

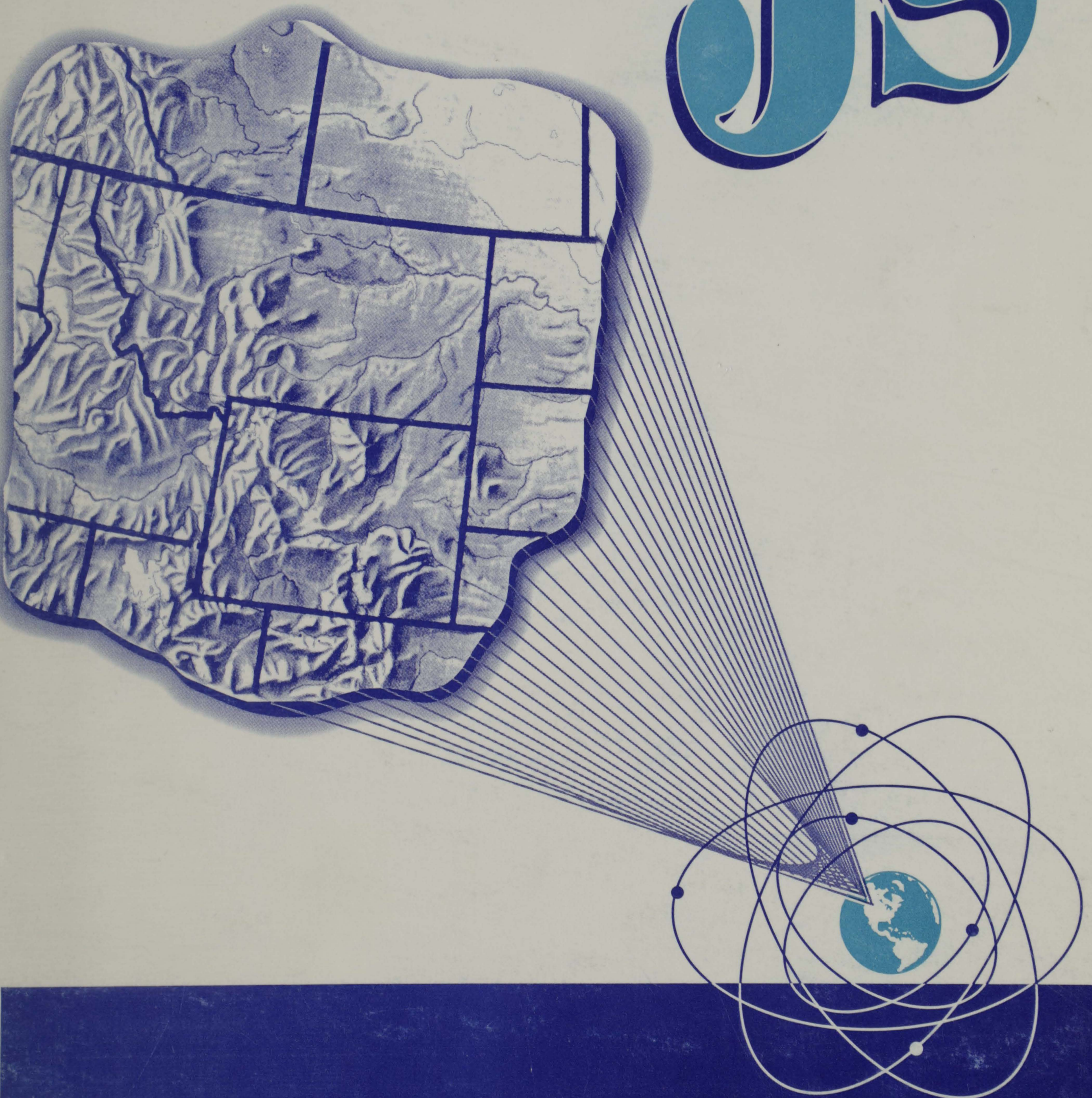
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# Intermountain Journal of Sciences

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# IJS



# INTERMOUNTAIN JOURNAL OF SCIENCES

*The Intermountain Journal of Sciences* is a regional peer-reviewed journal that encourages scientists, educators and students to submit their research, management applications or viewpoints concerning the sciences applicable to the intermountain region. Original manuscripts dealing with biological, environmental engineering, mathematical, molecular-cellular, pharmaceutical, physical and social sciences are welcome.

Co-sponsors/publishers include the Montana Academy of Sciences, the Montana Chapter of The Wildlife Society, and the Montana Chapter of The American Fisheries Society. This journal offers peer review and an opportunity to publish papers presented at annual meetings of the co-sponsor organizations. It is the intent of the governing bodies of the co-sponsor organizations that this journal replace printed proceedings of the respective annual meetings. Therefore, it is the policy of the editorial board that presenters at annual meetings of the co-sponsors be given priority in allocation of space and time of publication, although submission of other manuscripts for review and publication without regard to membership is encouraged.

Initial funding was provided by the co-sponsor organizations. Long-term funding will be derived from page charges assessed authors, sponsoring organizations or agencies at \$35 per printed page upon acceptance of each manuscript and from annual subscriptions: student \$6; regular member \$15; patron member \$25; library \$25; life member \$150; and, sustaining subscriber \$2,500.

The intent of the co-sponsors and editorial board is that *The Intermountain Journal of Sciences* be expanded to a quarterly journal. Achieving that objective depends upon numbers of acceptable manuscripts received and available funding. It also is the intent of the editorial board that contributing authors be assured of publication within 12 months of acceptance of their manuscript by the managing editor.

The organizational staff is voluntary and consists of an editorial board, an editor-in-chief, a managing editor, associate editors, a business manager and a panel of referees. The editorial board is responsible for establishing policy and the chair of the editorial board serves as liaison to the sponsoring organizations. The editor-in-chief is responsible for determining acceptability and level of revision of manuscripts based on referees' comments and recommendation of an associate editor. The managing editor serves as liaison for layout and printing. Associate editors include but are not limited to the section vice presidents of The Montana Academy of Sciences. Referees are selected on the basis of their field and specific area of knowledge and expertise.

Referees and associate editors judge submitted manuscripts on originality, technical accuracy, interpretation and contribution to the scientific literature. Format and style generally follow the *Guidelines for Manuscripts Submitted to the Intermountain Journal of Sciences*, Dusek 1995.\* Organization may vary to accommodate the content of the article, although the text is expected to elucidate application of results.

\*For detailed information about IJS, please go to our website at:  
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BALANCE 01/01/00 ..... \$ 3,732.29

## INCOME

|  |                    |
|--|--------------------|
| Regular Member .....                       | 1,275.00           |
| Student Member .....                       | 12.00              |
| Life Member .....                          | 300.00             |
| Library Subscription .....                 | 425.00             |
| Patron Member .....                        | 25.00              |
| Subscription Total .....                   | \$2,037.00         |
| Page Charges .....                         | 7,424.20           |
| Reprints .....                             | 871.39             |
| Back Issue Sales .....                     | 58.00              |
| Grants (Bur. Rec., Western Div. AFS) ..... | 3,500.00           |
| <b>Total Income .....</b>                  | <b>\$13,890.59</b> |

## EXPENSES

|                                 |                    |
|---------------------------------|--------------------|
| Design and Printing .....       | 9,544.36           |
| Mailing Service .....           | 256.60             |
| Postage .....                   | 295.36             |
| Supplies .....                  | 209.52             |
| P.O. Box Rent .....             | 64.00              |
| Bank and Credit Card Fees ..... | 91.65              |
| Photocopies .....               | 1.26               |
| Reprints and Layout .....       | 1,688.91           |
| Website Layout .....            | 1,025.00           |
| Refunds .....                   | 592.32             |
| <b>Total Expenses .....</b>     | <b>\$13,768.98</b> |

BALANCE 12/31/00 ..... \$ 3,853.90

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# EDITORIAL REVIEW POLICY

The *Intermountain Journal of Sciences* (IJS) is a fully refereed journal.

Manuscripts are submitted to the Editor-in-Chief (EIC) for initial consideration for publication in the IJS. This review shall include, but not be limited to, appropriateness for publication in this journal, correct formatting, and inclusion of a letter of submittal by the author with information about the manuscript as stated in the "Guidelines for manuscripts submitted to the *Intermountain Journal of Sciences*" (Dusek 1995). This cover letter must also include a statement by the author that this paper has not been submitted for publication or published elsewhere. The EIC notes the date of receipt of the manuscript and assigns it a reference number, IJS-xxxx. The EIC forwards a letter of manuscript receipt and the reference number to the corresponding author. The corresponding author is the author who signed the submittal letter.

The hard copy of the submitted manuscript, with copies of the "Guidelines and checklist for IJ referees" attached and forwarded to the appropriate Associate Editor. The Associate Editor retains one copy of the manuscript and guidelines for his/her review, and submit a similar package to each of two other reviewers. A minimum of two reviewers, including the Associate Editor, is required for each manuscript. The two other reviewers are instructed to return the manuscript and their comments to the Associate Editor, who completes and returns to the EIC a blue "Cover Form" and all manuscript and reviewer comment plus a recommendation for publication, with or without revisions,

or rejection of the manuscript. This initial review process is limited to 30 days.

The EIC reviews the recommendation and all comments. The EIC then notifies the corresponding author of the results of the review and the publication decision.

## ACCEPTANCE

For accepted manuscripts, each copy of the manuscript containing comments thereon and other comments are returned to the corresponding author. Revised manuscripts are to be returned to the EIC in hard copy, four copies if further review is required, or one hard copy plus the computer disk if only minor revision or formatting is necessary. The revised manuscript shall be returned to the EIC within 14 days of the notification. Review of the revised manuscript by the Associate Editor and reviewers shall be completed and returned to the EIC within 14 days. An accepted manuscript will then be forwarded to the Managing Editor (ME) for final processing.

## REJECTION

Each manuscript that is rejected for publication is returned by the EIC to the corresponding author along with the reasons for rejection. The author is also advised that the manuscript may be resubmitted, provided all major criticisms and comments have been addressed in the new manuscript. The new manuscript may be returned to the initial review process if deemed appropriate by the EIC. If the manuscript is rejected a second time by either the EIC or the Associate Editor and reviewers, no further consideration will

be given for publication of the manuscript in IJS. The corresponding author will be notified of this decision.

### **REVIEWER ANONYMITY**

The identity of all reviewers shall remain anonymous to the authors, called a blind review process. All criticisms or comments by authors shall be directed to the EIC; they may be referred to the ME or the Editorial Board by the EIC for resolution.

### **MANUSCRIPTS SUBMITTED BY EDITORS**

Each manuscript submitted by an Associate Editor shall be reviewed by the EIC and a minimum of two other reviewers with expertise in the subject being addressed. Each manuscript submitted by the EIC shall be forwarded with the necessary review materials to the Chairman of the Editorial Board of IJS, who will serve as the EIC for that manuscript.

### **ABSTRACTS**

Only abstracts from the annual meetings of the sponsoring organizations will be published in IJS. Other submissions of abstracts shall be considered on a case-by-case basis by the Editorial Board. Sponsoring organiza-

tions shall collect abstracts, review them for subject accuracy, key or scan them onto a 3.5" diskette, and submit the diskette and hard copy of each abstract to the EIC on or before November 1. Each abstract shall be reviewed by the EIC to assure proper grammar, compliance with IJS "Guidelines for Abstracts Only" and for assignment to the appropriate discipline section. All abstracts will be published in the December issue only.

### **COMMENTARY**

Submissions concerning management applications or viewpoints concerning current scientific or social issues of interest to the Intermountain region will be considered for publication in the "Commentary" Section. This section will feature concise, well-written manuscripts limited to 1,500 words. Commentaries will be limited to one per issue.

Submissions will be peer reviewed and page charges will be calculated at the same rate as for regular articles.

### **LITERATURE CITED**

Dusek, Gary L. 1995. Guidelines for manuscripts submitted to the *Intermountain Journal of Sciences*. *Int. J. Sci.* 1(1):61-70.

# TABLE OF CONTENTS

## ARTICLES

### BIOLOGICAL SCIENCES - TERRESTRIAL

- A VASCULAR PLANT CHECKLIST FOR TWO MOON PARK NEAR BILLINGS,  
MONTANA ..... 333  
Tasneem F. Khaleel, Shannon Barnard, Melissa Ullman

- ASSOCIATIONS BETWEEN BIGHORN SHEEP AND ELK IN THE TOM MINER BASIN,  
MONTANA ..... 339  
Kristin L. Legg, Lynn R. Irby

- COMPARISON OF COYOTE DIETS BETWEEN TWO AREAS OF JACKSON HOLE,  
WYOMING ..... 355  
Rachel R. Wigglesworth, Nathan McClennen, Stanley H. Anderson,  
Douglas G. Wachob

### TECHNICAL COMMUNICATIONS

- NOXIOUS WEEDS FOUND IN TWO MOON PARK NEAR BILLINGS, MONTANA .. 368  
Tasneem F. Khaleel, Shannon Barnard, Melissa Ullman

## INDEX

- SUBJECT INDEX FOR IJS VOLUMES 1-6 (1995-2000) ..... 370

## ABSTRACTS

- BIOLOGICAL SCIENCES - TERRESTRIAL ..... 374



Tasneem F. Khaleel  
Shannon Barnard  
Melissa Ullman

## A VASCULAR PLANT CHECKLIST FOR TWO MOON PARK NEAR BILLINGS, MONTANA

### ABSTRACT

*We list the vascular-plant flora of Two Moon Park, an isolated tract of land located north of the Yellowstone River, east of Billings, Montana. This 61-ha Yellowstone County Park is a designated wildlife Preserve. Over a two-year period, we identified and catalogued 114 vascular-plant species, belonging to 95 genera from 40 families. Voucher specimens and slide photographs of each plant in its natural habitat are located in the MSU-Billings herbarium.*

**Key words:** Two Moon Park, vascular-plant flora, Yellowstone River, Montana

### INTRODUCTION

Two Moon Park is the largest county park in Yellowstone County, Montana, and its development was a Billings Bicentennial project in the late 1970s. With the first road access to this area in 1961, the current park site and adjacent land became a land developer's dream and generated controversy for more than a decade. Besides frequent natural floods, threats to the Park included potential development of a gravel pit, golf course, motorcycle cross trail, and mobile home court. Through the persistent efforts of Billings environmentalists, concerned citizens, and Yellowstone County commissioners, the Park has been preserved as an ecological area. This has initiated recovery of the site to a natural state from damages caused by human intrusions.

Designated as a "watchable wildlife viewing area" in 1989 by Montana Fish, Wildlife and Parks, Two Moon Park has a varied vegetative cover with high taxonomic diversity. Until now, however, no systematic study of its vascular plant composition has been conducted. Such information is valuable to both the scientific and nonscientific communities in this region and elsewhere. Therefore, we identified and systematically listed species of vascular plants of this area. Whereas the broader scope of this study was to produce a complete written and pictorial catalogue of all flora of Two Moon Park, this paper is limited to a checklist of vascular-plant species including common and scientific names and family. We intend this effort to serve taxonomists, ecologists, environmentalists, and other interested persons.

### STUDY AREA DESCRIPTION

Two Moon Park, located north of the Yellowstone River east of Billings, Montana, was formed when the Yellowstone River channel cut through 46 m (150 ft) of bedrock and then meandered in the opposite direction onto a broad flood plain, leaving a 61-ha

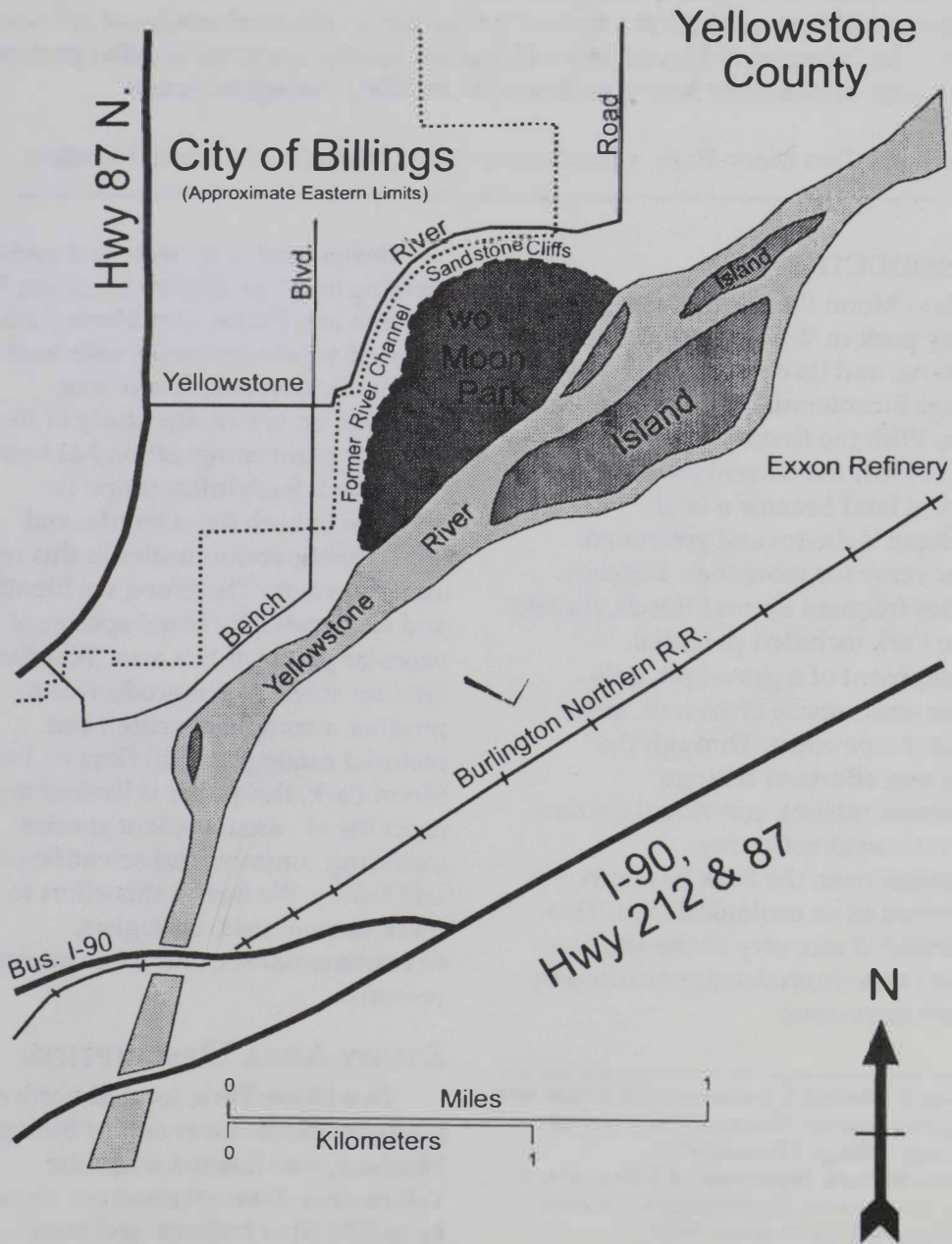
Tasneem F. Khaleel, Department of Biological and Physical Sciences, Montana State University-Billings, Billings, Montana 59101

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(150-acre) isolated area (Fig. 1). Thus, steep cliffs border Two Moon Park on the north and west, and the Yellowstone River borders it on the south. These features isolated the area from extensive human intrusion until a road was built that accessed the site. The cliffs were formed from the Clagget and Judith River formations. Granite gravel deposits, originating from glaciation of

the Beartooth Mountains during the late ice ages, lie on top the cliffs; flooding of the ancient Yellowstone River deposited the outwash there. The thin soil mantle of Two Moon Park developed from recent alluvial deposits of silt, sand, and gravel (Meshnick *et al.* 1972) of which the oldest of these is estimated to be  $\leq 200$  years old.



**Figure 1.** Billings area map showing the location of Two Moon Park and the Yellowstone River.

## METHODS

Plant specimens were collected each week over a two-year period beginning in April 1998. Field notes included location, date, relative abundance, soil type, and special characteristics of each plant. Five specimens were collected for preparation for the herbarium and for identification using the keys relevant to flora of this region (Booth 1966, Cronquist 1981, Dorn 1984, 1992, Hahn 1977, Hitchcock and Cronquist 1973). All taxa were arranged alphabetically by family, genus, and species in a checklist. Current scientific names of all taxa were verified with The PLANTS database published on the Internet (USDA NRCS 1999).

Standard collection and herbarium procedures for vascular plants were used to collect, press, prepare, mount, and label specimens, which were mounted on acid-free herbarium paper and deposited in the MSU-Billings herbarium.

## RESULTS AND DISCUSSION

We identified 114 species among 40 families and 95 genera of vascular plants (Appendix A). Six families were monocotyledonous (13 genera and 14 species), one family was non-flowering (one genus with a single species), and all other taxa were dicotyledonous. The largest Family was Asteraceae (22 genera and 31 species). The second largest was Brassicaceae with 11 genera and 12 species, the third largest Fabaceae with nine genera and 13 species, and the fourth was Poaceae with six genera and seven species. Seven families were represented with two genera, two families with three genera, and 27 families each had just one genus and a single species.

## ACKNOWLEDGEMENTS

The Montana Space Grants Consortium Awards for Research in Engineering and Science program

supported this study. The authors gratefully acknowledge Dr. William Hiscock, Director of the Montana Space Grants Consortium and Dr. Matthew Benacquista, MSU-B Campus Space Grant representative, for support and awarding the grant. The authors thank Dr. Norman Shoenthal, Professor Emeritus, MSU-Billings and caretaker, Two Moon Park for valuable historical information and David Kuzara, undergraduate student, MSU-B, for help with the study area map.

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**Appendix A.** Checklist of vascular plants of Two Moon Park, Yellowstone County, Montana.

| Family         | Scientific(botanical) name  | Common Name  |
|----------------|---|--|
| Aceraceae      | <i>Acer negundo</i> L.  | boxelder   |
| Amaranthaceae  | <i>Amaranthus retroflexus</i> L.  | redroot amaranth   |
| Apiaceae       | <i>Carum carvi</i> L.<br><i>Conium maculatum</i> L.   | caraway<br>poison hemlock  |
| Apocynaceae    | <i>Apocynum</i> x <i>floribundum</i> Greene (pro sp.)<br>(= <i>Apocynum medium</i> Greene)  | dogbane  |
| Asclepiadaceae | <i>Asclepias speciosa</i> Torr.   | showy milkweed   |
| Asteraceae     | <i>Ambrosia psilostachya</i> DC.<br><i>Arctium minus</i> Bernh.<br><i>Artemisia absinthium</i> L.<br><i>Artemisia frigida</i> Willd.<br><i>Boltonia asteroides</i> (L.) L'Her.<br><i>Centaurea biebersteinii</i> DC.<br>(= <i>Centaurea maculosa</i> auct. non Lam.)<br><i>Cichorium intybus</i> L.<br><i>Cirsium arvense</i> (L.) Scop.<br><i>Cirsium brevifolium</i> Nutt.<br><i>Cirsium canovirens</i> (Rydb.) Petrak<br><i>Cirsium vulgare</i> (Savi) Ten.<br><i>Conzya canadensis</i> (L.) Cronq.<br><i>Erigeron glabellus</i> Nutt. var. <i>pubescens</i> Hook.<br><i>Erigeron glabellus</i> Nutt. var. <i>glabellus</i><br><i>Euthamia occidentalis</i> Nutt.<br>(= <i>Solidago occidentalis</i> (Nutt.) Torr. & Gray)<br><i>Grindelia squarrosa</i> (Pursh) Dunal<br><i>Lactuca ludoviciana</i> (Nutt.) Riddell<br><i>Lactuca serriola</i> L.<br><i>Packera cana</i> (Hook.) W.A. Weber & A. Löve<br>(= <i>Senecia canus</i> Hook.)<br><i>Pyrrocoma integrifolia</i> (Porter ex Gray) Greene<br>(= <i>Haplopappus integrifolius</i> Porter ex Gray)<br><i>Ratibida columnifera</i> (Nutt.) Woot. & Standl.<br><i>Rudbeckia hirta</i> L.<br><i>Symphotrichum lanceolatum</i> (Willd.) Nesom ssp.<br><i>hesperium</i> (Gray) Nesom var. <i>hesperium</i><br>(= <i>Aster hesperius</i> Gray var. <i>laetevirens</i> (Greene) Cronq.)<br><i>Solidago canadensis</i> L.<br><i>Sonchus asper</i> (L.) Hill.<br><i>Sonchus oleraceus</i> L.<br><i>Tanacetum vulgare</i> L.<br><i>Taraxacum officinale</i> G.H. Weber ex Wiggers<br><i>Tonestus lyallii</i> (Gray) A. Nels.<br>(= <i>Haplopappus lyallii</i> Gray)<br><i>Tragopogon dubius</i> Scop.<br><i>Xanthium strumarium</i> L. | cuman ragweed<br>lesser burdock<br>absinthium<br>prairie sagewort<br>white doll's daisy<br>spotted knapweed<br>chicory<br>canadian thistle<br>palouse thistle<br>graygreen thistle<br>bull thistle<br>canadian horseweed<br>streamside fleabane<br>streamside fleabane<br>western goldentop<br>curlycup gumweed<br>biennial lettuce<br>prickly lettuce<br>woolly groundsel<br>manystem goldenweed<br>upright prairie coneflower<br>black-eyed susan<br>white panicle aster<br>canada goldenrod<br>spiny sowthistle<br>common sowthistle<br>common tansy<br>common dandeloin<br>lyall's goldenweed<br>yellow salsify<br>rough cocklebur |
| Balsaminaceae  | <i>Impatiens ecalcarata</i> Blank.  | spurless touch-me-not  |
| Boraginaceae   | <i>Cynoglossum officinale</i> L.  | gypsyflower or houndstongue  |
| Brassicaceae   | <i>Alyssum alyssoides</i> (L.) L.<br><i>Capsella bursa-pastoris</i> (L.) Medik.<br><i>Cardaria draba</i> (L.) Desv.   | pale madwort<br>shepherd's purse<br>whitetop or hoary cress  |

Appendix A. continued.

| Family               | Scientific(botanical) name   | Common Name                |
|----------------------|--|----------------------------|
| Brassicaceae (cont ) | <i>Descurainia pinnata</i> (Walt.) Britt.  | western tansy mustard      |
|                      | <i>Erysimum cheiranthoides</i> L.  | wormseed wallflower        |
|                      | <i>Lepidium densiflorum</i> Schrad.  | common pepperweed          |
|                      | <i>Lepidium perfoliatum</i> L.   | clasping pepperweed        |
|                      | <i>Rorippa sinuata</i> (Nutt.) A.S. Hitchc.  | spreading yellowcress      |
|                      | <i>Sinapsis arvensis</i> L.  | charlock mustard           |
|                      | (= <i>Brassica kaber</i> (DC.) L.C. Wheeler)   |                            |
|                      | <i>Stanleya pinnata</i> (Pursh)Britt.  | desert princeplume         |
|                      | <i>Thelypodium sagittatum</i> (Nutt. ex Torr. & Gray)<br>Endl.ex Walp.                               | arrow thelypodium          |
|                      | <i>Thlaspi arvense</i> L.  | field pennycress           |
| Cactaceae            | <i>Opuntia polyacantha</i> Haw.  | plains pricklypear         |
| Caprifoliaceae       | <i>Lonicera involucrata</i> Banks ex Spreng.   | twinberry honeysuckle      |
|                      | <i>Symphoricarpos occidentalis</i> Hook.   | western snowberry          |
|                      | <i>Symphoricarpos oreophilus</i> Gray  | mountain snowberry         |
| Chenopodiaceae       | <i>Endolepis dioica</i> (Nutt.) Standl.  | suckley's endolepis        |
|                      | (= <i>Atriplex dioica</i> (Nutt.) J.F. Macbr.)   |                            |
| Commelinaceae        | <i>Tradescantia occidentalis</i> (Britt.) Smyth.   | prairie spiderwort         |
| Convolvulaceae       | <i>Convolvulus arvensis</i> L.   | field bindweed             |
| Cornaceae            | <i>Cornus sericea</i> L. ssp. <i>sericea</i>   | redosier dogwood           |
|                      | (= <i>Cornus stolonifera</i> Michx.)   |                            |
| Cyperaceae           | <i>Carex foenea</i> Willd. var. <i>foenea</i><br>(= <i>Carex aenea</i> Fern.)                        | dryspike sedge             |
| Elaeagnaceae         | <i>Elaeagnus angustifolia</i> L.   | russian olive              |
| Equisetaceae         | <i>Equisetum laevigatum</i> A. Braun   | smooth horsetail           |
| Euphorbiaceae        | <i>Euphorbia esula</i> L.  | leafy spurge               |
| Fabaceae             | <i>Astragalus americanus</i> (Hook.) M. E. Jones.  | american milkvetch         |
|                      | <i>Dalea candida</i> Michx. ex Willd. var. <i>candida</i><br>(= <i>Petalostemon candidus</i> Michx.) | white prairie clover       |
|                      | <i>Glycyrrhiza lepidota</i> Pursh.   | american licorice          |
|                      | <i>Medicago lupulina</i> L.  | black medic                |
|                      | <i>Medicago sativa</i> L.  | alfalfa                    |
|                      | <i>Melilotus alba</i> Medic.   | white sweetclover          |
|                      | <i>Melilotus officinalis</i> (L.) Lam.   | yellow sweetclover         |
|                      | <i>Robinia pseudoacacia</i> L.   | black locust               |
|                      | <i>Thermopsis montana</i> Nutt.  | mountain goldenbanner      |
|                      | <i>Thermopsis rhombifolia</i> (Nutt. ex Pursh)<br>Nutt. ex Richards.                                 | prairie thermopsis         |
|                      | <i>Trifolium pratense</i> L.   | red clover                 |
|                      | <i>Trifolium repens</i> L.   | white clover               |
|                      | <i>Vicia americana</i> Muhl. ex Willd.   | american vetch             |
|                      | Grossulariaceae  | <i>Ribes aureum</i> Pursh. |
| Lamiaceae            | <i>Lycopus uniflorus</i> Michx.  | northern bugleweed         |
|                      | <i>Nepeta cataria</i> L.   | catnip                     |
| Lemnaceae            | <i>Lemna minor</i> L.  | common duck weed           |
| Liliaceae            | <i>Asparagus officinalis</i> L.  | garden asparagus           |
|                      | <i>Leucocrocinum montanum</i> Nutt. ex Gray  | common starlily            |
|                      | <i>Yucca glauca</i> Nutt.  | soapweed yucca             |

## Appendix A. continued.

| Family           | Scientific(botanical) name   | Common Name  |
|------------------|--|--|
| Malvaceae        | <i>Malva neglecta</i> Wallr.   | common mallow  |
| Onagraceae       | <i>Gaura mollis</i> James<br>(= <i>Gaura parviflora</i> Dougl. ex Lehm.)<br><i>Oenothera villosa</i> Thunb. ssp.<br><i>strigosa</i> (Rydb.) W. Dietr. & Raven<br>(= <i>Oenothera strigosa</i> (Rydb.)Mackenzie & Bush.)  | velvetweed<br><br>hairy evening primrose   |
| Plantaginaceae   | <i>Plantago major</i> L.   | common plantain  |
| Poaceae          | <i>Agropyron cristatum</i> (L.) Gaertn.<br><i>Alopecurus arundinaceus</i> Poir.<br><i>Bromus anomalus</i> Rupr. ex Fourn.<br><i>Elymus elymoides</i> (Raf.) Swezey ssp. <i>elymoides</i><br>(= <i>Sitanion hystrix</i> (Nutt.) J.G. Sm.)<br><i>Elymus repens</i> (L.) Gould.<br>(= <i>Agropyron repens</i> (L.) Beauv.)<br><i>Phalaris arundinacea</i> L.<br><i>Poa compressa</i> L. | crested wheatgrass<br>creeping meadow foxtail<br>nodding brome<br>squirreltail<br><br>quackgrass<br><br>reed canarygrass<br>canada bluegrass |
| Polygonaceae     | <i>Polygonum douglasii</i> Greene<br>ssp. <i>austiniiae</i> (Greene) E. Murr.<br>(= <i>Polygonum austiniiae</i> Greene)<br><i>Polygonum hydropiper</i> L.<br><i>Polygonum lapathifolium</i> L.<br><i>Rumex crispus</i> L.<br><i>Rumex venosus</i> Pursh  | austin knotweed<br><br>marshpepper knotweed<br>curlytop knotweed<br>curly dock<br>veiny dock   |
| Primulaceae      | <i>Lysimachia ciliata</i> L.   | fringed loosestrife  |
| Ranunculaceae    | <i>Clematis ligusticifolia</i> Nutt.<br><i>Ranunculus acrifolius</i> Gray.   | western white clematis<br>sharpleaf buttercup  |
| Rosaceae         | <i>Malus sylvestris</i> P. Mill.<br>(= <i>Pyrus malus</i> L.)<br><i>Prunus virginiana</i> L.<br><i>Rosa nutkana</i> K. Presl   | european crabapple<br><br>chokecherry<br>nootka rose   |
| Rubiaceae        | <i>Galium triflorum</i> Michx.   | fragrant bedstraw  |
| Salicaceae       | <i>Populus deltoides</i> Bartr. ex Marsh.<br><i>Salix exigua</i> Nutt.   | eastern cottonwood<br>narrowleaf willow  |
| Scrophulariaceae | <i>Verbascum thapsus</i> L.  | common mullein   |
| Solanaceae       | <i>Solanum dulcamara</i> L.  | climbing nightshade  |
| Tamaricaceae     | <i>Tamarix ramosissima</i> Ledeb.  | saltcedar  |
| Typhaceae        | <i>Typha latifolia</i> L.  | broadleaf cattail  |
| Ulmaceae         | <i>Ulmus pumila</i> L.   | siberian elm   |
| Verbenaceae      | <i>Verbena bracteata</i> Lag. & Rodr.  | bigbract verbena   |

The scientific and common names conform to those contained in the PLANTS database. published on the Internet; (<http://plants.usda.gov/plants>), accessed August 28, 2000.

Kristin L. Legg  
Lynn R. Irby

## ASSOCIATIONS BETWEEN BIGHORN SHEEP AND ELK IN THE TOM MINER BASIN, MONTANA

### ABSTRACT

*One of the hypotheses proposed for declines of bighorn sheep (*Ovis canadensis*) is competition for forage between bighorns and elk (*Cervus elaphus*). We tested the rationale underlying this hypothesis in the Tom Miner Basin, Montana. Bighorn numbers in this area declined by 70 percent or more between the mid-1970s and mid-1990s. Elk numbers apparently increased substantially during the same period. Pellet counts and vegetation surveys in 1975 and 1994-1995 indicated an increase in elk use of areas near bighorn wintering sites but no negative changes in vegetation composition. During 1994-1995, elk pellets were found in >40 percent of plots in bighorn wintering areas that contained bighorn pellets. This evidently represented elk summer use of bighorn winter habitat because we did not observe elk using bighorn wintering areas during the winter. Multivariate habitat models indicated proximity to escape terrain was the primary factor determining use of specific sites on bighorn winter range, but tree analysis indicated a secondary negative association between elk and sheep pellet densities in 1995. Our measurements of summer utilization of forage in 1994 and 1995 did not indicate that use of sheep range by elk had detectable impacts on availability of forage for sheep during winter.*

**Key words:** bighorn sheep, *Cervus elaphus*, elk, interspecific interactions, *Ovis canadensis*

### INTRODUCTION

Management of ungulates in the Yellowstone ecosystem has a long and controversial history (Tyers 1981, Houston 1982, Chase 1986, Kay 1990, Wagner *et al.* 1995, Yellowstone National Park 1997). Although ungulates in the Yellowstone ecosystem have been studied more intensively and for a longer time-span than ungulates in most, if not all, other areas of North America, no consensus on appropriate population levels or on factors regulating population levels has been reached (Boyce 1998, Kay 1998, Singer *et al.* 1998, Wambolt 1998). The attention

ungulates in the Yellowstone ecosystem have received may be part of the problem. Records of counts, distribution, and impacts span more than 100 years (Tyers 1981, Yellowstone National Park 1997). This long data string includes reports and studies conducted by dozens of biologists and land managers using a wide array of techniques at varying levels of intensity. Faced with the choice of ignoring historic data sets or using them despite their limitations, most biologists elect to acknowledge historic data and struggle to find objective ways in which to use them. In this paper, we attempted to use historic data to provide insight on the relationship between elk and bighorn sheep in the Yellowstone ecosystem and to describe the problems we encountered when we compared new data with historic data.

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Rocky Mountain bighorn sheep were once abundant throughout the Rocky Mountains of North America (Couey 1950, Buechner 1960). By the late 1800s, most bighorn populations in the United States had declined due to competition with livestock, introduction of livestock diseases, hunting pressure, and development (Buechner 1960, Keating 1982). Sheep in Yellowstone National Park (YNP) received more protection than many herds, but numbers in the ecosystem outside the Park probably declined through the 1930s. By the 1960s, bighorn populations in the Yellowstone ecosystem outside YNP were increasing in response to regulation of hunting, changes in land use, and reduction of livestock stocking rates adjacent to the Park, but bighorns did not recolonize all areas occupied prior to European settlement and have never reached population levels implied by descriptions from early European settlers in the Yellowstone Valley (Buechner 1960, Keating 1982, Yellowstone National Park 1997).

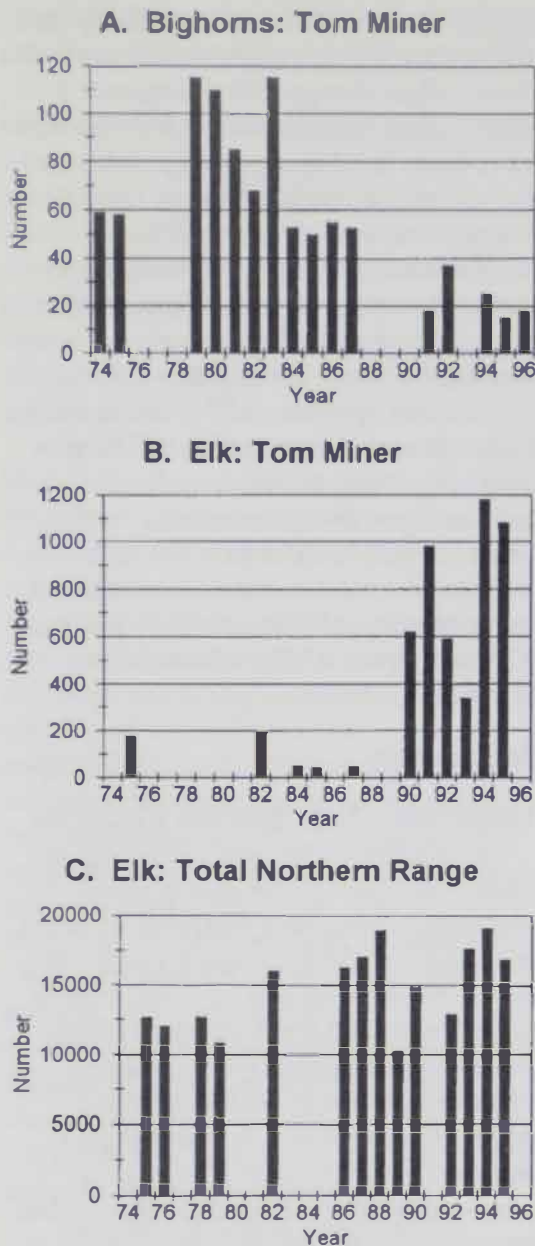
Declines in bighorn sheep populations due to disease have occurred in the Yellowstone ecosystem (Buechner 1960, Meagher 1992), but disease seemingly does not explain declines, or failure to recover from declines, in units within this metapopulation that have occurred in the last two decades. Keating (1982) and Wagner (1995) speculated that high elk numbers could be directly or indirectly responsible for declines in other ungulate species in the system, including bighorn sheep, but were unable to unambiguously support their positions. Analyses of counts and age-structure data by Houston (1982) and Singer and Norland (1994) revealed no strong relationships between elk and sheep population trends in the Yellowstone ecosystem.

We discovered an unpublished U.S. Forest Service report (Grunigan 1976) in

files of the Gardiner Ranger District of the Gallatin National Forest that contained precise information on pellet counts and vegetation composition, utilization, and condition on bighorn winter ranges in one area of the Yellowstone ecosystem, the Tom Miner Basin of Montana. To our knowledge, these data represent the earliest historic records that provide repeatable data on elk and sheep distribution as related to vegetation conditions in wintering areas shared by elk and bighorns in the Tom Miner Basin. Other available survey data indicated a decline in bighorn numbers concurrent with an increase in elk numbers in the Tom Miner Basin between the mid-1970s and mid-1990s (Legg *et al.* 1996, Yellowstone National Park 1997, Irby unpubl., Montana Fish, Wildlife, and Parks unpubl.). Although counts of elk and sheep during 1974-1996 were incomplete, limited mostly to winter and did not employ consistent techniques, we were able to piece together a probable scenario of population changes.

Counts of bighorn sheep in the Tom Miner Basin (Fig. 1) using fixed-wing aircraft during 1974-1987 averaged 75 ( $n = 11$ ,  $SD = 27$ ). The number of sheep apparently increased from the mid-1970s to the early 1980s and declined by  $\geq 50$  percent between the 1982-1983 and 1983-1984 winters. Counts from helicopter surveys during 1990-1996 averaged 23 ( $n = 5$ ,  $SD = 9$ ). Part of the decline may have been due to a shift in sheep distribution to lower-elevation winter ranges outside the Tom Miner Basin (Legg *et al.* 1996). We could not accurately separate losses due to demographic factors (reduced natality, mortality) from losses due to changes in distribution because of the way in which data from survey flights in the 1970s were summarized.

Data for elk in the Tom Miner Basin were sparse during the 1974-1987 period (Fig. 1), but no fixed-wing surveys recorded more than 200



**Figure 1.** Summary of bighorn sheep (A) and elk (B) counts in the Tom Miner Basin during 1974-1996 from Legg *et al.* (1996), Irby (unpubl.), and Montana Fish, Wildlife, and Parks (unpubl.). Surveys prior to 1990 were made with fixedwing aircraft. Surveys from 1990 to 1996 were made using helicopters. Counts from a mix of helicopter and fixedwing surveys reported in Yellowstone National Park (1997) for numbers of elk wintering in the Northern Range (including areas inside and outside Yellowstone National Park) are given in graph C. Labels on x-axes refer to January of each winter (1974 = winter 1973-1974).

animals (mean = 102,  $n = 5$ ,  $SD = 78$ ). Helicopter counts, initiated by Montana Fish, Wildlife, and Parks in the 1989-1990 winter, averaged 798 elk ( $n = 6$ ,  $SD = 330$ ) during 1990-1996. Increased survey efficiency from use of helicopters during the 1990s probably accounted for some of the difference between recent surveys and the earlier counts. However, elk on the northern Range of Yellowstone National Park, which includes the Tom Miner Basin, increased in number and winter distribution between the 1970s and 1990s (Yellowstone National Park 1997, Lemke *et al.*, 1998) suggesting that a real increase in elk numbers in the Tom Miner Basin occurred.

If the population scenario we outlined is valid, did increasing elk numbers cause the decline in sheep numbers? We assessed the potential for a cause and effect relationship by comparing forage condition, forage utilization patterns, and habitat use patterns for bighorns and elk in 1975 (Grunigen 1976) with those in 1994-1995 (Legg 1996). The specific study objectives were to:

- 1) Compare the relative intensity of ungulate use, vegetation coverage, and plant species composition in areas occupied by sheep in the Tom Miner Basin during 1975 with the same sites during 1994-1995; and
- 2) Assess the potential for forage abundance as a limiting factor for bighorn sheep on winter ranges in the Tom Miner Basin during 1994 and 1995.

## STUDY AREA

The Tom Miner Basin winter range (TMWR) is located in the upper Yellowstone River Valley and is one of five bighorn winter ranges adjacent to the northern boundary of Yellowstone National Park. It is 26 km northwest of Gardiner, Montana, in the Gallatin Mountains of southwestern Montana. Elevations in Tom Miner Basin range

from 1500 m to >3000 m. The climate is cool continental with heavy snowfall. Snow cover restricts sheep to winter ranges from November to May in most years. Summers are short and mild (Chester 1976). The TMWR is composed of several small (<1-5 km<sup>2</sup>) areas used by sheep scattered over 150 km<sup>2</sup>. Wintering sites are typically on grass-covered southwest-facing slopes between 1800 m and 2500 m. These small wintering areas include whitebark pine (*Pinus albicaulis*)-subalpine fir (*Abies lasiocarpa*), bunchgrass, and subalpine vegetation types (Grunigen 1976). Most ridges are oriented from northwest to southeast. Summer ranges associated with the TMWR are ridge tops and alpine meadows  $\geq 2000$  m in elevation. Summer ranges are separated from wintering sites by <1 to 10 km (Keating 1982, Irby *et al.* 1989, Legg 1996).

Land ownership in the Tom Miner Basin is a mix of private, state, and federal (YNP and Gallatin National Forest) lands. No public roads cross wintering sites in the TMWR, but public trails run through or near most sites. Seventy percent of the wintering areas used by sheep in the TMWR are publicly owned. Livestock grazing and hunting are the primary land uses on the winter and summer ranges. The USFS leases land for cattle grazing from late June through October. Grazing leases are mostly in mountain meadows from 1800-2500 m and overlap some bighorn winter ranges. The USFS rotates the duration and timing of use for each allotment to vary the distribution of cattle use in Tom Miner Basin each year. Cattle and horses are grazed on private lands in the basin year round. Most of the hunting pressure in the Tom Miner Basin is directed towards elk and mule deer (*Odocoileus hemionus*). The number of permits for hunting sheep associated with the TMWR is unrestricted, but only rams with  $\geq 3/4$ -curl horns can be

legally harvested. Land ownership and sheep distribution limit hunter access to sheep. Over the past 20 years, restrictions on season length or quotas have been used to control harvest, and the general trend has been to increase restrictions (Irby *et al.* 1989).

In addition to elk and mule deer, the study area supported populations of white-tailed deer (*Odocoileus virginianus*), mountain goats (*Oreamnus americanus*), and moose (*Alces alces*). Only elk were abundant at the time of the study. Potential mammalian predators on sheep included grizzly bears (*Ursus arctos*), black bears (*U. americana*), coyotes (*Canis latrans*), and mountain lions (*Felis concolor*). Wolves (*C. lupus*) from YNP colonized the area in 1996.

## METHODS

### Ungulate Distribution Patterns

*Comparisons Between 1994-1995 and 1975.*—We used pellet group counts to compare density and distribution of elk and bighorn sheep at specific sites in 1994-1995 with results of pellet counts in 1975 reported by Grunigen (1976). Problems with pellet group counts include bias due to plot size (more pellet groups missed in a larger plot), observer error (missed groups and misidentification of species responsible for pellets), variability in defecation rates, and lack of consistency in number of pellet groups counted and time spent by ungulates at a specific site (Neff 1968, Collins and Urness 1981, Lancia *et al.* 1994). We used pellet counts despite their limitations because they allowed us to compare counts at sites identified and counted by Grunigen with those made 20 years later.

Grunigen (1976) selected transects based on maps of winter sheep distribution compiled from several years of observation by USFS and Montana Fish, Wildlife, and Parks personnel and information on cattle

grazing allotments in USFS files at the Gardiner Ranger District. He tried to place transects in all areas where bighorn sheep winter range could be accessed by grazing cattle. He used techniques described in detail in USFS manuals (USDA Forest Service 1977), and he included topographic maps and aerial photographs with sites marked and accompanying descriptions that allowed us to place our plots within approximately 50 m of his plots.

In 1975, USFS personnel completed 38 pellet group transects during July–August. These transects were placed in areas of potentially high sheep use and ran perpendicular to the contours of open slopes on the southwest side of the Tom Miner Basin. Although we followed sampling techniques employed in 1975 to insure compatibility with 1994 and 1995 ungulate fecal counts, we made some modifications. In 1975, Grunigen counted only new pellet groups from bighorn sheep, elk, cattle, and other ungulates in each transect. In 1994 and 1995, we counted old and new pellet groups. Pellet group age was distinguished by the color, sheen, and texture of pellets as described by Grunigen (1976). To avoid confusion of old from new pellets, we did not measure transects on rainy days.

Each of Grunigen's transects consisted of 10 81-m<sup>2</sup> circles. Each transect in 1994 and 1995 included 10 161-m<sup>2</sup> circles. The potential for missing pellet groups in large plots (Neff 1968) was minimized by breaking the plots into smaller increments within each circle. Each plot was divided into four concentric circular belts with radii of 1.8, 3.7, 5.6, and 7.2 m, respectively. We totaled counts within the four circular belts for a whole plot count. To compare our data with Grunigen's 1975 data, we used only the new pellet group counts from the three inner increments (95 m<sup>2</sup>). Pellet group counts for each ungulate species were converted to pellet

groups/ha by dividing total pellet groups counted in the 10 plots by the total area sampled in the 10 plots in each transect. We assessed differences in pellet density using paired *t*-tests (Iman 1994) in the MSUSTAT package (Lund 1993). Deer and mountain goat observations at these sites during 1994–1995 were low, and opportunities for confusion of pellets from deer and mountain goats with those from sheep were negligible at most sites.

*Use Patterns in 1994–1995.*— In 1994 and 1995, additional pellet group transects were completed throughout the Tom Miner Basin as an index to ungulate use and distribution on bighorn winter range during all seasons. Transects were selected to cover areas with different cattle grazing pressure, and all were in open, grass-dominated vegetation types that appeared adequate for sheep. Total new pellet groups from the 161-m<sup>2</sup> plots were used for analysis. Slope angle (% slope), distance to escape terrain ( $\leq 100$  m or  $>100$  m), grass cover density (ground visible or ground not visible through vegetation canopy), elevation, and aspect were measured for each transect. This analysis included transects used in comparisons with Grunigen's (1976) data.

Transects were completed every 73 m in elevation from the bottom to top of a sample unit to determine if ungulate use differed with elevation. The number of transects per unit varied from two to four, and eight to 10 plots were measured on each transect. When time permitted, units were measured three times in the summer and fall field season: prior to cattle grazing, immediately following cattle grazing, and before snowfall. Because all transects could not be measured three times in both years, we averaged available counts on units counted more than once to obtain a single estimate of pellet density/transect or plot/year.

*Analysis.*—We used  $\chi^2$  analysis ( eu

et al. 1974) to measure habitat availability vs. bighorn habitat use for individual independent variables and as an aid in interpreting the regression and classification trees used in the multivariate analysis. Years were analyzed separately to evaluate stability of relationships we observed. Habitat characteristics identified as independent variables in univariate and multivariate tests included elevation (categorized in 305-m intervals), aspect (two categories - cool, wet slopes [NE, N, E,] and dry warm slopes [S, SE, SW, W, NW]), slope (categorized in 10% intervals), distance to escape terrain (< 100 m, > 100 m), grass cover density (ground visible or ground not visible), elk pellet density (0; 1-14 pellet groups/plot; >14 pellet groups/plot), and cattle feces density (0; 1-19 fecal piles/plot; >19 fecal piles/plot).

Classification and regression trees were used in multivariate analysis of the distribution of bighorns with the same habitat characteristics used in  $X^2$  analysis to determine if combinations of habitat features were important in defining habitat use. Classification and regression trees are similar to the approach used to create dichotomous botany keys and have been used extensively in the medical field (Ripley 1996) and in raptor studies (Grubb and King 1991). Tree analysis can be considered a nonparametric alternative to linear or linear logistic and additive or additive logistic models for identifying structure in complex multivariate data (Clark and Pregibon 1992, Steinberg and Colla 1995). Classification trees are used with categorical data, and regression trees are used with continuous data (Steinberg and Colla 1995). The computer program S was used to analyze the ungulate use data that we collected on the TMWR. Methods for this analysis are described in Statistical Models in S (Clark and Pregibon 1992).

The level of significance for all  $X^2$  and tree tests was set at  $P < 0.05$ .

## Vegetation Trend, Condition, and Utilization

*Vegetation and Soil Trends Between 1975 and 1994-1995.*-Five vegetation condition and trend transects read in 1975 were repeated in 1994 to assess changes in vegetation in the TMWR the past 20 years. Six additional transects in sites used by or suitable for use by sheep were read in 1995. All transects were in the *Festuca idahoensis*/*Agropyron spicatum* or *Artemisia tridentata*/*Festuca idahoensis* habitat types (Mueggler and Stewart 1980). Grunigen (1976) used pace-line transects and an evaluation system for vegetation and soil developed by the USFS. We repeated the techniques as closely as possible based on guidelines in a USFS manual (USDA Forest Service 1977). During both periods, transects were 50 paces in length and placed in open grassland or sage (*Artemisia tridentata*) grassland parallel to ridge lines. The dominant ground cover type in a 2-cm diameter circle was recorded at each pace. Ground-cover types included bare soil, erosion pavement, rock, litter, moss, and individual plant species. Vegetation condition was given one of five categorical ratings (Very Poor to Excellent) based on abundance of "desirable", "intermediate", and "undesirable" plant species noted in the handbook for specific range types. Vegetation trend was categorized as declining, stable, or improving based on visual assessment of vigor in desirable plant species, presence of exotics, ground coverage by vegetation and litter, and estimated utilization of standing biomass. Soil condition was categorized (Very Poor to Excellent) based on the number of 2-cm diameter plots with bare soil and/or evidence of erosion. Soil trend was based on litter accumulation, extent of visible erosion soil compaction, and extent of bare soil.

*Vegetation Utilization in 1994-1995.*—Grazing transects were completed with each pellet transect to assess range utilization. Transects followed the USFS method of measuring range utilization (USDA Forest Service 1977). Each grazing transect consisted of four 100-pace lines with 50 sampling points at two-pace intervals. A sampling point was considered grazed if 5 percent or more of the vegetation in a 133-cm<sup>2</sup> diameter loop was grazed. We obtained percent utilization for each line by calculating the frequency of grazing (number of sampling points grazed divided by 50) and comparing this with a graph used to convert percent grazed to percent utilized for mountain grasslands (USDA Forest Service 1977). We then averaged percent utilization of the four lines to estimate percent utilization of each grazing transect. The USFS manual classified transects with >30 percent utilization as high-use and potentially overgrazed.

## RESULTS

### Ungulate Use of Bighorn Winter Range

*1975 Versus 1994-1995.*—Detailed information on pellet group density comparisons has been reported in Legg (1996), but a summary of the changes we observed between 1975 and 1994-1995 appears in Table 1. Mean sheep pellet group density for 1994-1995 was 82 percent lower than in 1975, mean elk pellet group density in 1994-1995 was 176 percent higher than in 1975, and mean cattle fecal pile density in 1994-1995 was 75 percent lower than in 1975 (paired *t*-tests,  $P < 0.01$ ). Pellet group densities were not significantly different between 1994 and 1995 for sheep and elk (paired *t*-tests,  $t = 0.57$  and  $1.33$  for sheep and elk, respectively,  $P > 0.19$ ). The rotational grazing system in use on national forest land allowed more cattle on sites near sheep winter range in 1994 than in 1995, so fecal density in 1994

**Table 1.** Mean pellet group/ha (SD in parentheses) and frequency of occurrence of fecal material for bighorn sheep, elk, and cattle for 38 transects in Tom Miner Basin during 1975, 1994, and 1995.

| Category                           | 1975        | 1994        | 1995        |
|------------------------------------|-------------|-------------|-------------|
| <b>Mean pellet groups/ha (SD)</b>  |             |             |             |
| Bighorns                           | 31.4 (56.5) | 4.8 (11.2)  | 6.5 (19.6)  |
| Elk                                | 19.8 (24.1) | 47.7 (46.2) | 61.8 (67.1) |
| Cattle                             | 32.4 (42.6) | 13.7 (38.2) | 2.2 (6.6)   |
| <b>Frequency of occurrence (%)</b> |             |             |             |
| Bighorns                           | 47          | 51          | 44          |
| Elk                                | 82          | 100         | 97          |
| Cattle                             | 66          | 28          | 13          |
| Bighorns + elk                     | 24          | 51          | 41          |
| Bighorns + cattle                  | 32          | 15          | 3           |
| Bighorns + elk + cattle            | 24          | 15          | 3           |

was higher than in 1995 (paired  $t = 1.92$ ,  $P = 0.06$ ). Pellet groups from deer and moose were rare (< 1 pellet group/ha) in all years at all sites. Mountain goats were observed within 1 km of only one transect in 1994 or 1995.

In 1975 Grunigen found new (<1-yr old) sheep pellets on 47 percent of the transects, new elk pellets on 82 percent, and new cattle feces on 66 percent (Table 1). Both sheep and elk pellets were found on 24 percent of his transects. In our study new sheep pellets were located on 44 (1995) to 51 (1994) percent of the transects, elk pellets on almost all transects in both years, and cattle pellets on <30 percent of the transects in both years. Sheep and elk pellets occurred on 51 percent (1994) and 41 percent (1995) of the transects.

*Habitat Use Patterns in 1994-1995.*—One hundred and forty-seven pellet transects measured in 1994 and 1995 were available for univariate and multivariate habitat use analysis. Two transects were excluded from all univariate and multivariate analysis. One transect occurred in a location with high mountain goat use. It was excluded from analyses because pellets from bighorns were difficult to

distinguish from goat pellets. Another transect was excluded because numbers of new bighorn pellets were unreasonably high (several times higher than any other site). This indicated that we were unable to accurately distinguish new from old pellets at this site.

Of the 145 usable transects, 24 (17%) were repeated 3 times in the 1994 and 1995 field seasons. The 65 transects measured in 1994 included 206 plots used in  $\chi^2$  analysis. The 80 transects measured in 1995 yielded 369 plots for  $\chi^2$  analysis. One hundred and forty-five plots on 54 transects were measured in both years.

Even after we narrowed the habitat range included by restricting transects to open, grass-covered sites on slopes, the univariate chi-square analyses indicated selection by sheep for all features we included (elevation, aspect, slope, escape terrain, grass cover, elk pellet groups, and cattle pellet groups). Within our restricted habitat matrix, sheep selected moderate to high elevations, the drier slopes, a mix of slope steepness, areas close to escape terrain, sites with relatively low grass cover, and sites with low densities of elk and cattle feces (Table 2).

Classification and regression trees

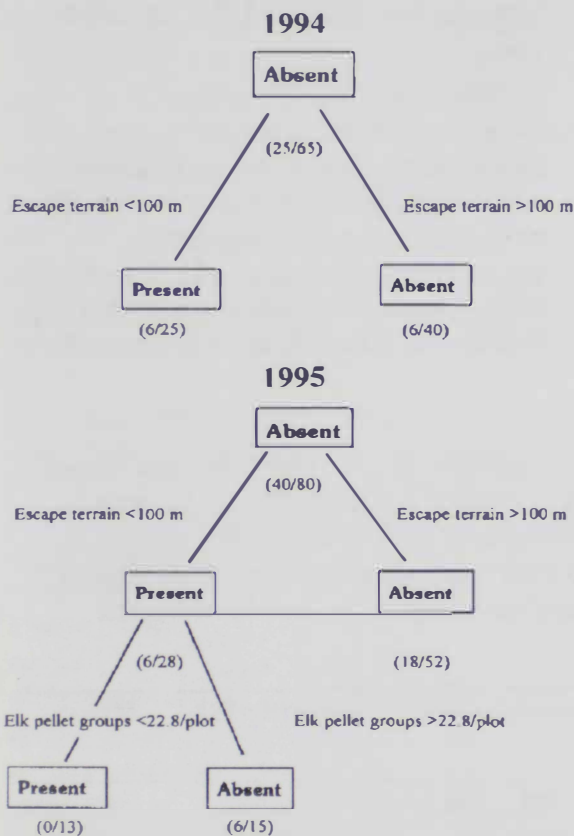
**Table 2.** Chi-square ( $\chi^2$ ) analysis of bighorn habitat use versus habitat availability for pellet group transects in 1994 (65 transects), 1995 (80 transects), and 1994 and 1995 combined (54 transects measured in both years) for habitat features of elevation, aspect, slope, escape terrain, grass cover, elk pellet groups, and cattle feces counts. Contribution of levels within categories to  $\chi^2$  values<sup>1</sup> was determined following Neu et al. (1974).

| Habitat feature           | 1994 $\chi^2$ (P) | 1995 $\chi^2$ (P) | 1994/1995 $\chi^2$ (P) |
|---------------------------|-------------------|-------------------|------------------------|
| <b>Elevation (m)</b>      | 110.05 (<0.01)    | 48.15 (<0.01)     | 88.46 (<0.01)          |
| 1829 - 2133               |                   |                   |                        |
| 2134 - 2438               | o                 | +                 | +                      |
| 2439 - 2743               |                   | o                 |                        |
| ≥2744                     | +                 | o                 | o                      |
| <b>Aspect</b>             | 13.17 (<0.01)     | 6.23 (0.01)       | 14.55 (<0.01)          |
| N, NE, E, SE              |                   |                   |                        |
| S, SW, W, NW              | +                 | +                 | +                      |
| <b>Percent slope (%)</b>  | 47.28 (<0.01)     | 157.28 (<0.01)    | 79.11 (0<0.01)         |
| <10                       |                   |                   |                        |
| 10-20                     | o                 | +                 |                        |
| 20-30                     | o                 |                   | +                      |
| >30                       | o                 | +                 | o                      |
| <b>Distance to escape</b> | 280.70 (<0.01)    | 429.30 (<0.01)    | 401.28 (<0.01)         |
| ≤ 100 m                   | +                 | +                 | +                      |
| > 100 m                   |                   |                   |                        |
| <b>Grass Cover</b>        | 25.78 (<0.01)     | 48.93 (<0.01)     | 57.01 (<0.01)          |
| low (ground visible)      | +                 | +                 | +                      |
| high                      |                   |                   |                        |
| <b>Elk pellet groups</b>  | 41.30 (<0.01)     | 270.06 (<0.01)    | 68.55 (<0.01)          |
| low <sup>2</sup>          | +                 | +                 | +                      |
| high                      |                   |                   |                        |
| <b>Cattle feces</b>       | 43.18 (<0.01)     | 120.26 (<0.01)    | 130.88 (<0.01)         |
| 0                         | +                 | +                 | +                      |
| ≤ 19 per plot             |                   |                   |                        |
| > 19 per plot             |                   |                   |                        |

<sup>1</sup> (-) bighorn sheep use < expected; (+) bighorn sheep use > expected; (o) bighorn sheep use no different from expected ( $P < 0.05$ ).

<sup>2</sup> Low and high break points of elk pellet groups were #10.4 and >10.4 for 1994, < 23 and >23 for 1995, and < 14 and >14 for 1994 and 1995 combined.

identify relationships between independent and dependent variables in a hierarchal fashion with the most consistent factors forcing the earliest dichotomies. Hierarchal divisions based on presence or absence of bighorn pellet groups, classification trees (Fig. 2), indicated that the most consistent habitat selection criterion for sheep was proximity to escape cover. In 1994 this was the only division that met entry requirements. In 1995 sheep evidently selected sites near escape terrain that were not used heavily by elk.

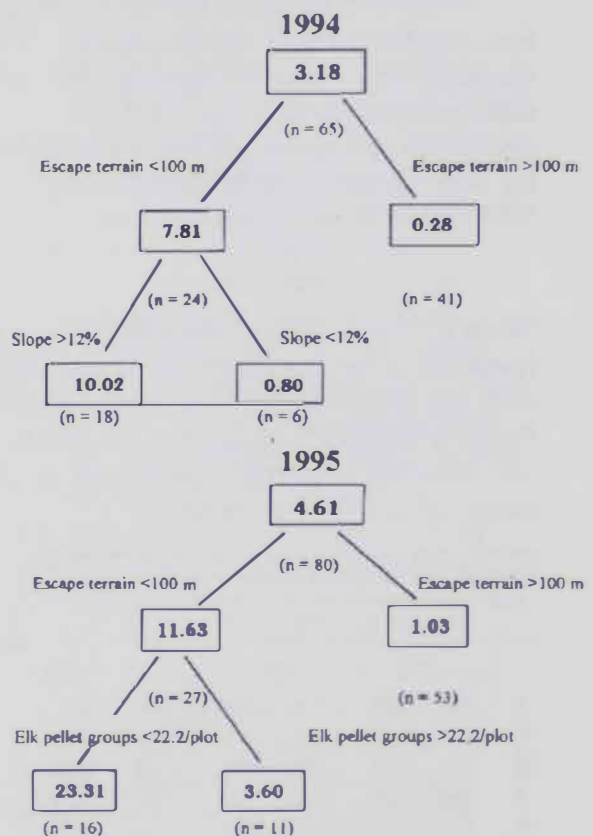


**Figure 2.** Classification trees for 1994 and 1995 based on presence or absence of bighorn pellet groups in 161-m<sup>2</sup> plots. The ratios below node boxes represent misclassification fractions with the denominator as the total number of transects for the node and the numerator as the number of transects selected incorrectly for the node. The habitat characteristic that determined node branching is printed adjacent to the node branch.

Hierarchal divisions based on continuous variables, regression trees (Fig. 3), also indicated sheep selected proximity to escape terrain as a primary site factor in both years. In 1994 a second selection division entered suggesting sheep next considered slope steepness. In 1995, the second branching indicated they avoided areas with high elk use.

### Vegetation /Soil Trend and Condition

Grunigen (1976) classified vegetation condition at four of five sites in the Tom Miner Basin as fair in 1975. He assessed vegetation trend as improving at four of five sites. In 1994



**Figure 3.** Regression tree analysis for 1994 and 1995. Boxes defining classification nodes include mean bighorn pellet groups per 161-m<sup>2</sup> plot at the node. Number of plots for each branch (n) and the characteristics determining branching are given in the figure.

at the same sites, we rated vegetation as good (Table 3) at four of five sites, and rated trend as improving on all sites. Vegetation condition at additional sites that we measured in 1995, and used by sheep, elk, or both species, were classified as fair-to-excellent. Graminoids that were most common in 1975 (*Festuca idahoensis*, *Agropyron spicatum*, perennial *Bromus* spp., *Poa* spp., and *Carex* spp.) also were most common in 1994 and 1995.

In 1975 soil condition was rated at fair to excellent, and soil trend was classified as improving in four of five sites (Table 3). In 1994 and 1995 soil condition at 10 of 11 transects was rated as good or excellent, and the predicted trend was upward at nine of 11 sites.

When we examined the relationship between intensity of use by elk and sheep during winter and spring prior to measurement, as indicated by fecal density, to condition and trend ratings for sites measured in 1975, 1994, and 1995 (Table 3), we found a mixed

pattern. The four sites with high elk use (>10 pellet groups/ha), all from the 1994-1995 period, had good to excellent vegetation and soil condition and improving vegetation and soil trends. We identified five sites with high use by sheep, four from 1975 and one from 1995. Vegetation condition was ranked as fair on four sites and good on one. Vegetation trend, however, was classified as upward on four of five sites. Soil condition was classified as excellent on three sites, good on one, and fair on one. Soil conditions were rated as improving on all five sites.

### Vegetation Utilization in 1994-1995

The 147 grazing transects completed in 1994 and 1995 were located at the same sites as pellet-group transects. Only 14 transects (9% of all transects) indicated >30 percent utilization of the range in 1994 and 1995. All other transects had little-to-no visible utilization. The transects with

**Table 3.** Vegetation and soil condition and trend measures in 1975 and 1994 from transects completed in the Tom Miner Basin. Condition was rated on a 5-category scale (very poor, poor, fair, good, excellent) and trend was classified as up, stable, or down based on USDA Forest Service (1977) guidelines. Transects 1-5 were measured in 1975 and 1994. Transects 6-11 were only measured in 1995. Relative elk and sheep use<sup>1</sup> at the sites based on fecal counts are indicated in the table.

| Transect | Ungulate use <sup>1</sup> |       | Vegetation condition |       | Vegetation trend |             | Soil condition |             | Soil trend  |             |      |    |
|----------|---------------------------|-------|----------------------|-------|------------------|-------------|----------------|-------------|-------------|-------------|------|----|
|          | Elk                       | Sheep | Elk                  | Sheep | 1975             | 1994        | 1975           | 1994        | 1975        | 1994        |      |    |
|          | <b>1975</b>               |       | <b>1994</b>          |       | <b>1975</b>      | <b>1994</b> | <b>1975</b>    | <b>1994</b> | <b>1975</b> | <b>1994</b> |      |    |
| 1        | low                       | high  | low                  | mod   | fair             | fair        | down           | up          | fair        | fair        | down | up |
| 2        | low                       | high  | mod                  | mod   | good             | good        | up             | up          | excellent   | excellent   | up   | up |
| 3        | low                       | high  | mod                  | low   | fair             | good        | up             | up          | excellent   | excellent   | up   | up |
| 4        | low                       | high  | high                 | low   | fair             | good        | up             | up          | good        | good        | up   | up |
| 5        | mod                       | low   | high                 | low   | fair             | good        | up             | up          | excellent   | excellent   | down | up |
|          | <b>1995</b>               |       | <b>1995</b>          |       | <b>1995</b>      | <b>1995</b> | <b>1995</b>    | <b>1995</b> | <b>1995</b> | <b>1995</b> |      |    |
| 6        |                           |       | mod                  | low   | fair             |             | up             |             | good        |             | down |    |
| 7        |                           |       | high                 | low   | excellent        |             | up             |             | excellent   |             | up   |    |
| 8        |                           |       | high                 | low   | excellent        |             | up             |             | excellent   |             | up   |    |
| 9        |                           |       | mod                  | mod   | good             |             | up             |             | good        |             | down |    |
| 10       |                           |       | low                  | low   | good             |             | up             |             | good        |             | up   |    |
| 11       |                           |       | low                  | high  | fair             |             | up             |             | excellent   |             | up   |    |

<sup>1</sup> Low = < 5 pellet groups/ha; mod = 5-10 pellet groups/ha; high = >10 pellet groups/ha.

>30 percent utilization all occurred >100 m from escape terrain and in areas with high densities of cattle feces. Areas with high densities of elk or bighorn feces had low utilization (91% of 147 transects had < 25% utilization).

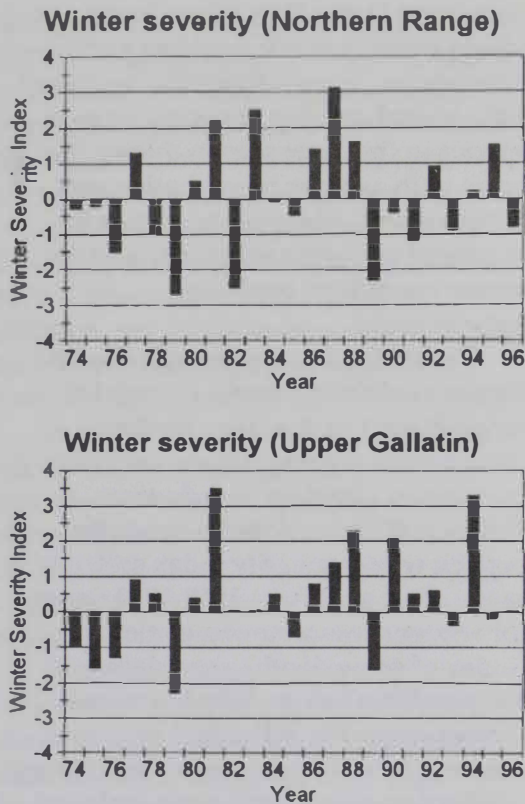
## DISCUSSION

We encountered many problems in our attempt to integrate Grunigen's (1976) data with new data. They ranged from a mathematical error that we made when calculating radii, which resulted in a slight difference in area covered in the inner three belts of our pellet sampling areas vs. plots counted by Grunigen. We also encountered philosophical problems associated with using techniques known to have major limitations (Neff 1968), i.e., maintaining consistency in comparisons. We were fortunate to have study sites physically marked on aerial photographs that allowed us to relocate Grunigen's plots with a high degree of accuracy, but we doubt that our plots were as accurately sited as would be possible today with geographic positioning technology. We also were fortunate to have a detailed description of the techniques Grunigen used for counting pellets and published descriptions of techniques he used to measure vegetation and soil status. Unfortunately, the vegetation techniques described in the USFS monitoring manual were designed to obtain general trend information in a manner that required as little time as possible. This did not allow us to detect small differences between conditions in 1975 and 1994-1995.

The differences we observed in regression and classification trees for 1994 and 1995 indicated that winter conditions could influence pellet distribution. If this were the case, differences in pellet distribution between 1975 and 1994-1995 could reflect differences in animal distribution rather than changes in population size. Although we do not know how winter

variability in the Tom Miner Basin affects overlap in elk and sheep distribution, Legg (1996) observed very little spatial overlap between the two species in the same season during two years with average precipitation and temperatures. Plausible scenarios for increased or decreased overlap under severe conditions could be hypothesized.

Variability in snow conditions and forage availability across the winter range during each winter further complicated interpretation of winter impacts on ungulate distribution. Farnes (1999) developed a spatially explicit winter severity index scaled to a range of +4 to -4 from 1949-1999 means for winter snow water equivalents (index of snow depth), cumulative temperatures below defined critical temperatures for individual ungulate species (index of cold stress), and forage production on winter ranges (index of food availability). Houston (1981:65) indicated that winter 1974-1975, the winter preceding Grunigen's pellet counts, was severe enough to cause over 500 elk deaths on the northern winter range. The Farnes *et al.* (1999) model indicated that winter was severe (-1.7) in the high elevation areas of the northern winter range but much milder (-0.2) in the lower elevation winter range outside YNP. We have no basis upon which to judge the reliability of the Farnes (1999) model, but plots of the two sites closest to Tom Miner Basin for which Farnes (1999) calculated winter severity, the high elevation upper Gallatin elk winter range and the low elevation portions of the northern winter range (Fig. 4), indicated wide differences between severity at the two sites in the same winters. We do not know how this variability would influence sheep or elk distribution in the Tom Miner Basin, but nine radio-collared sheep followed for two or more consecutive years in three studies in the Tom Miner area (Keating 1982, Legg



**Figure 4.** Winter severity calculated by Farnes (1999) for elk on the Northern Winter Range outside Yellowstone National Park and on the Upper Gallatin Winter Range, 1974-1996. The winter severity index is based on winter precipitation, estimated forage production in year preceding the winter, and number of days with temperatures below critical values for elk. The index is scaled to a range of -4 (most severe winter = very low temperatures, low forage availability, and high precipitation) to +4 (mildest winter = warm temperatures, high forage availability, and low precipitation) with average temperature, forage availability, and precipitation = 0. Labels on the x-axis refer to January of each winter (1974 = winter 1973-1974).

1996, and Irby, unpubl.) did not exhibit marked changes in winter range between years.

Despite the problems we described, pellet counts on bighorn wintering sites in the Tom Miner Basin were consistent with a decrease in sheep and an

increase in elk between 1975 and 1994. Pellet counts were sensitive enough to detect a documented decrease in cattle AUMs on bighorn winter ranges between 1975 and 1994 (Legg *et al.* 1996), and they did reflect changes in cattle distribution between 1994 and 1995.

If pellet counts were valid indicators of distribution for sheep and elk, we had two snapshots in time to use in assessing the validity of a "cause" (increase in elk numbers) for a biological "effect" (decline in sheep numbers). Grunigan's vegetation and soil measurements in 1975 and our replication of these measurements in 1994-1995 enabled us to go one step farther than correlation analysis in examining this hypothesis. Pellet counts and the limited population surveys available were consistent with a negative relationship between sheep and elk numbers but not proof of this relationship (Romesburg 1981, Ratti and Garton 1994).

If elk were responsible for the decline in sheep, they could do so by actively or passively excluding sheep from suitable grazing areas or by utilizing limited forage before sheep could use it. We believe active exclusion of sheep by elk was unlikely. In 20 years of observing bighorn sheep in the Yellowstone ecosystem, Irby has never observed active aggression by elk towards sheep. Sheep were seldom seen in the same area as elk, but when groups of the two species were together, neither species appeared to be influencing movement of the other species.

Passive exclusion (elk occupying a site thereby denying it to sheep) is more feasible but would be difficult to distinguish from different habitat preferences of the two species and require significant spatial overlap during the same seasons. Tree analysis identified low elk pellet numbers and frequency as a secondary factor in

predicting high sheep pellet numbers and frequency in 1995 transects, but elk were not abundant in sheep habitat in the same seasons as sheep. During the 1994 and 1995 summer seasons, Legg spent 1,054 hours on bighorn summer (16%) and winter ranges (84%) in the Tom Miner Basin (Legg 1996). During summer ground work, she recorded 820 elk observations on or near bighorn winter ranges. She sighted only 50 elk on summer ranges used by bighorns, but no elk were seen within 1.6 km of sheep. Elk were not observed on any bighorn wintering sites during November through May in either year of the study.

Grazing by other ungulate species on bighorn winter ranges during the growing season could effectively deny sheep forage during winter. However, this would require either heavy long-term grazing pressure, which should be reflected in species composition changes and site condition declines, or in heavy utilization of current growth. If competition for forage from other ungulates were a factor in the decline or failure to recover from the decline, elk were the most likely species involved. Fecal transects indicated that elk did use many areas on or near bighorn winter ranges in 1975 and that elk use had increased by 1994-1995. Cattle use of bighorn winter range was much higher in 1975 than in 1994 or 1995, but most cattle use in both periods was on relatively gentle slopes (Legg 1996) >100 m from escape terrain. Deer use of sheep winter range was low in both periods. Mountain goats were not observed in the study area until after the bighorn population decline.

Measurements that we expected to identify long-term plant community changes were not consistent with overuse by ungulates. Floral composition at sites measured in 1975 and 1994-1995 remained relatively stable, and palatable climax species dominated grassland communities in

both periods. Vegetation and soil condition in 1994-1995 were similar to or rated higher than condition in 1975.

Measurements that we expected to identify short-term utilization, which could have influenced sheep forage available for the 1994-1995 and 1995-1996 winters, indicated low frequency of utilization in the Tom Miner Basin in both the 1994 and 1995 summers. Sites classified as heavily utilized (USDA Forest Service 1977) were grazed by cattle and were not in preferred sheep winter habitat. Forage utilization on preferred sheep winter habitat was undetectable or low in both summers.

Our measurements and analyses indicated that any negative impacts of elk on sheep numbers in the Tom Miner Basin were subtle, if they occurred. There were several ways in which elk use of forage could impact sheep numbers that would have been missed in our design. Summer and early autumn vegetation and pellet measurements did not identify elk use of bighorn wintering areas in late autumn after our measurements were taken. We were unable to measure forage utilization following severe winter conditions when elk use of sites critical to sheep survival could have conceivably depleted essential winter forage for sheep without creating long-term impacts on soils or vegetation. We also may have made vegetation and soil comparisons over too short a period to detect changes due to increased elk numbers. Measurable changes in vegetation composition and soil trend, due to over-use on bighorn winter ranges, may require more than one or two decades.

Elk also may have impacted sheep indirectly. High elk numbers could support a high predator density. Occasional sheep kills by these predators could be sufficient to heavily influence population trends in a small sheep population while having minimal effects on a large elk population. This

hypothesis is consistent with our data and with probable trends in predator numbers over the past two decades (Legg *et al.* 1996). We, however, are considerably more cautious in proposing this hypothesis after our analysis of data related to herbivore distribution and site condition.

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## COMPARISON OF COYOTE DIETS BETWEEN TWO AREAS OF JACKSON HOLE, WYOMING

### ABSTRACT

*Coyotes (Canis latrans) have moved into urban and suburban areas across North America, presumably taking advantage of anthropogenic food sources. We compared diets between coyotes in an undeveloped and a suburban/agricultural area in Jackson Hole, Wyoming from July 1998 to August 1999. We analyzed 170 and 169 scats from the suburban/agricultural and the undeveloped area, respectively. Voles (Microtus spp.) were the predominant prey item in scats from both areas during all seasons. Scats collected in the suburban/agricultural area had a significantly higher percent occurrence of voles during all seasons and annually (49%) than the undeveloped area (24%). Coyotes from the undeveloped area consumed significantly more pocket gophers (Thomomys talpoides) in summer and more cervids in winter than coyotes from the developed area. Foods of human origin were rarely found in scats. We used Sherman live traps to assess relative availability of small mammals. More voles were captured in the suburban/agricultural area than in the undeveloped area. Deer mice (Peromyscus maniculatus) were most frequently captured mammals in both study areas, but they comprised <1 percent of the diet. This study confirms the generalist nature of the coyote with the exception that the coyotes consumed few deer mice, which appeared to be highly abundant in the area. Coyotes in the suburban/agricultural area took advantage of an abundant vole population that may have been elevated due to human disturbances.*

**Key words:** agriculture, *Canis latrans*, coyote, diet, prey, scat analysis, suburban development, Wyoming

### INTRODUCTION

Recently, coyotes (*Canis latrans*) have moved into suburban and urban areas (MacCracken 1982, Atkinson and Shackelton 1991, McClure *et al.* 1995, Quinn 1997). They have been able to do this because they are dietary generalists, and because human-influenced or disturbed areas provide an abundant food source (Shargo 1988,

Toweill and Anthony 1988). Most dietary studies of urban and suburban coyotes have found that these coyotes supplement their diets with foods that are related to human presence (e.g. MacCracken 1982, Atkinson and Shackelton 1991, McClure *et al.* 1995, Quinn 1997). However, few of these studies occurred in areas where dietary comparisons could be made between adjacent developed and undeveloped areas (McClure *et al.* 1995).

Local prey abundance is one of the major factors that regulates coyote abundance (Knowlton and Gese 1995). Developed areas may have an artificially enhanced food base as a result of domestic pets, pet food, garbage, and rodents associated with humans (Shargo 1988). Shargo (1988)

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explained the high coyote density he found in urban areas of Los Angeles as a result of plentiful food sources, which were a result of both human activities and a productive habitat. Increased food availability in urban and suburban settings may allow coyotes to successfully live in those areas at high densities, and thus may, in part, ultimately cause human/coyote conflicts. Because coyotes also rely on human related foods, they may approach human-inhabited areas closer than many people's comfort level warrants.

Coyotes in developed areas apparently can exploit resources offered by urban, suburban, and agricultural settings while minimizing risks associated with being in close proximity to people. Coyotes tend to exist at high densities and occupy smaller home ranges in urban and suburban areas than they do in undeveloped areas (Shargo 1988, McClennen 2000, McClennen *et al.* 2000). When food is plentiful, coyote densities may increase (Atkinson and Shakelton 1991, Knowlton and Gese 1995).

Our objective was to compare diets of coyotes in developed and undeveloped areas of Jackson Hole, Wyoming. We predicted that coyotes in the developed area would use more human associated foods such as garbage, pets, and livestock. Additionally, we hypothesized that coyotes in the undeveloped area would consume more wild ungulates such as elk (*Cervus elaphus*), moose (*Alces alces*), bison (*Bison bison*), deer (*Odocoileus hemionus*, *O. virginianus*), and pronghorn (*Antilocapra americana*).

## MATERIALS AND METHODS

### Study Area

We designated two study areas in the valley of Jackson Hole (43° 40' latitude, 110° 43' longitude) in northwest Wyoming (Fig. 1). The

undeveloped area (UNDA) encompassed southern Grand Teton National Park (GTNP), the National Elk Refuge (NER), and parts of Bridger-Teton National Forest (BTNF). This area has little human influence, and was relatively undisturbed. Housing density in areas that coyotes used ranged from 0 - 0.08 houses/ha. Kelly, Wyoming, with a human population of 200, one campground, and a few small private inholdings are located within the UNDA. Cattle grazing was permitted during limited times on specified allotments during summer in GTNP.

The suburban/agricultural study area (SAA) surrounded the towns of Jackson and Wilson, Wyoming. It was bordered by GTNP to the north, BTNF to the east and west, and the NER to the east. This area consisted of private land primarily devoted to agricultural, commercial, and residential uses. Cattle ranching was a major land use. Housing density in areas that coyotes used ranged from 0.03 - 0.99 houses/ha.

Jackson Hole is a high valley with elevations averaging 1880 m in the SAA and 2014 m in the UNDA. Summers are short and winters are long. Precipitation most often occurs in the form of snow from October to April. Mean annual precipitation (1961-1990) was 42 cm in the SAA area and 54 cm in the UNDA. Mean annual temperatures (1961-1990) ranged from -9 to 16 °C in the SAA area and -11 to 16 °C in the UNDA (High Plains Climate Center, Lincoln, NE).

### Diet Analysis

We collected coyote scats approximately every six to eight weeks from July 1998 to August 1999 on transects along trails and dirt roads. Initially, we cleared scats from each transect to ensure that only scats deposited in a known time period were collected. Approximately 33 and 22 km of transects were walked in GTNP and the SAA, respectively. Transect lengths ranged from 1.4 - 3.0 km in the UNDA

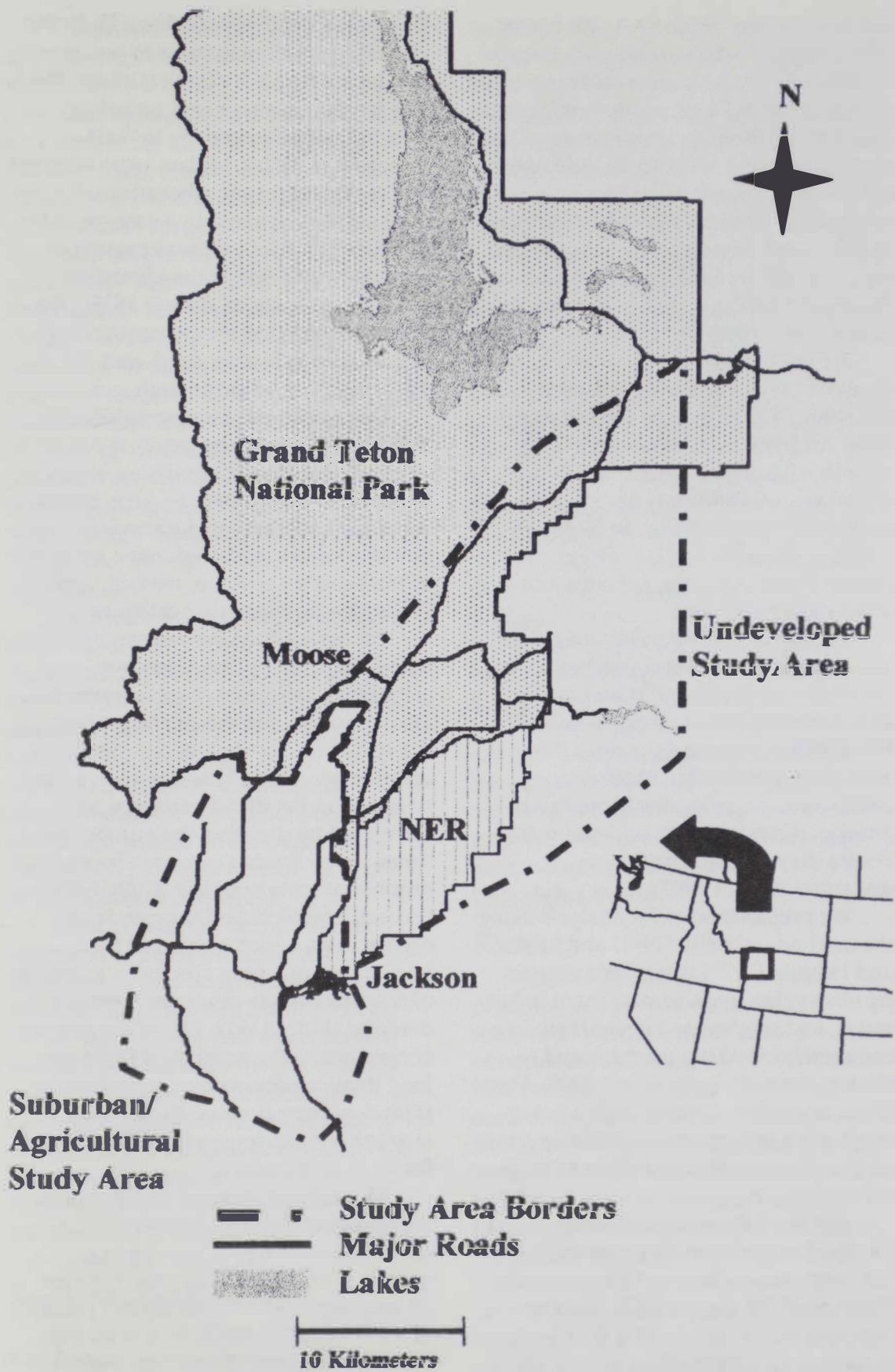


Figure 1. Study Area: Jackson Hole, Wyoming. NER refers to the National Elk Refuge.

and 1.4 - 3.6 km in the SAA. We placed scats in paper bags labeled with transect location, date, and Universal Transverse Mercator (UTM) location determined by a Global Positioning System unit (GPS12, Garmin Inc., Olathe, KS). We did not walk transects when snow covered the ground. Instead, scats were opportunistically collected when found on top of the snow in both study areas. Scats were air dried in the summer and frozen during winter.

A total of 786 scats was collected on transects, 476 from the UNDA and 310 from the SAA, from July 1998 to August 1999. An additional 100 scats were opportunistically collected. From this collection, we randomly selected and analyzed 170 scats from the SAA and 169 scats from the UNDA. Only opportunistically collected scats from winter were analyzed.

We identified coyote scats by size and consistency when compared to red fox (*Vulpes vulpes*), wolf (*Canis lupus*), and domestic dog feces (Weaver and Fritts 1979, Green and Flinders 1981). Scats that contained > 50 percent commercial dog food (as identified by grain particles) were considered to be from a domestic dog and were discarded (Quinn 1997).

We prepared scats for analysis using the methods of Kelly (1991) and Johnson and Hansen (1979). We placed scats in rip stop nylon bags, soaked them in hot water, and washed and dried them in a commercial washing machine and clothes dryer (Wigglesworth 2000). Once dried, we sifted scats through a 1-mm mesh sieve to separate identifiable scat residue from particles of dirt and fecal matter.

Aware of the potential biases involved with determining an animal's diet from scat dissection (Weaver and Hoffman 1979, Andelt 1985, Kelly and Garton 1997, Wigglesworth 2000), we analyzed scats using the methods of Murie (1935) and Weaver (1977) to compare our results with previous

coyote diet studies in Jackson Hole. We identified small mammals to genus and species primarily by teeth (Gilbert 1980), and larger mammals and ungulates were identified primarily by hair (Moore *et al.* 1974). Molars were counted so that the largest number of small mammals recognized in a scat could be identified. If only hair was present in a scat, then only one of the identified species was counted (Murie 1935). We visually estimated the percent volume of hair, insect, feather, seed, and vegetation contained in each scat.

Due to difficulties associated with hair identification and inaccuracy associated with distinguishing bison from cattle hair (T. Moore, pers. comm.), we combined cattle and bison into the bovid category. Although not a member of the Family Cervidae, we included pronghorn in the cervid category.

We determined prey consumption using two calculations. First, we calculated frequency of occurrence, i.e., also known as percent of scats when converted to a percent (Kelly 1991), which represented how common a prey item was in the diet. Frequency was calculated by dividing the number of times a prey species occurred by the number of scats sampled (Kelly 1991). Second, we calculated the percent of occurrences, which measured the importance of a prey species in a sample of scats relative to other prey species detected (Kelly 1991). We define percent occurrence as the number of times one food item or prey species occurred in a sample of scats divided by the total number of occurrences of all food items found in that sample.

We analyzed percent and frequency of occurrence by defining occurrence as the presence of a prey species in a sample of scats, and this was done for all prey types. We also analyzed percent of occurrence for small mammals only using the number of small mammals found per scat as indicated by tooth counts (Wigglesworth 2000).

We analyzed percent and frequency of occurrence data annually and seasonally. We defined three seasons: scats that were collected between July and September of 1998 were called late summer scats; scats collected between October 1998 and mid May 1999 were called winter scats; and scats collected from mid May to August 1999 were called early summer scats. Because snow falls in Jackson Hole as early as October and may not completely melt until May, these seasons reflected potential seasonal differences in prey. Both summer seasons encompass times of Uinta ground squirrel (*Spermophilus aramatus*) activity. Additionally, most coyote pups are born in early May when energy demands are high, and this period may reflect dietary differences.

We used tests for two proportions (95% CI,  $\alpha = 0.05$ ; Reynolds and Aebischer 1991) and chi-square tests ( $\alpha = 0.05$ ), respectively for annual and seasonal comparisons of food items between the SAA and UNDA. We calculated adjusted residuals to determine where differences occurred within chi-square tables (Agresti and Finlay 1997; Minitab version 12 and SPSS statistical packages).

Most vegetation found in scats appeared to be from incidental ingestion or was attached to the scat when it was collected. Additionally, some vegetation appeared macerated and likely came from the gut of small mammalian prey. For these reasons we excluded vegetation from the total occurrences of all food items when we calculated percent of occurrence. However, we did include seeds, which indicated the consumption of berries, in our analyses.

### Small Mammal Surveys

We placed Sherman live traps in five habitat types: aspen, conifer, grass, riparian, and shrub. For each study area, four transects, each with five 0.04

ha plots, were randomly placed in each of the five habitat types in summers of 1998 and 1999. One trap was placed at the center of each plot and one at the edge of each plot in the four cardinal directions, totaling five traps/plot. Traps were opened in the evening and checked in the morning after sunrise.

We captured small mammals for a total of 500 trap-nights/study area during each trap session. Trapping sessions lasted two weeks and were conducted in July and September of 1998 and late May-early June and July of 1999. Traps were open during part of the daylight hours to account for diurnal activity of small mammals but were closed during the heat of the day to minimize mortality. Traps were open for two nights at a set of transects and then moved to another set of transects. Trapping transects were located in different habitat patches but were equally dispersed in the five habitat types. Because the numbers of individual small mammal species caught were proportionately similar between the 1998 and 1999 trapping sessions, we combined data for the four trapping sessions. Thus, for each study area, we analyzed the data from 2,000 trap nights together.

### RESULTS

Voles (*Microtus* spp.) were the predominant prey item during all seasons in both study areas by percent of occurrences (24% in the UNDA and 49% in the SAA) and by frequency of occurrence (65% UNDA, 91% SAA; Tables 1 and 2). Annually, SAA coyotes consumed significantly more voles than UNDA coyotes as measured by both frequency of occurrence and percent of occurrences (Test of two proportions,  $P < 0.01$ ). Scats collected in the UNDA had a significantly higher frequency of occurrence of bird, insect, seed, pocket gopher, and cervid remains than scats from the SAA (Test of two proportions,  $P \leq 0.01$ ). We found similar results when

**Table 1.** Percent occurrence of prey items found in coyote scats in undeveloped (UNDA; n = 169) and suburban/agricultural (SAA; n = 170) areas of Jackson Hole, Wyoming, July 1998 to August 1999. Sample sizes are also indicated.

| Food Item <sup>1</sup> | Annual |       | Late summer<br>July - Sept '98 |       | Winter:<br>Oct '98 - May '99 |       | Early summer:<br>May - Aug '99 |       |
|------------------------|--------|-------|--------------------------------|-------|------------------------------|-------|--------------------------------|-------|
|                        | UNDA   | SAA   | UNDA                           | SAA   | UNDA                         | SAA   | UNDA                           | SAA   |
| <b>Mammals</b>         | 62.4*  | 72.0* | 53.2                           | 60.2  | 63.2*                        | 80.8* | 71.8                           | 77.9  |
| <i>Small Mammals</i>   | 45.7*  | 58.8* | 43.5                           | 53.4  | 38.7*                        | 63.5* | 55.8                           | 61.1  |
| Vole                   | 23.5*  | 48.7* | 20.1*                          | 44.9* | 24.5*                        | 56.7* | 26.3*                          | 45.3* |
| Pocket Gopher          | 15.8*  | 7.5*  | 17.5*                          | 7.6*  | 9.7                          | 4.8   | 20.5*                          | 10.5* |
| Ground Squirrel        | 2.4    | 1.9   | 0.6                            | 0.8   | 1.9                          | 1.0   | 4.5                            | 4.2   |
| Chipmunk               | 2.1    |       | 2.6                            |       | 1.9                          |       | 1.9                            |       |
| Jumping Mouse          | 1.1    |       | 1.9                            |       |                              |       | 1.3                            |       |
| Deer Mouse             | 0.4    |       | 0.6                            |       | 0.6                          |       |                                |       |
| Red Squirrel           | 0.2    |       |                                |       |                              |       | 0.6                            |       |
| Red-backed Vole        | 0.2    | 0.3   |                                |       |                              |       | 0.6                            | 1.1   |
| Water vole             |        | 0.3   |                                |       |                              | 1.0   |                                |       |
| <i>Ungulates</i>       | 14.7*  | 9.1*  | 7.8                            | 3.4   | 22.6*                        | 12.5* | 14.1                           | 12.6  |
| Cervids                | 10.5*  | 5.0*  | 5.2                            | 1.7   | 16.8*                        | 8.7*  | 9.6                            | 5.3   |
| Bovids                 | 4.3    | 4.1   | 2.6                            | 1.7   | 5.8                          | 3.8   | 4.5                            | 7.4   |
| <i>Other Mammals</i>   | 1.9    | 4.1   | 1.9                            | 3.4   | 1.9                          | 4.8   | 1.9                            | 4.2   |
| Weasel                 | 0.5    |       | 0.6                            |       |                              |       | 0.6                            |       |
| Porcupine              | 0.6    | 0.6   | 0.6                            |       | 1.3                          | 1.0   |                                | 1.1   |
| Skunk                  |        | 0.3   |                                |       |                              | 1.0   |                                |       |
| Beaver                 |        | 0.6   |                                |       |                              | 1.9   |                                |       |
| Coyote                 | 0.2    | 0.9   |                                | 1.7   | 0.6                          |       |                                | 1.1   |
| Canid                  | 0.6    | 0.6   | 0.6                            | 0.8   |                              | 1.0   | 1.3                            |       |
| Raccoon                |        | 0.3   |                                |       |                              |       |                                | 1.1   |
| Black Bear             |        | 0.3   |                                |       |                              |       |                                | 1.1   |
| House Cat              |        | 0.3   |                                | 0.8   |                              |       |                                |       |
| <b>Birds</b>           | 5.1    | 3.1   | 6.5                            | 4.2   | 3.2                          | 2.9   | 5.8                            | 2.1   |
| <b>Insects</b>         | 16.0*  | 9.4*  | 20.8                           | 13.6  | 12.3*                        | 3.8*  | 15.4                           | 10.5  |
| <b>Seeds</b>           | 12.2   | 10.7  | 14.8                           | 16.9  | 15.5                         | 8.7   | 6.3                            | 5.2   |
| <b>Unknown</b>         | 2.6    | 4.4   | 4.5                            | 5.1   | 2.6                          | 3.8   | 0.6                            | 4.2   |
| <b>Human-Related</b>   | 1.7    | 0.3   | 0.7                            |       | 3.2                          |       | 1.3                            | 1.0   |
| Sample size            | 169    | 170   | 47                             | 53    | 69                           | 68    | 53                             | 49    |

<sup>1</sup> Scientific names of prey species not referred to in the text: Chipmunk (*Tamias* spp.), red squirrel (*Tamiasciurus hudsonicus*), red-backed vole (*Clethrionomys gapperi*), water vole (*Microtus richardsoni*), weasel (*Mustela erminea*, *Mustela frenata*), porcupine (*Erithizon dorsatum*), skunk (*Mephitis mephitis*), beaver (*Castor canadensis*), raccoon (*Procyon lotor*), black bear (*Ursus americanus*)

\* Significant differences between the SAA and UNDA within each season, Test of two proportions,  $P < 0.05$

scats were analyzed by percent of occurrences (Test of two proportions,  $P \leq 0.05$ ), with the exception that there were no significant differences between the two areas in bird remains and seeds found in scats. Chipmunk (*Tamias* spp.) remains were found only in scats from the UNDA. Insects (21%) occurred at similar percents as voles (20%) during the late summer in the UNDA (Table 1).

By use of percent occurrences, we found a higher proportion of mammals present in the SAA scats than the UNDA scats when all mammals were combined (Test of two proportions,  $P < 0.05$ ; Table 1). Scats from the SAA had a higher proportion of small mammals (rodents) than the UNDA, and scats from the UNDA had a higher proportion of large mammals

**Table 2.** Frequency of occurrence (expressed in percents) of prey items found in coyote scats in undeveloped (UNDA; n = 169) and suburban/agricultural (SAA; n = 170) areas of Jackson Hole, Wyoming, July 1998 to August 1999.

| Food Item       | UNDA  | SAA   | Late summer:<br><u>July - Sept '98</u> |        | Winter:<br><u>Oct '98 - May '99</u> |       | Early summer:<br><u>May - Aug '99</u> |       |
|-----------------|-------|-------|--|--------|-------------------------------------|-------|---------------------------------------|-------|
|                 |       |       | UNDA                                   | SAA    | UNDA                                | SAA   | UNDA                                  | SAA   |
| Vole            | 65.1* | 91.2* | 66.0*                                  | 100.0* | 55.1*                               | 86.8* | 77.4                                  | 87.8  |
| Pocket Gopher   | 43.8* | 14.1* | 57.4*                                  | 17.0*  | 21.7*                               | 7.4*  | 60.4*                                 | 20.4* |
| Ground Squirrel | 6.5   | 3.5   | 2.1                                    | 1.9    | 4.3                                 | 1.5   | 13.2                                  | 8.2   |
| Chipmunk        | 5.9   |       | 8.5                                    |        | 4.3                                 |       | 5.7                                   |       |
| Jumping Mouse   | 3.0   |       | 6.4                                    |        |                                     |       | 3.8                                   |       |
| Deer Mouse      | 1.2   |       | 2.1                                    |        | 1.4                                 |       |                                       |       |
| Red Squirrel    | 0.6   |       |  |        |                                     |       | 1.9                                   |       |
| Red-backed Vole | 0.6   | 0.6   |  |        |                                     |       | 1.9                                   | 2.0   |
| Water vole      |       | 0.6   |  |        |                                     | 1.5   |                                       |       |
| Cervids         | 29.0* | 9.4*  | 17.0                                   | 3.8    | 37.7*                               | 13.2* | 28.3*                                 | 10.2* |
| Bovids          | 11.8  | 7.6   | 8.5                                    | 3.8    | 13.0                                | 5.9   | 13.2                                  | 14.3  |
| Weasel          | 1.2   |       | 2.1                                    |        |                                     |       | 1.9                                   |       |
| Porcupine       | 1.8   | 1.2   | 2.1                                    |        | 2.9                                 | 1.5   |                                       | 2.0   |
| Skunk           |       | 0.6   |  |        |                                     | 1.5   |                                       |       |
| Beaver          |       | 1.2   |  |        |                                     | 2.9   |                                       |       |
| Coyote          | 0.6   | 1.8   |  | 3.8    | 1.4                                 |       |                                       | 2.0   |
| Canid           | 1.8   | 1.2   | 2.1                                    | 1.9    |                                     | 1.5   | 3.8                                   |       |
| Raccoon         |       | 0.6   |  |        |                                     |       |                                       | 2.0   |
| Black Bear      |       | 0.6   |  |        |                                     |       |                                       | 2.0   |
| House Cat       |       | 0.6   |  | 1.9    |                                     |       |                                       |       |
| Bird            | 14.2* | 5.9*  | 21.3                                   | 9.4    | 7.2                                 | 4.4   | 17.0                                  | 4.1   |
| Insect          | 44.4* | 17.6* | 68.1*                                  | 30.2*  | 27.5                                | 5.9   | 45.3*                                 | 20.4* |
| Seed            | 33.7* | 20.0* | 48.9                                   | 37.7   | 34.8*                               | 13.2* | 18.9                                  | 10.2  |
| Unknown         | 7.1   | 8.2   | 14.9                                   | 11.3   | 5.8                                 | 5.9   | 1.9                                   | 8.2   |
| Human Related   | 4.7   | 0.6   | 2.1                                    |        | 7.2                                 |       | 3.8                                   | 2.0   |
| Sample size     | 169   | 170   | 47                                     | 53     | 69                                  | 68    | 53                                    | 49    |

\* Significant differences between the SAA and UNDA within each season, Test of two proportions,  $P \leq 0.05$ .

(ungulates). Coyotes in the UNDA consumed higher proportions of cervids, pocket gophers, and insects, and the SAA coyotes consumed a higher proportion of voles (Table 1).

We found fewer between-area differences in diets of coyotes in the two study areas when prey remains in scats were compared seasonally by percent occurrence. During all seasons voles were significantly more common in the diet of SAA coyotes than UNDA coyotes. Coyotes from the UNDA ate a significantly higher proportion of pocket gophers (*Thomomys talpoides*) during both summer seasons and ate significantly more cervids than SAA

coyotes only during the winter season. Coyotes from the UNDA ate significantly more insects than SAA coyotes during the winter, however due to small sample sizes the normal approximation may have been inaccurate (Test of two proportions,  $P \leq 0.05$ ; Table 1).

The diet of coyotes from each study area varied seasonally. Seasonal differences in prey items found in the diet were determined with chi-square contingency tables and adjusted residuals. Seasonally, by frequency of occurrence, UNDA coyotes had a significantly higher frequency of voles in their diet in early summer and a

lower frequency in winter, although the *P*-value was marginal (Table 2;  $\chi^2 = 7.57$ , 2 d.f., *P* = 0.048; adjusted residuals > |2|). Chi-square tests were unreliable for frequency of voles found in SAA scats because of cell counts <5. However, coyotes consumed a higher frequency of voles in late summer than expected ( $\chi^2 = 7.57$ , 2 d.f., *P* = 0.023; adjusted residuals > |2|). We found no seasonal difference in pocket gopher remains in scats in the SAA but found a higher frequency of pocket gophers in both summer seasons than in the winter season in the UNDA ( $\chi^2 = 22.50$ , 2 d.f., *P* = 0.000; adjusted residuals > |2|). There was a marginal increase in the frequency of cervids found in UNDA scats in the winter, and a decrease in the late summer ( $\chi^2 = 6.08$ , 2 d.f., *P* = 0.048; adjusted residuals > |2|). As expected, frequencies of seeds in scats were higher in late summer and lower in the early summer (UNDA:  $\chi^2 = 10.14$ , 2 d.f., *P* = 0.006; adjusted residuals > |2|; SAA:  $\chi^2 = 15.10$ , 2 d.f., *P* = 0.001; adjusted residuals > |2|). Analysis of percent occurrence data found fewer but similar seasonal differences.

When percent of occurrences of small mammals, as determined by total counts of individual small mammals/scat by tooth count, was analyzed

separately from all other food items, voles comprised 96 percent of small mammals eaten by SAA coyotes (Table 3). Voles occurred in more scats from the SAA than the UNDA, but pocket gopher remains were found in more scats from the UNDA (Test of two proportions, *P* ≤ 0.001). Coyotes from the UNDA had a higher proportion of Uinta ground squirrels in their diets (Test of two proportions, *P* ≤ 0.05). Deer mice (*Peromyscus maniculatus*) occurred in few scats from either study area.

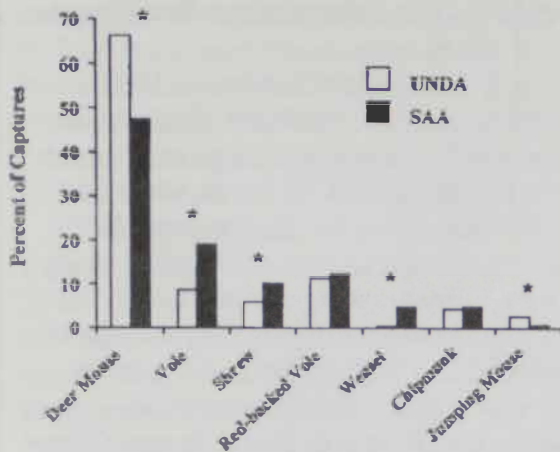
As an indicator of small mammal occurrences in the two study areas, we combined the number of each small mammal species captured in each of five habitat types during the four trapping sessions (Fig. 2). We captured a total of 393 small mammals in the UNDA and 360 in the SAA. More deer mice (66 and 48% of the respective captures in the UNDA and SAA) were caught than any other small mammal, but deer mice comprised <1 percent frequency of occurrence among scats from the UNDA and were not found in SAA scats. Voles comprised 9 percent of the captures in the UNDA and 19 percent in the SAA, and were found in 62 and 96 percent of respective scats in the UNDA and SAA (Table 3, Fig. 2).

Jumping mice (*Zapus princeps*) were

**Table 3.** Percent occurrence of small mammals by tooth counts in coyote scats in undeveloped (UNDA; n = 169) and suburban/agricultural (SAA; n = 170) areas of Jackson Hole, Wyoming, July 1998 to August 1999.

| Food Item       | Annual |       | Late summer:<br>July - Sept '98 |       | Winter:<br>Oct '98 - May '99 |       | Early summer:<br>May - Aug '99 |       |
|-----------------|--------|-------|---------------------------------|-------|------------------------------|-------|--------------------------------|-------|
|                 | UNDA   | SAA   | UNDA                            | SAA   | UNDA                         | SAA   | UNDA                           | SAA   |
| Vole            | 61.6*  | 95.8* | 55.8*                           | 97.2* | 77.8*                        | 97.4* | 53.1*                          | 90.6* |
| Pocket Gopher   | 30.1*  | 3.3*  | 34.7*                           | 2.5*  | 16.7*                        | 1.8*  | 38.3*                          | 6.8*  |
| Ground Squirrel | 2.9*   | 0.7*  | 1.1                             | 0.3   | 2.4                          | 0.4   | 4.3                            | 2.1   |
| Chipmunk        | 2.6    |       | 4.2                             |       | 2.4                          |       | 1.9                            |       |
| Jumping Mouse   | 1.3    |       | 3.2                             |       |                              |       | 1.2                            |       |
| Deer Mouse      | 0.5    |       | 1.1                             |       | 0.8                          |       |                                |       |
| Red Squirrel    | 0.3    |       |                                 |       |                              |       | 0.6                            |       |
| Red-backed Vole | 0.3    | 0.1   |                                 |       |                              |       | 0.6                            | 0.5   |
| Water vole      |        | 0.1   |                                 |       |                              | 0.4   |                                |       |

\* Significant differences between the SAA and UNDA within each season, Test of two proportions, *P* ≤ 0.05.



**Figure 2.** Percent of small mammals caught during four trap sessions in five habitat types in undeveloped (UNDA) and suburban/ agricultural (SAA) areas of Jackson Hole, Wyoming, July and September 1998 and May- June and July 1999. Asterisks (\*) indicate significant differences between the SAA and UNDA (test of two proportions,  $P < 0.05$ ; the normal approximation may be inaccurate for the weasel and jumping mouse due to small samples).

captured only during the 1999 trapping sessions (1 and 8% of the respective SAA and UNDA captures). Shrews (*Sorex* spp.) were captured predominantly during the 1998 trapping sessions. In 1998 shrews comprised 18 and 9 percent of respective SAA and UNDA captures, but they comprised only 1 percent of the captures in 1999 in both the UNDA and SAA. We captured significantly more deer mice in riparian habitats than in grass and aspen habitats in the UNDA and significantly more in conifer and shrub than grass habitats in the SAA (one-way ANOVA, Tukey's pairwise comparison family error rate of 0.05 and Tamhane's T2 test).

We did not detect garbage or human related foods frequently in any of the scats. Items that we detected included cloth, string, tin foil, plastic, and shotgun pellets. We found a claw from a domestic cat in a scat from the SAA in the late summer season.

## DISCUSSION

The results from this study were similar to results from previous studies of coyote diets in Jackson Hole, Wyoming. Like Murie (1935) and Weaver (1977), we found that voles were important prey items for coyotes. Additionally, because we caught more deer mice than voles in both study areas, coyotes apparently were selecting voles more than expected and deer mice less than expected. We could not validate this conclusion because low deer mice counts in scats precluded a valid chi-square test. When data from both study areas were combined, voles accounted for only 14 percent of captures in small mammal traps but were the predominant prey item in the diet of coyotes in both areas. The opposite was true for deer mice. We detected 10,673 vole teeth but only six deer mice teeth in the 339 scats we examined. Similarly, Murie (1935) and Weaver (1977) found few deer mice in the diets of coyotes.

Murie (1935) and Weaver (1977) also found a discrepancy between deer mice availability and presence in the diet of coyotes. Reichel (1991) found that coyotes ate few deer mice in proportion to their availability in Montana and concluded that voles were more vulnerable to coyote predation than deer mice. He also noted studies that have shown that deer mice may be easier for researchers to capture than voles.

Our small mammal capture methods were biased toward capturing more deer mice than voles. Voles are more diurnal than deer mice, which are primarily nocturnal, and voles tend to travel along runways they have created (Streubel 1989). The disproportionate amount of deer mice we captured relative to voles is partially explained by the fact that we captured small mammals primarily at night and at fixed locations not necessarily near vole runways.

The presence of voles in the diet of coyotes may be elevated because voles tend to be vulnerable to predation by coyotes that display both diurnal and nocturnal hunting patterns (Streubel 1989). Higher susceptibility of deer mice to trapping also may have elevated the true abundance of deer mice in relation to voles. However, we do not believe that this completely accounted for the absence of deer mice in the diet of coyotes. In years when both voles and deer mice were abundant, coyotes selected for voles (Hamlin *et al.* 1984). Vole populations tend to be cyclic (Streubel 1989); thus, the presence of voles in the diets of coyotes likely would change during vole population highs and lows. Hamlin *et al.* (1984) found that when vole populations were low, coyotes ate proportionally more deer mice than they did when vole populations were high. The duration of our study precluded a determination of vole population cycles.

Voies prefer habitats with dense and abundant grasses (Streubel 1989). Our ground cover measurements found no significant differences in percent grasses between the two study areas with the exception that riparian habitats in the SAA had significantly higher grass cover than riparian habitats in the UNDA (Wigglesworth, unpublished data). Wigglesworth (unpublished data) also found no difference between the two study areas in the amount of dimensional ground cover (vegetation that grew taller than 2.54 cm). However, the UNDA, which had only limited cattle grazing and sporadic grazing by bison, may have provided more cover for voles than the SAA, parts of which were regularly grazed by cattle. Likewise, cover for small mammals was reduced to a minimum when hay was cut on agricultural lands in mid summer. Thus, any differences in cover that might have existed between the two study areas may not explain the

difference in vole presence between the two areas.

Although McClure *et al.* (1995) concluded that coyotes in a suburban area of Arizona might have consumed more human-related foods, we found little evidence of anthropogenic foods in the diet of coyotes from either study area. Our sampling methods and difficulty in identifying hair may have limited our finding domestic pets in scat samples. Likewise, our scat collection routes in the SAA, mostly on ranches, may not have been located where scats containing human-related foods would be deposited. Coyotes in Jackson Hole may not need foods directly related to humans but eat prey animals that have increased as a result of human presence and disturbance. Shargo (1988) found that suburban areas of Los Angeles had high prey abundance, and McClure *et al.* (1995) noted a higher number of rodents in areas influenced by human development. Because we captured significantly more voles in the SAA than the UNDA, we speculate that coyotes from the SAA were approaching developed areas to forage for small mammals of which abundance may have increased due to human presence.

Coyotes from the UNDA ate more cervids than did coyotes in the SAA. Because mule deer are not very abundant in the UNDA, most of the cervids detected in the scats likely were elk. However, mule deer, moose, and pronghorn were possibilities. Elk were likely more abundant in the UNDA than the SAA, and many elk carcass remains were left in the UNDA during the annual fall hunt. Consumption of elk likely was in the form of carrion. We did not observe coyotes preying upon cervids although we did witness them chasing pronghorn in the spring, and occasionally elk on the National Elk Refuge. Wells and Bekoff (1982) reported similar observations in the

same area. We speculate that bovid hair in SAA scats were from cattle, and bovid hair from UNDA scats were from bison. No cattle died during their limited grazing allotment in the UNDA, and bison are not found in the SAA.

The high percent occurrence of insects is likely a misrepresentation. Small remains of insects (grasshoppers and beetles) and seeds were found in many scats, however, insects and seeds each comprised on average <4 percent by volume of each scat. We attempted to separate insects into categories of grasshopper and beetle although often finding only pieces of insect exoskeletons in scats made identification difficult. However grasshoppers were present in more scats than were beetles. We found carrion beetles infrequently, but those we could identify were not counted separately from other beetles. Notably, some scats were comprised of almost all insects indicating that insects can be an important supplement to the diet of coyotes in Jackson Hole.

The coyote is a generalist predator capable of switching prey items when the population of one prey species declines (Johnson and Crabtree 1999). Coyotes in the UNDA ate voles and pocket gophers in the summer and supplemented their diet in late summer with insects as availability increased and berries as they ripened. Other studies have shown seasonal dietary changes due to food availability (Bowen 1981, Andelt 1895, Gese *et al.* 1988, Toweill and Anthony 1988, Quinn 1997). In winter coyotes took advantage of ungulate carrion. They also consumed cervids in early summer during the calving season. Scat analysis indicated a drop in cervids in the diet from winter to early summer accompanied by an increase in pocket gophers. Coyotes from the SAA took advantage of abundant voles. This area receives less snowfall than the UNDA, which may make prey acquisition easier. Relative

occurrence of voles in the diet of coyotes was highest in the winter. Coyotes from the SAA also increased their consumption of cervids in winter and early summer when such animals were easier to obtain for food.

High-density development has the potential to decrease natural prey items, which in turn could cause coyotes to seek human-related foods. This does not appear to have occurred in developed areas of Jackson Hole, Wyoming. Human development appeared to have little effect on the diet of coyotes in suburban/agricultural areas when compared to the diet of coyotes in an adjacent undeveloped area. Pockets of high and low-density developments exist in the SAA, but they are interspersed with agricultural areas and open spaces and are surrounded by public lands. Natural prey items may be sufficiently abundant due to open spaces found within the SAA that coyotes have little need to forage for anthropogenic food sources.

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## NOXIOUS WEEDS FOUND IN TWO MOON PARK NEAR BILLINGS, MONTANA

**Key words:** noxious weeds, Two Moon Park, Yellowstone River.

Two Moon Park, a 61-ha (150-acre) Yellowstone County Park, located north of the Yellowstone River east of Billings, Montana, is a designated wildlife preserve. In a checklist of the vascular plants of Two Moon Park, 114 species were catalogued among 40 families and 95 genera (Khaleel *et al.* 2000). Examination of these taxa revealed several species that are designated as noxious weeds in Montana and several others classified as INVADERS/USDA noxious weeds listed in PLANTS database (USDA National Resources Conservation Service 1999). Of the Montana noxious weeds, seven species among six genera were Category I noxious weeds, and one species, saltcedar (*Tamarix ramosissima* Ledeb.), was Category 2 noxious weed (USDA National Resources Conservation Service 1999). The Category I noxious weeds included three species of Asteraceae and one each of Apiaceae, Brassicaceae, Convolvulaceae and Euphorbiaceae (Table 1). Except hoary cress (*Cardaria draba* [L.] Desv.), all noxious weeds that we identified were exotic species (Zamora 1991). Category I

noxious weeds are currently established and generally widespread in Montana. Therefore, management for these weeds should include awareness and education (Mullin 1991). In Two Moon Park spotted knapweed (*Centaurea maculosa* Lam.) was relatively more abundant than Canadian thistle (*Cirsium arvensis* [L.] Scop.) or gypsyflower (*Cynoglossum officinale* L.). Among other species listed in the INVADERS/USDA noxious weeds database (USDA, National Resources Conservation Service 1999) we found 26 species in Two Moon Park (Table 1). These included 10 species among nine genera of Asteraceae, five species among five genera of Brassicaceae, three species among two genera of Polygonaceae, two species among two genera of Apiaceae, and one species each of Amaranthaceae, Asclepiadaceae, Fabaceae, Poaceae, Scrophulariaceae, and Solanaceae. Voucher specimens and slide photographs of each plant in its natural habitat are located in the MSU-Billings herbarium.

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**Table 1.** Checklist of noxious weeds from Two Moon Park, Yellowstone County, Montana.

| Family           | Scientific name  | Common name                        |
|------------------|--|------------------------------------|
| Amaranthaceae    | <i>Amaranthus retroflexus</i> L.   | redroot amaranth                   |
| Apiaceae         | <i>Carum carvi</i> L.  | caraway                            |
|                  | <i>Conium maculatum</i> L.   | poison hemlock                     |
| Asclepiadaceae   | <i>Asclepias speciosa</i> Torr.  | showy milkweed                     |
|                  | <i>Arctium minus</i> Bernh.  | lesser burdock                     |
|                  | <i>Artemisia absinthium</i> L.   | absinthium                         |
|                  | <i>Artemisia frigida</i> Willd.  | prairie sagewort                   |
|                  | * <i>Centaurea biebersteinii</i> DC.<br>(= <i>Centaurea maculosa</i> auct. non Lam.) | spotted knapweed                   |
|                  | <i>Cichorium intybus</i> L.  | chicory                            |
|                  | * <i>Cirsium arvense</i> (L.) Scop.  | Canadian thistle                   |
|                  | <i>Cirsium vulgare</i> (Savi) Ten.   | bull thistle                       |
|                  | <i>Grindelia squarrosa</i> (Pursh) Dunal   | curlycup gumweed                   |
|                  | <i>Lactuca serriola</i> L.   | prickly lettuce                    |
|                  | <i>Sonchus oleraceus</i> L.  | common sowthistle                  |
|                  | * <i>Tanacetum vulgare</i> L.  | common tansy                       |
|                  | <i>Taraxacum officinale</i> G.H. Weber ex Wiggers                                    | common dandeloin                   |
|                  | <i>Xanthium strumarium</i> L.  | rough cocklebur                    |
|                  | Boraginaceae   | * <i>Cynoglossum officinale</i> L. |
| Brassicaceae     | <i>Capsella bursa-pastoris</i> (L.) Medik.   | shepherd's purse                   |
|                  | * <i>Cardaria draba</i> (L.) Desv.   | whiteweed or hoary cress           |
|                  | <i>Descurainia pinnata</i> (Walt.) Britt.  | western tansy-mustard              |
|                  | <i>Erysimum cheiranthoides</i> L.  | wormseed wallflower                |
|                  | <i>Sinapsis arvensis</i> L.<br>(= <i>Brassica kaber</i> (DC.) L.C. Wheeler)          | charlock mustard                   |
|                  | <i>Thlaspi arvense</i> L.  | field pennycress                   |
| Convolvulaceae   | * <i>Convolvulus arvensis</i> L.   | field bindweed                     |
| Euphorbiaceae    | * <i>Euphorbia esula</i> L.  | leafy spurge                       |
| Fabaceae         | <i>Glycyrrhiza lepidota</i> Pursh.   | American licorice                  |
| Poaceae          | <i>Phalaris arundinacea</i> L.   | reed canarygrass                   |
| Polygonaceae     | <i>Polygonum hydropiper</i> L.   | marshpepper knotweed               |
|                  | <i>Polygonum lapathifolium</i> L.  | curlytop knotweed                  |
|                  | <i>Rumex crispus</i> L.  | curly dock                         |
| Scrophulariaceae | <i>Verbascum thapsus</i> L.  | common mullein                     |
| Solanaceae       | <i>Solanum dulcamara</i> L.  | climbing nightshade                |
| Tamaricaceae     | * <i>Tamarix ramosissima</i> Ledeb.  | saltcedar                          |

\* Montana state-listed noxious weeds as on 2/14/00.

The scientific and common names conform to those contained in the PLANTS database. Published on the Internet; (<http://plants.usda.gov/plants>), accessed August 28, 2000.

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## SUBJECT INDEX FOR IJS VOLUMES 1-6 (1995-2000)

- acetylcholinesterase: 1:1-15  
adrenocorticotropin: 1: 29-36  
algae: 2(2):17-26  
amphibians: 4:33-49  
arginine vasopressin: 1: 29-36  
*Artemisia cana*, see silver sagebrush  
aspens: 6:49-55  
**Aquatic ecosystems:**  
    cover, 6:232-248  
    macroinvertebrates: 6:178-196  
    macrophytes, 6:249-262  
    habitat, 3:125-130, 6:178-196,  
    6:232-248  
sedimentation, 6:232-248  
avian assemblages: 5:1-11, 6:33-48  
bald eagle: 1:1-15  
**Bears:**  
    grizzly bear, 3:17-37  
beaver: 3:11-16  
behavior: 3:55-61  
benthos: 3:11-16  
bighorn sheep: 6:339-354  
biculturalism: 3:131-142  
binary vector spaces: 4:82-87  
bison: 6:18-32  
Bitterroot River, Montana: 4:68-81  
Black Hills, South Dakota: 6:33-48  
brook trout: 6:217-222, 6:232-248  
butyrylcholinesterase: 1:1-15  
*Canis latrans*, see coyote  
*Castor canadensis*, see beaver  
catalysis: 2:35-39  
**Census:**  
    capture efficiency, 3:1-6  
    distance sampling (streams),  
    6:223-231  
    live trap, 2(2):10-16, 3:1-6  
    pitfall trap, 2(2):10-16, 3:1-6  
    Shannon diversity index, 2(2):10-16  
    snap trap, 2(2):10-16, 3:1-6  
    track surveys, 6:78-85  
*Cervus elaphus*, see elk  
cetyltrimethylammonium bromide:  
1:37-43  
channel catfish: 5:28-34  
Charles M. Russell National Wildlife  
Refuge, Montana: 6:57-67  
chlorofluorocarbons: 6:119-142  
chromatography: 1:44-52  
Clark Fork River, Montana: 2(2):17-26  
composted sewage sludge: 3:38-46  
computational complexity: 4:82-87  
Conservation Reserve Program:  
2(2):10-16  
corticotropin releasing factor: 1:29-36  
cougar: 1:16-28  
**Coyote:**  
    bounties, 3:62-72  
    control, 3:62-72  
    density, 6:78-85  
    diets, 6:355-367  
    longevity, 3:62-72  
    prey, 6:355-367  
    survival, 3:62-72  
cutthroat trout: 217-222  
*Cygnus buccinator*, see trumpeter swan  
*Cyprinidae*, see minnows  
**Decarboxylase:**  
    amino acid decarboxylase (AADC),  
    6:95-101  
decarboxylation, 2:35-39  
**Deer:**  
    mule deer, 2:1-7, 3:62-72  
    white-tailed deer, 2:1-7, 3:87-93  
**Deer mice:**  
    abundance, 2(2):10-16  
    habitat relations, 3:117-124, 5:12-22  
differential adjustment: 3:131-142  
discriminant functions: 3:47-53  
Douglas-fir: 2:1-7  
Ephemeroptera: 6:178-196  
electrical conductivity: 1:37-43  
electrogravimetric analysis: 4:50-55  
electrolysis: 4:50-55  
**Elk:**  
    browsing, 4:57-67, 6:49-55  
    effects of ecosystem management,  
    2:1-7  
    interspecific interactions, 6:339-354  
    mortality, 6:86-94  
    population trends, 4:1-9  
    vulnerability, 6:86-94  
    winter range, 4:1-9

- environmental contaminants: 1:1-15
- epinephrine: 1: 29-36
- feedback iteration function: 2:16-25
- Festuca idahoensis*, see Idaho fescue
- Fisheries ecology:**
- competition, 6:197-216
  - fish ecology, 6:10-17
  - fish passage, 6:232-248
  - introduced fish, 6:57-67
  - movements, 6:232-248
  - native fish, 6:57-67
  - prairie stream fishes, 6:57-67
  - redds, 6:223-231
  - spawning, 6:223-231
  - survival, 6:197-216, 6:232-248
  - winter research, 6:232-248
- Fisheries management:**
- angler response, 3:94-100, 6:68-77
  - electrofishing, 5:35-38
  - hatcheries, 6:197-216
- Flathead Indian Reservation, Montana: 4:33-49
- fluid flow: 2:26-34
- forensic anthropology: 3:47-53
- Forestry:**
- ecosystem management: 2:1-7
  - forest stand structure, 4:10-21
  - growth form: 4:57-67
  - landscape analysis, 4:10-21, 6:86-94
  - landscape ecology, 5:12-22
  - logging effects on song birds, 6:33-48
  - thinning treatment effects on small mammals, 5:12-22
- geographical information systems (GIS): 5:23-27, 6:86-94, 6:178-196
- golden eagle: 1:1-15
- Grand Teton National Park, Wyoming: 5:1-11
- Great Plains:**
- Crow Creek, Wyoming, 3:11-16
  - Laramie Plains Lakes, Wyoming, 3:73-81
- Headwaters State Park, Montana: 2(2):1-9
- heavy metals: 1:1-15
- Henry's Lake: 6:263-284
- Henry's Fork of the Snake River, Idaho:** 6:103-332
- aquatic resources. 6:312-332
  - bibliography, 6:312-332
  - consumer surplus, 6:285-292
  - economics, 6:106-118, 6:285-292
  - geography, 6:106-118
  - geomorphology, 6:159-177
  - hydrology, 6:119-142, 6:312-332
  - history of fisheries management, 6:263-284
  - landuse, 6:178-196
  - nonnative fish, 6:197-216
  - recreation, 6:285-292
  - watershed, 6:106-118, 6:178-196
  - watershed management, 6:293-311
- Home range:**
- fidelity, 3:62-72
- Ictalurus punctatus*, see channel catfish
- Idaho fescue: 4:22-26
- Immigration:**
- Russian-Americans, 3:131-142
- immiscible fluid: 2:26-34
- incubation: 3:55-61
- insulin replacement: 1: 29-36
- Island Park Reservoir, Idaho: 6:263-284
- kinetics: 2:35-39
- Lemmiscus curtatus*, see vole, sagebrush
- Lewis' woodpecker: 3:55-61
- lichens: 2:1-7, 2(2):1-9, 3:82-86
- light scattering: 1:37-43
- limestone: 1:44-52
- Liu pyramids: 2:16-25
- Madison River, Montana: 6:1-9
- Machrybopsis gelida*, see sturgeon chub
- macroinvertebrates: 3:11-16
- magnetic float: 2:35-39
- mass spectrometry: 1:44-52
- Melanerpes lewis*, see Lewis' woodpecker
- metal complexation: 3:38-46
- micelles: 1:37-43, 3:101-106
- Microtus* spp., see voles
- mine reclamation: 3:38-46
- minnows: 6:10-17
- miscible fluid: 2:26-34
- Mississippian Lodgepole Formation: 1:44-52
- Missouri River, Montana:**
- fishery, 6:10-17, 6:68-77
- monoid: 2: 16-25
- natural resources: 6:293-311
- normal alkanes: 1:44-52
- noxious weeds: 6:368-369

- National Elk Refuge, Wyoming: 6:49-55  
 NP-complete: 4:82-87  
 nuclear magnetic resonance spectra:  
 3:101-106  
 numerical wave propagation: 1:53-60  
*Odocoileus hemionus*, see deer, mule deer  
*Odocoileus virginianus*, see deer, white-  
 tailed  
*Oncorhynchus clarki*, see cutthroat trout  
*O. c. bouvieri*, see Yellowstone cutthroat  
 trout  
*O. mykiss*, see rainbow trout  
 organochlorines: 1:1-15  
*Ovis canadensis*, see bighorn sheep  
 paddlefish: 3:94-100, 5:35-38, 6:68-77  
 peer mediation: 2:8-15  
*Peromyscus maniculatus*, see deer mice  
 photo interpretation: 4:10-21  
 pine, ponderosa: 2:1-7  
 Plecoptera: 6:178-196  
*Polydon spatula*, see paddlefish  
*Populus tremuloides*, see aspen  
 porous media: 2:26-34  
 predation: 1:16-28, 3:62-72, 6:1-9  
 propagule: 4:27-32  
*Pteronarcys californica*, see salmonflies  
**Public involvement:**  
   communication, incentives,  
   6:293-311  
   community building, 6:293-311  
   cooperation, 6:293-311  
   incentives, 6:293-311  
 rainbow trout: 6:223-231, 6:232-248,  
 6:249-262, 6:263-284  
*Reithrodontomys megalotis*, see western  
 harvest mice  
 remote sensing: 4:10-21  
 reptiles: 4:33-49  
**Riparian:**  
   ecology, 6:159-177  
   vegetation, 6:159-177  
**Rocky Mountains: 3:1-6**  
   East Front, Montana, 3:17-37  
   Bangtail Range, Montana, 4:22-26  
   Jackson Hole, Wyoming, 6:49-55,  
   6:78-85, 6:355-367  
   Laramie Range, Wyoming, 3:55-61  
   Teton Range, Wyoming, 6:106-118  
 salmonflies: 6:1-9  
*Salvelinus fontinalis*, see brook trout  
 scat analysis: 6:355-367  
 seed dissemination: 4:27-32  
 selenium: 1:1-15  
 shrews: 2(2)10-16  
 silver sagebrush: 4:27-32  
 small mammals: 2(2)10-16, 3:1-6, 3:117-  
 124, 5:12-22  
 Snake River, Wyoming: 5:1-11  
**Soils:**  
   fertility, 4:22-26  
   leaching, 4:22-26  
 song birds: 5:1-11, 6:33-48  
*Sorex* spp., see shrews  
 spectrophotometric analysis: 4:50-55  
 stable isotopes: 6:119-142  
*Stizostedion vitreum*, see walleye  
**Springs:**  
   recharge, 6:119-142  
**Streams:**  
   channel morphology, 6:143-158  
   discharge, 3:82-86  
   groundwater seepage impacts,  
   4:68-81  
   morphology, 4:68-81  
   peak flood, 3:82-86  
   riparian corridor, 5:1-11  
   spring-fed, 6:143-158, 6:159-177,  
   6:178-196  
 streptozotocin: 1: 29-36  
 sturgeon chub: 3:125-130  
 suburban development: 6:78-85,  
 6:355-367  
 surfactants: 2:35-39, 3:101-106  
*Tamias amoenus*, see yellow pine  
 chipmunk  
**Terrestrial ecosystems:**  
   browsing history, 4:57-67, 6:49-55  
   food habits, 1:16-28, 6:355-367  
   foraging, 3:55-61, 6:18-32  
   forest openings, 3:87-93  
   grazing influences, 3:17-37, 6:18-32  
   habitat, 2:1-7, 3:1-6, 3:55-61  
   habitat fragmentation, 6:33-47  
   habitat security, 3:87-93, 6:86-94  
   habitat selection, 1:16-28  
   human disturbance, 5:1-11  
   terrain ruggedness, 5:23-27  
   vascular plants: 6:333-338  
 Trichoptera: 6:178-196  
 trumpeter swan: 6:249-262

*Ursus arctos*, see bear, grizzly  
visible spectra: 3:101-106

**Voles:** 2(2)10-16, 3:117-124  
sagebrush vole, 3:117-124

walleye: 3:7-10

waterfowl: 3:73-81

**Water:**

management, 6:249-262

quality, 6:1-9, 6:312-332

western harvest mice: 3:117-124

**Wildlife management:**

Montana Indian reservations,  
3:107-115

Northern Yellowstone elk herd, 4:1-9  
tribal law enforcement and criminal  
codes, 3:107-115

*Xanthoria elegans*, see lichens

yellow pine chipmunk: 5:12-22

**Yellowstone cutthroat trout:** 6:263-284  
population status, 6:197-216

Yellowstone National Park: 4:1-9, 4:57-  
67, 6:18-32, 6:143-158

**Yellowstone River, Montana:**

paddle fishery, 3:94-100, 5:28-34

Two Moon Park, 6:333-338, 6:368-369

# ABSTRACTS

## BIOLOGICAL SCIENCES - TERRESTRIAL

### IS THIS REALLY HAPPENING? OLD GROWTH IN DNRC<sup>TWS</sup>

Jane Adams  
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Jane Adams describes her experience as a “whistle blower” while working as a wildlife biologist for the DNRC. She tells the story of a large timber sale in the Swan Valley in which DNRC planned to harvest over 600 ac of high-quality old growth, yet the EIS didn’t even mention that old growth would be harvested. The EIS instead analyzed “old stands”, defined as stands at least 150 years old with 4 MMBF per acre, regardless of forest type. This definition is met by 6 large trees per acre. Such stands provide little to no habitat for old-growth associated wildlife species and few of the ecological characteristics of old growth. However, using this definition allowed DNRC to harvest most of the trees from virgin old growth stands, and claim that the number of acres of old stands would not change. DNRC also claimed they only needed to maintain 13 percent of the Swan River State Forest as old growth, despite the fact that about 74 percent of it was old growth historically, and they have publicly committed to maintain at least 50 percent of historic old growth. Jane refused to support the analysis in this EIS, and management made working conditions so intolerable she felt forced to quit.

### MONTANA-WIDE BURROWING OWL SURVEYS; A SYNTHESIS OF FIRST YEAR EFFORTS—1999<sup>TWS</sup>

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Population trend information, as well as present dispersion and abundance measures, are sorely lacking for burrowing owls (*Athene cunicularia*) inhabiting Montana. To develop baseline information that can lead to assessments of population trends, we invoked a cooperative network of 28 surveyors to sample black-tailed prairie dog (*Cynomys ludovicianus*) colonies across the state. Prairie dog towns were randomly selected, stratified by quarter latilong (0.5° x 0.5°) from the 1,302 prairie dog towns contained in the statewide database archived by the Montana Natural Heritage Program. Three hundred, seventeen towns were selected for survey based upon a proportional sampling regime. Area-based surveys were

*Title footnote indicates organization, location and date presentation was made:*

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<sup>TWS</sup> Montana Chapter of the Wildlife Society Annual Meeting, Great falls, MT, Feb. 23-25, 2000

performed between 15 July-8 August. We surveyed 209 colonies (204 with usable data; 10,079 ac; 4081 ha) observing 474 burrowing owls and a minimum of 123 burrowing owl pairs. Seventy eight colonies were occupied by owls (38.24%) with average number of owls per town equaling 2.33 (SD = 4.23), with most supporting one pair ( $\bar{X} = 0.61 + 1.00$  pair,  $n = 204$ ). Based upon these data, we estimate that Montana prairie dog colonies supported between 787 and 819 burrowing owl pairs in 1999. Plans for 2000 include defining 'bellweather' colonies for longterm trend monitoring through sampling with partial replacement and expanding the network of cooperators.

## THE EFFECTS OF GROOMED ROADS ON THE BEHAVIOR AND DISTRIBUTION OF BISON IN YELLOWSTONE NATIONAL PARK<sup>TWS</sup>

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The road grooming needed to support snowmobile travel in Yellowstone National Park has come under examination for its effects on bison (*Bison bison*) ecology. Data were collected from November 1997 through May 1998 and again from December 1998 through May 1999 on the effects of road grooming on bison in the Madison-Gibbon-Firehole area of Yellowstone National Park. The study area roads were surveyed by crewmembers for use by bison. The trend for both seasons showed moderate numbers of groups traveling on roads in late fall/early winter, prior to road grooming. Road use leveled off in midwinter before peaking sharply in April. This sharp increase coincided with the beginning of spring melt at lower elevations of the study area and occurred after road grooming had ceased. Bison surveys of the entire study area were conducted over both field seasons. These surveys provided data on bison locations and behavior from over 28,000 bison observations. During the road-grooming period, 18 percent of observed bison travel took place on groomed roads. Most travel (57 %) took place off of roads and established trails. For December through March, travel accounted for only 0.7 percent of observed snow-displacing bison behavior, while foraging accounted for 42.5 percent. Bison appeared to utilize corridors such as waterways for off-road travel pathways. Location data, along with data from infrared trail monitors, were utilized to assess the aspects of off-road movements. These data indicate that the Mary Mountain trail between the Hayden Valley and the Firehole continued to be the major route for bison winter distributional shifts.

## HABITAT RELATIONSHIPS OF SYMPATRIC MOOSE AND ELK IN THE GARNET MOUNTAINS OF WESTERN MONTANA<sup>TWS</sup>

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A low-density moose population in the Garnet Mountains of western Montana is being studied to evaluate the effects of managing forest habitats for elk. From 1993-1996, over 2800 locations from 69 elk were collected and analyzed to evaluate the long-term effects of timber harvest on habitat use, home ranges, and distribution

of elk as part of the Chamberlain Creek Elk Studies. This has provided an opportunity to evaluate a sympatric moose population, of interest to local land managers. Since January 1998, > 700 locations of 18 radio-collared moose have been obtained to evaluate moose habitat preferences as well as habitat use overlap with elk, and the potential influence of implementing elk management guidelines on this moose population. Additionally, in early January 2000 we counted 44 moose during a helicopter census of moose in the study area. Preliminary results at the end of 2 years of field work were described.

## **SPECIES OCCURRENCE AND DISTRIBUTION OF BATS IN NORTH CENTRAL MONTANA: RANGE MAP CHANGES RESULTING FROM TWO YEARS OF FIELD SURVEYS<sup>TWS</sup>**

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Bat surveys were conducted in north central Montana, as part of vertebrate species inventories of FWP wildlife management areas in 1998 and 1999. As a group, bats are poorly known in Montana. The most basic biological information on bats (species occurrence, distribution, habitat use) has not been collected in north central Montana. Knowledge of the occurrence and distribution of bats would enable conservation efforts to be initiated, if needed, to protect declining species. Occurrence records obtained from the Montana Natural Heritage Program in early 1998 included only 26 records from FWP Region 4. Most were museum specimens collected prior to 1970. The purpose of this study was to evaluate Region 4 Wildlife Management Areas and other FWP properties for potential bat use and contribute to knowledge of the species occurrence and distribution of bats in Montana. We captured over 250 bats using mist-nets, identified them to species, and determined forearm length, sex, age, weight, and reproductive status when possible. We documented large range extensions for the fringed myotis (*Myotis thysanodes*), which is a Species of Special Concern and dramatically increased the known occurrences of several other species. Information for some species indicate recent population declines, but for other species we may simply lack information to determine population status. Additional surveys of bats in Montana are needed to fill in these information gaps and get conservation efforts directed where needed most. Conservation actions to reverse population declines are most effective when taken before populations drop to the critical levels that lead to endangered species listing.

## **STORIES FROM A WILDLIFE ADVOCATE<sup>TWS</sup>**

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Being an advocate can affect you professionally, as well as personally. Carefully planning when and how to act is important. As a wildlife advocate for twenty years, I will talk about some of the personal experiences I've faced - and some of the lessons learned.

## SNOW AND CLIMATE DATA IN WILDLIFE STUDIES<sup>TWS</sup>

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Implementation of the snow survey telemetry (SNOTEL) system in the mountainous areas of the west by the Natural Resources and Conservation Service (NRCS) has provided near real-time daily climatic data year-around from areas typically inhabited by wildlife. Parameters measured typically include maximum, minimum, and average air temperatures, precipitation and snow water equivalent. When combined with National Weather Service Climatological Station data at lower elevation valley locations, a profile of climatic data can be extrapolated to most areas and elevations. The availability of daily data also makes it possible to calculate soil moisture and growing degree-days to estimate forage production on summer, transition, and winter ranges and to calculate index of winter severity for different species for various areas. Migration from summer to winter ranges can be related to snow water equivalent. Time of snowmelt and spring green-up can be related to temperature. In addition, analysis of critical climatic data parameters can be used to estimate whitebark pine cone and huckleberry production critical to grizzly bear survival. These data can also be used to estimate winter mortality, reproduction, predation, and physical condition of ungulates going into the winter. These are just a few examples of how climate and wildlife interact. Procedures to develop useable climatic data and algorithms used to develop independent parameters were presented and discussed. Examples of how these data might be used in wildlife management also were discussed.

## A BLACK-TAILED PRAIRIE DOG CONSERVATION STRATEGY FOR MONTANA<sup>TWS</sup>

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Evolution of black-tailed prairie dog (*Cynomys ludovicianus*) conservation in Montana is documented, including initial efforts, development of management guidelines, establishment and composition of a working group, response to the petition to list the species, drafting of a Montana conservation strategy, and relationships between Montana's efforts and those of other states. Updated information on the current status of Montana's black-tailed prairie dog population is presented. Montana's conservation efforts predate those of other states, resulting in a unique leadership role in regional conservation planning. Details of the Montana Conservation Plan are discussed, including the goal of providing for management of prairie dog populations and habitats to ensure long-term viability of prairie dogs and associated species. Five objectives and associated strategies deemed necessary to achieve this goal are described. The relationship between state planning and conservation efforts and potential federal classification is discussed as well as updated information on the status of the listing petition.

## TWENTY-THREE YEARS OF RAPTOR TREND DATA FOR MONTANA<sup>TWS</sup>

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A state-wide system of raptor survey routes was established in 1977 to develop long-term trend data on diurnal raptors. One route is located in each of the states 47 latilongs (degree blocks), and routes average 50 miles long. Routes are run by cooperators during nesting season annually from May 15-June 5. Number of birds seen per 1000 miles of route are calculated by species. Three year running means are presented to reduce effect of uncontrollable variables, and a regression is calculated to illustrate species' trends over the course of the survey effort. Population increases and decreases are reported for species for which this technique is adequate, and an example is provided for a species which cannot be monitored with this technique. Comparisons are made with Breeding Bird Survey data as well as other studies which corroborate and validate this technique. Since use of extensive transect data is not equally valid for all species, cautions are provided.

## ENVIRONMENTAL VARIATION AND DEMOGRAPHY OF A YELLOWSTONE ELK POPULATION<sup>TWS</sup>

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We conducted an intensive 7-year radio-telemetry study (1991-1998) of variations in vital rates of a nonmigratory population of elk in the upper Madison River drainage of Yellowstone National Park, Wyoming. Adult survival rates derived from 185 animal years of monitoring documented consistently high annual survival rates for animals 1-11 years of age (0.97), a pronounced onset of senescence beginning at age 12, and no animals surviving beyond age 15. The major cause of mortality was starvation in senescent animals with logistic regression indicating poorer survival in years with higher winter snowpack. Using fecal progesterone concentrations, we estimated late gestation pregnancy rates ranging from 0.83 to 0.96 annually. Logistic regression detected no significant annual differences in pregnancy rates ( $n=137$  animal years) with a rate of 0.92 estimated for animals  $\geq 2$  years. A comparison of simulation-based parturition calf-cow ratio estimates and calf-cow ratios observed at the onset of winter suggested that 40-50 percent of the calves born each year were lost during the first 6 months of life. Overwinter calf survival, as indexed by changes in calf-cow ratios, was highly variable, with regression models revealing a strong correlation between annual variation in winter snowpack and calf recruitment. All documented overwinter calf mortality was attributed to starvation with the most severe winter conditions resulting in the virtual elimination of the juvenile cohort. Data collected in the study were synthesized into a population projection model by combining stochastic Monte Carlo simulations and the bootstrapping technique and suggested a considerable degree of stability in the system, in spite of substantial variability in final population sizes.

## PROFESSIONAL ETHICS AND RESOURCE MANAGEMENT IN THE NATIONAL PARK SERVICE<sup>TWS</sup>

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The credibility of our profession depends on how we as wildlife biologists respond to the ethical challenges confronting us. Institutional tendencies, human nature, and political pressures exert an increasingly powerful influence on our daily activities. This may result in the transfer of information favorable to the leaders and culture of an organization rather than to the resource. Yet our ethical standards for professional conduct dictate avoidance of activities "detrimental to the well-being of the wildlife resource and its environment." This dilemma is compounded in the National Park Service, an agency that has yet to live up to its mandated role in environmental leadership and resource protection. Contemporary examples of ethical challenges will be presented in the context of the history and traditions of that agency.

## FETAL DEVELOPMENT AND TIMING OF BIRTHS OF YELLOWSTONE NATIONAL PARK BISON<sup>TWS</sup>

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Historical and contemporary reductions in Yellowstone National Park (Y P) bison (*Bison bison*) allowed us to describe changes in fetal development and timing of births over years and by herd. Fetuses were collected from 244 bison cows that were killed in various management actions (20 January-6 February 1941,  $n = 74$ ; 16 January-1 April 1989,  $n = 49$ ; 20 November 1996-6 March 1997,  $n = 88$ ; and 8 January-15 April 1999,  $n = 33$ ). We recorded collection date, herd, and weight (g) for each fetus. Assuming mean gestation length at 281 days and mean birth weight at 25,000 g, we estimated calving dates. Fetal weights varied from 64 to 27,000 g. Subsequent fetal ages were estimated at 96 to 286 days. Median predicted birth dates varied from late April in 1941 and 1989 to early May in 1997 and 1999. Median predicted birth date in 1941 was approximately 11 days earlier than contemporary estimates. Contemporary birth date estimates were approximately 1 week earlier for the Northern Range (NR) herd than the Central herd. Median predicted birth dates were

consistent with previously reported peaks, calf-to-adult ratio estimates of peak calving, and births of captive YNP bison calves. However, estimated births were highly skewed, with calves appearing up to 17 weeks beyond the herd peaks. For the NR and Central herds, 90 percent of births would have occurred by late May, 95 percent by mid to late June, and 99 percent by late July to late August. Knowledge of birth dates could allow managers to reduce the risk of contact with cattle during critical periods when brucellosis is suspected to be transmittable.

## **DEVELOPMENT OF AERIAL SURVEY METHODOLOGY FOR BISON POPULATION ESTIMATION IN YELLOWSTONE NATIONAL PARK<sup>TWS</sup>**

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Aerial survey methods for statistically rigorous bison population estimation are being developed for Yellowstone National Park (YNP) to support sound resource management decisions and to understand bison ecology. This survey methodology quantifies a sampling universe and sampling units, standardizes search effort, and employs a stratified sampling design, which accounts for undetected animals. Including seasonally occupied areas outside YNP boundaries, 76 survey units with area of 2,339 km<sup>2</sup> comprise the entirety of our designated survey extent, roughly equivalent to 26 percent of the area of YNP. The same survey units and total extent are used both in winter and in summer, but survey units have different strata designations for each season. During winter, 52 percent of the entire survey area is designated to be in the high density stratum, although in summer, 41 percent of this area is in the high density stratum. Concurrent intensive ground surveys, or 'double sampling', in the Madison-Gibbon-Firehole areas and the Northern Range in winter were used to estimate the magnitude and variability in detectability during specific aerial surveys. In comparing these simultaneous ground and aerial surveys primarily in winter, only 84.3 percent of the groups were detected on average from aircraft, although 94.8 percent of individual bison were detected. During the summer breeding period, as much as 70 percent of the entire bison population is aggregated in significantly larger, highly visible groups in Hayden Valley than observed during winter. Low variability between counts and high detectability suggest that precise and unbiased population estimates should be readily obtainable.

## EFFECTIVENESS OF COVERED TRACK PLATES FOR DETECTING AMERICAN MARTEN<sup>TWS</sup>

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I assessed the effectiveness of covered track plates for detecting American marten in western Montana by 1) estimating the probability of detecting marten when they are present on a survey unit ( $POD_{su}$ ), 2) estimating the probability of detecting a particular individual that resides on a survey unit ( $POD_{ind}$ ), and 3) assessing the behavior of marten near track plates. Additionally I tested the validity of deriving  $POD_{su}$  from latency to detection (LTD). I radio-collared and branded the toe pads of 1-2 marten on each of 10 10.44-km<sup>2</sup> survey units. I located marten daily during 12-day survey periods. Concurrently, I deployed track plates as per the USFS protocol. Additionally, I monitored a subset of track plates with modified telemetry systems (MTS) that logged the presence of marten near plates. Radio locations indicated that all collared marten were present on their respective survey units and should have been detected by plates.  $POD_{su}$  was fairly high ( $POD = 0.70$ ,  $n = 10$ , 95% CI: 0.42 – 0.98), but  $POD_{ind}$  was quite low ( $POD_{ind} = 0.067 - 0.133$ ,  $n = 15$ , 95% CI: 0.00 – 0.31). MTS data indicated that 2 of 8 marten approached track plates, but never entered.  $POD_{su}$  derived empirically was lower than that derived from LTD. Track plates seem to work acceptably well in areas where marten densities are relatively high. However, low  $POD_{ind}$  indicates they may not work as reliably in areas with low marten density. More research is required to determine how POD varies with marten density, home range, behavior, and environmental variables.

## HUNTING AND FISHING RIGHTS, TREATIES, COURT CASES, THE TANGLED WEB OF HISTORY, OR THE POLITICS OF RESOURCE REGULATION<sup>TWS</sup>

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One underlying purpose of Indian treaties was to enable the Indians to sustain themselves to maintain their livelihood on the reservations. Some treaties expressly guaranteed that Indians could continue certain subsistence activities (including hunting and fishing primarily, but also gathering, cutting timber and grazing livestock) outside the boundaries of their reservations in common with non-Indian citizens. All treaties expressly or implicitly reserved an exclusive right for tribes to carry out subsistence activities inside their reservations. These guarantees are generally known as “reserved rights.” Courts have spent almost a century grappling with these subsistence rights themselves, governmental jurisdiction over such rights, and Congress’ intentions towards them.

## SELECTIVE USE OF BLACK-TAILED PRAIRIE DOG COLONIES BY MOUNTAIN PLOVERS—A SECOND LOOK<sup>TWS</sup>

Craig J. Knowles

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A study conducted by Knowles et al. (1982) in 1979 documenting the selective use of black-tailed prairie dog (*Cynomys ludovicianus*) colonies by mountain plovers (*Charadrius montanus*) on the Charles M. Russell National Wildlife Refuge (CMR) in north-central Montana was repeated in July 1999. During the 20 year interval between plover surveys, prairie dog acreage in the survey portion of the CMR declined from 908 ha to about 200 ha in 1999 due to an apparent epizootic of sylvatic plague from 1992 to 1996. The 1979 survey recorded an average of 9.1 mountain plovers per survey run with 99 percent of these observations being recorded on prairie dog colonies. The 1999 survey recorded an average of 0.5 mountain plovers per survey run along the identical survey route. All 3 mountain plovers were observed on 1 of the few non-plague impacted prairie dog colonies remaining in this area. Within the survey portion of the CMR, prairie dogs are necessary to provide suitable habitat for mountain plovers. Prairie dogs reduce vegetation height, total plant cover and plant litter, and increase the amount of bare ground. Large, closely spaced prairie dog colonies are probably important for the long-term persistence of mountain plovers on the glaciated plains in north-central Montana.

## ELECTRICITY IN WILDLIFE MANAGEMENT; THE SHOCKING TRUTH!<sup>TWS</sup>

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Behavior, movements, and survival of several wildlife species have been successfully managed with electrified fences. Electric fences have protected endangered black-footed ferrets (*Mustela nigripes*) from predation by excluding coyotes (*Canis latrans*) and badgers (*Taxidea taxus*) from >1,000 acre black-tailed prairie dog complexes for months in Montana and South Dakota. Several large carnivore species have been successfully excluded from human conflict sites along Montana's Rocky Mountain East Front with a variety of electrically charged wires and configurations. Wolves (*Canis lupus*) have been temporarily contained at release sites inside electrified enclosures to increase establishment success in Arizona and Montana. Wildlife management with electric fences is not a panacea but has been useful in a variety of situations. This presentation reviews our successes and the limitations of these techniques so that others may learn from our experiences with electric fencing in wildlife management.

## CANYON WREN OBSERVATIONS IN SANDERS COUNTY MONTANA DURING 1999<sup>TWS</sup>

Gene Miller

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Canyon wrens (*Catherpes mexicanus*) have been observed between Weeksville Creek and Munsen Creek, approximately 100 miles northwest of Missoula, during the last 15 years on this northern edge of their known range. Since there is little information on canyon wrens for this area, an effort to gain basic information (local distribution, density, nesting phenology, seasonal occurrence, territory components) was initiated on 20 February. Surveys were conducted along cliff/talus habitat north of the Clark Fork River for approximately 5 miles. Sixty-eight sites were surveyed using playback of recorded canyon wren songs, resulting in observed responses at 16 sites and a total of 206 separate observations during a 12-month period. Canyon wrens were observed in this area during each month. Pairs, nests, first-nest fledglings, and second-nest fledglings were found at 6, 2, 6, and 4 sites, respectively. Fledglings were first found on 6 June at the base of talus in 3 territories. Second nests were found on 27 June with young leaving the nest on 11 July. Four fledglings were found at 1 territory. Territories where fledglings were found ranged in size from 10,000 to 49,000 m<sup>2</sup> (talus 6,000-38,000 m<sup>2</sup>/cliff 3,000-11,000 m<sup>2</sup>). Other territory components include elevation (742-1036 m), slope (30-40°), aspect (170-210°), and mean size of rock at talus base (62-115 cm) and mid-elevation talus (14-46 cm). This observational study has contributed to the limited knowledge for canyon wrens, has documented that they can nest twice each season this far north, and that they are yearlong residents near the northern limit of their range.

## MULTI-SCALE ANALYSIS OF FIRE-KILLED DEAD FOR MANAGEMENT OF WOODPECKERS<sup>TWS</sup>

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Fire-killed dead is an important landscape component as well as critical habitat for many wildlife species. Salvage sales are common on National Forest lands after wildfires and result in loss of habitat for many species, including woodpeckers. Limited information is available to help design salvage sales to maintain adequate habitat for these woodpeckers. We propose a multi-scale analysis of this important habitat. This analysis was done for wildfires that occurred in 1998 on the Lolo National Forest in western Montana, which resulted in the decision to salvage within only one fire. Within this fire, we assumed that all stands of fire-killed dead were of equal value to woodpeckers, regardless of patch size or location and a portion of the fire-killed dead was proposed for logging. To test this assumption, we inventoried the fire in 1999 and located 29 woodpecker nests within the 600 ha of stand replacement fire. Results indicate that within the stand replacement burn,

burn intensity, patch size and patch location may be important indicators of the relative value of patches for several woodpecker species. This information can be used to help plan future salvage sales.

## **ASSESSING PATTERNS OF URBAN DEVELOPMENT TO PREDICT FUTURE HABITAT AVAILABILITY AND SPECIES DIVERSITY<sup>TWS</sup>**

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The western portion of the United States is the fastest growing region in the country in both population and per capita income. With growth and increased wealth come development and the conversion of lands from natural habitats to urban and rural residential landscapes. Loss and alteration of habitat directly affect members of biotic communities. As habitat loss is the leading cause of species' extinction and endangerment, it is wise to assess habitat availabilities and roles in biodiversity prior to extensive land change or fragmentation. This study employs a GIS and aerial photographs to determine the pattern of urbanization in the Gallatin Canyon/Big Sky planning district of Gallatin County, Montana. Analysis of building locations in reference to vegetation identifies those habitats most often chosen for development. Multivariate analysis is used to assess the correlation of abiotic and biotic variables with development. The results of this analysis are used to assess the similarity of all undeveloped areas to those that have been impacted by development. Species distribution models from the Montana GAP project are used to classify suitable/unsuitable habitat for all potential vertebrate species (excluding fishes) and assess biodiversity. 'Hot spots' of biodiversity are identified, and the environmental variables at those locations are compared to those in developed areas. The information generated by these analyses is useful to human communities wanting to make better-informed decisions regarding zoning plans and open-space preserves.

## **GROUND –BASED RADIOMETERS, REAL-TIME GPS RECEIVERS, AND LASER RANGEFINDERS—NEW TECHNIQUES FOR ESTIMATING VEGETATION PARAMETERS AND ANIMAL USE SITES<sup>TWS</sup>**

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Wildlife personnel have long desired methods to estimate live herbaceous biomass and utilization at a fine scale over large areas. New techniques incorporating ground-based radiometers and satellite imagery may provide methods for estimating biomass at different times during the growing season, thereby allowing utilization to be estimated by differences between estimates. Although these techniques are very promising, they are not without limitations. Preliminary results for biomass estimation in the Hayden Valley of Yellowstone National Park, the Sun River Game Range, and a portion of the Missouri Breaks area will be presented along with some of the limitations of this technique. The non-destructive methods of biomass estimation with ground-based radiometers are particularly suited for monitoring selected locations over time as long as they can be

precisely located. Real-time GPS can provide a far more accurate way to relocate monitoring sites than the averaging mode of commercially available GPS receivers or military PLGR's. Initial results indicate real-time GPS can relocate positions within 1m, making the combination of ground-based radiometers and real-time GPS ideal for monitoring temporal change. Although remote sensing techniques and real-time GPS can greatly increase our ability to accurately assess vegetation parameters, analysis of animal use sites is only as good as the positional accuracy of animal locations. A laser rangefinder and digital compass interfaced with a GPS receiver can provide positional accuracy of animal use sites consistent with the accuracy of sampling data. Although an accuracy assessment has not been completed, preliminary results indicate locations obtained at a distance in excess of 500 m with a laser rangefinder to be within 1m of the true location. In addition to providing more accurate locations for analysis, animal locations obtained with a laser rangefinder can subsequently be revisited using a real-time GPS receiver.

## HAWK SHOOTING: NOT JUST A PROBLEM OF THE PAST<sup>TWS</sup>

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During the winters of 1997-1998 and 1998-1999, I investigated the causes, frequencies, and characteristics of human-related winter mortality of raptors in the Mission Valley, Montana, by systematically searching along roadside corridors for dead birds. Surveys included both primary and secondary roads, and most were paralleled by power lines. I found a total of 126 dead raptors during the two winters, including 58 in 1997-98, and 68 in 1998-99. Nine different species were found, but most were Rough-legged Hawks (*Buteo lagopus*) (49%) and Red-tailed Hawks (*Buteo jamaicensis*) (29%). Of 88 birds collected and examined, 74 (84 %) were shot, 8 (10%) were electrocuted, 4 (5%) the cause remained unknown, 1 (1%) died by collision, and 1 (1 percent) died from predation. Those not examined were either too scavenged or too decomposed for necropsy, but did not differ in location from those examined. Although 52 percent of dead birds were found directly beneath power poles or lines, and dead birds were found under a wide variety of pole configurations, very few were actually electrocuted. Furthermore, electrocuted birds were associated with only a few types of pole configurations, and most included jumper wires and/or transformers. As for characteristics, shot birds more often had shattered bones and bruising and/or hematomas and were characterized by shearing of flight feathers, sprayed or spattered blood, and bullet fragments within entrance wounds. Electrocuted birds always showed some evidence of burns, but many (44%) required magnification optics to verify singeing of feathers. Curled, deformed, or incinerated talons also occurred with many electrocutions (33%). So, although electrocution and car collision are well recognized as major causes of winter mortality of raptors, and continue to be major sources of raptor mortality around the world, in certain areas shooting may still be the leading cause of raptor mortality.

## THE USE OF FECAL CORTICOSTERON AND BEHAVIORAL OBSERVATIONS TO EVALUATE HUMAN DISTURBANCES TO BIGHORN SHEEP<sup>TWS</sup>

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This study investigated the impact of human activity in Yellowstone National Park through the use of non-invasive fecal corticosterone monitoring and behavioral observations. Intensive behavioral observations were used to determine rates of human related disturbances in four distinct ewe groups and rams. Results indicated that the prevalence of humans did not correlate with the rate of overt disturbances observed in bighorn sheep groups. Foot traffic was the activity least likely to cause overt disturbances, while helicopter traffic caused the greatest and most predictable disturbances. The yearly cycle of corticosterone in free ranging bighorn sheep was determined from the analysis of 348 fecal samples from collared and non-collared rams and ewes. No significant difference was found in radio collared and non-collared bighorn sheep. Results indicated that higher levels of fecal corticosterone corresponded with greater disturbance rates of bighorn sheep groups. Cold temperatures and depletion of forage quantity and quality did not cause detectable increases in environmental stress on bighorn sheep during winter months. Significant increases in the fecal corticosterone levels of both rams and ewes during spring, can best be explained by increases in social activity and the near term conditions of pregnant ewes. Significant differences were also found between mature rams and both ewes and younger males. If the accumulation of disturbances was high enough, populations could experience poor recruitment and higher rates of disease and mortality. The baseline information collected on levels of fecal corticosterone will allow further environmental impact assessments of bighorn sheep and other vertebrate species.

## ADVOCACY AND RESEARCH: CAN CREDIBILITY BE MAINTAINED?<sup>TWS</sup>

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Research in wildlife biology frequently involves an investigation of the relationship between a human-caused perturbation and a vertebrate population; often, the perceived or actual relationship evokes strong emotional and/or economic consequences. A researcher who examines these relationships and is highly partisan generally has little credibility among the public due to real or perceived bias. Whether the bias is real or perceived makes little difference in terms of credibility. For example, a researcher from Safari Club International examining whether a rare ungulate population in Africa would benefit from a trophy hunting program would have credibility similar to a researcher from People for the Ethical Treatment of Animals with a large segment of the public. Most people would expect results from timber company researchers into the effects of timber harvesting on a wildlife species would be quite different than similar research conducted by wilderness advocates. Researchers using public funds are expected and trusted to produce reliable information that can be used in the decision-making process. Wildlife

researchers should strive to eliminate bias and maintain credibility. They should publish their results through the peer-review process *and* make their information available to the public through talks and the media.

## PUTTING THE ADVOCACY TIGER TO SLEEP— A MONTANA CASE HISTORY<sup>TWS</sup>

Jim Posewitz

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Professional ethics and advocacy are timely topics to be addressed by this society. Ethics, as a subject, rarely penetrates the educational curriculums preparing natural scientists for professional lives. Advocacy, one a traditional role of fish and wildlife biologists, became a rare commodity within government as political favor replaced it as the currency of career advancement and leadership. Taken together, ethics and advocacy, pose a powerful question. Are there ethical responsibilities we have as fish and wildlife biologists to be advocates for fish, wildlife and the public interest in those resources? To address this question fish and wildlife professionals need to develop an awareness of our origin and the history of the resources placed in our professional custody. This presentation outlines how fish, wildlife, and portions of the public estate came into our contemporary custody. It also relates personal experiences of the author while in an agency transitioning from a strong fish and wildlife advocate to a politically responsive entity.

## TIGER SALAMANDER AXOLOTLS IN BLUE LAKE<sup>TWS</sup>

Ryan L. Rausher

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The axolotl is a life form of the tiger salamander (*Ambystoma tigrinum*), which retains larval characteristics as a sexually mature adult. This phenomenon, known as paedomorphosis, may be facultative (capable of metamorphosis) or obligate (incapable of metamorphosis). Although paedomorphosis occurs rather frequently in salamander breeding ponds, relatively few larva are actually paedomorphic in these ponds. Populations of salamanders where the majority of larvae are paedeomorphic are rare. The only known population of axolotls in southwestern Montana occurs in the Axolotl Lakes area in Madison County. Other axolotl populations may occur in other ponds or lakes with similar characteristics. This study sought to identify the type of paedomorphosis present in the Madison County population and develop a long-term conservation strategy. Axolotls were captured in June of 1998 and placed in a room temperature aquarium to determine if metamorphosis would occur. All axolotls initiated metamorphosis within 48 days of placement in the aquarium. Diet may have played a role in initiating metamorphosis. Morphological measurements were taken on 204 individuals. Four size classes are apparent. Ages based on skeletal chronology varied from 0 to 12 years with apparent age gaps. Using a Lincoln/ Peterson population estimate, 5220 individuals occupied the lake in 1998. Three groups of axolotls captured in June, 1999 were exposed to three different water temperatures (Cold - 13 °C, Room - 21 °C,

Warm - 29 °C) to determine if metamorphosis was temperature dependent. Some paedomorphs metamorphosed from each tank. However, several paedomorphs in each tank failed to metamorphose well beyond 48 days suggesting a percentage of paedomorphosis may be obligatory. Conservation should begin with protection of Blue Lake from fish introduction.

**PREDICTION AND REALITY: COMPARING LOGGERHEAD SHRIKE  
LOCATIONS WITH PREDICTED DISTRIBUTION MAPS  
BY MONTANA GAP ANALYSIS<sup>TWS</sup>**

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Wildlife biologists and land managers often must make management recommendations with limited information and with limited distributional data for species such as the loggerhead shrike (*Lanius ludovicianus*). The Montana Gap Analysis Project (MT-GAP) may provide a tool to assist with such decisions. MT-GAP is a statewide assessment of biodiversity completed in 1998. For 425 species, ranges were delineated based on existing presence/absence data, and habitat associations were recorded in a wildlife-habitat relationships (WHR) database. After preparing GIS layers to represent specific habitat features, a raster-based modeling approach was used to combine range limits and WHR databases into predicted distributions. The loggerhead shrike model selected a number of shrub cover types, and also selected agricultural and grassland types where they fell within 500 m of the mesic shrub type. An elevation limit of 1950 m also was applied. Predicted habitat was 10,795,456 ha, or 28.35 percent of the state. An independent study recorded 101 locations of loggerhead shrikes statewide from 1997 to 1999. GIS analysis revealed that 44 point observations fell directly within the predicted distribution. To include the average home range size of loggerhead shrikes and to compensate for any locational inaccuracies, buffers then were applied to point observations, and overlap between buffers and predicted habitat was calculated. Sixty nine percent overlap was observed for 282 m home range buffers, and 80 percent for 500 m buffers. Despite the limitations of MT-GAP predicted distributions, they can be useful for broad-scale conservation planning, particularly for species with limited information.

## PREVALENCE OF HANTAVIRUS IN MONTANA—AN UPDATE<sup>TWS</sup>

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The Polson, Wisdom, Gold Creek, Cascade, Cutbank, and CMR areas of Montana were surveyed for rodent density and presence of antibodies to hantavirus from June 1994 to October 1999. Surveys were made from May through October of each year except 1994, which was surveyed from June through October. We captured 7222 individual rodents, consisting of 18 species, within forest, grassland, sagebrush, and meadow habitats. Five of the 18 rodent species were confirmed to be positive for antibodies to hantavirus. Meadow voles (*Microtus pennsylvanicus*), boreal red-backed voles (*Clethrionomys gapperi*), sagebrush voles (*Lemmiscus curtatus*), and yellow-pine chipmunks (*Tamias amoenus*) made up a combined 5.4 percent of the infected rodents. We focused demographic analysis on deer mice (*Peromyscus maniculatus*) which totaled 94.6 percent of the positive rodents. Infected deer mice were predominately males ( $\chi^2 = 7.06$ , 1df,  $P = .0079$ ) and primarily adult males ( $\chi^2 = 90.6$ , 2 df,  $P < 0.001$ ). Deer mice with scars had a greater infection rate than mice without scars ( $\chi^2 = 67.4$ , 1 df,  $P < 0.0001$ ). Polson was shown to have the highest percent of infected deer mice of the 5 areas. Among habitats, sagebrush had the highest infection rates among deer mice. Higher infection rates among deer mice were found in May followed by July, June, August, September, and October.

## ESTIMATING EFFECTIVE POPULATION SIZE IN WILD POPULATIONS FOR CONSERVATION AND MANAGEMENT<sup>TWS</sup>

Michael K. Schwartz

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Gordon Luikart

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David A. Tallmon

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Estimating abundance of wildlife has challenged managers for nearly a century. Relatively recently, wildlife biologists have been employing techniques used by molecular biologists to estimate an abundance parameter, called effective population size. Effective population size is the size of an ideal population that would have the same rate of genetic change as the population under consideration. Effective population size is approximately 10 percent of the census population size, and is an important parameter because it determines the rate of loss of genetic variation, fixation of deleterious alleles, and inbreeding. I will review three methods that take advantage of recent developments in DNA sampling techniques and technology to estimate local, current, effective population size. The first technique is called gametic disequilibrium and requires approximately 90 samples from a

population to estimating effective population size. The second technique is called the heterozyote excess method, which again requires many samples from only one sampling occasion. Due to large sample size constraints, the gametic disequilibrium and heterozygote excess methods are more commonly used with anadromous fish and marine invertebrates. Lastly, the temporal allele method, which requires approximately 30 samples from two sampling occasions may be the most promising for estimating effective population size of endangered vertebrates. Recent advances in molecular genetics have also allowed researchers to "mark" animals by using individual genotypes obtained through either invasive, i.e., capturing animals and collecting ear punches or blood samples, or non-invasive, i.e., collection of scat and hairs, techniques. Combining DNA technology, which allows us to non-invasively mark elusive animals, with well-established capture-mark-recapture techniques provides promising ways to monitor endangered wildlife.

### **A COMPARISON OF NON-INVASIVE SAMPLE COLLECTION TECHNIQUES FOR USE IN GENETIC ANALYSIS<sup>TWS</sup>**

Jeff Stetz, Kris Peterson, Katherine Kendall, and Lisette Waits  
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No reliable information currently exists on the status of the grizzly bear (*Ursus arctos horribilis*) population within Glacier National Park (GNP) or for the Northern Continental Divide Ecosystem in northwest Montana. Recently developed genetic techniques allow us to determine the species, sex, and individual identity of bears using DNA extracted from hair and scat samples. We utilized two non-invasive sample techniques to study grizzly bear population status. Hair corrals were established in a systematic grid in the Greater Glacier area to estimate population density. To assess the power of sign surveys to monitor population trends, bear hair and scat were collected along trails in GNP. Different segments of the population appear to be sampled by the two methods. Only 16 percent of the 200 individual grizzly bears were identified in both sign surveys and hair traps. The female:male ratio of bears identified from hair trap samples was 1.2:1, whereas the ratio sampled in sign surveys was 1:3. To assist future project planning, we compare uses, biases, and costs of estimating population density using genetic techniques to those of traditional telemetry studies.

### **EVALUATING MOTORIZED-ACCESS IMPACTS ON GREATER YELLOWSTONE GRIZZLY BEAR: A POPULATION SLATED FOR DELISTING<sup>MAS</sup>**

Keith D. Stockmann,  
Predator Conservation Alliance, PO Box 6733, Bozeman, MT 59771

Several goals must be met for the US Fish and Wildlife Service (USFWS) to determine that the Yellowstone grizzly bear (*Ursus arctos horribilis*) population has recovered from its Endangered Species Act 'threatened species' status. These goals are broken down into both demographic and habitat objectives. Although some debate exists surrounding the attainment of demographic goals, the USFWS anticipates meeting these goals soon. On the other hand, the realization of habitat requirements for recovery seems unlikely. Recent literature demonstrates that

roads, motorized trails and snowmobile routes all pose serious threats to Yellowstone Ecosystem grizzly bear habitat. The US Forest Service (USFS) is the most extensive land manager in the Yellowstone Ecosystem. Predator Conservation field inventories reveal that USFS of motorized access are incomplete and inaccurate. As part of the Conservation Strategy, the USFWS is developing a scientifically defensible cumulative effects model to evaluate motorized impacts to grizzly bears. This model is needed to both declare recovery and manage the landscape after delisting. However, because the US Forest Service has yet to demonstrate that it can effectively inventory, monitor, and regulate motorized impacts to bear habitat crucial to the long term health of this grizzly population, the inputs for this model are not adequate to produce a reliable output. Due to this problem, I recommend not delisting this population of grizzly bears, until such time that the USFS significantly improve its ability to assess and control motorized impacts to grizzly bear habitat.

## DOCUMENTING GRIZZLY BEAR MOVEMENT PATTERNS WITH GPS TECHNOLOGY<sup>TWS</sup>

John Waller

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Christopher Servheen

Grizzly Bear Recovery Program, US Fish and Wildlife Service,  
Missoula, MT 59812

Grizzly bears (*Ursus arctos horribilis*) currently occur in only five isolated populations: the Yellowstone Ecosystem of Idaho, Montana, and Wyoming; the Northern Continental Divide Ecosystem (NCDE) of Montana; the Cabinet/Yaak Ecosystem of Montana; the Selkirks Ecosystem on northern Idaho; and the Northern Cascades Ecosystem of Washington. The extent of grizzly bear movement between these ecosystems is unknown, but may be nonexistent; no movement between ecosystems has been documented. Linkage between these populations is important to maintain genetic diversity within each population and to lesson the impacts of demographic and environmental stochasticity. Linear human development that occurs within or between grizzly bear habitats can fragment resident grizzly bear populations. Previous research concerning grizzly bear movements through human development corridors or use of "linkage zones" has been hampered by the difficulties inherent to radio telemetry in mountainous terrain. These difficulties include poor accuracy of ground telemetry and limited opportunity for aerial telemetry due to expense, weather conditions, and restriction to daylight hours. Recent advancements in GPS technology may allow us to overcome these difficulties, allowing accurate 24 hour tracking of grizzly bears. In 1998, we initiated a 3-year study of grizzly bear habitat and movement patterns along the US Highway 2 corridor in northwest Montana. This corridor lies between Glacier National Park to the north, and the Bob Marshall Wilderness complex to the south. We captured nine grizzly bears within the corridor and subsequent aerial telemetry established that five of the nine were resident to the corridor and crossed US Highway 2 frequently. In 1999, we attempted to recapture these five individuals and fit them with GPS collars. We did not succeed in recapturing these five individuals, but three GPS collars were deployed on adult females not previously captured in the corridor.

One of the three collars did not function due to internal failure. However, the other two functioned admirably, collecting over 3200 locations over a 114 day period. Here I present some preliminary results from this state-of-the-art positioning system and our plans for continuing research.

## **GALLATIN COUNTY FISH AND WILDLIFE HABITAT ASSESSMENT: A GIS INTERFACE<sup>TWS</sup>**

Bo Wilmer and Bob Garrott  
Fish and Wildlife Management Program, Montana State University,  
Bozeman, MT 59717

Situated directly adjacent to Yellowstone National Park, Montana's Gallatin County provides a gateway to this unique ecosystem for both human recreationists as well as native wildlife. As such, expanding human land use has recently encroached upon historic migratory routes and important habitat for native species. Recognizing this conflict, Gallatin County has developed a comprehensive management plan for "smart growth" that allows for both continued economic development as well as effective conservation of native habitat. However, this plan lacked any inventory of habitat distributions across the County. Therefore, a team of graduate students at Montana State University (MSU-Bozeman) embarked on the first attempt to compile such an inventory. The resulting "Gallatin County Fish and Wildlife Habitat Assessment" represents not only a synthesis of the best available wildlife science, but it also provides for the first time a relevant context of reference data layers in a user-friendly GIS interface. This digital mapping tool allows planners to turn on map layers that are relevant to a particular planning decision. It is our hope that this product will contribute to the County's GIS initiative in a way that encompasses long-term habitat protection in concert with more immediate smart growth.

## **FINAL REPORT ON RECREATION AND WILDLIFE PROJECT<sup>TWS</sup>**

Heidi Youmans and Gayle Joslin  
Montana Fish, Wildlife, and Parks, Helena, MT 59620

The Montana Chapter of The Wildlife Society's Committee on Effects of Recreation on Rocky Mountain Wildlife completed a 3 year project to compile literature on this topic and assemble an on-line bibliography that can be accessed at [www.montanatws.org](http://www.montanatws.org). The Committee, comprised of about 45 active members, utilized approximately 1300 of the 4500 references in the bibliography to prepare a synthesis of literature entitled *Effects of Recreation on Rocky Mountain Wildlife: A Review for Montana*. The effects of recreation on various wildlife species groups, are addressed, including: amphibians and reptiles, small mammals, birds, semi-aquatic mammals, ungulates, carnivores, and the impacts of domestic dogs upon wildlife in the company of recreationists. In addition, the report provides a project overview, guide to the on-line bibliography, and four appendices including position statements, vertebrate species lists, project planning guidelines (MEPA checklists), and regulation and policy references. The project is on-going as efforts continue to build the annotated bibliography and provide on-line second editions to chapters of

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the report. Printed copies of the report are available for \$25 and are being widely distributed across North America and abroad. Approximately 100 individuals participated in this endeavor in some fashion. The project was supported through grants from fourteen entities.





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