary food was jackrabbit (Lepus spp.) throughout the winter but varying proportions of fish and waterfowl occurred dependent on availability. Use of the SLV by wintering bald eagles is probably relatively recent and coincident with agriculture. Advancing monoculture will probably result in fewer eagles using the SLV in the future. Age ratios in wintering areas are most likely a reflection of food availability and type rather than indicative of population trends. Six eagles were tracked on spring migration. Two eagles were followed to a nesting ground and 2 others found in their summering area, all in northeastern Saskatchewan. Migration routes and wintering areas of adult bald eagles appear to be related to the watershed in which summering grounds are located.

BALD EAGLES OF THE SAN LUIS VALLEY, COLORADO: THEIR WINTER ECOLOGY AND SPRING MIGRATION

by

Alan Robert Harmata

A thesis submitted in partial fulfillment
of the requirements for the degree

of

Doctor of Philosophy

in

Biological Sciences

MONTANA STATE UNIVERSITY
Bozeman, Montana

April 1984

D378
H2275
cop. 2

APPROVAL

of a thesis submitted by

Alan Robert Harmata

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

April 4, 1984
Date

Robert S. Eng
Chairperson, Graduate Committee

Approved for the Major Department

4 April 1984
Date

Robert E. Moore
Head, Major Department

Approved for the College of Graduate Studies

May 2, 1984
Date

Henry L. Parsons
Graduate Dean

STATEMENT OF PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements for a doctoral degree at Montana State University, I agree that the Library shall make it available to borrowers under rules of the Library. Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgement of course is made.

Permission for extensive quotation from or reproduction of this thesis may be granted by my major professor, or in his/her absence, by the Director of Libraries when, in the opinion of either, the proposed use of the material is for scholarly purposes. Any copying or use of the material in this thesis for financial gain shall not be allowed without my written permission.

Signature 

Date 04-12-84



Recently arrived from her wintering ground in the San Luis Valley, Colorado, an adult bald eagle vocalizes from a perch near her nest in northeastern Saskatchewan.

For the 57,939 who never got the chance...

VITA

Alan Robert Harmata was born 2 June 1945 in Passaic, New Jersey to Howard John and Mabel Beatrice Harmata. He graduated from Rutherford High School, Rutherford, New Jersey in June 1963. He attended Nichols College in Dudley, Massachusetts from September 1963 to June 1964 and subsequently worked in the construction trades. On 26 February 1966 he was inducted into the U.S. Army and served in the infantry with the 1st Bn. 5th Cav, 1st Air Cav Div. in the Republic of Vietnam. He was retired from the U.S. Army on 6 February 1968 due to "disabling" wounds received in action. In September 1969 he enrolled in Fairleigh Dickenson University, Teaneck, New Jersey, transferring to the University of Illinois, Champaign in September 1970 and received a Bachelor of Science degree in Biology in June 1972. He began graduate study in wildlife during January 1973 at Colorado State University, Ft. Collins, and completed required coursework by June 1974. After working in the wildlife consulting field and for the National Audubon Society for several years, he received a Master of Science degree in wildlife biology from Colorado State University in December 1977. He began studies for a Doctor of Philosophy degree in Fish and Wildlife Management at Montana State University in March 1979. He has a daughter, Caryn Jeanne (age 13) and a son, Peter John (age 10) and is sharing life with Elizabeth Bowman Spettigue of Duluth, Minnesota.

ACKNOWLEDGEMENT

I am grateful to Dr. Robert Eng, graduate committee chairman, for guidance, supervision and assistance during this study. Drs. Lynn Irby, John E. Taylor, William Gould, Robert Moore, and James DiBerardinis reviewed the manuscript and served as committee members.

I thank George Montopoli, Betsy Spettigue, Susan Werner, and C. J. and P. J. Harmata, first as supportive friends and companions, and second for their superior abilities as wildlife biologists; without their contributions the study could not have been completed.

J. Michael Lockhart and Dr. B. Riley McClelland offered valuable comments on study design, methods, and interpretation and reviewed the manuscript. The patience and cooperation of Fred Jense in facilitating financial and logistical support from the V.A. is greatly appreciated.

Lastly, I extend my sincere appreciation to the many San Luis Valley residents who permitted access to their land and homes and whose good humor, insight, and cooperation made the field work even more enjoyable and rewarding.

This study was made possible by funds granted by the Veterans Administration Voc. Rehab. Act, Montana Dept. Fish, Wildl. & Parks SE-1 Sec. 6 Endang. Sp. Act, The Amer. Wilderness Alliance, Nat. Audubon Soc., Nat. Wildl. Fed., Eagle Valley Environmentalists, The Wildl. Manage. Inst. & Amer. Petrol. Inst., Montana Agr. Exp. Sta., Montana St. Univ. Res. Creativity Prog. and Biology Dept., Montana St. Univ.

TABLE OF CONTENTS

	Page
VITA	vi
ACKNOWLEDGEMENT	vii
TABLE OF CONTENTS	viii
LIST OF TABLES	xi
LIST OF FIGURES	xv
ABSTRACT	xxv
INTRODUCTION	1
STUDY AREA	5
Geography and Hydrology	5
Climate	8
Vegetation	8
Human History and Ecology	9
Historical Use by Bald Eagles	13
METHODS	15
Capture	15
Handling and Marking	19
Monitoring	24
Mated Status, Plumage and Morphology	25
Winter Ecology	30
Home Range and Movements	30
Activity	31
Eagle Responses to Human Activity	33
Habitat Selection	34
Habitat Use	38
Roost Site Determination and Description	38
Roost Site Suitability	40
Roost Site Preference	43
Food Habits	44
Perch Structures	45
Location of Perches	47
Public Information Programs	47

TABLE OF CONTENTS—Continued

Page

Migration 48
Factors Associated with Initiation of Migration. . . 48
Migration Tracking 48

RESULTS. 50

Capture 50
Population Estimate 53
Marking and Monitoring. 54
Age Determination 54
Age Class Determination by Measurement 54
Aging by Eye, Plumage, and Beak Coloration 57
Sex Determination 66
Age and Sex Size Relationships. 71
Flight Related Characteristics 72
Aspect Ratio. 72
Tail/Wing Ratio 74
Wing Loading. 74
Lift Surface Loading. 74
Prediction of Wing Area from Linear Measurement 75
Size Dimorphism. 75
Winter Ecology. 76
Traditional Use of the Wintering Grounds 76
Home Range 77
Intra-Range Movements. 81
Activity 86
Eagle Responses to Human Activity. 92
Habitat Selection. 96
Habitat Use. 108
Roost Site Description 114
Roost Site Suitability 116
Roost Site Preference. 124
Age Class Composition at Roost Sites 126
Food Habits. 127
Perch Structure Construction and Use 130
Migration 132
Colormarking and Band Recoveries 132
Initiation of Migration. 135
Migration Routes, Mechanics, and Destination 138

DISCUSSION 146

The SLV as a Wintering Area for Bald Eagles 146
Size Differential, Resource Partitioning, and Choice of Wintering Areas. 156

TABLE OF CONTENTS—Continued

Page

The Ecology of Northward Migration. 163
Research and Management 170
Winter Capture of Bald Eagles. 170
Aging and Sexing 174
Colormarking vs Radio-Tracking as a Research Technique. 176
Bald Eagle Management in the SLV 178
Management Strategy 182

LITERATURE CITED 185

APPENDICES 197

Appendix A - Tables 198
Appendix B - Figures. 204

LIST OF TABLES

		Page
Table 1.	Group variables measured at bald eagle roost sites, San Luis Valley, CO	41
Table 2.	Trap days and total wintering eagles captured, San Luis Valley, CO.	50
Table 3.	Trap success for wintering eagles in the San Luis Valley, CO.	51
Table 4.	Numbers of eagles captured and success of trapping technique with 2 species of lure eagles, San Luis Valley, CO, winter 1981	52
Table 5.	Trap success of sets with and without a lure eagle, San Luis Valley, CO, winter 1981.	53
Table 6.	Monitoring data, mated status, and emmigration date of radio-tagged adult bald eagles, San Luis Valley, CO, winter 1980-81.	55
Table 7.	Classification results of a stepwise discriminate analysis to determine discriminating variables to separate immature vs adult bald eagles by measurement at 3 levels of significance (F-to-enter levels).	56
Table 8.	Discriminating variables and coefficient values for classification functions to be used in determining age class of bald eagles. Classification equation with the highest score determines age class.	57
Table 9.	Aging criteria for juvenile and subadult bald eagles in hand	67
Table 10.	Means and 1 standard deviation of cluster groups found by K-means clustering algorithm analysis of measurements of bald eagles (n = 68).	69
Table 11.	Means and 1 standard deviation of morphological measurements of immature and adult bald eagles	72

LIST OF TABLES—Continued

Page

Table 12. Measurements of characters related to flight dynamics of 2 age classes of bald eagles by sex. Measurements were derived from 18 eagles whose wing areas were measured 73

Table 13. Flight related statistics and sample size (n) of bald eagles of 2 age classes by sex 73

Table 14. Dimorphism indices (DI; Storer 1966) for bald eagles captured in the San Luis Valley, CO 76

Table 15. Resightings of bald eagles marked in the San Luis Valley, CO subsequent to the year of color-marking. 78

Table 16. Minimum seasonal home range size of radio-tagged adult bald eagles wintering in the San Luis Valley, CO determined after at least 10 hrs monitoring 80

Table 17. Mean minimum seasonal home range sizes (n) by mated status and sex of radio-tagged adult bald eagles, San Luis Valley, CO. 81

Table 18. Independent variables and P values derived from frequency and cross tabulation analysis of bald eagle responses to human activity (disturbance). . . 94

Table 19. Probability of response of bald eagles to any human activity (disturbance) at different distances under varied sky conditions. 94

Table 20. Descriptive statistics for 14 continuous variables measured at major bald eagle roost sites, San Luis Valley, CO. 116

Table 21. Significance of difference (P value) between variables at bald eagle roost sites in the San Luis Valley, CO, on (1) the Rio Grande and Conejos Rivers, (2) used vs nonused areas on the Rio Grande River, (3) used vs nonused areas on the Conejos River as determined by Kruskal-Wallis test. 117

LIST OF TABLES—Continued

Page

Table 22. Variables that distinguish most between used and nonused bald eagle roost sites, order of entry and classification coefficients for 3 comparisons of San Luis Valley, CO rivers as determined by 2 way stepwise discriminate analyses 119

Table 23. Classification matrix from discriminate analysis of known used and nonused roost sites in the San Luis Valley, CO on the Rio Grande and Conejos Rivers combined. 120

Table 24. Classification matrix from discriminate analysis of known used and nonused roost sites on the Rio Grande River, San Luis Valley, CO. 121

Table 25. Predictability of site use by roosting bald eagles with discriminating variables derived for 1 river and used to classify the other in the San Luis Valley, CO. 121

Table 26. Bald eagle use of major winter roost sites in the San Luis Valley, CO, 1977-81 124

Table 27. Parametric* and non-parametric correlation between count and continuous variables measured at bald eagle roost sites, San Luis Valley, CO 125

Table 28. Number and composition by taxonomic class of bald eagle castings and prey debris collected in the San Luis Valley, CO 128

Table 29. Percent of each taxonomic class contained in bald eagle castings and prey debris collected in the San Luis Valley, CO, by month 129

Table 30. Species identified in bald eagle castings and debris collected beneath perches and roosts in the San Luis Valley, CO 129

Table 31. Use of perch structures for wintering bald eagles in the San Luis Valley, CO, January 1982 and 1983. 131

LIST OF TABLES—Continued

Page

Table 32. Mean ± 99% confidence interval for climatological variables measured on (1) days bald eagles initiated northward migration from the San Luis Valley, CO and (2) randomly selected days which eagles did not initiate migration. 137

Table 33. Mean ± 99% confidence interval for climatological values measured on days bald eagles initiated northward migration from the San Luis Valley, CO during (1) the hour period nearest the departure time and (2) other hours of the day. . . . 137

Table 34. Bald eagle wintering areas in the U.S., percent immatures in the population, food, habitat, and relative severity of weather in mid-winter . . . 162

Table 35. Habitat types of San Luis Valley, CO used in bald eagle habitat selection analysis by GEOSCAN. 199

Table 36. Discriminating variables in order of entry in a stepwise discriminate analysis, coefficients and constants for used (observed) and nonused (expected) tree perch classification functions . . . 200

Table 37. Discriminating variables in order of entry in a stepwise discriminate analysis, coefficients and constants for used (observed) and nonused (expected) ground perch classification functions. 201

Table 38. Characteristics of used and nonused bald eagle roost sites on the Rio Grande River, Colorado. . . . 202

Table 39. Characteristics of used and nonused bald eagle roost sites on the Conejos River, Colorado 203

LIST OF FIGURES

		Page
Figure 1.	Locator and political map of the San Luis Valley, CO.	6
Figure 2.	Distribution of 1,724 center pivot irrigation systems as of January 1982. (Courtesy Colorado State University Cooperative Extension Service, Alamosa, CO).	12
Figure 3.	Placement of leg traps around jackrabbit carcass for capture of eagles. Traps were then covered with fine soil for concealment.	20
Figure 4.	Trap site with bald eagle lure. Lure bird was placed no closer than 1.5 m to the bait. Flat open areas were preferred.	20
Figure 5.	Adult bald eagle captured by the modified Lockhart technique.	21
Figure 6.	Radio transmitter mounting procedure on proximal ventral tail of adult bald eagle ½ complete. Note alcohol-soaked feathers permitting unobstructed access to the base of the tail.	23
Figure 7.	Completed attachment of radio transmitter to adult bald eagle tail. Note loose suture on distal left central rachis (bottom left) to permit spreading of tail.	23
Figure 8.	Procedure for tracing wing area of bald eagles. . .	28
Figure 9.	Procedure for tracing tail area of bald eagles. . .	28
Figure 10.	Scanning circle around a hypothetical perch location used by bald eagles.	37
Figure 11.	Major winter roost site and primary roost tree (arrow), used by bald eagles along the Rio Grande River, San Luis Valley, CO	40
Figure 12.	Perch structure for bald eagles placed in the San Luis Valley, CO, May 1981	46

LIST OF FIGURES—Continued

Page

Figure 13. Telemetry receiving antenna position on high wing aircraft. Antenna was mounted for reception of signal from front of aircraft. 49

Figure 14. Plumage of juvenile bald eagle 0.5 to 1 year old. 58

Figure 15. Plumage of subadult bald eagle 1.5-2 years old 59

Figure 16. Plumage of subadult bald eagle 2.5-3 years old 60

Figure 17. Plumage of bald eagle 3.5-4 years old and 4.5+ years old. Eagles 4.5+ cannot be distinguished from 3.5-4 year old at a distance 61

Figure 18. Wing of a 1.5 yr-old bald eagle. Note 2 generations of secondary and secondary covert feathers. 63

Figure 19. Plumage of bald eagle C14 1 year after initial capture as a 0.5 yr-old. Iris, mandible, and cere coloration along with wing and tail plumage were typical 1.5 yr-old. White belly and white triangular patch on back were absent however 63

Figure 20. Bald eagle C01 exhibiting typical 1.5 yr-old plumage, iris, mandible, and cere coloration. . . . 64

Figure 21. Bald eagle C01 at recapture 1 year after marking as a 1.5 yr-old (Fig. 18) exhibiting typical 2.5 yr-old plumage, iris, mandible, and cere coloration 64

Figure 22. Bald eagle C19 at marking as a 0.5 yr-old in San Luis Valley, CO, 1977 65

Figure 23. Bald eagle C19 as a full adult in 1980, Glacier National Park, MT. Photo by B. R. McClelland. 65

LIST OF FIGURES—Continued

Page

Figure 24. Cluster groups based on 6 morphological measurements of bald eagles as determined by K-means cluster analysis. Figure is a 2 dimensional "shadow" of 3 dimensional groupings 68

Figure 25. Centroids and range of discriminant scores of each age/sex group of bald eagles as determined by discriminant analysis. Variables under age groups are the most discriminating variables to determine sex, in order of entry in a stepwise procedure 70

Figure 26. All perch and flight locations for adult male bald eagle #8-81, San Luis Valley, CO, 1981 79

Figure 27. Home range of adult male bald eagle #8-81 determined by connecting all peripheral locations (Fig. 26) 79

Figure 28. Representative direct flights of an adult mated female bald eagle within the home range, San Luis Valley, CO, 2 February 1981. 83

Figure 29. Routes of typical soaring and direct flights of a mated adult male bald eagle, San Luis Valley, CO, 1980. Corkscrew path indicates soaring flight. 84

Figure 30. Routes of typical soaring and direct flights of an adult mated female bald eagle, San Luis Valley, CO 1981. Corkscrew path indicates soaring flight. 85

Figure 31. Habitual range (see text) of mated adult male bald eagle #4-80, San Luis Valley, CO. Area encompassed 54.5 km^2. 86

Figure 32. Total mean daily percent activity by hour block for 15 radio-tagged adult bald eagles wintering in the San Luis Valley, CO, 1980 and 1981. Vertical lines indicate 99% confidence interval 87

LIST OF FIGURES—Continued

Page

Figure 33. Total mean daily percent activity by hour block and year for male and female adult bald eagles wintering in the San Luis Valley, CO. Vertical lines indicate 99% confidence interval. 89

Figure 34. Mean daily percent activity of radio-tagged adult bald eagles by month for 1980 and 1981, San Luis Valley, CO 90

Figure 35. Mean daily percent activity of radio-tagged adult male bald eagles by month in 1980 (n = 3) and 1981 (n = 4), San Luis Valley, CO. 91

Figure 36. Regression of total monthly mean percent daily activity on Winter Severity Index (see text, 32). Solid line is regression including all months. Dashed line is regression omitting 1 aberrant month (February 1981), San Luis Valley, CO. 92

Figure 37. Percent of perched eagles observed (n) that flushed in response to human activity occurring at different distances, San Luis Valley, CO. 95

Figure 38. Portion of the San Luis Valley, CO, selected for habitat selection analysis. 97

Figure 39. Location of home ranges of 15 radio-tagged adult bald eagles within the area selected for habitat selection analysis, San Luis Valley, CO. 98

Figure 40. Location of 322 tree perches used by 15 adult radio-tagged bald eagles and respective circles of 2.2 km scanning radii in relation to the major rivers within a 90 x 90 km area chosen for habitat selection analysis, San Luis Valley, CO. 99

Figure 41. Location of 246 ground perch locations used by 15 radio-tagged adult bald eagles and respective circles of 760 m scanning radii in relation to the major rivers within a 90 x 90 km area chosen for habitat selection analysis, San Luis Valley, CO 100

LIST OF FIGURES—Continued

Page

Figure 42. Distribution of 72 regularly spaced points and respective scanning circles used as expected or nonused perch locations, within 90 x 90 km area chosen for habitat selection analysis, San Luis Valley, CO 101

Figure 43. Centroids and ranges of discriminant scores of groups of used bald eagle tree perches and nonused points, San Luis Valley, CO, as determined by discriminate analysis. Variables and associated relative values are listed in order of entry in a stepwise procedure and explained 70% of variation. 103

Figure 44. Histograms of discriminate scores for tree perches used by bald eagles (bottom) and nonused or regular points (top) San Luis Valley, CO. 104

Figure 45. Centroids and ranges of discriminant scores of groups of used bald eagle ground perches and nonused points, San Luis Valley, CO as determined by discriminate analysis. Variables and associated relative values are listed in order of entry in a stepwise procedure and explained 66% of variation. 106

Figure 46. Histograms of discriminate scores for ground perches used by bald eagles (bottom) and nonused or regular points (top), San Luis Valley, CO. 107

Figure 47. Relative frequency of use and location of tree perches with the home range of bald eagle #2-80, San Luis Valley, CO 109

Figure 48. Relative frequency of use and location of tree perches within the home range of eagle #4-80, San Luis Valley, CO 110

Figure 49. Relative frequency of use and location of tree perches within the home range of eagle #5-81, San Luis Valley, CO 111

Figure 50. Relative frequency of use and location of tree perches within the home range of eagle #8-81, San Luis Valley, CO 112

LIST OF FIGURES—Continued

Page

Figure 51. Bald eagle roost sites in the San Luis Valley, CO, 1980, 1981. * indicates major roost sites ($\bar{x} \geq 10$ eagles/night). x indicates roost lost to installation of center pivots. 115

Figure 52. Group centroids, ranges of discriminate scores, and relative magnitudes of variables that discriminate most between used and nonused bald eagle roost sites on the Rio Grande and Conejos Rivers, San Luis Valley, CO 120

Figure 53. Group centroids and discriminate score ranges of bald eagle roost site use categories using the most discriminating variable selected for the Conejos River (actual) to predict use of sites on the Rio Grande River (predicted) San Luis Valley, CO 122

Figure 54. Group centroids and discriminate score ranges of bald eagle roost site use categories using the most discriminating variables selected for the Rio Grande River (actual) to predict use of sites on the Conejos River (predicted), San Luis Valley, CO 123

Figure 55. Age class composition at roost sites in the San Luis Valley, CO, by month for all counts (n) 1980 and 1981 126

Figure 56. Bald eagle on perch structure placed in an area of high prey density in the San Luis Valley, CO. 131

Figure 57. Resightings of eagles with yellow patagial markers. GNP indicates origin probably Glacier National Park, MT. SLV indicates origin probably San Luis Valley, CO. (C) indicates confirmed origin. 133

Figure 58. Severely abraded patagium of an adult bald eagle that had worn wrap-around patagial wing tags for 5 years. 134

LIST OF FIGURES—Continued

Page

Figure 59. Centroids, ranges of discriminant scores and relative magnitudes of climatological variables that discriminate most between days bald eagles initiated northward migration from the San Luis Valley, CO and days they did not 136

Figure 60. Migration route of 3 adult bald eagles from a wintering ground in the San Luis Valley, CO, 21 March-5 April 1980. Numbers indicate radio channels. Large dot is the nesting ground of #2-80. Dotted lines indicate hypothesized route not actually documented 139

Figure 61. Migration routes (—) and summering areas (*) of bald eagles wintering in the San Luis Valley (SLV), CO 1981. (...) indicates hypothesized route, but not documented. (X_1) and (X_2) are respective 1981 and 1982 recovery locations of bald eagles banded in the SLV, January 1977. (X_3) is October 1981 recovery location of a bald eagle radio-tagged in the SLV, March 1981. Numbers indicate radio channels 141

Figure 62. Migration routes and stopover locations in Montana of radio-tagged bald eagles that wintered in the San Luis Valley, CO. A, Yellowstone River 1 km north of Sanders; B, Little Rocky Mountains 1.5 km east of Lodgepole; C, Fort Peck Reservoir 32 km north-northwest of Brussett. ---- is hypothesized route, ——— actual route through Montana 145

Figure 63. Hypothetical model of bald eagle use of the San Luis Valley, CO and the effects of important historical events 155

Figure 64. Data form for bald eagle disturbance study. 205

Figure 65. Side 1 of educational flyer distributed in the San Luis Valley, CO 1981. 206

Figure 66. Side 2 of educational flyer distributed in the San Luis Valley, CO 1981. 207

Figure 67. Bald eagle 0.5 years old. Iris is dark brown, upper mandible and cere black 208

LIST OF FIGURES—Continued

Page

Figure 68. Ventral plumage of 0.5 yr-old bald eagle. Belly is tawny and bib dark brown 208

Figure 69. Dorsal plumage of 0.5 yr-old bald eagle 209

Figure 70. Bald eagle 1.5 years old. Iris is beige with brown speckling. Yellowing of upper mandible and cere begins at the base and progresses anteriorally with age 209

Figure 71. Dorsal plumage of 1.5 yr-old bald eagle. White feathers on anterior back often appear triangular when eagles are perched. 210

Figure 72. Ventral plumage of bald eagle 1.5 years old. Note distinct dark bib and white belly. 211

Figure 73. Bald eagle 2.5 years old. Iris mostly beige, base of upper mandible and most of cere yellow. . . 211

Figure 74. Dorsal plumage of 2.5 yr-old bald eagle 212

Figure 75. Ventral plumage of 2.5 yr-old bald eagle. 212

Figure 76. Typical rectrix coloration of 2.5 yr-old bald eagle. 213

Figure 77. Full adult bald eagle probably at least 6.5 years old 213

Figure 78. Home range of an unmated adult male bald eagle #1-80, encompassing 470.9 km^2 of the San Luis Valley, CO. Lines are irrigation ditches and canals. 214

Figure 79. Home range of a mated adult male bald eagle #2-80, encompassing 184.7 km^2 of the San Luis Valley, CO. Lines are irrigation ditches and canals. 214

Figure 80. Home range of an adult female bald eagle #3-80, encompassing 215.9 km^2 of the San Luis Valley, CO. 215

Figure 81. Home range of an unmated adult female bald eagle #3-81, encompassing 540.8 km^2 of the San Luis Valley, CO 215

LIST OF FIGURES—Continued

Page

Figure 82. Home range of an unmated adult male bald eagle #4-81, encompassing 795 km^2 of the San Luis Valley, CO. 216

Figure 83. Home ranges of mated adult bald eagles #5-81 (female) and #8-81 (male) encompassing 77.2 and 66.5 km^2 of the San Luis Valley, CO respectively. Lines are irrigation ditches and canals. 216

Figure 84. Home range of an unmated adult female bald eagle #6-81, encompassing 375.8 km^2 of the San Luis Valley, CO 217

Figure 85. Home range of a mated adult female bald eagle #7B-81, encompassing 310 km^2 of the San Luis Valley, CO. 217

Figure 86. Home range of a mated adult female bald eagle #9-81, encompassing 60.9 km^2 of the San Luis Valley, CO. 218

Figure 87. Home range of an adult male bald eagle #10-81, encompassing 561.6 km^2 of the San Luis Valley, CO. 218

Figure 88. Natural water courses (line habitat type) within a 90 x 90 km study area of the San Luis Valley, CO 219

Figure 89. Irrigation ditches and canals (line habitat type) within 90 x 90 km study area of the San Luis Valley, CO 219

Figure 90. Paved roads (line habitat type) within a 90 x 90 km study area of the San Luis Valley, CO. 220

Figure 91. Gravel roads (line habitat type) within a 90 x 90 km study area of the San Luis Valley, CO. 220

Figure 92. Cities (area habitat type) within a 90 x 90 km study area of the San Luis Valley, CO 221

LIST OF FIGURES—Continued

Page

Figure 93. Crop and irrigated pasture land (area habitat type) within a 90 x 90 km study area of the San Luis Valley, CO 221

Figure 94. Valley sand and salt meadows (area habitat type) within a 90 x 90 km study area of the San Luis Valley, CO 222

ABSTRACT

Approximately 100-300 bald eagles (Haliaeetus leucocephalus) winter in the San Luis Valley (SLV) of southcentral Colorado. Between January and mid-March 1980-1981, bald eagles were captured, measured, and plumage described. An aging protocol based on plumage, iris, and mandible coloration was developed. A sexing technique was developed based on 4 measurements. Morphological differences were related to resource partitioning between age classes and sexes and also migration differences between sexes of adults. Fifteen adult bald eagles were marked with tail-mounted transmitters to study winter ecology. Over 1300 hours of monitoring showed mean seasonal home range size was 310.7 km^2. Single day movements typically covered only a small portion of the home range. Mean daily activity was 15.5% of daylight hours and monthly activity was negatively correlated with severe weather. Human activity within 150 m of an eagle perched in a tree or 760 m of an eagle on the ground usually elicited a flush response. Perch trees were usually near irrigation ditches surrounded by agricultural land. Foraging habitat consisted of areas of brushland/cropland interspersion. Habitat use shifted from upland to riparian areas as ice-out on rivers progressed. Roost site suitability appeared dependent on distance from human activity while roost site preference seemed dependent on proximity to food. Primary food was jackrabbit (Lepus spp.) throughout the winter but varying proportions of fish and waterfowl occurred dependent on availability. Use of the SLV by wintering bald eagles is probably relatively recent and coincident with agriculture. Advancing monoculture will probably result in fewer eagles using the SLV in the future. Age ratios in wintering areas are most likely a reflection of food availability and type rather than indicative of population trends. Six eagles were tracked on spring migration. Two eagles were followed to a nesting ground and 2 others found in their summering area, all in northeastern Saskatchewan. Migration routes and wintering areas of adult bald eagles appear to be related to the watershed in which summering grounds are located.

INTRODUCTION

Considerable public and professional attention has been focused on the bald eagle (Haliaeetus leucocephalus) since the late 1960's, when DDT and its metabolites were associated with poor reproduction and drastic decreases in numbers (Krantz et al. 1970, Wiemeyer et al. 1972). Investigations also revealed that severe losses of winter and summer habitat were contributing to the decline of this species. As a result, in 1978 the bald eagle was classified as endangered (threatened for Alaska, Michigan, Minnesota, Oregon, Washington) in the entire contiguous United States (U.S. Code of Federal Regulations: 43; 6233, 14 February 1978). Implicit in this classification is the need for more complete knowledge of the species and its habitat requirements to insure its survival.

The importance of winter habitat to populations of other avian species has been shown (Eng and Schladweiler 1972, Fredrikson and Drobney 1979). The quantity and quality of winter habitat available may determine the number of migrant birds returning to the summering grounds in breeding condition (Chadbreck 1979). With the reduction of DDT use, winter habitat may become a more critical factor in maintaining future populations of bald eagles. Each year, approximately 3,000-4,000 bald eagles winter in the Rocky Mountain region of the U.S. (Spencer 1976, National Wildlife Federation winter count 1982). Fewer than 110 pairs are known to breed in this region and the

majority of wintering birds are presumed to summer in central and northern Canada. This implies that certain habitats in the lower 48 states are essential to the maintenance of a large percentage of the existing continental population.

Few data are available concerning specific aspects of this bird's winter ecology. Home range size, habitat selection and use, food habit variability, age/sex composition of the population, individual fidelity to wintering areas, roost site choice, and intra- and inter-specific competition are all aspects of the biology of bald eagles that are poorly understood. A better understanding of these factors will be of great value in development of management plans.

Bald eagles wintering in the U.S. seem to be associated with 2 main types of habitat. Some appear to be primarily associated with riparian habitats such as the Mississippi and Missouri River Systems relying heavily on fish and/or waterfowl as food (Fawks 1961, Steenhof et al. 1980, Fisher et al. 1981). In contrast, in southern Colorado (Harmata and Stahlecker 1977), central Utah (Edwards 1969) and eastern Montana (Swenson et al. 1981), eagles are associated with upland habitats characterized by prairie grassland, agricultural valleys, and mountain parks and appear to rely heavily on ungulate carrion and lagomorphs which they kill or take as carrion (Harmata and Stahlecker 1977).

Habitat used by eagles during migration is equally as important as winter and summer habitat. Certain aspects of bald eagle migration have been largely ignored due primarily to the lack of developed techniques and logistical problems. Nestling bald eagles banded and

marked in northcentral Saskatchewan have been recovered or seen in Arizona, New Mexico, Utah, Wyoming, Colorado, and Montana (Gerrard et al. 1978). However, no information is available as to the exact origin of adult eagles wintering in these states. Immatures of several raptor species have been shown to wander considerably prior to selecting a breeding site (Brown 1977, Newton 1979). Thus, the breeding grounds of adult bald eagles wintering in the Rocky Mountains may be entirely different from those indicated by movements of immatures.

From January through March 1977 and 1978, 36 bald eagles were colormarked with yellow patagial wing markers in the San Luis Valley (SLV) of southern Colorado (Harmata and Stahlecker 1977). Although significant data concerning wintering ground fidelity, distribution, sexing and capture techniques, and aging by plumage were gathered, the primary objectives of determining winter home ranges, migration routes, and summering grounds were not realized by the marking program. This was due partially to difficulty of maintaining extended observation of colormarked eagles and researchers in other areas of the west also using yellow patagials. The origin of yellow-marked eagles subsequently sighted outside of the SLV was therefore questionable since the marker letter was usually not recorded. Only 3 sightings outside the SLV were of confirmed origin and none were in an established nesting area or during summer.

In 1978, radio-tracking colormarked individuals provided more unique information, but inadequate funding and manpower problems prevented complete description of home ranges and ecology of wintering

eagles. However, 1 adult female eagle that was radio-tagged left the SLV on 28 February 1978 and was subsequently tracked for 2 days and over 300 km of her northward migration. This effort established the feasibility of an expanded project designed to determine breeding areas and migration routes of the population.

Between 1 January and 30 April 1980 and 1981, research was conducted on bald eagles in the SLV. Objectives of this study were to: (1) document the ecology of adult bald eagles wintering in an upland area in Colorado and to describe habitats used within that area, (2) determine the exact breeding grounds of adult bald eagles from a distinct wintering population in the Rocky Mountain region, and (3) gather information regarding migration routes, duration, stopover habitats used, and other factors affecting the successful completion of migration. Information concerning ecology and movements obtained during this period was further supported by sightings and encounters of eagles banded and marked in 1977 and 1978 and reported between January 1977 and February 1983.

STUDY AREA

Geography and Hydrology

The San Luis Valley (Fig. 1) located in southcentral Colorado is the largest of 4 large intermountain basins in Colorado. The periphery of the valley floor is approximately 2,440 meters (m) above MSL and at its longest and widest extent is about 161 and 130 kilometers (km), respectively. The SLV encompasses approximately 6,475 km^2, approximately the size of the state of Delaware. It is bounded on the west by the San Juan Mountains and on the east by the Sangre de Cristo Range. These 2 ranges meet at the northern end of the valley and exceed 3,050 m in elevation. Nine peaks over 4,250 m are visible from the central valley. Mean elevation of the nearly level valley is 2,286 m.

The SLV is geologically young and is an intermountain basin filled with alluvium, volcanic debris, and tuffs of Oligocene to Holocene origin (Larsen and Cross 1956). Most of the area was occupied by an extensive lake in the early Pleistocene. Many peripheral streams flowing from the surrounding mountains filled the valley with deposits of up to 910 m deep (Gaca and Karig 1966). This left the valley floor level after the lake outlet at the south end became so deep that the lake was drained (Ramaley 1942).

Two major rivers now flow through the SLV. The Rio Grande emanates in the San Juan Mountains to the west, enters about mid-valley, and

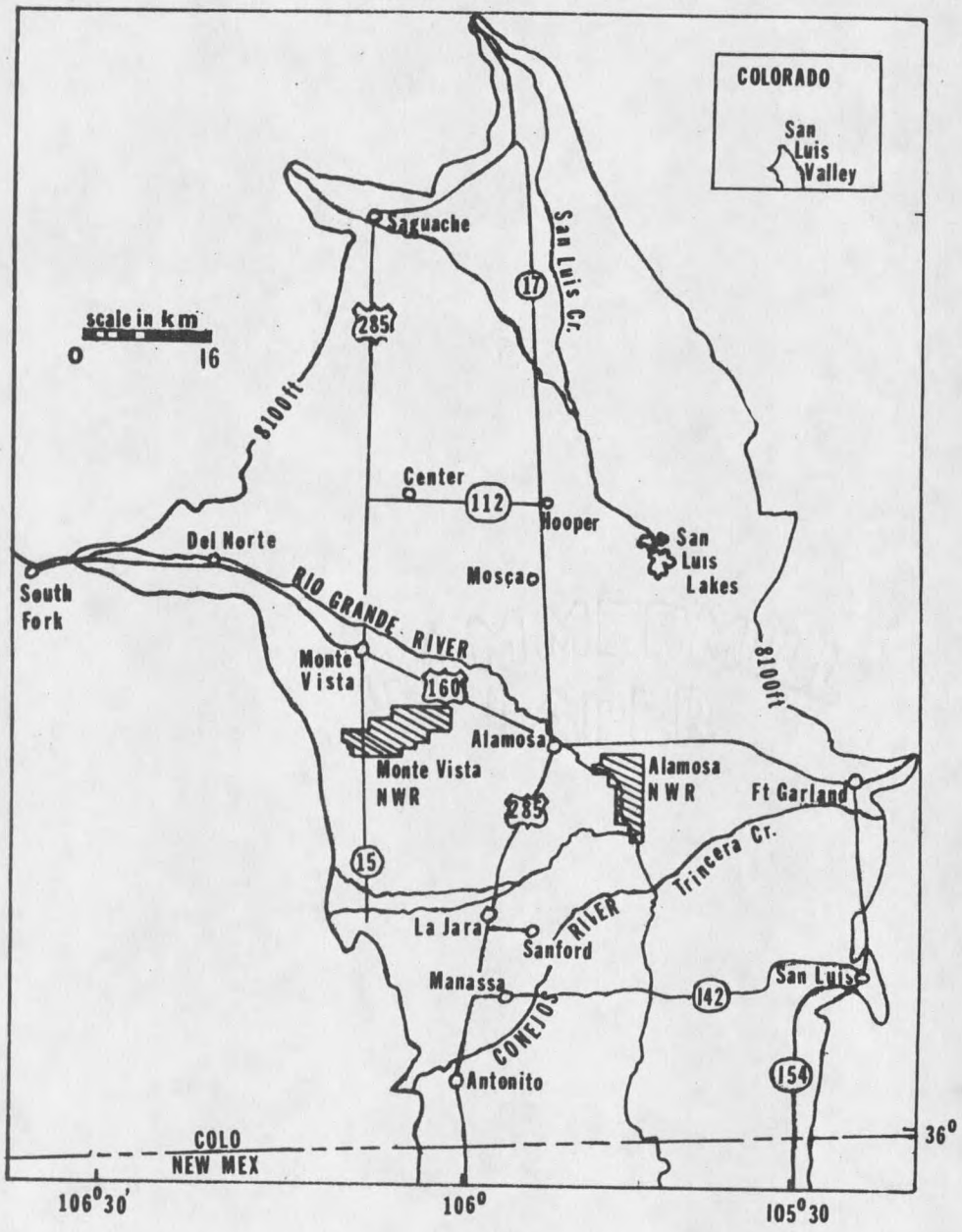


Figure 1. Locator and political map of the San Luis Valley, CO.

flows generally east then south. The Conejos River also begins in the San Juans but enters the valley farther south and flows northeast to the confluence with the Rio Grande River (Fig. 1). The total annual water supply to the SLV averages 2.5 million acre-feet. About 60% is streamflow, collected from about 12,200 km^2 of surrounding mountain watershed. Precipitation on the valley floor contributes the remainder (Emery 1972). About 80% of the annual water supply is lost primarily through evapotranspiration of phreatophytes such as greasewood (Sarcobatus spp.) rabbitbrush (Chrysothamus spp.), and salt grass (Distichlis spp.) (Emery 1972).

Ground water is derived from unconfined and confined aquifers. The depth to water in the early 1970's averaged less than 3.6 m and the unconfined aquifer extended from 0 to 60 m below the surface. Recharge to the unconfined aquifer comes primarily from infiltration of peripheral streams, leakage from ditches and canals, applied irrigation water, and seepage from the confined aquifer. All streams flowing into the northern half of the valley are emptied by percolation into beds of sand at the edge of the valley floor (Fenneman 1931) where a deeper clay layer is absent. Water drains towards the valley center and is trapped under the layer of clay recharging the confined aquifer. The only outlet is through artesian wells (Hopper et al. 1975). Between 1910 and the 1970's irrigation water from the major rivers raised the level of the unconfined aquifer between 1 and 2.5 m (Ramaley 1942, Dillon 1981). There is a daily fluctuation in the water table of between 2.5 and 20 centimeters (cm), reaching its lowest stage at 1800 to 1900 hours (hrs) MDT then rising until 0900. The amount and

timing of the fluctuation presumably depends on evapotranspiration of plants and evaporation from the soil.

Climate

Classified as cold desert (Lantis 1949) the SLV has cool dry summers and cold winters. Mean annual temperature is 5.5 centigrade (C). Nighttime temperatures in January commonly reach -30 C and occasionally lower than -45 C. Precipitation averages less than 30 cm per year and is lowest in the central valley (Ramaley 1942). Snow depths seldom exceed 15 cm, with average annual snowfall about 63.5 cm (Colorado State Planning Division 1964). Humidity is low, and evaporation high. Ramaley (1942) reported a summer average humidity of 41% and an average per annum evaporation of 126.8 cm, the highest of all Colorado recording stations. Winds prevail from the southwest and are strongest in late March and early April, when entire days with 40 km per hour (km/hr) winds are common. Sunny weather predominates and seldom are there more than 5 days per month with cloud cover of 75% or more.

Vegetation

The valley floor is approximately 70% brushland. The vegetation of the northern valley, with a high water table and alkaline soils is primarily black greasewood (Sarcobatus vermiculatus) also known as chico, and inland saltgrass (Distichlis stricta). In the southern valley, with a lower water table rabbitbrush (Chrysothamnus spp.) predominates (Costello 1954). Big sagebrush (Artemisia tridentata) is common on well drained margins of the peripheral valley.

Artesian wells and high water table have created many wetlands. Vegetation in natural lakes, ponds, marshes, and wet meadows consists primarily of spike sedge (Eleocharis spp.), baltic rush (Juncus balticus), and sedges [Carex spp., (Hopper et al. 1975)].

River bottom forest/shrub communities consist mostly of cottonwood (Populus angustifolia) and willows (Salix spp.), with rabbitbrush, roses (Rosa spp.), currants and gooseberries (Ribes spp.). Common grasses include wheatgrass (Agropyron spp.), blue grama (Bouteloua gracilis), smooth brome (Bromus inermis), muhly (Muhlenbergia spp.), bluegrass (Poa spp.), and dropseed (Sporobolus spp.). In more mesic riparian areas, Smilacina spp. and meadow rue (Thalictrum spp.) are common.

Human History and Ecology

The Folsom points which many SLV residents own are mute testimony that humans inhabited the valley more than 10,000 years ago. Folsom culture is thought to have come to the SLV via the eastern plains, as nomadic hunters wandered down the front range of the Rocky Mountains and into the valley in pursuit of game (Roberts 1948).

On 8 September 1598, Don Juan de Oñate of Spain and governor of New Mexico, established the first permanent European settlements in the New World after St. Augustine. These settlements were on the southern tip of the SLV in present day New Mexico (Simmons 1980). The first European to set foot in Colorado was actually Juan de Archuleta in 1664. He entered the SLV while chasing runaway Indian slaves from Taos (Hafen 1948).

By 1807 when the first Americans entered the SLV, a road on the eastern side of the valley was "well worn" (Jackson 1966). This road was used by the Spanish as a supply route from Taos to forts just east of the Sangre de Cristos on the Arkansas and Huerfano Rivers.

Thomas Jefferson charged Lt. Zebulon Montgomery Pike to explore the Louisiana Territory, and on 28 January 1807 Pike entered the SLV from the east. He spent most of the winter along the Conejos River. Other surveys entered the SLV in the mid 1800's to map railroad routes and document geography and natural history. The Hayden Survey looked for a railroad route and documented natural history in 1873 and 1874 (Toll 1929). The Wheeler Survey was the first to map the SLV in June 1875 (Bartlett 1962).

Today the SLV supports a population of over 36,000 people, most of whom live in 3 central valley counties: Alamosa, Rio Grande, and Conejos. Major population centers are Alamosa, Monte Vista, Center, Del Norte, and LaJara (Fig. 1). The remaining population is somewhat evenly distributed throughout the remaining 2 counties of Sagauche and Costilla. The economy is based on irrigated crop production and commercial livestock enterprise. The SLV is noted for its potato industry and the production of high quality barley, the latter used primarily for ingredients in Coors beer. Approximately 25% of the valley (128,600 hectares) is cultivated (Dillon 1981). Crops in descending order of planted hectares (ha) are: alfalfa, barley, grass hay, potatoes, spring wheat, and oats. Sheep operations seem to outnumber cattle ranches, especially in the central valley.

Flood and subirrigation were the primary means of irrigation prior to the late 1960's. Water for irrigation was derived at the time from the major rivers (Rio Grande and Conejos) and mountain streams (Alamosa, Saguache, Trinchera, and LaJara creeks) in addition to existing artesian and shallow wells. Many large canals were built between 1880-90 to irrigate the eastern and central part of the valley and many new cottonwood stands were established as a result. Intensive irrigation early in the century artificially raised the water table rendering originally valuable cropland useless by 1920. The water-soaked condition of previously tillable land increased the soil salinity and some soils now have a pH of 9.0. These areas, long since left fallow have returned or are returning to their native condition of greasewood, rabbitbrush, native grasses, and herbs (Ramaley 1942).

Since 1975 the use of center pivot irrigation systems has proliferated. These systems are much more efficient than flood irrigation often increasing yields by 120%. Center pivots require flat unobstructed fields, averaging 0.6 km^2 but often as large as 2.59 km^2. These systems do not normally utilize ditch or river water, but well water derived from artesian or drilled wells. Consequently, the number of large capacity wells (>1300 liters per minute) has increased dramatically since 1975, depleting the water resource in the shallow (unconfined) aquifer. Wetlands which existed prior to the arrival of European man in the SLV are drying up because the aquifer is not being recharged. As of January 1982, 1,724 center pivots were operational in the SLV (Fig. 2) and the number increases an estimated 10% per year. A moritorium on new wells has been imposed in some areas of the valley.

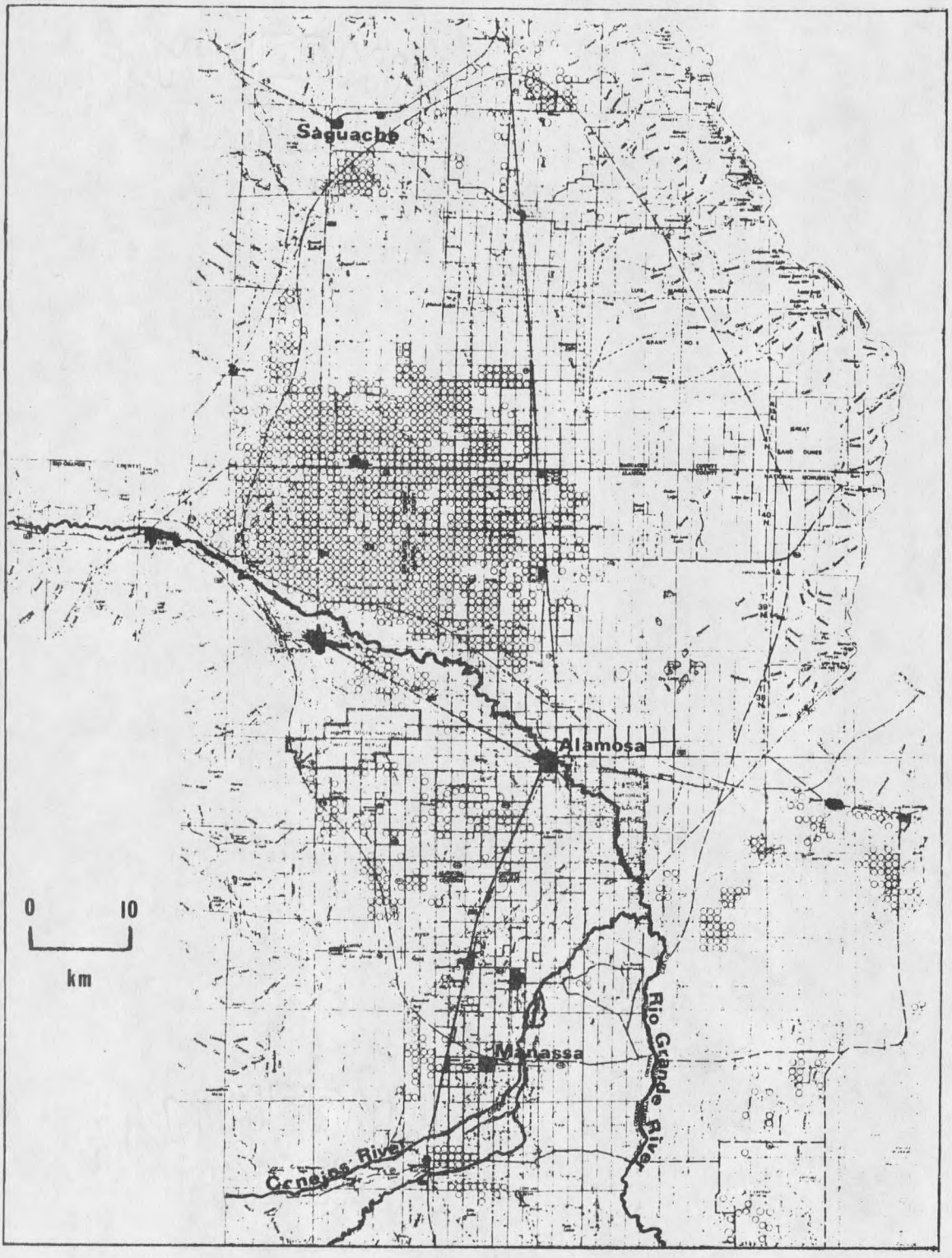


Figure 2. Distribution of 1,724 center pivot irrigation systems as of January 1982. (Courtesy Colorado State University Cooperative Extension Service, Alamosa, CO)

The proliferation of these systems also has changed the face of the valley dramatically. Cottonwood stands throughout the valley are being lost at an alarming rate and the amount of brushland is being reduced. Trees along unused irrigation ditches and now dry stream beds are dying or have died and disappeared, due to lack of water. Other trees and stands have been and are being removed to clear a path for new center pivots. Herbicide and pesticide use is increasing coincident with an advancing monoculture.

Historical Use by Bald Eagles

The earliest documented sighting of a bald eagle in Colorado was on 29 July 1839 in Grand County about 200 km north of the SLV (Marsh 1931). First mention of wintering bald eagles in Colorado concerned sightings on the eastern plains (Cooke 1897). Spanish expeditions to the SLV in the 17th and early 18th centuries and American expeditions in the 19th century made reference to wildlife in the SLV but none mentioned eagles. References by Spanish (Thomas 1932) and American expeditions (Sanford 1933, Jackson 1966) to abundance of fish and waterfowl indicate a food base capable of supporting eagles was present.

Earliest records of bald eagles in the SLV were made by Ryder on 7 April 1949 and Armagest on 19 February 1950 (Ryder 1965). By 1955 bald eagles often were seen in winter and commonly recorded at the Monte Vista and Alamosa National Wildlife Refuges (Ryder 1965, Alamosa NWR narratives 1954-1983). Each winter from 1976 to 1979, personnel

from the U. S. Fish and Wildlife Service (USFWS), the National Audubon Society (NAS), and the Colorado Division of Wildlife (CDW) conducted an aerial survey of the SLV for eagles. Random north-south transects were flown over a 10% portion of the valley in January. Bald eagle winter population estimates of 280, 180, 150 and 130 were calculated for the entire valley during 1976-1979 respectively (Craig 1981).

METHODS

Capture

All bald eagles were captured by a modified "Lockhart" method (Miner 1975) which Harmata and Stahlecker (1977) found more successful than cannon nets and bownets. This method, originally developed for capture of golden eagles (Aquila chrysaetos), utilizes leg-hold traps placed around a small animal carcass with a live lure eagle placed nearby. The presence of the live lure also deters non-target birds and mammals from the bait.

Double long spring leg-hold traps, #3 or #3N, were used exclusively. Number 3N traps were preferred since stake down chains are more substantial and less likely to become entangled in the environment and jaws are offset. Each trap was padded with 2x20 cm strips of latigo leather wrapped barber-pole style around each jaw. The leather was secured with vinyl electrical tape, wrapped in a similar manner. Soft padding material such as foam rubber was not used since it allowed an eagle caught by only the talons to escape. Jump traps were not used because these traps grasp the eagle around the leg (tarsus) when sprung. Catching an eagle by the toe is preferable and less injurious. Lockhart (pers. comm.) also found jump traps less efficient for capturing golden eagles. The stake-down chains of 2 traps were wired together to form pairs. Trap springs were not weakened,

but new traps were not used. Springs of new traps are substantially stronger than well used traps and are potentially dangerous to eagles.

A pad of 7.6 cm thick fiberglass building insulation was cut to fit under the trigger pan and between the jaws. The pad insured that soil would not fill in under the pan and impede release of the jaws when triggered. Insulation was used rather than traditional pancovers because it saved time in trap placement and allowed for differential trigger pressures. Common ravens (Corvus corax) and black-billed magpies (Pica pica) often are attracted to carcass baits and may walk over the traps many times, gradually depressing the pan and eventually setting off traps equipped with traditional pan covers. Insulation provided sufficient resistance and resilience to return the pan trigger to a pre-set position each time a bird lighter than a raptor depressed it, reducing captures of non-target birds.

Trapping operations during 1977 and 1978 were designed to capture as many bald eagles as possible, regardless of age. In 1980 and 1981 efforts were directed at capturing only adult mated bald eagles. Observations during 1977-78 indicated that a portion of the SLV eagles wintered as mated pairs. Often 2 eagles remained separated from others during the day and were thought not to go to communal roosts at night. Other pairs using communal roosts apparently foraged together during the day but were seldom in association with other eagles.

Trap sites were chosen after at least 1 week of observation each year. Observations revealed specific trees or groves of trees frequented by pairs of bald eagles in the study area. Since sexual dimorphism in bald eagles is manifested in size differences, trap

sites were subjectively chosen on the basis of frequency and duration of the presence of 2 adult bald eagles of distinctly dissimilar size.

Most trap sites were in areas unused by livestock and on small mounds that could be observed at least 1 km away. Trap sites were no closer than 50 m from fences or irrigation ditches and as far as possible from shrubs.

In 1981, after 4 adult eagles presumed to be mated and from 4 different pairs were captured, trap sites were placed in areas where eagles congregated, but emphasis remained on capture of adult bald eagles. Less emphasis was placed on capture of mated eagles because time expended on determining trap sites detracted from time spent monitoring previously captured eagles. No trap site was within 3 km of a known roost site.

The wariness of adult bald eagles dictated that all traps be set in darkness. Sets were usually made in the evening between 1700 and 0000 hrs for trapping eagles the following day. Trap setting at this time insured that eagles were either at communal roosts out of sight or were unable to associate bait carcasses with humans. Because wind greatly increased the lift capacity of an eagle, no sets were left operational in winds over 20 km/hr.

Previous trapping operations in the SLV (1977-78) indicated that golden eagle lure birds often discouraged extremely wary adult bald eagles from visiting a bait. Therefore, trap sets without lure birds were used most often. However, an immature bald eagle or an immature golden eagle also were used to determine the best lure for attracting and capturing immature and adult eagles of either species. The lure

birds were transported in a large wooden box designed and built specifically for that purpose. At trap sets where lure birds were used, sets were made just prior to sunrise or during early morning to reduce the possibility of lure birds being injured or harrassed by great horned owls (Bubo virginianus), coyotes (Canis latrans), bobcats (Lynx rufus), striped skunks (Mephitis mephitis), or feral and domestic dogs (Canis familiaris) during the night.

Snow cover was removed from the trap site. Absence of snow cover possibly helped alert foraging eagles to the presence of a carcass. The carcass of a jackrabbit (Lepus spp.) was placed on its side on the ground. Four traps (2 pairs) were set and 1 each placed close to head, back, tail, and belly of the rabbit. The bait was then removed and depressions for all traps and chains were excavated. Before placing, each trap was set and sprung 10 times to eliminate any rust or metal burrs on the jaws that would impede quick and complete closure. Insulation pads were placed under the pan triggers and the triggers set so that maximum pressure was needed to spring the traps. The traps were then placed in position (Fig. 3) and completely but lightly covered with fine soil, often brought to the site in buckets. Trap chains were not staked down nor run under the bait carcass position. Snow was not used to help conceal traps. Snow would melt and refreeze, fouling the traps. To prevent fouling of the traps by an eagle dragging the bait over the set, the rabbit was secured with binding wire attached to the heads of the 60d spikes driven into the ground near the head and pelvic region. The securing wire was concealed within the fur. To simulate a raptor kill, fur was plucked from the thoracic

region of the rabbit and allowed to drift away with the wind, and the carcass opened to expose blood and viscera. Human urine was liberally deposited around the trap site in order to repel carnivorous mammals.

If a lure eagle was used, a 45 cm government trap stake was driven into the ground about 1.5 m (Fig. 4) from the bait leaving about 5 cm exposed. The leash of the lure eagle was secured with a falconer's knot under the top washer of the stake and the stake driven completely into the ground. The lure eagle was presented with just enough food for satiation just prior to leaving the site. Feeding prevented repeated attempts by the lure eagle to obtain the bait while presenting an additional incentive to foraging eagles since feeding eagles attract other eagles (Knight and Knight 1983). Traps were checked in daylight every 30 minutes or watched continuously.

Handling and Marking

Eagles captured in leg traps were approached with slow deliberate steps. Most eagles attempted to escape, dragging the traps 10 to 30 m, then remained motionless with wings outstretched (Fig. 5). The untrapped leg was secured first, and the trap removed. Eagles were restrained by both tarsi and either cradled in 1 arm or "slung" over a shoulder with head upright and above the trapper's head, while being transported to the processing site. If not processed immediately, eagles were wrapped in a field jacket and transported in a prone position to prevent respiratory distress.

All eagles were processed by at least 2 persons. Eagles were placed in a supine position on the tail gate of a pickup truck, feet

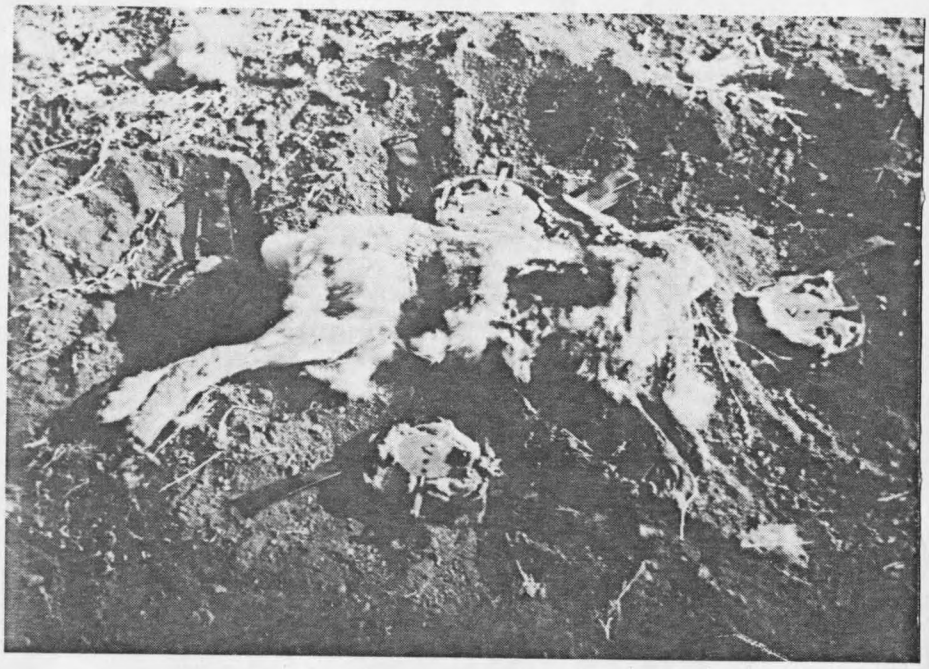


Figure 3. Placement of leg traps around jackrabbit carcass for capture of eagles. Traps were then covered with fine soil for concealment.



Figure 4. Trap site with bald eagle lure. Lure bird was placed no closer than 1.5 m to the bait. Flat open areas were preferred.

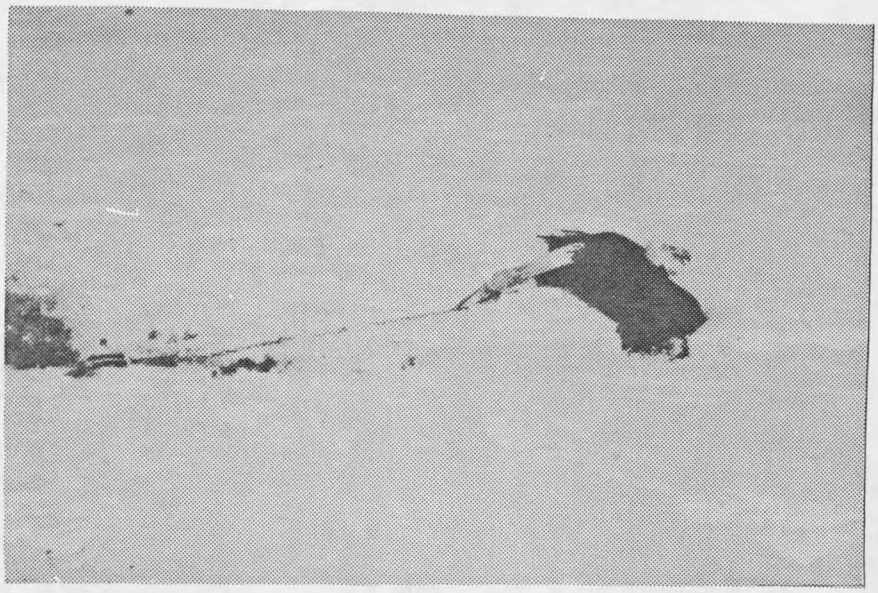


Figure 5. Adult bald eagle captured by the modified Lockhart technique.

restrained, and head covered. No hoods, foot bags, trusses, harnesses, or tape were used to restrain captured eagles.

All adult eagles were radio-tagged with Telonics 1B5 configuration transmitters mounted proximo-ventrally on the tail. Transmitter frequencies were between 148.500 and 148.950 Megahertz (MHz) with a pulse rate of 60 beats per minute and an associated life expectancy of 5+ months. Dimensions of transmitters were 4.1 x 2.4 x 2.0 cm. The length of the flexible whip antenna was 43.2 cm. A 7.2 x 1.8 cm tab with eight, 3 millimeter (mm) diameter holes was mounted on the transmitter to facilitate attachment to the center 2 rectrices. Complete transmitter packages (transmitter, antenna, mounting tab) weighed 50 to 57 grams (g).

After each adult eagle was banded, weighed, and measured, it was placed in a supine position with the head covered by a jacket, and isopropyl alcohol applied liberally to the undertail coverts. The alcohol matted the feathers permitting unobstructed access to the ventral calamus and rachis of the central rectrices (Fig. 6). The transmitter package was placed in position approximately 5 to 10 mm from the skin of the feather follicle and suturing points were marked on the feather shafts. The transmitter was removed and holes drilled laterally in the calamus and rachis with a 1 mm drill bit.

The drill and drill bit were fashioned from a tip cleaning tool for an oxy-acetelene gas welding unit. The tip cleaning bits were sharpened on a grinder and the brace permitted easy penetration of the feather shaft.

Vetafil, a veterinary suture material, was used to secure the transmitter to the feather shafts (Fig. 6). One side of the transmitter package was sutured tightly at 4 points to 1 feather shaft. Suture points on the other shaft were loosely tied to permit at least 1.5 cm spreading of the tail feather at the most distal suturing point (Fig. 7). The whip antenna was sutured at 2 points along the feather shaft to which the transmitter package was tightly sutured, and tied at least once distally where the shaft was too narrow to permit drilling. The antenna was allowed to protrude 20 to 25 cm beyond the tip of the tail. Each fastening point was individually tied and knots secured with a cyano-acrylic glue.

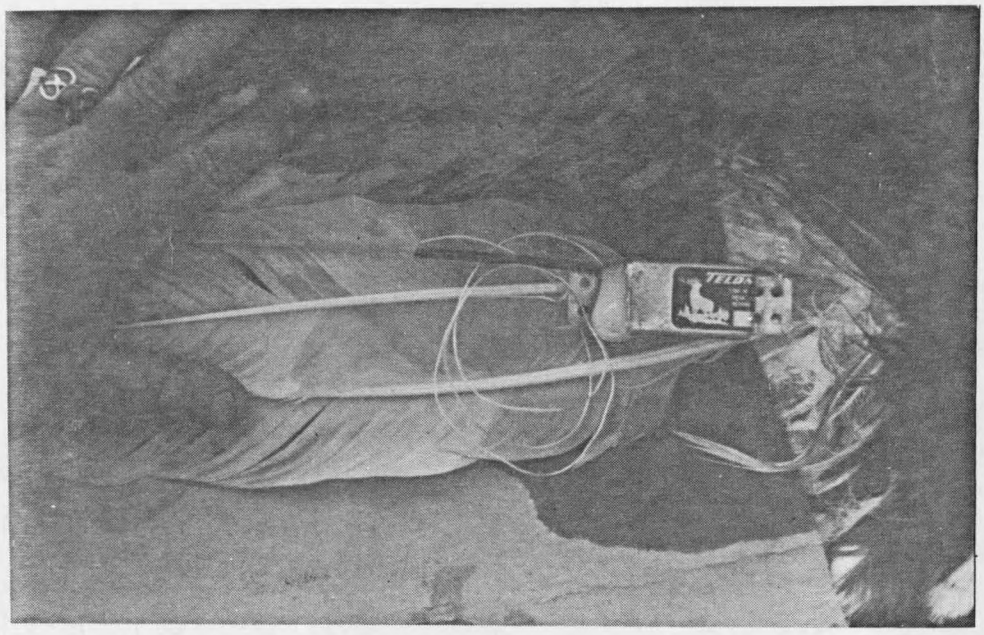


Figure 6. Radio transmitter mounting procedure on proximal ventral tail of adult bald eagle ½ complete. Note alcohol-soaked feathers permitting unobstructed access to the base of the tail.

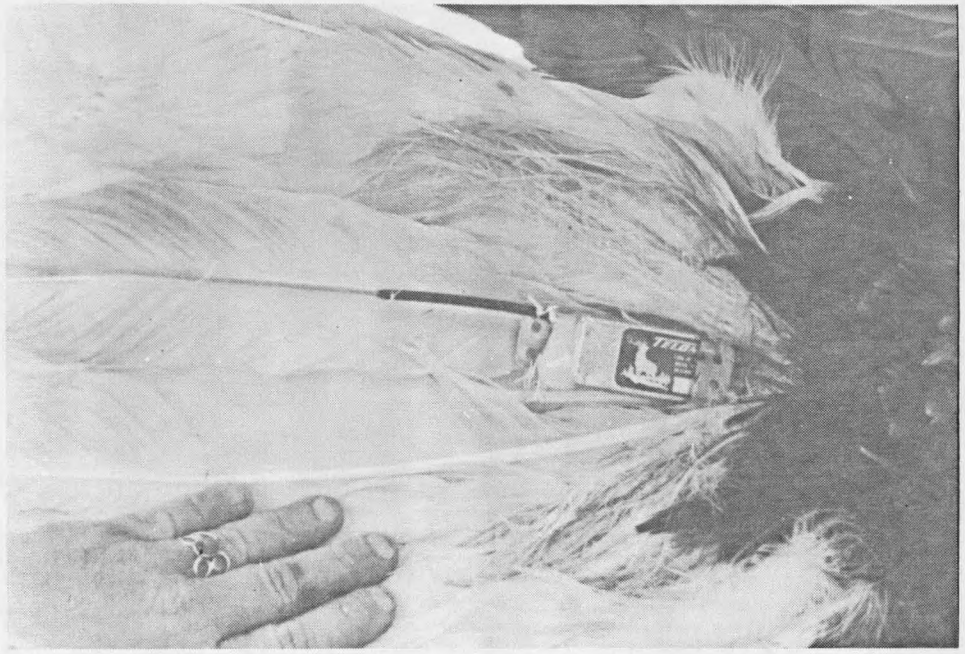


Figure 7. Completed attachment of radio transmitter to adult bald eagle tail. Note loose suture on distal left central rachis (bottom left) to permit spreading of tail.

All captured eagles were released between 0.8 and 1.6 km from the capture site. Frequently eagles returned to and continued using a perch adjacent to the trap site.

Monitoring

On the wintering ground, instrumented eagles were monitored throughout the day from a vehicle and on foot. Each tracker was equipped with a Telonics receiver (TR-1 10 channel or TR-2 programmable), an omni-directional antenna and either a Telonics 2 element "H" yagi, 3 element or 7 element High Gain yagi antenna. Large size and relatively sedentary activities of bald eagles allowed visual tracking by 1 observer per eagle rather than by triangulation as required for tracking small, highly mobile species such as prairie falcons (Falco mexicanus) (Harmata et al. 1979). The monitoring strategy was to locate the eagle via telemetry in the morning and maintain visual contact throughout the day. Telemetry also assisted in following eagles' extended flights within their home ranges when visual contact was lost. Signal characteristics permitted interpretation of movements and activity when eagles were out of sight.

Eagle activities were observed and recorded in a narrative style in a notebook as suggested by Hall and Kelson (1959), while flight paths and perches were drawn with grease pencil on an acetate covered U.S.D.I., Bureau of Land Management, San Luis Resource Area (SLRA) map, ca. 1976, 1.2 cm = 1.6 km. Movements were transferred to tracing paper overlays at the end of the day and stored for analysis. All tracings of daily movements were subsequently overlayed on a base SLRA

map and only areas actually covered by eagles were included in the home range polygons.

Attempts to follow a statistically valid monitoring regimen failed. Logistical problems and inadequate funding dictated expedient choice of the eagle to be followed each day. Consequently, most time was expended monitoring eagles judged to be mated and with ranges closest to field quarters.

Mated Status, Plumage, and Morphology

An eagle's mated status was determined by considering proximity to and time spent feeding, perching, and roosting with another eagle of distinctly dissimilar size both before and after capture, observed copulation, or association with an active nesting grounds. Remnants of a brood patch observed at time of capture assisted in determination of status. Sex was determined initially in the field by size and ultimately by measurements.

Plumage characteristics and morphology of each captured eagle were described and measured. Data were collected to: (1) use in the development of techniques to quickly age and sex bald eagles in hand under field conditions, (2) create an aging protocol to be used by observers censusing eagles during aerial surveys, (3) help determine latitudinal origin of eagles by specific measurements, and (4) determine the relationship of wing loading (Brown and Amadon 1968), aspect ratio, and tail/wing ratio (Brown 1976) to migration mechanics and activity patterns.

An aging protocol was determined from general trends of iris and mandible coloration and feather length, wear, and replacement noted on all captured birds. These trends were verified by (1) observing plumages, iris and mandible color on nestling and fledgling eagles during summer banding in the Greater Yellowstone Ecosystem (GYE), (2) inspecting plumages of 3 subadult bald eagles retrapped 1 and 2 years after initial capture as 0.5 year (yr)-old birds in the SLV, (3) observing plumages of colormarked eagles up to 6 years after being marked as 0.5 yr-old birds, and (4) inspecting plumage characteristics of 2 bald eagles banded as nestlings in the GYE and recovered 2.5 and 3.5 years later.

Culmen length and tarsal width were measured with calipers. All other linear measurements were taken with a carpenter's rule. Tarsal width was measured at the narrowest point of the right tarsometatarsus, anterio-posteriorly. Wing span was taken by slowly stretching the right wing of the eagle to its fullest extent without hyper-extending. The measurement was taken from the tip of the longest primary remige to the keel bone. Wing chord measurements were standard, but primary remiges were flat rather than relaxed. Tail length was measured dorsally from the uropygial gland to the tip of the longest central rectrix.

Wing and tail areas were obtained by tracing the outline on brown wrapping paper, tacked to a 61 x 122 x 23 cm sheet of plywood. A falconer's "rufter" hood was used during the procedure but not secured by pulling the braces. The wing was not forcibly depressed but held firmly against the paper so the outline could be traced while the

wing retained its natural curvature. Primary and secondary feathers were not spread but allowed to lie naturally against the paper (Fig. 8). The tail was traced in a similar manner, but feathers were spread in an approximate 90° arc by grasping the base of each outermost rectrix (Fig. 9).

The outlines of wing and tail tracings were electronically digitized (x-y coordinates coded to the points) on a digitizing tablet of a Hewelett-Packard 964ØA mini-computer (H-P 964ØA) running on the RTE-III operating system. Wing and tail areas were calculated by GSA2D subprogram of the GEOSCAN System (Lonner and Pexton 1983). Wing loading was determined by weight to wing area ratios. Length and width measurements were secured from wing tracings to determine aspect ratio. Tail/wing ratios were calculated for all eagles using wing span and tail X 2 length variables.

Morphological measurements of all bald eagles captured in the SLV were analyzed. The main purpose of analyses was to categorize each bird into 1 of 2 classes, male or female. Classification was based on variables defined as: WEIGHT, TAIL LENGTH, WING CHORD, WING SPAN, TARSAL WIDTH, and CULMEN LENGTH. Age was classified only as adult or immature, and determined by obvious plumage characteristics. Five birds, all males, were positively sexed either by necropsy (n = 3) or by position during copulation; their sex was included in the analyses as justification for groupings.

Initially, 2-way stepwise discriminate analysis (Program 7M, Dixon 1981) was run by a Honeywell Level-66 mainframe computer running on Honeywell's CP6 (HW-CP6) operating system at Montana State University.



Figure 8. Procedure for tracing wing area of bald eagles.



Figure 9. Procedure for tracing tail area of bald eagles.

This analysis was used to determine whether variables measured had sufficient discriminating power to distinguish among known adult and immature eagles.

Probabilities of the analysis used was assumed to be 50/50. The analysis generates a canonical correlation valve, which is roughly equivalent to an R^2, and indicates how closely the data fit the discriminate function. The resultant classification function can be used to predict group memberships, i.e. age class of eagles, for which only measurements are available.

A second computer analysis used relied on a "K-means clustering algorithm" (Dixon 1981) or pseudo-nearest neighbor approach of BMDP Program KM to determine if there were 4 natural, biological groupings within the data, and ultimately to determine the variables which distinguished sex. Three approaches were taken:

(1) Look for 4 groupings with no pregroupings, using all data.

(2) Look for 4 groups, but specifying the first level of grouping with the AGE variable (adult/immature). This approach used measurements of all eagles, but initiated with AGE groupings and split each of those groups into 2 or more.

(3) Look for 2 groupings but using only adult eagles and repeated using only immature eagles.

Using the 4 groupings determined by K-means clustering algorithm, 2-way stepwise discriminate analyses were run to determine which variables discriminated most between genders for both age classes (adult, immature). Classification functions using these variables were then

derived to be used as a technique to sex eagles of both age classes by measurements.

A dimorphism index was calculated by the method used by Storer (1966) and Snyder and Wiley (1976) using (1) all variables plus flight related statistics, (2) only variables used by Storer (1966), and (3) only flight related statistics. Indices were calculated between males and females and adults and immatures. For age class indices, adults were treated as males and immatures as females and the sign of values ignored during calculations.

Winter Ecology

Home Range and Movements

All continuous observations of radio-tagged adult bald eagles in 1980 and 1981 were converted to discrete location points. Daily movement tracings were sequentially overlayed on a base map and all perches and flight paths electronically digitized (x-y coordinates coded to points) on a digitizing tablet of an H-P 9640A. Points were digitized at 1 minute (min) intervals along flight paths. Eagles commonly sat on 1 perch for many hours, therefore a location was digitized once for every 5 min of consecutive time at a single perch. Single locations were also digitized.

All digitized points were displayed on a Tektronics 4014-1 graphics terminal that produced a copy. Seasonal home range boundaries were drawn by connecting all peripheral points in a manner suggested by Macdonald et al. (1980), while attempting to include only areas visited or flown over by eagles.

Flight paths from perch to perch (including perch to ground or roost and vice-versa) were drawn and measured on SLRA maps; flight durations were timed by chronograph. Characteristics of non-direct flights varied among individuals but generally were greater than 2 min and were considered soaring flights. Soaring flights were also most often characterized by circling while ascending or at constant altitude.

Home range areas were calculated by GSA2D subprogram of the GEOSCAN system on the H-P 964ØA. One-way and 2-way analyses of variance (ANOVA) were used to compare mean home range size among various groupings based on year, sex, and mated status. A Newman-Keuls procedure (Snedecor and Cochran 1972) was used to indicate where differences were.

Activity

When eagles are perched, activities such as hunting, loafing, and sleeping must be subjectively assessed. Activity was, therefore, defined as the percentage of total monitoring time an eagle was engaged in flight, or spent on the ground, or both. Time spent on the ground was considered active time since most eagles observed on the ground were either actively feeding or perched near other feeding eagles, presumably waiting for a feeding opportunity at a carcass. If not feeding or waiting, eagles on the ground were walking near or approaching a food source.

Since eagles are strictly diurnal, activity for individual eagles was derived by dividing the monitoring day into standard hourly intervals from 0600 hrs to 1900 hrs MST and calculating the percent of time active for all monitoring days for each eagle. Activity (A)

for interval (x) was calculated by dividing the total minutes active (t_a) during interval (x), by total min of monitoring (t_m) during interval (x), multiplied by 100. Therefore, $A_{(x)} = t_{ax}/t_{mx}$ (100). Percent activity in each hour period was averaged to obtain total percent activity for specific groups of eagles (i.e. males, females, mated).

Student's t-tests were used to compare mean activity level between various groupings based on gender and year. One-way ANOVA's were used to compare mean activity between and among months (January, February, March) for males, females, and all eagles for both years. A Scheffe procedure (Snedecor and Cochran 1972) was employed to determine which months were different.

A Winter Severity Index (Picton and Knight 1971) correlated monthly activity for all eagles with meteorological conditions. Local Climatological Data Monthly Summary Sheets containing data recorded at Alamosa, CO (Fig. 1) were obtained from the National Oceanic and Atmospheric Administration (NOAA), Asheville, NC 28801. Average temperature was chosen as an indicator of severity. Stalmaster (1981) determined that the lower critical temperature for captive bald eagles was 10.6°C. Therefore, a temperature of 10°C was chosen as a transition point for the Winter Severity Index. Average wind velocity during daylight hours was chosen as a multiplier of low temperature effects. However, since Steenhof (1983) found the highest portion of eagles foraging during winds 15-20 km/hr, these average wind velocities were considered to ameliorate low temperature effects. Velocities <15 and >20 km/hr compounded low temperature effects.

Eagle Responses to Human Activity

Data on behavioral responses of bald eagles to human activity were collected during the winter and spring of 1981. Any human activity that caused a bald eagle to flush from a perch was defined as a disturbance.

Human activity and bald eagle responses were documented throughout the SLV. Human activity beyond 760 m from the affected eagle was not recorded due to the possibility that the factor actually causing the behavioral response may have been undetected by the observer. Parameters of human activity that were considered important were recorded on a data form (Appendix, Fig. 64). An observation was composed of the type of response of 1 bald eagle to human activity within 760 m. Eagles in their first year (0.5 yr-olds) were referred to as juveniles, 1.5 through 3.5 yr-olds were grouped as subadults and 4.5 yr-olds and older birds recorded as adults. Volume of sound was used as the criterion for classifying the intensity of human activity. The volume at the site of the eagle was subjectively determined. A Rangematic, Mark V, optical range finder was initially used to increase field personnel's ability to estimate distance. Weather conditions were those on site at the time of observation. Other variables are explained on the data form (Appendix, Fig. 64).

Response was treated as the dependent variable and all others were treated as independent variables. Data were mostly categorical, therefore, frequency and crosstabulation (contingency) tables were used in data analysis. Tables were constructed on the HW CP-6 computer using the Statistical Package for Social Sciences (SPSS) subprogram

CROSSTABS (Nie et al. 1975) to search for possible relationships between response and each independent variable. Variables were subsequently recoded and those showing no relationships were dropped.

Stepwise multiple regression with dummy coding of variables using the SPSS REGRESSION subprogram was performed to identify important sets of independent variables. The dependent variable, response, was coded as only presence or absence of response to human activity. A log linear, multiway frequency model (BMDP Program 4F; Dixon 1981) was used to confirm relationships between independent variables and their effect on response.

Habitat Selection

Habitat selection by bald eagles in the SLV was assessed by comparing used perch/habitat relationships to habitat relationships of points of nonuse. "Habitat types" were mostly vegetative associations, but also included roads, cities, plant and soil associations, rivers, etc. GEOSCAN (Lonner and Pexton 1983), a computer based system that correlates animal locations with geographic/habitat data was used to quantify perch/habitat relationships. Discriminate analyses were run to determine the most important variables that distinguished between observed (used) and expected (nonused) perch locations.

Only a portion of the SLV was used for analysis of habitat selection by GEOSCAN. This area contained all bald eagle locations but size was determined primarily by scale of available land use and terrain maps in conjunction with size of the digitizing tablet.

Habitat types within the study area were digitized on a H-P 964ØA tablet and fell into 3 groupings: points, lines, and areas. Although GEOSCAN has the capacity to use a fourth variable, topography or uniform grid, the SLV is flat and topography was not included in the analysis. Natural plant community associations and agricultural land use (areas) were digitized from U.S. Dept. of Agriculture, Soil Conservation Service Land Use and Natural Plant Communities, 1:126,270 maps of each county. Roads, creeks, rivers (lines), houses (points), and cities (areas) were digitized from SLRA maps.

Most eagles observed perched on the ground were either feeding or waiting for a feeding opportunity; therefore, it was assumed that ground perches represented habitat in which eagles actually foraged. However, it was unknown if eagles selected tree perches in foraging areas. Tree perches may have simply represented adequate secure substrate for perching high, thereby permitting eagles with their superior visual acuity to scan foraging habitats well removed from the perch. To test this association, tree and ground perches were analyzed separately.

Input data for used ground and tree perches to be related to habitat feature data were derived from digitzed perch locations on daily movement overlays (see Home Range and Movements: 30). Nonused locations were generated from digitized points systematically distributed throughout the study area to adequately sample all available habitats.

All locations of used perches and nonused locations were input to the GEOSCAN system based in a Digital Equipment Corporation (DEC) VAX 11/780 mini-computer. GEOSCAN can build a circular area with a scanning radius of any size dependent on the user's choice, around

each used and nonused location (Fig. 10). A scanning radius was selected and GEOSCAN computed the following on command:

1) Minimum distance point to point (MDPP): the distance between a location and the nearest point (i.e. house) within the entire study area.

2) Minimum distance point to line (MDPL): the distance between a location and the nearest line within the entire study area for each line category (i.e. river, road).

3) Habitat area (A2D): the total area of each habitat type (i.e. city, cropland) contained within the scan area around each location.

4) Total edge of a habitat type (EDGE): the total linear measure (km/km^2) of the edge of a habitat type area contained within the scan area around a location.

5) Total expressions of a habitat type (EXP): the number of non-coterminous expressions of a single habitat type contained within the scan area around each location.

GEOSCAN output was transferred to HW-CP6 for analysis. A 2-way discriminate analysis (BMDP program P7M; Dixon 1981) was used to rank variables (MDPP, MDPL, A2D, EDGE, EXP for each habitat type) relative to their ability to distinguish between used and nonused perch locations. Therefore, habitat variables which discriminate well in predicting perch locations used by bald eagles were considered selected for or against by bald eagles depending on the relative value.

In these analyses, variables entered the stepwise procedure if the F statistic was above 1.0. A priori classification was 50/50,

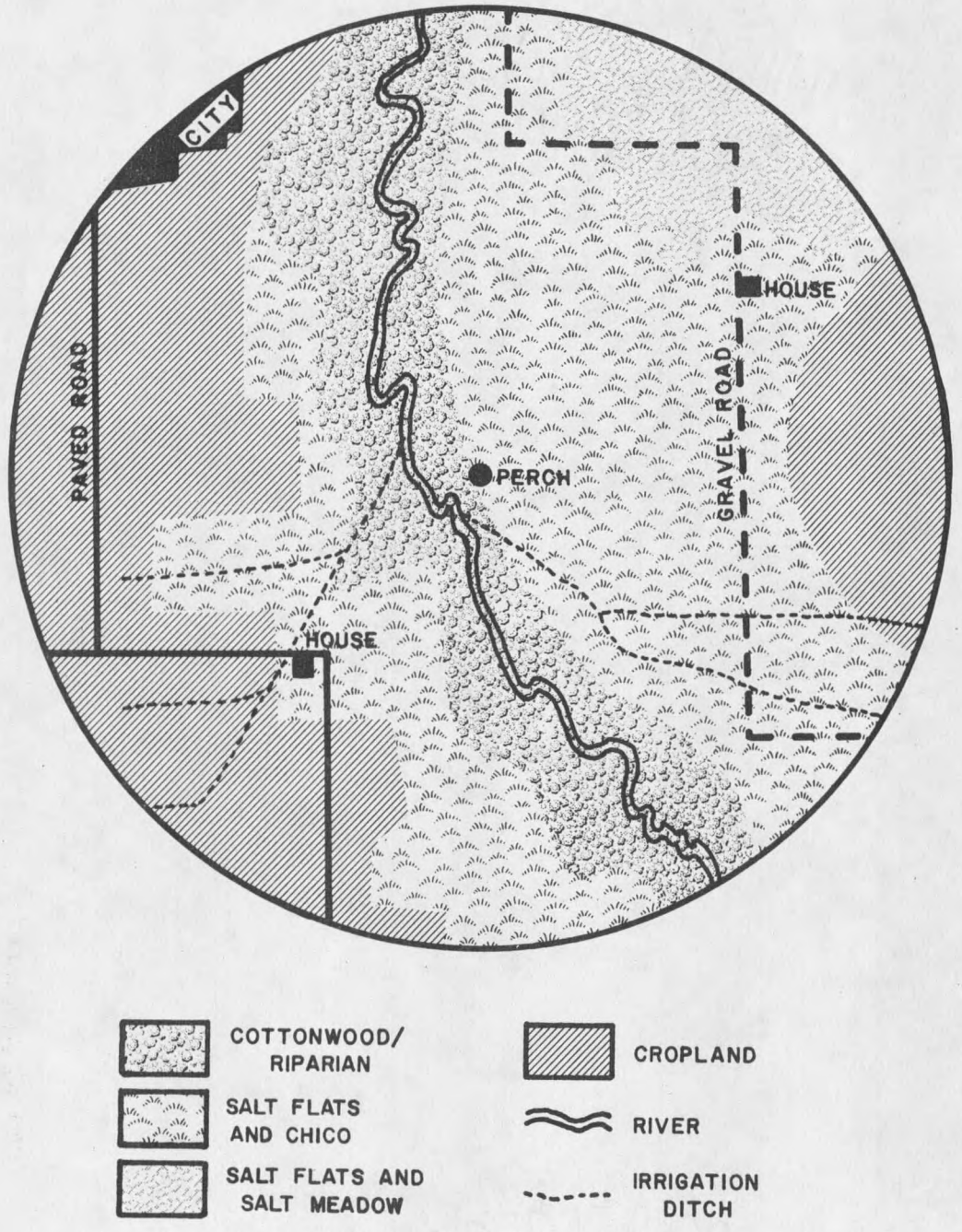


Figure 10. Scanning circle around a hypothetical perch location used by bald eagles.

since no quantified information concerning the probability of use of a site was available.

Habitat Use

Home range and frequency of tree perch use (F_p) data were used to illustrate relative area use by adult bald eagles in the SLV. Data from movements of 3 males (2 in 1980 and 1 in 1981) and 1 female in 1981, each monitored over 190 hours and presumed to be mated, were selected for analysis.

SYMAP program (Harvard Univ. 1971a) based in the HW-CP6 was used to compile X-Y-Z coordinate data for SYMVU graphical display program (Harvard Univ. 1971b) also based in HW-CP6. SYMVU using SYMAP output, produced 3 dimensional displays on a Calcomp plotter.

X-Y coordinate input for SYMAP included home range boundary coordinates and coordinates of tree perch sites. Z-coordinates were F_p. F_p was not weighted for time spent on the perch. If an eagle used a perch 3 times for 5 minutes each time, then $F_p = 3$. If an eagle used a perch once for 5 hr, then $F_p = 1$.

Roost Site Determination and Description

Ten active and 2 potential roost sites were identified in the SLV by Harmata and Stahlecker (1977). A roost site is defined here as an area containing trees in which bald eagles perch for the duration of at least 1 night.

Spatial limits of a "site" were often intuitive but usually consisted of areas no larger than 5 ha. During 1978, 1980, and 1981 radio-telemetry studies of adult bald eagles confirmed use of some of

these sites, eliminated consideration of others and discovered additional ones. Other sites were found by incidental observations coincident with radio-tracking.

Counts of eagles flying to known roosts were conducted periodically over 3 winters. The site chosen for counting each night was dependent on proximity of the nearest site at the end of each day's activities and logistical considerations. Sampling counts were not systematic nor random and known high use sites were counted more often. Counting periods normally began ½ hour before sunset and continued until ½ hour after sunset.

Roost sites containing an average of 10 or more eagles per night and/or sites used more than 5 nights by radio-tagged eagles were classified as major roosts. Trees containing approximately 30 to 50% of roosting eagles at a site were considered primary roost trees (Fig. 11).

To assess physical characteristics of roost sites, 25 parameters categorized into 4 groups were measured at 6 major roosts (Table 1). Three of the groups were physical/vegetative parameters. The remaining group was related to human disturbance. Disturbance variables measured distance between sites and the continuous presence (city) or intermittent presence (road) of human activity.

Area of the stand containing the roost site, direction of optimal view (degree of maximum line of sight distance), degrees of view (width) and distance to potential disturbances were measured on U.S. Geological Survey (USGS) county maps, 2 cm = 1 km scale and USGS 7' quad maps. Tree density was estimated by the point-centered quarter method (Mueller-Dombois and Ellenberg 1974); the primary roost tree



Figure 11. Major winter roost site and primary roost tree (arrow), used by bald eagles along the Rio Grande River, San Luis Valley, CO.

was the center point. Distances on site were measured by a Rangematic Mark V optical range finder and tree heights determined by distance, inclinometer and sine function analysis. Diameter at breast height (dbh) was measured with a dbh tape. Other variables were recorded on site.

Roost Site Suitability

A "suitable" roost site was assumed to be one which was actually used by any number of eagles for at least 1 night. Chi-square analysis was used to test for differences in distribution of roost sites within the study area. In an attempt to determine the importance of selected variables in determining roost site "suitability" the null hypothesis

Table 1. Group variables measured at bald eagle roost sites, San Luis Valley, CO.

Group							
Habitat		Tree Stand		1° Roost Tree		Disturbance	
Rubric	Variable	Rubric	Variable	Rubric	Variable	Rubric	Variable
HGS	Surrounding habitat[1]	SA*	Area (hectares)	TC	Condition[4]	DOD*	Distance to nearest occupied dwelling (km)
HNB*	Distance to vegetative break	SD*	Density 100/m^2	TH*	Height (m)	DDD	Direction to nearest occupied dwelling
HBB	Habitat beyond break[2]	SS	Side of stand roost situated[3]	TT	Trunk type	DCR*	Distance to nearest county road (km)
HPW	Prevailing wind directions[3]	SH*	$\bar{x}$ height of trees in stand	TD*	Dbh		
SINU*	Sinuosity (km of river within 0.8 km of site)	SN*	# roost trees in stand	TW*	Distance to H_2O(m)	DRD	Direction to nearest county road
				TV	Side of tree used[3]	DVT*	Distance to nearest vehicle trail (km)
				TV	Direction of optimal view degrees	DTD	Direction to nearest vehicle trail
				TM	Maximum view angle (degrees)	CITY*	Distance to nearest urban area (km)

*Continuous Variable

[1] 0 = Upland
1 = Riparian

[2] 0 = Slough
1 = Cultivated field
2 = River
3 = Brushland
4 = Grassland

[3] 0 = N
1 = NE
2 = E
3 = SE
4 = S
5 = SW
6 = W
7 = NW
8 = All
9 = Center

[4] 0 = Dead
1 = Decadent
2 = Live

that bald eagles randomly select roost sites along the timbered corridor of the river was tested. However, time and lack of funds prevented on site measurements of the same variables at nonused sites as at used sites. Therefore, USGS 7' quad maps were used to randomly select nonused sites along the 2 major rivers in the SLV. Fifteen nonused sites were selected on the Rio Grande River and 6 on the Conejos River.

A corridor was drawn on the maps along the timbered portions of the Conejos and Rio Grande Rivers. The corridor was 1.6 km wide; 0.8 km perpendicular from the center of the main channel of the river. Segments of river were selected by random numbers generator; limits represented the range of section numbers contained in the river corridor on each 7' quad map. When a section number was chosen by random numbers generator all stands (timbered areas as shown on the map) contained in that section were numbered and 1 stand chosen by random numbers generator. As most known roost sites were at the periphery of a stand, the site within the selected stand was chosen by randomly selecting a degree between 1 and 360.

Six parameters (3 physical and 3 disturbance) for used and nonused sites were measured on the map. Stand area (SA) was measured by polar compensating planimeter. River sinuosity (SINU) was defined as the total length in kilometers of all river channels and sloughs within a 0.8 km radius of the site and was determined by map wheel measure. Site distance from water (TW) was also measured. Disturbance related variables were distance to nearest occupied dwelling (DOD), distance to nearest county road (DCR) and distance to the nearest incorporated city (CITY).

Non-parametric Kruskal-Wallis tests incorporated the 6 variables SA, SINU, DOD, DCR, TW, CITY, to test for differences between used sites on the Rio Grande River and the Conejos River and between used and nonused sites on each river to determine if rivers should be analyzed collectively or separately.

A 2-way discriminate analysis (BMDP program P7M, Dixon 1981) was used to rank variables relative to their ability to distinguish between used and nonused roost sites. In these analyses, variables entered if the F statistic was above 0.99. Although there are intuitive reasons to classify certain sites in use or nonuse categories, probability cannot be determined unless based on original case memberships. A priori classification was therefore 50/50. Variables which discriminated well in predicting use of known roost sites can be used to predict the likelihood of areas of unknown use to be used or not. The values of the discriminating variables may help in management schemes designed to create suitable roost sites.

An initial analysis was performed using 6 continuous variables (SA, SINU, DOD, DCR, TW and CITY) measured at used and nonused sites on both the Rio Grande and Conejos Rivers combined. Subsequent runs analyzed each river independently and used the variables determined to be most discriminating for 1 river as a model to classify cases on the other river.

Roost Site Preference

Roost sites that supported more eagles were considered "preferred". Preference may not be due just to 1 variable but a combination of the

25 measured at each known site (Table 1). However, with data available for only 6 roost sites it is not possible to find statistically significant multiple correlations of more than 2 variables. Hence, roost site preference was examined through simple comparisons of eagle counts (mean number of eagles for all counts at each roost site) vs each individual variable.

In an attempt to explain why eagles preferred 1 roost site over another, Spearman and Kendall correlations (non-parametric) were employed (Snedecor and Cochran 1972). Levels of $P \leq 0.10$ were accepted as significant on all statistical tests.

Food Habits

Precise documentation of bald eagle food habits in the SLV became of secondary importance during the study due to its potential conflict with the primary objective of documenting movements and activity of radio-tagged eagles. This conflict arose primarily as a result of the high disturbance potential associated with collection and/or identification of food remains near perching, roosting, or feeding eagles. Often, approaching a feeding eagle close enough to determine the taxonomic category of the food item resulted in the eagle flushing and leaving the area. Conversely, waiting until an eagle or group of eagles finished feeding often resulted in no remains left to identify. Collection of food remains under roost and perch sites was difficult due to the almost continuous presence of eagles at some sites. Therefore, to partially determine food habits, remains were collected under heavily used roosts and perches only when eagles were absent, a strategy

which precluded a systematic sampling regimen. These data were supplemented by collection of debris under some perches at locations where eagles fed and evidence remained and by witnessing eagle kills.

Indigestible material regurgitated periodically by eagles, hereafter referred to as castings, were collected, bagged, identified, and dated by site for later analysis. Only complete castings were analyzed. Great horned owls used the same perches as eagles but the occasional owl pellets (casting) were easily identified by their osseous remains and appearance. Contents of castings were identified generally only to taxonomic class, but where obvious, to genus and species. One casting was considered to represent 1 individual unless 2 classes were represented. Where castings and numerous remains were found, the minimum number of recognizable prey individuals (Alt 1980) were identified. One casting plus 2 (or 1) posterior extremity plus 2 (or 1) anterior extremity represented 1 individual.

Perch Structures

Perch structures designed for use by bald eagles as day perches were constructed and placed (Fig. 12). Nonserviceable lodgepole pine (Pinus contorta) or cedar (Libocedrus spp.) electrical transmission poles, 10.7 and 12 m long were obtained from San Luis Valley Rural Electrification Association (REA). Previous observations in the SLV indicated that bald eagles seldom used man-made structures higher than fence posts for perches, so cottonwood branches 2.5 to 4.5 m long with basal diameters of 2.5 to 7 cm were used to make structures appear more "natural." An appropriate sized hole was drilled in the pole in

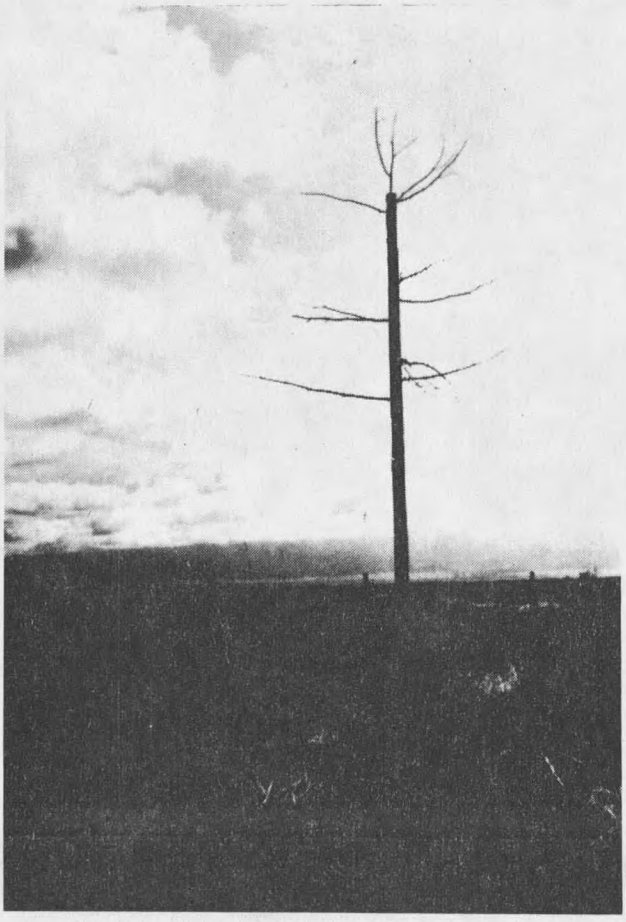


Figure 12. Perch structure for bald eagles placed in the San Luis Valley, CO, May 1981.

10 positions. Each branch and hole set was individually marked, for later assembly on site. Perches were constructed and placed between mid-April and mid-May, 1981, after bald eagles migrated north, in order to avoid their associating perches with human activity. The top 2 tiers of branches were fitted in their respective holes and secured with 16d nails. The ground hole was drilled by augur and the

pole placed in with a hoist (hoist and augur on REA vehicle). The branches of the third tier were then secured by climbing the pole.

Location of Perches. Perches were located at sites in the following priority:

(1) Sites where trees which received high eagle use had been removed. High use was subjectively determined as at least 1 eagle present during 90% of observations at that site.

(2) Sites where the food base (sheep carcasses and jackrabbits) was high and disturbance potential was low, but where no perches previously existed.

(3) Sites where trees that received moderate eagle use had been removed and disturbance was high.

Public Information Programs

Attempts to inform the public to the value of eagles, their problems, and potential solutions were made. During 1980, extended conversations with landowners whose property bald eagles frequented expended considerable time. In 1981 a poster and a flyer (Appendix, Fig. 65 and 66) were placed in agricultural supply stores where many valley farmers and ranchers congregated. Several articles in valley newspapers were published along with 1 in a major Denver newspaper.

A local public affairs radio station carried brief announcements describing the SLV bald eagle population and the study. Presentations were also made at the local Audubon chapter meetings and 3 valley schools.

Migration

Factors Associated with Initiation of Migration

Climatological data associated with days and hours that bald eagles left the SLV on northward migration were analyzed by stepwise discriminate analysis. Climatological data recorded at Alamosa, CO were obtained from NOAA, Monthly Summary Sheets. Data for days that eagles left the SLV were compared to data for randomly selected days between 1 January and 15 April 1980 and 1981 that they did not. Variables selected for comparing days were maximum temperature (MAXT), average temperature (AVGT), range of temperature (RANGE), percent of sky clear (PCTCLR), average wind speed (WINDSPD), and average wind direction (WINDIR). Climatological data recorded during the hour period closest to the time an eagle left on migration were compared to data recorded during daylight hour periods of the same day. Since eagles seldom flew subsequent to 1700 hrs, only 3 hour periods were included in the analysis; 0800, 1100, and 1400 hrs. Variables selected for hour comparisons were temperature (TEMP), WINDIR, WINDSP, PCTCLR, visability (VIS), and hour (HOUR).

Migration Tracking

Migrating eagles were followed primarily by vehicle. The receiving antenna was mounted on an external traversing mount, allowing for directional tracking while the vehicle was moving. Occasionally, when contact with the migrating eagle was lost, an aerial search was implemented. The antenna was taped to the wing strut (high wing) (Fig. 13) or step (low wing) of the aircraft and

the area surveyed in transect style with intermittent lazy circles at high altitude. Frequencies were scanned to search for the missing eagle and others. When contact was regained and the eagle's status discerned as stationary, vehicle tracking resumed.



Figure 13. Telemetry receiving antenna position on high wing aircraft. Antenna was mounted for reception of signal from front of aircraft.

RESULTS

Capture

The average time required to set traps at 1 site was 20 minutes. Total trap sets, inclusive days, and eagles captured are shown in Table 2.

Table 2. Trap days and total wintering eagles captured, San Luis Valley, CO.

Year	Trap days[a]	Days of Trapping	Eagles Captured				
			Golden Eagles		Bald Eagles		
			Adult	Immature	Adult	Immature	Total
1980	32	9	2	-	4	4	10
1981	80	25	2	14	12	15	43
Subtotal			4	14	16	19	
Total	112	34	18		35		53

[a]A trap-day is any number of traps around 1 bait presented for any part of 1 day.

Sixteen adult bald eagles were target birds. In addition to eagles 5 ferruginous hawks (Buteo regalis), 3 red-tailed hawks (Buteo jamaicensis), 2 ravens, and 1 rough-legged hawk (Buteo lagopus) were captured, banded, and released. Two other rough-legged hawks were captured and released but not banded.

Table 3 illustrates trap success for bald eagles each winter of trapping and total success for both years combined. Trap success was

greater in 1981 for all categories. Traps placed about 100 m away from heavily used perches of target eagles were generally more successful. Traps placed directly under a perch were usually unsuccessful even though adult eagles sat for hours watching the bait. When the bait was placed farther away, eagles seemed more likely to fly to the site to investigate the bait and then seemed more likely to take it.

Table 3. Trap success for wintering eagles in the San Luis Valley, CO.

	Sets[a] per Capture		Days[c] per Capture	
Year	Bald Eagle	Target Adult Bald Eagle	Bald Eagle	Target Adult Bald Eagle
1980	4.0 (25)[b]	8.0 (13)	1.12	2.25
1981	2.96 (34)	6.66 (15)	0.92	0.48
Mean	3.2 (31)	7.0 (14)	0.1	2.31

[a] 1 set is any number of traps around 1 bait presented for any part of 1 day

[b] Percentage of trap sets that actually caught eagles are given in parenthesis.

[c] Any portion of 1 day where at least 1 set was placed.

Golden eagle and bald eagle lure birds were used at 10 sets in 1981. Seven immature golden eagles and 1 adult bald eagle were captured at sets with lure eagles. Success per set was greater with a golden eagle lure but the only target eagle (adult bald eagle) captured was at a trap set with a bald eagle lure (Table 4).

Trap success using a lure bird was lower than at sets without a lure bird (Table 5). Traps with a lure bird were more successful at capturing immature golden eagles (70%) than sets without a lure bird

Table 4. Numbers of eagles captured and success of trapping technique with 2 species of lure eagles, San Luis Valley, CO, winter 1981.

Lure species	Sets	Days	Species Captured				Trap Success as Sets per capture[a]	
			Golden Eagle		Bald Eagle			
			Adult	Immature	Adult	Immature	Eagle	Bald Eagle
Golden Eagle	3	3		3			1.0 (100)	-
Bald Eagle	7	7		4	1		1.4 (71)	7.0 (14)
Total	10	10		7	1	mean	1.25 (80)	10 (10)

[a]Percent of trap sets that actually caught eagles are given in parenthesis

(12%). No set with a lure bird caught an adult golden eagle (Table 4); sets without lure birds caught 4 (Table 2). Trap sets with a lure eagle were less successful at capturing both adult and immature bald eagles than those without (Table 5).

Table 5. Trap success of sets with and without a lure eagle, San Luis Valley, CO, winter 1981.

Trap Set Type	# Sets	# Eagles Captured	Sets Per Capture		
			Eagle[a]	Bald Eagle[b]	Adult Bald Eagle
With lure	10	8	1.25 (80)[c]	10 (10)	10 (10)
Without lure	112	45	2.48 (40)	3.29 (30)	7 (14)

[a]Both species
[b]Both age classes
[c]Percent of trap sets that actually caught eagles are in parentheses.

Population Estimate

An estimate of the SLV bald eagle winter population in 1981 was calculated by a Lincoln index (Giles 1971) $N = m(n)/R$, where m = number of eagles banded to January 28, n = number of trap sets after January 28, and R = number of eagles recaptured January 28 - March 18. Population estimate was 170 bald eagles.

Few of the assumptions implicit in the Lincoln index were met. However, empirical data, i.e. survey flights and incidental observations, indicated the estimate was quite accurate, especially when viewed in the context of earlier estimates based on statistically valid sampling (p. 14).

Marking and Monitoring

Fifteen adult bald eagles were radio-tagged between 18 January 1980 and 18 March 1981. Monitoring data, mated status, sex, and age are shown in Table 6. Three eagles were tracked less than 10 hrs; 5 were tracked between 10 and 100 hrs; 3 were tracked between 100 and 200 hrs; and 3 were tracked over 200 hrs.

Age Determination

Age Class Determination by Measurement

Sixty-nine eagles were measured in the SLV between January 1977 and April 1981. Since data were incomplete for 17, only 52 birds were included in stepwise discriminate analysis to determine if measurements could be used in separating adults from immatures. Using a significance level of P = 0.05 (F-to-enter = 4.0), only 2 variables could be used to classify age--TAIL LENGTH and CULMEN LENGTH since correct classification was low (82%, Table 7). Reducing the significance level to P = 0.1 (F-to-enter = 2.7), WING CHORD entered the function, with an overall classification rate of 90.4%. By reducing the F-to-enter to 1.0 (P = 0.5), no additional variables entered into the discriminate function and classification percentage was unchanged. Finally, using all variables (F-to-enter = 0.01, P>0.5) a lower classification (88.5%) was obtained (Table 7). Therefore, the strongest discriminating variables to distinguish age class (adult vs immature) were TAIL LENGTH (TL), CULMEN LENGTH (CL) and WING CHORD (WC) with a 90.4% reliability. The respective classification coefficients for use in classification

Table 6. Monitoring data, mated status, and emmigration date of radio-tagged adult bald eagles, San Luis Valley, CO, winter 1980-81.

Eagle #	Date Captured	Sex	Age	Hours Monitored	Inclusive Days	Mated Status	Date Left SLV
80-1	01-27-80	M	7	158	27	Mated	03-08-81
80-2	01-23-80	M	8	204	39	Unmated	03-21-80
80-3	01-18-80	F	6	118	23	U[a]	03-21-80
80-4	01-23-80	M	6	209	41	Mated	03-22/24-80
81-1	03-18-81	M	10	0.5	1	U[b]	unknown
81-2	02-05-81	F	8	6.5	1	U[b]	02-06-81
81-3	01-07-81	F	7	40	4	Unmated	02-11-81
81-4	01-09-81	M	5	57	8	Unmated	02-20-81
81-5	01-09-81	F	6	205	36	Mated	03-27-81
81-6	01-15-81	F	6	27.2	8	Unmated	03-25-81
81-7A	01-10-81	F	8	0.1	1	U[a]	unknown
81-7B	03-18-81	F	7	30	6	Mated	04-01-81
81-8	01-11-81	M	4	193	22	Mated	03-27-81
81-9	01-17-81	F	8	43.5	5	Mated	01-24-81[b]
81-10	03-15-81	M	6	10	1	U[b]	03-21-81[b]

[a]Uncertain but brood patch present.
[b]Undocumented due to insufficient monitoring time.

Table 7. Classification results of a stepwise discriminate analysis to determine discriminating variables to separate immature vs adult bald eagles by measurement at 3 levels of significance (F-to-enter levels).

Classification	F = 4.0[a]			F = 2.7[b]			F = .01[c]		
	Immature	Adult	% Cor.	Immature	Adult	% Cor.	Immature	Adult	% Cor.
Immature	21	4	84	23	2	92	23	2	92
Adult	5	22	81	3	24	88.9	4	23	85.2
			$\bar{x}$ = 82.7			$\bar{x}$ = 90.4			$\bar{x}$ = 88.5
Discriminating variables entered	CULMEN LENGTH, TAIL LENGTH			CULMEN LENGTH, TAIL LENGTH, WING CHORD			CULMEN LENGTH, TAIL LENGTH, WING CHORD		

[a] P value = 0.05.
[b] P value = 0.10
[c] P value > 0.5.

functions to determine age by measurement are shown in Table 8. Form of the function to determine age group is: $CS_1=C_{i1}(TL)+C_{i2}(WC)+C_{i3}(CL)+K_i$

Table 8. Discriminating variables and coefficient values for classification functions to be used in determining age class of bald eagles. Classification equation with the highest score determines age class.

Discriminating Variable	Coefficient	
	Immature Equation $(C_I)^1$	Adult Equation $(C_A)^1$
TAIL LENGTH (TL)	2.55748	-.32513
WING CHORD (WC)	37.05921	35.69942
CULMEN LENGTH (CL)	-1.85846	-1.09278
CONSTANT (K)	-414.19687	-385.06964

[1]Form of the equations are: $CS_{I/A}=C_{I/A}(TL)+C_{I/A}(WC)+C_{I/A}(CL)+K_{I/A}$

Aging by Plumage, Eye, and Beak Coloration

Photographs and notes on plumage of 69 adult and immature bald eagles captured in the SLV during winter revealed a general trend in plumage, iris, mandible, and cere coloration change with chronological age. Plumage conditions useful for aging bald eagles at a distance are presented in Figures 14-17.

Eagles exhibiting plumages most similar to those seen on nestling and fledgling eagles during summer banding in the Greater Yellowstone Ecosystem, were judged to be 0.5 yr-old birds (Fig. 14). Plumage differences between late nestling eaglets and 0.5 yr-old birds were primarily in wear and fading. Iris color of 0.5 yr-olds and late nestlings was the same. Remiges obviously were all of the same generation. Upper mandible and cere were totally black. Appendix Figures

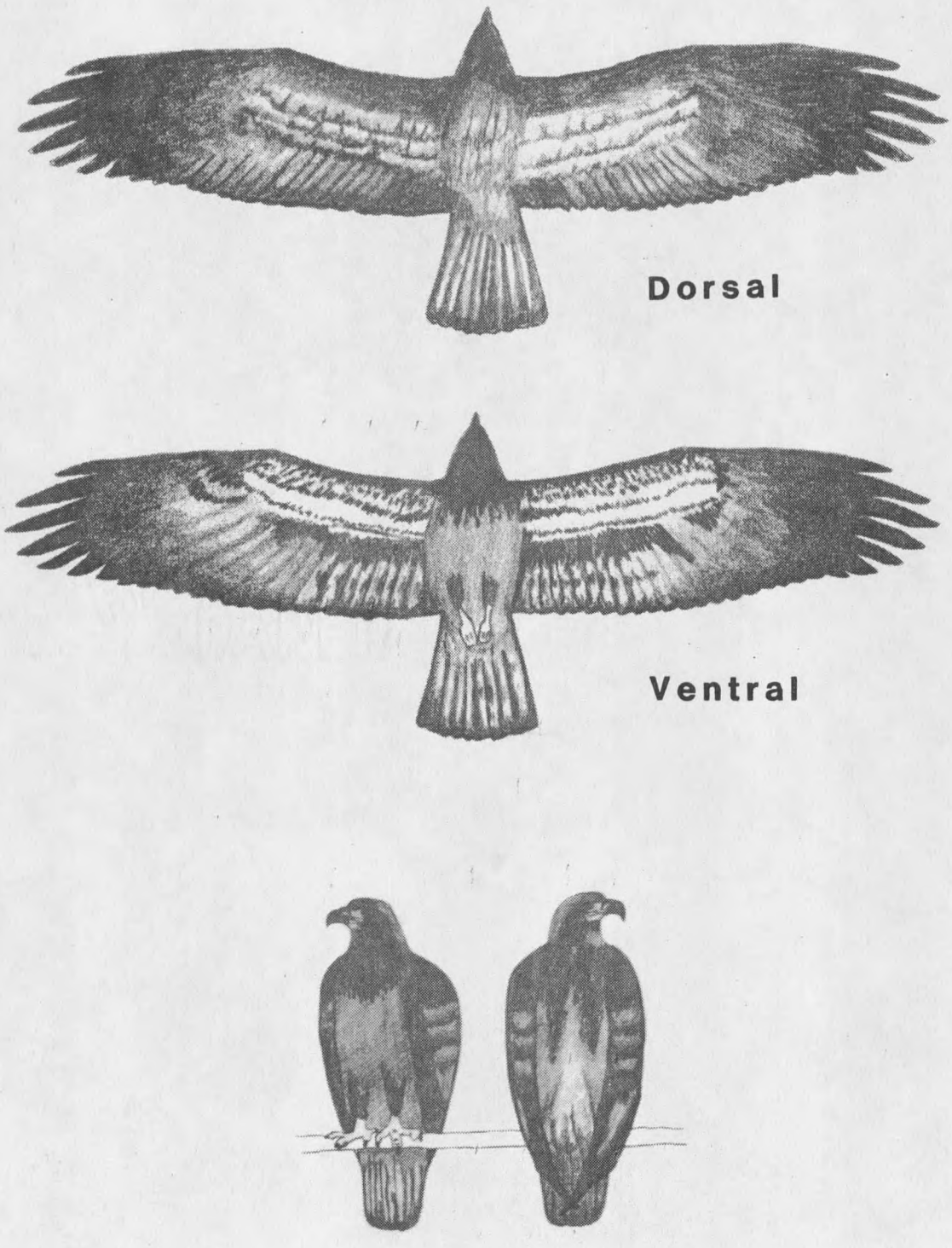


Figure 14. Plumage of juvenile bald eagle 0.5 to 1 year old.

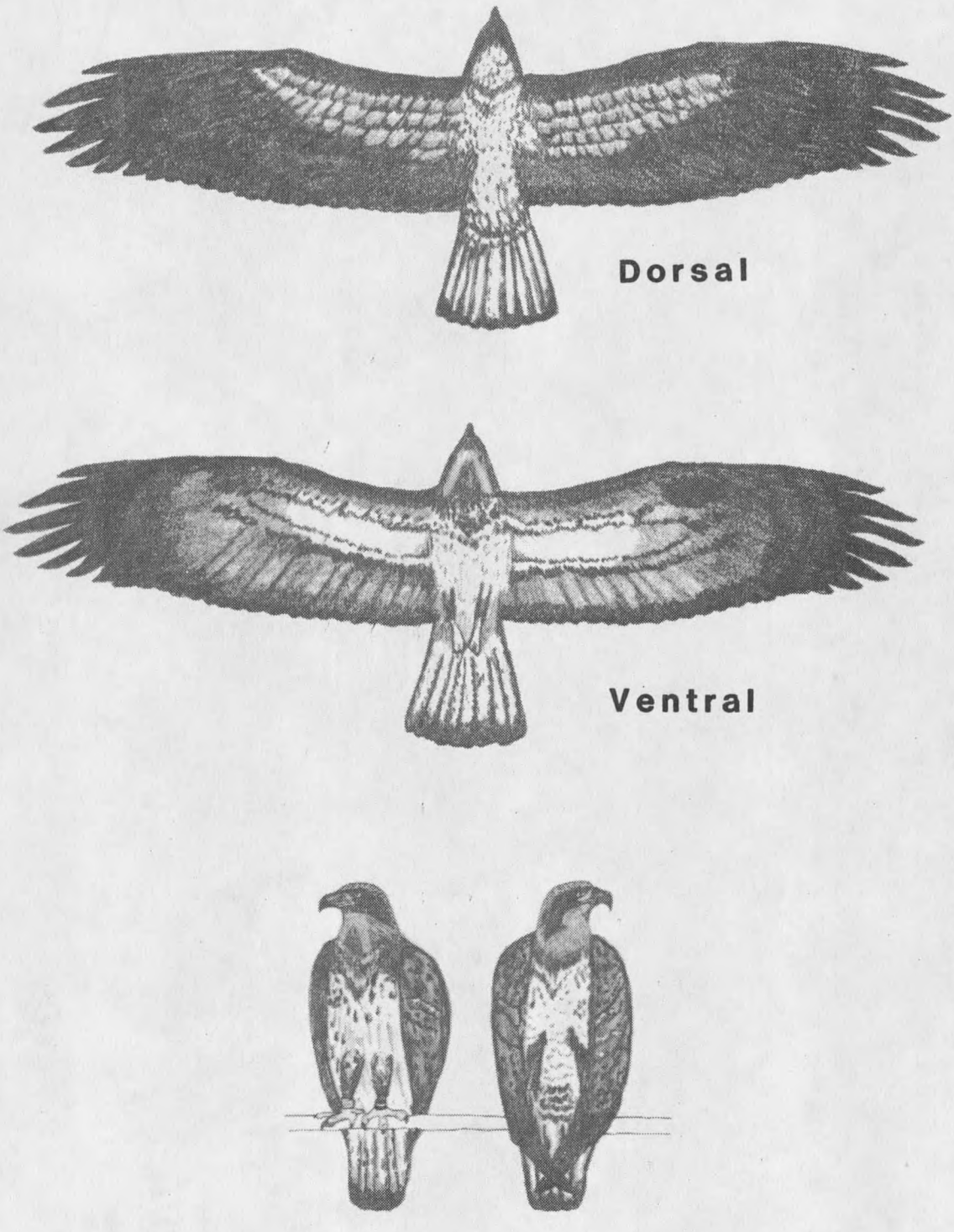


Figure 15. Plumage of subadult bald eagle 1.5-2 years old.

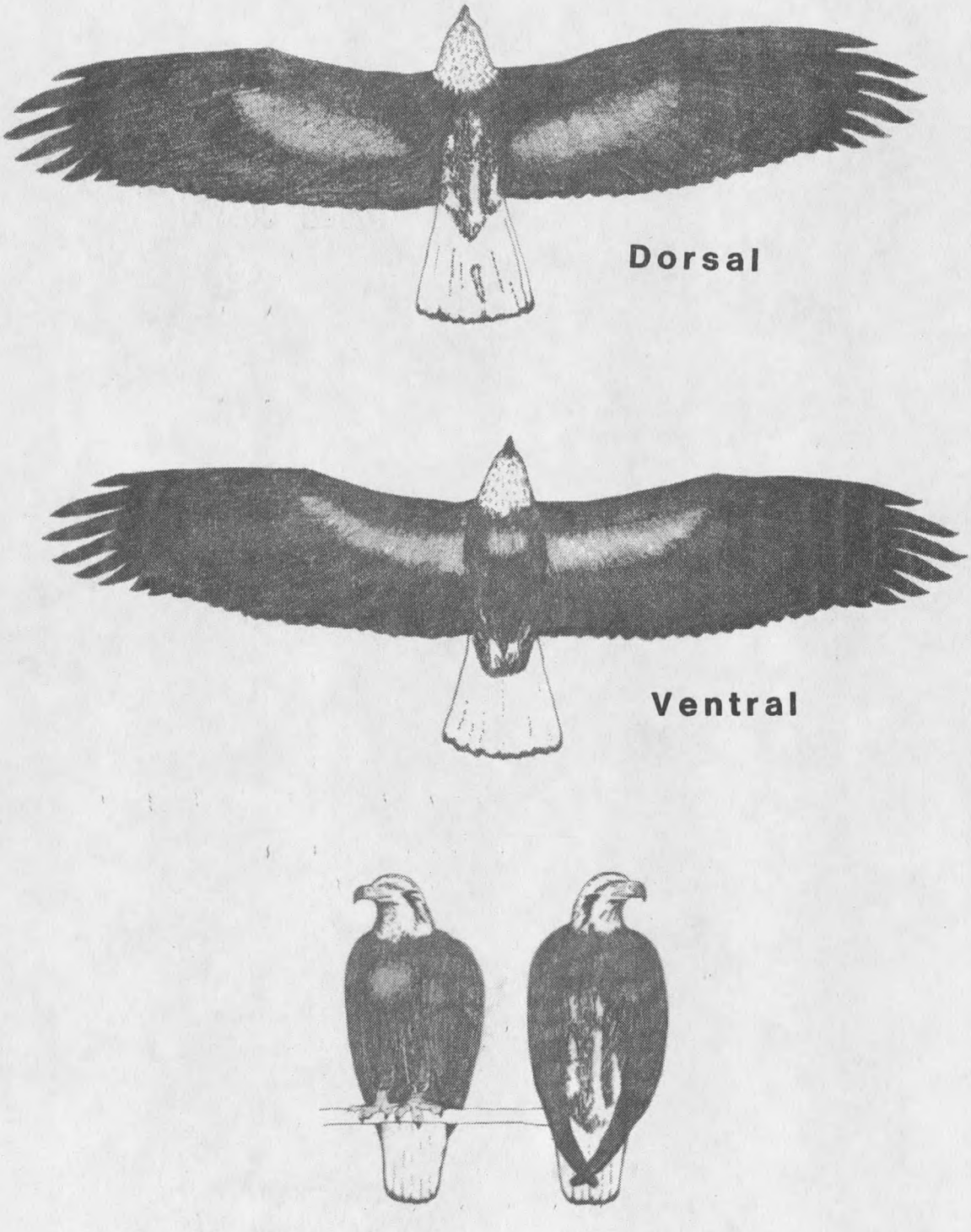


Figure 16. Plumage of subadult bald eagle 2.5-3 years old.

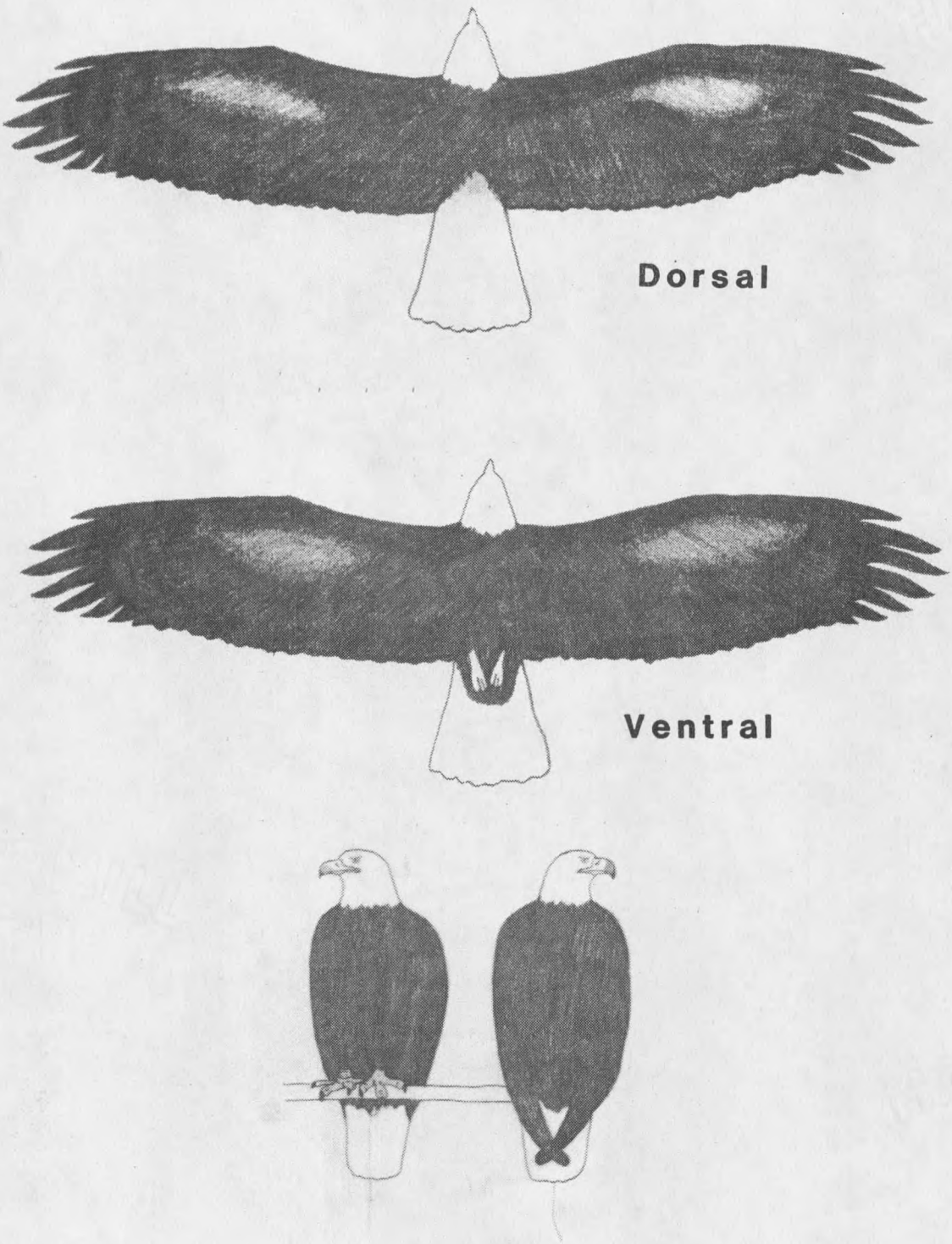


Figure 17. Plumage of bald eagle 3.5-4 yrs-old and 4.5+ yrs-old. Eagles 4.5+ cannot be distinguished from 3.5-4 year old at a distance.

67-69 illustrate plumage, iris, and mandibular coloration of a 0.5 yr-old eagle.

Progressive lightening of the iris and mandible occur with advancing age. Between 0.5 and 1.5 years of age, iris color changes from brown to beige or cream eroded with brown and mandible color changes from black towards yellow. Remige molt appears incomplete for 1.5 yr-olds (Fig. 15) as 2 generations of secondaries are most obvious on this age class during fall/winter (Fig. 18). Plumage, iris, and mandibular coloration associated with 1.5 yr-olds are shown in Appendix Figures 70-72. Ventrally, this age class most often exhibits a white speckled belly with a dark bib (Appendix, Fig. 72). The 1.5 year age class distinction was verified by the recapture of C14 (Fig. 19). This eagle was originally banded and marked 1 year earlier, then exhibiting the plumage pattern of a 0.5 yr-old (Fig. 14).

Verification of the 2.5 yr age class distinction (Fig. 16) was supported by the recapture of eagle C01. Originally banded and marked exhibiting 1.5 yr-old plumage (Fig. 20), she was recaptured 1 year later exhibiting a 2.5 yr-old plumage (Fig. 21). Eagle C14 was re-sighted 2 years after initial capture exhibiting this plumage condition, also. Appendix, Figures 73-76 illustrate plumage, iris, and mandible coloration of 2.5 yr-olds.

Resightings of other marked eagles supported the protocol. Eagles C07, C14, and C19, all banded and marked initially as 0.5 yr-olds, were resighted up to 6 years afterwards as full adults (Fig. 17). One was marked in the SLV in March 1977 (Fig. 22) and was seen each fall until 1982 in Glacier National Park (Fig. 23). His plumage

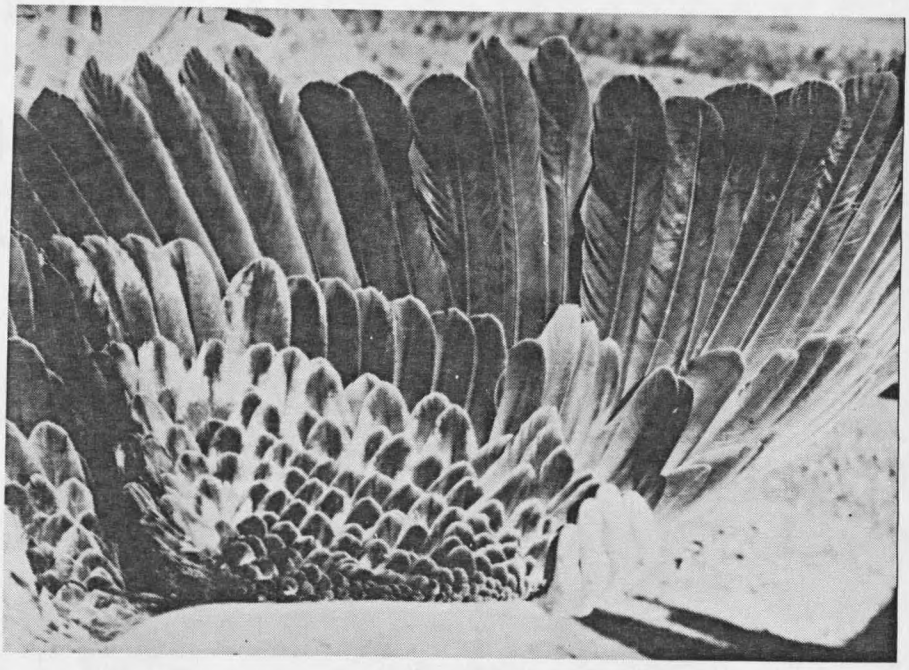


Figure 18. Wing of a 1.5 yr-old bald eagle. Note 2 generations of secondary and secondary covert feathers.

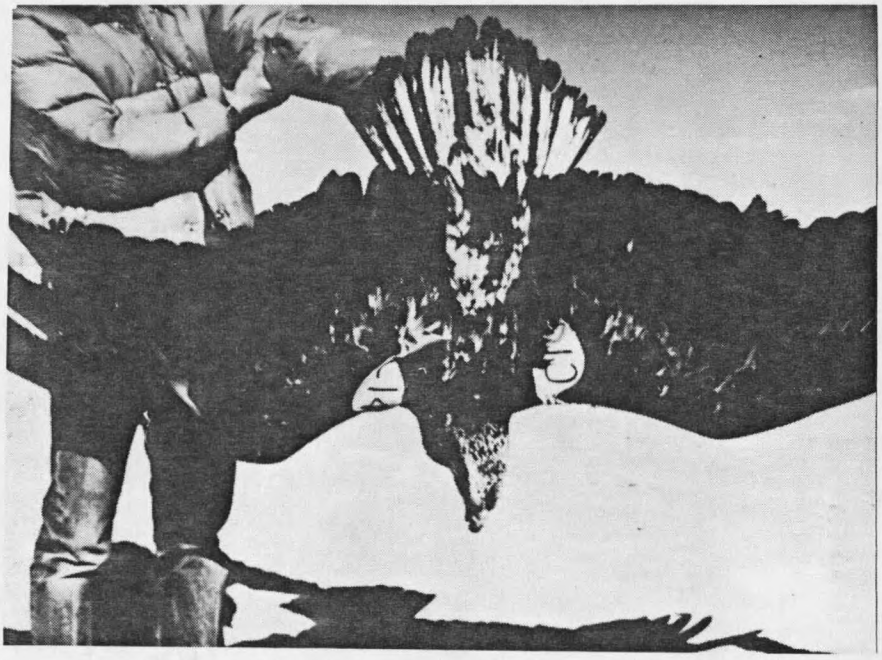


Figure 19. Plumage of bald eagle C14 1 year after initial capture as a 0.5 yr-old. Iris, mandible, and cere coloration along with wing and tail plumage were typical 1.5 yr-old. White belly and white triangular patch on back were absent however.

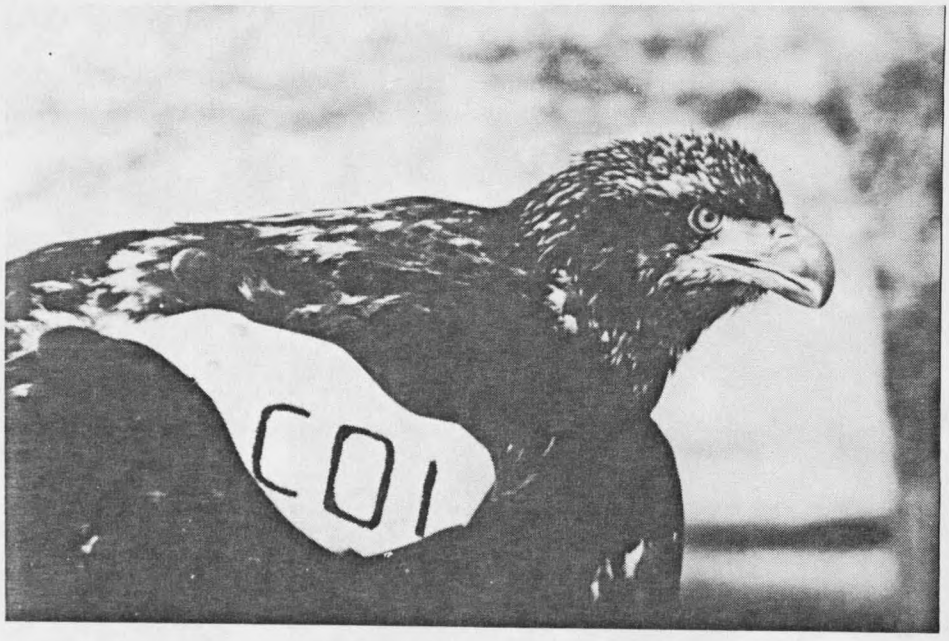


Figure 20. Bald eagle C01 exhibiting typical 1.5 yr-old plumage, iris, mandible, and cere coloration.

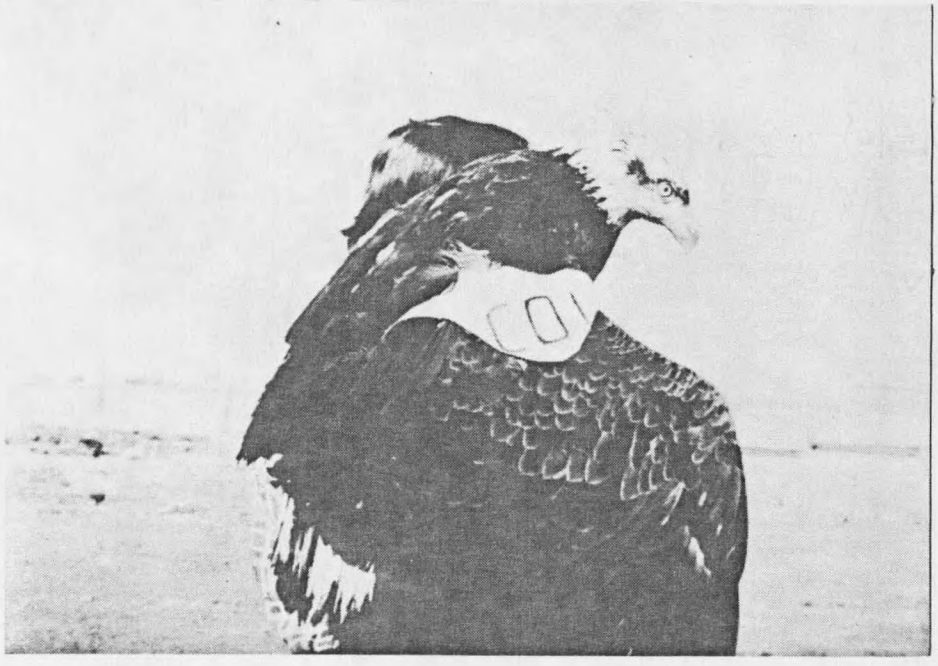


Figure 21. Bald eagle C01 at recapture 1 year after marking as a 1.5 yr-old (Fig. 28) exhibiting typical 2.5 yr-old plumage, iris, mandible, and cere coloration.



Figure 22. Bald eagle C19 at marking as a 0.5 yr-old in San Luis Valley, CO, 1977.

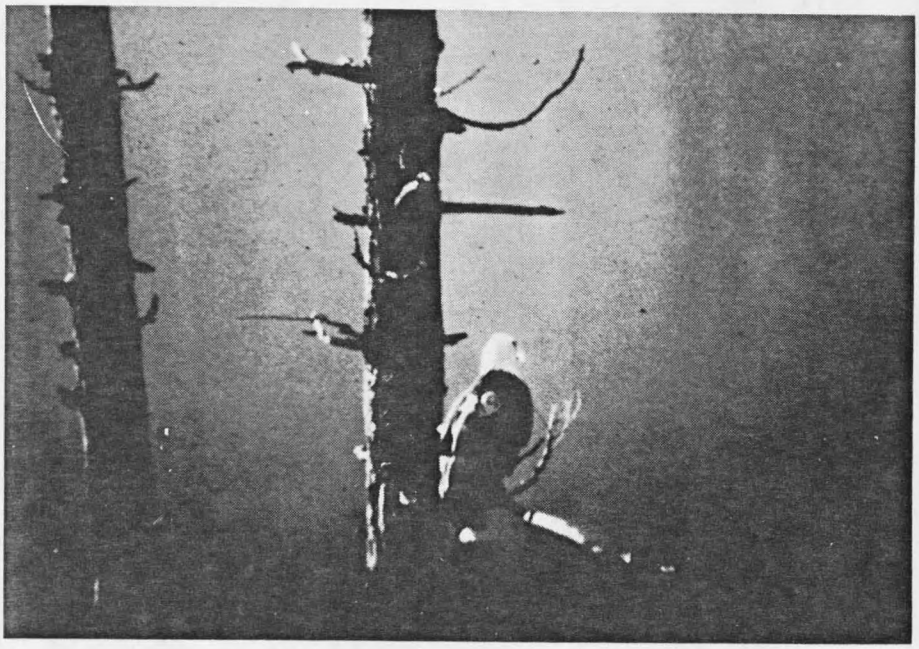


Figure 23. Bald eagle C19 as a full adult in 1980, Glacier National Park, MT. Photo by B. R. McClelland

progression appeared to follow the protocol presented here (McClelland pers. comm.). These sightings suggest that after the 3rd molt (3-3.5 years), plumage of bald eagles attain mostly adult characteristics and in fact 3.5 yr-old eagles marked as 0.5 yr-olds often appeared as full adults from a distance. Iris, mandible, and cere coloration are not usually fully adult by this time but this usually can only be determined if the eagle is in hand. Criteria presented in Table 9 may then be used to age beyond 3 years.

The criteria for aging juvenile and subadult bald eagles in hand (Table 9) should be used in conjunction with plumage characteristics. The protocol presented here represents general patterns, but much variation exists between individual eagles of the same age class. These variations undoubtedly result from demographic origin, physiological condition, and individual habits.

Sex Determination

All 3 approaches used on a K-means clustering algorithm analysis revealed 4 natural groupings based on age. Clustering revealed 2 categories of adult and immature and an unknown variable also consisting of 2 categories, assumed to be gender (Fig. 24). Table 10 gives means and 1 standard deviation above and below for variables in all 4 groups.

Using measurements of groupings determined by K-means cluster analysis, stepwise discriminate analysis selected 4 variables to distinguish sex of immature eagles and 3 variables to distinguish sex of adults. In order of entry for immatures the analysis selected WING

Table 9. Aging criteria for juvenile and subadult bald eagles in hand.

Age	Cere Color	Upper Mandible Color	Iris Color
Fledgling to 0.5 yr	black	black	dark brown
0.5 to 1.0 yr	brown	black	dark brown
1.5-2.0 yr	75-80% yellow	proximal 25% yellow distal 25% black eroded with yellow	brown with 10% beige specks
2.5-3.0 yr	mostly yellow	50-70% yellow distally black	brown with beige 50/50
3.5-4.0 yr	yellow	proximal 80% yellow distal 10% streaked with brown	mostly beige lightly speckled with brown
4.5+	yellow	yellow	beige or cream with light brown speckling

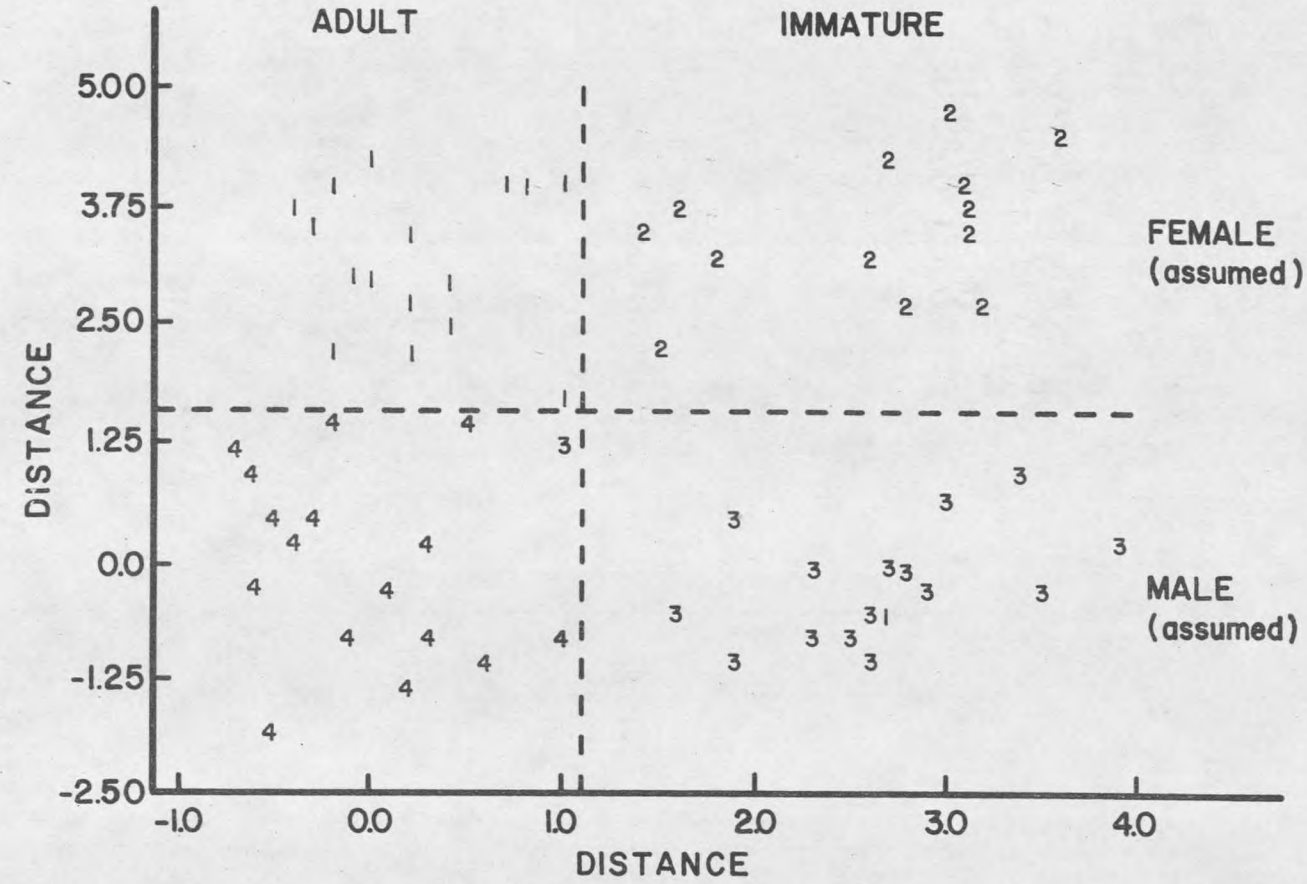


Figure 24. Cluster groups based on 6 morphological measurements of bald eagles as determined by K-means cluster analysis. Figure is a 2 dimensional "shadow" of 3 dimensional groupings.

Table 10. Means and 1 standard deviation of cluster groups found by K-means clustering algorithm analysis of measurements of bald eagles (n = 68).

	Group (n)							
	1[a] (14)		2[b] (17)		3[c] (20)		4[d] (17)	
Variable	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
TAIL LENGTH (mm)	355	± 13.0	317	± 11.0	338	± 18.0	301	± 11.0
CULMEN LENGTH (mm)	54.7	± 1.6	55.4	± 2.0	49.3	± 1.6	50.4	± 2.0
TARSAL WIDTH (mm)	17.0	± 0.7	17.0	± 1.2	14.7	± 1.0	14.9	± 0.6
WING SPAN (cm)	217	± 5.9	214	± 5.7	202	± 5.7	201	± 5.4
WING CHORD (mm)	629	± 13.0	605	± 14.0	597	± 12.0	574	± 14.0
WEIGHT (kg)	5.18	± 0.5	5.32	± 0.7	3.83	± 0.4	4.74	± 0.7

[a]Immature females
[b]Adult females
[c]Immature males
[d]Adult males

CHORD (WC), WING SPAN (WS), TARSAL WIDTH (TW), and CULMEN LENGTH (CL) as the most discriminating variables of sex, explaining 93.4% of the variation ($P<0.001$). Classification of known cases was 100% with good separation (Fig. 25). For adults, variables and order of entry was TW, CL, and WC (Fig. 25) which explained 87.4% of the variation ($P<0.001$). Classification of known cases was 94.1%. Therefore, classification functions derived from the discriminate analysis may be used as a sexing technique with a high degree of reliability for immature and adult bald eagles. Sex of an immature eagle, 0.5 to 3.5 years, may be predicted by inserting raw measurements of WC, WS, TW and CL into the following equations:

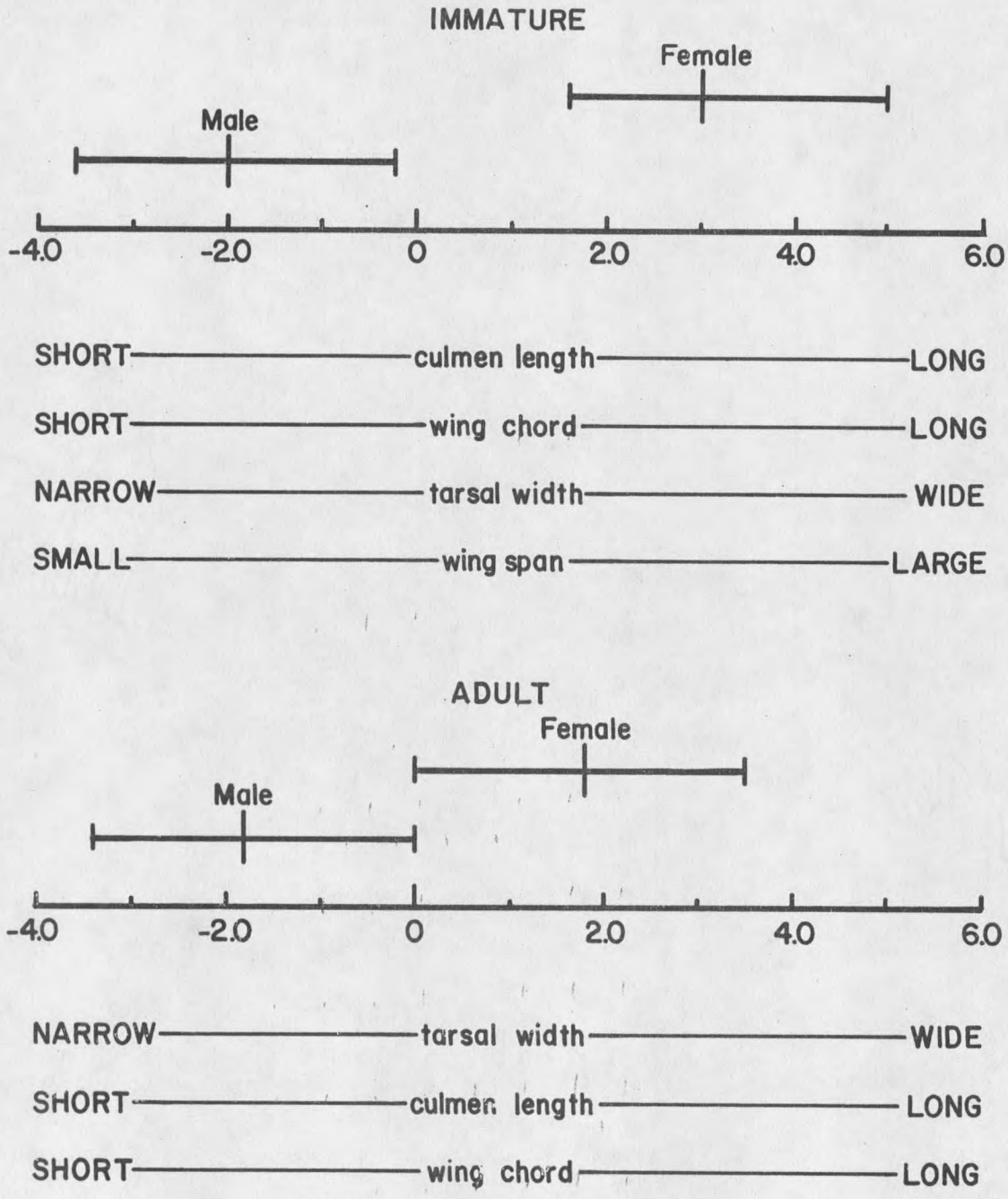


Figure 25. Centroids and range of discriminant scores of each age/sex group of bald eagles as determined by discriminant analysis. Variables under age groups are the most discriminating variables to determine sex, in order of entry in a stepwise procedure.

IM = 62.7208(WC)+12.64311(WS)+23.63167(TW)+12.63915(CL)-1721.101

IF = 66.4441(WC)+13.72274(WS)+26.73271(TW)+14.03257(CL)-2021.438

If IM > IF then the eagle probably is a male, if IF > IM then the eagle probably is a female.

Sex for an adult eagle may be predicted by inserting raw measurements into the equations:

AM = 58.28297(WC)+11.66061(TW)+6.419966(CL)-908.2806

AF = 60.58821(WC)+14.29185(TW)+7.157471(CL)-1042.796

If AM > AF the eagle is probably a male; if AF > AM the eagle is probably a female. The greater the disparity of values between male and female classification equations, the more likely the eagle will be a member of the group with the higher value.

Age and Sex Size Relationships

Mean wing feather length as manifested in wing chord (WC) of immature bald eagles 0.5 to 3.5 years old was about 3% longer (3.7% for eagles 0.5 years old only) than adults but mean wing span values were identical (Table 11). Mean rectrix lengths of immatures were over 9% longer than adults. Culmen length and tarsal width were from 3 to 3.6% larger for adults. Mean adult weight was 14% heavier than the mean immature weight (Table 11). This suggests that skeletal structures of bald eagles continue to grow after fledging, possibly as much as 4% in some eagles.

Mean weight of adult eagles captured in mid-March (n = 3) was 0.5 kg heavier than adults captured in January and February. An adult female captured in mid-March, weighted 0.54 kg more than her weight

Table 11. Means and 1 standard deviation of morphological measurements of immature and adult bald eagles.

Measurement	Immatures[1] (n=25)		Adults[2] (n=27)	
	$\bar{X}$	±SD	$\bar{X}$	±SD
TAIL LENGTH (mm)	341	24	309	13
WING CHORD (mm)	608 (613)[3]	24 (18)[3]	591	19
WING SPAN (cm)	208	10	208	8
TARSAL WIDTH (mm)	15.5	1.5	16	1.2
CULMEN LENGTH (mm)	51.1	3.1	53	3.3
WEIGHT (Kg)	4.3	0.85	5	0.9

[1]All immature ages, .5 through 3.5
[2]All adults ages, 4.5+
[3].5 yr olds only, n=16

at initial capture in early January. This suggests eagles gain weight in the wintering area, perhaps just prior to migration.

Flight Related Characteristics

Wing tracings were obtained from 18 bald eagles captured in the SLV between 7 January and 18 March 1981. Tail tracings were obtained for 15 of the 18. Table 12 shows areas of lift surfaces and related measurements involved in flight dynamics of eagles from which wing tracings were obtained.

Aspect Ratio. Aspect ratio was expressed as $AR = \frac{WS(mm)}{\text{wing width (mm)}}$. Student's t-tests indicated a significant difference between adult and immature bald eagles ($t = -3.57$, $df = 16$, $P<0.005$) with adults having larger ratios (longer, narrower wings) than immatures (Table 13).

Table 12. Measurements of characters related to flight dynamics of 2 age classes of bald eagles by sex. Measurements were derived from 18 eagles whose wing areas were measured.

Age Class	Sex	Wing Chord (mm) $\bar{x}$(n)	Wing Span (cm) $\bar{x}$(n)	Wing Area (cm^2) $\bar{x}$(n)	Tail Area (cm^2) $\bar{x}$(n)	Weight (g)[1] $\bar{x}$(n)
Immature	Male	582 (5)	201 (5)	5200 (5)	994 (3)	3738 (5)
	Female	635 (7)	219 (7)	6457 (7)	1107 (7)	5069 (5)
Adult	Male	587 (2)	208 (2)	4720 (2)	862 (1)	4720 (2)
	Female	606 (4)	210 (4)	5588 (4)	878 (4)	5131 (3)
		609 (18)	211 (18)	5783 (18)	1007 (15)	4591 (15)

[1]Eagles without crop contents

Table 13. Flight related statistics and sample size (n) of bald eagles of 2 age classes by sex.

Age Class	Sex	Wing Loading (g/cm^2)	Aspect Ratio (L/W)[1]	Tail/Wing Ratio (%)[2]	Lift Surface Loading (g/cm^2)[3]
Immature	Male	0.72 (5)	5.5 (5)	56.6 (20)	0.35 (3)
	Female	0.79 (5)	5.3 (7)	56.4 (14)	0.37 (5)
Adult	Male	0.89 (2)	5.7 (2)	52.1 (17)	0.46 (1)
	Female	0.90 (3)	5.8 (4)	52.6 (17)	0.42 (3)
All	All	0.80 (15)	5.5 (18)	54.3 (68)	0.38 (12)

[1]Wing Span ÷ width of wing at widest point
[2]Tail Length ÷ Wing chord
[3]Weight ÷ 2 (Wing Area) + (Tail Area)

Immature males had significantly larger ratios than immature females ($t = 2.19$, $df = 10$, $P<0.1$).

The small sample of adult males (2) for which wing tracings were available prevented statistically valid comparisons of adult aspect ratios by gender, but adult female ratios tended to be slightly greater than those of adult males.

Tail/Wing Ratio. Tail/wing ratios (Brown 1977: 63) were calculated for 68 bald eagles captured in the SLV. Tail lengths were a significantly greater percentage of wing length for immatures than adults ($t = -3.62$, $df=65$, $P<0.001$). No statistical differences were found between male and female tail/wing ratios but relationships were similar to those between aspect ratios of genders (Table 13).

Wing Loading. Wing loading values (g/cm^2) were calculated for 15 of 18 eagles for which wing areas were available (Table 13). Three eagles had ingesta in their crops and therefore were not included in wing loading comparisons. Wing loading of adults was over 15% greater than for immatures and was statistically significant ($t = -2.67$, $df = 13$, $P<0.025$). No statistical differences were found between genders, but female wing loading tended to be greater in both age classes (Table 13).

Lift Surface Loading. Lift surface loading = $\frac{\text{Eagle's weight (g)}}{2\ (\text{Wing Area}) + \text{Tail Area}}$ (Table 12). There were no statistical differences in lift surface loading among genders and age classes but adult and female lift surface loading tended to be greater than immatures and males respectively. As expected, lift surface loading was directly and highly correlated with wing loading ($r = 0.99$).

Prediction of Wing Area from Linear Measurement. Combinations of variables, wing chord, wing span, and aspect ratio were regressed on wing area in an effort to develop an index to determine wing area without the use of mechanical or electronic planimeters. The best predictive model involved separating eagles by age class and using wing chord (WC) and wing span (WS) to determine immature (0.5 to 3.5 years) wing area ($r = 0.93$, $P<0.01$) and wing chord (WC) and aspect ratio (AR) to determine adult (4.5+ years) wing area (WA) ($r = 0.84$, $P<0.01$). Resultant equations are:

Immature WA = -7784.54-1.83(WC)+70(WS)

Adult WA = -2290.85-281.87(AR)+15.66(WC)

Where WA is in cm^2, WC in mm, WS in cm and AR = $\frac{\text{WS (mm)}}{\text{wing width (mm)}}$.

Size Dimorphism

As Baker-Gabb (1982) pointed out, the variables used by Storer (1966) in the calculation of dimorphism indices ignore some potentially significant differences in morphology that may permit a greater partitioning of resources among raptors. For bald eagles, the most representative indices are probably those which incorporate as many measurements as possible or those which ignore weight (DI^1, DI^3; Table 14). There were highly significant differences among indices when considering male/female relationships (ANOVA, $P<0.005$) and significant differences when considering immature/adult relationships (ANOVA, $P<0.025$).

Considering mean indices of DI^1 and DI^3 (Table 14), dimorphism is greater between adults and immatures ($\bar{x} = 11.2$) than between males

and females (6.3). Snyder and Wiley (1976) considered raptors with indices of 7.0 moderately dimorphic and those 12.0 or above strongly dimorphic. Dimorphism was greater between males of each age class ($\bar{x}$ DI^1+DI^3 = 13.8) than females of each age class ($\bar{x}$ DI^1+DI^3 = 9.5). Sexual dimorphism was also greater between immature males and females (7.8) than adult males and females (6.4).

Table 14. Dimorphism indices (DI; Storer 1966) for bald eagles captured in the San Luis Valley, CO.

Measured variable	Male to Female			Adult to Immature		
	Immature	Adult	Both Ages	Male	Female	Both Sexes
wing chord	5.9	5.3	6.8	3.3	3.9	2.8
culmen length	10.6	9.5	10.1	2.4	1.3	7.4
weight	29.7	18.9	21.2	13.6	2.7	10.4
wing span	7.7	6.3	5.7	0	1.4	0
tarsal width	14.5	13.2	13.8	1.4	0	3.2
tail length	7.0	5.2	4.0	9.5	11.3	9.8
wing loading	9.3	1.1	7.5	21.1	13.0	16.4
aspect ratio	3.7	1.7	1.8	3.6	9.0	6.4
tail/wing ratio	3.3	7.0	3.6	16.3	12.7	14.0
lift surface loading	6.1	2.8	0	29.3	13.7	17.7
DI^1	9.9	7.8	7.7	10.0	6.9	8.8
DI^2	15.4	11.2	12.7	6.4	2.6	6.7
DI^3	5.6	4.9	3.9	17.6	12.1	13.6

[1]for all variables
[2]for variables used by Storer (1966)
[3]for flight related variables only

Winter Ecology

Traditional Use of Wintering Grounds

Recaptures and sightings of marked eagles suggest fidelity to the wintering grounds is high, at least for some eagles. Two immature eagles, C01 and C14 were recaptured 1 year after marking only 8.3 and 7 km from the original capture sites, respectively. All

additional sightings of C14 (Table 15) in subsequent years were within 12 km of the original capture site. The marked eagle seen most often in subsequent years was C11 (Table 15). All sightings of C11 were within a 10 km^2 area. Twenty-six percent of marked immatures were resighted in subsequent years in the SLV but the average number of years seen after marking was only 1.4 (range 1-3). Twenty-three percent of adults marked were seen in subsequent years but average number of years seen after marking was 3.0 (range 1-6).

Home Range

Minimum seasonal home range boundaries were determined by connecting all peripheral locations (Fig. 26) by hand, resulting in irregularly shaped areas (Fig. 27). Areas were computed for all eagles monitored more than 10 hrs (Appendix, Figs. 78-87).

Home ranges of adult bald eagles wintering in the SLV varied in size (Table 16) and shape. Mean minimum seasonal home range size was 310.7 km^2 (n = 12, SD = 241). Mean minimum seasonal home range sizes by mated status and sex are shown in Table 17. ANOVA and Newman-Keuls analysis of home range sizes showed no differences among groupings of sex and years but differences between mated and unmated eagles were evident (Table 17). Eagles judged to be mated had home ranges significantly smaller than those judged to be unmated (P = 0.001). Home ranges of mated males were smaller than unmated males (P = 0.027) and the same relationship held for mated and unmated females (P = 0.08) but was not significant at the P = 0.05 level. Home range sizes for mated males were also smaller than mated females but not significantly so.

Table 15. Resightings of bald eagles marked in the San Luis Valley, CO subsequent to the year of colormarking.

Marker #	Age[a]	Sex	Date Captured	Year and (#) of Sightings	Wing Tags Present
CO1	I(0.5)	M	01-77	78 (1)[b]	2
CO4	A	M	02-77	78 (3)	2
				79 (1)	
CO7	I(1.5)	F	02-77	80 (2)	2
C11	A	M	02-77		2
				78 (>5)	2
				79 (1)	
				80 (>5)	2
				81 (>5)	2
				82 (1)	
				83 (2)	1
C14	I(1.5)	F	02-77	78 (1)[b]	2
				80 (2)	2
				81 (1)	2
C23	A	M	01-78[c]	79 (4)	1
				80 (5)	1
				81 (3)	1
C26	A	F	01-78[c]	79 (1)	2
C29	A	F	01-78[c]		2
				79 (2)	2
				80 (3)	2
				81 (2)	2
C32	I(1.5)	F	02-78	79 (1)	1
C2[d]	I	-	01-78	79 (1)	1

[a] at time of capture: I=immature, A=adult, actual age in years in parentheses
[b] retrapped
[c] radio-tagged
[d] second number obscured by feathers

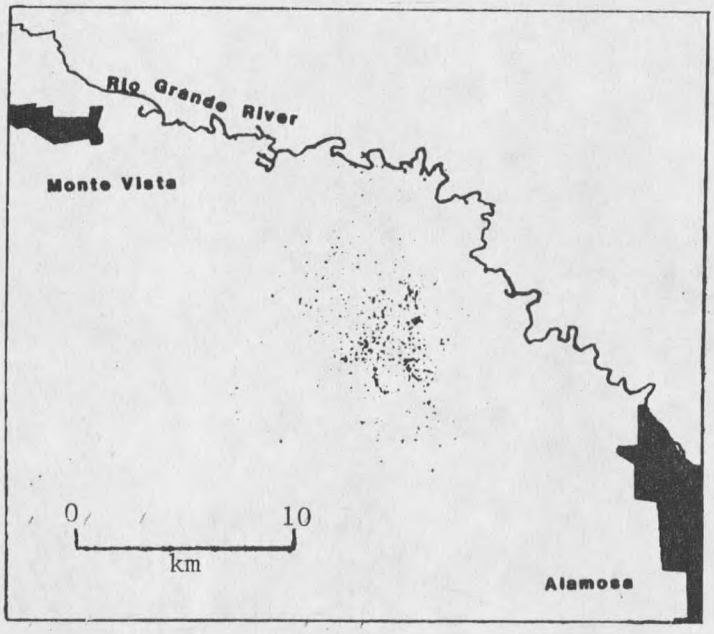


Figure 26. All perch and flight locations for adult male bald eagle #8-81, San Luis Valley, CO, 1981.

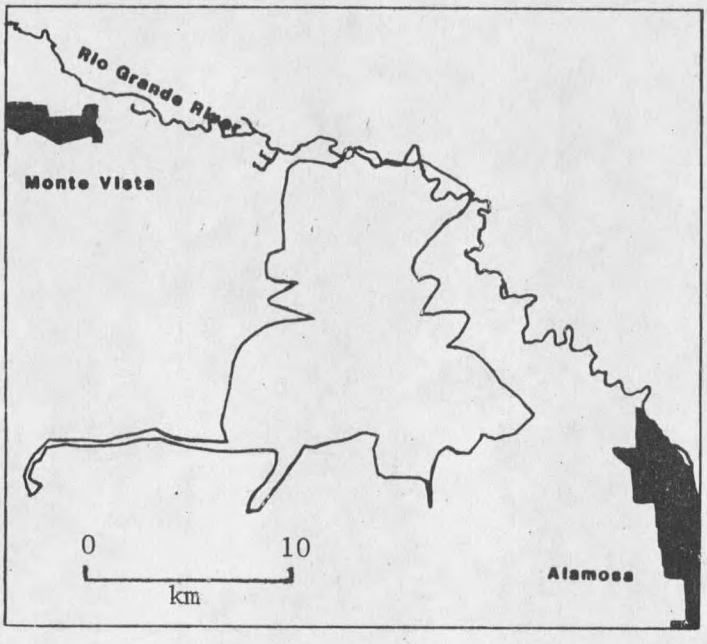


Figure 27. Home range of adult male bald eagle #8-81 determined by connecting all peripheral locations (Fig. 26).

Table 16. Minimum seasonal home range size of radio-tagged adult bald eagles wintering in the San Luis Valley, CO determined after at least 10 hrs monitoring.

Year	#	Sex	Approx. Age	Mated Status	Minimum Home Range (km^2)	Roosts Used
1980	1	M	7	unmated	470.9	6
	2	M	8	mated	184.7	5
	3	F	6	U[a]	215.9	3
	4	M	6	mated	69	1
1981	3	F	7	unmated	540.9	4
	4	M	5	unmated	795	5
	5	F	6	mated	77.2	1
	6	F	6	unmated	375.8	9
	7B	F	7	mated	310	1
	8	M	4	mated	66.5	3
	9	F	8	mated	60.9	1
	10	M	6	U[b]	561.6	1

[a]Uncertain, but brood patch present
[b]Undocumented due to insufficient monitoring time

Ranges of unmated males, however, were larger than unmated females (Table 17).

Although ranges of all eagles monitored more than 10 hr included parts of 1 or both major rivers in the SLV, most of the home range area consisted of upland habitats up to 40 km from the river(s). Home ranges commonly overlapped (Appendix, Fig. 83) and although certain eagles appeared to defend particular perches, none was observed attempting to exclude other eagles from the range. Aggressive encounters occurred but were most often related to disputes over food or infringements on individual space.

Table 17. Mean minimum seasonal home range sizes (n) by mated status and sex of radio-tagged adult bald eagles, San Luis Valley, CO.

Mated Status	Sex		
	Males	Females	Both
mated	106.7 (3)	149.4 (3)	128 (6)
unmated	632.9 (2)	458.4 (2)	545.7 (4)
uncertain	561 (1)	215.9 (1)	388.5 (2)
	358 (6)	263.5 (6)	310.7 (12)

Intra-Range Movements

Routes and distances of 260 direct flights of radio-tagged bald eagles were documented during the winters of 1980 and 1981. Average distance per direct flight for all eagles both years was 1.7 km ± 2.7 km (α=0.01). ANOVA of 32 randomly selected direct flights indicated differences among years and sexes ($P<0.01$). However, only direct flights of females in 1981 were found to be significantly farther than

females in 1980 ($t = -3.59$, $df = 14$, $P<0.005$). Figure 28 shows routes and distances of representative direct flights of 1 eagle on 1 day.

Durations of 231 soaring flights of bald eagles were timed in 1980 and 1981. Mean duration of all soaring flights was 27.3 min ± 6 min ($\alpha=0.01$). ANOVA indicated durations of soaring flights of mated eagles were significantly shorter than for unmated eagles. Mean soaring flight durations for all eagles was 22.8 min and 31.6 min in 1980 and 1981 respectively and were significantly different ($t = 1.82$, $df = 229$, $P = 0.07$). Males had significantly longer soaring flights in 1981 than in 1980 ($t = -1.91$, $df = 154$, $P = 0.05$) but females did not. Figures 29 and 30 illustrate routes and distances of representative soaring and direct flights of bald eagles for 1 day.

Daily movements usually covered little of the entire calculated range. Most direct perch-to-perch flights were by commonly used routes to habitually used perches. When eagles soared, often for more than 2 hr, it usually was over rather small areas in their range. For most eagles, the majority of movement over many days was within only a small portion of the home range. Extended, long ranging flights were the exception and occurred mostly on relatively warm windy days. Occasionally, eagles made extended combination direct/soaring flights over areas not previously included in the home range and not known to be subsequently duplicated. These flights added significant area to the home range and confounded definition of it. A home range of 1 eagle monitored over 200 hr not including areas flown over or perched in for just 1 day is shown in Figure 31. This "habitual" range was 21% smaller than the total minimum home range, but the relationship may

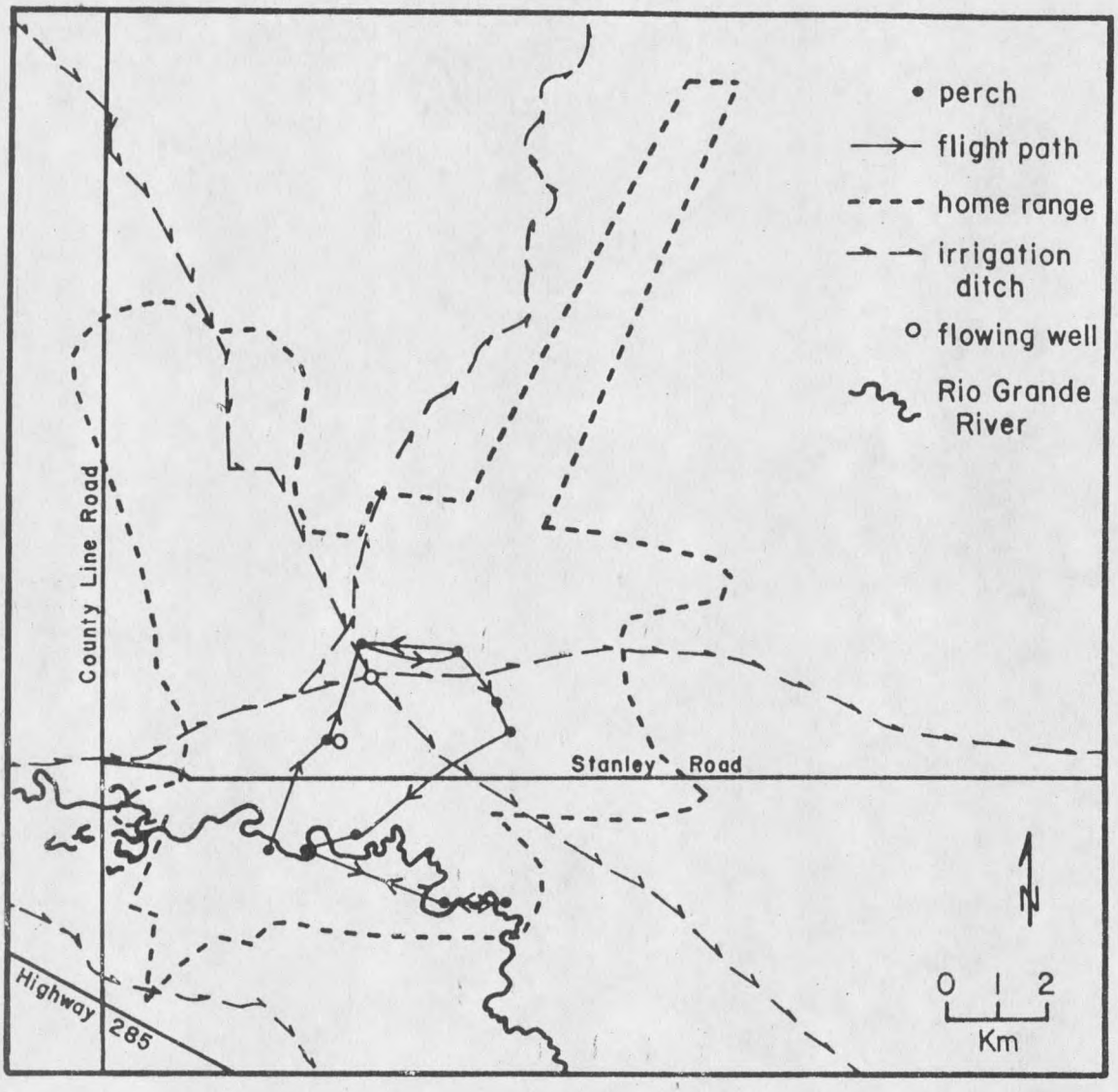


Figure 28. Representative direct flights of an adult mated female bald eagle within the home range, San Luis Valley, CO, 2 February 1981.

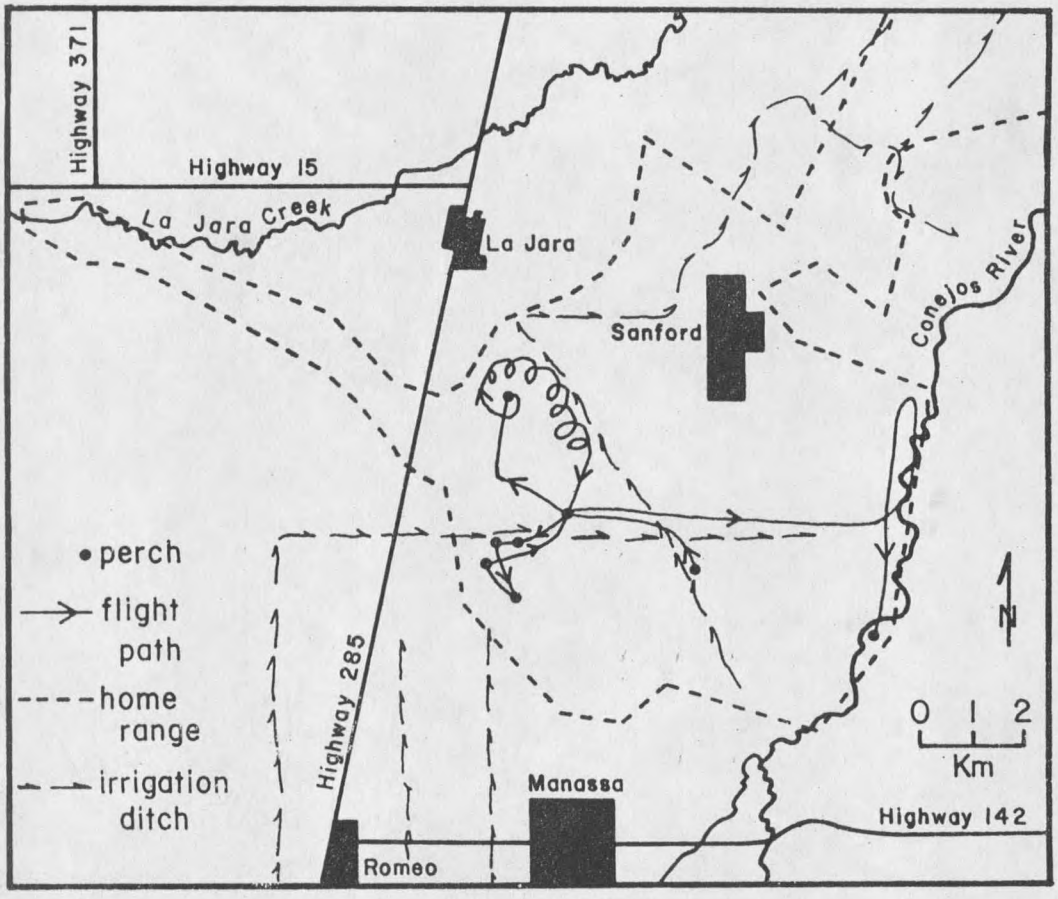


Figure 29. Routes of typical soaring and direct flights of a mated adult male bald eagle, San Luis Valley, CO, 1980. Corkscrew path indicates soaring flight.

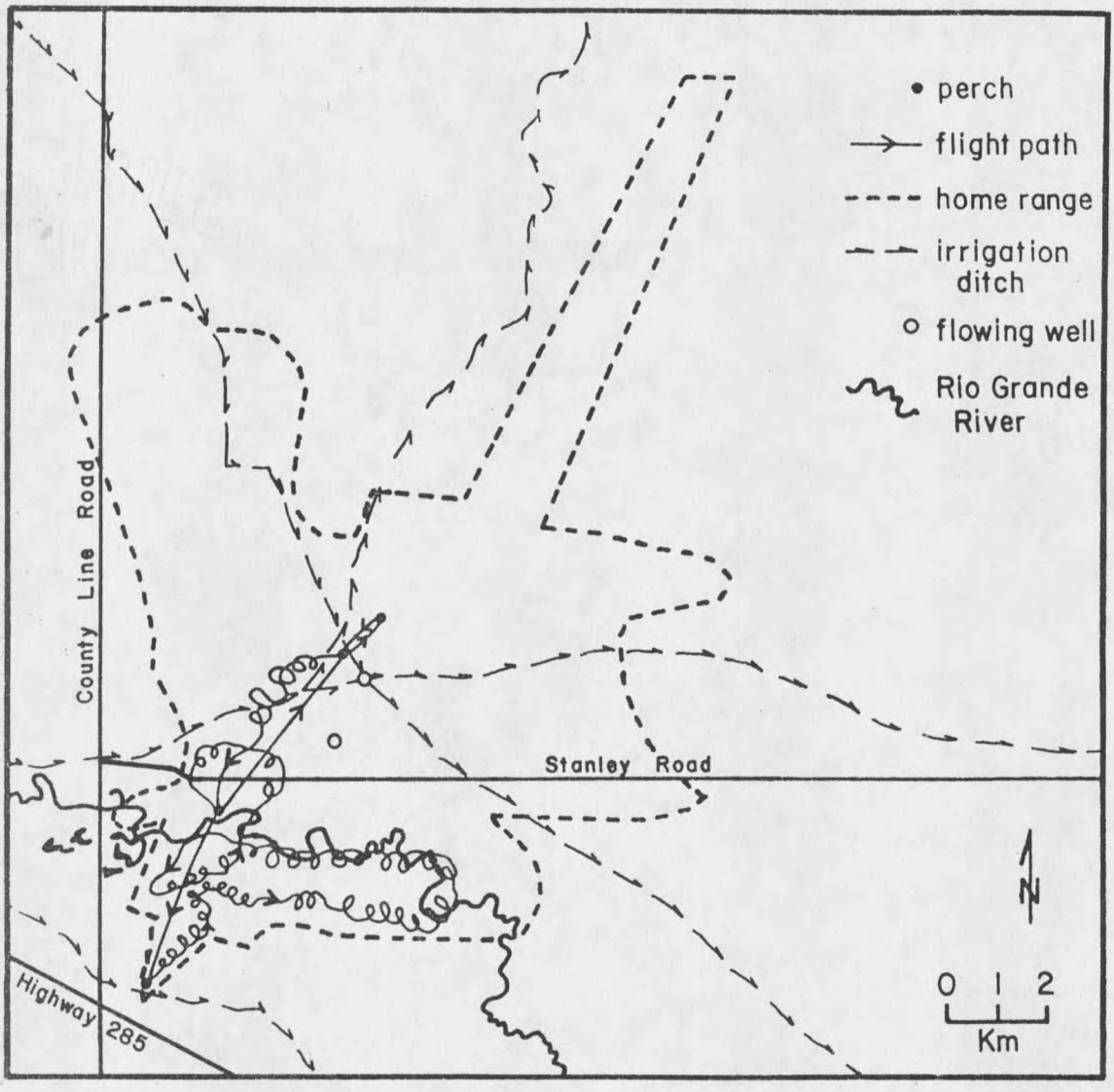


Figure 30. Routes of typical soaring and direct flights of an adult mated female bald eagle, San Luis Valley, CO 1981. Corkscrew path indicates soaring flight.

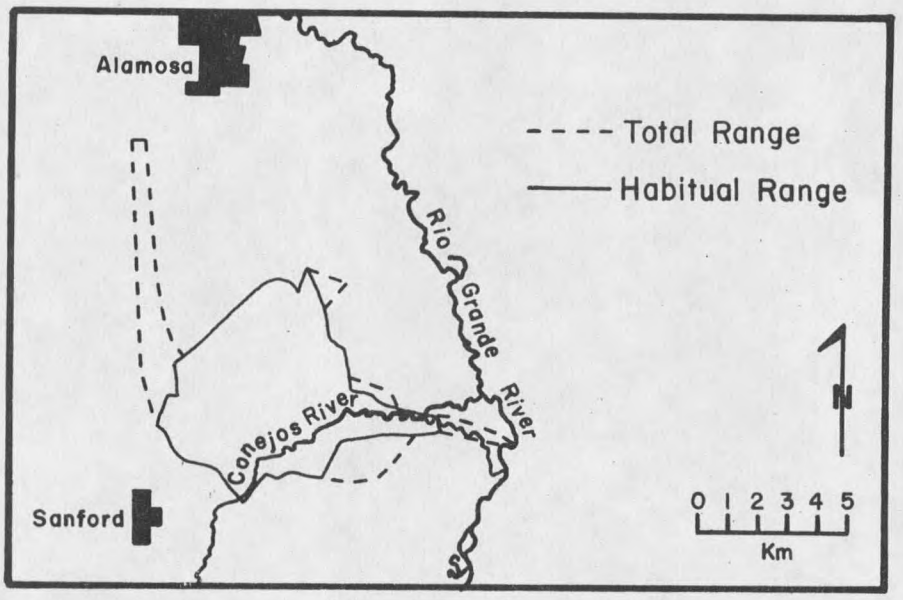


Figure 31. Habitual range (see text) of mated adult male bald eagle #4-80, San Luis Valley, CO. Area encompassed 54.5 km^2.

hold only for mated eagles that are "attached" to certain areas and a mate.

Activity

Mean daily percent activity, hereafter referred to as "activity", for all eagles is illustrated in Figure 32. Since eagles are strictly diurnal, activity was monitored only between 0600 hrs and 1900 hrs. Total daily activity was 15.5% of daylight hours. Hourly periods of greater than 15.5% activity occurred between 2 hrs after sunrise and 1 hr before sunset, with periods of most activity 6 to 7 hrs after sunrise. A slight bimodal activity pattern is evident but initial activity between 0600 and 0700 hrs almost always consisted of direct flights from the roost site to habitually used perches in foraging areas.

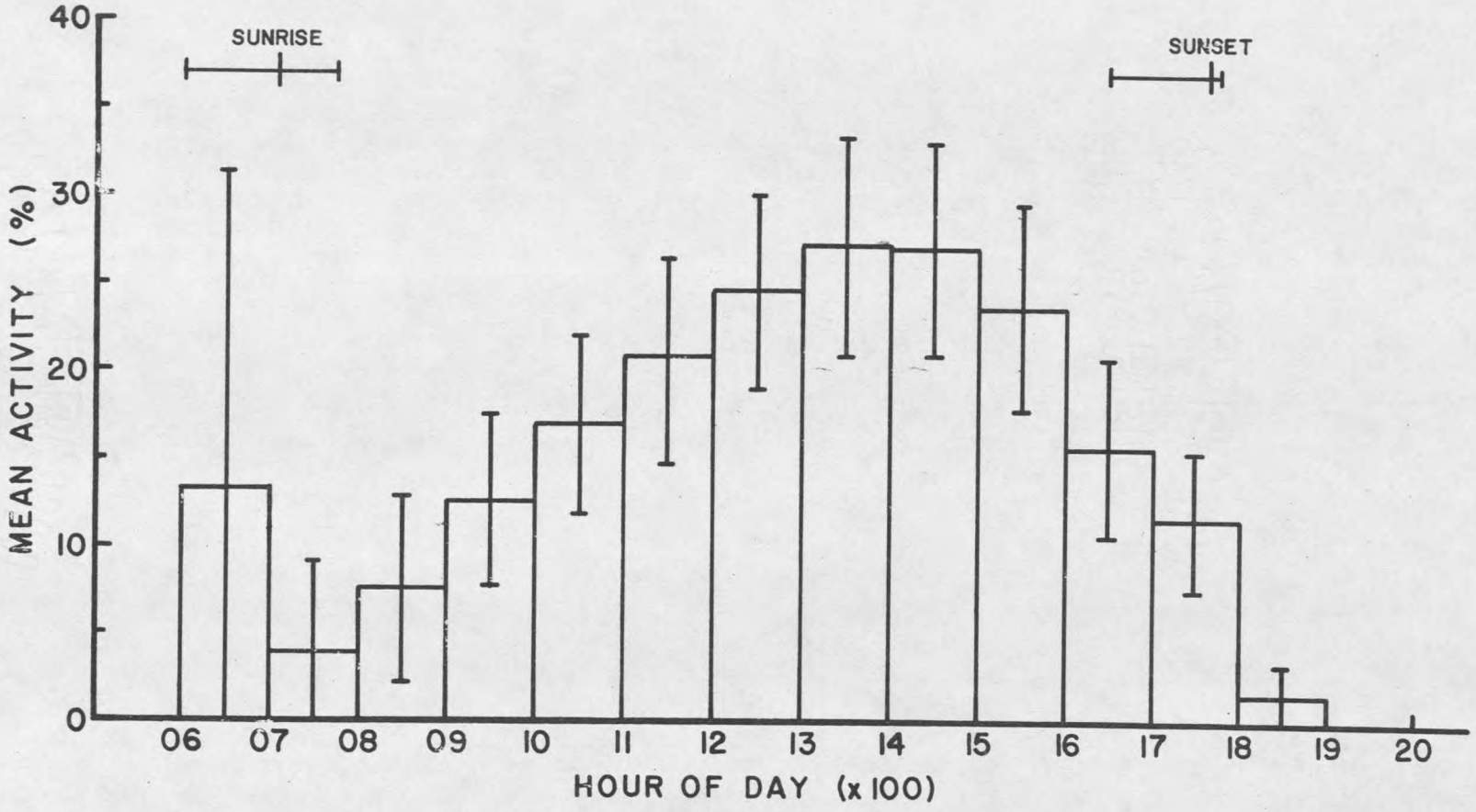


Figure 32. Total mean daily percent activity by hour block for 15 radio-tagged adult bald eagles wintering in the San Luis Valley, CO, 1980 and 1981. Vertical lines indicate 99% confidence interval.

Activity for all eagles was 14.7 and 16.4% of daylight hours in 1980 and 1981 respectively and was significantly different between years (ANOVA, $P<0.001$). Figure 33 shows activity of males and females each year. Total activity of males in 1980 and 1981 was 17.1 and 19% of daylight hours respectively and not statistically different. Female activity between years was significantly different (t-test, $P<0.001$) but represented comparison of activity of only 1 female in 1980 (4%, 159 counts) to 7 females in 1981 (14.9%, 559 counts). Comparison of total activity between males and females indicated a significant difference (t-test, $P<0.001$), with males (18%) being active more of the day than females (9%). Males also tended to be active earlier and over a greater part of the day (Fig. 33).

ANOVA results indicated significant differences in total activity between eagles of different mated status. A Sheffe procedure showed differences were between mated and unmated eagles in 1980 ($P<0.001$). Mated eagles were significantly more active during the day (17%, t-test $P<0.001$) than unmated eagles (14.8%).

Activity of all eagles among months was different (ANOVA, $P<0.04$) in both 1980 and 1981 (Fig. 34). A Sheffe procedure indicated that eagles as a group were significantly less active in January than February and March both years. Males were considerably less active in January than February and March both years (Fig. 35) but females tended to be equally active over the entire winter. As a group all eagles tended to be most active in February (Fig. 34).

Regression of the Winter Severity Index on total activity for all eagles per month (Fig. 36) revealed a moderate negative correlation

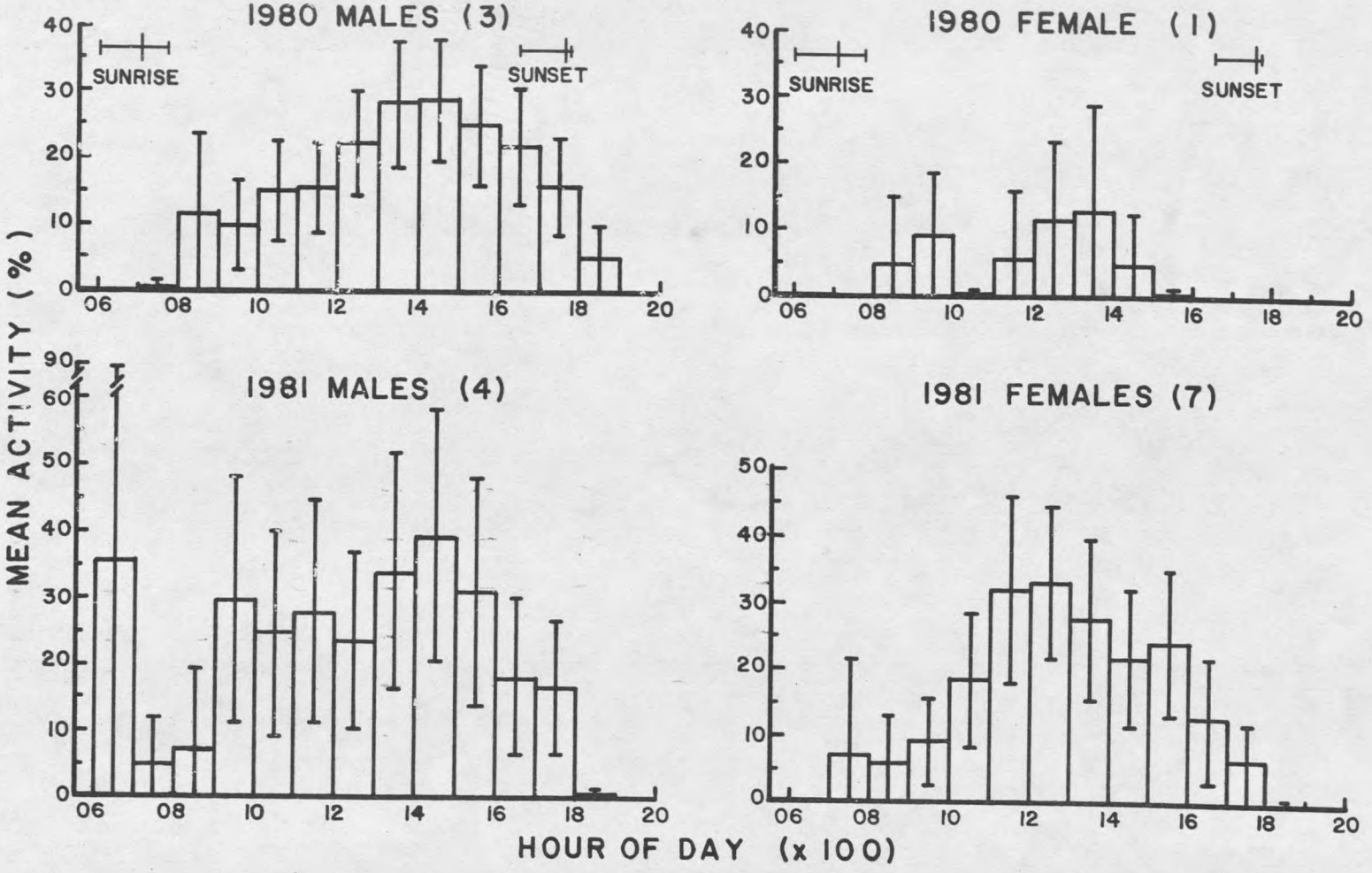


Figure 33. Total mean daily percent activity by hour block and year for male and female adult bald eagles wintering in the San Luis Valley, CO. Vertical lines indicate 99% confidence interval.

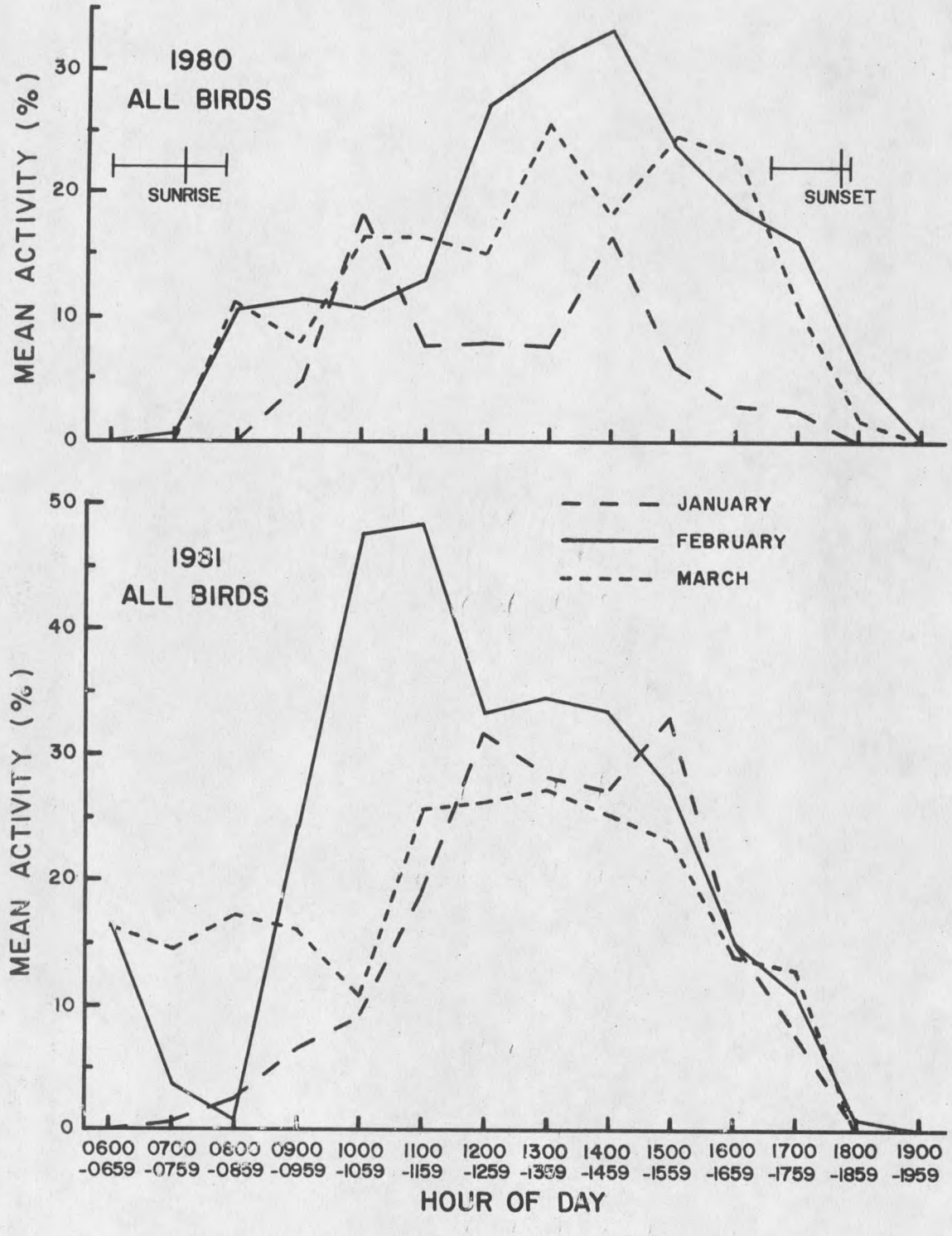


Figure 34. Mean daily percent activity of radio-tagged adult bald eagles by month for 1980 and 1981, San Luis Valley, CO.

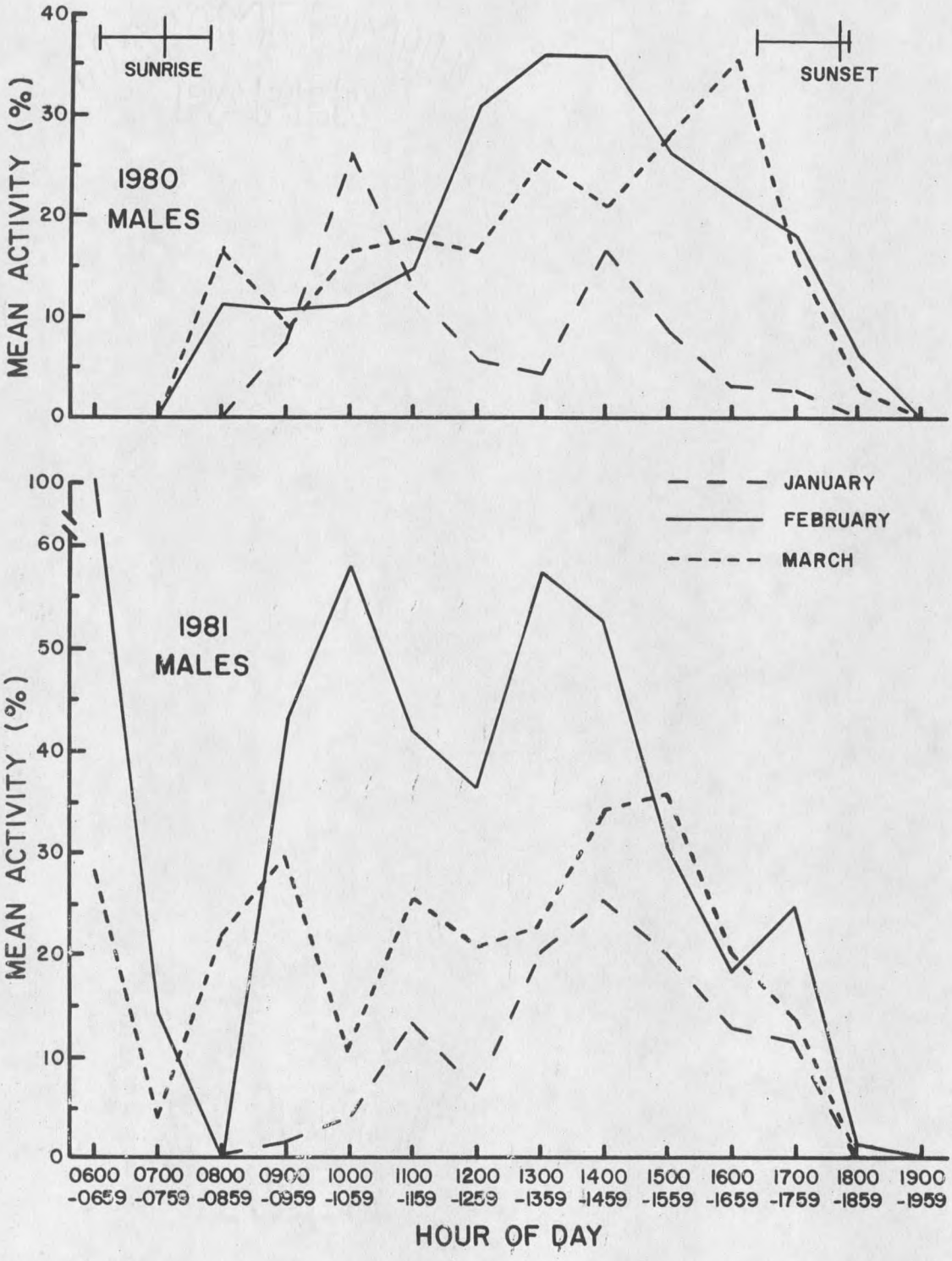


Figure 35. Mean daily percent activity of radio-tagged adult male bald eagles by month in 1980 (n = 3) and 1981 (n = 4), San Luis Valley, CO.

(r = -0.5) of activity with severe weather (P<0.15). Eliminating 1 aberrant month (February 1981) almost a perfect negative correlation (r = -0.98) of activity with severe weather (P<0.001) was obtained (Fig. 36). Eagles tended to be less active during months of lower average temperatures and in winds 0 to 15 km/hr and over 20 km/hr.

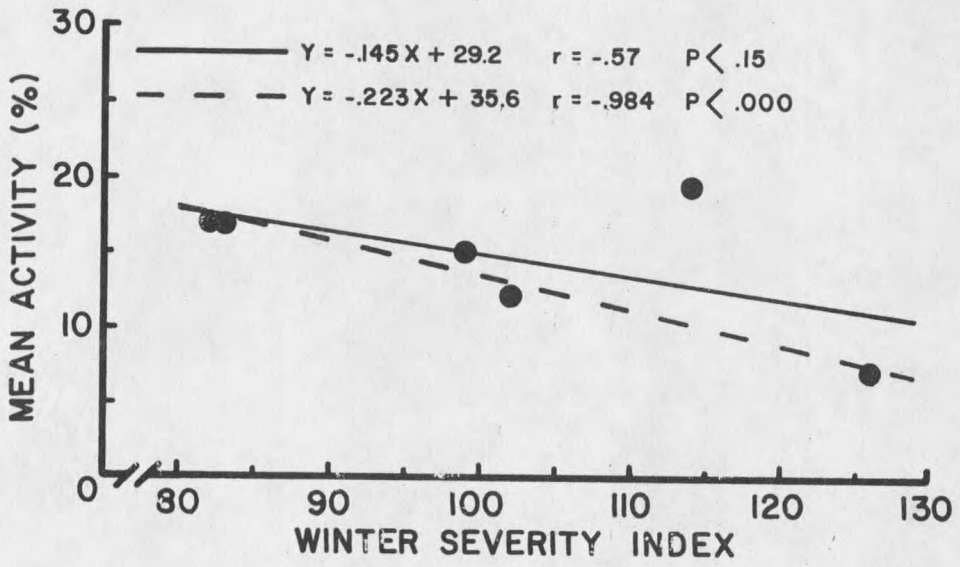


Figure 36. Regression of total monthly mean percent daily activity on Winter Severity Index (see text: 32). Solid line is regression including all months. Dashed line is regression omitting 1 aberrant month (February 1981), San Luis Valley, CO.

Eagle Responses to Human Activity

Seventy-one observations of eagles responding to human activity (disturbance) were recorded during the study. Thirteen were of feeding eagles and not included in analysis. Frequency and cross tabulation analysis revealed most significant affectors of response were sky condition, proximity of disturbance, intensity of disturbance, and type of disturbance (Table 18). After cross tabulations were recoded and

less significant variables (P values > 0.2) eliminated, the 3 most significant affectors of response were again proximity, sky condition, and intensity, but ordered differently (Table 18, second analysis).

Stepwise multiple regression with dummy coding of variables reaffirmed the most significant affectors of response were proximity of disturbance (P = 0.012) and sky condition (P = 0.038). No other significant (P<0.05) variables were found.

The most significant variables (proximity and sky conditions) were regressed to test for interactions. Although a relationship was found, it was not considered significant (P = 0.26). Log linear approaches to multiway tables supported the stepwise multiple regression analysis. The first test incuding all variables showed no significant relationships among independent variables. The second test indicated an effect of sky condition, intensity of disturbance, and proximity of disturbance on response. The last test indicated that the strongest relationship existed between proximity of disturbance and response. Responses of eagles to human activity at increasing distances are shown in Figure 37.

Empirical data imply bald eagles respond differently and even habituate to human activity depending upon the circumstances. Eagles tolerated vehicular traffic closer to perches near state and U.S. highways and heavily used county roads than on lightly traveled roads, as long as vehicles kept moving. Vehicles stopping or slowing within 150 m of adjacent perches caused most eagles to flush. Some eagles tolerated constant traffic within 150 m, but only along the most heavily travelled road in the SLV.

Table 18. Independent variables and P values derived from frequency and cross tabulation analysis of bald eagle responses to human activity (disturbance).

Response Affector (Independent Variable)	Analysis	
	First	Second
Sky conditions	.0297	.0793
Proximity of disturbance	.1302	.0778
Intensity of disturbance	.1614	.1158
Type of disturbance	.1894	.1759
Vegetation zone	.3074	
Wind conditions	.3528	
Temperature	.4252	
Age Class	.6523	

Table 19. Probability of response of bald eagles to any human activity (disturbance) at different distances under varied sky conditions.

Sky Conditions	Proximity to Bald Eagle (m)		
	0 - 150	150 - 300	over 300
Sunny	0.878	0.680	0.370
Partly Cloudy	1.0	1.0	0.734
Overcast	0.737	0.539	0.230

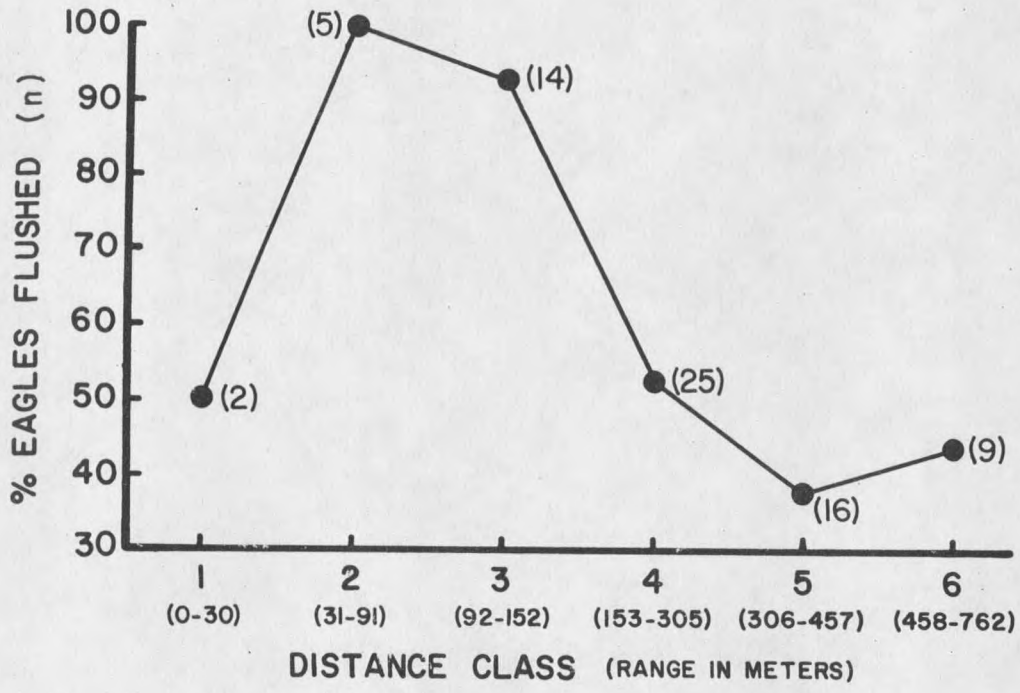


Figure 37. Percent of perched eagles observed (n) that flushed in response to human activity occurring at different distances, San Luis Valley, CO.

Eagles appeared to recognize individual vehicles and humans and responded selectively. Eagles which had been banded and marked on a vehicle usually did not tolerate that vehicle within 0.7 km subsequent to release, although other research vehicles were tolerated much closer. Farmers and ranchers conducting routine activities often drove or worked less than 100 m from perched eagles. Researchers involved in handling and marking eagles subsequently were not tolerated within 300 m when on foot.

Habitat Selection

The portion of the SLV selected for analysis of habitat selection is shown in Figure 38. All locations of radio-tagged bald eagles occurred within this approximate 90 x 90 km area (Fig. 39). Twenty habitat/terrain types were selected and digitized. Nomenclature and plant and soil associations are described in Appendix Table 35. Examples of line and area habitat types are shown in Appendix Figures 88-94. For each area habitat type, GEOSCAN calculated EDGE, A2D and EXP (see p. 36, Nos. 3-5) resulting in 42 variables available for analysis.

Over 22,600 points, representing all perch, ground, and flight locations of radio-tagged bald eagles were digitized. Elimination of all flight and repetitious perch locations resulted in 568 locations to be analyzed by GEOSCAN. Locations were segregated into 322 tree perches and 246 ground perches. Eighty percent of direct flights of all eagles were 2.2 km or less and all eagles on the ground flushed when human activity occurred 760 m or less from their position. Therefore, radii of 2.2 km and 760 m were selected for scanning circles around tree and ground perch locations respectively (Figs. 40 and 41).

Considering the distribution of habitat types in the SLV, a regular distribution of 72 nonused or "expected" points with scanning radii adjusted accordingly (Fig. 42), was selected for comparison with used tree and ground perches. Random sampling seemed inappropriate as clumped points are often a result. Habitat types in the SLV were not randomly distributed; therefore, regular distribution of nonused

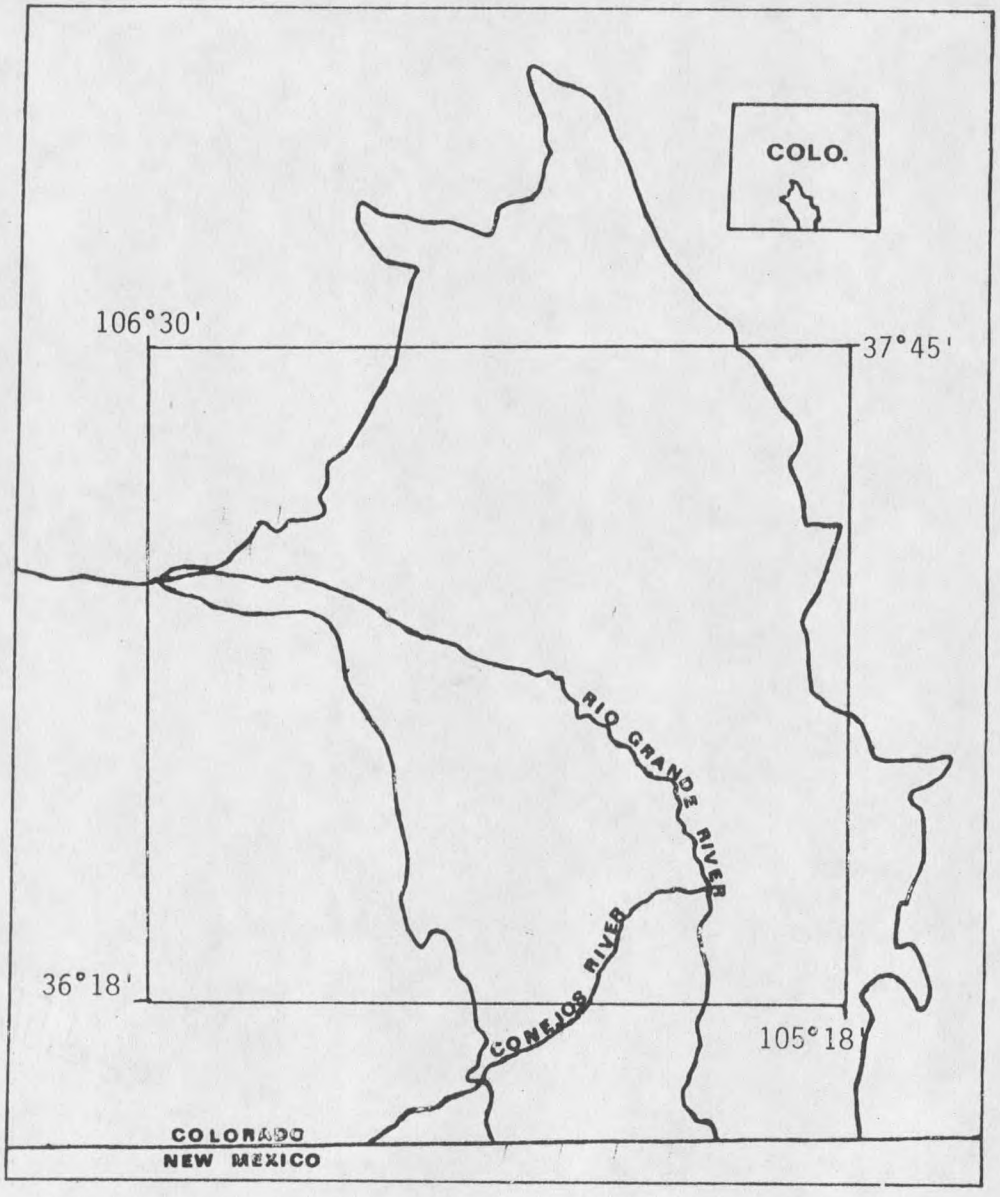


Figure 38. Portion of the San Luis Valley, CO, selected for habitat selection analysis.

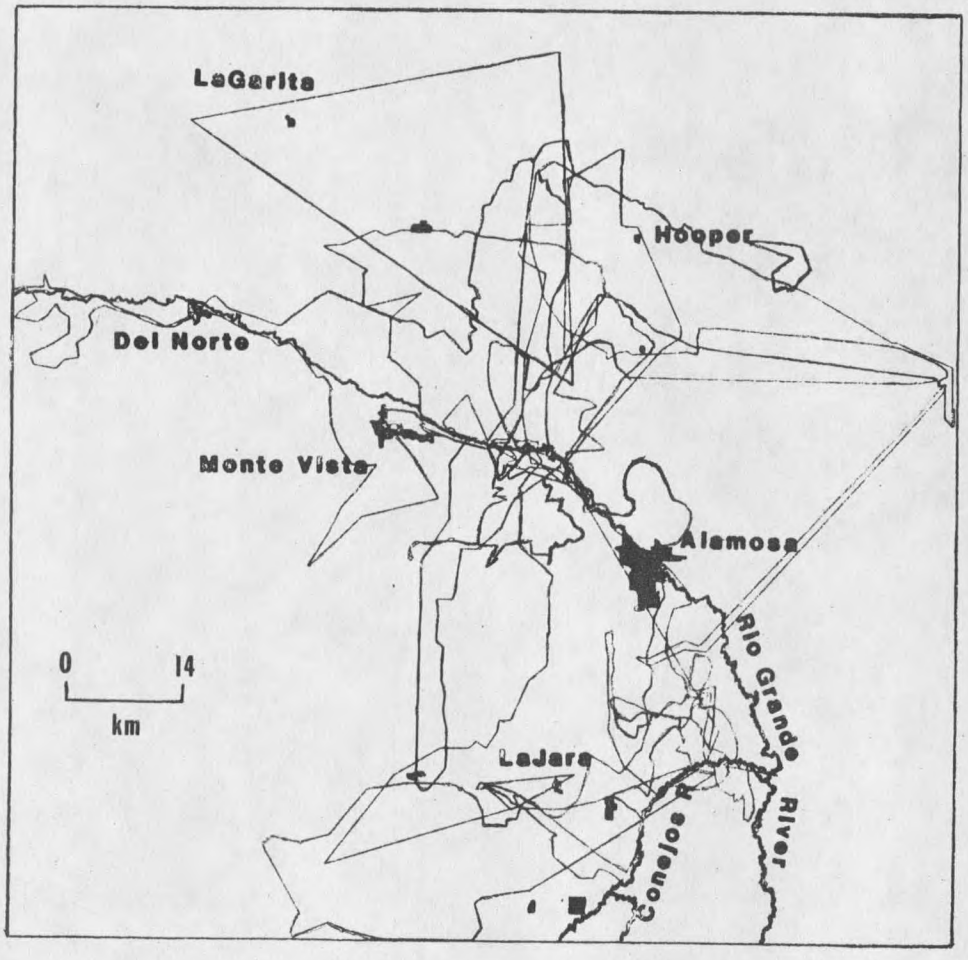


Figure 39. Location of home ranges of 15 radio-tagged adult bald eagles within the area selected for habitat selection analysis, San Luis Valley, CO.

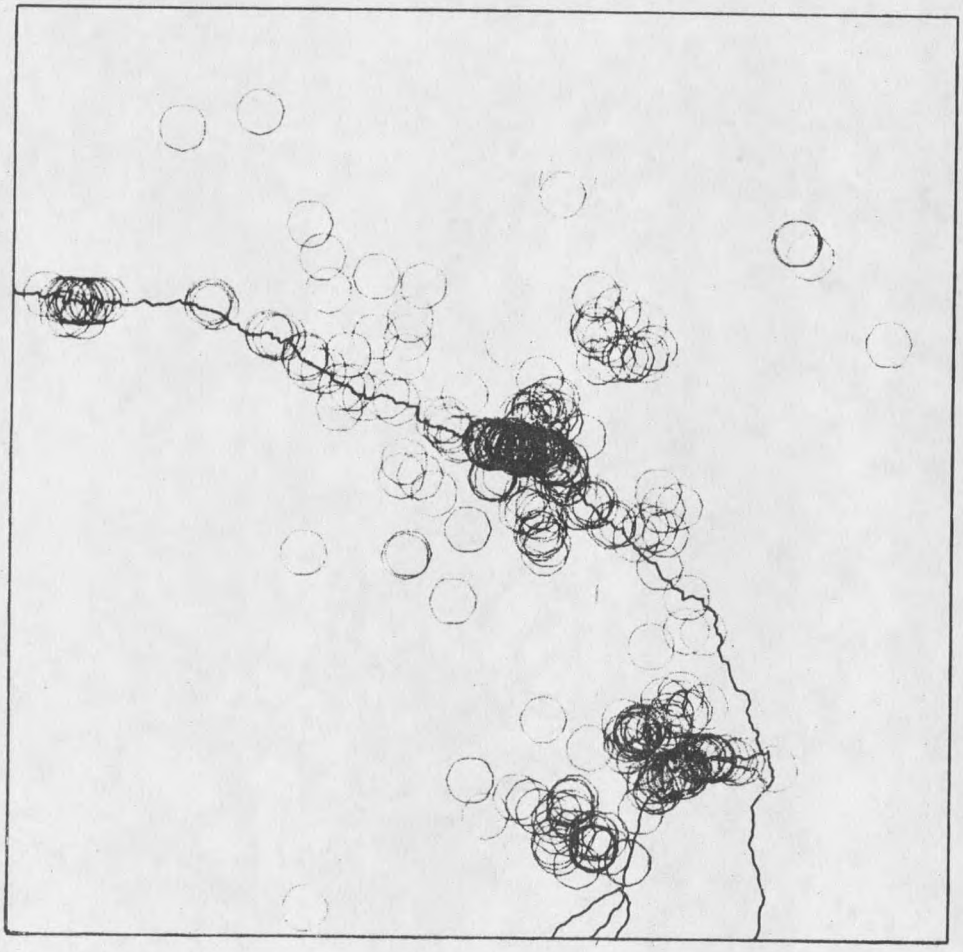


Figure 40. Location of 322 tree perches used by 15 adult radio-tagged bald eagles and respective circles of 2.2 km scanning radii in relation to the major rivers within a 90 x 90 km area chosen for habitat selection analysis, San Luis Valley, CO.

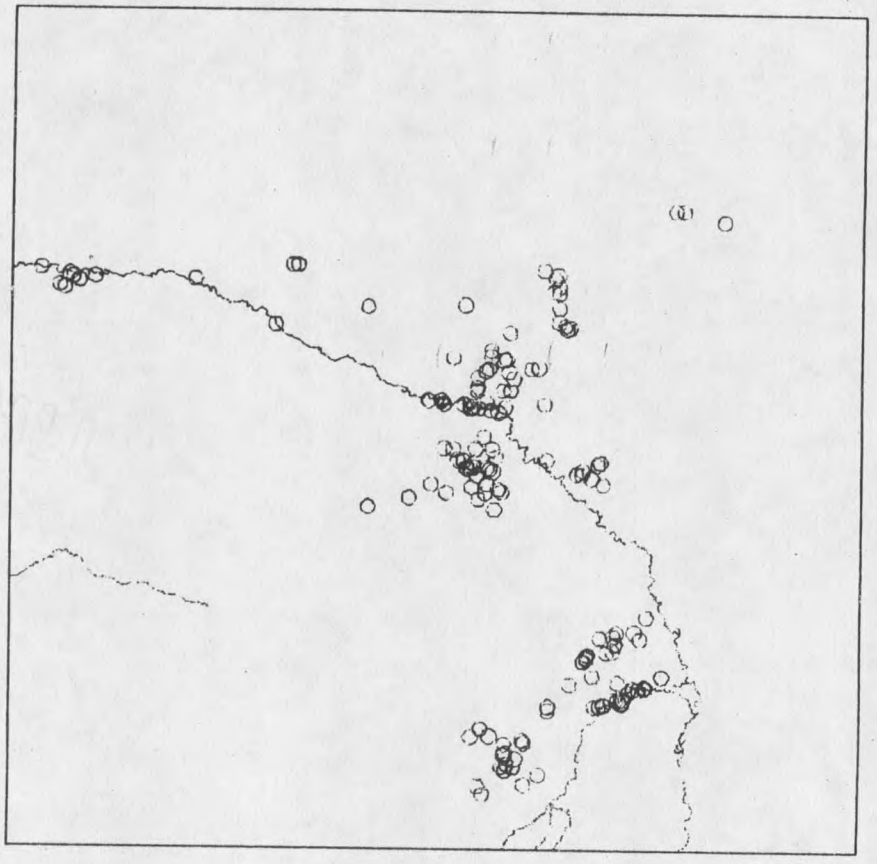


Figure 41. Location of 246 ground perch locations used by 15 radio-tagged adult bald eagles and respective circles of 760 m scanning radii in relation to the major rivers within a 90 x 90 km area chosen for habitat selection analysis, San Luis Valley, CO.

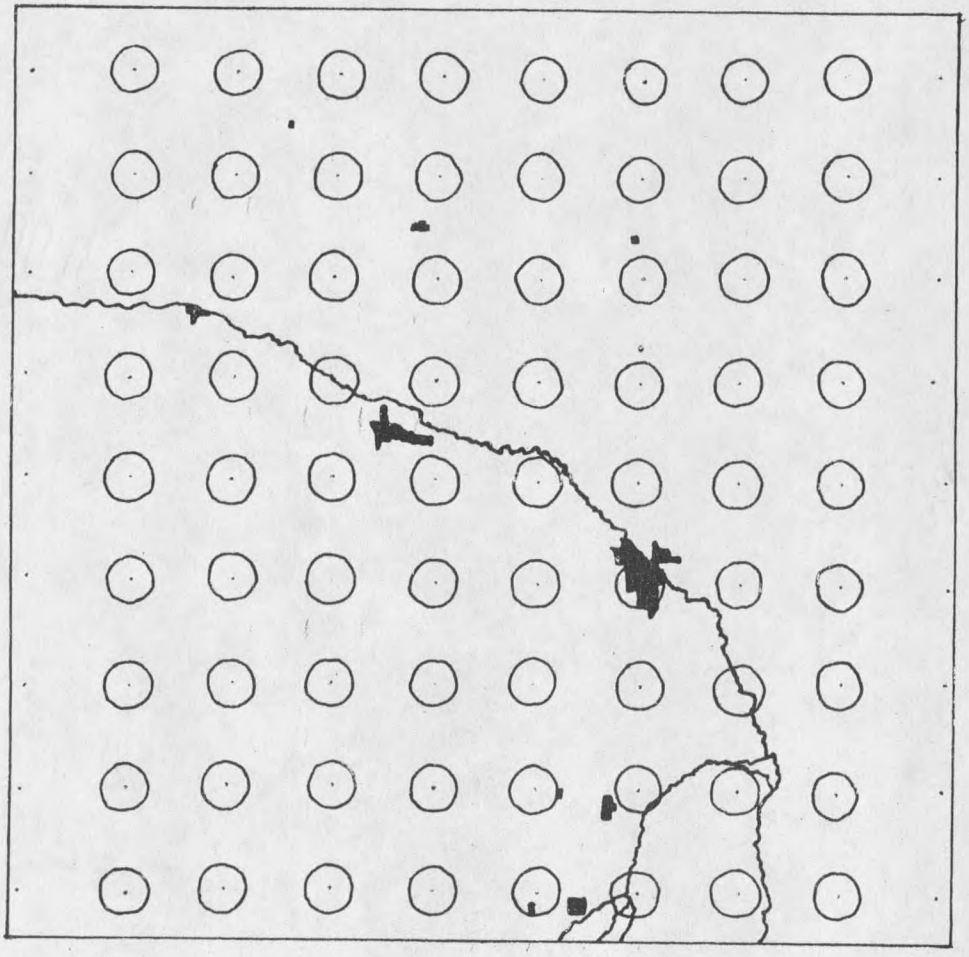


Figure 42. Distribution of 72 regularly spaced points and respective scanning circles used as expected or nonused perch locations, within 90 x 90 km area chosen for habitat selection analysis, San Luis Valley, CO.

points resulted in a more representative sampling of available habitat types within the study area.

Stepwise discriminate analysis determined 31 variables (Appendix, Table 36) that significantly ($P<0.001$) discriminated between used tree perch locations and regular (nonused) points, explaining 77% of the variation. However, 6 variables explained 70% of the variation (Fig. 43). Reclassification of known used and nonused tree perches by the discriminate function using the 31 variables resulted in 95% total correct classification with used cases clumping and nonused cases fairly evenly distributed over the discriminate score range (Fig. 44). The data fit the linear function well since the canonical correlation (R^2) was 0.84. Bald eagle use of trees or stands as perch sites in the SLV may be predicted by inserting raw measurements of 31 important variables and related coefficient values (Appendix, Table 36) into the equations:

$$TP_{use} = C_{1ob}(V_1) + C_{2ob}(V_2) + \ldots C_{34ob}(V_{34}) + K_{ob}$$

$$TP_{nonuse} = C_{1E}(V_1) + C_{2E}(V_2) + \ldots C_{34E}(V_{34}) + K_E$$

Where C_{nob} = observed coefficient value of variable n (V_n), C_{nE} = expected coefficient value of V_n, K_{ob} = constant for observed function and K_E = constant for expected function.

If $TP_{use} > TP_{nonuse}$ then the tree/grove is likely to be used by bald eagles as a perch. If $TP_{use} < TP_{nonuse}$ it likely will not be used.

Twenty-six variables were selected by discriminant analysis as significantly ($P<0.001$) contributing to the discrimination of used and nonused ground perches, explaining 73% of the variation (Appendix, Table 37). The first 6 variables selected explained 66% of the

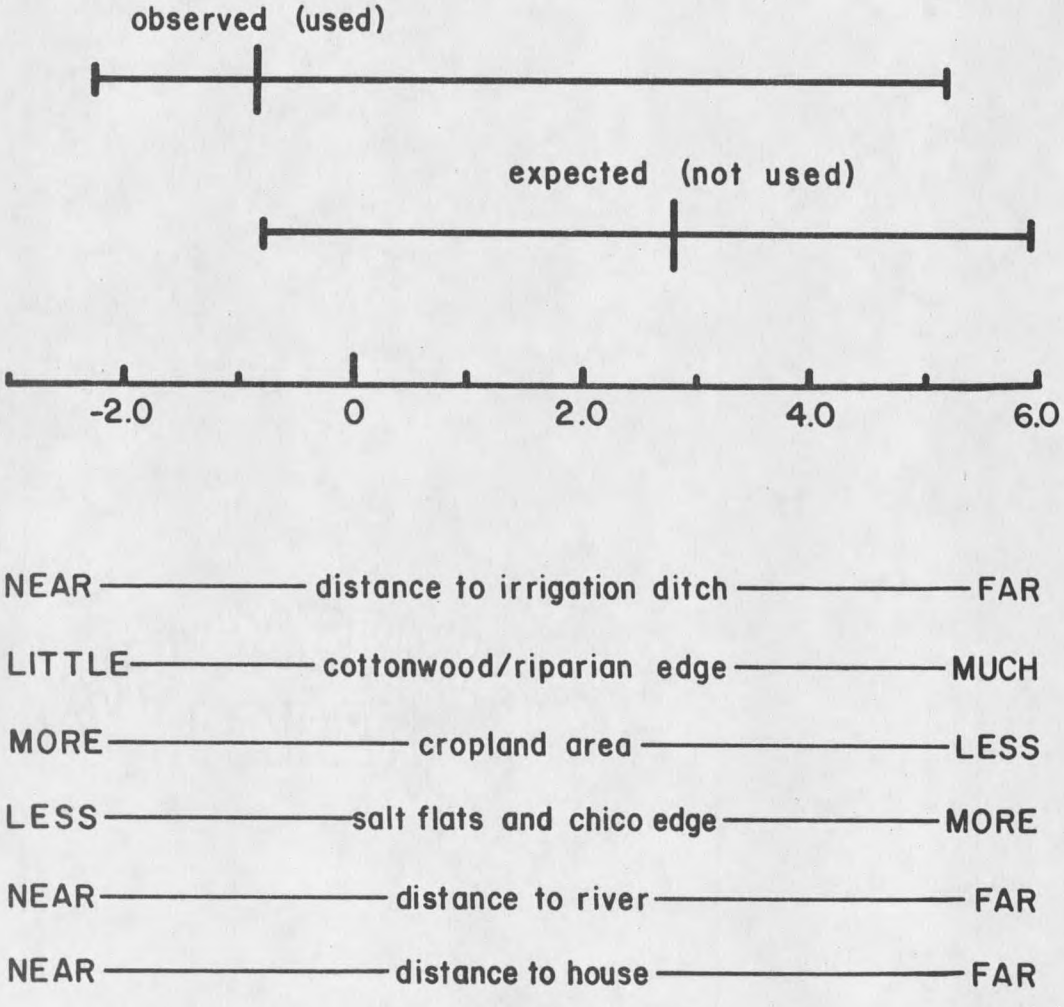


Figure 43. Centroids and ranges of discriminant scores of groups of used bald eagle tree perches and nonused points, San Luis Valley, CO, as determined by discriminate analysis. Variables and associated relative values are listed in order of entry in a stepwise procedure and explained 70% of variation.

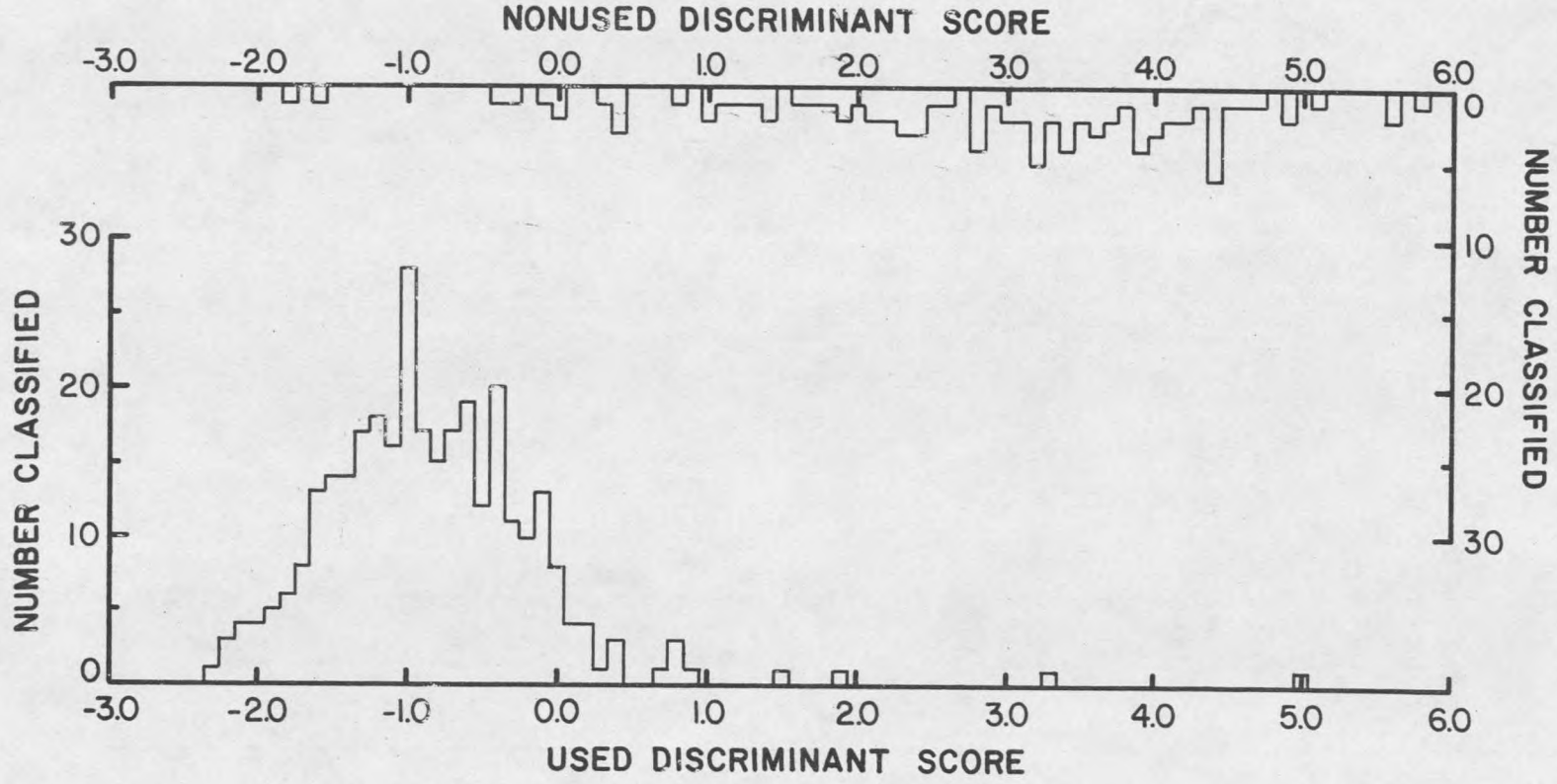


Figure 44. Histograms of discriminate scores for tree perches used by bald eagles (bottom) and nonused or regular points (top) San Luis Valley, CO.

variation (Fig. 45). Reclassification of used and nonused ground perches by the discriminate function using 27 variables resulted in 90.7% total correct classification. Used cases tended to be clumped at 1 end of the discriminate score spectrum (Fig. 46). The canonical correlation (R^2) was 0.798 indicating the data fit the linear function fairly well. Foraging habitat for bald eagles in the SLV may be assessed by selecting a point and inserting associated raw values of the 26 important variables for ground perches and respective coefficient values (Appendix, Table 37) into the equations:

$$GP_{use} = C_{1ob}(V_1) + C_{2ob}(V_2) \ldots C_{27ob}(V_{27}) + K_{ob}$$

$$GP_{nonuse} = C_{1E}(V_q) + C_{2E}(V_2) \ldots C_{27E}(V_{27}) + K_E$$

If $GP_{use} > GP_{nonuse}$ then the area may likely be bald eagle foraging habitat; if $GP_{use} < GP_{nonuse}$ then it will likely not be.

One variable, distance to nearest irrigation ditch (MDDITCH), was the most discriminating variable between used and nonused tree and ground perch locations, explaining 60 and 59% of the variation respectively. The closer a perch was to an irrigation ditch, the more likely it was to be used. Four of the 6 most important variables were common to both tree and ground perch use, but ordered differently in the stepwise procedure (c.f. Figs. 43 and 45). The relationship of use to distance to river (MDRIVER) and nearest house (MDHOUSE) held for both tree and ground perches, i.e. closer = use, but for variables salt flats and chico edge (SNEDGE) and cropland area (CRA2D) (Appendix, Table 35) the opposite relationship was true. Tree perches tended to be used when the amount of salt flats and chico edge was small and cropland area large within the scanning radius, but ground perches tended

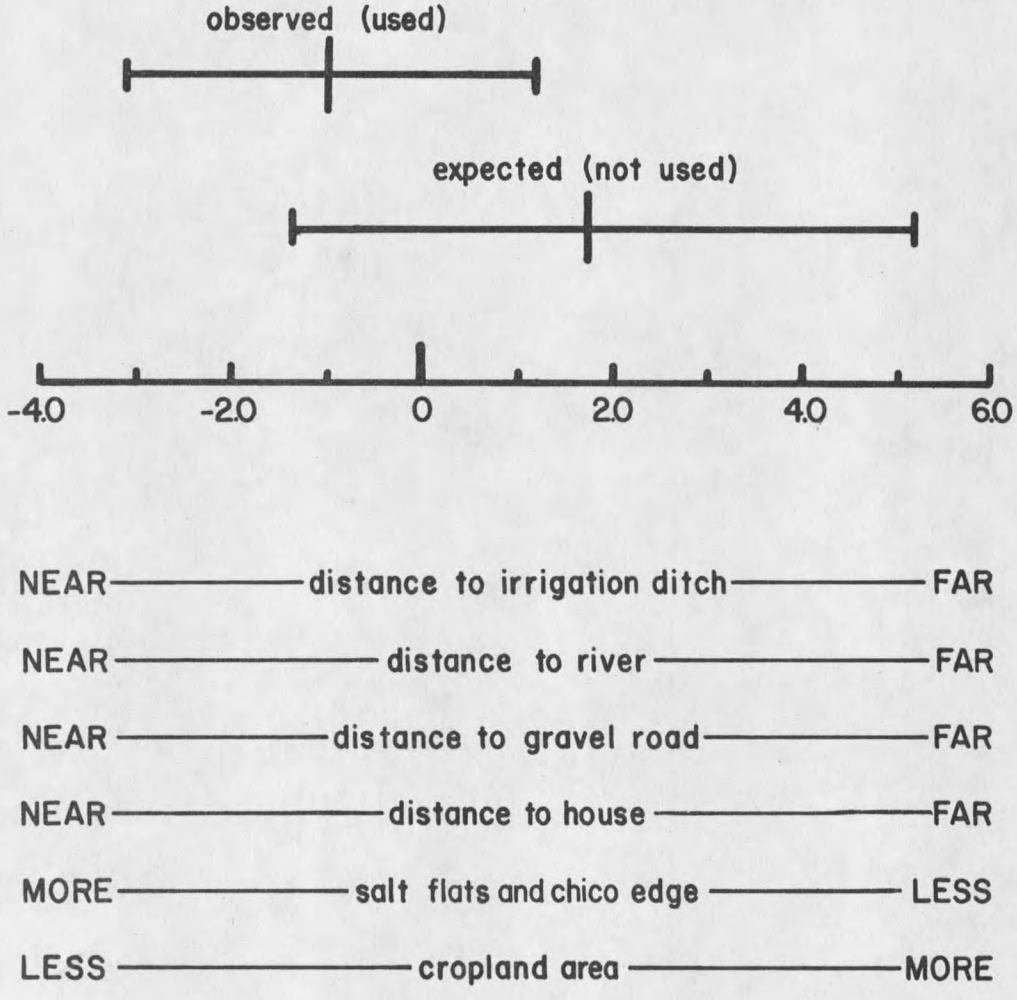


Figure 45. Centroids and ranges of discriminant scores of groups of used bald eagle ground perches and nonused points, San Luis Valley, CO as determined by discriminate analysis. Variables and associated relative values are listed in order of entry in a stepwise procedure and explained 66% of variation.

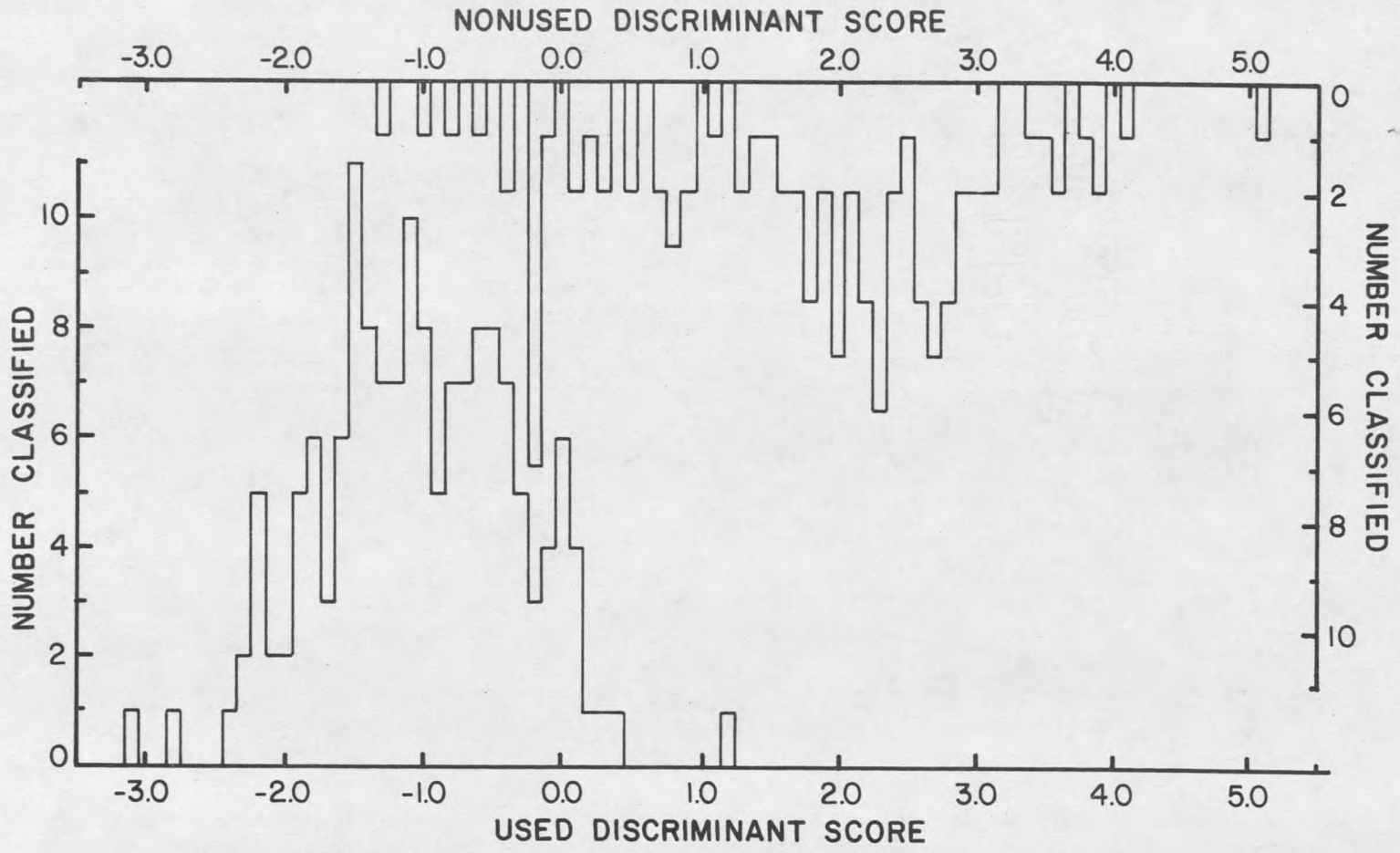


Figure 46. Histograms of discriminate scores for ground perches used by bald eagles (bottom) and unused or regular points (top), San Luis Valley, CO.

to be used when salt flats and chico edge was large and cropland area small (c.f. Figs. 43 and 45).

Habitat Use

Figures 47 through 50 graphically illustrate relative perch use of 4 adult bald eagles each radio-tracked more than 190 hours. Although perch use was not weighted for time, clearly some perches were used much more than others and may in fact have been "preferred." Eagles used only a small number of perches available in their home range, except for eagle #2-80 (Fig. 47).

Distribution of perches indicates shifting of habitat use during the winter. Two distinct clumpings of perches are discernable in the ranges of eagle #2-80 and eagle #4-80 (Fig. 48). The clumpings in the southern part of #2-80's home range are almost all in upland habitat at least 3 km from the Conejos River. This portion of the home range was used from 23 January until 20 February. In the afternoon of 20 February, #2-80 flew north to the Rio Grande River to roost. He returned to the southern portion of the home range the next day and remained there until 25 February. He then flew to the northern portion of the range again where he remained until he left the SLV on northward migration. Although the 2 perches that received the highest use in the northern part of the range were to the northwest of the Rio Grande River in upland habitat, more perches were used in riparian habitat on the banks of the river. Clearly he shifted from using primarily upland habitat in mid-winter to riparian habitat as spring approached, although he continued some use of upland perches also.

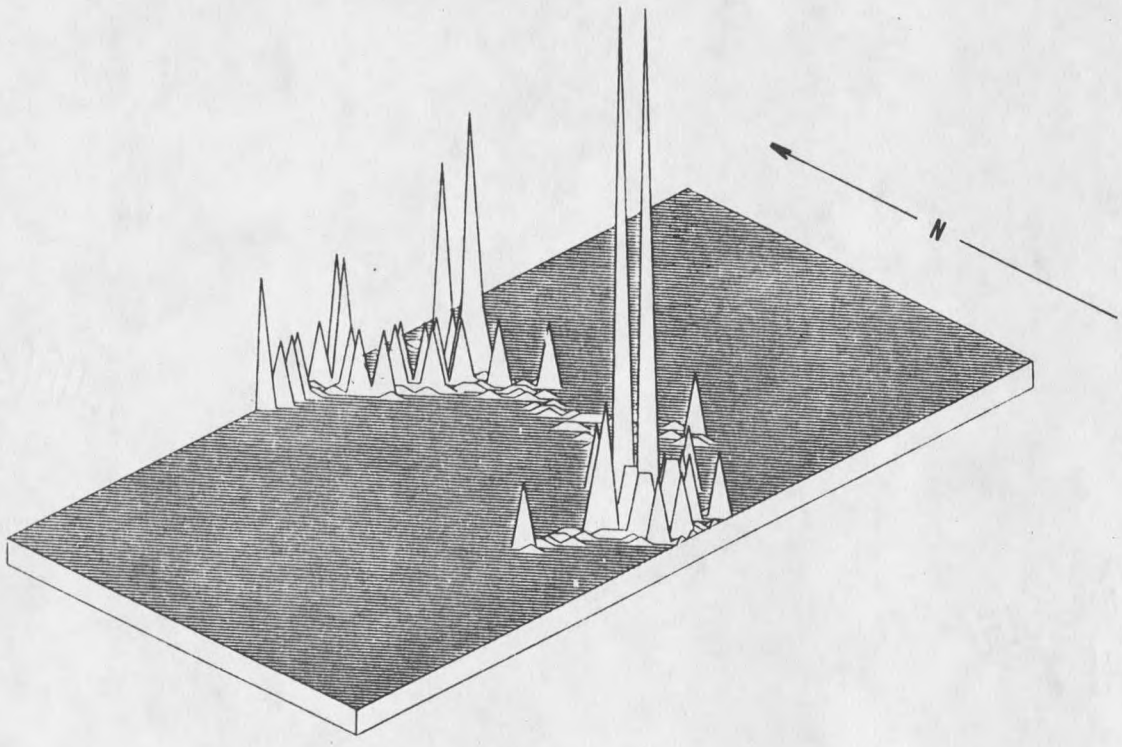


Figure 47. Relative frequency of use and location of tree perches with the home range of bald eagle #2-80, San Luis Valley, CO.

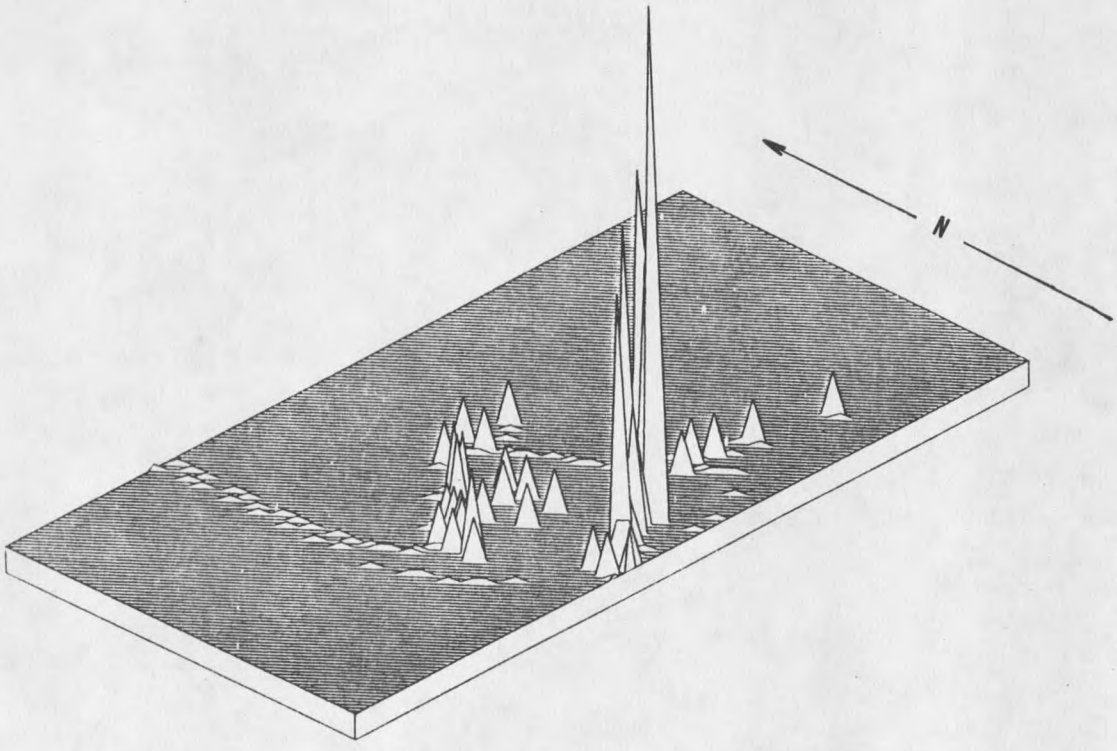


Figure 48. Relative frequency of use and location of tree perches within the home range of eagle #4-80, San Luis Valley, CO.

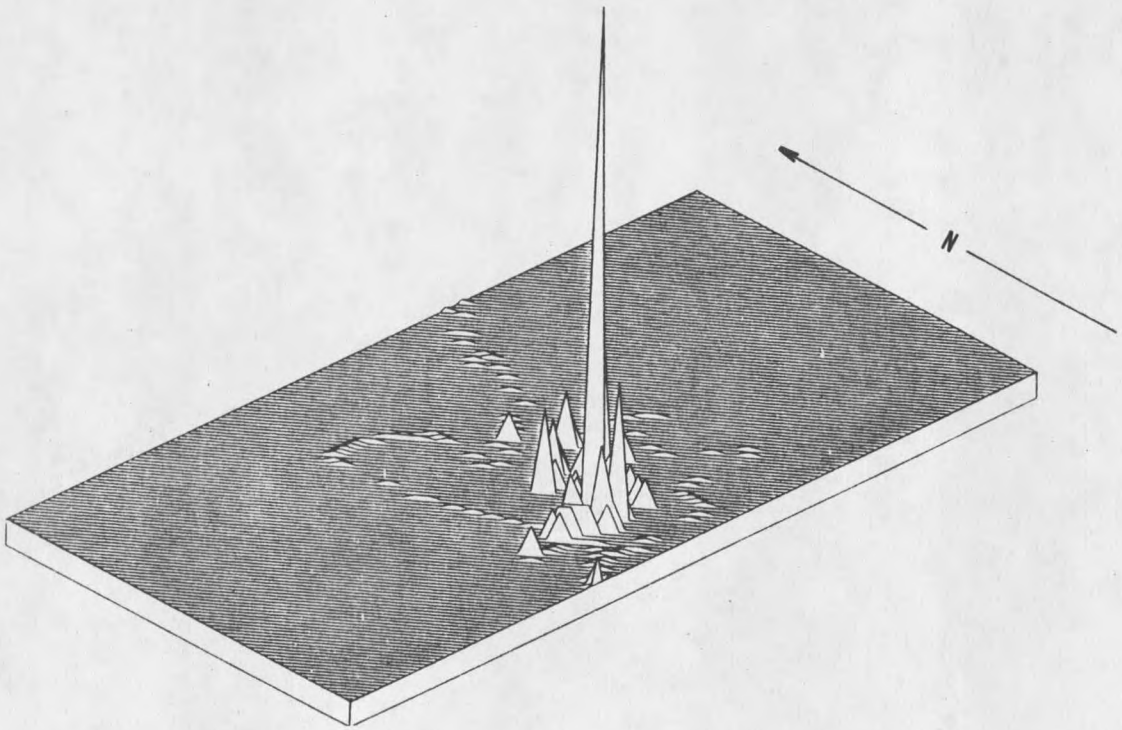


Figure 49. Relative frequency of use and location of tree perches within the home range of eagle #5-81, San Luis Valley, CO.

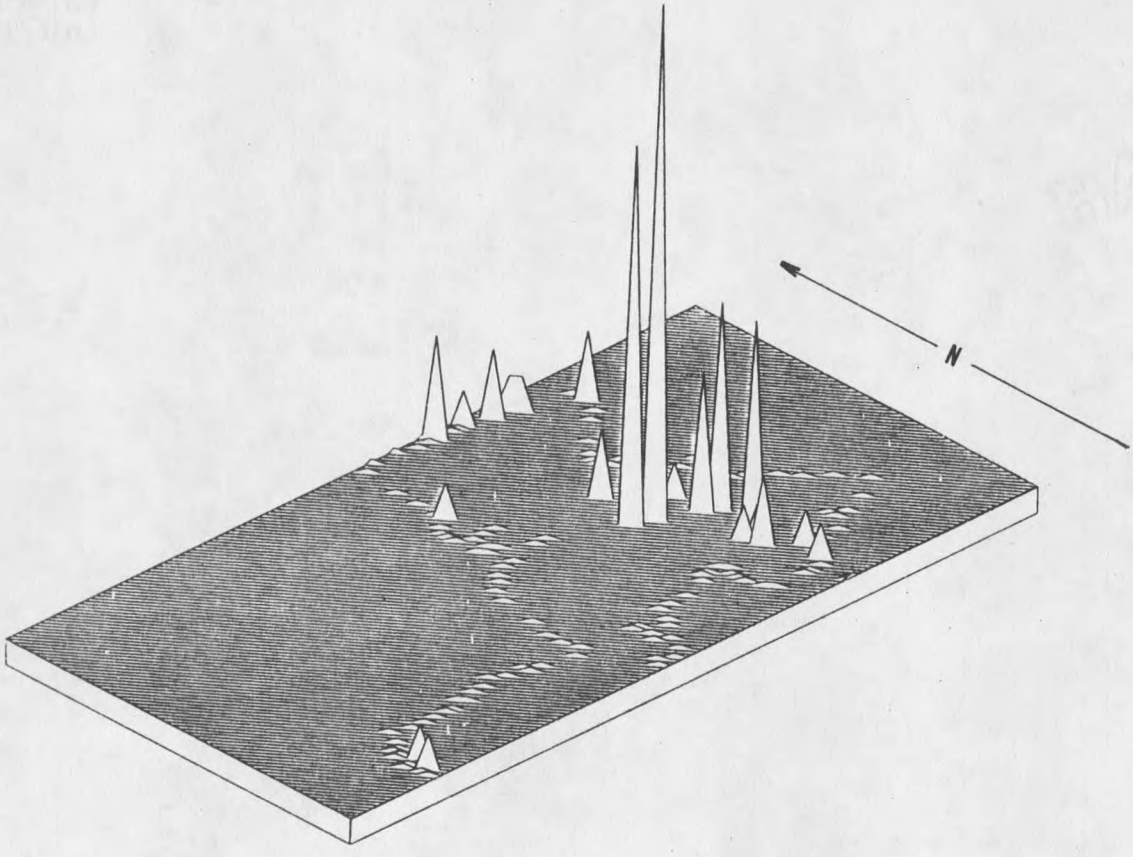


Figure 50. Relative frequency of use and location of tree perches within the home range of eagle #8-81, San Luis Valley, CO.

Eagle #4-80 also shifted habitat use over the winter. The perch used most often was about 0.5 km from the Conejos River and above a small pond kept open by geothermal activity of adjacent McIntire Spring. The area around the spring is essentially riparian habitat. Other heavily used perches in the southern portion of his home range are along the Conejos River. Those in the northern portion of the range are in upland habitat. From 23 January until late February, #4-80 spent most of his time with his mate at McIntire spring and along the Conejos River. Between 27 February and 4 March, his activity gradually shifted to the north central portion of his range about 5.5 km from the river. His movements in this upland habitat were more dispersed and many perches were used. Most of his activity occurred in this area until he left the SLV on spring migration.

Recapture of a 1.5 yr-old bald eagle the same year indicates a similar pattern of habitat shift may hold for immatures. The immature eagle was first captured on 18 January 1981 within the southern area that #2-80 used as a home range in January and February 1981 (Fig. 47). The immature was recaptured on 15 March 1981 in the area encompassed by the northern portion of the home range of eagle #2-80.

Eagle #5-81 did not stray far from the Rio Grande River in the southern portion of her range (Fig. 49). Most of the perches she used were located there and most of her time was spent along or near the river. Throughout the winter, however, she would occasionally forage up to 7 km north of the river in upland habitat. She was known to have perched south of the river only once.

Eagle #8-81 foraged almost entirely south of the Rio Grande River in upland habitat in the southern part of his home range (Fig. 50). He seldom used perches along the river and those that were used were primarily pre- or post-roost perches and not obviously foraging perches.

Perches used along the major rivers by all eagles were usually adjacent to riffles, oxbows, or sharp bends in the river. The rivers occasionally became ice free in these areas during the winter and waterfowl would congregate there. Fishes probably congregated in deeper pools along banks undercut by the curving river and upwellings were common, presumably making fish more available.

Roost Site Description

Previous study (Harmata and Stahlecker 1977), observations, and telemetry identified 28 roost sites in and around the SLV. Two sites were lost through installation of center pivots, 1 in 1978 and 1 in 1980. Two other roosts were not used during 2 or more years of study. Additionally, 4 sites were not checked in 1981. Ultimately, 22 roosts were known to be used during 1980 and 1981 (Fig. 51).

All major ($\bar{x}$ > 10 eagles/night) upland roosts (>2 km from the river) and all major riparian roosts in the valley were in cottonwood groves with primary roost trees at least 21 m tall. Of all primary roost trees used during the study (n = 22), only 4 were in decadent trees, (2 in mountain, 1 in upland and 1 in riparian roost sites). Ponderosa pine (Pinus ponderosa) was the only other species used as a primary roost tree and all were at mountain sites (n = 4). These trees were usually 50 to 75% to the top of a ridgeline or hill.

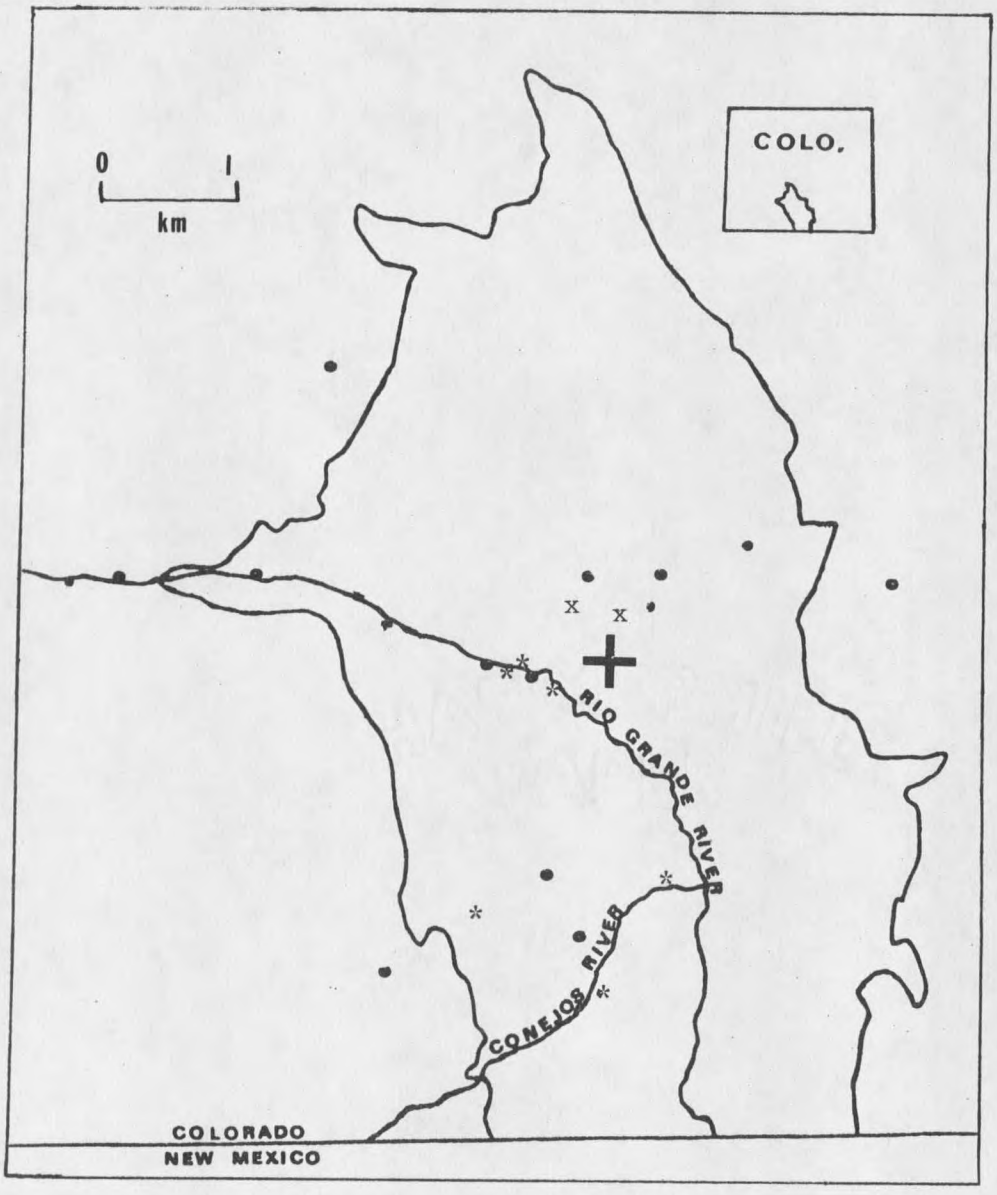


Figure 51. Bald eagle roost sites in the San Luis Valley, CO, 1980, 1981. * indicates major roost sites (x ≧ 10 eagles/night). x indicates roost lost to installation of center pivots.

Table 20 illustrates measured parameters at major roost sites in the SLV. Primary roost trees measured in the valley proper were between 0.75 and 2.6 km from an occupied dwelling. County roads were no closer than 0.58 km and no farther than 1.6 km from roosts measured in the valley proper. Vehicle trails were closer, ranging from 1 m to 1 km away. Roost sites in the valley proper generally were close to perennial water ($\bar{x}$ = 75 m) and usually (6 of 7 cases) on the edge of a stand of cottonwoods. The land use of the immediate area around the stands containing roosts was primarily livestock grazing.

Table 20. Descriptive statistics for 14 continuous variables measured at major bald eagle roost sites, San Luis Valley, CO.

Variable[a]	N	$\bar{x}$	± SE (α=0.05)	SD	Range
TH(m)	6	23.4	2.01	1.92	21.1-25.2
TD(cm)	6	62.6	20.41	19.45	51.6-99.3
TW(m)	7	75.0	61.3	66.21	0.15-160
TM(x°)	6	60.0	2.01	1.92	21.1-25.2
SA(A)	7	14.04	13.08	14.12	3-41
SD(/100m^2)	6	5.08	3.39	3.39	0.04-10.7
SH(m)	6	21.63	2.63	2.63	17.3-24
SN	6	5.0	3.0	3.0	1-10
HNB(m)	6	1.22	2.0	2.0	0-5
SINV(ms)	7	4.49	1.4	1.51	2.56-7.06
DOD(km)	7	1.03	0.66	0.71	0.75-2.6
DCR(km)	7	1.08	0.4	0.43	0.58-1.6
DVT(km)	6	0.55	0.4	0.44	0.001-1
CITY(km)	7	8.46	2.52	2.73	4.8-12

[a]Variable rubrics defined in Table 1: 41.

Roost Site Suitability

Dividing the SLV into quarters with the origin at approximately the center of the valley (Fig. 51), Chi-square analysis showed a significantly (P = 0.025) greater number of roost sites in the western

half of the valley. There was no difference in number of roost sites between the north and south half of the valley. Most (54.5%) roosts used 2 or more years were along major rivers. Values of 6 variables measured at used and nonused sites on the Rio Grande and Conejos Rivers are presented in Appendix Tables 38 and 39, respectively.

Kruskal-Wallis tests indicated significant differences between the Rio Grande and Conejos Rivers for sinuosity (SINU) (P = 0.033) and distance to the nearest occupied dwelling (DOD) (P = 0.058) (Table 21). Therefore, roost data for each river were analyzed separately. Comparing used and nonused sites on each river, non-parametric tests found few significant differences among variables. Distance to cities (CITY) was significantly greater (P = 0.073) at used sites than nonused sites on the Rio Grande River (Table 21). On the Conejos River, distance to nearest county road (DCR) was significantly greater (P = 0.046) for used than nonused sites (Table 21).

Table 21. Significance of difference (P value) between variables at bald eagle roost sites in the San Luis Valley, CO, on (1) the Rio Grande and Conejos Rivers, (2) used vs nonused areas on the Rio Grande River, (3) used vs nonused areas on the Conejos River as determined by Kruskal-Wallis test.

Variable[a]	River	Used vs Nonused Sites	
	Rio Grande vs Conejos	Rio Grande	Conejos
SA	.727	.058*	.80
SINV	.033*	.073*	.505
DOD	.058*	.171	.182
DCR	.838	.429	.046*
TW	.560	.398	.505
CITY	.930	.073*	.317

[a]Variable rubrics defined in Table 1: 41
*Significant at the $\alpha = 0.10$ level

With combined data from both the Rio Grande and Conejos Rivers, the stepwise discriminant analysis selected 3 of 6 variables that significantly contributed to discrimination between used and nonused sites for both rivers (Table 22: Analyses R+C). The discriminate function classified 85.7% of used sites and 72.2% of nonused sites correctly using these variables (Table 23). The total percent correct classification (76%) and canonical correlation (R^2) of 0.55 indicates the variables chosen did fairly well in separating use categories. The discriminate function scores and influence of each variable on the separation of use categories are illustrated in Figure 52.

As non-parametric tests showed differences between rivers (Table 21), each river was also analyzed separately. Selected variables were then used to classify known sites on the river. For the Rio Grande, 5 variables were selected to separate use categories and for the Conejos River 1 variable (DCR) was entered (Table 22: Analyses R and C). A high degree of discrimination was achieved with the entered variables for the Rio Grande River (Table 24). Total correct classification was 94.1%, canonical correlation was 0.72. The 1 variable entered for the Conejos River had less power to discriminate (62.5%: Table 22) and the canonical correlation also was less significant (0.633).

Using variables derived for 1 river to classify known use categories on the other resulted in poor classification percentages (Table 25). Using the most discriminating variable for the Conejos River, predicted use means (group centroids) for the Rio Grande River were not widely separated (Fig. 53) and therefore DCR is of little use in discriminating use categories of sites on the Rio Grande River.

Table 22. Variables that distinguish most between used and nonused bald eagle roost sites, order of entry and classification coefficients for 3 comparisons of San Luis Valley, CO rivers as determined by 2 way stepwise discriminate analyses.

Analysis	Rubric[a]	Order Entered	Classification Coefficient Used	Classification Coefficient Nonused	F Statistic	df F_1	df F_2	% Variation Explained
R + C[b]	CITY	1	0.697	0.39	5.15	1	23	55
	SA	2	0.126	0.05	3.89	2	22	58
	TW	3	0.003	0.008	3.12	3	21	59
	K		-4.646	-2.398				
R[c]	CITY	1	0.917	0.229	4.32	1	5	56.3
	SA	2	0.106	0.008	3.08	2	14	59.0
	DCR	3	-3.895	1.217	3.01	3	13	62.8
	SINU	4	1.1699	0.553	2.57	4	12	65.0
	TW	5	-0.00394	0.004	2.33	5	11	67.3
	K		-6.627	-3.086				
C[d]	DCR	1	5.497	2.364	4.109	1	6	62.5
	K		-4.816	-1.455				

[a] Variable rubrics defined in Table 1: 41
[b] Rio Grande and Conejos Rivers combined; $P<0.10$
[c] Rio Grande River; $P<0.25$
[d] Conejos River; $P<0.10$

Table 23. Classification matrix from discriminate analysis of known used and nonused roost sites in the San Luis Valley, CO on the Rio Grande and Conejos Rivers combined.

Actual Category	Predicted Category		Percent Correct
	Use	Nonuse	
Use	6	1	85.7
Nonuse	5	13	72.7
		Total	76.0

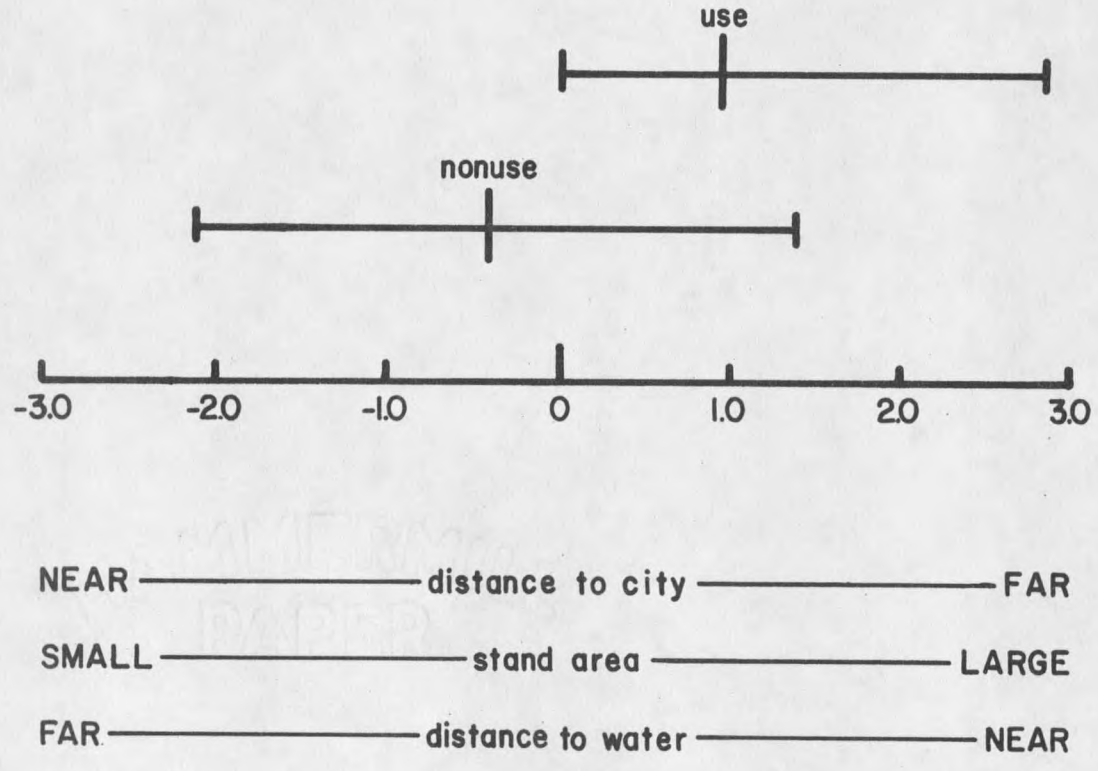


Figure 52. Group centroids, ranges of discriminate scores, and relative magnitudes of variables that discriminate most between used and nonused bald eagle roost sites on the Rio Grande and Conejos Rivers, San Luis Valley, CO.

Table 24. Classification matrix from discriminate analysis of known used and nonused roost sites on the Rio Grande River, San Luis Valley, CO.

Actual Category	Predicted Category: Use	Nonuse	Percent Correct
Use	5	0	100
Nonuse	1	11	91.7
		Total	94.1

Table 25. Predictability of site use by roosting bald eagles with discriminating variables derived for 1 river and used to classify the other in the San Luis Valley, CO.

River Classified	Discriminating Variable(s)[a]	Actual Category	Predicted Category: Use	Nonuse	Percent Correct
Conejos	CITY, SA, DCR, SINU, TW	Use	0	2	0
		Nonuse	1	5	16.6
				Total	12.5
Rio Grande	DCR	Use	2	3	40.0
		Nonuse	3	9	25.0
				Total	29.4

[a]Variable rubrics defined in Table 1: 41

Similarly, important variables found for the Rio Grande River are of little use for discriminating use categories on the Conejos (Fig. 54). This further supports the findings of statistical tests indicating that the 2 rivers have different characteristics. Assessment of the potential for riparian sites along the major rivers for use by roosting bald eagles in the SLV should, therefore, be made by considering each river separately. Using the variables and their respective coefficients for each river as presented in Table 22 the resultant classification functions will indicate the potential for selected sites along each river to be used or not. Classification functions using coefficients

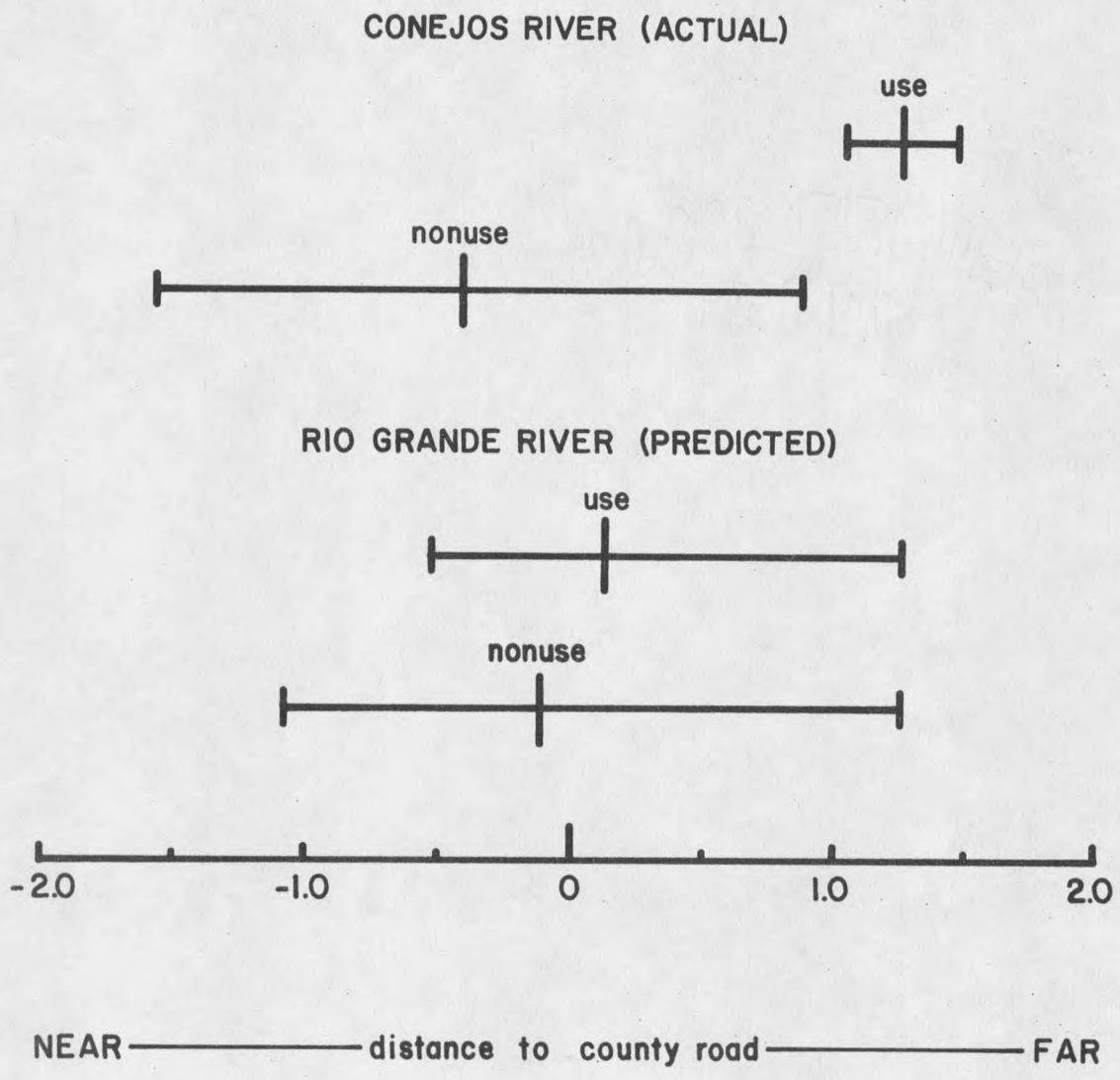


Figure 53. Group centroids and discriminate score ranges of bald eagle roost site use categories using the most discriminating variable selected for the Conejos River (actual) to predict use of sites on the Rio Grande River (predicted) San Luis Valley, CO.

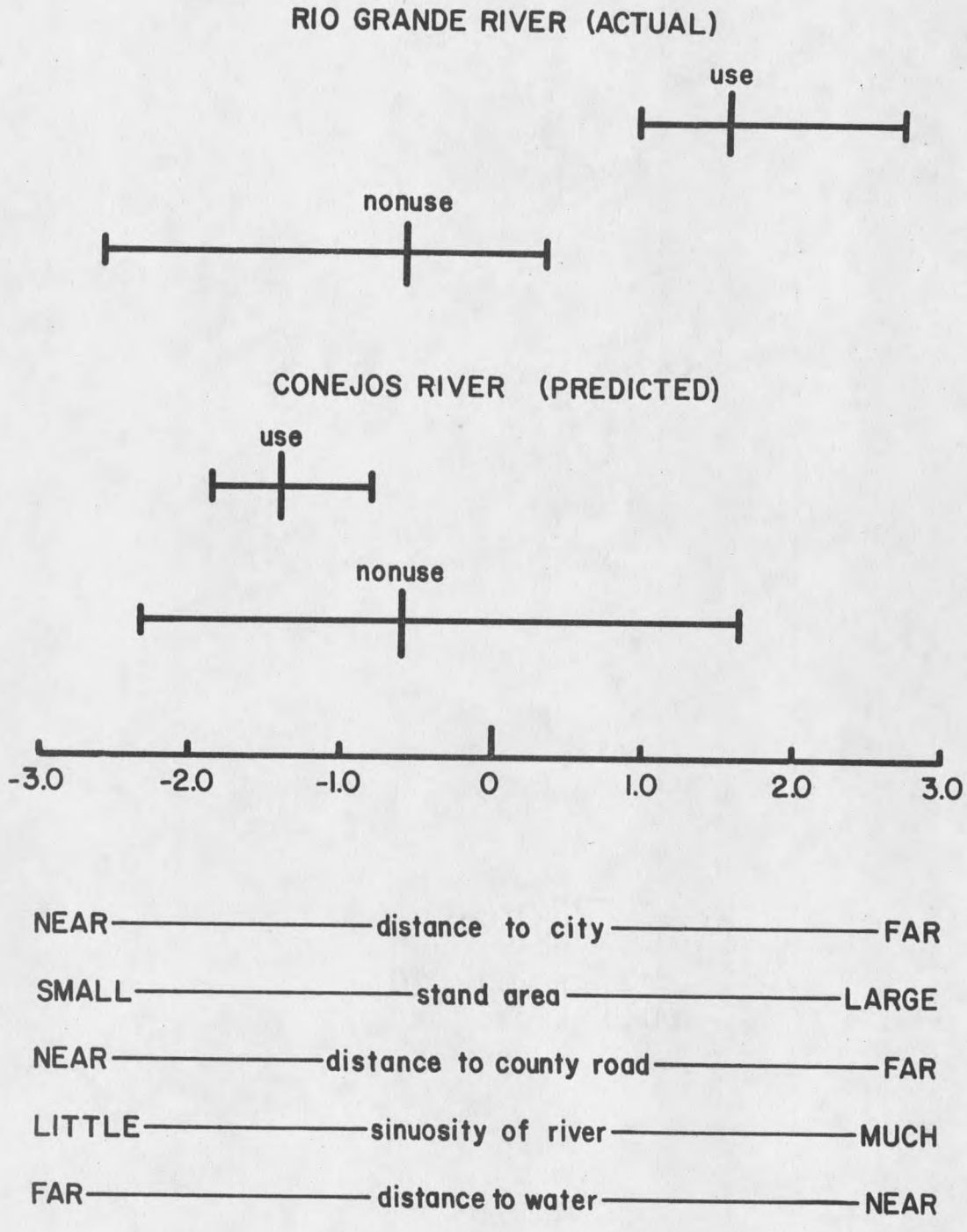


Figure 54. Group centroids and discriminate score ranges of bald eagle roost site use categories using the most discriminating variables selected for the Rio Grande River (actual) to predict use of sites on the Conejos River (predicted), San Luis Valley, CO.

(C) and variables (V) (Table 22) are:

$$R_{use\ (u)} = C_{1u}(V_{1u}) + C_{2u}(V_{2u}) + \ldots . C_{nu}(V_{nu})K_{use}$$

$$R_{nonuse\ (N)} = C_{1N}(V_{1N}) + C_{2N}(V_{2N}) + \ldots . C_{nN}(V_{nN})K_{nonuse}$$

If $R_{use} < R_{nonuse}$ then site probably will not be used;

If $R_{use} > R_{nonuse}$ then site potentially will be used.

Roost Site Preference

Bald eagle use of major roost sites in the SLV is shown in Table 26. Twelve continuous variables were chosen to correlate with count in an effort to determine if preference for roost sites occurs. Pearson and Spearman correlations of count with selected variables are presented in Table 27. Significant positive correlations were found for variables HNB, SA, SH and TW with count for Pearson tests and for variable DCR for Spearman tests. However, strong correlations (i.e., a value of 0.4 or above) with the same direction were found in both tests for variables SA, SH, SN, TW and DCR.

Table 26. Bald eagle use of major winter roost sites in the San Luis Valley, CO.

Roost	Number of Days Counted	Count $\bar{x}$ of Eagles	Range
Stillings	28	38	2 - 68
Collis	6	10	7 - 16
ECL	8	21	10 - 33
UCR	6	16	5 - 30
LCR	15	24	5 - 47
Peterson	15	15	2 - 36

Table 27. Parametric* and non-parametric correlation between count and continuous variables measured at bald eagle roost sites, San Luis Valley, CO.

Variable[1]	Pearson*		Spearman	
	Value	P	Value	P
HNB	.6446	.084	.2940	.478
SA	.8934	.008	.5508	.129
SD	.1370	.398	.6000	.104
SH	-.7199	.053	-.4928	.160
SN	-.5030	.155	-.5798	.114
TH	-.3315	.260	.0000	.500
TD	.0594	.456	.1429	.394
TW	-.6753	.071	-.4857	.164
TM	-.2940	.286	.0580	.457
DOD	.0689	.448	.0857	.436
DCR	.4413	.191	.6571	.078
DVT	.0711	.447	.2571	.311

[1]Variable rubrics are defined in Table 1: 41.

Age Class Composition at Roost Sites

Figure 55 illustrates mean percent composition by age class (adult/immature) of bald eagles at roost sites by month over 2 years of counts. Mean percent immatures for all months was 46.6. However, mean percent immatures for winter months (December-February) was 30, increasing to 71.5% for spring months (March and April). Increased percentage of immatures in March represented real increases in total numbers of immatures and decreases in total numbers of adults, indicating an influx of immatures into the valley coincident with an emigration of adults. However, April percentages represent fewer numbers of eagles present overall, with immatures remaining longer than adults.

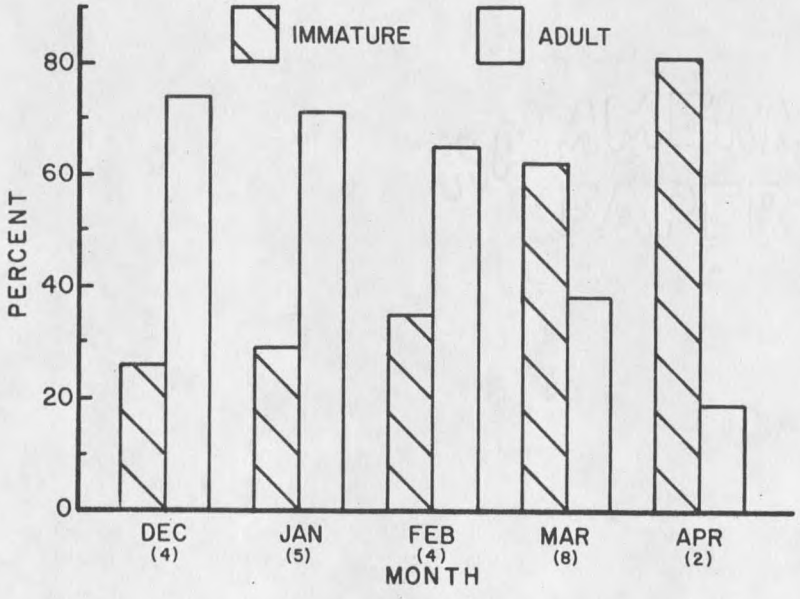


Figure 55. Age class composition at roost sites in the San Luis Valley, CO, by month for all counts (n) 1980 and 1981.

Food Habits

Over 380 bald eagle castings and numerous prey remains were collected from roost sites and 8 perch sites. Many castings deteriorated in transit and 227 were analyzed (Table 28). The largest casting was 130 x 50 mm and the smallest 15 mm in diameter. Most were about 75 x 40 mm. Most prey debris consisted of jackrabbit extremities and waterfowl wings. Castings containing representatives of 2 taxonomic classes comprised 9.9% of all pellets analyzed and none contained 3. Only 1 casting was found to contain more than 2 species. This casting contained Microtus spp., lagomorph(s) and waterfowl. Two pellets were composed completely of vegetative material. None contained lead or steel shot. In all, Leporids comprised 58% of minimum recognizable individual food items.

Although scant, the data indicate a shift in prey utilization as the winter progressed (Table 29). January is the coldest month in the SLV and major rivers are usually completely frozen, rendering piscian prey unavailable to eagles. This may be reflected in the total absence of piscian remains in castings collected in January. As winter progressed, the percent of collected castings containing waterfowl remains declined and those containing mammalian and piscian remains increased.

Twenty-two food items were identified as bald eagles fed or by inspecting remains after eagles left. Jackrabbits were involved in 11 instances, domestic sheep in 7, a horse (Equus caballus) in 2, and waterfowl in 2. In all, Leporids comprised 50% of all food items seen eaten by eagles. Identified food species are shown in Table 30. Mean

Table 28. Number and composition by taxonomic class of bald eagle castings and prey debris collected in the San Luis Valley, CO.

Collection Site	Collection Date	# Castings	Minimum # individuals	Class n(%) Aves[a]	Mammalia	Pices
Stillings Roost	01-28-80	6	10	5(50)	5(50)	0
County Line Roost	02-28-80	17	24	7(29.2)	16(66.6)	1(4.2)
Stillings Roost	03-01-80	23[2]	25	4(16)	19(76)	2(8)
Stillings Roost	03-16-81	60	60	3(5)	57(95)	0
Stillings Roost	04-18-80	53[b]	52	7(13.5)	38(73)	7(13.5)
Lower Conejos Roost	04-18-80	23	24	5(20.8)	19(79.2)	0
Peterson Roost	04-18-80	23[b]	23	0	23(100)	0
10' ditch III	02-07-80		2[c]	2(100)	0	0
McIntire Spring	02-27-80	1	2[c]	1(50)	1(50)	0
10' ditch	03-12-80	2	3[c]	0	3(100)	0
10' ditch II	03-21-80		6[c]	1(16.7)	5(83.3)	0
River Perch	[d]		4[c]	2(50)	2(50)	0
Lower Conejos	[d]	3	4[c]	3(75)	1(25)	0
Unknown	[d]	15	16[c]	2(15.5)	14(87.5)	0
		227	255	42(16.5)	203(79.6)	10(3.9)

[a] Waterfowl
[b] 1 casting completely of grass/hay
[c] includes castings and debris
[d] date not recorded

Table 29. Percent of each taxonomic class contained in bald eagle castings and prey debris collected in the San Luis Valley, CO, by month.

Month	# of collections	Minimum # of individuals	Class (%)		
			Aves	Mammalia	Pices
January	1	10	50.0	50.0	0
February	3	28	27.8	69.5	2.8
March	4	94	8.5	89.4	2.1
April	3	99	12.1	80.8	7.1

Table 30. Species identified in bald eagle castings and debris collected beneath perches and roosts in the San Luis Valley, CO.

Species	Common Name	Minimum No. of Indivuals
Mammalia		
Lepus townsendii	white-tailed jackrabbit	149
Sylvilagus audubonii	desert cottontail	16
Ovis aeries	sheep	13
Microtus spp.	vole	10
Bovus spp.	cattle	3
Mustela frenata	long-tailed weasel	1
Felis domestica	house cat	1
Equus caballus	horse	1
Aves		
Anas platyrhyncos	mallard	18
Anas americana	american widgeon	2
Colaptes auratus	common flicker	1
Pices		
Cyprinus carpio	carp	10

group size of eagles at a carcass was 3.43 (range 1-11, n = 23). A lone golden eagle was present in 6 of 11 instances where more than 1 bald eagle was observed at a carcass.

Five kills by adult bald eagles were witnessed and all were of ducks on ponds (3) or in irrigation ditches (2). Three additional kills were suspected to have occurred during observations but brush obscured the event. All involved jackrabbits. No eagles were observed attempting to take fish since observations along the river would have required a proximity disturbing to eagles.

Perch Structure Construction and Use

Six perches (Fig. 12) were constructed and placed in May 1981, with a total financial expenditure of <$20.00. Construction time was 22.5 hours, and 2 work days were required to place the poles. Two were placed in each of 3 areas of priority (see Locations of Perches: 47). In January 1982 and 1983 the SLV was briefly revisited to determine use, if any. Conversations with landowners indicated that bald eagles did indeed use the structures but the only quantitative data were available are shown in Table 31. Data on species and number of birds observed on perch structures in the SLV was gathered during 4 days in January 1982 and 3 days in January 1983.

Differential use of perch structures by eagles in areas of placement was highly significant ($P<0.005$), but sample size was small. Eagles of both species used structures placed in areas well away from dwellings and roads (Fig. 56) and where density and availability of prey

Table 31. Use of perch structures for wintering bald eagles in the San Luis Valley, CO, January 1982 and 1983.

Name	Priority Area[1]	Eagle Use: Golden Adult	Golden Imm.	Bald Adult	Bald Imm.	Other Species
Mosca East	1					magpies, ravens
Mosca West	3			2[a]		magpies, GHO[b], ravens, RLH[c]
3 mile	2	4	2			FH[d], RLH, ravens, magpies
Twos Place	1					
Sunken Truck	3		1			FH, GHO, RTH[e]
Al's Folly	2		2		4	GHO, RTH, RLH
		4	5	2	4	

[a] Confirmed report in January 1984
[b] Great horned owl
[c] Rough-legged hawk
[d] Ferruginous hawk
[e] Red-tailed hawk

[1] 1=where trees of high use had been removed
2=Food base high, disturbance low, no previous perches
3=Trees of moderate use removed

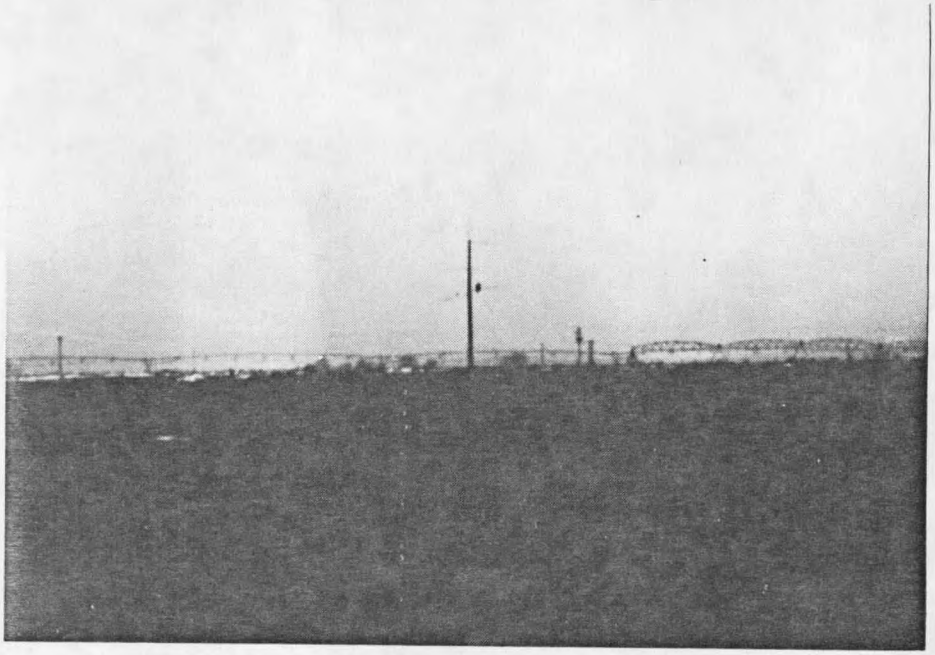


Figure 56. Bald eagle on perch structure placed in an area of high prey density in the San Luis Valley, CO.

(jackrabbits and sheep carcasses) was perceived to be higher than at other sites.

Migration

Colormarking and Band Recoveries

Thirty-six bald eagles were colormarked with yellow wrap-around patagial wing tags in the SLV in 1977 and 1978, but only 17 sightings of yellow marked birds outside of the SLV have been recorded up to March 1984. Due to the Bird Banding Laboratory issuing the same color to another project in the west, only 3 confirmed sightings were of eagles marked in the SLV (Fig. 57). Two were confirmed by date, since the other project had not yet been initiated, and only 1 was confirmed by number read on the patagial tag (C19). This eagle was resighted at Glacier National Park (GNP) every fall from 1977 until 1983, when it was found shot on the shore of Flathead Lake, Montana in February.

Two eagles colormarked in the SLV in 1977 were recovered dead in southwestern Saskatchewan, 1 in November 1980 (C05) and 1 in January 1982 (C06). Eagle #10-81 was found dead (shot) in eastcentral Wyoming with no feet or band but with the radio transmitter still attached to the rectrices. Curiously, the carcass was recovered in fair condition in October, 1981. This indicated it died on its fall migration the year following radio-tagging, but still retained the transmitter. Normally, rectrice molt is complete annually in bald eagles (pers. observ.) indicating the eagle had actually died the previous spring.

Physical reactions of bald eagles to patagial tags varied. Patagial tags directly contributed to the death of C06 (Fig. 58).

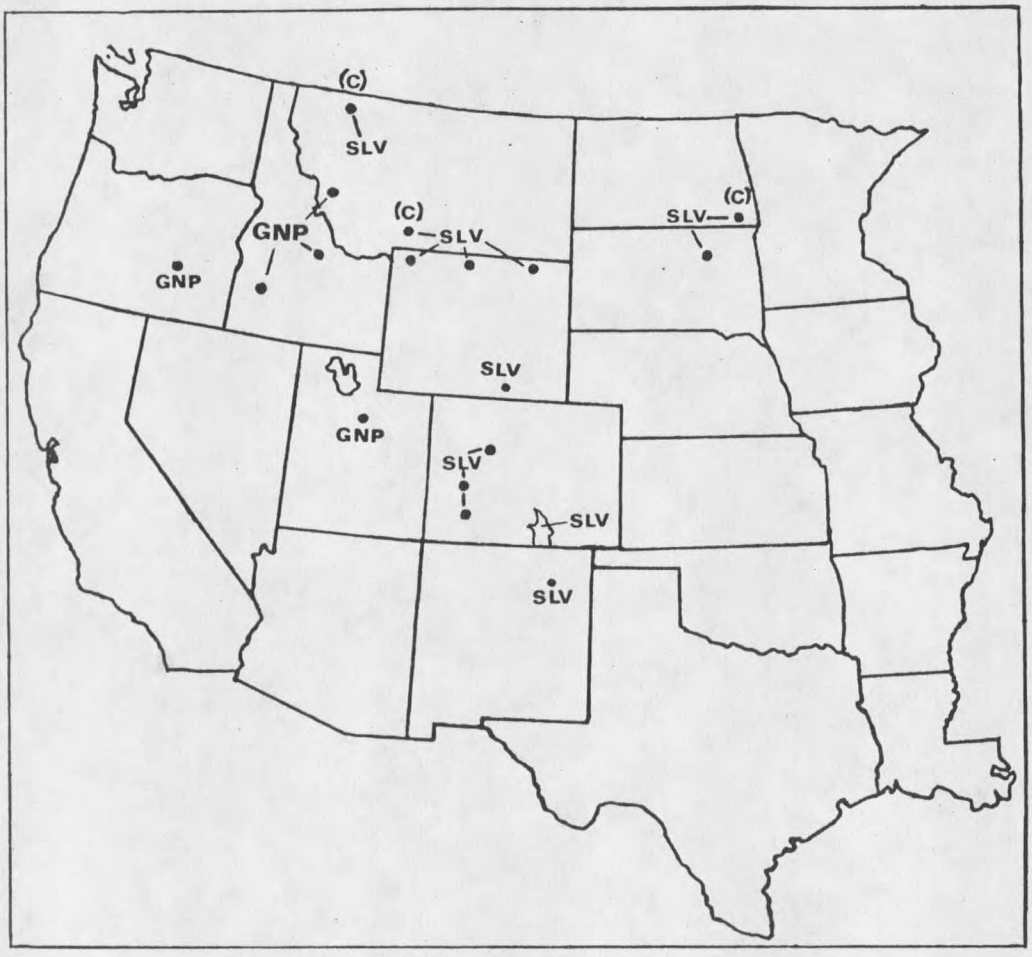


Figure 57. Resightings of eagles with yellow patagial markers.
GNP indicates origin probably Glacier National Park, MT.
SLV indicates origin probably San Luis Valley, CO.
(C) indicates confirmed origin.

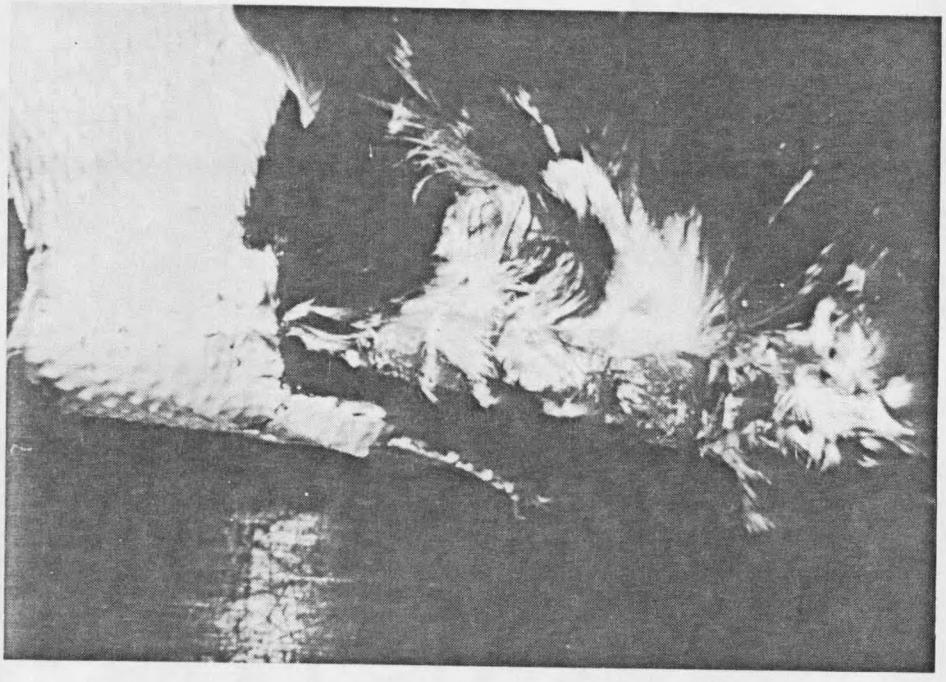


Figure 58. Severely abraded patagium of an adult bald eagle that had worn wrap-around patagial wing tags for 5 years.

The markers, however, had been on 5 years and had not been applied any differently than on other eagles. Eagle C05 was killed by a fur trapper who was afraid to remove a leg trap. She was in excellent condition, had worn the markers almost 4 years and no problems were evident. Eagle C19 removed 1 wing marker within 8 months of application, but when recovered over 6 years later, it was obvious the remaining marker had caused no problems.

Initiation of Migration

In 1980, all 4 radio-tagged eagles left the wintering grounds in March, 1 in the first week and 3 in the third week. The range of departure dates was much greater in 1981, with the first radio-tagged eagle leaving the SLV on 24 January and the last on 1 April (Table 6). Two radio-tagged eagles left the SLV on 21 March 1980 and 2 on 27 March 1981. One eagle departed on 22 March 1980 and traveled 145 km north before being stopped by severe snow squalls. He spent the night on a mountain pass and since the storm persisted to the north the next day, he returned to his home range. He spent the reminder of that day and part of the next in close association with his mate, and was observed to copulate with her during the hiatus. He initiated migration alone again on 24 March, leaving the SLV for the season.

Stepwise discriminate analysis selected 3 climatological variables that significantly ($P = 0.001$) discriminate between days that bald eagles left the SLV on migration and those that they did not. Figure 59 illustrates relative magnitudes of variables in order entered in the stepwise procedure and the association of each with initiation of

migration. Classification of known cases by the analysis was 76.5% correct. The canonical correlation (R^2) was 0.79 indicating the data fit the linear function fairly well. Table 32 gives mean values and confidence intervals for climatological variables measured on days which eagles initiated migration and those which they did not. Eagles appear to have initiated migration on days with higher maximum and average temperatures, that had much larger ranges of temperatures, and were more cloudy with higher winds than other days over the winter/spring. Wind direction tended to be more from the west-southwest on days eagles intiated migration as opposed to south-southwest on randomly selected days that they did not.

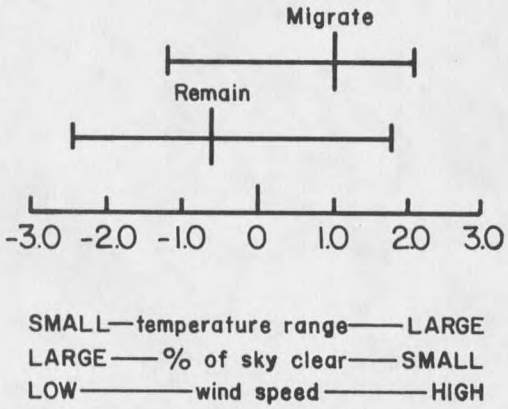


Figure 59. Centroids, ranges of discriminant scores and relative magnitudes of climatological variables that discriminate most between days bald eagles initiated northward migration from the San Luis Valley, CO and days they did not.

Only 1 variable (temperature) was selected by discriminate analysis as important (P = 0.09) in discriminating between conditions prevalent at times eagles initiated migration as opposed to times of the same day that they did not. The resultant discriminate function

Table 32. Mean ± 99% confidence interval for climatological variables measured on (1) days bald eagles initiated northward migration from the San Luis Valley, CO and (2) randomly selected days which eagles did not initiate migration.

	Maximum Temp. (C°)	Average Temp. (C°)	Temp. Range (C°)	% Sky Clear	Wind Speed (km/hr)	Wind Direction
Remain (21)	8±3	-1±3	19±4	56±20	16±5	216°±68
Depart (23)	11±4	0±4	24±5	50±26	22±5	253°±33

Table 33. Mean ± 99% confidence interval for climatological values measured on days bald eagles initiated northward migration from the San Luis Valley, CO during (1) the hour period nearest the departure time and (2) other hours of the day.

	Temp (C°)	Wind Direction	% of Sky Clear	Wind Speed km/hr	Visability (km)	Hour
Present (22)	1±6	217°±57°	61±23	16±8	76±7	1035±1.5
Depart (11)	1±5	225°±82°	57±36	20±6	72±14	1149±1.4

was only 57.6% successful in classifying known cases while the canonical correlation was less than 0.3. Table 33 gives mean values of variables prevalent at different times of the same day when eagles migrated.

Clearly the variables chosen to analyze factors associated with initiation of migration within a particular day were much less discriminating than those chosen for among days analysis. However, trends were similar. Eagles tended to initiate migration during hourly conditions of higher temperature and wind speed, more clouds and lower visability with wind directions more southwest than south. Migration tended to be initiated about 5 hr after sunrise.

Migration Routes, Mechanics, and Destination

In 1980, a relatively narrow migration corridor through Colorado, Wyoming, and Montana was used by 3 of 4 radio-tagged eagles (Fig. 60). One eagle, #2-80, was tracked to a nest site in northeastern Saskatchewan. He became associated with a nesting territory after 15 days of migrating, 6 of which were spent sitting out bad weather. After 4 days of almost continual soaring in the summer range, he became sedentary and was found perched close to a large female. The next day the pair began construction of a new nest on Chachukew Lake, north of Pelican Narrows, Saskatchewan. They eventually fledged 1 young in August, 1980. The fledgling was instrumented to determine if he would winter in the SLV, but incorrect attachment by cooperators caused the radio and central rectrices to be shed by late October, 1980.



Figure 60. Migration route of 3 adult bald eagles from a wintering ground in the San Luis Valley, CO, 21 March-5 April 1980. Numbers indicate radio channels. Large dot is the nesting ground of #2-80. Dotted lines indicate hypothesized route not actually documented.

In 1981, eagle #4-81 left the SLV on 20 February, and was followed for 2 days over 302 km through the mountains of Colorado before paucity of funds dictated abandonment of the tracking (Fig. 61). Two other eagles picked for migration tracking left the SLV on 27 March but logistical problems prevented their being followed. The only remaining radio-tagged eagle, #7B-81, left the SLV on 1 April and was followed to about 65 km north of Casper, Wyoming where she was lost in a snow storm (Fig. 61). A vehicle searching for other radio-tagged eagles in Wyoming continued while the vehicle in pursuit of #7B-81 returned to the SLV. Eagle #8-81 arrived at Ft. Peck Reservoir in Montana on 5 April (Fig. 61). After leaving Ft. Peck Reservoir, eagle #8-81 flew due north about 35 km then gradually shifted to a northwest course. This route took him directly to the Missouri Coteau in southwestern Saskatchewan. The Coteau is a north-south running ridge or bluff line. He continued north along the Coteau for about 100 km. Approaching the Canadian Shield, eagle #8-81 made a sudden change in course from north to northeast. This course paralleled the direction of elongated lakes and rivers in the Canadian Shield country. Eagle #8-81 was subsequently followed to Reindeer Lake, Saskatchewan arriving on 10 April.

On 22 April #8-81 was found by air on Kamuchuwie Lake on the Saskatchewan/Manitoba border. Additionally, eagle #3-81 was located on the Pagato River, south of Reindeer Lake, Saskatchewan and eagle #6-81 was heard briefly in the area of Trade Lake, south of the Churchill River (Fig. 61). The signal was weak and intermittent, which indicated either a radio malfunction, a dead eagle, or a bird



Figure 61. Migration routes (—) and summering areas (*) of bald eagles wintering in the San Luis Valley (SLV), CO 1981. (...) indicates hypothesized route, but not documented. (X_1) and (X_2) are respective 1981 and 1982 recovery locations of bald eagles banded in the SLV, January 1977. (X_3) is October 1981 recovery location of a bald eagle radio-tagged in the SLV, March 1981. Numbers indicate radio channels.

in incubation posture. Central Saskatchewan was searched for other SLV eagles but none were found.

Aspects and mechanics of bald eagle migration documented were:

1. Dates of initiation of spring migration were 8, 21 and 22 March for 4 radio-tagged eagles in 1980 and between 24 January and 1 April in 1981 (Table 6).
2. Breeding adult bald eagles apparently migrated alone in the spring with males leaving first. Eagle #4-80 left on his initial attempt at migration alone but when thwarted, returned to his mate and copulated. Eagle #2-80, also a male, was seen roosting alone at all but 1 stopover point (the Yellowstone River in Montana) along the migration route. He spent 4 days soaring over the nesting area after arriving, possibly "waiting" for his mate. Eagle #8-81 did not migrate with a mate but often moved northward with other adult eagles. He was observed roosting at Pelletier Lake in southwestern Saskatchewan near an immature bald eagle but left alone the following day. In the aspen (Populus tremuloides) parkland country of central Saskatchewan (Thickwood Hills) he roosted close to another adult bald eagle twice. These eagles were judged by size to be females. Subsequent observations of migration flight, however, indicated he moved alone. Once in the boreal forest/Canadian Shield country, local eagles appeared to meet him in flight and escort him through their territories.
3. Migration speeds varied from 22 to 144 km/hr in 1980 and 20 to 105 km/hr in 1981 but generally averaged about 50 km/hr.

4. Altitude of flight varied from 30 to 4572 m a.g.l. but averaged between 1500 and 3050 m.

5. Daily flights ranged from 144 to 435 km (n = 5) in 1980 and 33 to 248 km (n = 5) in 1981. Average daily flight was about 180 km.

6. Prominant physiographic features such as deep canyons, north-south mountain ranges and rivers seemed to aid in orientation.

7. Eagles did not migrate on days of total overcast nor during days with winds in excess of 35 km/hr when experienced prior to 0900 hrs. The altitude of the cloud layer may have an effect but overcast layers over 90 m were not experienced during tracking.

8. Strong winds apparently influence direction of flight. East winds of 60 to 80 km/hr began about 2 hours after initiation of flight on 1 migrating day and the eagle's flight path subsequently deviated about 50° west of direct line to the eventual goal and 56° west of flight direction for the remainder of migration.

9. Daily migration flights consistently began between 1015 and 1045 hrs MST and ended between 1715 and 1745 hrs.

10. The nesting territory of eagle #2-80 was located at 55° 13' N 102° 58' W, 1968 km (as the eagle flies) north of the winter range at 37° 30' N 105° 22" W. The nesting territory of eagle #8-81 was located at 56° 20' 102° W, 2077 km north of the winter range at 37° N 105° 40' W. The summer range of eagle #3-81 was located at 56° 2' N 102° 22' W, 2043 km north of the wintering range at 37° N 105° 50' W. Signals from eagle #6-81 were heard at 55° 22' N 103° 43' W, 1988 km north of the winter range at 37° 105° 50'W.

11. All eagles located on their summer range in 1981 were within 102 km ($\bar{x}$ = 80 km) of the nest site of eagle #2-80 followed from the SLV the previous year.

Both eagles followed to their summering grounds passed through eastern Montana (Figure 62) and 2 additional eagles found in their summering grounds probably did so. Considering the direction of movement when last located, another eagle (#7B-81; Figure 61) probably passed through eastern Montana also. The only 2 recoveries of bald eagles banded in the SLV were from southwestern Saskatchewan during autumn and early winter, 1 directly under and the other less than 20 km east of the flight path of eagle #8-81. These eagles probably were on a course that would have taken them through eastern Montana when they met their demise.

All radio-tagged eagles arrived in their summer range at a time when all lakes and most stretches of rivers were still frozen. The only areas of open water were rapids or narrows on rivers or between lakes. Radio-tagged eagles spent most of their time there, presumably foraging for fish. Other eagles observed were associated with ubiquitous holes in lake ice and viscera piles of fish left by native commercial fishing operations. Foraging eagles were also seen on or near caribou (Rangifer tarandus) and moose (Alces alces) carcasses killed by natives or wolves (Canis lupus). A few eagles were seen with snowshoe hare (Lepus americanus) remains.

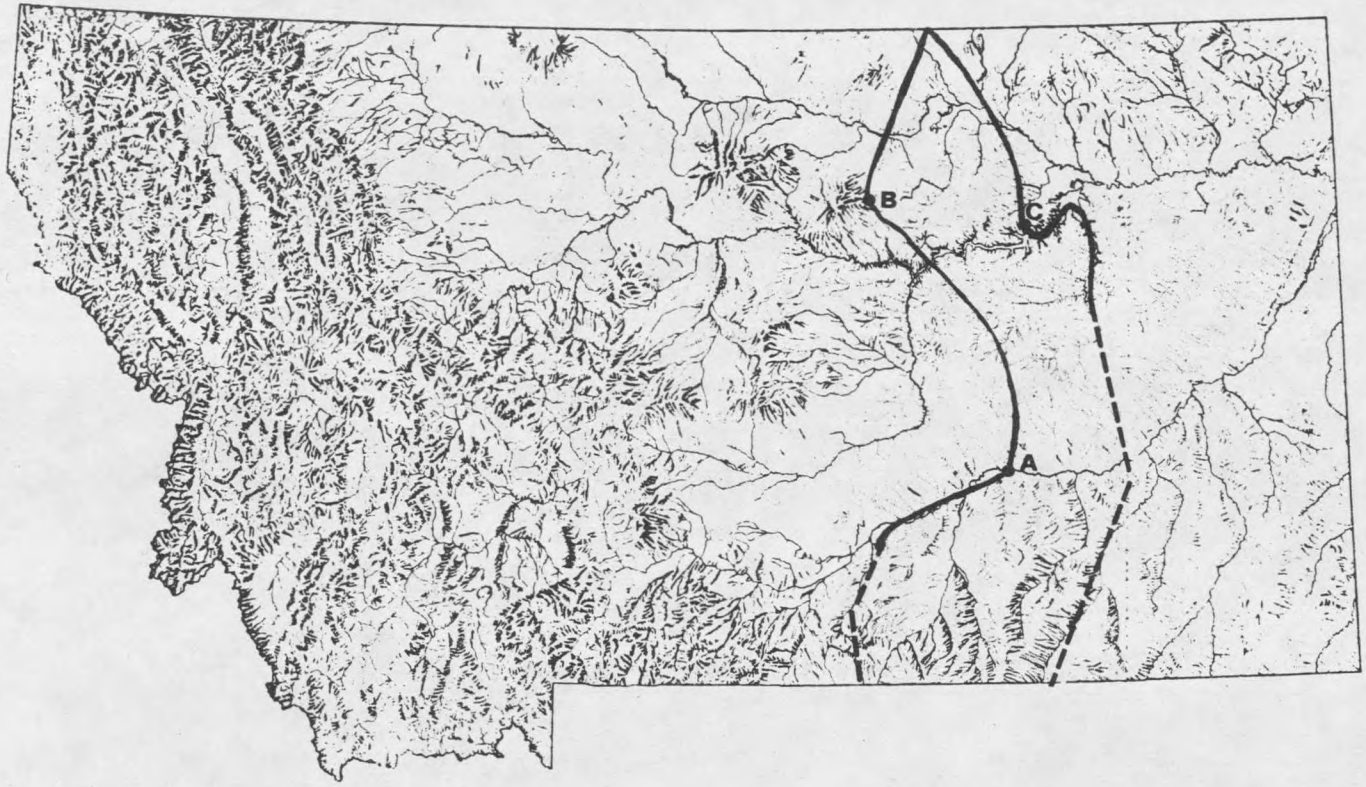


Figure 62. Migration routes and stopover locations in Montana of radio-tagged bald eagles that wintered in the San Luis Valley, CO. A, Yellowstone River 1 km north of Sanders; B, Little Rocky Mountains 1.5 km east of Lodgepole; C, Fort Peck Reservoir 32 km north-northwest of Brussett. ---- is hypothesized route, ——— actual route through Montana.

DISCUSSION

The SLV as a Wintering Area for Bald Eagles

Prior to the appearance of European man, the SLV was probably not an important wintering area for bald eagles. Extremely cold winters closed rivers and wetlands limiting availability of fish and waterfowl. Carrion was probably more available on the eastern prairie or farther south as mammals [primarily bison (B. taylori)] migrated out of the valley during winter.

Species accounts in journals of early expeditions suggest bald eagles were absent or rare in the SLV during the 16th through early 19th centuries. This species was not mentioned in the journals of Spanish expeditions in the SLV between 1500 and 1800 although they referred to presence and abundance of several mammalian and piscian species used as food by contemporary bald eagles. All Spanish expeditions were in the SLV during summer and fall, a time when nesting eagles would be inconspicuous and wintering eagles absent. American expeditions in the SLV in the early and mid 1800's noted birds and other wildlife but failed to record eagles. Even the Pike expedition, that camped in the riparian forest of the Rio Grande River and built a stockade on the Conejos River during mid-winter, did not record eagles. The stockade on the Conejos River where they spent most of winter of 1806-1807 and the camp sites on the Rio Grande are in areas used heavily by contemporary bald eagles.

Long time valley residents imply that eagles frequented the valley in winter as early as the 1930's but no one "paid much attention." Counts between 1949 and 1970 indicated low but increasing numbers to present day levels of 150-200 eagles.

Data from this study indicate bald eagle presence and distribution in the SLV is closely associated with agriculture, probably relatively recent, and is coincident with the arrival of modern man, his agriculture, and livestock. Irrigation ditches and canals constructed in the latter portion of the 19th century and artesian wells tapped and drilled for irrigation in the early 20th century created many wetlands and increased the distribution of cottonwoods and cropland/brushland interspersion. Bald eagle use probably increased slowly as cottonwoods matured and wintering waterfowl and rabbit populations increased.

Several factors undoubtedly contribute to the contemporary attractiveness of the SLV to wintering bald eagles. High quality food resources are abundant and available throughout the winter. Stalmaster (1981) found energy value of ducks and jackrabbits higher than that of fish. About 28,000 ducks now winter in the SLV along with 1600 Canada geese (Branta canadensis) (Hopper et al. 1975). Mammalian prey (primarily jackrabbit) is abundant and used heavily throughout the winter. When wintering waterfowl leave, they are partially replaced by migrants from wintering areas farther south. When rivers thaw fish appear to replace waterfowl in the diet.

Foraging perches are well distributed and facilitate exploitation of the abundant food resources. Cedar Valley, Utah is similar

to the SLV in several ways, but primarily in that wintering bald eagles feed mostly on jackrabbits (Edwards 1969). Fewer eagles winter there possibly due to the paucity of tree perches in the foraging areas.

The SLV appears to contain suitable roost sites of adequate number to support the population. Bald eagles commonly roost communally but occasionally will roost alone or in pairs as mated adults. Many studies have identified and described communal roosts of bald eagles throughout the western U.S. (Swisher 1964, Servheen 1975, Harmata and Stahlecker 1977, Stalmaster and Newman 1979, Steenhof et al. 1980, Keister and Anthony 1983). Most accounts have identified the site, described daily use in terms of numbers of eagles present and theorized as to the function of communal roosting behavior. None have compared used to nonused sites to determine what constitutes a suitable roost site or have attempted to explain why one site may support more roosting eagles than another.

Significantly more roost sites ($P = 0.025$) occurred in the west half of the valley than the east. Since most roosts are located on rivers, this uneven distribution is due to drainage patterns and vegetation. Both major water courses (Rio Grande and Conejos Rivers) emanate in the mountains to the west and flow primarily east to the center of the valley then south after the confluence. In addition, cottonwoods are also generally absent below the confluence of the Conejos with the Rio Grande as the river enters more xeric portions of the valley.

Mountain roost sites on the periphery of the valley are composed of coniferous trees. These roosts are located primarily on the western foothills. The western slopes are in the wind shadow of the mountains and terrain is more gently sloping with more sheltered draws. Prevailing easterly winds assault the foothills in the east and the terrain is steep with fewer draws.

Upland roosts in the valley proper were in cottonwood trees. These roost sites were located on the periphery of small isolated stands away from major population centers and human activity.

Stalmaster (1981) found bald eagles accrued significant energy savings by roosting in coniferous rather than deciduous roosts, primarily due to the effectiveness of dense foliation reducing wind velocity. Since mid-winter winds are rare in the SLV and primary foraging areas range 10 to 30 km from identified coniferous roosts, SLV bald eagles conserve energy by roosting close to foraging areas in deciduous roosts in the central valley. It is interesting that 2 radio-tagged eagles traveled 9.6 to 20 km to coniferous roosts on the valley's periphery subsequent to days of highest recorded wind velocities for the winter months (44 km/hr).

Acceptability of a roost site by bald eagles in the SLV appears to be influenced more by the proximity of disturbance factors than physical or vegetative characteristics around the site. Measured variables at riparian sites on the Conejos and Rio Grande Rivers indicated that disturbance variables are the most important suitability factors. There are no large cities along or near the Conejos River but 3 large cities exist along the Rio Grande. Therefore, it

may not be coincidence that the most heavily used roost is situated almost exactly between the 2 largest cities in the valley. In the absence of cities the next most disturbing variable may be a county road.

Riparian roost sites were generally closer to occupied dwellings than to county roads. Edwards (1969) and this study found that bald eagles recognized individual landowners and their vehicles and apparently became habituated to their presence, often allowing them to pass directly under the perch. However, they would flush from strangers, often at distances of 400 m or more. County roads, especially near riparian roosts in the center of the valley where the human population is concentrated, present a continuous stream of unfamiliar vehicles to which eagles cannot habituate. Upland roosts were closer to county roads than to occupied dwellings but traffic on these roads was light and consisted primarily of local landowners. Intermittent local traffic near upland roosts may be more tolerable than continuous activity around dwellings. These roosts seemed to be located in the largest trees in the vicinity.

Although not statistically significant, the mean values of stand area size, distance to nearest water, and sinuosity of the river at riparian roost areas compared to non-roost areas provide insight into suitability of a roost site. These trends indicate that eagles usually roosted in large timbered stands close to water and near dramatic bends in the river, situations that are common along the major rivers in the SLV.

All roost sites in the valley proper were on the edge of cottonwood stands, indicating that view from the roost, ease of approach and entry to primary roost trees are important in selection and use of a roost site. Although adjacent to clearings, roost sites in the riparian gallery forest were well concealed if not completely hidden from the nearest occupied dwelling or county road.

Once sites are established based on proximity to overt disturbance factors (cities, roads), physical and vegetative characteristics of the site may further insulate eagles from human disturbance. Results tend to support the following: more eagles used or "preferred" roost sites that (1) were in larger stands of timber, (2) had smaller stand height surrounding the roost trees, (3) had fewer roost trees, and (4) were closer to water. Visual barriers to human activity have been shown to be important in perch selection for bald eagles (Stalmaster and Newman 1979) and large stand areas would effectively insulate strategically placed roost sites from visual pollution. Bald eagles appear to prefer primary roost trees that permit extensive viewing of the landscape. The combination of lower height of the surrounding stand and fewer primary roost trees with generally greater dbh suggests that bald eagles select the oldest and tallest trees in the stand. Roosting in these trees would permit eagles to overlook the surrounding stand and increase visual security.

Proximity of roost sites to food resources may ultimately influence roost preference when several suitable sites are available. Stalmaster (1981) predicted net energy loss in bald eagles exploiting

foraging areas greater than 5.1 km from roost sites. Fluctuation of use between riparian and upland roosts may be a function of changes in availability of food near each site. Number of eagles and frequency of use by individual eagles increase at riparian roosts and decrease at upland roost sites as winter wanes. There is a tendency for riparian roosts to be closer to water (including ponds and sloughs) and near sections of the river with more sinuosity than randomly selected nonused sites. Aquatic food resources (fish and waterfowl) tend to congregate at or near oxbows and bends in the river where early ice-out occurs as spring approaches. Energy is conserved and fat deposits increased for migration by roosting near foraging areas. Therefore, while suitability of a roost site in the SLV appears dependent on the distance of a site to excessive human activity, preference seems dependent on close proximity to food resources.

The function of communal roosting behavior in bald eagles has been related most frequently to information transfer on food availability and location (Servheen 1975; Stalmaster 1976, 1981; Steenhof et al. 1980; Fisher et al. 1981; McClelland et al. 1982). However, observations of captive and wild golden and bald eagles indicate that security may be a function of primary importance for communal roosting behavior. Golden eagles often roost on the ground, their habitat usually being upland, treeless, and remote. Captive golden eagles can seldom be approached at night without wakening them. This tendency toward constant vigilance would likely be adaptive for birds with solitary roosting habits to protect themselves from nocturnal predators.

By contrast, bald eagles commonly nest in forest habitats and invariably in association with lentic, lotic, or marine systems, where the human population was historically dispersed. Wintering aggregations of bald eagles are most often associated with aquatic systems where other wildlife populations and humans have also concentrated for food, fuel, cover, and water. Migrant eagles would have enhanced security during a particularly vulnerable period by roosting communally. The chances of most individuals eluding or confusing a potential predator once alarmed, would be great. After dark a captive bald eagle can often be approached closely and even touched without waking. If sound sleeping behavior is indicative of wild bald eagles, security of numbers would be significant.

Communal roost sites may be aggregations of bald eagles individually seeking the most secure area (away from human activity) available. Increased security of numbers may be an extra bonus in this endeavor and facilitate traditional use of sites. Site preference may then be determined by proximity to food resources.

Weather conditions in the SLV during winter appear optimal for bald eagle survival. Although extremely cold nighttime temperatures commonly occur, they are rarely accompanied by wind or precipitation. High altitude and dry environment appear to facilitate generation of thermals at mid-day and bald eagle activity patterns reflected ease of flight during that time. Total activity of all radio-tagged bald eagles was 15.5% of daylight hours, approximately twice the activity level (flight, feed, ground perch) recorded for bald eagles on the Nooksack River, Washington (Stalmaster 1981). Knight and Knight (1983)

found flight activity increased as food availability decreased but differences between activity of Nooksack and SLV eagles was probably due to distribution of food resources rather than availability. Food for Nooksack eagles (fish) was concentrated along the river while distribution of food in the SLV was more dispersed. Higher activity of SLV bald eagles in the milder winter of 1981 over 1980 may have been due to fewer winter killed waterfowl, livestock, and/or rabbits but observations suggest flight was energetically less costly in 1981 due to the prevalence of winds over 15 km/hr (Steenhof 1983) and the absence of snow cover, which permitted stronger thermals. Monthly weather severity index was highly correlated with activity further suggesting activity was related to current conditions which facilitate flight rather than food availability. Winter mortality in wildlife is usually concentrated toward late winter and early spring (Rasmussen 1941, Errington 1963). If activity differences were dependent on availability of carcasses, eagles would tend to be more active early in the winter when carcasses were scarce. SLV eagles were less active in January.

More winter habitat for bald eagles produced by the construction of dams, locks, reservoirs, and wildlife refuges may have been responsible for an increase in the northern interior bald eagle population between the 1930's and present (Swenson 1983). It appears that SLV winter population increased during the same period also due to anthropogenic changes in habitat.

A hypothetical model of bald eagle use of the SLV as a wintering area is presented in Figure 63. Based on this model, peak of use

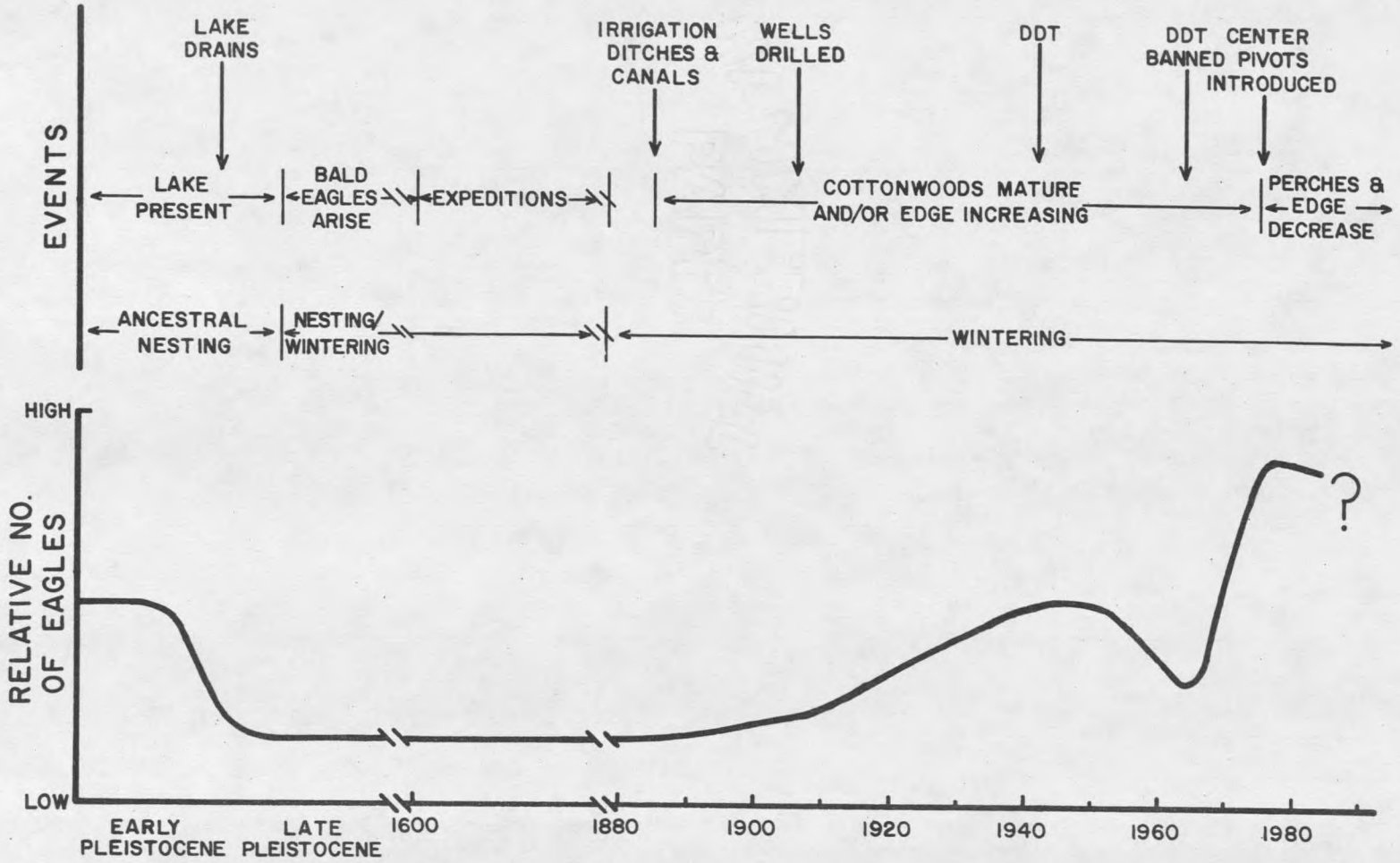


Figure 63. Hypothetical model of bald eagle use of the San Luis Valley, CO and the effects of important historical events.

occurred during the early to mid 1970's and use can be expected to decline in the future. Census figures have already shown over a 50% decline between 1976 and 1979 (Craig 1981). Advancing monoculture is reducing cropland/brushland edge and the vegetative mosaic, possibly effecting a decline in jackrabbit abundance. Center pivot irrigation systems and herbicide use are eliminating upland cottonwoods, decreasing the availability and distribution of foraging perches. Center pivot use also eliminates irrigation ditches where waterfowl and lagomorphs congregate. Center pivots are placing increased demand on the unconfined aquifer, drying wetlands essential to wintering waterfowl. Plans have been proposed to eliminate excessive evapotranspiration and "conserve" valuable water resources by eliminating the riparian gallery forest along the Rio Grande River. This would effectively eliminate most secure bald eagle roost sites in the SLV. Future use of the SLV as a wintering area by bald eagles will depend on several factors with the type and intensity of agricultural practices the primary determinate. Resultant declines may be offset by intensive and extensive management schemes designed to maintain present numbers.

Size Differential, Resource Partitioning, and Choice of Wintering Areas

Significant morphological differences exist between adult and immature bald eagles and to a lesser degree between males and females of each age class (Table 14). The relationship of diet to size differences between the sexes of raptorial birds has been noted (Amadon 1975, Cade 1960, 1982, Mueller and Berger 1970, Selander 1966, Snyder and Wiley 1976). Although remige lengths of immature raptors are

recognized to be longer than adults (Brown and Amadon 1968, Mueller et al. 1979, Orians 1980), few references have been made associating age dimorphism to resource partitioning. Mueller et al. (1981) hinted that morphological differences may influence foraging strategies, but did not hypothesize how.

The degree of sexual size dimorphism in raptors has been related most commonly to dietary differences between the sexes (Snyder and Wiley 1976, Newton 1979, Reynolds 1979) and thus functions in reducing competition (Selander 1966, Newton 1979). Competition between the sexes of adult bald eagles in summer is probably reduced by the abundance of food (Pianka 1974), and in winter by activity and behavioral differences. Adult males are active longer, earlier and later in the day than females in winter.

The degree of sexual dimorphism also has been related to degree of interspecific competition (Baker-Gabb 1982 and references therein). No congeneric competitors of the bald eagle exist in North America and only the osprey (Pandion haliaetus), few of which nest in northern Canada, might be considered a serious competitor in the summer range. The dimorphism index of adult bald eagles, ignoring weight which can vary up to 50% in raptors (Newton 1979), is low to moderate (Table 14) suggesting competition between the sexes of adults is not severe. Therefore, the sexual dimorphism that does exist in adult bald eagles may be a result of pressures other than competition (See Ecology of Northward Migration: 163).

Size differences between adults and immatures was strongly manifested in structure associated with flight (Table 14) and suggests

mechanisms of resource partitioning and amelioration of competition between age classes of bald eagles. The larger size of the young possibly functions as a mechanism to help inexperienced birds compete with adults -- their closest competitors other than among themselves. Swenson et al. (in prep) found nesting adult bald eagles progressively less tolerant of immatures around nest sites as the immatures grew older. Presumably older immatures represent more serious competitors. Dimorphism is more pronounced suggesting greater competition between adult and immature males than adult and immature females. This would be consistent with theories of sex-specific defense of territories (Harmata 1982) because males provide most of the food for the pair during the breeding season.

Aspect ratio, wing loading, and tail/wing ratio (Table 13) indicate adult bald eagles are adapted to pursuing and catching live prey while immatures lead a more vulturine existence. Savile (1957) classified 4 major types of wings. All bald eagles have primarily slotted high-lift wings, but immatures exhibit characteristics of elliptical wings while adults tend to possess more high speed wings. Wings of immatures have a lower aspect ratio than those of adults indicating a wider wing, since mean wing span values are identical (Table 11). Aerodynamically, a wider wing has more lift (Rüppell 1977) and would permit an immature eagle to fly slower and soar with less energy expended. Immatures also have longer primary remiges than adults (c.f. mean wing chord lengths, Table 11). Increased primary lengths permit greater emargination of the wing tip, which maintains lift while inhibiting induced drag (Rüppell 1977), further facilitating slow flight. Slower flying,

soaring species are usually carrion feeders (Brown 1976, 1977, Newton 1979). Adult wings with higher aspect ratio permit more speed and manuverability due to the small lift to drag ratio associated with narrower wings and less wing mass to move.

Wing loading of adult bald eagles is 15% greater than immatures. Schoener (1969) categorized Type I and Type II predators and Fox (1977) categorized raptors as attackers or searchers. Cade (1982) related these strategies to wing loading. Higher wing loading facilitates speed and adult bald eagles are comparable to "attackers" while immatures with their lower wing loading are comparable to "searchers". Low wing loading of immatures permits soaring in tighter circles allowing them to soar on smaller thermals (Mueller et al. 1981). Therefore, immature bald eagles can remain active for a greater portion of the day, soaring earlier in the morning and later in the afternoon than adults, "searching" for food as would a vulture (Type II predator). In fact, the majority of eagles seen flying during early morning census flights were immatures. However, adult bald eagles "sit and wait" (Stalmaster 1981) and always initiated "attacks" on live prey in the SLV from a perch, not from a soar (Type I predator). Juvenile (< 1 yr-old) bald eagles almost never attempt to capture fish in flight at GNP and obtain nearly 100% of their food by wading or kleptoparasitism (McClelland pers. comm.). Shea (1978) found that when immature eagles do attempt to capture prey they are less successful than adults (adults = 84%: immatures = 65%). Intraspecific competition for food resources, therefore, may be reduced by morphological differences between adults and immatures. Selection for these differences

may have occurred from pressures exerted in the wintering grounds since food of adult and immature bald eagles summering in the north is quite abundant and probably not limiting.

Behavioral adaptations of adults also may help to reduce competition between age classes. Stalmaster (1981) suggested that bald eagles are "time minimizers", limiting foraging activity as much as possible to gain a given amount of energy. Empirical data show adult bald eagles locate carcasses with minimal energy expenditure by watching other birds. Over 50% of observations involving groups of bald eagles at carcasses included lone golden eagles. Golden eagles commonly killed jackrabbits and ducks in the SLV and adult bald eagles appeared to follow some golden eagles around. Bald eagles never attempted to displace goldens from a carcass but fought over remains immediately after the goldens left. Bald eagles apparently are alerted to the presence of some carcasses by the movements of corvids. In the SLV, trap sets not visited by ravens or magpies were almost always unproductive. Some sets lay idle most of the day but within 15 minutes of being visited by corvids, eagles appeared. Eagles also seemed acutely aware of birds in trouble; traps reset after capture of a corvid were never productive. McClelland et al. (1982) hypothesized that bald eagles could see other eagles soaring at least 23 km away, and Knight and Knight (1983) felt bald eagles locate food in winter by the presence of other eagles. Indeed, the most faciliatory event in food finding of SLV bald eagles seems to be conspecifics dropping quickly to the ground after circling a small area. Observations of trap sets and sheep carcasses initiated prior

to the appearance of eagles showed that once an eagle dropped to a carcass, it was often joined by up to 12 others within 5 minutes. Bald eagles were seldom seen alone at carcasses. Competition for food between age classes of bald eagles may be reduced by immatures locating carcasses while flying and adults while perched; immatures arriving at carcasses first and remaining dominant after adults arrive.

Several researchers have suggested that age ratios in wintering areas may be influenced by food availability (Stalmaster et al. 1979, Fitzner 1980, Fielder 1982, Griffin et al. 1982). Examination of age ratios and food habits of eagles reported for many wintering areas lend additional support to the hypothesis. Fewer immatures tend to winter in upland areas where food is primarily live, agile species (game birds, rabbits, waterfowl) and where weather is severe (Fawks 1961, Griffin 1981), while more immatures winter in areas where fish are the primary food and weather is mild (Table 34). Presumably fish either alive, dead or dying are more available to immatures. McClelland et al. (1982) found 44% immatures early in the fall at GNP diminishing to 30% late in the season. Salmon carcasses were more abundant in early fall than late fall (Spettigue pers. comm.) and immatures probably left when availability decreased. Therefore, age ratios in wintering areas are probably more representative of the type of food and the presence of climatological conditions which facilitate optimal foraging for immatures while less representative of population trends. Consequently, short term fluctuations, especially drastic variations in year to year numbers (n.b. mid-winter counts) probably reflect local weather severity and food availability more than population trends.

Table 34. Bald eagle wintering areas in the U.S., percent immatures in the population, food, habitat, and relative severity of weather in mid-winter.

Location	Study	Habitat	Primary Food	Relative Winter Severity	Approximate Percent Immatures[1]
Missouri River, MO	Griffin et al. 1972	lotic	waterfowl, fish[2]	mod/severe	>60
Skagit River, WA	Servheen 1975	lotic	fish	mild	53
Skagit River, WA	Ralph 1980	lotic	fish	mild	50
Arizona	Grubb & Kennedy 1982	National Forests	varied[3]	mild	48
New Mexico	Schmidt 1978	state-wide	varied[3]	mild	47
Skagit River, WA	Hunt & Johnson 1981	lotic	fish	mild	45
Puget Trough, WA	Knight et al. 1980	estuarial	fish	mild	44
Lake Peteros, WA	Fielder & Starkey 1980	lentic	waterfowl[4]	mod	43
Eastern Montana	Hinz 1977	lotic	varied[2]	mod/severe	40
Cedar Valley, UT	Edwards 1969	upland	lagomorphs	severe	38
Nooksack River, WA	Stalmaster 1976	lotic	fish	mild	36
Rufus Woods Lake, WA	Knight et al. 1979	lentic	varied[5]	mod	34[6]
San Luis Valley, CO	This Study	upland	lagomorphs	severe	30
Rufus Woods Lake, WA	Fielder & Starkey 1980	lentic	waterfowl	mod	26
South Eastern, MT	Swenson pers. comm.	upland	lagomorphs	severe	13
Greater Yellow-stone Ecosystem ID, WY, MT	Swenson et al. in prep	upland/ lotic	varied[2]	severe	13
Long Pines, MT	Swenson et al. 1981	upland	lagomorphs	severe	0

[1] rounded to nearest whole number, for winter months (Dec.-Feb.)
[2] primarily carcasses
[3] combinations of ungulate carrion, waterfowl and fish
[4] fish may have been underrepresented
[5] varied, but authors feel fish are primary food
[6] approximated from tabular data (Dec.-Feb.)

The Ecology of Northward Migration

A composite of several contemporary definitions is appropriate in defining migration of birds. Migration may be defined, therefore, as the act of moving from 1 spatial unit to another (Baker 1978) facilitated by specialized behavior (Dingle 1980) and morphology (Moreau 1972).

Size differential between sexes and age classes of bald eagles hint at selection for morphological characteristics which reduce energy costs of migration in adults. Flight related characteristics of immatures permit slow, foraging flights but are not especially conducive to quick overland movements. Immatures, however, are probably less goal oriented than adults when migrating. Since immatures do not normally breed and ice covers aquatic resources in summering areas when breeding birds arrive, it is probably adaptive for immatures to arrive later when resources are more available. Immatures in fact, are not sighted in the summering areas earlier than 2 to 3 weeks after the arrival of adults. Delayed arrival of immatures close to breeding age would allow them to drop into totally or partially vacant territories with minimal territorial strife.

Flight characteristics which aid adults in the capture of live prey, would also produce a faster migratory flight. Adults must arrive in the breeding areas in a timely manner to successfully fledge young before winter sets in. Highly migratory species generally have longer, more pointed wings (Rüppell 1977, Kipp 1958) and these characteristics facilitate a quicker flight with less energy invested.

Comparison of the dimorphism index involving only characteristics related to flight (DI^3, Table 14) shows adults are indeed more adapted for more rapid, migratory flight than immatures.

Sexually dimorphic characters of bald eagles involving flight may be a compromise between assuaging resource competition and maximizing migratory efficiency, at least in males. Morphological factors that may be disadvantageous to migrating eagles may be countered by differential migration behavior. It seems more adaptive for a migratory female to develop morphological characters which would facilitate a fast, energetically inexpensive migration rather than males. A female is required to produce eggs soon after her arrival on the breeding ground. Males, however, could "afford" more prolonged energy draining migration while assuming the characteristics that would reduce intersexual competition at other times. Pennycuick (1975: 25) developed formulas to calculate range of migration for non-passerine birds. Using these formulas incorporating morphological data of adult bald eagles of the SLV plus known distances and duration of daily migratory flights, and assuming a 25% loss of mid-March weight during migration, calculations indicate differences in migratory capabilities between sexes. Results indicate that adult females could reach a summering area 2000 km from the SLV in 9.3 days while an adult male would need 10.6 days to make the trip. Males known to be mated left the SLV before their mates. Although 1 female arrived on the breeding grounds 4 days after the male, the duration of her migration flight was unknown.

Observations of migrating radio-tagged adults indicated that they indeed migrated alone. Occasional associations with other eagles appeared incidental and were of short duration. Solitary migration behavior in established pairs would also reduce the possibility of both members being lost in a catastrophe.

Photoperiodism is considered to be the ultimate stimulus for the onset of migration in birds (King and Farner 1963, Amadon 1968, Gauthreaux 1980). All radio-tagged bald eagles judged to be mated left the SLV within 1 week of the vernal equinox, indicating equal periods of light and dark stimulated migration. However, subsequent travel paralleled the northward movement of the 35° isotherm (Lincoln 1979) both temporally and spatially, hinting at thermal cues. Once the urge is kindled, proximate affectors of bald eagle migration appear to be coincident with incoming low pressure systems, associated wide range of temperatures, cyclonic air flows, and southerly winds; similar to conditions noted by Bagg et al. (1950). Although eagles are apparently sensitive to local conditions when migration is initiated, they appear to be cognizant of little beyond their visual range. One eagle was turned back by a severe storm and subsequently returned to the wintering area, a round trip of almost 290 km.

Total distances, speed, and daily duration of migratory flights indicate that under optimal weather conditions, bald eagles can reach their breeding grounds within 6 days after leaving the SLV. Calculations using formulas derived by Pennycuick (1975) indicate a 2000 km migration for bald eagles would be near maximum attainable without eating, assuming a 25% weight loss. No eagles were observed feeding

during migration and average migration distance was 2020 km. Eagles tracked from other wintering areas were observed feeding (McClelland pers. comm.) but the average migration distance was over 2500 km. Seldom are spring weather conditions optimal in the Rocky Mountain region. Captive eagles commonly fast more than 2 weeks with no apparent deleterious effects (Brown and Amadon 1968, pers. observ.) and wild raptors can lose up to 30% of body weight without problems (Newton 1979). Pennycuick (1972) estimated that a black stork (Ciconia nigra), a bird with similar mass and migration methods of a bald eagle, should be able to "lift" enough fat to last 48 days without feeding during migration. These compensatory capacities undoubtedly allow adult bald eagles to reach their breeding grounds with sufficient energy reserve for breeding, whether the trip has consumed 6 days or 3 weeks.

Geography, celestial cues, and weather may all play a role during migration of bald eagles. Physiographic features, mostly associated with north-south running drainages seemed to assist in visual navigation during flight (Griffin 1943). These features could have been imprinted in the memory of the eagle (kinesis theory, Welty 1969) during its first northward migration and experience dictated the direction during subsequent flights. Imprinting of migration routes from wintering areas which compliment survival during the first year would be more adaptive than imprinting during first southward migration. Eagles appear to home on areas from which they first migrate in fall rather than where they are raised. Bald eagles raised in the wild in Alaska and hacked (Sherrod et al. 1982) in New York State, returned to the hacking site after migration (Erickson 1982). Sun compass

orientation (Kramer 1952, 1957) with time compensation, commonly referred to as sun-azimuth orientation (Welty 1969) appears to be important for migration orientation of adult bald eagles. Eagles migrating from the SLV did not move, except locally, on days of total overcast, a phenomenon also noted by Gerrard and Gerrard (1982). True navigation, i.e. selection of a compass direction from unfamiliar territory (Able 1980) may also be a component of bald eagle migration. A radio-tagged adult bald eagle apparently displaced to the west by strong easterly winds, subsequently assumed a direction directly towards the eventual nest site. Unless the eagle had been exposed to the area on previous migrations, true navigation is indicated. It is not unreasonable to assume that an adult eagle over 5 years old, may indeed be familiar with a great portion of western U.S. as a result of vagaries of previous migrations. However, true navigation may be the only aid during the initial phases of northward migration for juveniles. As they approach the natal area, imprinting may intensify and then function in subsequent migrations. Redundancy in navigational systems has been illustrated for homing pigeons (Columbia livia) (Able 1980). In all probability, several backup navigational systems are available to bald eagles, especially experienced adults.

Adult bald eagles radio-tagged and banded in the SLV wintering area which is east of the Continental Divide, were tracked to breeding areas and recovered in Saskatchewan, all in the Churchill River watershed. Additionally, 4 SLV eagles located in their summer range in Saskatchewan were within 102 km of each other. McClelland (pers. comm.) noted that all bald eagles radio-tagged in GNP for which

movements are known wintered west of the Continental Divide and summered in the MacKenzie River watershed of northern Alberta, northwest Saskatchewan and Northwest Territories. This suggests that choice of wintering areas may be related to the watershed of origin. Additional evidence to support the "watershed" hypothesis comes from the movements of 2 adult bald eagles radio-tagged in Wyoming during winter. One trapped on the west side of the Continental Divide was followed to the MacKenzie watershed while 1 trapped on the east side of the Divide was followed to the Churchill watershed (Jenkins et al. 1982).

Stopover areas used during migration were generally widely distributed. A tree of adequate size, secure from human disturbance in any type habitat, was all that seemed necessary for roosting. Adults followed in 1980 were alone when observed roosting with 1 exception. Eagle #2-80 roosted with 6 other eagles on the Yellowstone River in Montana. In 1981, eagle #8-81 roosted with another eagle 3 times, but 2 sites obviously were not communal or traditional and paired roosting was probably a result of faciliatory behavior. In late March 1982, Swenson (1983) counted 232 bald eagles along the Yellowstone River between the mouth of the Bighorn River and Miles City, Montana. The site where eagle #2-80 roosted is mid-way in this stretch and within an area that contained the most highly braided portion of the river, the most heavily wooded islands, and the highest Canada goose populations of 3 sections of the river studied by Hinz (1974). The use of this section of the Yellowstone River by adults may be dictated primarily by tradition, since migrating adults were not known to feed.

Stopover areas may be more important to immature bald eagles than to adults. Immatures appear to migrate more slowly and will remain at food concentrations while adults continue migrating when weather permits.

Bald eagles congregate at GNP during fall migration to utilize temporarily available spawned out salmon (Oncorhynchus nerka). The importance of the area is illustrated by the large number of eagles present (McClelland et al. 1982). Areas in eastern Montana may be equally important to as many or more migrating eagles. Leighton et al. (1979) estimated a population of 14,000 bald eagles in Saskatchewan and some of these eagles pass through eastern Montana during migration (Gerrard et al. 1978, this study). However, the solitary habits of migrating eagles plus the dispersion of departure dates from the wintering grounds and presumably the summering grounds, prohibit any accurate estimate of the numbers. The apparently large number of potential roost sites available adds to the problem of adequate assessment of the importance of eastern Montana to migrating bald eagles. Departures of eagles from SLV wintering grounds were spread over 2 weeks in 1980 and 3 months in 1981. The relatively low numbers of eagles present at any particular time at some stopover areas in eastern Montana may not necessarily reflect the true importance of these areas to migrating eagles. Turnover of individuals moving through the state appears to be daily, over months. Stopover sites in Montana may be important to large numbers of eagles over long periods.

Winter Capture of Bald Eagles

Several methods have been employed for capture of bald eagles (Smith 1924, Southern 1963, 1964, Robards 1966, Adkins 1977, Harmata and Stahlecker 1977, McClelland and Shea 1978, Nye 1983). Most researchers have had at best, only moderate success in capturing large numbers (>10) of bald eagles, especially adult and target eagles.

The modified Lockhart technique is an efficient method for capturing wintering bald eagles in terrestrial situations. Although cannon nets and rocket nets permitted selective capture of target eagles and reduced the probability of trapping non-target species, preparation time was 240 min per set, cold weather caused many problems and sets had to be moved after the net was fired once (Harmata and Stahlecker 1977). Leg-hold traps can be set to reduce capture of non-target species and sets can be made ready in about 20 minutes. Harmata and Stahlecker (1977) compared the efficiencies of the 2 methods and found cannon net trap efficiency was 1 bald eagle for every 18 hours of trap setting time while 1 bald eagle was captured for each 64 minutes of trap setting time with leg-hold traps.

Time spent for selective capture with rocket nets or cannon nets is often spent watching the set waiting for specific birds. If not watching net sets from a blind, trappers approaching the site to fire the net may disturb eagles at the bait. Leg-hold traps require no potentially disruptive activity by trappers since they are triggered by the eagle. One individual can check many leg-hold trap sets

dispersed over a wide area. Considering funding and manpower problems that plague many contemporary research projects, trapping with leg-holds may be more efficient use of resources.

Inexperience with leg-hold traps probably would manifest itself in poor capture success since mistakes in trap setting would deter wary eagles from visiting the site. Inexperience with nets may be more apt to injure or kill eagles with projectiles or rapidly extending nets. Leg-hold traps are inherently safer than projectile expanded nets. In 4 years of bald eagle trapping with leg-hold traps, only 1 potentially damaging injury occurred. The trapped eagle wrapped the chain and trailing trap around a bush and struggled intensely to free itself. Abrasion on 2 toes appeared severe but the eagle, which was banded, radio-tagged and released untreated, was retrapped 2 months later. No sign of injury or damage was apparent and toe function was normal.

Leg-hold traps are more easily concealed than are nets. Harmata and Stahlecker (1977) found that bald eagles, especially wary adults, were apparently discouraged from utilizing baits at cannon nets, presumably by exposed cannons pointing at the carcass. Attempts to conceal the net and cannons facilitated visitation but compounded firing problems. Because no portion of a leg-hold trap is exposed, eagles are more likely to visit the bait and potential for recaptures increases.

Leg-hold traps concealed with soil also may be employed in riparian areas. Traps can be placed on sand bars or along the shoreline, provided adjacent water is less than 50 cm deep or traps are

constantly monitored to prevent captured eagles from venturing into deep water.

Visitation of trap sites by some non-target birds may actually be desirable since they appear to serve as lures and captures of non-target birds can be avoided. Trap sets with eagle lure birds were better for capturing immature golden eagles but seemed to deter adult golden eagles and all ages of bald eagles. Social facilitation in golden eagles seems strong, encouraging immatures to visit sites with other eagles present. Visitation of lure sets by adult golden eagles is less likely, presumably since adults are aware of restraining equipment and unsuccessful attempts of the lure eagle to fly, indicating an eagle in trouble. Immature golden eagles are either unaware or unconcerned with the lure eagle's condition. Encounters between golden eagles and bald eagles at carcasses indicated that golden eagles of all ages were clearly dominant over all ages of bald eagles. The presence of golden eagle lure birds very near carcass sets therefore, would tend to inhibit bald eagles from visiting the sets, but may attract bald eagles to the general area.

Immature bald eagles seemed to be dominant over adult bald eagles at carcasses. The presence of an immature bald eagle lure bird at a trap site probably attracts adult bald eagles to a site but might deter adults from visiting the actual set. The capture of 1 adult bald eagle at a site with an immature bald eagle lure bird indicates that the technique should be tested further, but the adult was much more aggressive than most other adults when handled. This particular adult bald eagle also was the only 1 out of 19 adult bald eagles instrumented

known to have shed the transmitter by breaking off her central rectrices, another indication of her unusual behavior. Lure eagles placed > 50 m from the set may be more successful.

Trap success in the SLV was higher in 1981 than in 1980, but slightly lower than in 1977 (Harmata and Stahlecker 1977). Higher success in 1977 may have been due to novel situations, i.e. the eagles never having experienced trap sites or seen other eagles trapped. Weather may have contributed to the higher success of 1981 over 1980. Eagles were more active in 1981, presumably due to milder temperatures (17^{o}C in early February) creating strong thermals. These thermals permitted extensive soaring flights, whereas eagles foraged mostly from stationary perches in 1980 and presumably were more familiar with their range. Thus, sedentary eagles would be more wary of unfamiliar situations in a familiar range while eagles soaring over large expanses would be less familiar with the range and more likely to visit an unfamilar carcass.

Problems encountered by other researchers using leg-hold traps seem to be related to 4 major factors: bait carcass size, excessive padding on the jaws and/or weakening trap springs, little or no prior observation of target eagles, and failure to place traps during darkness. Strategic placement around large carcasses such as deer (Odecoileus spp.) or sheep is difficult. Eagles visit large carcasses often by landing on the carcass itself, eating and flying off without ever touching the ground. Others that approach on the ground hop on top of the carcass from a meter or more away. Leg-holds around small carcasses are more likely to catch eagles; in some situations traps

around carcass parts of small animals, e.g. jackrabbit legs, are highly successful for capturing eagles (Harmata 1981). Excessive padding on the trap jaws permit eagles caught only by a talon or distal portion of a single toe to slip out after a short struggle. Too much padding also slows the closing of the trap. Padding with leather and tape rounds the sharp edges of jaw surfaces without excess cushioning or slowing of the trap and talon captures are facilitated. Weak trap springs not only reduce closing pressure, but more importantly reduce the quickness with which the trap closes. Quick traps are essential for trapping extremely alert, agile eagles. Lightly padded jaws and unmodified springs certainly induce pain but do no apparent damage on the vast majority of eagles captured.

Target eagles can be selectively captured by leg-hold traps, but prior observation of foraging activities of target eagles is essential for appropriate trap placement. Probability of visitation at a trap set is much greater if traps are placed while out of sight of target eagles.

Aging and Sexing

Grier (1980) argued convincingly that survival rates rather than reproductive rates may be more important to the status of bald eagle populations. He also cautioned on making inferences about populations based on observed age ratios (Grier 1979), but as McClelland et al. (1982) pointed out, long-term monitoring of age ratios along migration routes rather than wintering areas could serve as an index to

population trends. An accurate aging protocol could help in identifying age specific mortality among immature bald eagles.

The aging protocol presented in Figures 14-17 describes a more rapid attainment of definitive plumage than that often cited from Southern (1964, 1967). Southern felt full adult plumage was attained at 7 years. However, he worked with museum specimens and seemed overly influenced by Crandall's (1941) observations of a captive eagle. Sequence and frequency of feather molt in captive bald eagles appear to be similar to wild specimens but change to adult coloration may be protracted 2 to 3 years (pers. observ.). Clark (1983) noted immature plumages of wild bald eagles and loosely related them to age. He associated 4 plumages with immatures implying adult plumage was attained in 5 years. The protocol presented here shows definitive plumage is attained in 4 years. Observations of Gerrard et al. (1978) support this aging sequence. Also, bald eagles hacked as fledglings in New York returned to breed in 4 years (Erickson 1982), exhibiting full adult plumage. Recent recoveries of eagles banded in the Greater Yellowstone Ecosystem further support the existence of Clark's (1983:823) transitional plumage (Harmata unpubl. data). Unlike Clark's representation, this plumage appears intermediate between 0.5 and 1.5 yr-olds rather than for eagles over 2 years, at least in the Greater Yellowstone Ecosystem.

It is possible that bald eagle populations in some areas are experiencing an ecologically accelerated maturity phenomenon. The number of an eagle's immature years may be abbreviated in order to fill habitat left vacant by the effects of DDT and other pesticides.

Accelerated maturity may be facilitated by better nutrition due to the creation of more winter habitat. Delayed maturity in captive eagles may be a function of continual subordination by handlers. Captive eagles are seldom underfed and handlers constantly subordinate them in daily care, handling, and feeding. It would be interesting to note plumage acquisition in captive bald eagles that are imprinted on their handlers and not continually subordinated during molt.

Wing chord measurements have been used most often to determine the sex of monochromatic raptors in hand (Jollie 1947, golden eagles; Cade 1955, rough-legged hawks; Enderson 1964, prairie falcons; Storer 1966, accipiters). In bald eagles which are not highly dimorphic, a combination of measurements (Fig. 25) would be more accurate in determining sex than a single overlapping variable.

Amadon (1983: 2) stated there is only a gradual cline of size increase from south to north and it is doubtful that subspecies should be recognized in bald eagles. Therefore, the technique presented here probably would be applicable to the majority of eagles found in the interior of western North America in winter and at least those above 45° N latitude in summer.

Colormarking vs Radio-Tracking as a Research Technique

Although colormarking is an accepted technique for studying movements and population dynamics of raptors (Platt 1981, Kochert et al. 1983) it contributed little toward identifying the origin of SLV eagles nor winter ranges or movements. Aside from eagle C19, all sightings of colormarked eagles (Fig. 57) occurred within 2 years of

marking, none were confirmed by number/letter combinations on the marker, and none were observed in Canada. Only after eagles had been followed north and the summering area located by radio-tracking were band recoveries produced. These recoveries came 1, 3, and 5 years after banding. More data were generated by band recoveries than sightings of colormarked eagles, but recoveries alone provided little insight into long-range movements. Once telemetry elucidated routes of migration and summering areas, recovery data contributed much to show continuity in migration routes.

Observations indicated wrap around patagial wing tags (Fig. 19) disrupted pair bonds of adult bald eagles in the SLV but the duration and severity of the disruption is unclear. Four individuals judged to be from 4 mated pairs were captured and colormarked (among others) in 1977 and 1978. Subsequently, pairs were not together on heavily used perches as seen prior to capture. Some birds appeared to become reassociated again prior to leaving the valley, but one eagle, C11, did not appear mated in the wintering ground again until 1982, 5 years after marking. However, mated pairs may not always winter together and it is not known if any eagles marked in the SLV attempted to breed the summer after marking. Adult bald eagles marked with patagial wing tags at GNP attempted to breed the season following marking but success was low (Young 1983). Kochert and Lockhart (cited in Kochert et al. 1983) noted significantly lower breeding success of patagial marked adult golden eagles than unmarked controls.

These adverse behavioral and physical effects of patagial markers and the paucity of subsequent sightings of colormarked eagles seem to

make this technique a poor choice for use in documenting long-term, long-range movements of bald eagles. Documentation of short-term, short-range movements where expenditures for telemetry equipment may not be justified could be accomplished more efficiently and safely by notching of remiges and/or retrices, rather than applying permanent markers.

Telemetry facilitates both short and long-term tracking and documentation of local and long-range movements. Although telemetry equipment is expensive, costs can be compensated by reduced time spent capturing and locating marked birds. Small samples of radio-tagged individuals are offset by large amounts of quantitative movement data. Rectrix-mounted transmitters, attached proximo-ventrally, appear to have little effect on behavior and retention rate is excellent. Adult males copulated with transmitters in place and subsequently bred successfully. Fears of damage to eggs by females wearing rectrix-mounted transmitters are unwarranted. Behavior of eagles when settling to incubate is stereotypic and does not involve close proximity of tail and eggs. Problems with retention of rectrix-mounted transmitters are usually associated with dorsal attachment (Andersen 1980, pers. observ.).

Bald Eagle Management in the SLV

Management schemes designed to improve bald eagle winter habitat should be not directed at the entire home range. The habitual range of a bald eagle was 21% smaller than the entire range and daily movements of most radio-tagged eagles generally were confined to a small

portion thereof. Certain areas definitely were more important than others and emphasis should be on identification and monitoring of these areas with management schemes directed accordingly.

Roost sites, especially in areas not on or near rivers in the SLV proper are being lost by installation of center pivot irrigation systems. As these sites are lost, there seems to be a coincident increase in use of riparian sites, mostly along the Rio Grande River. Some small stands not used previously in the uplands now support small numbers of roosting eagles. These eagles appear to be accepting less suitable upland roost sites while maintaining proximity to traditional foraging areas. Others displaced by loss of upland roost sites may be saturating riparian sites and expending excessive energy in traveling to traditional foraging areas. This energy expenditure may become critical, especially during cold winters when soaring flights are not possible and/or when prey and carrion availability is reduced.

Management programs directed at bald eagle roost sites in the SLV should include protection of all existing and potential roost sites from development and human disturbance. Potential roost sites may be defined as areas in the riverine gallery forest consisting of large timber stands containing few, old growth trees taller than the rest of the stand, preferably on the periphery of the stand and close to a highly sinuous portion of the river. Most importantly, potential sites should be as far from human disturbances (towns, roads, and dwellings) as possible. Assessment of potential roost site suitability may be accomplished by using discriminating variables for respective rivers (Figs. 53 and 54) and classification equations (p 124).

New upland roost sites should be created through large scale plantings of cottonwoods, fenced, within traditional foraging areas. Plantings should be of maximum distance from (in descending order of importance) towns, roads, and dwellings.

Flood abatement structures and dams for reservoirs should be discouraged along the Rio Grande and Conejos Rivers from the head waters to central New Mexico. This would facilitate continual replacement of cottonwoods in the riparian gallery forests. Periodic local flooding and bank cutting create conditions required for the regeneration of cottonwoods.

It is clear from statistical analysis that the closer the human activity is to an eagle the more likely a flush response, regardless of type of human activity involved. Figure 37 indicates that human activity occurring within 300 m is most likely to stimulate a flush response of bald eagles. Ninety percent of eagles flushed when human activity occurred within 150 m. Eagles apparently selected perches at least 90 m from potential or actual human activity as evidenced by the lack of observations of eagles within 90 m of human activity. The percentage of eagles flushed decreased as distance between human activity from the eagle increased.

Eagles feeding on the ground seem to be more sensitive to human activity than those perched above ground. Field of view of an eagle on the ground is much more limited than those perched on fence posts or trees. The decreased field of view may render eagles much more vulnerable to attack. They may be more sensitive to human activity when activity cannot be kept in view.

The primary consideration when employing management techniques for bald eagles in the SLV should be proximity of potential or actual human activity to bald eagles. Should activity restriction zones be needed on rivers or in upland situations, disturbance results indicate boundaries should be at least 300 m from eagle concentrations. This is consistent with recommendations to establish activity restrictions zone boundaries for wintering bald eagles on the Nooksack River (Stalmaster and Newman 1979).

Bald eagles and other raptors are using perch structures in the SLV. Preliminary observations and communication with landowners indicate immature bald eagles are using the structures more than adults. Because fidelity to wintering grounds appears to be high, adult use may increase in the future through continued use by immatures and gradual acceptance by adults.

Significantly greater use of perch structures by bald eagles and golden eagles in areas of perceived high prey density indicates that distribution of eagles may be manipulated. Subjective assessment of prey density and availability may indeed be important when choosing locations for perch structures. It may be possible to induce bald eagles to use foraging areas where prey density is high and at least 300 m from human activity, thereby reducing excessive mortality from shooting, electrocution or starvation.

Deployment of perch structures could be considered a short-term solution for a long-term problem. Supplemental tree plantings would be preferable but valley politics may make strategically located large scale plantings unfeasible. Water is at a premium in the SLV

and cottonwoods are considered by many as nothing more than competitors for a scare resource.

Feeding stations, if needed, should be placed more than 760 m from any human activity to minimize the effects of human activity. This distance may be reduced if field of view around a feeding station is increased. Feeding stations on small hills in bare fields may be placed as close as 300 m to human activity and still be available to bald eagles.

Management Strategy. One of the most pressing needs in management of bald eagles is a change in direction and attitude of government agencies charged with the conservation of bald eagles. Agencies direct most of their management activities to their respective public lands, but the vast majority of perch, feeding, and roost sites of bald eagles in the SLV are on private land.

One very powerful management tool not restricted by mandates is often neglected and underrated by public agencies - public information and education. The most expensive and intensive management programs directed at peripheral low use lands make insignificant contributions toward bald eagle conservation unless coupled with programs designed to improve or protect essential habitat on private lands. Uninformed landowners cannot make informed decisions about activities which may potentially impact bald eagles. Before landowners become receptive to research based management suggestions of federal agencies, the attitude of federal agencies and the perception of private landowners should be changed from one of government exerted control to agency facilitated cooperation. Reduction of the adversial government/

landowner relationship as perceived by many residents of the SLV would be assisted by a more realistic classification of the status of bald eagles. Bald eagles are classified as an endangered species but it is difficult to convince some landowners that bald eagles have real problems when they see up to 30 on their land every day. Downlisting the species from endangered to threatened would be a more honest biological assessment and go a long way in relieving landowner fears of government interference. It would also expand the potential for research and applied management. The Section 7 consultation process of the Endangered Species Act would continue to maintain control over severely disruptive activities, only more subtly.

Once a more cooperative relationship exists, the primary goal of agencies should be to develop and maintain a conservation ethic. This can be most effectively accomplished by public information/education programs. Information programs appear to have been productive in the SLV at least with landowners who have bald eagles frequenting their land. Sheep ranchers contacted and informed as to bald eagles needs are anxious to assist in their conservation. Through information, some who thought all eagles killed livestock now realize avian depredators are more likely to be golden eagles of which there are few in the SLV. Some did not need to be told. However, several ranchers now drag livestock carcasses out to open fields for use by eagles rather than dumping them in large "dead pits."

The future of all wildlife is dependent on the size and distribution of human populations and associated habitat alteration and pollution. It is naive to expect significant reductions in the human

population. The most appropriate strategy for maintaining viable wildlife populations would be an integration of 3 objectives: 1) inculcate a change of attitude and direction of federal agencies, 2) propagate a conservation ethic in the general public, and 3) direct management activities based on sound research toward public and private lands based on biological rather than political realities and priorities.

LITERATURE CITED

LITERATURE CITED

Able, K.P. 1980. Mechanisms of orientation, navigation and homing. Pages 284-373 in S.A. Gauthreaux, Jr., ed. Animal migration, orientation and navigation. Academic Press, New York. 389 pp.

Adkins, J. 1977. Bald eagle research and management program: Trapping and marking program. Washington Department of Game. 11 p.

Alt, K.L. 1980. Ecology of the breeding bald eagle and osprey in Grand Teton-Yellowstone National Parks complex. M.S. Thesis. Montana State University, Bozeman. 95 pp.

Anderson, C.M. 1980. Problems with a bald eagle tail-mounted radio transmitter. Pages 243-247 in R.L. Knight, G.T. Allen, M.V. Stalmaster and C.W. Servheen, eds. Proc. Washington Bald Eagle Symposium. 14-15 June, Seattle. 254 pp.

Amadon, D. 1980. Varying proportions between young and old raptors. Proc. IV Pan-Afr. Ornithol Congr. 327-331.

_____. 1983. The bald eagle and its relatives. Pages 1-4 in D.M. Bird (Chief ed.) Biology and management of bald eagles and ospreys. Harpell Press, Ste. Anne de Bellevue, Quebec. 325 pp.

Bagg, A.M., W.W.H. Gunn, D.S. Miller, J.T. Nichols, W. Smith and F.P. Wolforth. 1950. Barometric pressure - patterns and spring bird migration. Wilson Bull. 62(1):5-19.

Baker, R.R. 1978. The evolutionary ecology of animal migration. Homes & Meier, New York.

Baker-Gabb, D.J. 1982. Comparative ecology and behavior of swamp harriers Circus approximans, spotted harriers C. assimilis and other raptors in Australia and New Zealand. Ph.D. Diss. Monash Univ., Clayton, Vic. Australia. 286 pp.

Bartlett, R.A. 1962. Great Surveys of the American west. Univ. Okla. Press, Norman. 408 pp.

Brown, L.H. 1976. Eagles of the world. Universe Books, New York. 224 pp.

_____. 1977. Birds of prey: their biology and ecology. Hamlyn Publ. Group Ltd, Middlesex, England. 256 pp.

Brown, L.H. and D. Amadon. 1968. Eagles, hawks, and falcons of the world. McGraw-Hill Book Co., New York, 2 vol.

Cade, T.J. 1955. Variation of the common rough-legged hawk in N.A. Condor 57:313-346.

_____. 1960. Ecology of the peregrine and gyrfalcon populations in Alaska. Univ. Calif. Publ. Zool. 63:151-290.

_____. 1982. The falcons of the world. Cornell Univ. Press, Ithaca, New York. 192 pp.

Chabreck, R.H. 1979. Winter habitat of dabbling ducks - physical, chemical and biological aspects. Pages 133-140 in T.A. Bookhout, ed. Waterfowl and wetlands - an integrated review. Proc. of 39th Midwest Fish and Wild. conf., Madison, WI, December 1977. N. Central. Sect. The Wildl. Soc. 152 pp.

Clark, W.S. 1983. The field identification of North America eagles. Am. Birds 37(5):822-826.

Colorado State Planning Division. 1964. Colorado Year Book: 1962-1964. Denver, CO. 1064 pp.

Cook, W.W. 1897. The birds of Colorado. Bull No. 37. Tech Ser. No. 2. Colorado Ag. Coll. Smith-Brooks Printing Co., Denver, CO.

Costello, D.F. 1954. Vegetation zones in Colorado. Pages iii-x in H. D. Harrington, ed. Manual of plants of Colorado. Sage Books, Denver, CO. 666 pp.

Craig, J.R. 1981. Bald and golden eagle winter population surveys. Wildl. Res. Rept. Part 1 Federal Aid Job Final Report. Proj. No. W-124-R. Job No. 1. 140-144.

Crandall, L.S. 1941. Notes on plumage changes in the bald eagle. Zoologica 26:7-8.

Dillon, M., Compiler. 1981. San Luis Valley crop summary, 1975-80. Colo. Agric. Sta. Bull. 1:81. Colo. St. Univ. Coop. Ext. Ser., Alamosa.

Dingle, H. 1980. Ecology and evolution of migration. Pages 2-101 in S.A. Guathreaux, Jr., ed. Animal migration orientation and navigation. Academic Press, New York. 389 pp.

Dixon, W.J. 1981. BMDP. Statistical Software. Univ. Cal. Press, Berkley. 726 pp.

Edwards, C.C. 1969. Winter behavior and population dynamics of American Eagles in western Utah. Ph.D. Diss. Brigham Young Univ., Provo, UT. 142 pp.

Emery, P.A. 1972. Water resources of the San Luis Valley, Colorado. U.S. Geol. Sur., Denver, CO. 4 pp.

Enderson, J.H. 1974. A study of the prairie falcon in the Central Rocky Mountain region. Auk 81(4):332-352.

Eng, R.L. and P. Schladweiler. 1972. Sage grouse winter movements and habitat use in Central Montana. J. Wildl. Manage. 36(1):141-146.

Erickson, D. 1982. Bald eagle restoration: No longer an experiment. The Eagle 2(3):1-5.

Errington, P.L. 1963. Muskrat populations. Iowa St. Univ. Press, Ames, 665 pp.

Fawks, E. 1961. A survey of wintering bald eagles 1960-61. Iowa Bird Life 31:54-60.

Fenneman, N.M. 1931. Physiography of western United States. McGraw-Hill Book Co., Inc. New York. 534 pp.

Fielder, P.C. and R.G. Starkey. 1980. Wintering bald eagle use along the upper Columbia River, Washington. Pages 177-193 in R.L. Knight, G.T. Allen, M.V. Stalmaster, and C.W. Servheen, eds. Proc. Washington Bald Eagle Symposium. 14-15 June, Seattle 254 pp.

Fisher, L.E., V.E. Hartman, V. Howell, and D. Busch. 1981. A survey of wintering and migrating bald eagles and critical habitat in the lower Missouri Region--Colorado, Kansas, Nebraska, and Wyoming. USDI Bur. Rec., Lower Missouri Reg., Denver, CO. 97 pp.

Fitzner, R.E., D.G. Watson, and W. Rickard. 1980. Bald eagles of the Hanford National Environmental Research Park. Pages 207-215 in R.L. Knight, G.T. Allen, M.V. Stalmaster, and C.W. Servheen, eds. Proc. of Wash. Bald Eagle Symp. 14-15 June, Seattle. 254 pp.

Fox, N.C. 1977. The biology of the New Zealand falcon (Falco novaseelandiae Gemlin 1788). Ph.D. Diss. Univ. of Cantebury. Page 27 in T.J. Cade. 1982. The falcons of the world. Cornell Univ. Press, Ithaca, New York. 192 pp.

Fredrickson, L.H. and R.D. Drobney. 1979. Habitat utilization by post breeding waterfowl. Pages 179-131 in T.A. Bookhout, ed. Waterfowl and wetlands - an integrated review. Proc. of 39th Midwest Fish & Wild. Conf., Madison, Wisconsin, December 1977. N. Central Sec., The Wildl. Soc. 152 pp.

Gaca, J.R and D.E. Karig. 1966. Gravity survey in the San Luis Valley area, Colorado. U.S. Geol. Sur. open-file report. 21 p.

Gerrard, J.M., D.W.A. Whitfield, P. Gerrard, P.N. Gerrard, and W.J. Maher. 1978. Migratory movements and plumage of subadult Saskatchewan bald eagles. Can. Field Nat. 92:375-382.

Gerrard, J.M. and P.N. Gerrard. 1982. The spring migration of bald eagles in the vicinity of Saskatoon. Blue Jay 40:56-60.

Giles, R.H. 1971. Wildlife management techniques. Third. ed. The Wildlife Society, Washington., DC. 633 pp.

Grier, J.W. 1979. Caution on using productivity or age ratios alone for population inferences. Raptor Res. 13(2):20-24.

_____. 1980. Modeling approaches to bald eagle population dynamics. Wildl. Soc. Bull. 8(4):316-322.

Griffin, C.R. 1981. Interactive behavior among bald eagles wintering in north-central Missouri. Wilson Bull. 93(2):259-264.

Griffin, C.R., T.S. Baskett, and R.D. Sparrow. 1982. Ecology of bald eagles wintering near a waterfowl concentration. U.S. Fish & Wild. Ser. Spec. Sci. Rept. - Wildl. No. 247. Washington, D.C. 12 pp.

Griffin, D.R. 1943. Homing experiments with herring gulls and common terns. Bird-Banding 14(1):7-23.

Grubb, T.G. and C.E. Kennedy. 1982. Bald eagle winter habitat on south-western National Forests. Res. Paper RM-237. USDA Rocky Mountain Forest and Range Exp. Sta. Fort Collins, CO. 13 pp.

Hafen, L.R. ed. 1948. Colorado and its people: A narrative and topical history of the centennial state. Lewis Historical Publ. Co. Inc., New York. 2 vols.

Hall, E.R. and K.R. Kelson. 1959. The mammals of North America. Ronald Press, New York, 2 vols.

Harmata, A.R. 1981. Capture and radio-tagging adult golden eagles in conflict with Pit No. 5, Black Butte Coal Lease, Sweetwater Co., Wyoming. Black Butte Coal Co. Wildl. Rep. #81-1. 19 pp.

_____. 1982. What is the function of undulating flight display in golden eagles? Raptor Res. 16(4):103-104.

Harmata, A.R., J.E. Durr, and H.L. Geduldig. 1979. Home range, activity patterns and habitat use of prairie falcons nesting in the Mojave Desert. USDI, Bur. Land Manage. Contract #YA-512-CT8-43. Denver, CO. 89 pp.

Harmata, A.R. and D.W. Stahlecker. 1977. Trapping and colormarking wintering bald eagles in the San Luis Valley, CO. 1st Annual Report, May 1977. 38 pp. (typescript)

Harvard University. 1971a. SYMAP program. SYMAP manual. Lab. for computer graphics and spatial analysis, 114 Memorial Hall, Cambridge, MA. 157 pp.

Harvard University. 1971b. SYMVU program. SYMVU manual. Lab. for computer graphics and spatial anlaysis, 114 Memorial Hall, Cambridge, MA. 158-210.

Hinz, T.C. 1974. Seasonal activity, numbers and distribution of Canada geese (Branta canadensis) in the lower Yellowstone Valley, Montana. M.S. Thesis. Montana St. Univ., Bozeman. 88 pp.

_____. 1977. The effect of altered streamflow on migratory of birds of the Yellowstone River Basin, Montana. Montana Dept. of Nat. Res. and Conserv. Tech. Rep. No. 7.

Hopper, R.M., A.D. Geis, J.R. Grieb, and L. Nelson, Jr. 1975. Experimental duck hunting seasons, San Luis Valley, Colorado, 1963-1970. Wildl. Mono. No. 46. 68 pp.

Hunt, W.G. and B.S. Johnson. 1981. Impacts of a proposed copper creek dam on bald eagles: second winter study. Biosystems Analysis, San Francisco, CA 113 pp. plus Appendices.

Jackson, D., ed. 1966. The journals of Zebulon Montgomery Pike. Univ. of Okla. Press, Norman. 2 vol.

Jenkins, M.A., T.P. McEneaney, L. Hanebury, and J.R. Squires. 1982. Bald eagle (Haliaeetus lecocephalus) essential habitat on and near Bureau of Land Management lands in Wyoming. Draft final report - FY 1981 & 1982. Wintering bald eagles. U.S. Dept. of Interior. Fish & Wildl. Ser., Denver, CO. 107 pp.

Jollie, M.T. 1947. Plumage changes in the golden eagle. Auk 64:549-576.

Keister, G.P., Jr. and R.G. Anthony. 1983. Characteristics of bald eagle communal roosts in the Klamath Basin, Oregon and California. J. Wild. Manage. 47(4):1072-1079.

King, J.R. and D.S. Farner. 1963. The relationship of fat deposition to Zugunruhe. Condor 65(3):200-223.

Kipp, F.A. 1958. Zur geshichte des volgelauges auf der Grundlage der Flugelanpassungen. Volgelwarte 19:233-242.

Knight, S.K. and R.L. Knight. 1983. Aspects of food finding by wintering bald eagles. Auk 100(2):477-484.

Knight, R.L., R.K. Taylor, and J. Vanden Bos. 1980. A summary of the mid-winter bald eagle survey in Washington. Wa. Dept. Game, Olympia. 38 pp.

Knight, R.L., J.B. Athearn, J.J. Bruggeman, and A.W. Erickson. 1979. Observations on wintering bald and golden eagles in the Columbia River, Washington. Murrelet 60:99-105.

Kochert, M.N., K. Steenhof, and M.Q. Moritsch. 1983. Evaluation of patagial markers for raptors and ravens. Wildl. Soc. Bull 11(3):271-281.

Krantz, W.C., B.M. Mulhern, G.E. Bagley, A. Sprunt IV, F.J. Ligas and W.B. Robertson, Jr. 1970. Organochlorine and heavy metal residues in bald eagle eggs. Pes. Mont. J. 3:136-140.

Kramer, G. 1952. Experiments on bird orientation. Ibis 94:265-285.

_____. 1957. Experiments on bird orientation and their interpretation. Ibis 99:196-227.

Lantis, D. W. 1949. Saga of the San Luis Valley in Colorado. Folks and Fortunes 1(1): 38-40.

Larson, E.S., Jr., and W. Cross. 1956. Geology and petrology of the San Juan Region, Southwestern Colorado. U.S. Geol. Surv. Prof. Paper 258. 303 pp.

Leighton, F.A., J.M. Gerrard, P. Gerrard, D.W.A. Whitfield, and W.J. Maher. 1979. An aerial census of bald eagles in Saskatchewan. J. Wild. Manage. 43(1):61-69.

Lincoln, F.C. 1935. The migration of North American birds. U.S. Dept. Agr. Cir. 363, Washington, D.C. 72 pp.

_____. 1979. Migration of birds. Revised by S.R. Peterson and P.A. Anastasi, eds. Fish & Wildl. Ser. Circlar 16. U.S. Dept. of Interior. Washington, D.C. 119 pp.

Lonner, T.N. and M.F. Pexton. 1983. GEOSCAN: A system of computer programs for quantifying animal distribution - habitat relationships. Working draft. Res. Bur. Mont. Dept. of Fish, Wildl. & Parks, Bozeman. 459 pp.

Macdonald, D.W., F.G. Ball and N.G. Hough. 1980. The evaluation of home range size and configuration using radio tracking data. Pages 405-423 in C. Amlaner and D.W. Macdonald, eds. A handbook on biotelemetry and radio tracking: International conference: Biotelemetry and radiotracking in biology and medicine, Oxford, UK, 20-22 March, Pergamon. 826 pp.

Marsh, R.G. 1931. A history of the first records of all the birds reported to have been seen within the present boundaries of the state of Colorado prior to settlement. Thesis. Univ. of Denver. 84 pp.

McClelland, B.R. and D.S. Shea. 1978. Local and long-range movements of bald eagles associated with autumn concentrations in Glacier National Park. Prog. Rep. Univ. of Montana, Missoula. 19 pp.

McClelland, B.R., L.S. Young, D.S. Shea, P.T. McClelland, H.L. Allen, and E.B. Spettigue. 1982. The bald eagle concentration in Glacier National Park, Montana: Origin, growth and variation in numbers. Living Bird 19:133-155.

Miner, N. R. 1975. Montana golden eagle removal and translocation project. Proc. Second Great Plains Wildl. Damage Control Workshop. 155-162.

Moreau, R.E. 1972. The Palearctic-African bird migration systems. Academic Press, New York. 327 pp.

Mueller, H.C., D.D. Berger and G. Allez. 1979. Age and sex differences in size of sharp-shinned hawks. Bird-banding 50:34-44.

_____. 1981. Age and sex differences in wing loading and other aerodynamic characteristics of sharp-shinned hawks. Wilson Bull. 93(4):491-499.

Mueller, H.C. and D.D. Berger. 1970. Prey preferences in the Sharp-shinned hawk: The role of sex, experience and motivation. Auk 87(4):452-457.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley and Sons, New York. 547 pp.

Newton, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, SD. 399 pp.

Nie, N.H., C.H. Hull, J.G. Jenkins, K. Steinbrenner, and D.H. Bent. 1975. SPSS: Statistical package for the social sciences, second edition. McGraw-Hill Book Co., New York. 675 pp.

Nye, P.E. 1983. II: Determination of the current status, maintenance and enhancement of bald eagle populations in New York State. Performance Rep. Endg. Species. Invest. Job #II-3. New York State Dept. Environ. Con. Delmar. 13 pp. plus Appendix.

Orians, G.H. 1980. Why are bald eagles bald? Pages 3-11 in R.L. Knight, G.T. Allen, M.V. Stalmaster and C.W. Servheen. Proc. of the Washington Bald Eagle Symposium. 14-15 June, Seattle. 254 pp.

Pennycuick, C. J. 1972. Soaring behavior and performance of some East African birds, observed from a motor-glider. Ibis 114:128-218.

_____. C.J. 1975. Mechanics of flight. Pages 1-75 in D.S. Farner, and J.R. King, eds., Avian biology. Volume V. Academic Press, New York. 521 pp.

Pianka, E.R. 1974. Niche overlap and diffuse competition. Proc. Nat. Acad. Sci. 71:2141-2145.

Picton, H.D. and R.R. Knight. 1971. A numerical index of winter conditions of use in big game managment. Snow and Ice Symp. Iowa St. Univ., Ames. 29-37.

Platt, S.W. 1981. Prairie falcon: Aspects of population dynamics, individual vocal identification, marking and sexual maturity. Ph.D. Diss. Brigham Young Univ. Provo, Utah. Manuscripts and reprints of journal articles.

Ralph, S.C. 1980. Wintering bald eagle census along the mainstream Skagit River, Washington, from Sedro Wooley to Rockport, 1979-80. Pages 147-162 in R.L. Knight, G.T. Allen, M.V. Stalmaster and C.W. Servhaen. Proc. of the Washington Bald Eagle Symposium. 14-15 June, Seattle. 254 pp.

Ramaley, F. 1942. Vegetation of the San Luis Valley in southern Colorado. Univ. of Colo. Studies Series D, Phys. & Biol. Sci. 1:231-277.

Rasmussen, D.I. 1941. Biotic communities of Kaibab Plateau, Arizona. Ecol. Monogr. 3:229-275.

Reynolds, R.T. 1979. Food and habitat partitioning in two groups of coexisting accipiter. Ph.D. Diss. Oregon St. Univ., Eugene. 116 pp.

Robards, F.C. 1966. Capture, handling, and banding of bald eagles. U.S. Fish & Wildl. Ser. Res. Rep., Washington D.C. 25 pp.

Roberts, F.H.H. 1948. Prehistoric peoples. In: L.R. Hafen, ed. Colorado and its peoples. Lewis. Publ. Co., Inc., New York. 4 vols.

Ruppell, G. 1977. Bird flight. Van Nostrand Reinhold Co., New York. 191 pp.

Ryder, R.A. 1965. A checklist of the birds of the Rio Grande drainage of southern Colorado. Colo. St. Univ., Ft. Collins. 14 pp.

Sanford, A.B. 1933. Recollections of a trip to the San Luis Valley in 1877. Colo. Mag. 10(1):10-17.

Savile, D.B.O. 1957. Adaptive evolution in the avian wing. Evolution 11:212-224.

Schmitt, C.G. 1978. Bald eagle surveys in New Mexico, winter 1977-78. New Mexico Dept. Game and Fish, Sante Fe. 5 pp.

Schoener, T.W. 1969. Models of optimal size for solitary predators. Am. Naturalist 103:277-313.

Selander, R.K. 1966. Sexual dimorphism and differential nich utilization in birds. Condor 68(2):113-151.

Servheen, C. W. 1975. Ecology of the wintering bald eagles on the Skagit River, Washington. M.S. Thesis. Univ. of Washington, Seattle. 96 pp.

Shea, D.S. 1978. Bald eagle concentrations in Glacier National Park. Western Birds 9:35-37.

Sherrod, S.K., W.R. Heinrich, W.A. Burnham, J.H. Barclay, and T.J. Cade. 1982. Hacking: A method for releasing peregrine falcons and other birds of prey. The Peregrine Fund, Ft. Collins, CO. 61 pp.

Simmons, V.M. 1980. The San Luis Valley: Land of the six armed cross. Pruett Publ. Co., Boulder, CO. 193 pp.

Smith, H.I. 1924. Eagle snaring among the Ballacoola Indians. Can. Field-Nat. 38(9):167-168.

Snedecor, G.W. And W.G. Cochran. 1972. Statistical methods. Iowa St. Univ. Press, Ames. 593 pp.

Snyder, N.R. and J.W. Wiley. 1976. Sexual size dimorphism in hawks and owls of North America. Ornithol. Monogr. 20:1-96.

Southern, W.E. 1963. Winter populations, behavior and seasonal dispersal of bald eagles in northwestern Illinois. Wilson Bull. 75(1):42-55.

_____. 1964. Additional observations on winter bald eagle populations: Including remarks on biotelemetry techniques and immature plumages. Wilson Bull. 76(2):121-137.

_____. 1967. Further comments on subadult bald eagle plumages. Jack-Pine Warbler 45(3):70-80.

Spencer, D.A. 1976. Wintering bald eagle. Nat. Agric. Chem. Assoc, Washington, DC. 170 pp.

Stalmaster, M.W. 1976. Winter ecology and affects of human activity on bald eagles in the Nooksack River Valley, Washington. M.S. Thesis. Western Washington State College, Bellingham. 100 pp.

_____. 1981. Ecological energetics and foraging behavior of wintering bald eagles. Ph.D. Diss. Utah State Univ., Logan. 157 pp.

Stalmaster, M. V. and J. R. Newman. 1979. Perch-site preferences of wintering bald eagles in Northwest Washington. J. Wildl. Mange. 43(1):221-224.

Stalmaster, M.V., J.R. Newman and A.J. Hansen. 1979. Population dynamics of wintering bald eagles on the Nooksack River, Washington. Northwest Sci. 53:126-131.

Steenhof, K. 1983. Activity patterns of bald eagles wintering in South Dakota. Raptor Res. 17(2):57-62.

Steenhof, K., S.S. Berlinger, and L.H. Fredrickson. 1980. Habitat use by wintering bald eagles in South Dakota. J. Wildl. Manage. 44(4): 798-805.

Stewart, P.A. 1980. Further research needed on present day movements as a clue to the evolution of bird migration. N. Amer. Bird Bander 5:4-7.

Storer, R.W. 1966. Sexual dimorphism and food habits in three North American accipiters. Auk 83(3):423-436.

Swenson, J.E., K.L., Alt, and R.L. Eng. In prep. Ecology of the bald eagle in the Greater Yellowstone Ecosystem.

Swenson, J.E. 1983. Is the northern interior bald eagle population in North America increasing? Pages 23-34 in D.M. Bird (chief ed.). Biology and Management of bald eaglesnad ospreys. Harpell Press, Ste Anne de Bellevue, Quebec, 325 pp.

Swenson, J.E., T.C. Hinz, S.J. Knapp, H.J. Wentland and J.T. Herbert. 1981. A survey of wintering bald eagles in southeastern Montana. Raptor Res. 15(4): 113-120.

Swisher, J.F. 1964. A roosting area of bald eagles in northern Utah. Wilson Bull. 76:186-187.

Thomas, A.B. 1932. Forgotten frontiers: A study of the Spanish Indian policy of Don Juan Bartista de Anza Governor of New Mexico 1777-1787. Univ. Okla. Press, Norman. 417 pp (plus maps).

Toll, R.W. 1929. The Hayden Survey in Colorado in 1873 and 1874. Colorado Mag. 6(4):152-154.

Welty, J.C. 1969. The life of birds. W.B. Saunders Co., Philadelphia. 546 pp.

Wiemeyer, S.N., B.M. Mulhern, F.J. Ligas, R.J. Hensel, J.E. Mathisen, F.C. Robards, and S. Postupalsky. 1972. Residues of organochlorine pesticides, polychlorinated biphenyls and mercury in Bald Eagle eggs and changes in shell thickness--1969 and 1970. Pesticide Monit. J. 6: 50-55.

Young, L.S. 1983. Movements of bald eagles associated in Glacier National Park. M.S. Thesis. Univ. of Montana., Missoula. 99 pp.

APPENDICES

APPENDIX A

TABLES

Table 35. Habitat types of San Luis Valley, CO used in bald eagle habitat selection analysis by GEOSCAN.

GEOSCAN File Type	Rubric	Description
Point	HOUSE	all occupied dwellings outside of urban areas
Line	RIVER	major rivers
	CREEK	natural water courses
	DITCH	irrigation ditches and canals
	RDPAV	paved roads
	RDGRL	dirt or gravel roads
Area	BENCH (BE)	limy bench 70%, mountain outwash 30%
	BRUSH (BR)	salt flats[1] 60%, chico[2] 40%
	CHICO (CH)	sand hummocks 40%, chico 40%, salt flats 20%
	CITY (CI)	incorporated urban areas
	CROP (CR)	irrigated crop or pasture land
	CWRIP (CW)	cottonwood-willow creek/river bottom
	GRESE (CR)	Chico 100%
	HILLS (HI)	basalt hills
	LAKE (LA)	lakes and ponds
	SAND (SA)	valley sand 70%, salt flats 30%
	SALFL (SL)	salt flats 60%, salt meadow[3] 50%
	SNDSA (SN)	salt flats 60%, chico 40%
	WETMW (WM)	salt meadow 60%, wet meadow 40%
	WOODS (WO)	forested land, mixed confiers 80%, aspen 10%

[1] rabbitbrush (Chrysothamnus spp.) and salt grass (Distichlis stricta)
[2] black greasewood (Sarcobatus vermiculatus)
[3] primarily salt grass

Table 36. Discriminating variables in order of entry in a stepwise discriminate analysis, coefficients and constants for used (observed) and nonused (expected) tree perch classification functions.

Variable[1]	Classification Coefficient	
	Nonused Function	Used Function
MDDITCH	0.594	0.037
CWEDGE	2.228	6.845
CRA2D	1.818	2.050
SNEDGE	14.692	22.315
MDRIVER	0.594	0.344
MDHOUSE	8.732	6.339
BEEDGE	21.122	0.351
CREDGE	15.310	17.827
SAA2D	-0.090	0.600
GREDGE	10.463	13.911
WOEDGE	-30.824	-8.833
WOEXP	6.036	2.738
SNEXP	0.469	-0.776
HIEXP	-3.020	-1.306
CHA2D	2.316	1.633
WMEXP	-7.046	-1.235
SAEXP	8.835	3.843
MDCREEK	0.437	0.596
SAEDGE	-31.828	-16.309
CHEDGE	-5.184	0.413
WOA2D	2.073	1.695
CWA2D	0.124	-0.518
CIEXP	0.309	1.419
SLEDGE	0.167	4.951
SLA2D	1.807	1.348
BEA2D	2.634	2.201
BEEXP	-8.051	-4.547
HIA2D	1.684	1.169
HIEXP	-3.020	-1.306
MDRDGRL	-0.810	-0.519
MDRDPAV	1.188	1.063
Constant	-27.837	-23.943

[1]Variables beginning with MD indicate minimum distances followed by habitat/terrain type presented in Appendix Table 35. First 2 letters of other variables are area habitat/terrain types (Appendix Table 35) followed by variable explained in Habitat Selection section, Nos 3-5, page 37.

Table 37. Discriminating variables in order of entry in a stepwise discriminate analysis, coefficients and constants for used (observed) and nonused (expected) ground perch classification functions

Variable[1]	Classification Coefficient	
	Nonused function	Used Function
MDDITCH	0.165	-0.115
MDRIVER	0.480	0.246
MDRDGRL	-0.079	-0.234
MDHOUSE	7.125	5.036
SNEDGE	-1.917	-0.162
CRA2D	4.206	6.039
CIEXP	11.414	3.135
CREXP	2.207	5.118
BEEXP	4.532	-1.552
CHA2D	4.724	3.235
CWEDGE	-1.090	1.219
HIEXP	5.340	2.900
SAA2D	-2.109	0.577
SLEDGE	5.168	9.468
MDCREEK	0.364	0.463
CREDGE	3.114	4.768
WMEDGE	-10.952	3.771
SNEXP	5.259	8.654
BREDGE	1.078	2.224
CWA2D	2.964	0.299
WOEDGE	4.563	-1.978
WMEXP	15.711	9.806
SNA2D	-0.824	0.647
WDEXP	-7.477	-0.574
BEEDGE	3.088	9.007
WOA2D	8.591	5.354
Constant	-12.880	-11.098

[1]Variables beginning with MD indicate minimum distances followed by habitat/terrain type presented in Appendix Table 35. First 2 letters of other variables are area habitat/terrain types (Appendix Table 35) followed by variable explained in Habitat Selection section, Nos 3-5, page 37.

Table 38. Characteristics of used and nonused bald eagle roost sites on the Rio Grande River, Colorado.

Use Category	Name	Measured variable[1] SA (hectares)	SINU (km/0.8 km radius)	DOD (km)	TW (m)	DCR (km)	CITY (km)
Used	Kessler	1.9	4.4	0.6	5	0.72	7.3
	Dairy	10.5	4.0	0.5	20	0.58	4.8
	ECL	3.8	5.58	0.8	150	0.65	8.6
	Collis	1.2	4.73	0.98	160	1.1	12
	Stillings	16.6	7.06	0.75	5	1.5	10.2
Not Used	33:4:201	0.8	2.3	0.16	50	0.3	2.33
	25:3:220	0.6	2.8	0.29	400	0.55	1.95
	29:14:19	1.1	2.7	0.4	75	0.45	0.16
	29:13:340	2.3	3.8	0.57	110	0.87	7.6
	8:14:312	0.1	2.5	0.36	25	0.48	9.5
	22:9:220	16.7	6.4	0.7	350	1.03	3.8
	4:3:323	1.0	2.75	0.31	100	0.32	0.3
	19:2:0	1.1	1.6	0.33	1	0.29	5.0
	10:1:39	1.4	3.75	1.2	240	1.6	12.4
	25:1:308	6.9	3.0	1.3	1	1.5	5.6
	32:3:210	0.5	6.3	0.45	70	0.93	1.15
	35:24:60	1.7	10.6	0.84	220	1.27	5.9

[1]See Table 1 in METHODS section for description of variable rubrics.

Table 39. Characteristics of used and nonused bald eagle roost sites on the Conejos River, Colorado.

Use Category	Name	Measured Variable[1] SA (hectares)	SINU (km/0.8 km radius)	DOD (km)	TW (m)	DCR (km)	CITY (km)
Used	LCR	2.8	2.56	2.6	95	1.6	10.8
	UCR	2.8	3.12	1.0	90	1.4	5.5
Not Used	20:5:270	0.9	2.17	0.9	5	0.01	2.7
	6:6:106	2.0	1.7	1.7	135	1.06	3.6
	9:4:316	1.5	1.18	0.57	480	0.06	4.7
	10:2:168	1.5	4.4	1.14	75	1.08	13.2
	14:9:349	0.8	3.28	0.6	145	1.3	5.6
	22:6:84	4.9	2.36	0.36	100	0.36	2.4

[1]See Table 1 in METHODS section for description of variable rubric.

APPENDIX B

FIGURES

DATA FORM

BEHAVIORAL RESPONSES OF WINTERING BALD EAGLES TO HUMAN ACTIVITY

San Luis Valley, Colorado

Date (1-6) _____ Time (7-10) _____ Number of Eagles (11-12) _____

Age Class (13) _____ Type of Disturbance* (14) _____ Intensity of Disturbance* _____

Reaction to Disturbance* (16) _____ Proximity to Bald Eagle (17) _____

Vegetation Zone (18) _____ Weather Conditions (19-24) _____

COMMENTS (25-80) _____

_____

(* Read disturbance as Human Activity)

* *

Age Class

1. Juvenile
2. Subadult
3. Adult

Type of Disturbance*

1. Vehicle
2. Boat
3. Farm Equipment
4. Undetermined Noise
5. Other

Intensity of Disturbance*

1. Loud
2. Medium
3. Soft
4. Other

Response to Disturbance*

1. Remains perched
2. Flushes and returns to same/nearby perch
3. Flushes and soars in area
4. Flushes and leaves the area
5. Other

Proximity to Bald Eagle

1. 0 - 100 feet
2. 101 - 300 feet
3. 301 - 500 feet
4. 501 - 1,000 feet
5. 1,001 - 1,500 feet
6. 1,501 - 2,500 feet
7. Other

Vegetation Zone

1. Agriculture - lone tree
2. Agriculture - wind break
3. River Channel
4. Known Roost
5. Other
6. Agriculture - field feeding

Weather Conditions

Skies

1. Sunny
2. Partly Cloudy
3. Overcast

Wind Direction

4. North
5. NE
6. NW
7. South
8. SE
9. SW
10. West
11. East
17. No wind

Temperatures

12. -15 - 0°
13. 1 - 15°
14. 16 - 32°
15. 33 - 49°
16. Other

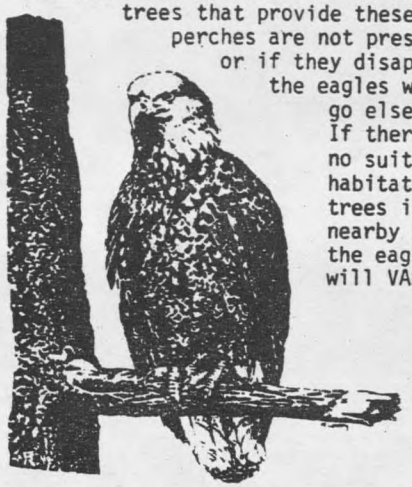
Figure 64. Data form for bald eagle disturbance study.

WHY HELP THE BALD EAGLE?

On June 20, 1782 the bald eagle was formally adopted as the emblem of the United States, a living symbol of our nation's strength and freedom. Today it is an endangered species fighting for its life and very existence.

The gathering of eagles in the SLV is the largest wintering concentration in Colorado. The bald eagles that frequent the SLV are a race that prefer inland waterways with trees for perching. Bald eagles feed on fish and waterfowl when river courses are open, feeding on *carrion* (dead animals) and jackrabbits when the rivers are frozen over.

Perches are essential to the eagles' existence, a place where the bird can survey for food with an unobstructed field of vision. If the trees that provide these perches are not present, or if they disappear, the eagles will go elsewhere. If there is no suitable habitat with trees in other nearby places, the eagles will VANISH!



For more information, contact:

San Luis Valley Audubon Society
Post Office Box 1094
Alamosa, CO 81101

San Luis Valley

BALD EAGLES



CAN USE YOUR HELP!

For thousands of years, bald eagles have been living here, arriving in the fall and leaving in the spring. Strong evidence suggests that since white men lived in the valley the eagle population has increased. Why? Because irrigation and homebuilding created something that the eagles needed to survive - TREES!

Although there have always been trees along the Rio Grande and Conejos Rivers, outlying tree plantings have widened the prehistoric eagle range. But times are changing and one thing that is changing fast is the number of trees on the valley floor. They are disappearing, being cut down or dying out, and not being replaced.

Figure 65. Side 1 of educational flyer distributed in the San Luis Valley, CO 1981.

THE PROBLEM ...

The major contributor to the demise of the valley trees has been the center pivot irrigation system. Although these systems offer more efficient use of water, they cannot pivot through objects. Thus, old woodlots, windbreaks, and lone trees have and are being cut down at alarming rates.

The growth of center pivot systems has been phenonmenal. In 1973, only 262 systems were in operation. In 1981, there were an estimated 2,000. The widespread use of these systems has also caused the deaths of trees that line now unused irrigation ditches. The potential reduction of the water table in the valley will cause further deaths when the roots cannot reach the water supply.

Cultivation of maximum field area has reduced the amount of cover available to provide food and homes for animals which the eagles might feed on.

Most sprouting young trees are eaten by grazing animals as well as beaver. The sad fact is that trees are not being replanted.

So without young trees replacing the old, and old trees being cut down or dying out, we are facing a TREE SHORTAGE in the San Luis Valley (SLV).

WHAT YOU CAN DO TO HELP ...

As a landowner, you can plant trees, preferably cottonwoods. Be sure to protect them from grazing animals. Cottonwoods offer the best perches for eagles. In areas where the water table is high enough, cottonwoods should survive after a few years care. Your local tree expert may have other suggestions for hardy species that can live in this high, arid valley.

The trees should be planted well away from homes or heavily used roads, as eagles are reclusive birds and are easily disturbed by humans. Some of those corners that do not receive water or that are not producing crops would be ideal for planting cover and trees.

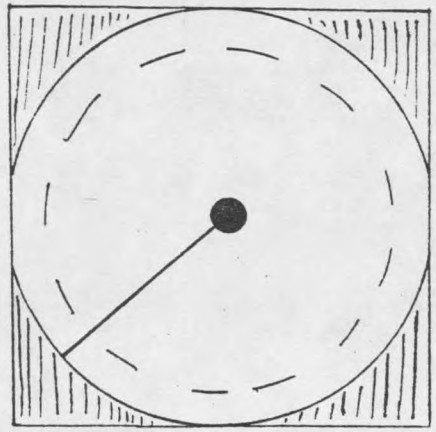
Other things you can do to help ...

- Drag dead livestock into unused pastures or areas where there is little activity so eagles can feed undisturbed.
- Throw road-killed animals (except skunks!) off into a field. Many eagles and hawks are accidently injured or killed while feeding on road-killed animals.
- Look for a silver band attached to the leg of *any dead bird.* This band has instructions where to send the band number, location, and condition of the bird.

TREES ARE LIFE ...

By replenishing our valley with trees, we will not only help the bald eagles, but aid other wildlife as well. Trees provide food and homes for owls, hawks, woodpeckers, and flickers, as well as many species of songbirds. With your help, we can continue to keep the SLV what it is - a beautiful place for people and wildlife to live.

Those unused corners of your fields make excellent spots to plant trees and other ground cover.



Center Pivot Irrigation System

Figure 66. Side 2 of educational flyer distributed in the San Luis Valley, CO 1981.

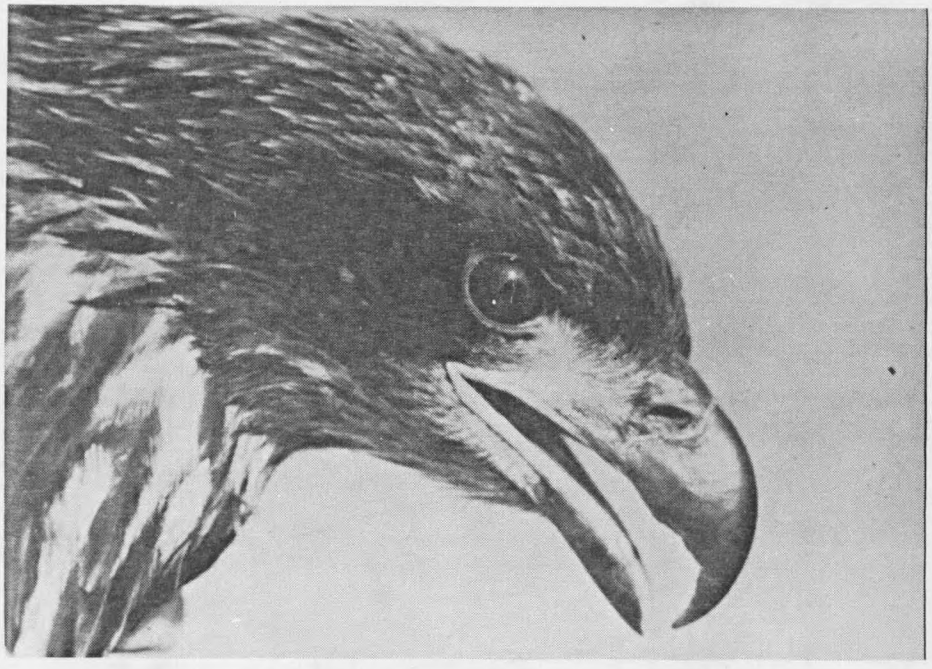


Figure 67. Bald eagle 0.5 years old. Iris is dark brown, upper mandible and cere black.



Figure 68. Ventral plumage of 0.5 yr-old bald eagle. Belly is tawny and bib dark brown.

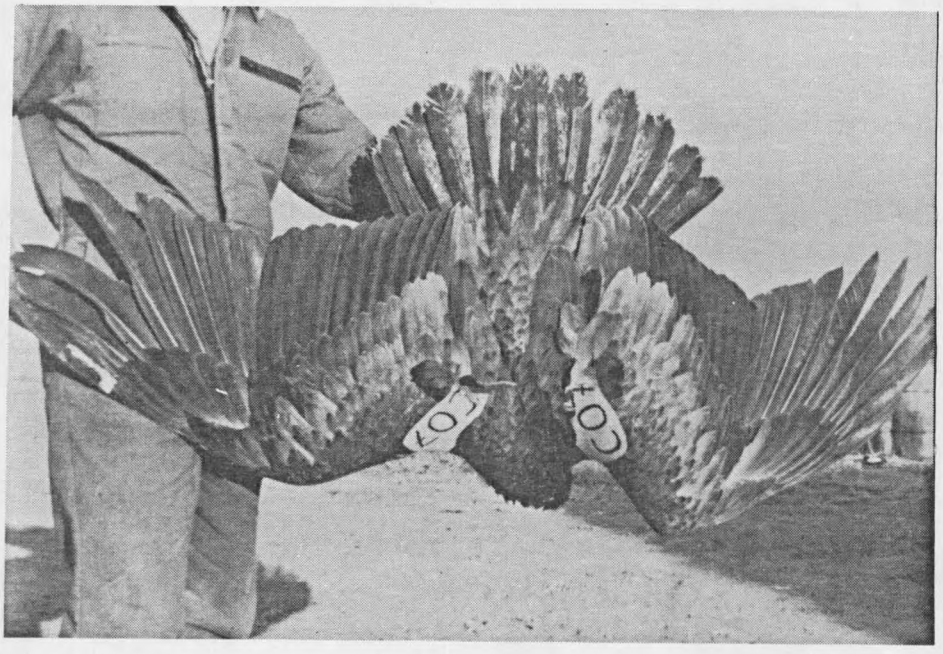


Figure 69. Dorsal plumage of 0.5 yr-old bald eagle.



Figure 70. Bald eagle 1.5 years old. Iris is beige with brown speckling. Yellowing of upper mandible and cere begins at the base and progresses anteriorally with age.

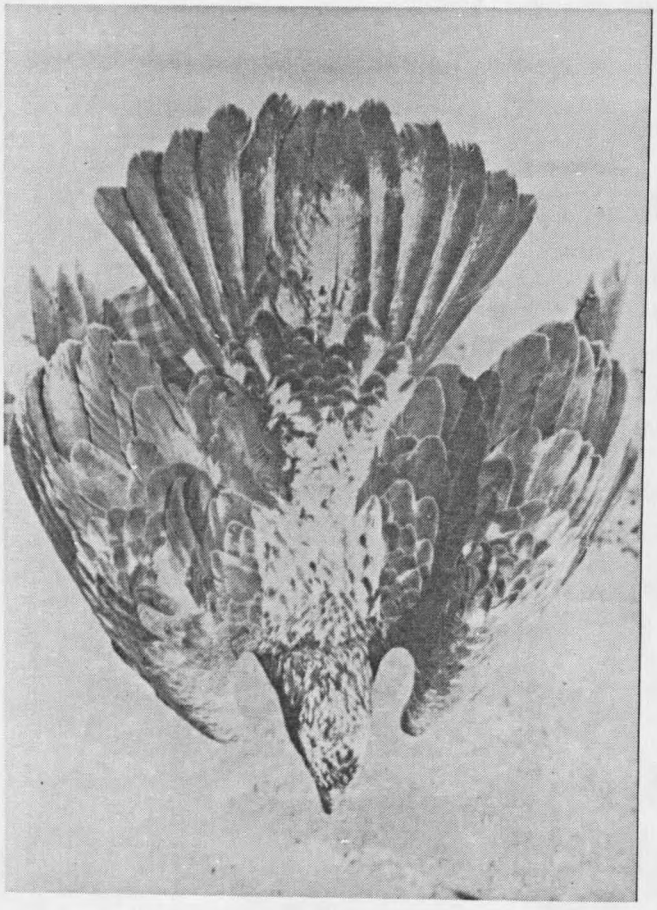


Figure 71. Dorsal plumage of 1.5 yr old bald eagle. White feathers on anterior back often appear triangular when eagles are perched.



Figure 72. Ventral plumage of bald eagle 1.5 years old. Note distinct dark bib and white belly.

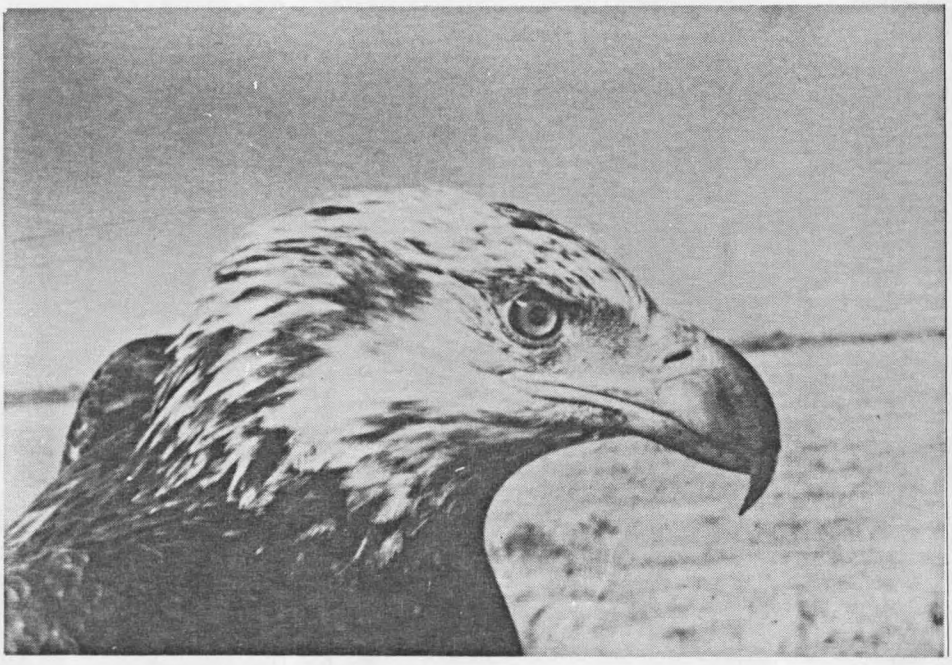


Figure 73. Bald eagle 2.5 years old. Iris mostly beige, base of upper mandible and most of cere yellow.

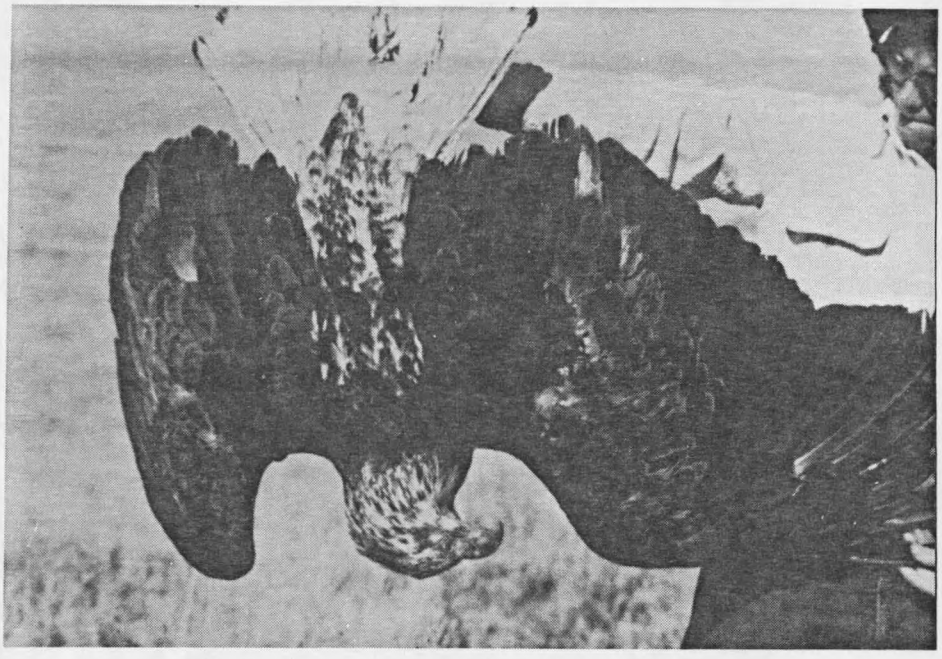


Figure 74. Dorsal plumage of 2.5 yr-old bald eagle.



Figure 75. Ventral plumage of 2.5 yr-old bald eagle.



Figure 76. Typical rectrix coloration of 2.5 yr-old bald eagle.

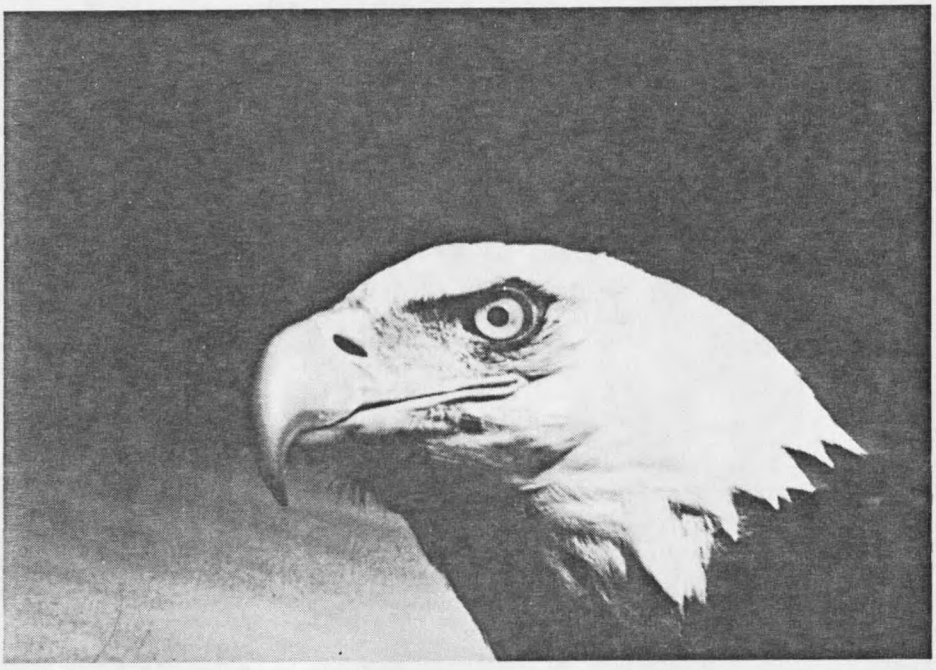


Figure 77. Full adult bald eagle probably at least 6.5 years old.

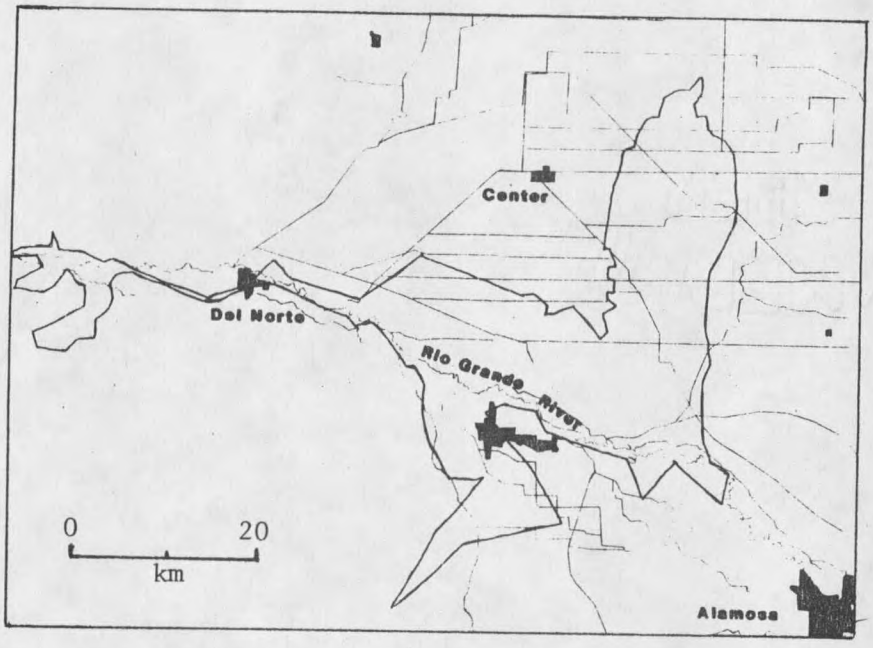


Figure 78. Home range of an unmated adult male bald eagle #1-80, encompassing 470.9 km^2 of the San Luis Valley, CO. Lines are irrigation ditches and canals.

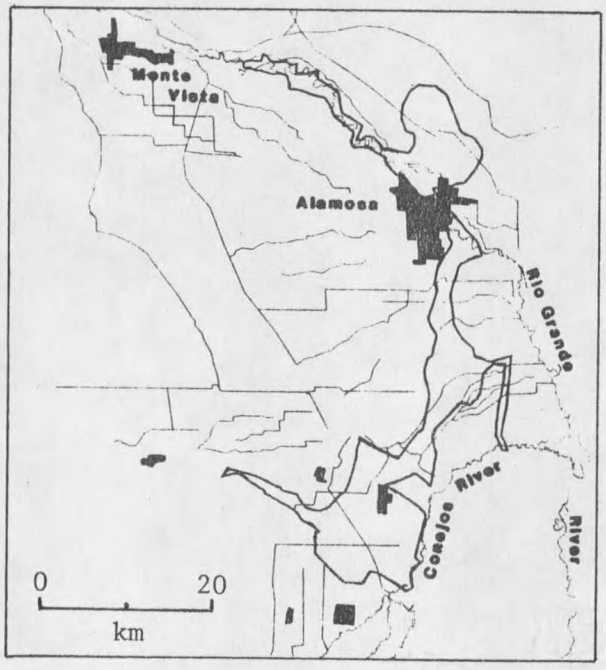


Figure 79. Home range of a mated adult male bald eagle #2-80, encompassing 184.7 km^2 of the San Luis Valley, CO. Lines are irrigation ditches and canals.

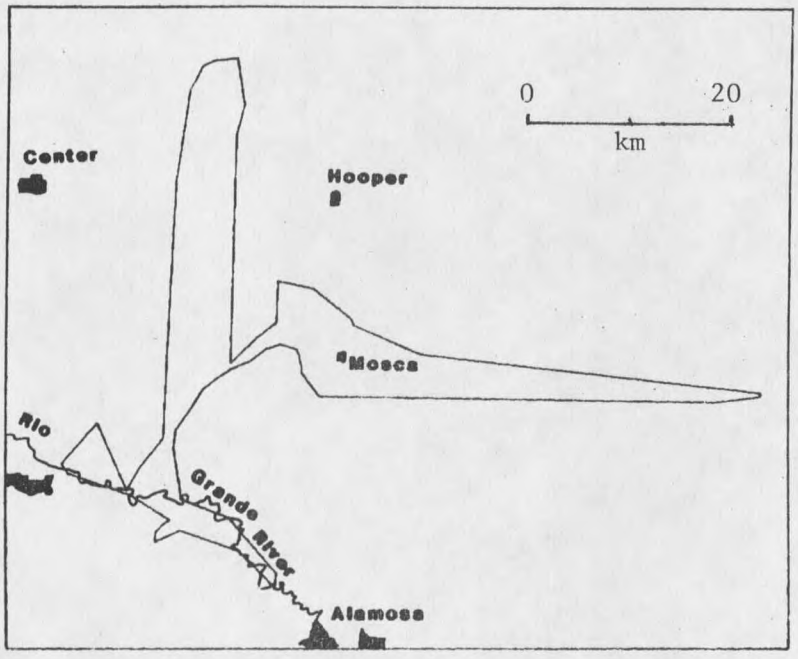


Figure 80. Home range of an adult female bald eagle #3-80, encompassing 215.9 km^2 of the San Luis Valley, CO.

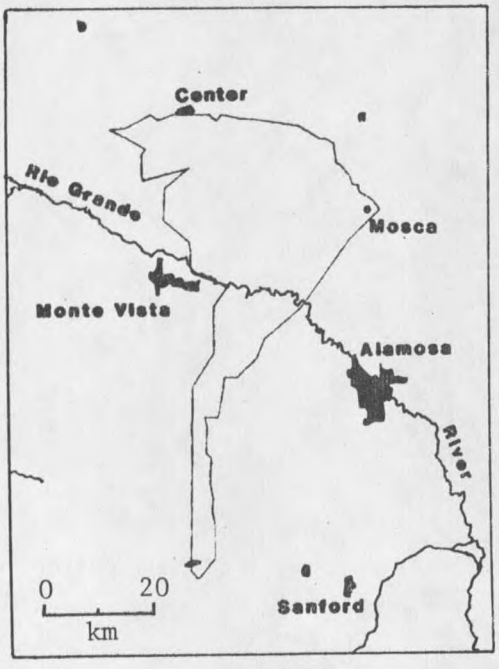


Figure 81. Home range of an unmated adult female bald eagle #3-81, encompassing 540.8 km^2 of the San Luis Valley, CO.

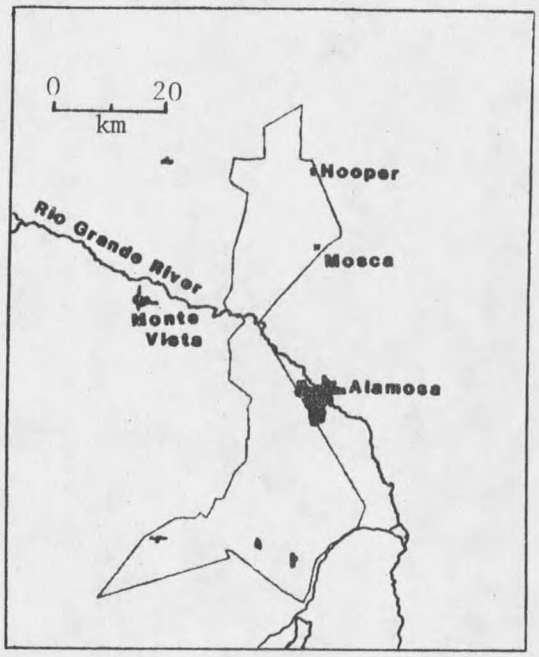


Figure 82. Home range of an unmated adult male bald eagle #4-81, encompassing 795 km^2 of the San Luis Valley, CO.

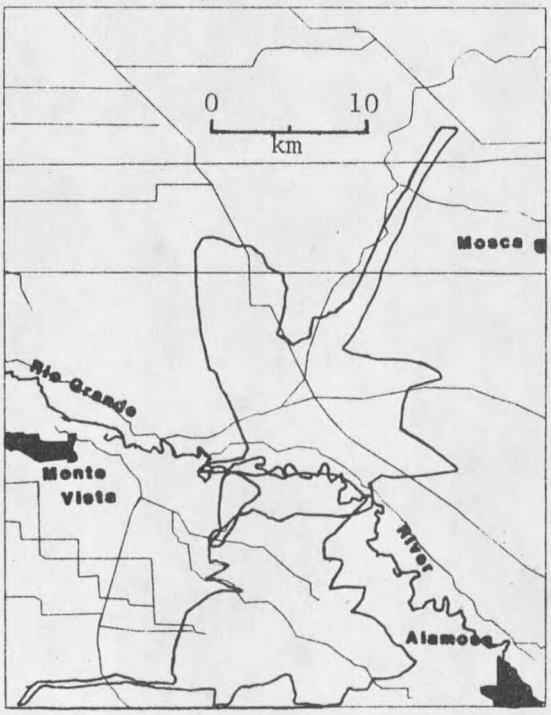


Figure 83. Home ranges of mated adult bald eagles #5-81 (female) and #8-81 (male) encompassing 77.2 and 66.5 km^2 of the San Luis Valley, CO respectively. Lines are irrigation ditches and canals.

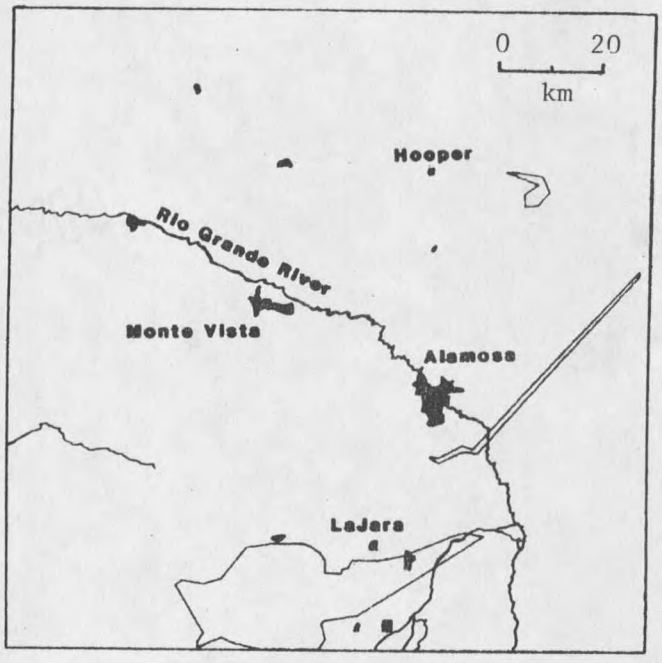


Figure 84. Home range of an unmated adult female bald eagle #6-81, encompassing 375.8 km^2 of the San Luis Valley, CO.

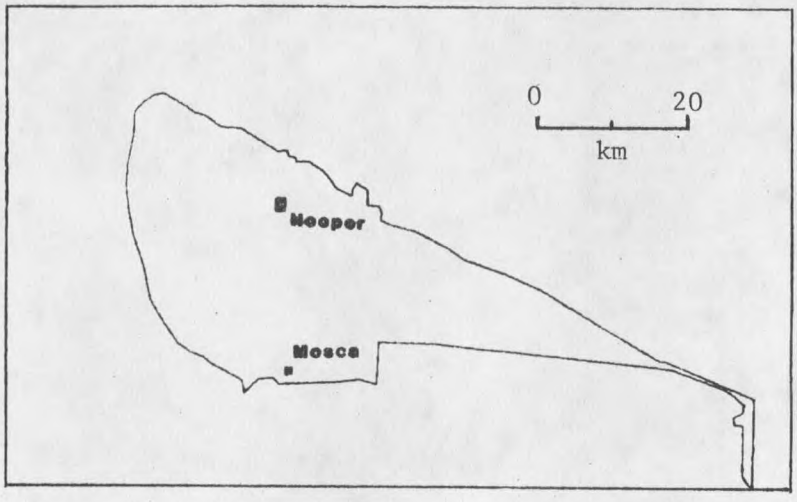


Figure 85. Home range of a mated adult female bald eagle #7B-81, encompassing 310 km^2 of the San Luis Valley, CO.

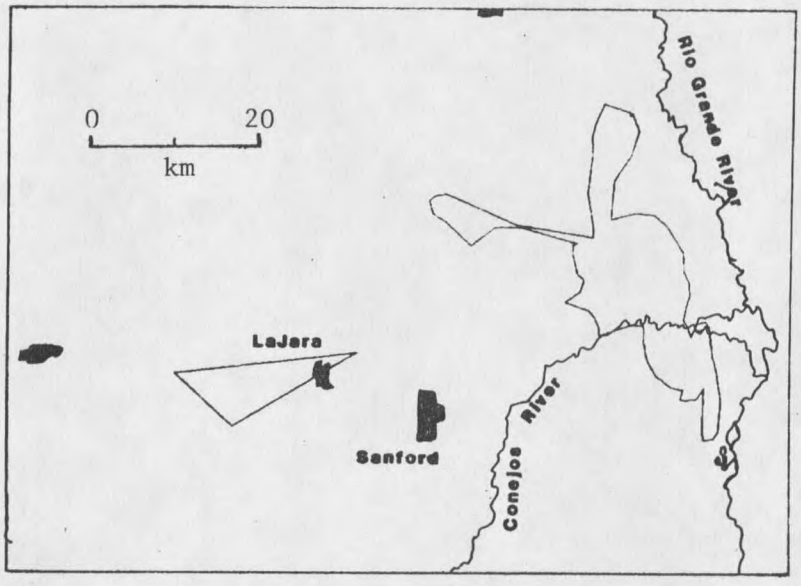


Figure 86. Home range of a mated adult female bald eagle #9-81, encompassing 60.9 km^2 of the San Luis Valley, CO.

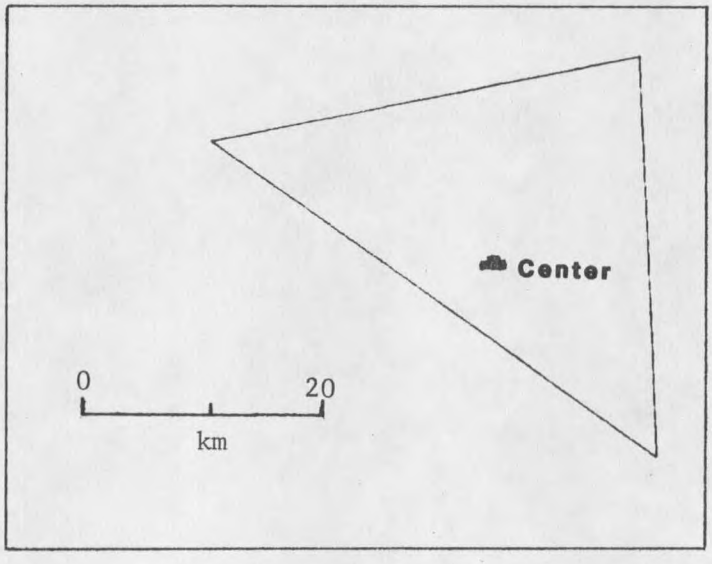


Figure 87. Home range of an adult male bald eagle #10-81, encompassing 561.6 km^2 of the San Luis Valley, CO.

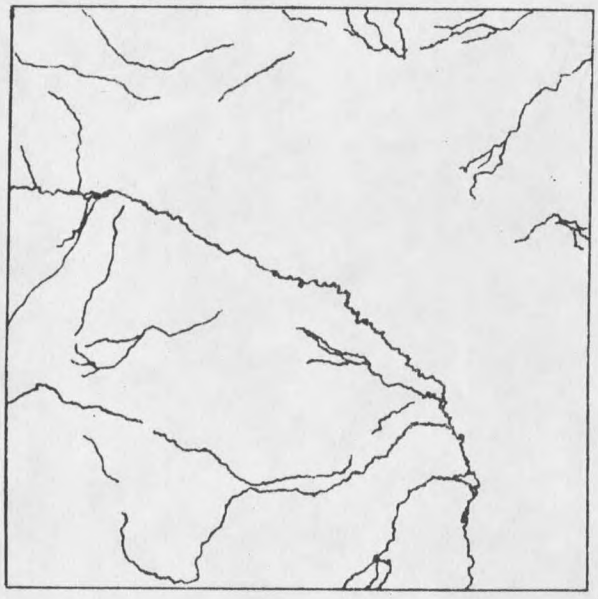


Figure 88. Natural water courses (line habitat type) within a 90 x 90 km study area of the San Luis Valley, CO.

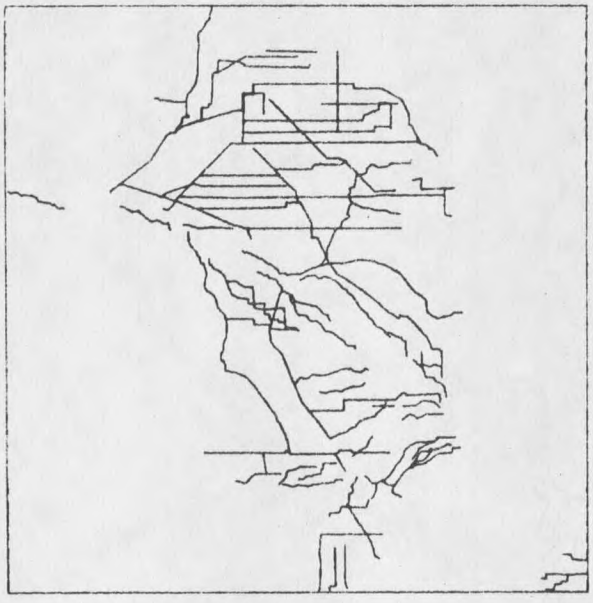


Figure 89. Irrigation ditches and canals (line habitat type) within 90 x 90 km study area of the San Luis Valley, CO.

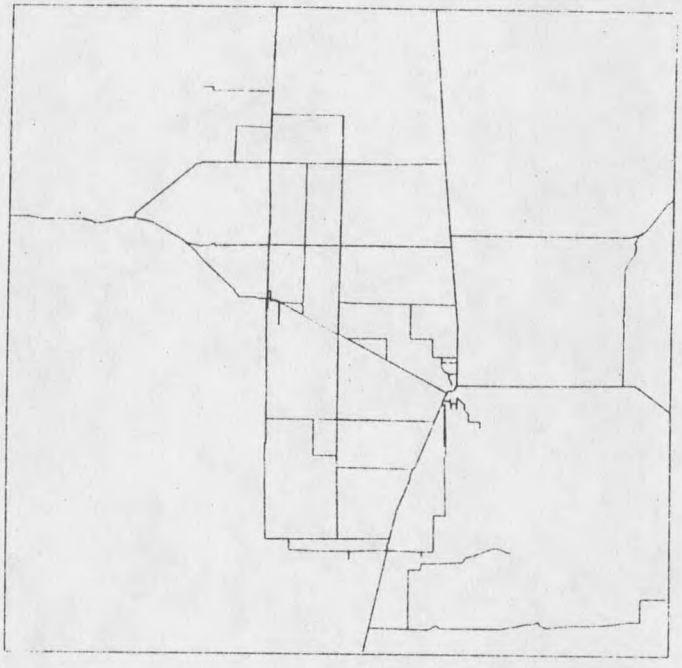


Figure 90. Paved roads (line habitat type) within a 90 x 90 km study area of the San Luis Valley, CO.

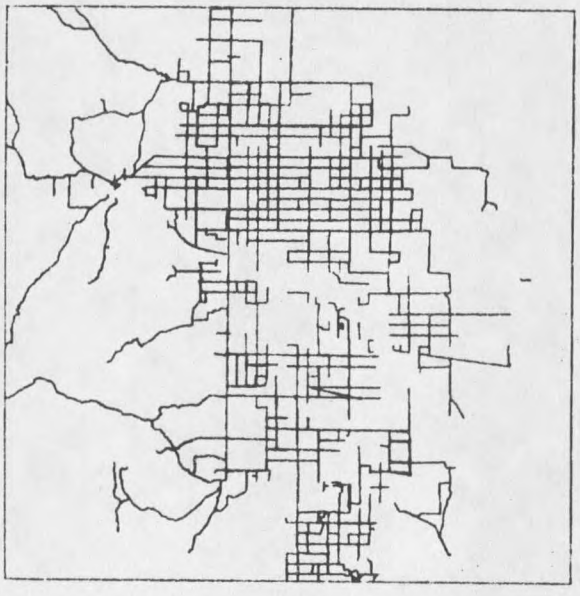


Figure 91. Gravel roads (line habitat type) within a 90 x 90 km study area of the San Luis Valley, CO.

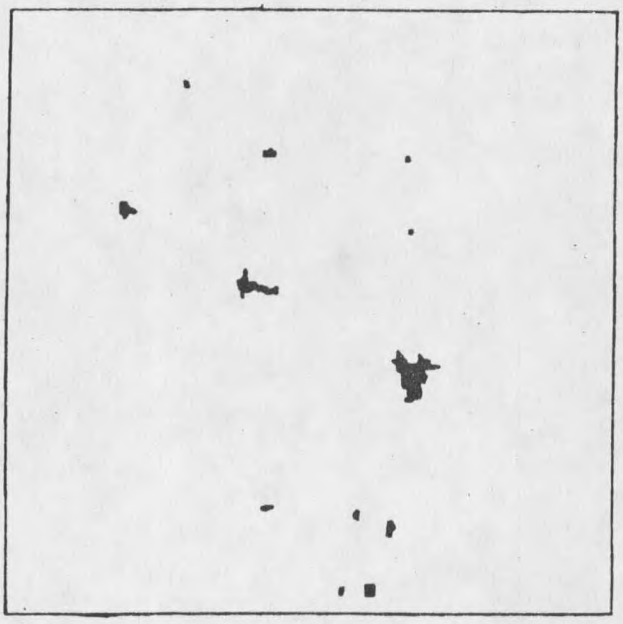


Figure 92. Cities (area habitat type) within a 90 x 90 km study area of the San Luis Valley, CO.

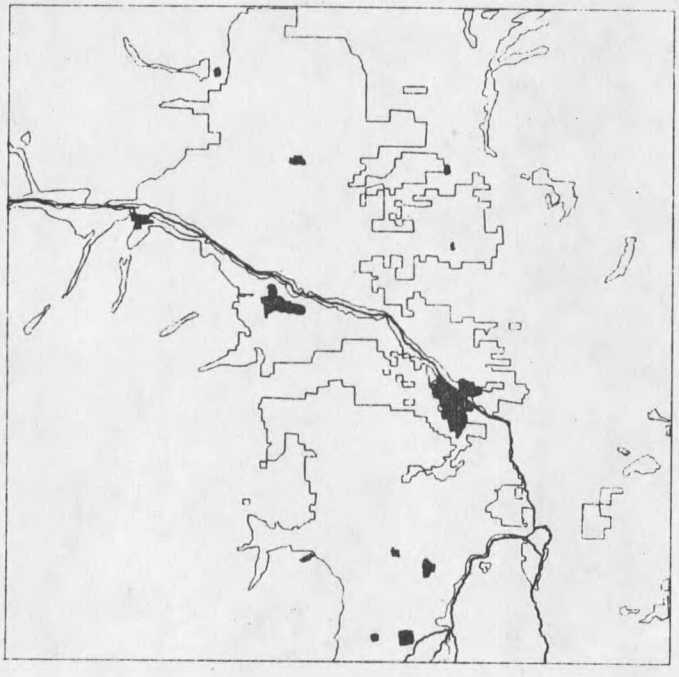


Figure 93. Crop and irrigated pasture land (area habitat type) within a 90 x 90 km study area of the San Luis Valley, CO.

MONTANA STATE UNIVERSITY - BOZEMAN
3 1762 10425057 4