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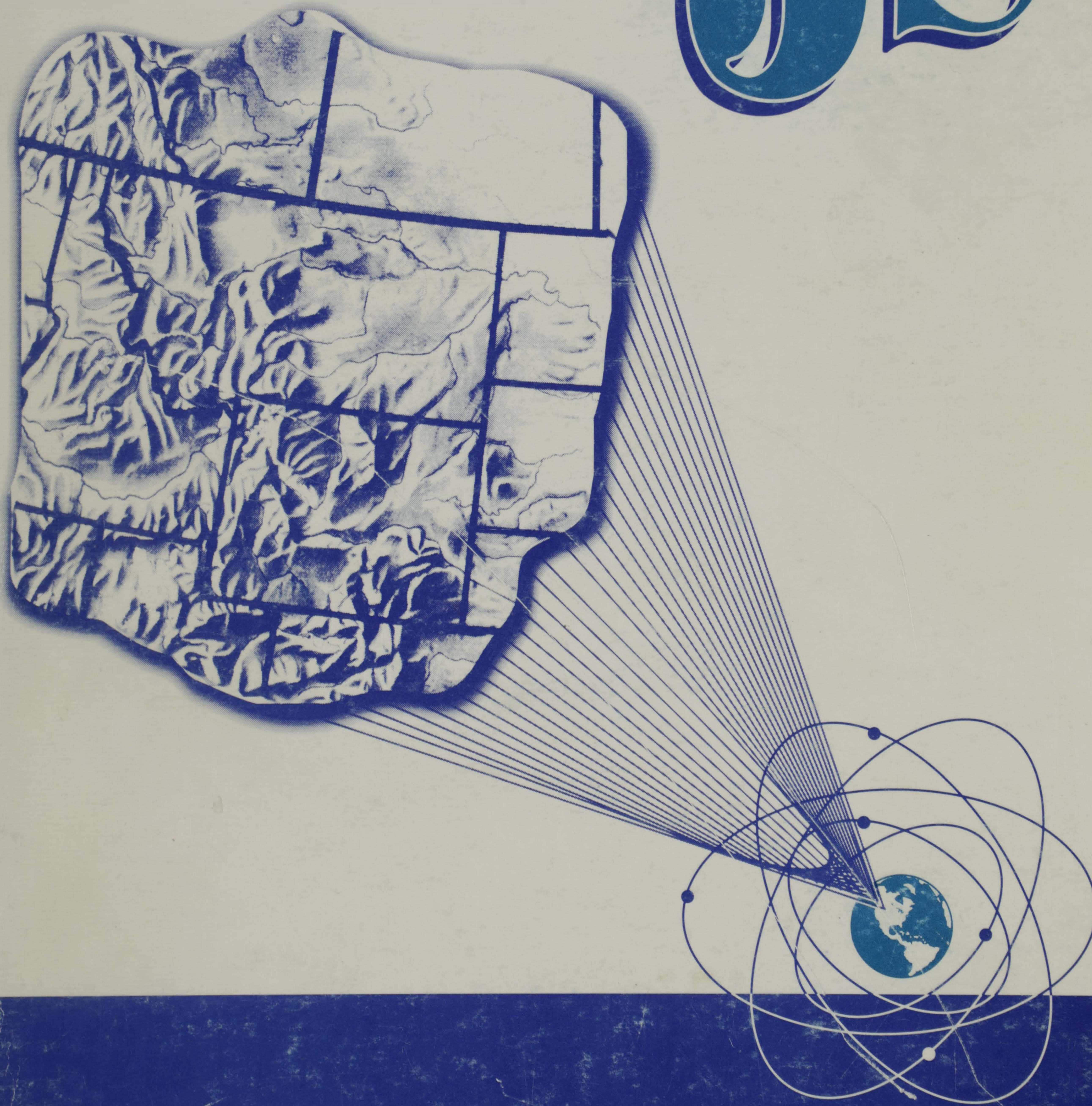

Intermountain Journal of Sciences

The Intermountain Journal of Sciences is a regional peer-reviewed journal that encourages scientists, educators and students to submit their research, management applications or view-points 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.

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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.

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Life Member	1		$ 150.00
Library or Patron	1		$ 25.00
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Page Charges			$ 1,890.00
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Submitted by Kenneth L. Hamlin, BusinessManager - IJS

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.

Three hard copies of the submitted manuscript, with copies of the "Guidelines and checklist for IJS referees" attached are forwarded to the appropriate Associate Editor. The Associate Editor retains one coy of the manuscript and guidelines for his/her review, and submits 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 manuscripts and reviewer comments 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 organizations 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.

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Abstracts

Design and Layout ~ Media Works, Bozeman, Montana
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Matt L. Buhler
Stanley H. Anderson

Human Influence on Avian Assemblages Along The Snake River, Wyoming

Abstract

We conducted bird surveys during the breeding season on eleven 100-m strip transects located within areas used heavily by humans. Bird abundance and composition were then compared to eleven 100-m strip transects of similar vegetation composition and structure to determine what effect human intrusion had upon avian communities. Human-use areas had similar vegetation structure (tree stem density, tree dbh, shrub density, nearest tree, largest log, canopy cover, ground cover, vertical and horizontal cover, and canopy height) and composition (number of snags and plant species) according to statistical analysis ($P \geq 0.05$). Observed differences in avian species composition and abundance could therefore be attributed to the presence of humans. We compared species richness and relative abundance of birds in both treatments. Thirty-six of the 77 avian species observed (47 %) were significantly less abundant where human use was prevalent. The following decreases in avian species richness were observed in the six cover types studied when human use was present: lodgepole pine (Pinus contorta) *(three species), Engelmann spruce* (Picea engelmannii) *(four), willow* (Salix sp.) *(seven), narrowleaf cottonwood* (Populus angustifolia) *(nine), big sagebrush* (Artemisia tridentat) *(nine), and cottonwood/conifer mixture (11). Nine bird species were more abundant in human-use areas: downy woodpecker* (Picoides pubescens), *hairy woodpecker* (Picoides villosus), *dusky flycatcher* (Empidonax oberholseri), *common raven* (Corvus corax), *black-capped chickadee* (Parus atricapillus), *American redstart* (Setophaga ruticilla), *green-tailed towhee* (Pipilo chlorurus), *Brewer's blackbird* (Euphagus cyanocephalus), *and brown-headed cowbird* (Molothrus ater). *Only the common raven ($P = 0.002$) and black-capped chickadee ($P = 0.035$) were significantly more abundant in human-use areas.*

Key words: avian abundance, avian diversity, Grand Teton National Park, human disturbance, riparian corridor, Snake River, Wyoming.

Introduction

Approximately 3 million people visit Grand Teton National Park during an average year, mainly during the summer months. Park managers were concerned about human impacts on songbirds using riparian areas. Eleven areas within the riparian zone along a 40 km section of the Snake River below Jackson Lake dam were heavily used by humans. Those areas included picnic areas, fishing access, and boat launch ramps, which were minimally altered vegetatively. Areas of similar vegetation composition that had little or no human use were located on islands or across the

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river channel, which denied easy access to the public. Comparison of bird communities within areas of heavy human use to adjacent areas with similar vegetation composition and structure allowed us to determine what effect human presence had on bird assemblages.

Some research suggests little correlation between avian abundance and species richness as a result of human intrusion (Confer and Holmes 1995, Riffell *et al.* 1996). Most research, however, indicates that many bird species decline as a result of human intrusion (Knight and Temple 1986a, 1986b, Rodgers and Smith 1995, Steidl and Anthony 1996).

Both direct and indirect human presence can affect bird assemblages. Certain avian species avoided direct association with humans (Knight and Temple 1986a, Gutzwiller *et al.* 1994, Confer and Holmes 1995, Rodgers and Smith 1995, Riffell *et al.* 1996, Steidl and Anthony 1996). Indirect alteration of avian communities has resulted from predator attraction (Wilcove 1985, Sullivan and Dinsmore 1990, Andrén 1992, Miller and Knight 1993, Rudnicky and Hunter 1993, Suhonen 1993), habitat alteration (Lynch and Whigham 1984, Yahner 1988, Robbins *et al.* 1989, Hoover *et al.* 1995), or nest parasitism (Brittingham and Temple 1983, Scott and Ankney 1983, Johnson and Temple 1990, Hahn and Hatfield 1995). Temporal intervals of disturbance are seemingly an important factor when determining human influence on avian assemblages. Certain avian species seemed to tolerate human presence better if the intrusion interval was spaced farther apart (Steidl and Anthony 1996). The birds returned to the area to resume their activity after the intruder left. Gutzwiller *et al.* (1994) found that song occurrence and singing consistency were more affected by 25 percent human disturbance than by 100 percent disturbance. They attributed the increased singing in 100 percent human-disturbed areas to birds discerning observers as non-predators, while the 25 percent disturbance may have caused a reduction in singing to avoid detection.

In addition, if adequate habitat is available, bird species tolerate human activity better (Confer and Holmes 1995). Unfortunately, human use and vegetation complexity is usually inversely related (Askins *et al.* 1987).

Methods of intrusion also were important. For example, birds were more influenced by an intruder walking into a habitat than by a motor boat approaching a colony of nesting waterbirds (Rodgers and Smith 1995). Researchers have concluded that birds may perceive walking humans as predators more so than mechanical vehicles. Predation of songbird nests in human-dominated landscapes also may have decreased bird species richness and abundance (Angelstam 1986, Martin 1988, Baillie *et al.* 1991, Andrén 1992). Increased predation was attributed to predators using ecotones. Predatory species such as American crow *(Corvus imparatus),* common raven, gray jay *(Perisoreus canadensis),* and black-billed magpie *(Pica pica)* were observed scavenging human food scraps. Attraction and subsequent concentration of those species may negatively impact breeding songbirds. Unusually large numbers of common ravens have been reported in the Jackson Hole region (Dunk *et al.* 1994). We assumed that high common raven numbers were due to numerous elk perishing each winter on the National Elk Refuge. Large quantities of carrion possibly increased over-winter survival of scavengers. Nest parasites (brown-headed cowbird) also were associated with human presence (Brittingham and Temple 1983, Rothstein *et al.* 1984). Cowbirds have become established in the Jackson Hole region and seem to be increasing (Cody 1996).

We determined how human

intrusion affected avian species composition within riparian habitat. We defined human-use areas as those that were used for picnic grounds, fishing access, and boat launch areas. Non-use areas were defined as isolated areas that were infrequently visited by humans. Used versus non-used areas were compared to ascertain (1) how various avian species were affected by human intrusion; and, (2) avian species composition within each cover type in areas of human-use and non-use.

Study Area

We surveyed a 40-km segment of the Snake River riparian corridor within Grand Teton National Park in northwest Wyoming from Jackson Lake downstream to the bridge at Moose, Wyoming. The width of the riparian corridor ranged from 0.25 km to 2.6 km (mean = 1.4 km). Elevation decreased from 2066 m at Jackson Lake to 1968 m at the Moose bridge. Primarily stands of mature, closed-canopy lodgepole pine and Engelmann spruce surrounded the upper 10-km segment of the study site (Mattson and Despain 1985). Adjacent habitat along the lower 30-km segment was dominated by big sagebrush and silver sagebrush *(Artemisia cana).* Temperatures varied from a winter low of -40°C to summer highs that rarely exceeded 32°C (Ruszkowski 1996). Annual precipitation averaged 40 cm, mostly consisting of snowfall between December and May (Boyce 1989).

We defined six cover types in the riparian corridor: lodgepole pine, engelmann spruce, willow, narrowleaf cottonwood, big sagebrush, and a mixture of narrowleaf cottonwood/ engelmann spruce/lodgepole pine (Mattson and Despain 1985). The "willow" cover type included a variety of willow species varying primarily with soil moisture.

Methods and Materials

Human-use and non-use areas (11 each) were identified within the study site by personal inspection and through communication with Park personnel. Transects were 100 m in length, originating at the water's edge and extending inland. Each transect was marked at 10 m intervals as well as 50 m to each side for a total area of 10,000 m^2 (1 ha). Transects were at least 200 m apart to ensure independent sampling at each location (Emlen 1971). Preliminary vegetation variables were collected from random locations within each transect according to guidelines set by James and Shugart (1970) and later modified by Noon (1981). We identified adjacent locations with minimal human presence in which we compared vegetation to that in areas of human use through one-way analysis of variance (ANOVA). A preliminary analysis revealed no differences between areas ($P \geq 0.05$). Areas determined to be the most similar to human-use areas (i.e., high P-values) were selected for avian assemblage comparisons to minimize biases caused by variations in habitat composition/ structure. Vegetation analysis was conducted within a 0.4 ha bird-centered circular plots (Noon 1981) based upon activity patterns (singing, foraging, nesting, and perching) of each species (Buhler 1998).

We conducted bird surveys in early morning (0530-1030) and late evening (1900 - 2200) hours during peak singing and displays by breeding males (Crompton 1994, Ruszkowski 1996). Evening surveys were conducted to include thrush species that typically sing during the evening hours (Crompton 1994). Surveys were conducted between 20 May and June 30 during 1996 and 15 May and June 30 in 1997. Each day, we surveyed different areas in random order to assure equal sampling in each of the areas across all hours of the morning and evening. Surveys were not conducted during periods of inclement weather. We conducted eight replicate counts at each transect for a total of 88 surveys in each use category.

Bird surveys were conducted by the same observer who walked each transect at 0.6 km/hour and recorded each individual bird heard or seen within 50 m on either side of the transect. We counted individual birds as independent observations and also counted each flock as a single observation to avoid pseudoreplication. We assumed that bird avoidance decreased as birds became familiar with the observer and transect patterns (Knight and Temple 1986a). Each sighting was recorded separately and included: species, sex, number of individuals, location, and activity. Comparison of diversity and abundance between utilization treatments was done through means as well as presence/absence.

Results

Avian species abundance varied depending on cover type; many exhibited lower (L) abundance in human-use areas and a few were more abundant (H) (Table 1). Those that significantly differed ($P \leq 0.05$) in human-use areas were noted with an asterisk (*). The cottonwood/conifer cover type had a total of 41 avian species; with 19 species (46%) less abundant and three species (7 %) more abundant in human-use areas. Cottonwood totaled 37 avian species, 15 (41 %) less abundant and four (11 %) more abundant. Engelmann spruce totaled 33 avian species, 15 (45 %) less

Table 1. *Avian species for which abundance was lower (L) or higher (H) at sites with high human use for each cover type within the riparian corridor of the Snake River, Grand Teton National Park.*

	COVER TYPE						average # of individual birds	
species	cottonwood & conifer	cottonwood	Engelmann spruce	willow	sagebrush	lodgepole pine	human-use	non-use
black-crowned night-heron				L			0	1
sandhill crane	L				L		0	1.6*
bald eagle							0	1.3*
Cooper's hawk	L*		L*				0	1.3*
red-tailed hawk		L*	L				0	3.1*
American kestrel	L	L					0	1.8
ruffed grouse			L*			L*	0	2.1*
common snipe				L			0	2.7*
great-horned owl	L		L				0	1.4
great-gray owl			L*				0	0.4
common nighthawk							0	2.2*
calliope hummingbird							0	3.5*
broad-tailed hummingbird	L			L			2.5	3.8
Lewis' woodpecker						L*	0	3.2*
red-napped sapsucker						L	0	1.1
Williamson's sapsucker	L						0	1.6*
downy woodpecker							1	1
hairy woodpecker							3	1.4
northern flicker		L			L	H	1.2	2
western wood-pewee	L	L*					0	2.2*
willow flycatcher				L*			1.9	3.8*
Hammond's flycatcher	L*	L*	L*				0	1.6*
dusky flycatcher		H	L	H	H	L	7.5	6.4
tree swallow							1.3	7.5*
northern rough-winged swallow							0	4.2*
gray jay							0	2.6*

Table 1. con't

species	COVER TYPE cottonwood & conifer	cottonwood	Engelmann spruce	willow	sagebrush	lodgepole pine	average # of individual birds human-use	non-use
black-billed magpie	H			H*			1.2	2.6*
American crow		L	L				0	3.7
common raven			H*			H*	5.3*	1.8
black-capped chickadee		H*					4.7*	2.9
mountain chickadee		L	H			L	3.4	6.2*
red-breasted nuthatch	L	L				L*	2.3	4.6*
white-breasted nuthatch		L*				L	0	2.3*
brown creeper	L		H			L*	1	2.3*
American dipper			L				0	1
golden-crowned kinglet	L					L	0	1.5
ruby-crowned kinglet	L*	L*	L*			L*	6.7	12.3*
mountain bluebird		L					1.7	2.1
hermit thrush	L*		L*			L*	0	1.9*
American robin	H	H			H*		9.8	11.2
warbling vireo		L				L	4	4.1
orange-crowned warbler	L						0	1
yellow warbler			L				12.3	15.4
yellow-rumped warbler			L		H		6.1	7.7
American redstart							1	0
MacGillivray's warbler	L	L		L*			0	5.8*
common yellowthroat	L			L*			4	12.8*
Wilson's warbler				L			0	1.9*
western tanager	L		L*			L*	1.3	2.6*
green-tailed towhee							2.2	1.5
spotted towhee	L*						0	0.4
chipping sparrow	L		H		L	L	3.7	6.7*
Brewer's sparrow					L*		0	3.0*
vesper sparrow					L*		0	2.6*
savannah sparrow					L*		0	17.3*
song sparrow				L	L	L	7.8	8.1
white-crowned sparrow		L		L	L	L	2.5	7.8*
dark-eyed junco		L				L	3.6	5.5
red-winged blackbird				L			0	3.3*
western meadowlark					L		0	1
yellow-headed blackbird				L*			0	2.1*
Brewer's blackbird		H		L	H		5.1	4.6
brown-headed cowbird	H*			H*	H*	L	4.5	3.2
Cassin's finch							2	3.1
red crossbill			L			L*	0	3.8*
pine siskin							5.6	10.4*
American goldfinch							0	1.3

* - Significant at $P \leq 0.05$.

abundant and four (12 %) more abundant. Willow totaled 30 avian species, 12 (40 %) less abundant and three (10 %) more abundant. Sagebrush totaled 25 avian species, nine (36 %) less abundant and five (20 %) more abundant. Lodgepole pine totaled 36 avian species, 19 (53 %) less abundant and two (6 %) more abundant.

Of 77 avian species observed, 68 were less abundant in human-use habitats (36 at $P \leq 0.05$) while nine species were more abundant (two at $P \leq 0.05$) or exhibited similar abundance

(Table 1). Those nine species were downy woodpecker, hairy woodpecker, dusky flycatcher, common raven (P = 0.002), black-capped chickadee (P = 0.035), American redstart, green-tailed towhee, Brewer's blackbird, and brown-headed cowbird. Brown creepers *(Certhia familiaris)* were more abundant (P = 0.042) within Engelmann spruce in human-use areas. Brown creepers were, however, significantly less abundant (P = 0.002) in lodgepole pine or in overall abundance's (P = 0.048).

Human-use effects on avian species abundance varied with cover types (Fig. 1). Sagebrush (sage) had nine bird species that were lower in abundance in human-use areas of which three were significant ($P \leq 0.05$); four species were higher in abundance of which two were significant. Willow (willow) had 12 species lower in abundance of which four were significant; three were higher in abundance of which two significant. Cottonwood (cotton) had 15 species lower in abundance of which five were significant; four species were higher of which one significant. Engelmann spruce (spruce) had 15 species lower in abundance of which seven were significant; four species higher in abundance of which one significant. Cottonwood/conifer mixture (C & C) had 19 species lower in abundance of which five were significant; three species higher in abundance of which one was significant. Lodgepole pine (pine) had 19 species lower in abundance of which eight were significant and two species higher in abundance of which one significant.

Both numbers of species and overall abundance (number of individuals) were lower in all cover types in human-use areas than in non-use areas (Fig. 2). For example, willow contained 16

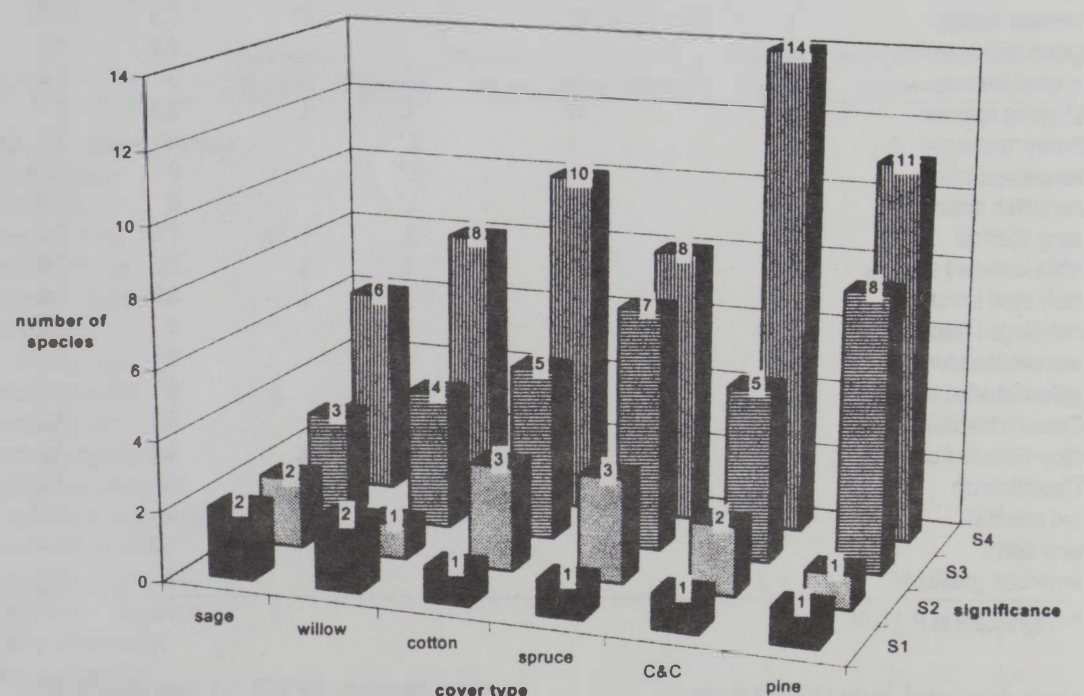

Figure 1. *Human influences on avian species for each cover type. S1 denotes number of species significantly (P ≤ 0.05) higher in abundance in human-use areas. S2 denotes number of species higher in abundance in human-use areas, but not significantly. S3 denotes number of species significantly (P ≤ 0.05) lower in abundance in human-use areas. S4 denotes number of species higher in abundance in human-use areas, but not significantly.*

species in human-use and 20 in non-use areas. A total of 12 species were common to both areas. Human–use areas contained dusky flycatcher, yellow-rumped warbler *(Dendroica coronata)*, American redstart, and chipping sparrow *(Spizella passerina)* in addition to the shared 12 species. Non-use areas contained eight additional species that included black-crowned night-heron *(Nycticorax nycticorax)*, common snipe *(Gallinago gallinago)*, calliope hummingbird *(Stellula calliope)*, northern rough-winged swallow *(Stelgidopteryx serripennis)*, violet-green swallow *(Tachycineta thalassina)*, MacGillivray's warbler (Oporornis tolmiei), red-winged blackbird *(Agelaius phoeniceus)*, and yellow-headed blackbird *(Xanthocephalus xanthocephalus)*. This pattern remained constant in other habitats. Sagebrush was the only cover type that did not show any difference between use areas and non-use areas. The other five cover types showed lower avian species diversity at sites with increased human use.

Discussion

Our data suggest that human use negatively influenced the abundance of avian species within the riparian corridor of the Snake River (Table 1). Within each of six cover types, the number of avian species was lower in areas used by humans as compared to non-use areas (Fig. 1). Those differences were most pronounced in conifer cover types (Engelmann spruce and lodgepole pine). Engelmann spruce stands contained four avian species that were more abundant in human-use areas whereas lodgepole pine only had three. Broad-leaf cover types contained more

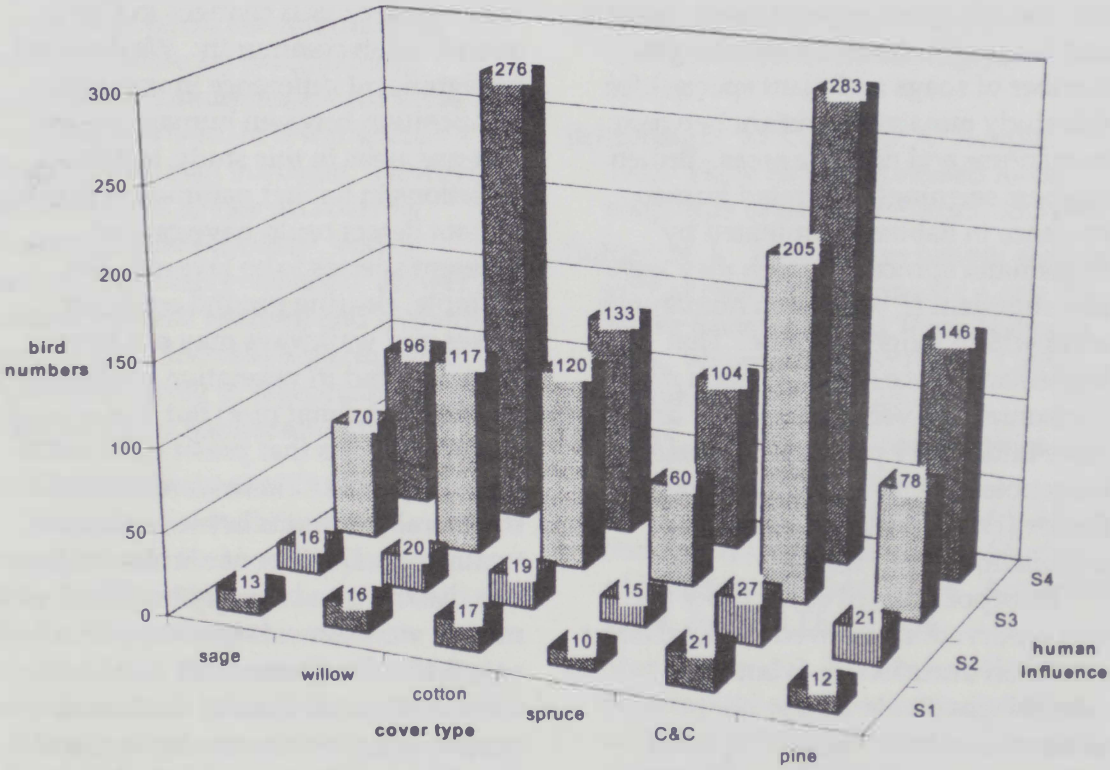

Figure 2. *Average number of bird species and individuals recorded in each cover type for human-use and non-use areas. S1 denotes average number of species observed in human-use areas. S2 denotes average number of species observed in non-use areas. S3 denotes average number of individuals observed in human-use areas. S4 denotes average number of individuals observed in non-use areas.*

avian species that were more abundant in human-use areas. Cottonwood, cottonwood/conifer, willow, and sagebrush cover types had nine, eleven, seven, and nine species, respectively, which increased in abundance within human-use areas. Broad-leafed cover types (excluding sagebrush) had greater horizontal and vertical vegetation structure than coniferous types (Buhler 1998). This additional screening cover may have provided adequate habitat structure, allowing avian species to remain relatively undisturbed closer to human activities (Sherry and Holmes 1985, Holway 1991, Suhonen 1993).

Within Engelmann spruce, brown creepers were more abundant ($P = 0.042$) in human-use areas. Keller (1987) found that brown creepers avoided areas with habitats altered by humans. Habitat variables (e.g. tree stem density, tree dbh, shrub density, nearest tree, largest log, canopy cover, ground cover, vertical and horizontal cover, canopy height, number of snags and plant species) for this study remained constant between human-use and non-use areas. Brown creepers seemingly tolerated human presence in habitats dominated by Engelmann spruce although they were less abundant ($P = 0.002$) in human-use areas within lodgepole pine. That Engleman spruce stands contain more horizontal and vertical structure and more understory plant species than lodgepole pine, as earlier described by Buhler (1998), provided a possible explanation of our results.

Incorporating all cover types and bird observations showed the total effect of human intrusion on avian assemblages (Table 1). For all observations, nine out of 77 species (12%) were more abundant although only two were significant. Those nine species were downy woodpecker, hairy woodpecker, dusky flycatcher, common raven ($P = 0.002$), black-capped chickadee ($P = 0.035$), American redstart, green-tailed towhee, Brewer's blackbird, and brown-headed cowbird. The remaining 68 species were lower in abundance of which 36 were significant (Table 1). The reasons for these patterns are unclear; in this study we did not differentiate between direct and indirect human influences nor did we identify cause-specific differences in abundance. However, habitat alteration would not be a consideration since both areas were of similar vegetation composition.

Both species richness and abundance were greatest in areas not used by humans for all six cover types except sagebrush which had equal species richness (Fig. 2). Past research noted that human intrusion altered the composition of the avian communities (Riffell *et al.* 1996) with the primary explanation being alteration of habitat structure (Confer and Holmes 1995). Alteration of vegetation composition by human use caused changes in the overall avian community. We detected no significant difference in vegetation composition between human-use and non-use areas in this study, but small variations in habitat parameters that we did not detect could have caused different species to be favored. For example, clearing ground cover for drives and walkways may not have been detected in vegetation analysis (0.4 ha circular habitat plot) but was enough to allow species that prefer open cover types to persist. There were some structural variations between the two treatments. Deciduous shrubs, nearest tree distance, and density board 0.0 - 1.0 m high were almost significant ($P > 0.05 \Leftrightarrow \leq 0.10$). For human-use areas, deciduous shrub density decreased, nearest tree distance was farther, and density board measurements decreased. This indicated that the human-use areas were slightly more open than adjacent non-use areas. The openness may have contributed to the number of avian species that were lower in abundance in human-use areas. It may not simply be the presence of humans that lowered avian abundance, but a decrease in vegetation complexity, or combination of factors. Five out of six cover types had lower species richness with human-use. Only sagebrush remained constant with an average of nine species.

Impacts to avian communities can be immense in areas such as the Snake River, which receive extensive human use. Since there is limited road access into this region, human influence can be restricted in a few locations. However, further development and increased access can impact the relative abundance and diversity of birds. The planning of these developments should consider selection of habitat types by birds. Our data suggested that birds in broad-leafed habitats might be more resilient to human intrusion. Habitat requirements for species of concern should be determined and minimal impacts to those areas considered. Sagebrush communities are the most simplistic and contain fewer species affected by human intrusion. However, species such as savannah sparrow *(Passerculus sandwichensis)*, vesper sparrow *(Pooecetes gramineus)*, Brewer's sparrow *(Spizella breweri)*, and western meadowlark *(Sturnella neglecta)* were found exclusively in sagebrush and may be impacted by habitat alteration.

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Initial Effects of a Landscape Ecology Treatment of Coniferous Forest on Small Mammals

Abstract

*We present the initial response of small mammal communities and populations of deer mice (*Peromyscus maniculatus*) and yellow pine chipmunks (*Tamias amoenus*) to thinning and under-burning of mixed ponderosa pine (*Pinus ponderosa*) – Douglas fir (*Psuedotsuga menziesii*) stands in southwestern Montana. Live-trapping on six control and six treated grids from 1992 through 1996 suggested no change in the number of species of small mammals from pre-treatment to immediately post treatment. Numbers of deer mice and yellow pine chipmunks per trap grid were greater on treated grids than on a control grid although the post treatment increase of yellow pine chipmunks was not significant. A separate study in the same area showed an increase in the number of species on treated grids with a shift from boreal red-backed voles (*Clethrionomys gapperi*) on a control grid to meadow voles (*Microtus pensylvanicus*) and long-tailed voles (*M. longicaudus*) on treated grids. Post treatment populations of deer mice and yellow pine chipmunks also were greater on treated grids than on a control grid.*

Key words: Landscape Ecology, deer mouse, *Peromyscus maniculatus*, yellow pine **chipmunk, *Tamias amoenus*, thinning treatment effects, Montana.**

Introduction

We assessed the initial response of small mammal communities and populations to thinning and under-burning included in a USDA Forest Service (FS) "Landscape Ecology" treatment of a coniferous forest in western Montana. Landscape Ecology is a term used by the FS for land management over large areas to address ecological goals rather than commodity production. The management objective was to return the forest to a condition in which ecological processes believed to exist prior to 1860 could resume.

Ponderosa pine (*Pinus ponderosa*) stands are well adapted to periodic fire. In many parts of western Montana, fires have been suppressed and/or livestock grazing reduced the forest fuel load to the point that natural fires effectively ceased by 1900. A consequence of lack of fire is a decline in ponderosa pine in part due to the encroachment of Douglas fir (*Pseudotsuga menziesii*).

Mixed stands of mostly old, even-age ponderosa pine and mixed-age Douglas fir occur on the north slopes of the Flint Range south of Gold Creek, Montana. Fire scar analysis of old trees indicated that fires occurred at about 40-yr intervals prior to 1860. No significant fires have occurred in this area since

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1900. By 1992, the fuel load had increased (primarily from increasing densities of Douglas fir) to the point, that if a fire were to occur, it would probably eliminate the ponderosa pine. The FS attempted to recreate ecological conditions by thinning and under-burning that would allow fire to maintain stands of ponderosa pine.

Thinning, particularly of Douglas fir, should reduce the probability of a catastrophic fire and increase the abundance of understory vegetation that should carry the ground fire necessary to control Douglas fir encroachment and stimulate ponderosa pine generation. Naturally occurring (lightening caused) fires can then be allowed to burn, or controlled anthropogenic fires can be used to simulate a natural fire regime.

The objective of this study was to determine the side effects of thinning and under-burning (treatment) on small mammal communities and populations of common species, deer mice (*Peromyscus maniculatus)* and yellow pine chipmunks (*Tamias amoenus*).

We studied small mammals because they are a significant component of the ecosystem that can be useful indicators in ecological monitoring (Douglass 1989). They form the prey base of nearly all carnivores: coyotes (Wagner 1978, Johnson and Hansen 1979), weasels and ermine (Errington 1967, Maher 1967), and many raptorial birds (Phelan and Robertson 1978, Hamerstrom 1979). Small mammals can have significant impacts on plant communities by modifying plant species composition (Summerhays, 1941, Meuggler 1967, Frischknecht and Baker 1972) and by modifying soil-building processes and nutrient cycling (Grant and French 1979).

We expected thinning and under-burning to alter small mammal habitats that have developed since 1860. Effects of other types of forest treatments on small mammals depend on type of treatment and the species of small mammals. Effects include shifts in species composition and positive, negative, or no effect on common species such as deer mice (e.g., Cole *et al*, 1998, Sullivan *et al*. 1998, Black and Hooven 1974, Sullivan and Sullivan 1982, Ahlgren 1966, Gashwiler 1970, Kirkland 1977). We hypothesized that initially, deer mouse population densities would not change, densities of yellow pine chipmunk would increase as they have in clear cuts (Gashwiler 1970), and if herbaceous cover and litter increase, meadow voles would eventually invade (Birney *et al*. 1976).

Study Area and Experimental Design

The study area was located on the north end of the Flint Range in Western Montana south of Gold Creek. Treated areas were small (< 20 ha), scattered, and at an average elevation of 1585 m. Within several of these prior to treatment, we constructed six 1-ha live-trapping treatment grids. Within 1 km of each treatment grid in similar forest types to be maintained under previous management regimes, we constructed six control grids. During 1992, we trapped only four control grids and four treated grids. For the remainder of the study we trapped six of each. Grids were placed to maximize distance among grids within the study area. Treated stands were previously delineated by the FS. The original plan was to sample during one pre-treatment year (1992) and then for four years following treatment. However, treatment did not occur until 1995 and 1996. Treatment involved thinning in 1995 with under-burning occurring during summer 1996 just before the study ended. Consequently the study consisted of three pre-treatment years with two years post thinning and one year post burning on previously thinned stands.

Methods

We estimated the percent cover of lichens, mosses, grasses, forbs, shrubs, and charred vegetation to determine the effects of thinning and under-burning on understory vegetation. Contact with one of 10 vertical rods mounted in a 0.5 m long point frame was considered 10 percent cover. We collected samples within 0.5 m of each trap on all twelve grids (49 per grid) during August 1992 and again during August 1996.

During July and August from 1993 through 1996, we live-trapped bi-weekly for a period of three nights on each of 12 grids. During 1992 we trapped only eight grids. Each grid consisted of 49 traps set in a 7X7 configuration with approximately 15 m spacing. We trapped each grid for three periods each year. Traps were baited with peanut butter and rolled oats and supplied with synthetic cotton. Beginning in 1994, we reduced our exposure to Hantavirus as suggested by Mills *et al.* (1995) by replacing each trap that had captured an animal with a clean disinfected trap each day. We also wore high efficiency particulate attenuating (HEPA) filter respirators and surgical gloves while handling animals.

We ear-tagged, weighed, sexed, and determined breeding condition (Krebs *et al.* 1966) of all animals. We used body mass as an index to age. We considered deer mice weighing 18 grams or more and chipmunks weighing 30 grams or more to be adults.

We used the enumeration technique (Chitty and Phipps 1966) to determine the minimum number alive (MNA) as an index to population size. We used computer programs provided by C. J. Krebs of the University of British Columbia (Small mammal programs for mark-recapture data analysis) to make the MNA calculations as well as estimates of survival and summaries of age and breeding condition.

We used non-overlapping, 95 percent confidence intervals (Graybill and Iver 1994, Johnson 1999) to identify significant differences between control grids ($n = 4$ during 1992 and $n = 6$ for the remainder of the study) and treated grids ($n = 4$ for 1992 and $n = 6$ for the remainder of the study).

Results and Discussion

Vegetation

The FS management plan required a substantial opening of the forest. Thinning and under-burning reduced the tree density as planned and significantly altered understory vegetation coverage (Fig. 1). On control grids, except for an increase in grass cover, the general vegetation was similar between pre-treatment (1992) and the immediate post-treatment period. Cover of moss, lichens and shrubs decreased on treated grids, primarily because they are perennial and their above ground structures were damaged by fire. Cover of grasses and forbs was similar between pre- and post-treatment periods probably as a result of regeneration from seed or roots that were not affected by fire.

Much of the forest floor was still charred when we sampled vegetation during 1996 (Fig. 1). Some slash was still smoldering but new grass and forbs were growing through the ashes.

Mammalian Species Composition

We captured 1271 individuals of five species of rodents in 23,520 trap-nights (Table 1). Deer mice and yellow pine chipmunks were most common. Bushy tailed wood rats (*Neotoma cinerea*), meadow voles (*Microtus pennsylvanicus*), and western jumping mice (*Zapus princeps*) were rarely captured. Completion of treatments in 1996 obviously did not affect the number of species of rodents captured. Deer mice were the most numerous species on both treated and control grids throughout the study. Yellow pine

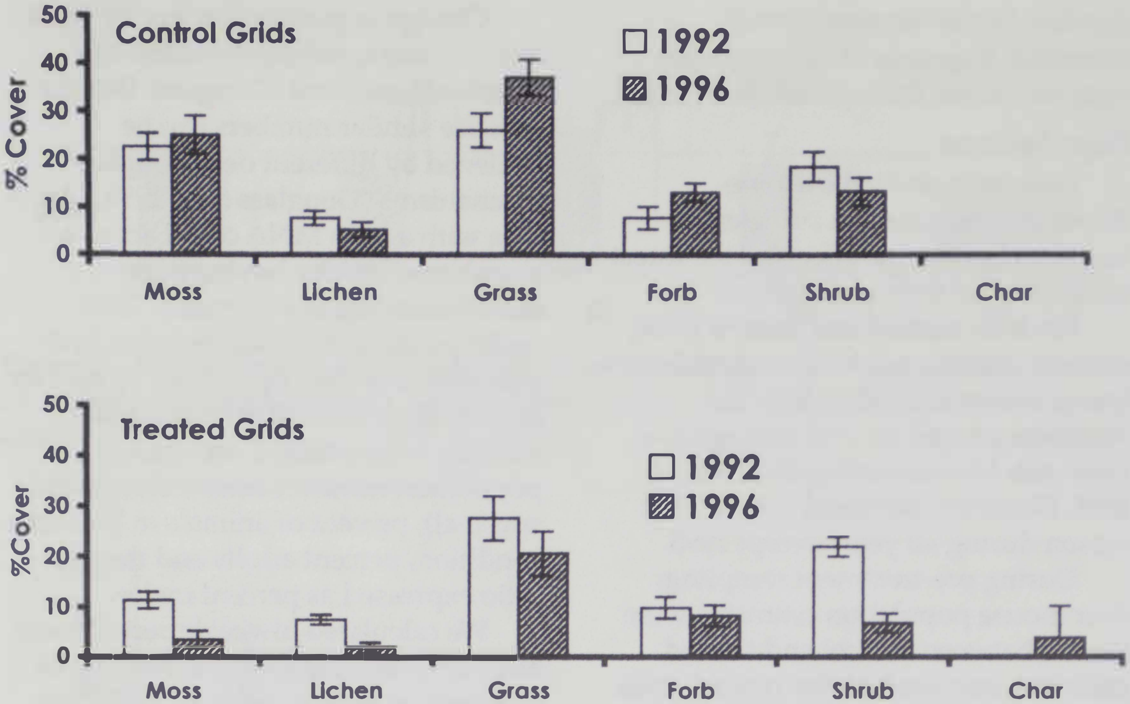

Figure 1. *Average habitat characteristics on six control grids and six treated grids before treatment (1992) and immediately after treatment (1996) near Gold Creek, Montana. Treatments included removal of small Douglas fir trees in 1995 and under-burning in 1996. Bar represents 95 percent confidence interval.*

Table 1. *Number of individuals captured on treated and control grids near Gold Creek Montana from 1992 through 1996.*

		Pretreatement			Thinned	Burned	
	Treatement	1992	1993	1994	1995	1996	Total
Deer Mice	**Control**	34	160	105	62	125	480
(Peromyscus maniculatus)	**Treated**	57	185	102	102	216	677
Yellow pine chipmunks	**Control**	1	8	4	3	11	23
(Tamias amoenus)	**Treated**	8	19	2	3	40	73
Bushy tailed woodrats	**Control**	0	0	0	0	10	10
(Neotoma cinerea)	**Treated**	0	0	0	0	0	0
Meadow voles	**Control**	0	0	3	0	0	3
(Microtus pennsylvanicus)	**Treated**	0	0	2	1	0	3
Jumping mice	**Control**	0	0	1	0	0	1
(Zapus princeps)	**Treated**	0	0	0	1	0	1
Total # of Individuals		100	372	219	172	402	1271
No. species	**Control**	2	2	4	2	3	5
No. species	**Treated**	2	2	3	4	2	4

chipmunks also were relatively abundant. Captures of other species were incidental throughout the study.

Populations

Deer mice and yellow pine chipmunks occurred in sufficient numbers to examine effects of the forest treatments on their populations.

For both control and treated grids, average deer mouse MNA varied from a low of five to high of 27 (Fig. 2). Numbers peaked in 1993 and again in 1996 with lows occurring in 1992 and 1995. Numbers increased through the season during all years except 1993.

During pre-treatment sampling, deer mouse population estimates were similar between control and treated grids but increased on the treated grids after treatment (Fig 2). During eight pre-treatment trapping periods, confidence intervals of populations size for control and treated grids overlapped seven times. This suggests that deer mouse population sizes were not significantly different between the control and treated grids during the pre-treatment period. During three periods of the post-treatment period, deer mouse populations were higher on treated grids than on control grids. Confidence intervals overlapped during the other three of the six post-treatment periods.

Change in population size by itself may not demonstrate the complete effects of treatment (Douglass 1989) because similar numbers can be achieved by different demographic mechanisms (Douglass *et al*. 1992). An area with a high MNA could act as a population sink by having high recruitment but low survival. This could produce high numbers but little persistence of the population. To further explore the effects of thinning and burning we examined deer mouse population turnover rates (recruitment/survival), percent of animals in breeding condition, percent adults and the sex ratio expressed as percent males.

We calculated biweekly recruitment and survival rates for the second week of sampling each year on all grids (Fig. 3). Confidence intervals of average turnover rates overlapped between control and treated grids during all five years. This suggested that recruitment and survival rates were similar after treatment even though treated grids tended to have more deer mice

During seven trapping periods prior to treatment, the percent of deer mice breeding was nearly equal on all grids with control grids having a higher percentage breeding during one period in 1993 (Fig. 4). After the initial treatments, a smaller percent of deer

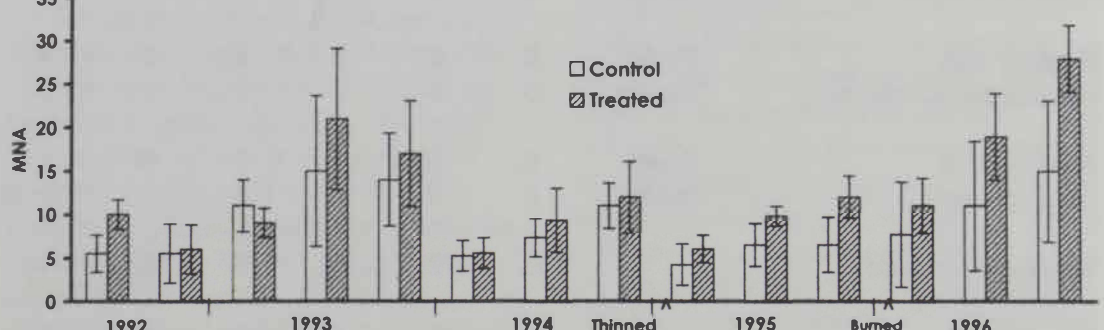

Figure 2. *Average MNA for deer mice on six treated and six control grids near Gold Creek, Montana 1992 -1996. Bars represent 95 percent confidence intervals.*

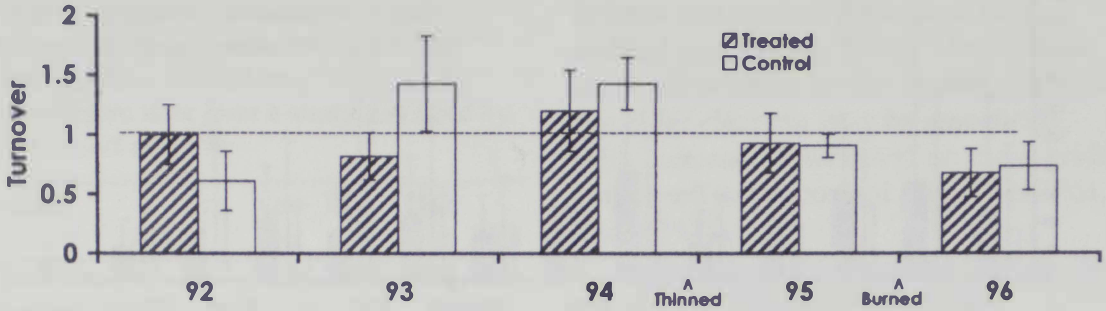

Figure 3. *Population turnover rates (survival/recruitment) for deer mice on six control and six treated grids near Gold Creek, Montana 1992 - 1996. Bars represent 95% confidence intervals.*

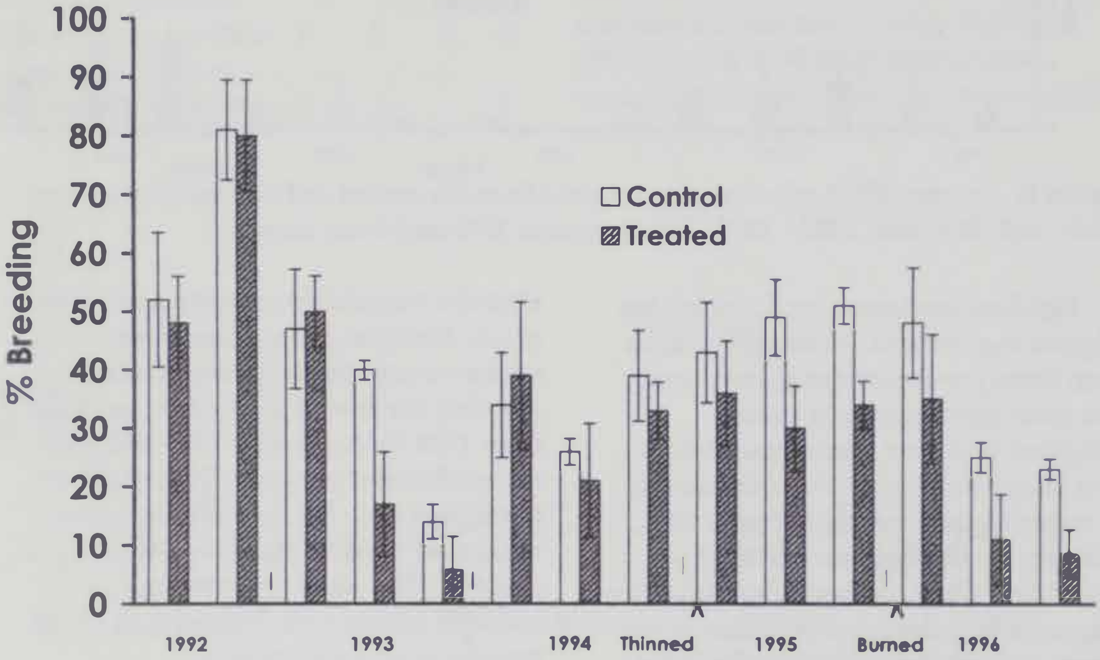

Figure 4. *Percentage of deer mice in breeding condition on six control and six treated grids near Gold Creek, Montana 1992 - 1996. Bars represent 95% confidence intervals.*

mice were in breeding condition on treated than control grids during all trapping periods with confidence intervals overlapping on only two occasions. Because the MNA tended to be higher on treated grids after treatment, this difference could reflect a higher proportion of juvenile non-breeding animals on treated grids. Although deer mouse populations on treated grids had consistently lower average percentages of adults after treatment, differences were small and insignificant (Fig. 5).

Yellow pine chipmunks occurred on all grids during most trapping periods (Fig. 6). Average MNA varied from zero to three per grid over five years (Fig. 6) with highs occurring during 1993 and 1996 on both treated and control grids. Chipmunk MNA was not significantly greater on treated grids than on control grids during these two years (Fig. 6). Also, average chipmunk numbers were higher on treated grids after treatment than anytime during the study but the difference was not statistically significant.

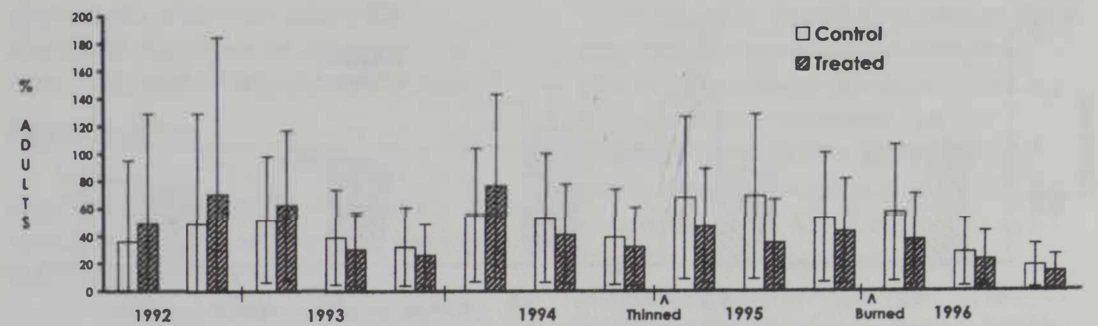

Figure 5. *Average percent of adult deer mice captured on control and treated grids near Gold Creek, Montana, 1992 - 1996. Bars indicate 95% confidence intervals.*

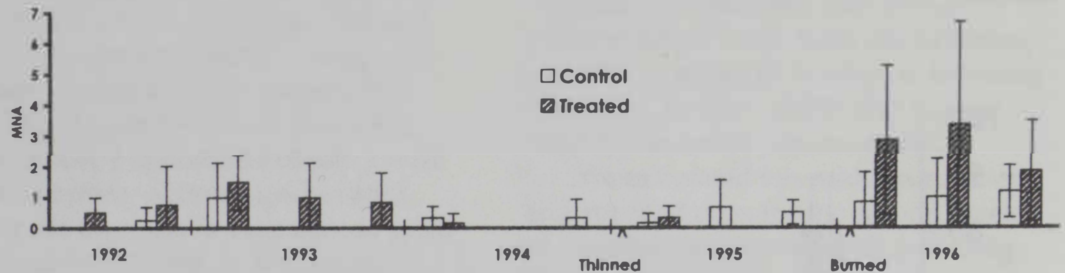

Figure 6. *Average MNA of yellow pine chipmunks on six control and six treated grids near Gold Creek, Montana, 1992 - 1996. Bars represent 95% confidence intervals.*

Delayed treatment confounded the original experiment. However, results from three pre-treatment seasons and two semi-post-treatment years, indicated that deer mouse and yellow pine chipmunk populations increased on treated grids, but the increase in yellow pine chipmunks was not significant. Only continuation under the original study design would clarify the effects of thinning and under-burning on rodent populations.

Results From A Concurrent Study

Some indication of effects for a longer period after treatment than available for this study was gained from another study in the same area that began in 1994, continued over two years post-treatment (Douglass *et al.* 1996), and was designed to monitor Hantavirus in rodents. Three grids similar to those in the current study were live-trapped. One of these grids was placed in a treated area another in a control and a third in an old clear-cut (all trees removed) dominated by aspen (*Populus tremuloides*), shrubs and thick grass. Sampling procedures were similar excep that trapping occurred monthly for five to six months per year from 1994 through May 1999 and there were 100 traps per grid. This study (Douglass *et al.* 1996) provided a non-replicated view of three post-treatment seasons. The clear-cut provides an example of what the treated grid could become over a longer time.

More species were captured from 1994 through spring 1999 (Table 2) than in the current study. A six-month trapping regime probably allowed more opportunity to capture rare species. Potentially significant differences in species composition occurred among control, treated, and clear-cut grids. Boreal red-backed voles (*Clethrionomys gapperi*) were the second most abundant species on the control grid and meadow voles were second most abundant species on the other grids. The apparent decrease in red-backed voles and increase in meadow voles on treated grids has been described for other treatments that reduced tree cover,

Table 2. *Numbers of small mammals captured on three grids near Gold Creek Montana from 1994 through May 1999. Unpublished data from a study described by Douglass et al. 1996.*

Species	Con-trol	Treat-ted	Clear cut	Total
Deer mice	214	379	260	853
Meadow voles	0	79	81	160
Yellow Pine chipmunks	6	65	45	116
Boreal red-backed vole *(Cletrionomys gapperi)*	22	3	4	29
Western jumping mice	0	1	6	7
Long-tailed voles *(Microtus longicaudus)*	0	2	1	3
Northern flying squirrels *(Gloucomys sabrinus)*	2	0	0	2
Northern pocket gopher	0	0	1	1

lichens and mosses (Douglass 1977, Pollard and Relton, 1973). The increase in meadow voles on the treated grid and the older clear cut may be associated with increased litter cover on these grids compared to the control grid (Getz 1961, Grant 1971).

Changes in deer mouse MNA on the control and treated grids of the Hantavirus study were similar to those of the current study for the three years the studies coincided (Figs. 2 and 7). However, the divergence between MNA on control and treated grids seen during 1995 in the current study did not occur and was inconsistent during 1996 and 1997. During 1998 (two years post-treatment), the MNA on the treated grid increased to nearly three times

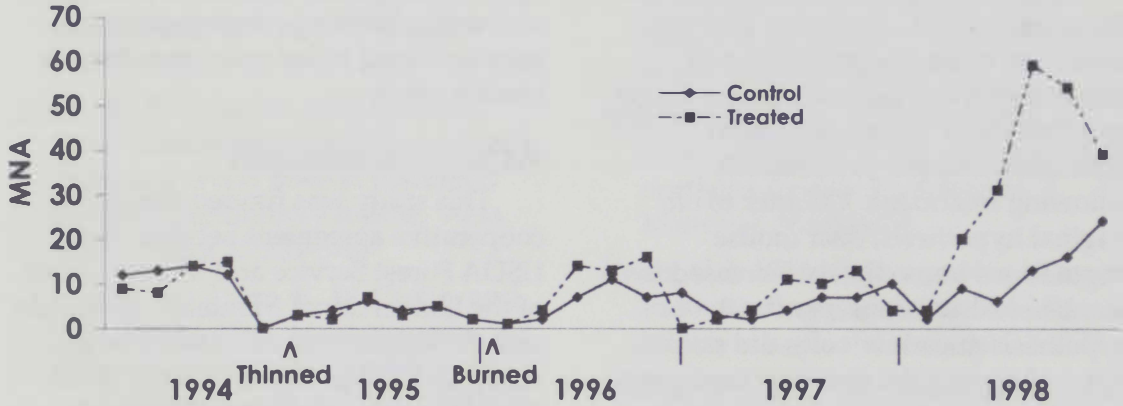

Figure 7. *Deer mouse MNA on one control and one treated grid near Gold Creek, Montana,1994 - 1998. These grids were trapped during a separate study conducted in the study area (unpublished data, Douglass et al. 1996).*

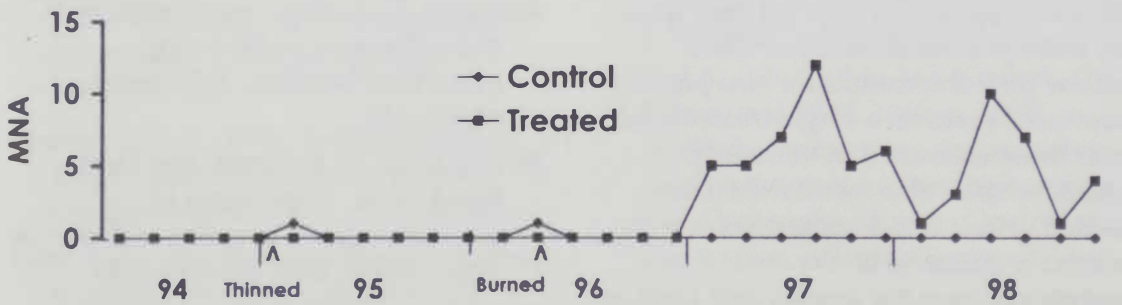

Figure 8. *Yellow pine chipmunk MNA on one control and one treated grid near Gold Creek, Montana 1994 - 1998. These grids were trapped during a separate study conducted in the study area (unpublished data Douglass et al. 1996).*

pretreatment levels and only two times the previous high on control grids. This non-replicated post-treatment increase in deer mouse densities is consistent with the results of the current study.

Except for an occasional capture, Yellow pine chipmunks were absent from both treated and control grids until after treatment (Fig. 8). One year after treatment, yellow pine chipmunks were present only on the treated grid during all trapping periods with numbers reaching maxima of 10 or more animals each year. This type of response of chipmunks was consistent with that described by Gashwiler (1970) and may be a continuation of the initial, though non-significant, response demonstrated in the current study.

Conclusion

Although we were unable to assess the impact of the Landscape Ecology project on rodent populations and communities during more than a single post treatment season, we found significant changes immediately following treatment. Counter to our original hypothesis, deer mouse populations immediately increased in numbers. Also inconsistent with our hypothesis, meadow voles did not respond during the first post treatment year. Consistent with our hypothesis, yellow pine chipmunk populations increased on treated grids but the increase was not significant. Non-replicated data from an ongoing study (Douglass *et al.*1996), also showed increase population sizes for deer mice for three post-treatment years and yellow pine chipmunks for two post-treatment years on a single treated grid near those examined in this study. Meadow voles also increased on the treated grid and red-backed voles were relatively common on the control grid and absent from the treated grid after treatment.

Although we were unable to complete the study as planed, we found considerable evidence that thinning and under-burning affected rodent communities as well as population sizes of some species. Habitat modifications created by treatment allowed deer mouse and probably yellow pine chipmunk population sizes to increase. From a concurrent study we conclude that treatment may eliminate red-backed voles when present and allow the invasion and increase of meadow voles.

The management ramifications are that this type of treatment should increase ecological factors dependent on small mammal numbers (prey base, nutrient cycling). The effect on the biodiversity of small mammals could be that a few locally rare species are replaced by other rare species. For example, red-backed voles and flying squirrels may be eliminated by thinning and under-burning whereas jumping mice and long tailed voles may invade treated areas.

Ackowledgement

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Shawn J. Riley
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A Terrain Ruggedness Index That Quantifies Topographic Heterogeneity

Abstract

Terrain is an important feature of the structural niche occupied by terrestrial species. However, most researchers refer to terrain only in qualitative terms that precludes testing hypotheses about the actual importance of terrain. We present an easily calculated terrain ruggedness index (TRI) that provides an objective quantitative measure of topographic heterogeneity. Our model computes TRI values for each grid cell of a digital elevation model using a "DOCELL" command in an Arc/Info geographical information system that calculates the sum change in elevation between a grid cell and its eight neighbor grid cells. The concept and algorithm we present can be used at any scale relevant to the species of concern and question being asked for which elevation data exist.

Key Words: Habitat, terrain, ruggedness, geographical information systems, Montana

Terrain heterogeneity is an important variable for predicting which habitats are used by species and the density at which species occur across a variety of environments (Koehler and Hornocker 1989, Fabricius and Coetzee 1992), and is often an important component of a species' niche (Whittaker *et al.* 1973). Terrain functions as concealment cover for prey (Riley and Dood 1984, Canon and Bryant 1997), stalking cover for predators (Kruuk 1986), and affects the form and function of species (Geist and Bayer 1988). Terrain also affects the behavior of some species to disturbance from humans (Edge and Marcum 1991). Yet, most researchers describe terrain only in qualitative terms such as undulating, broken, rugged, or dissected. Estimates of terrain heterogeneity have been mostly calculated using labor-intensive techniques or techniques designed for specific areas (Beasom *et al.* 1983, Fabricius and Coetzee 1992, Nellemann and Fry 1995). An easy-to-use, quantitative measure of terrain heterogeneity is needed to test hypotheses regarding terrain as a component of habitat and provide for more informative comparisons between areas.

Beasom *et al.* (1983) presented a technique for assessing land surface ruggedness that was based on the intersection of contour lines on US Geological Survey (USGS) topographic maps and dots from a clear transparency. The technique is useful, but laborious if the area of concern is large. Technological advances in personal computers, the Internet, and software to analyze spatial data have provided easier access to geographical databases and permitted many new uses of spatial data (Koeln *et al.* 1996). As

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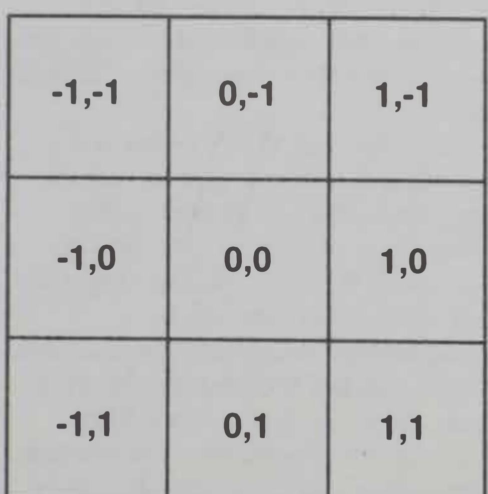
part of a study on the effect of terrain on abundance of mountain lions *(Puma concolor)* (Riley 1998:12-34), we developed a terrain ruggedness index (TRI) that is derived from USGS digital elevation models (DEM) using a terrain analysis function implemented in a geographical information system (GIS). This TRI provides a rapid, objective measure of terrain heterogeneity.

Our model computes TRI values for each grid cell of a DEM using a "DOCELL" command in Arc/Info that calculates the sum change in elevation between a grid cell and its eight neighbor grid cells (Fig. 1). We used a square grid network with 1 km^2 grid cells (Collins and Moon 1981). Grid cell-level TRI values were then averaged across any given area such as a county or hunting district for a total TRI. The TRI values also can be displayed in the form of maps that clearly reveal the distribution of terrain heterogeneity (Fig. 2). In our example, we used an "equal area" classification method to group continuous ranges of TRI values into seven classes of unequal range, but equal area. The range in TRI values for each grouping are as follows: level = 0 - 80 m; nearly level = 81-116 m; slightly rugged = 117 - 161 m; intermediately rugged = 162 - 239 m; moderately rugged = 240 - 497 m; highly rugged = 498 -958 m, and; extremely rugged = 959 - 4367 m. The classification scheme can be easy changed in Arc/Info to meet the particular needs of the map.

Several examples may help clarify the calculations used in our TRI model (Fig. 3). Figure 3a is a simulated peak with an elevation in the center grid cell much greater than in surrounding grid cells. The bowl or pit terrain depicted in Figure 3b is an inverse of Figure 3a and has an equal TRI value. The two types of terrain are viewed equally rugged by the model. A more gentle, undulating landscape is depicted in Figure 3c where the range in elevation is only 25 units and no grid cell has a greatly different elevation than the center.

Digital elevation data are now readily available on the Internet from a variety of sources. We obtained our data electronically from USGS databases (http://www.nmd.usgs.gov/www/products/1product.html). Digital elevation models depict elevations across a specified landscape and may be discrete measurements of elevation or a mean value for a specified portion of the



If each square represents a grid cell on a digital elevation model, then
TRI = Y [$\Sigma(x_{ij} - x_{00})^2$]$^{1/2}$ where x_{ij} = elevation of each neighbor cell to cell (0,0).

The docell command is:

DOCELL ssdiff = ((sqr(el(0,0) - el(-1,-1))) + (sqr(el(0,0) - el(0,-1))) + ... (sqr(el(0,0) - el(1,1))).

TRI = sqr(ssdiff)

end

Where: ssdiff = temprorary scalar, square feet, and el = name of elevation grid.

Figure 1. *A terrain ruggedness model that uses digital elevation model data and an Arc/Info geographical information system.*

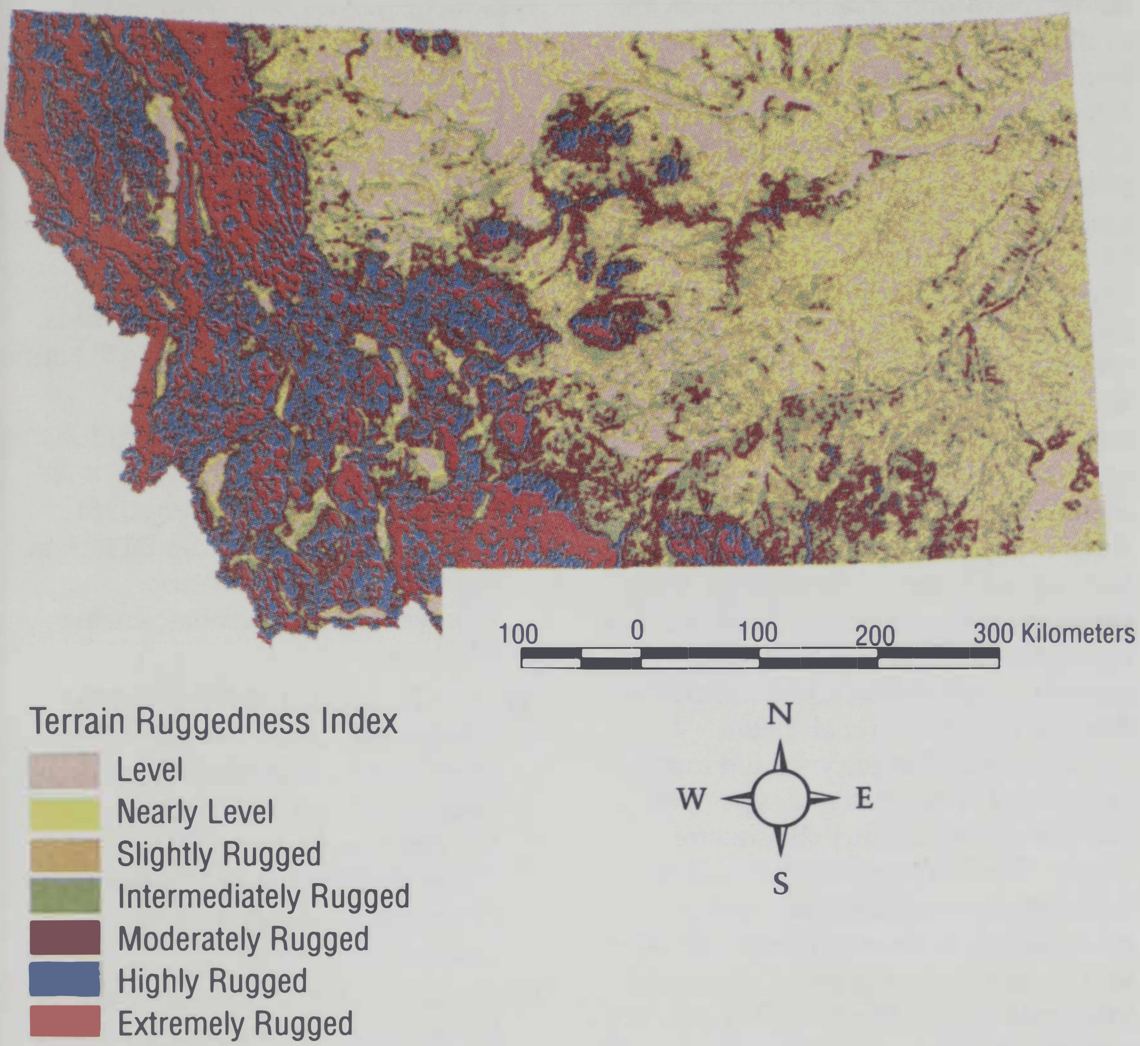


Figure 2. *A terrain ruggedness map for the state of Montana.*

100	125	100
125	200	125
100	125	100

(a)

TRI = 700

200	175	200
175	100	175
200	175	200

(b)

TRI = 700

200	210	220
210	225	225
205	210	220

(c)

TRI = 100

Figure 3. *Hypothetical square grid digital elevation data from a) a peak type topography, b) a pit type topography, and c) a gentle undulating topography and respective terrain ruggedness index (TRI) values.*

landscape (Moore *et al.* 1991). Data are available for the entire United States from USGS 3 arc-second (1° latitude by 1° longitude) DEM of North America.

Researchers must be aware of potential biases that originate in DEMs when TRI values are interpreted. All DEMs contain inherent inaccuracies due to underlying sources of error in original data that were used to generate the DEM (Carter 1989). Whereas a DEM is referenced to a "true" elevation from published maps, there is no way to evaluate the accuracy of the original map data. In addition, most DEMs have some interpolation of elevations which may not accurately represent the true elevation at any particular location. The elevational accuracy of a DEM is greatest in flat terrain and decreases in steep terrain (Koeln *et al.* 1996).

The scale of inquiry should match the species of concern and type of the question under inquiry (Bissonette 1997). The TRI model we present is appropriate with large area habitat analyses where sources of error in DEMs will not appreciably affect biological interpretations of the data. The concept and algorithm we present could be used for smaller areas with higher quality data or corrected DEMs.

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Age and Growth of Channel Catfish in the Lower Yellowstone River, Montana

Abstract

Channel catfish (Ictalurus punctatus) *provide a significant rod and hoop net sport fishery in the Lower Yellowstone River, Montana. In order to obtain age and growth information for fish stock assessment, lengths, weights, and pectoral fin spines from 120 fish were used to back-calculate length-at-age and to fit von Bertalanffy growth curves. Fish ranged in age from 3 to 21 years old. A 300-mm long fish was age-4, a 450-mm fish was age-8, and a 700-mm fish age-14. Maximum observed age of this stock was higher than nearly all other stocks in the literature, and comparable to fish from the Tongue River, a nearby tributary. Growth rates of the stock were also slower than for most stocks. Based on a minimum quality size for anglers of 41 cm, a quality-sized Yellowstone River channel catfish was about age-7.*

Key words: Fish ecology, channel catfish, Ictaluridae, *Ictalurus punctatus*, Yellowstone River, Montana

Introduction

Channel catfish *(Ictalurus punctatus)* inhabit the lower Yellowstone River, a large, turbid, free-flowing river traversing eastern Montana and extreme western North Dakota. The species supports an angling and recreational hoop net fishery in Montana. Although extensive research on the biology and ecology of channel catfish has been conducted (Carlander 1969; Hesse et al. 1982), little information is available for stocks in the extreme northwestern portion of the species' native range. The channel catfish is primarily a warmwater species, and size-at-age and longevity in this extreme portion of their range probably differs from more southerly latitudes. Channel catfish in the Tongue River, a Yellowstone River tributary, occasionally achieved lengths of 750 mm and 19 years of age (Elser et al. 1977). Fish of ages 10 to 15 were common. In contrast, Carlander (1969) reviewed numerous age and growth studies and found only one stock, in Quebec (Magnin and Beaulieu 1965), where fish exceeded age-13. One fish was estimated to be age-22. Vladykov (1951; cited in Magnin and Beaulieu 1966) reported a fish from that province estimated to be nearly age-40. Carlander (1969) also observed that the faster growing stocks tended to be in the southern portion of the species' range.

Our objectives were to (1) determine the size-at-age, maximum age and growth rates of channel catfish from the Yellowstone River, and (2) compare these results to those of stocks from other rivers in the species' range. Differences in age and growth between Yellowstone River fish and those of other locations may necessitate different management strategies. Information collected at this time, when harvest rates

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are thought to be low, may be useful in the future when harvest rates can be expected to increase.

Methods

One hundred twenty channel catfish were collected in May and June 1992 from angler creels and hoop net catches at Intake, a low-head irrigation diversion dam on the Yellowstone River, 27 km downriver from Glendive, Montana. Total lengths and weights were recorded, and pectoral spines were removed for age determination. Sex was undetermined for most of the sample so data were not analyzed separately by sex.

The relation between total length (L) and weight (W) was expressed as $W = aL^b$ where a and b are parameters (Sparre et al. 1989). The length-weight relation was compared to a standard length-weight relation for the species (Anderson 1980) to assess if Yellowstone River catfish were plumper or thinner than fish from other populations.

Spines were sectioned (Marzolf 1955) using a Buehler Isomet low-speed saw. Two sections per spine were cut at 0.6350 mm thickness and mounted on a microscope slide using transparent nail polish. Nail polish allowed for a quick, permanent mount which did not hinder microscopic examination.

Annual marks (annuli), on the spine sections were enumerated (Appelget and Smith 1951) using a Biosonics Optical Pattern Recognition System (OPRS). Annuli appeared as opaque bands. Luminosity plots on the OPRS were used to detect questionable or false annuli. False annual marks were distinguished as less distinct and less luminous bands. After age was determined, distances were measured along a standard axis from the center of the spine to each annulus and to the edge of the spine section.

The relation between spine radius (S) and total length (L) was fitted with a linear model $S = a_1 + a_2L$ and a quadratic model $S = a_3 + a_4L + a_5L^2$, where a_i are parameters. The quadratic model was used in back-calculation. Back-calculated lengths were obtained using the scale-proportional hypothesis (SPH) method as described by Francis (1990).

Back-calculated lengths-at-age were compared with lengths-at-age at the time of capture by development of von Bertalanffy growth curves. The generalized von Bertalanffy growth curves were expressed as $L_t = L_\infty(1-e^{-K(t-t_0)})$, where L_t is the length at age t, L_∞ is the expected length of an infinitely old fish, K is the growth coefficient or curvature parameter (Moreau 1987; Sparre et al. 1989), and t_0 is the time when length is theoretically 0. A growth curve was also fitted by setting $t_0 = 0$, i.e., forcing the curve through the origin. Weight-converted von Bertalanffy growth curves were calculated based upon the expression $W_t = W_\infty (1-e^{-k(t-t_0)})^b$ where b is the parameter in the relation between length and weight.

To investigate if any tendency existed for back-calculated lengths to be less for samples obtained from older fish than for younger fish (Lee's phenomenon; Tesch 1971), von Bertalanffy curves were also fitted separately for fish greater than age-7 (called old fish) and for fish age-7 and younger (called young fish). Confidence intervals were compared to evaluate differences ($P<0.05$ for significance). All curve fitting was conducted using Statistical Analysis Systems (SAS) Version 6.11 (SAS Institute, Inc. 1990).

Length-at-age and longevity data from other studies were obtained from Carlander (1969), Hesse (1982) and Hesse et al.(1982) in order to compare the Yellowstone River channel catfish to those in other localities.

Results

The relation between length (mm) and weight (g) was given by the expression $W = 7.32(10^{-7})L^{3\ 40260}$. A 40-cm long fish thus weighed 0.5 kg and a

70-cm long fish 3.5 kg (Fig. 1). Weight of Yellowstone River fish for a given length was less than for a standard (benchmark) population (Anderson 1980); Yellowstone River fish 30 cm and 60 cm total length weighed 196 g and 2076 g respectively versus 242 g and 2293 g for fish in the standard population.

The channel catfish in our sample ranged from 3 to 21 years old. Although the sample of fish was not random, fish age 10 or older constituted 22 percent of the sample.

The relationship between fish length (L) and spine radius (S) was adequately described by a linear relation $S = 117.00105 + 0.44301L$ ($r^2 = 0.87$; $P<0.0001$; Fig. 2) but was somewhat better described by a quadratic expression $S = 8.21525 + 0.96294L - 0.00054L^2$ ($r^2 = 0.90$; $P<0.0001$; Fig. 2). The quadratic expression was therefore used in back-calculation. Back-calculated lengths-at-age were expressed by the von Bertalanffy growth equation $L = 1149.4004\,(1-e^{(-0.0573*(Age-0.3269))})$; (Fig. 3). Length-at-age estimates were higher based on actual lengths and ages of fish caught than on back-calculated lengths; the expression developed from fish at time of capture was $L = 1676.0959\,(1-e^{(-0.03456*(age+1.2033))})$; (Fig. 3). Based on this equation, a 300-mm long fish was age-4, a 450-mm fish was age-8, and a 700 -mm fish was age-14. The two-parameter growth equation ($t_0 = 0$) had a much lower L_∞ term, but curves were very close over observed fish lengths (Fig. 3). Length-at-age up to age-7 based on back calculations for old fish (>age-7) were significantly less than for fish age-7 or less($P<0.05$; Fig. 3).

The weight-converted von Bertalanffy growth curve for fish at time-of-capture was given by $W_t = 7.32\,(10^{-7})[1676.096(1-e^{(-0.03456*(age+1.2033))})]^{3.40260}$.

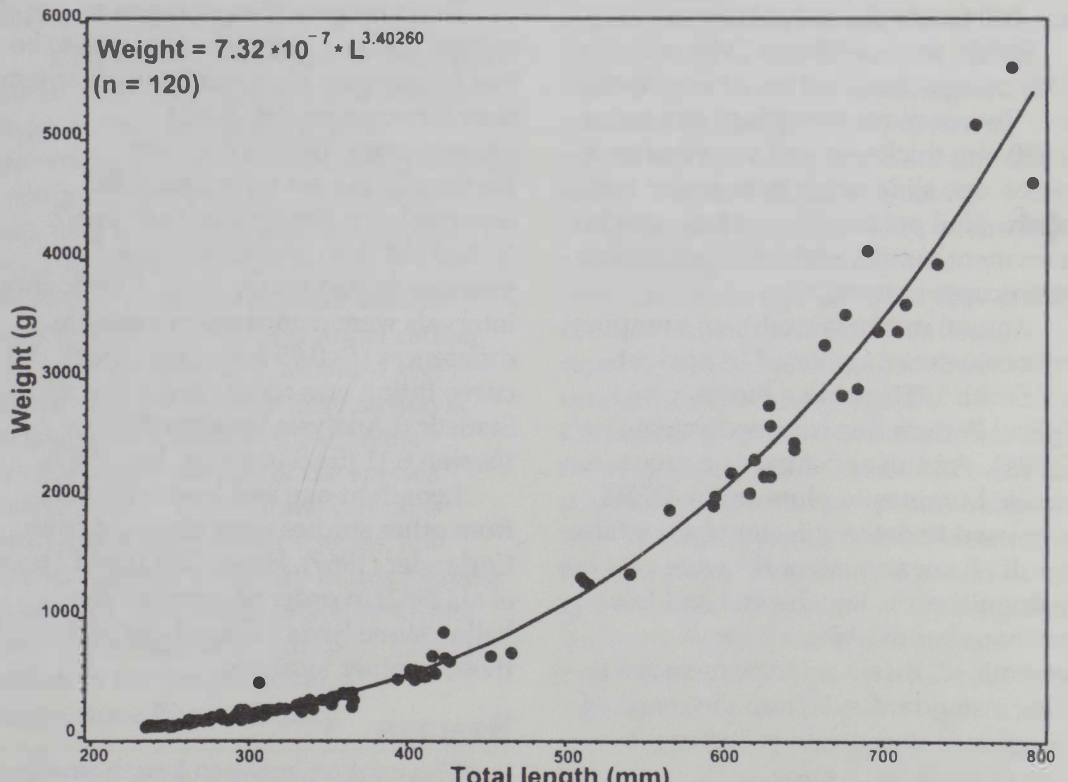

Figure 1. *Length(mm)-weight(g) relationship for Yellowstone River channel catfish, r= 0.99, P<0.01.*

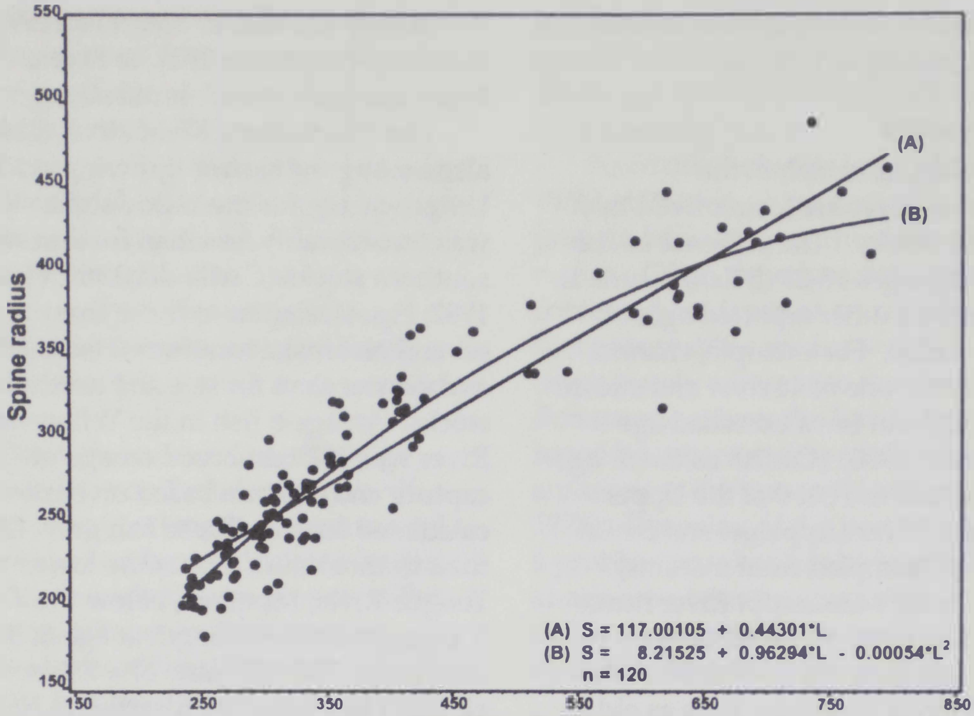

Figure 2. *Relations between spine radius and fish total length fitted with a) a linear model and b) a quadratic model.Spine radius is in Optical Pattern Recognition System standard units.*

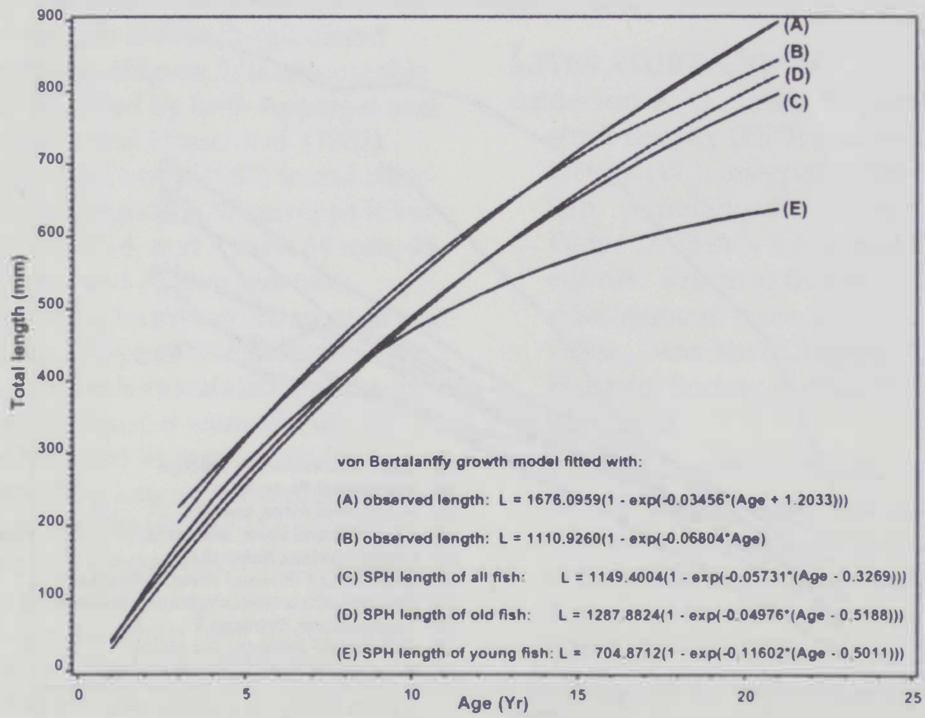

Figure 3. *von Bertalanffy growth curves for Yellowstone River channel catfish based on : a) length at time of capture with t_0 parameter included; b) length at time of capture with $t_0 = 0$ (forced through origin); c) back-calculated lengths at age for all fish; d) back-calculated lengths-at-age for fish greater than age-7; and e) back-calculated lengths-at-age for fish age-7 and under.*

Beyond age-6, there was considerable variation in weight with age.

Discussion

The channel catfish in the Yellowstone River are longer lived than most other stocks. The presence of fish in this study ages 15-21 (5 fish) contrasts with nearly all other reported ages of channel catfish. For example, channel catfish at only one of 44 river and stream sites throughout Iowa exceeded age-9 (Paragamian 1990). Catfish as old as age-12 were found in Pool 9 of the Upper Mississippi River (Appelget and Smith 1951). Fish (sampled from markets) taken from the Mississippi River near Chester, Illinois were as old as age-13 (Raibley and Jahn 1991). Fish from the Missouri River, Nebraska were as old as age-10 (Hesse 1982), although maximum age was not specified. In contrast, Magnin and Beaulieu (1966), reported an age-22 fish from Quebec, and Elser et al. (1977) reported that 25 of 469 fish (5% of the sample) from the Tongue River, Montana, were age-15 or older.

The Yellowstone River stock was also among the slower- growing stocks. Length-at-age for the Yellowstone stock was considerably less than for several southern stocks (Carlander 1969; Hesse 1982; Fig. 4), similar to those from several Nebraska locations (Hesse 1982), and greater than for selected northern stocks. An age-8 fish in the Yellowstone River was 452 mm based on age-at-capture and 406 mm based on back-calculated length. These fish grew faster than channel catfish from the lower Tongue River, Montana, below the T and Y Dam (mean total length at age-8, 389 mm; range 353-437 mm; N = 7; Elser et al. 1977) and faster than catfish in the St. Lawrence River, Canada (mean total length at age-8, 361 mm; Magnin and Beaulieu 1966). Recruitment of fish to the Yellowstone fishery will thus take

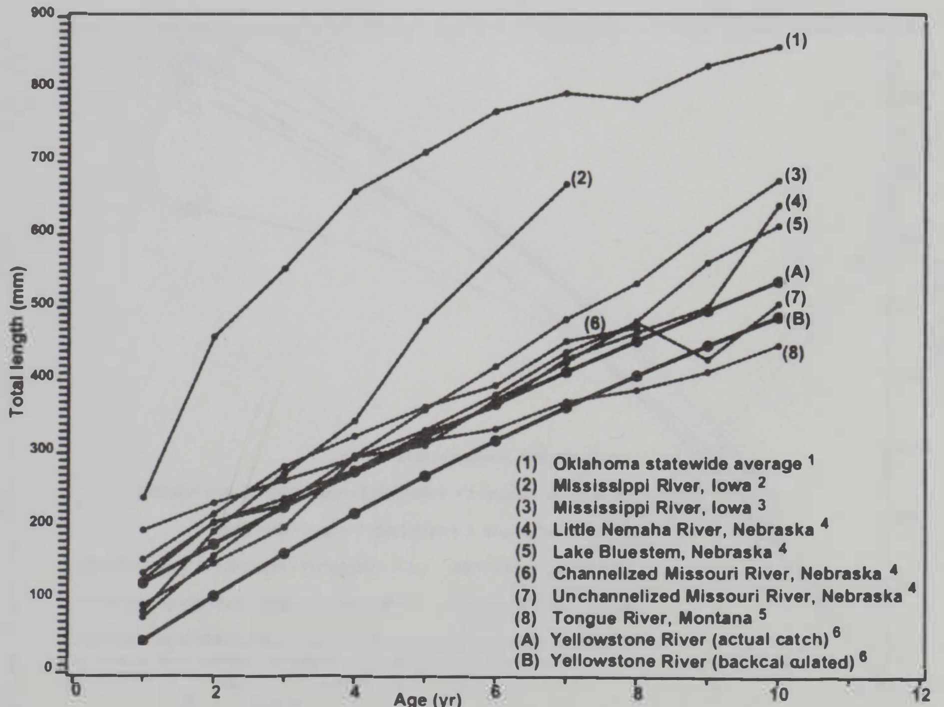

Figure 4. *Size at age of channel catfish from the lower Yellowstone River in relation to other systems.* [1]*Data from Houser and Bross (1963; cited in Hesse et al. 1982),* [2]*Data from Harrison (1957, cited in Hesse et al. 1982),*[3] *Data from Appelget and Smith (1969, cited in Carlander 1969),* [4] *Data from by Hesse et al. (1982),* [5]*Data from Elser et al. (1977),* [6]*Data from this study.*

longer than in more southerly localities. Anderson et al. (1983) considered a 41-cm long catfish to be of quality size; such a fish on the Yellowstone River would be age-7, in Nebraska waters age-6 and in Oklahoma waters age-2 or age-3 (Figure 4). At present, slow growth rates of channel catfish are not a problem in the Yellowstone River because harvest rates are sufficiently low that many large fish remain in the stock.

The differences in length-at-age between the von Bertalanffy growth curves based on length-at-capture and those based on back-calculated lengths may have resulted from growth of fish in spring, after annulus formation. Back-calculated lengths-at-age, which indicate fish length at the time of annulus formation, would be expected to be less than at the time of capture, because fish captured in May and June will have grown since time of annulus formation. The consistent 40-50 mm increment between length-at-age at the time of capture and back-calculated lengths-at-age (Figure 3) is comparable to those reported by both Appelget and Smith (1951) and Hesse et al. (1982). Appelget and Smith (1951) found back-calculated lengths for Mississippi River catfish ages 4,5,6, and 7 to be 64 mm, 45 mm, 50 mm and 31 mm less than corresponding lengths-at-capture. For 8 sites in the Missouri River (Hesse et al. 1982) mean back-calculated lengths for fish ages 3,4,5,and 6 were 49 mm, 43 mm, 44 mm and 71 mm less than corresponding lengths-at-capture. Appelget and Smith (1951) noted that younger age classes of channel catfish usually grew more rapidly in the early part of summer than later in summer, which would increase differences between back-calculated lengths and lengths-at-capture.

Although Yellowstone River catfish were not as plump as a standard (benchmark) catfish (Anderson 1980), the fish did not appear emaciated. Plumpness of river fish would be expected to be less than for fish in ponds, lakes and reservoirs, on which the standard length-weight relation is at least partially based.

As in other studies (e.g., Marzolf 1955), detection of the first annulus proved difficult in many of the older catfish. Often the edge of the lumen contained evidence of an annulus, or the first observable annulus was immediately adjacent to the lumen edge. Bone erosion from the lumen has been noted by others as responsible for loss of annuli near the lumen (Hesse et al. 1978). If erosion of the first annulus was a problem, our back-calculated lengths-at-age are overestimates. Age validation is needed to verify our decisions regarding assigned age.

Acknowledgments

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Caution On The Use Of Electrofishing For Paddlefish

Key words: electrofishing, Montana, paddlefish, *Polydon spathula*

Numerous concerns have been expressed in recent years about possible negative effects of electrofishing on target species (Snyder 1995). Electrofishing is an important fish sampling method (Reynolds 1996), so concerns about its effects can have far-reaching implications. For threatened and endangered species, or for physiologically fragile fishes, a safe sampling method is necessary to permit the release and subsequent survival of each fish.

No formal studies have adequately addressed the effects of electrofishing on paddlefish (*Polyodon spathula*). Although it has long been known that electrofishing can be used for sampling paddlefish, no one has evaluated delayed mortality. Available information is observational or anecdotal. D. Helms, Iowa Conservation Commission biologist, inn biologist, in a letter dated 22 September 1966, reported electrofishing for paddlefish below Lock and Dam 12 of the Upper Mississippi River at Bellevue, Iowa. Helms reported shocking for a total of two hours and 10 minutes on 15-16 September 1966, and seeing paddlefish (mean weight 13.6 kg) surface at a rate of 1.2-1.5 fish per minute. Dead paddlefish were found below the dam on September 19 by anglers. Helms investigated on 21 September 1966 and counted 68 dead paddlefish in the area. He did not prove that electrofishing was the cause but concluded that "all evidence points in this direction."

Helms reported in a May 1997 telephone conversation with the senior author that he had used alternating current with 3-4 electrodes in front of the boat, extending downward 1 meter into the water. Helms made no attempt to switch the current on and off, but left it on for periods of several minutes. Fish were observed jumping out of the water.

Van Eeckhout (1980) reported mortality of paddlefish, probably from electrofishing, in the Yellowstone River, North Dakota in 1977 and 1978. The results were presented at the Great Plains Fisheries Workers Association Meeting in Billings, Montana in 1979. Fish were ampled within 2 km of the Fairview Bridge with a commercially-produced pulse-DC unit with a 3500-watt generator. The most successful results were obtained at 6 A, 60 pulses per second (pulse width 3-4 msec) and

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voltages of 420 V or 560 V. The field was generated between six stainless steel anodes (46 cm long and 1.3 cm in diameter) and the boat, which acted as the cathode. Sampling occurred in depths of 0.3-2.5 m. Of 24 fish captured by electrofishing and tagged in 1977, one was found dead later the same day and a second dead fish was recovered three days later. In addition, four injured, untagged specimens were collected nearby within a three-week period after the initial electrofishing events. One dead fish was recovered with similar damage in 1978, following electrofishing. A post-mortem of this fish revealed blood in the musculature above the notochord, a rupture in the notochord sheath (Figure 1a), sequential hematomas along the notochord and ruptures in the notochord itself (Figure 1b). Although linkage among electrofishing, notochord damage, and dead or moribund fish was not established conclusively under controlled and replicated conditions, Van Eeckhout (1980) attributed the effects to electrofishing. He concluded that "It has been surmised that the physical damage to paddlefish notochords is probably a function of electrofisher design, construction, efficiency and electrical conductivity of the water."

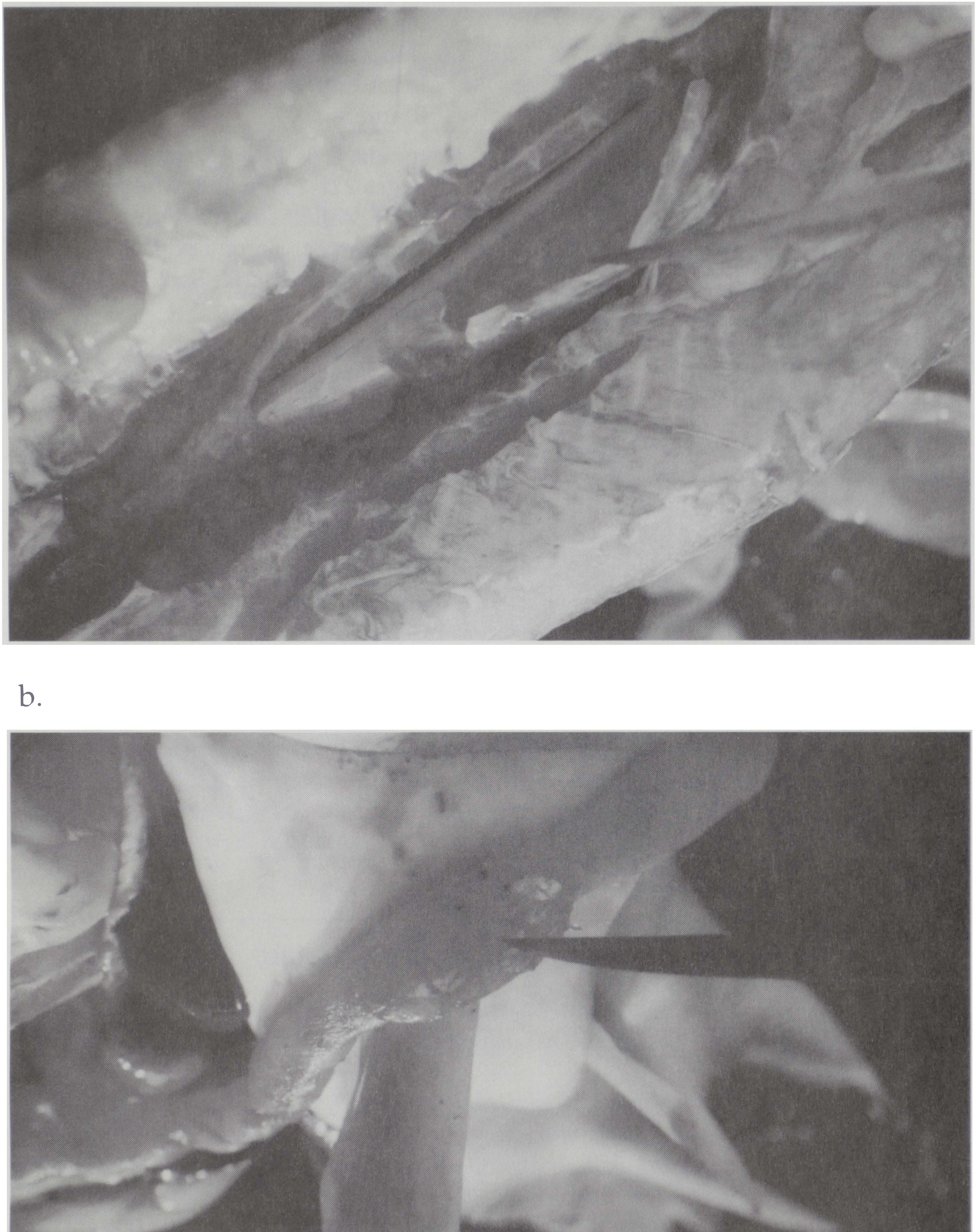
Numerous paddlefish were shocked in the Missouri River below Fort Peck Dam and Yellowstone River below the Intake Diversion Canal (River Kilometer 114.4) in the 1980s and were observed to be substantially stressed (P. Stewart, Personal Observation). Fish were often weak after being released and barely righted themselves, although none were known to have been killed outright. Internal damage, although suspected, was not confirmed. Because of concerns about the effects of electrofishing, multi-filament gillnets, drifted and checked immediately upon contact with a fish, are used for sampling paddlefish in Montana and North Dakota.

Snagging and netting were the only methods listed in the protocol in Louisiana's paddlefish management plan (Reed 1991). Electrofishing was excluded as a sampling technique for three reasons: 1) paddlefish were rarely collected by electrofishing and when they were seen they were moving rapidly away from the boat, 2) chase boats with extra large nets would be required to catch them, and 3) health of the fish would be questionable for tagging and release.

Contacts with representatives of the 22 states involved in a Mississippi Interstate Cooperative Resource Agreement (MICRA) provided information regarding their use of electrofishing for sampling paddlefish. Three states, Illinois, Indiana, and Kentucky, reported using electrofishing for sampling paddlefish, and then only in places too swift to use gill nets or trammel nets.

If electrofishing will allow paddlefish to be sampled in places where other gears such as multi-filament gillnets are ineffective, then the effects of electrofishing on paddlefish should be assessed in a well-designed research study addressing both short-term and long-term effects. Such a study has not yet been conducted. Delayed mortality is the primary concern based on the findings of Helms and Van Eeckhout (1980). The issue of delayed mortality must be addressed before accepting the viability of electrofishing as a safe research tool for sampling paddlefish. A study might involve shocking and capturing fish using different types of current (AC, DC, pulse DC) and holding fish in large ponds for periods of at least two weeks. Comparisons with gillnetting should also be made.

Until definitive studies are conducted, we recommend the use of multi-filament gillnets for sampling paddlefish. It is an effective gear in a.



b.

Figure 1. *Photographs of paddlefish musculature and notochord following electrofishing in 1978 showing a) a 5.0-7.5 cm rupture in notochord sheath and b) a rupture in notochord. Photographs by G. Van Eeckhout, North Dakota Game and Fish Department.*

most river situations. In sampling in the Yellowstone and Missouri Rivers, North Dakota over the period 1993-1998, by F. Ryckman and D. Scarnecchia, a total ot 3,624 fish was sampled. Nets were checked immediately upon contact with a fish, and each fish was released immediately after jaw tagging. No immediate (pre-tagging) or short-term (post-tagging) mortalities were observed. Observations downriver in subsequent days did not reveal any delayed mortality, but fish were not held in ponds for observation.

Acknowledgments

We thank D. Helms for his helpful information and comments.

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ABSTRACTS

BIOLOGICAL SCIENCES - TERRESTRIAL

UTILIZATION OF NEST TREES AND NEST STANDS BY NORTHERN GOSHAWKS IN SOUTHWESTERN MONTANA[MAS]

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In this study, 60 Northern goshawk (*Accipiter gentilis*) nest trees, including all known alternative nest sites in the Dillon, Wisdom and Wise River Districts of the Beaverhead-Deerlodge National Forest in southwest Montana, were measured for species and diameter at breast height (dbh). Our study assesses whether species composition of the nest stands differs significantly from what is available in the forest districts under study. Within the selected nest stand we also determined if there was a preference for a particular nest tree species and dbh class. Tree species and dbh may be two important and easily identifiable physical characteristics that may prove useful in predicting the nest tree selection by goshawks. Further, if goshawks do exhibit a nest tree preference, these two factors could be considered in regard to formulating management decisions about particular timber stands. From the results of this study, we can infer that species of tree alone is not the most important variable, but rather it is the selection of a sufficiently large dbh that may be the characteristic which more strongly influences the goshawk's choice of a nest tree. Our results also indicate a possible preference by the Northern goshawk toward pure stands of Douglas fir (*Pseudotsuga menezesii*) and pure stands of lodgepole pine (*Pinus contorta*) in southwest Montana.

GEOGRAPHICAL DISTRIBUTION OF WILDLIFE DISEASES IN MONTANA[TWS]

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Wildlife diseases have gained recognition as important factors affecting wildlife populations and their management. In order to gain information on the distribution of select wildlife diseases, biological and questionnaire surveys have been conducted by the MFWP Wildlife Laboratory since 1981. We examined and evaluated information gained from surveys on brucellosis, tuberculosis, sylvatic plague, leptospirosis, epizootic hemorrhagic disease, and other pertinent diseases and their distribution within Montana. A brief description of each disease, the wildlife species affected and its known geographical distribution in Montana is presented. Poster.

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

[MAS] *Montana Academy of Sciences Annual Meeting, Butte, MT, April 16-17, 1999*
[TWS] *Montana Chapter of the Wildlife Society Annual Meeting, Bozeman, MT, March 10-12, 1999*

Relationships between salvage logging and forest avifauna in lodgepole pine forests of central Oregon[TWS]

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We present results from a study examining habitat relationships, nesting success, and response of forest avifauna to salvage logging in lodgepole pine forests on the Fremont and Winema National Forests in central Oregon. Relative abundance data were collected in 6 salvage-logged and reference lodgepole pine stands each on both Forests from 1996-1998. A total of 31 different bird species were recorded during point count surveys on both Forests. Mountain chickadee, yellow-rumped warbler, and dark-eyed junco were the most common species detected in both reference and treatment stands. We detected few significant differences ($P < 0.05$) in relative abundance for individual species between reference and treatment stands on either study area. Two-hundred-ninety-eight nests of 20 different species were monitored in 1997 and 1998. While individual species nest success did vary, it appears that birds generally fledged young successfully from treatment stands at equal or higher frequency than reference stands. We discuss structural habitat relationships, as well as recommendations for managing habitat structure for birds in lodgepole pine forests.

Mountain lion conflict and mortality patterns in Montana, 1990-1998[TWS]

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Many biological factors can be derived from examinations of mortality records and human-lion conflicts. We look at hunting and non-hunting mountain lion mortality records available at the MFWP Wildlife Laboratory 1971-1998. Reports to the state from the USDA/ APHIS Wildlife Services for mountain lion conflicts were examined to determine conflicts between livestock and mountain lions. From July 1989-July 1998 we enumerated all human/livestock conflicts with mountain lions by examining MFWP records, newspaper accounts, and telephone reports. Additionally, carcasses of most mountain lions destroyed by Wildlife Services or MFWP were examined and whenever possible detailed post-mortem examinations were conducted. Trends and seasonal patterns in harvest, non-hunting mortality, and conflict incidents were graphically analyzed. Information on the physical characteristics, reproductive performance and condition indexes were examined in relation to causes of mortality, age of lions, and seasons. Some implications to management are discussed. Poster.

Bison management in the Greater Yellowstone area:

defining the known, the unknown and the unknowable[TWS]

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Bison management in the Greater Yellowstone Area (GYA) illustrates a classic environmental dilemma of the twentieth Century. Historically bison symbolized the vast and wild nature of western North America. Following the destruction of wild bison at the turn of the century the few remaining wild bison herds went unnoticed and unstudied. The human perspective of bison shifted from a free-ranging wildlife resource to uncommon, semi-domesticated bovid in one century. Bison restoration was accomplished through intense husbandry therefore what was known about free-ranging bison was lost. Historic and recent research has improved our knowledge of bison and relationships to the landscape. We discuss bison movements, social behaviors, herd dynamics, and reproductive strategies in the GYA that are evolutionary adaptations for existence in vast open landscapes. The introduction of brucellosis in free-ranging bison caused reproductive impacts and socio-political conflict. Bison-brucellosis research has improved our knowledge of the ecology of brucellosis in GYA but much remains unknown. Our studies from 1995-1998 have disclosed that some bison are infected and a smaller portion are infectious. Transmission routes are not entirely understood but mechanisms are becoming clearer. We are attempting to define the risk for transmission to cattle and methods to control or perhaps eradicate the disease. What cannot be predicted through scientific investigation are the social/political climates that are significant influences on management.

Lynx and development on the Kenai Peninsula, Alaska[TWS]

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The influence of development on lynx (*Lynx canadensis*) is likely to become a controversial management issue for certain populations in the future. Because there is little information on this subject, we present findings on the responses of lynx to humans, vehicles, roads, residences, domestic animals, and industrial sites on and adjacent to the Kenai National Wildlife Refuge, Kenai Peninsula, in south-central Alaska. Causes of mortality and recruitment of lynx using developed areas are also discussed. Information was extracted from a 16+year (1983-1998) database of 141 live-captured lynx that were fitted with radio collars and from observations of uncollared lynx. Some monitored lynx used commercial oil gas production and public recreational areas on the refuge while others used residential areas off-refuge.

Lynx displayed little apparent fear of humans and were regularly observed near oil and gas facilities, along roads, and in the off-refuge residential areas. Human-related mortality (88%) exceeded natural mortality (12%) among 26 selected radio-collared lynx that used developed areas. Although there is undoubtedly some threshold of development beyond which the habitat becomes unsuitable for lynx, our observations suggest that lynx can adapt to, or at least tolerate, some level of development as long as the surrounding habitat provides sufficient protective cover with abundant natural prey. However, because most monitored lynx using developed areas succumbed to some form of human-related mortality, developed areas may function as lynx population sinks before this threshold level of habitat suitability is reached. Public outreach programs may help reduce this mortality on lynx.

Gray Wolf Restoration in the Northwestern United States[TWS]

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Nez Perce Tribe

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USDA, Wildlife Services

Sixty years after being exterminated, the gray wolf *(Canis lupus)* was listed under the Endangered Species Act (ESA) and restored to Montana, Idaho and Wyoming. Recovery efforts in northwestern Montana began in the late 1970's and encouraged natural dispersal from nearby Canadian wolf populations. Wolves first denned there in 1986 and about 80 wolves now that live in the area. Livestock losses annually averaged 5 cattle and 4 sheep. After years of planning and exhaustive public involvement, 61 wolves were reintroduced to wilderness areas in central Idaho and Yellowstone National Park, Wyoming in 1995 and 1996. Those wolves were designated as nonessential experimental populations to increase management flexibility. Wolves adapted better than predicted and by late 1998 there were 110-120 wolves in each area. Wolves settled primarily on remote public lands. The wolf restoration program caused no disruption of traditional human activities such as logging, mining, livestock grazing, hunting, or wildland recreation. Over 30,000 visitors to Yellowstone National Park have seen wolves and public interest in them is extremely high. Livestock losses have been lower than predicated, annually averaging 2 cattle, 20 sheep, and 1 dog in the Yellowstone area and 4 cattle, 13 sheep, and 1 dog in central Idaho. Livestock producers who experienced wolf-caused losses were compensated about $70,000 by a private fund. The interagency wolf recovery program concentrates its efforts on interacting with people who live near wolves and removing the few wolves that do cause conflicts. Wolf populations should be fully recovered (30 packs for 3 successive years) and will no longer need protection under the ESA in 2002.

Wolf Recovery: Implications for the Future[TWS]

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Every wolf population and associated human culture have unique characteristics that effect management decisions and recovery efforts. Wolves are recovering in the US, Canada, and Europe because of a combination of increasing ecological awareness and affluence that allows conservation efforts to succeed. I will describe three stages of wolf recovery, which involve increasing levels of management: 1) *Natural recolonization*: Wild wolf populations exist within dispersal distance in landscapes with connectivity (e.g. northwestern Montana, southern Canada). Wild wolves recolonize unoccupied habitat through dispersal and rely on their wild experience for survival. 2) *Wolf reintroduction from wild, native stock*: Wild wolf populations exist for reintroduction stock but dispersal to desired area is severely compromised (e.g. Yellowstone National Park, central Idaho, Olympic Peninsula). Wild-caught wolves are reintroduced into an area and rely on their wild experience for survival. 3) *Wolf reintroduction from captive-raised, remnant stock*: Wild populations of the distinct population segment are extinct (e.g. red wolf of southeastern US, Mexican wolf of southwestern US). Captive-reared wolves are reintroduced into an area and must learn skills necessary to survive in the wild. As habitat is degraded, we move down this list and recovery requires more precious resources and intensified management. Furthermore, our endeavors may result in creating island populations, which face an increased risk of extinction. We must take a long hard look from ecological, ethical, and sociopolitical perspectives, and evaluate the successes and failures of previous recovery efforts to improve upon the potential outcome of future efforts.

Recreation and Travel Management Guidelines for Ungulates[TWS]

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As part of a project by the Montana Chapter of The Wildlife Society to provide guidelines and a comprehensive bibliography on the interaction of recreationists and wildlife, we have summarized information and provided draft guidelines for ungulates by season. The potential effects of recreational activities on ungulate populations are discussed relative to seasonal biology. The relevant literature is

reviewed, and recommendations for recreation management are given for winter/spring, summer, and hunting season. During winter, game managers routinely recommend that human disturbance of wintering animals be prevented. Summer vehicle traffic on forest roads affects the amount of habitat used by ungulates. Indirect effects include the establishment and spread of noxious weeds. During the big game hunting season, motorized vehicle uses affect security areas, which in turn have a strong relationship to buck/bull carryover. Providing security is a joint responsibility of both game and land managers. Where hunter numbers overwhelm security, modification of hunting regulations is recommended.

Behavioral Ecology of Black Bear Damage to Conifer Stands[TWS]

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Black bear damage to conifer stands can result in substantial forestry losses while little is known about the reasons for black bear damage. This paper tests several hypotheses regarding the behavioral aspects of black bear damage to conifer stands and black bear habitat use. This study took place on the Olympic Peninsula of Washington State on a private industrial forest. Bears were implanted with radio-transmitters and monitored with aerial telemetry one to twice weekly. Site investigations wee then made to assess damage occurrence and habitat use. We monitored 21 bears (12 males, 9 females) throughout the damage period (May to August) of 1998. Our preliminary analyses show that adult females appeared to cause more damage than the other sex/age classes ($p=0.004$) and with a higher intensity ($p=0.09$). This supports the hypothesis that adult females are damaging because of sexual competition from adult males. Our habitat analyses demonstrated that there is also habitat segregation of subdominant sex/age classes in this population ($p=0.012$). This supports the hypothesis that all subdominant sex/age classes avoid males because of competition for food. The results for testing if adult females were specifically avoiding adult males were inconclusive due to a small sample size at this time. Males and females appear to be causing damage differentially ant to be using different habitats. Whether this is due to sexual competition and adult female segregation from adult males remains to be seen in 1999. Poster

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Comparative Food Habits of Great Horned Owls in Three Distinct Habitats in Yellowstone National Park[TWS]

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Relatively few studies have been done on great horned owls (*Bubo virginianus*) in Yellowstone National Park and even less is known about their prey habits. These

diverse hunters are found throughout the Park in many different habitats and utilize a variety of prey from small mammals, birds, amphibians and reptiles. In 1998, great horned owl nesting and roosting sites were identified and 373 pellets were collected from at least four different pairs of owls from three distinct habitats: 1) low elevation xeric grassland (Gardiner); 2) mid-elevation sagebrush grassland (lower Slough Creek); and 3) mid-elevation lodgepole forest and mesic grassland (Old Faithful). tested whether food habits from three different habitats within the Park are truly distinct or more similar to each other than would be expected. This was done by calculating the diet diversity at both the class and species level of mammalian prey and the mean weight of mammalian prey in their diet from pellet samples from different habitats. Shannon diversity indices were used to calculate diet diversity and diet breadth, chi-squared contingency tables were used to compare diets among owls and among different habitats. Owls in all three habitats had a similar diet composition, preying heavily on mammals and birds; but at the species level differences were found between habitats.

USING CARNIVORE HABITAT SUITABILITY MODELS TO DESIGN NATURE RESERVES[IWS]

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This paper is a review of recent work using GIS-based habitat suitability models of key carnivore species as an approach to designing reserves capable of maintaining viable populations of those species. The emphasis is upon single-species models used as an 'umbrella' to delineate habitat necessary to support a population with an estimated genetic effective size of 500. Recent models developed by the authors include grizzly bear habitat suitability models for coastal British Columbia and the U.S. Northern Rockies, and forest carnivore models for the U.S. Northern Rockies. Recent work by other investigators on similar species will be briefly reviewed. The development of these types of habitat suitability models is constrained by the type and accuracy of the data available over large (regional) spatial scales. Thus, predictions of the amount of habitat needed, and the delineation of spatially-explicit reserves, is a 'best-guess' estimate which can be improved over time in subsequent iterations of the model as better data become available. It is apparent that reserves of the size necessary for long-term conservation of large carnivore can not be designed from contiguous blocks of habitat in most areas of temperate North America because of current land ownership and habitat fragmentation. The use of 'core' blocks of contiguous habitat connected by linkage 'corridors' is discussed along with evidence of dispersal through those corridors. For conservation purposes it is argued that current land-use practices, particularly on public lands, should be focused on protecting enough habitat for long-term persistence rather than minimum viable populations.

Recolonization of Black-tailed Prairie Dogs in Southern Phillips County, Montana[TWS]

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Black-tailed prairie dogs (*Cynomys ludovicianus*) are an integral component of prairie ecosystems, but in recent years their numbers have been reduced due to eradication programs, conversion of grassland to cropland, and the spread of sylvatic plague. In an effort to re-establish prairie dogs into plagued out historic colony sites, translocation efforts began in 1997 on Charles M. Russell National Wildlife Refuge. Translocation experiments require several issues be determined: 1) Conditions needed for successful translocation such as release method, stocking density, age and sex ratios; 2) Survival and dispersal of translocated animals; and 3) Colony size. Preliminary studies have determined two release methods for future testing. Comparison studies for stocking, age and sex ratios, will be performed between colonies with similar attributes such as soil, vegetation, and slope. Survival rates of translocated animals will be determined using mark-recapture techniques and requires each animal to be individually marked with Passive Integrated Transponder (PIT) tags and dye. Using visual counts of dyed animals, and live-trapping techniques, the numbers of translocated animals within the release area will be determined. Nearby towns will be monitored for dispersers. Monitoring colony sizes and burrow densities provides important information necessary for determining changes due to recolonization, augmented and natural. The perimeters and burrow densities of each colony within Southern Phillips County are currently being mapped using GPS (Global Positioning System) for use as baseline data. From the information gathered, we will be able to determine the affects of augmentation and best release methods.

The Black-backed Woodpecker in an Era of Fire Suppression and Salvage Sales: Is Loss of Fire-killed Forest a Threat to this Species?[TWS]

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Black-backed woodpeckers are often described as a fire-dependent species. The species is most abundant within 5 years of a burn, though they also occur in unburned forest with insect infestations. Intense fire suppression efforts have reduced "early-post-fire" habitat in forested areas at low- to mid-elevation compared to levels in the past century. In lodgepole forest, areas that would have burned are now dying from epidemics of mountain pine beetle. "Salvage" timber sales target dead and dying forest, including burns and insect-infested areas that are breeding habitat for black-backed woodpeckers. The Forest Service is charged with maintaining viable populations of all species within each forest. Given the current low level of this species's primary habitat, biologists on the Lolo NF (Missoula, MT) are concerned about the effect of salvage sales on black-backed woodpeckers.

Information about the species's ecology and demographics (especially outside of burns and beetle-killed areas) is incomplete or contradictory. Data on local population and on population trends are non-existent. The "coarse filter" approach (comparing current available habitat to past levels) allows assessment of the species' local status and of the potential effects of salvage sales. In this paper, I discuss: (1) the methods used to assess amount of fire-killed habitat available in the past and trends over recent decades and results; (2) whether beetle-killed stands can be used as a substitute for fire-killed habitat; (3) whether mitigation via creation of fire-killed stands in prescribed fire is a feasible option; and (4) whether the species seems to be vulnerable and, if so, under what conditions.

Long-term Changes in Elk Distributions in Western Montana[TWS]

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Elk (*Cervus elaphus*) occur in herds that use almost exclusive areas during the spring through fall seasons, and these areas of use may shift over long time periods in response to increasing density. However, it is unknown if elk herds change distribution patterns over long time periods as a result of habitat modification. Our objectives were to (1) compare elk distributions in the same area before and after substantial habitat change, and (2) identify habitat characteristics related to elk distributions before and after habitat change. We compared distributions of radio-collared female elk from 1977 to 1983 and 1993 to 1996 for 2 elk herds. We used simple and multiple linear regression, and a Poisson regression modeling approach to determine relationships between numbers of elk locations within grid cells, at 3 different scales, and habitat variables. Elk distributions shifted between the 2 studies and road variables were important in explaining these shifts. Open roads were negatively correlated with elk locations, and elk were more tolerant of roads during the second study than during the first. Increased densities of closed roads were important in explaining decreased use of grid cells from first study to the next. Elk distributions were seasonally related to forested vegetation classes. Effective management of elk herds may require regular assessment of their distribution patterns, perhaps as frequently as every 10 years. Road closures are an important management tool. However, the long-term impact of closed roads on elk distributions warrants additional study.

Preliminary Results of Amphibian Monitoring on the Lewis and Clark National Forest[TWS]

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Preliminary amphibian and reptile surveys were conducted by the Montana Natural Heritage Program in 1994 on the Lewis and Clark National Forest in central Montana. These surveys provided initial distribution information for six species of amphibians, three of which have been identified as species experiencing declines across their historic ranges: northern leopard frog *(Rana pipiens)*, Columbia spotted frog *(Rana luteiventris)* and boreal toad (*Bufo boreas boreas*). A fourth species, the tailed frog *(Ascaphus truei)*, has been considered sensitive to habitat disturbance and an indicator of high-integrity native aquatic communities. Subsequent annual surveys through 1998 have expanded the known distribution areas, located breeding sites and revealed interesting habitat use characteristics of these amphibians, including overlap with fish habitats and potential for both positive and negative human effects. Insights on population dynamics and extinction risks can be drawn from limited, nonstatistical surveys such as these.

Population Dynamics of Bighorn Sheep on the Beartooth Wildlife Management Area, Montana[TWS]

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A study of reintroduced Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*) was conducted on the Beartooth Wildlife Management Area in west-central Montana between 1995 and 1998. Research included investigation of post-dieoff population dynamics and evaluation of a sheep augmentation program. Data were collected on sheep distribution and habitat use, reproduction, and lamb recruitment, lamb and adult mortality, and general health. Particular emphasis was placed on assessing the role of mountain lion (*Felis concolor*) predation on adult sheep. Transplanted sheep (n = 39) were closely monitored to determine the effectiveness of herd augmentation. Sheep were limited in distribution to low elevation, winter range-type habitats and did not express seasonal migration. Results suggest that limited annual lamb production, in conjunction with late summer lamb mortality and annual adult losses due to predation and disease, were responsible for a stable or declining sheep population. Augmentation had no influence on herd productivity due to loss of relocated sheep and limited annual reproduction.

Effect of Habitat Disturbance and Forest Fragmentation on Soricid Communities[TWS]

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In 1992 we initiated a 5-year study on species biodiversity as a function of forest management practices in conjunction with the Forest Service and Plum Creek Timber Company. Twelve forested sites, similar in their stand composition, tree density and size distribution, were chosen in the Swan Valley of westcentral Montana. Of these twelve, four remained unharvested as controls, four were treated using conventional overstory removal practices and four were treated as per New Forestry protocols. For three years, 1994 - 1996, in conjunction with on-going amphibian studies, we collected shrews in pitfall arrays across all plots. Concurrently, various measures of habitat composition were collected at each trap array, specifically percent forb cover, percent woody cover, and mean basal areas of the canopy dominants, lodgepole pine, ponderosa pine, and Douglas-fir. Four species of shrew [pygmy *(S. hoyi)*, common *(S. cinereus)*, montane *(S. monticolus)*, and vagrant *(S. vagrans)* shrews; N = 615 in 70,224 trapnights] composed the soricid community on these sites. Species associations were correlated with habitat characteristics across all sites using both discriminant functional and MANOVA analyses. No treatment by year interactions were seen. Significant decreases in capture of common and pygmy shrews were noted over the 3-year period. One slight, but significant treatment effect was seen; pygmy shrews increased on overstory removal plots. The overall lack in marked treatment effects may be due to the generalist nature of shrew foraging behavior. However, the increase observed in pygmy shrews on overstory removal sites may indicate a greater tolerance to drier habitat conditions.

Black-tailed Prairie Dogs and Conservation of Grasslands Ecosystems—Legal and Biological Perspectives[TWS]

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Arguably, no native North American mammal has been subject to the level of private and governmental eradication efforts as the black-tailed prairie dog (*Cynomys ludovicianus*). For a century this native species has been poisoned, ploughed, and shot with encouragement from all levels of government. The result, plus impacts from sylvatic plague, has been a reduction of >99 percent in the area occupied by this species in the 10 states with short-grass or mid-grass prairie dog habitat. In Montana alone, prairie dogs occupy only half of the area they occupied 12 years ago as a consequence of impacts of sylvatic plague exacerbated by the absence of regulatory controls on poisoning and shooting on public as well as private lands. In shortgrass prairie systems, control efforts are motivated primarily to reduce competition with livestock although there is no scientific basis for widely-held perceptions that

significant levels of competition exist. Regardless, all states within the prairie dog range classify the species in ways that encourage, subsidize, or authorize control activities. Although large areas of prairie dog colonies are essential to the highly endangered black-footed ferret (*Mustela nigripes*), surviving large prairie dog colonies are too few to recover ferrets. Numerous other species of birds and mammals that co-evolved with prairie dogs are also reduced as a consequence of reductions prairie dog abundance. In an effort to reverse these trends and to restore grasslands ecosystems, the National Wildlife Federation filed a petition to list black-tailed prairie dogs as a threatened species under the Endangered Species Act.

Population Dynamics of the Northern Yellowstone Mule Deer[TWS]

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We report trends in numbers and age and sex structure of mule deer wintering in the Gardiner Basin area of the northern Yellowstone winter range between 1987 and 1998. The ratios of fawns: 100 adults in early winter and spring are related to an index of winter severity and its component parts. Early winter fawn: 100 adult ratios are related significantly to the winter forage index as predicted by previous spring precipitation. Spring fawn: 100 adult ratios are related significantly to an index of snow water equivalency and the overall winter severity index. Survival of adult female mule deer from 1993 to 1997 as determined from radiotelemetry averaged 0.80 per year. Models of survival constrained by the components of the index of winter severity are all more parsimonious than a year-varying survival model. We conclude that variation in annual survival of adult females was a function of winter severity.

Maternal Behavior and Productivity of an Indigenous Desert Bighorn Sheep Population on the Navajo Reservation[TWS]

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The Fish and Wildlife Department of the Navajo Nation initiated this study to determine population size and trend, habitat requirements, and range capacity for a native desert bighorn sheep population inhabiting the San Juan River Canyon on the

Navajo Reservation in Southeastern Utah. Year 1 plant growth and forage availability was excellent due to above average precipitation related to El Nino weather patterns and light cattle grazing on the bighorn range. Year 2 precipitation was near average and heavy cattle grazing occurred on parts of the bighorn range. Observed lamb production was 1.00 lambs/ewe Year 1 and 0.76 lambs/ewe Year 2. Lamb survival from birth to 1 year was 0.71 Year 1, and 0.77 from birth to 8 months (Year 2). One set of twins was documented. Allo-mothering was common. Bonds between mothers and lambs were highly variable. One ewe apparently abandoned her lamb at less than 1 week of age. Scramble competition among lambs for milk was observed. The lambing period was extended year 1 (from 15 April through the 22 June) and shorter year 2 (from 11 April through May 25. Possibly due to excellent foraging conditions, some late lambs (including the latest one born each year) survived to mid-winter.

Egg-destroying Behavior by Brown-headed Cowbirds: Implications for Management and Conservation[TWS]

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Most interspecific obligate brood parasites, including brown-headed cowbirds (*Molothrus ater*), destroy or remove eggs from host nests, sometimes causing the host nests to fail. This behavior is extremely variable, however, as cowbirds may destroy none, one, several, or all of the eggs in a host nest. Although this behavior seems to be an integral part of the brood parasitic syndrome, the cues that influence egg destruction behavior are poorly understood. Experiments with free-ranging, territorial female cowbirds near Missoula, Montana, showed that their behavioral responses were influenced by both the number and types of eggs in experimental nests. Females destroyed few eggs in experimental nests containing two host eggs. In contrast, they destroyed most eggs in two-egg clutches if one was a strange cowbird egg, or in clutches containing four white host eggs. This behavioral flexibility likely allows parasites to increase their chances of successful parasitism. The management and conservation implications of egg-destroying behavior and variation in spatial ranging patterns of female cowbirds is discussed.

Interdisciplinary Sampling for Collection of Wildlife, Timber, and Other Resource data for Timber Sale Evaluatio s in Alaska[TWS]

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An interdisciplinary sampling method was developed to collect data for timber sale evaluations in Alaska. Teams consisting of a forester and a wildlife biologist systematically collected timber cruise and general habitat data (e.g., plant association, timber volume, canopy closure, stand structure, snag counts), and conducted deer

winter range habitat assessments, neotropical migratory bird point counts, and goshawk presence/absence surveys. Each team member was also cross-trained in collecting data on stream habitat, soil stability, visual concerns, and cultural resources. The forester-biologist teams thus identified specific areas that other specialists should examine. This interdisciplinary method is compared with a more traditional approach where each resource team conducts separate surveys/ reconnaissance. The advantages/disadvantages of each method is presented. We used the interdisciplinary sampling method on 2 projects: one on the Tongass National Forest in Southeast Alaska and one on the Chugach National Forest on the Kenai Peninsula. The interdisciplinary sampling method allowed for a more coordinated data collection effort and, therefore, more useful data were collected and better coverage for threatened and endangered species sampling was obtained. The method was also more cost-effective and allowed for a timber sale that incorporated wildlife and other resource information throughout the design process; therefore, better final products were produced. Poster.

A REVIEW OF THE MONTANA UPLAND GAME BIRD HABITAT ENHANCEMENT PROGRAM: THE GOOD THE BAD AND THE DEAD[TWS]

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The Pheasant Enhancement Program (PEP) was created through the passage of Senate Bill 331, by the 1987 Montana Legislature in response to concerns over low pheasant populations and the potential of additional habitat being created through the Conservation Reserve Program.. The program authorized state financial reimbursement to cooperators for raising and releasing pen reared pheasants to supplement the wild populations in the state of Montana. In 1989, the PEP was renamed the Upland Game Bird Habitat Enhancement Program (UGBHEP) and amended to allow annual surplus funds not used for stocking pheasants to be funneled into habitat improvement projects. The habitat portion of the program has had continuous support; however, various publics and agency personnel have expressed concern about the biological validity of stocking pheasants into the wild. Recent complaints by sportsmen groups, landowners and other program cooperators prompted Montana Fish, Wildlife and Parks (MFWP) to reevaluate the stocking portion of the program. Banding of pheasants and field surveys were used by MFWP to monitor post release survival and hunter harvest of released pheasants. Previous studies indicate high mortality rates, poor reproductive success and minimal enhancement of hunter harvest associated with the release of pen reared pheasants into the wild. These studies support the finding of MFWP. Habitat quality, climatic conditions, predation and the inability of released pheasants to cope with the transition from the pen to the field are the main factors limiting the survival of these birds.

Montana Gap Analysis: A First Approximation of Wilderness Contributions to Wildlife Conservation[TWS]

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Although we count on wilderness areas as the backbone of our current nature reserve networks, these areas seldom have been completely inventoried, raising questions about their specific contributions to conservation of biodiversity. Data sets developed for the National Gap Analysis Program provide a means to assess the biodiversity values of wilderness areas using geographic information systems (GIS); here, we present an example for the state of Montana. Gap analysis hinges on three GIS inputs: land cover, predicted distributions for native terrestrial vertebrates, and land stewardship. A land cover map was developed by classifying Landsat Thematic Mapper imagery using 23,351 ground-truth plots. For 414 vertebrates, habitat-relationship models were built; distributions were mapped using known ranges, land cover, topography, and hydrography. A stewardship map was compiled from digital data provided by the Bureau of Land Management and other agencies and organizations. Once all base layers were compiled, they were overlayed to describe current patterns of biodiversity management. Not surprisingly, cover types and wildlife species typically found at higher elevations were better protected. Furthermore, more area was reserved in western than in eastern Montana. Of 414 vertebrates, 62.6 percent had <10 percent of their predicted distributions in reserved lands (status 1 and 2), versus 1.7 percent with >50 percent of their distributions protected. By taxonomic group, reptiles were least protected, followed by amphibians, birds, and mammals. These results apply to all lands assigned status 1 and 2 (5.1% and 2.53% of the state, respectively); results specific to wilderness (3.7% of the state) also will be presented.

Impacts of Channel Modification on the Yellowstone River in Montana[TWS]

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The Yellowstone River in Montana is the longest free flowing river remaining in the contiguous United States. Consequently, it is considered a unique and valuable resource even though major changes and perturbations have taken place since Euro-American settlement. The value of a dynamic river floodplain to wildlife and fish communities continues to be eroded by man-made changes which threaten channel geomorphology. Threats to the river and associated floodplain habitat from bank stabilization efforts will be described, including levees, rip-rap, dikes, rock barbs, jetties and other man-made channel modifications. Currently these actions are being permitted at a pace which may ultimately threaten the ecology of the entire river system. This case study will discuss impacts of channel modification projects on

various vertebrate taxa and their habitat, with emphasis on threatened, endangered and sensitive species of mammals, birds, reptiles and amphibians. Techniques, ideas and potential solutions for reducing negative impacts to wildlife habitat in floodplain and riparian systems may necessitate a major policy change in existing permitting processes, consideration of cumulative effects and more rigorous environmental analysis to ensure that permitted actions do not affect the ecology of river systems.

AN ASSESSMENT OF THE SUITABILITY OF SALVAGED-LOGGED BURNED FORESTS FOR CAVITY-NESTING BIRDS IN WESTERN MONTANA[TWS]

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Practices of wildfire suppression and salvage logging of burned forests have prompted concern among biologists for fire-associated bird species in the northern Rocky Mountains. Therefore, in May 1997, we initiated a five-year study to examine the responses of cavity-nesting birds to salvage logging of recently burned forests. In 1997 and 1998, we systematically searched four study areas for nests of cavity-nesting birds and then monitored nests to determine reproductive success. We also measured habitat characteristics at nest and random plots (0.04 ha), and collected foraging information on three *Picoides* species. Nest searching efforts in all areas identified 335 active nests of 10 focal species. Black-backed and three-toed woodpeckers and brown creepers had the strongest affinity for nesting in unlogged forests; >75 percent of nests were found in unlogged portions of burned forests. The nests of hairy woodpeckers, Northern flickers, red-breasted nuthatches, and mountain bluebirds were found in almost equal numbers in logged and unlogged areas of burned forests. Small numbers of Lewis's woodpecker and Williamson's sapsucker nests were found primarily in the logged areas. Nesting success was higher for hairy and three-toed woodpeckers, 94 and 87 percent respectively, in unlogged nest plots. Northern flickers and mountain bluebirds experienced lower nesting success; however, nesting success was similar between logged and unlogged plots. Preliminary data suggest that post-fire forests that are salvage-logged provide nesting habitat for some cavity-nesting species. However, the suitability of logged nesting habitat, in terms of occupancy and/or nesting success, is markedly lower for black-backed, three-toed, and hairy woodpeckers, and brown creepers.

EFFECTIVENESS OF CARBON-SOOTED ALUMINUM TRACK PLATES FOR DETECTING AMERICAN MARTEN[TWS]

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Covered, carbon-sooted aluminum track plates have recently been proposed as a means of determining presence/absence of faorest carnivores in a given area. I asseessed the effectiveness of covered aluminum track plates for detecting American marten in the Bitterroot Mountains of western Montana. On five 10.44 km^2 survey units in my study area, I captured and uniquely branded the toe pads of seven marten so that they could be identified by their tracks. Concurrently, I deployed six track plates in each survey unit for a 12-day period as per the USFS protocol. Via telemetery data collected on six of the seven marten, I concluded that the branded individuals spent a majority of their time within the survey units and should have been detected by the track plates. However, I did not collect tracks from any of the toe-branded marten. Further, through modified telemetry systems, I found that two of the seven marten spent several minutes on several different days within 5 m of track plates without ever leaving their tracks. Despite not detecting branded marten known to reside on the survey units, I did collect tracks from unbranded individuals on four of the five survey units. Thus, probability of detecting marten on a survey unit when they are actually present appears to be quite high, but the probability of detecting any given individual may be quuite low. However, trap shyness and lack of durability of the toe brands may have influenced the results.

Gigantopithecus: How Large Were These Fossil Apes?[MAS]

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Select mandibular metrics of *Gorilla gorilla* are used to generate multiple regression equations using femur and humerus length and mid-shaft circumferences as criterion variables. Metrics from the four known mandibles of *Gigantopithecus bilaspurensis and blacki* are then used to estimate aspects of the post-cranial skeleton of these fossil apes. Assuming a linear relationship between mandibular and post-cranial metrics in *Gigantopithecus* and assuming further that these apes were quadrapedal with peculiar hominid parallelisms, regression estimates suggests that these apes were about 20 to 25 percent larger than living gorillas. No estimates of "body weight" were attempted largely because gross weight and skeletal estimates in mammals represent a non-linear relationship.

North American Review of Wild Sheep Capture, Handling, and Transport – A Call for Detailed Field Information[TWS]

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Wild sheep are very susceptible to stress, injury, and death when captured and handled. Yet, no single source of information has compiled wild sheep capture, handling, and transport protocols, techniques and equipment. In addition, few scientific publications allow authors to describe the subtle details, important

equipment, and logistical organization necessary for maximizing capture success and animal care. We are developing a single document summarizing the growing published and unpublished knowledge of wild sheep capture, handling, and transport. This extensive review will be a thorough resource for sheep researchers and managers for preparing and conducting successful field operations. The ultimate purpose of this project is to improve animal care and reduce injuries and mortalities. This review includes literature search, agency protocols/documents, and material from questionnaires to all interested sheep professionals. The review will cover: 1) every capture technique with detailed diagrams and photos, 2) equipment and techniques for sheep processing and transport, 3) equipment brands, models, and company information, and 4) considerations and approaches specific to each major subgroup of wild sheep. This project will be funded by several grants. The final book will be distributed by a non-profit organization to: 1) contributors, 2) state, federal, and private organizations working with wild sheep, and 3) western colleges. Additional copies will be available.

Canyon Wren Ecology, Lower Salmon River Gorge, Idaho[TWS]

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Canyon wrens (*Catherpes mexicanus*) are among the least-studied passerines in North America. These birds are residents of arid and semi-arid regions dominated by rock substrate from southern British Columbia, throughout the western United States, and into Mexico. To increase knowledge of canyon wrens and provide managers with baseline information for developing conservation strategies, we assessed wren dispersion, habitat-use patterns, and nest-cavity temperature regimes. We tested the hypothesis that canyon wren density was limited by availability of suitable-nesting cavities.

Montana Chapter TWS Committee on Recreation in Wildlife Habitat: A Progress Report[TWS]

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This project is prompted by increasing concern about unintended consequences to wildlife from the increasing variety of recreational activities occurring on public lands and waterways, increasing participation in these activities, rapid changes in technology in recreation equipment and expansion of developed recreation. A position statement titled "Motorized Recreation in Wildlife Habitat" adopted by the Montana Chapter of The Wildlife Society at its annual meeting in March, 1997, called for formation of an ad hoc committee to develop guidelines to address habitat needs of wildlife that should be considered in the planning and implementation of motorized access projects. A group of volunteer committee members expanded their charge to include non-motorized, as well as motorized forms of recreation and formulated a task outline that includes compilation of a partially annotated bibliography, a report that includes a historical perspective and issue summary, chapters on recreational impacts in habitat of five wildlife species groups, guidelines for use by resource managers, and a brochure. Committee members are organized into 5 species groups (ungulates, carnivores, birds, small mammals and herpetiles). Members of each specie group are annotating papers, developing foundation issues, identifying research needs, and drafting guidelines. A fundraising effort has secured $58,500 which is being used to fund a contract wildlife biologist/computer specialist to conduct literature searches and compile the bibliography. To date, 2600 references are included in the bibliography. The State Library has agreed to serve as repository for the bibliography. Finished products are scheduled to be available by September 1999, including the Bibliography, a report entitled: Recreational Impacts Upon Wildlife and Their Habitat - A Montana Report with Management Guidelines, and a Brochure summarizing the guidelines. The Committee welcomes assistance from interested individuals or groups - especially in the following areas: (1) Identification of relevant references that are not yet included in our bibliography, (2) Annotation of references, and (3) Documentation of case histories: how and why conflicts with wildlife occurred, or how such conflicts were avoided or resolved.

Effects of Habitat on Cougar Predation of Endangered Woodland Caribou[TWS]

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Recovery of the endangered southern Selkirk Mountain's woodland caribou (*Rangifer tarandus*) herd has been limited by high mortality of transplanted caribou. Cougar (*Puma concolor*) predation may be the primary cause of caribou mortality. We hypothesize that new forest management practices—which favor numerous, small clearcuts over fewer, larger cuts—have caused an increase in deer, which has allowed cougars to increase and resulted in more cougar-caribou encounters. Trophy hunting of dominant male cougars may have increased the cougar population also by allowing subdominant males to establish territories and breed. We will assess whether cougar predation is preventing caribou recovery and evaluate whether predator or habitat management could lower caribou mortality enough to achieve a stable caribou population. The transplanted caribou are radio-collared already. Forty cougars (10 in northeastern Washington, 10 in northern Idaho, and 20 in southern British Columbia) will be radio-collared during winter 1998-99. We will track the animals from fixed-wing aircraft for 3 years, with intensive monitoring from May-October when most caribou mortalities occur. We will investigate caribou mortalities to assess the extent of cougar predation, determine whether all cougars or only specific individuals prey on caribou, and evaluate the effect of removing specific cougars. We also will compare habitats used by cougars and caribou to identify specific habitat features that may increase the vulnerability of caribou to cougar predation. Poster

Hunter Management Strategies Utilized by Montana Ranchers[TWS]

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A survey of private ranchers was conducted to identify practices used in Montana by ranchers to manage hunters. A questionnaire was sent to 989 ranchers from a population identified as typical working ranches larger than 400 ha. Respondents (42% return) indicated 80 percent had no restrictions or simple permission to hunt on most of their land. Twelve percent of the respondents indicated their ranch was closed to hunting and 12 percent had fee-hunting operations or leased to outfitters. Past damage by hunters (42%) and conflicts with hunters (33%) were reasons most cited for closing ranches to hunting. Combinations of strategies were utilized with vehicle restrictions, advanced reservations and check in/out being most common. Ranch size influenced management strategies with 63 percent of ranches under 400 ha requiring only simple permission to hunt compared to 28 percent of ranches over 400 ha. Sixteen percent of the smaller ranches had 50 percent or more of their land closed compared to 5 percent of the larger ranches. Implications of study results include a need for programs to address landowner concerns and programs to impress upon hunters the importance of their behavior in affecting public access to private land.

Status of the Black and White-tailed Prairie Dogs in Montana[TWS]

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An inventory of black and white-tailed prairie dogs in Montana was made during a 2-year period from 1996 through 1998. The inventory consisted of visiting previously recorded prairie dog colony sites, and mapping the colonies using satellite based mapping technology. We attempted to visit 1,004 prairie dog colony sites but obtained access to only 864 colonies. Of the 864 colony sites visited, 27 percent were not found at their previously designated location. Another 16 percent appeared to have previously been at the designated location but were abandoned for a variety of reasons. These reasons included suspected plague, poisoning and land conversion to agriculture. During the survey, 459 active prairie dog colonies were found, and 24,251 acres of prairie dog occupied landscape were mapped. Seventy-one percent of the prairie dog colonies were classified as containing either a high or medium prairie dog density, and 72 percent were classified as either increasing or stable. Approximately 50 percent of the prairie dog colonies were located in rolling prairies and 42 percent occurred in valley bottoms. The remainder of the colonies were situated on ridge tops. Fifty wildlife species were observed in prairie dog colonies.

Frequently occurring species included the horned lark, meadowlark, kill deer, mountain plover, burrowing owl, badger, pronghorn, and coyote. Data from this survey were combined with other survey information collected by the Bureau of Land Management in the Phillips, Judith, and Big Dry Resource Areas. The Bureau of Indian Affairs provided recent mapping data for the Fort Belknap, Northern Cheyenne, and Crow Reservations. The combined Montana data resulted in a minimum estimate of 1,353 active prairie dog colonies totaling 66,420 acres. This is approximately half of the prairie dog acreage estimated for Montana during the late 1980's. The cause of the decline is probably due to the spread of sylvatic plague. Prairie dogs occupied 1 percent or more of the landscape in only 3 quarter latilongs. The majority of the quarter latilongs with 1 or more prairie dog colonies contained less than 0.05 percent of the landscape occupied by prairie dogs. Only 2 white tailed prairie dog colonies remain in Montana and they total less than 100 acres. The black-tailed prairie dog in Montana is not threatened with extinction, but the risk of white-tailed prairie dogs being extirpated from the State during the next century is high.

Hantavirus in Peridomestic Populations of Deer Mice in Western Montana[TWS]

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Deer mice (*Peromyscus maniculatus*) are the principal reservoir of the Sin Nombre virus (SNV) which causes hantavirus pulmonary syndrome (HPS). Most human infections are believed to occur as a result of contact with deer mice and their excreta within human dwellings. Unfortunately little is known about the ecology of mice that inhabit buildings. We studied deer mouse populations at 2 study sites near Butte, Montana and 1 site near Cascade, Montana beginning in October 1996. Animals were trapped monthly in a variety of human structures including houses, barns, sheds, and granaries. At the same time populations outside of buildings were also trapped. Captured rodents were ear tagged and a blood sample taken prior to release. Blood samples were analyzed for the presence of antibody reactive with SNV. Prevalence of antibodies to SNV was higher in individuals that were captured only inside of buildings compared to those captured only outside of buildings. However the highest prevalence was found in individuals that were captured both inside and outside of buildings. Differences in survival and age and sex structure were also found between these 3 groups.

Conflict and Cooperation in Wilderness Wildlife Management[TWS]

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Although wildlife is an integral part of the definition and understanding of wilderness, there is significant conflict between federal wilderness managers and state wildlife managers. Our presentation examines the reasons for this conflict and offers a case study illustrating federal and state cooperation and coordination that improves the management of both wilderness and wildlife. There are biological, legislative, administrative, and personal reasons for this conflict. Many wildlife populations have been negatively affected by human activities, and actions taken by state managers to survey and manipulate these populations may directly conflict with wilderness values. Even within an agency, different goals may conflict, such as maintaining recreation that conflicts with broader stewardship goals. Legislative acts may contain wording that allows different interpretations depending on agency philosophies and cultures. Administratively, different missions of the agencies compel them to establish different goals. Agency policies, guidelines, and MOUs developed to prevent conflict are often inadequate, or ambiguous and open to interpretation. Further, states traditionally hold the authority for managing wildlife populations, while federal agencies hold the authority for managing wildlife habitat, adding considerable tension. Personal experiences, attitudes, and philosophies can create long-lasting conflict. The philosophy and actions of the Montana Department of Fish, Wildlife, and Parks to improve cooperation and coordination with federal managers in the Bob Marshall Wilderness Complex is examined as a case study illustrating the mechanisms and benefits of this cooperation.

The potential effects of ecosystem management alternatives on terrestrial species viability in the Interior Columbia River Basin[TWS]

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We assessed how current and proposed management alternatives for lands administered by the Forest Service and Bureau of Land Management within the Interior Columbia River Basin Ecosystem Management Project area would contribute to the long-term (100 years) viability of animal and plant species. We assessed seven alternatives that varied emphases to conserve, produce, or restore ecosystem attributes. Two alternatives would continue current plans with no modification or

with additional interim direction. Five new ecosystem management alternatives would vary the mix of emphases: updated plans with local input, active restoration, regional emphasis areas, adaptive management, and a large reserve system. We convened eight panels of scientists to judge the likelihood of viability outcomes under alternatives for 173 species of regional conservation concern. Viability outcomes represented 5 patterns of habitat distribution on federal lands: contiguous, gaps, patchy, isolated, and scarce. We used the distribution and weighted mean of likelihood scores to characterize effects, and the standard deviation of scores to estimate the uncertainty of effects. Currently, nearly twice the species have relatively unfavorable Outcomes 4 (isolated) and 5 (scarce) compared to the historical distribution. Continuing current management would result in more species in those outcomes and continue the decline of overall viability. Restoration, adaptive management, and reserve alternatives would reduce the number of species in unfavorable outcomes by about 30% and reverse the current decline in species viability. Historical levels of viability would not be reached, however. The majority of species would have no significant change (0.5 outcome units) in viability outcome.

Terrestrial Ecology Component Assessment for the Interior Columbia Basin Ecosystem Management Project[TWS]

Bruce G. Marcot
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The Terrestrial Science Staff of the Interior Columbia Basin Ecosystem Management Project analyzed the historical and current status of plants and animals, particularly their habitats; identified areas of species rarity, endemism, and biodiversity ("hot spots"); evaluated the broad-scale biogeography of species (major biophysical reasons for species distributions); assessed the contribution of natural areas to species and ecosystems conservation; analyzed ecological functions of species; identified species of interest to American Indian tribes; evaluated the status and conditions of threatened, endangered, candidate, and sensitive species and their habitats; evaluated the role of key ecological functions of individual species and species groups in maintaining ecosystem diversity, productivity, and sustainability; and identified further information needs for inventory, monitoring, and research. Species included in the assessment were rare fungi, lichens, bryophytes, and vascular plants; selected invertebrates, including insects and other arthropods, mollusks, soil micro-organisms, and species functional groups; and vertebrates, including all amphibians, reptiles, birds, and mammals.

Use of Bayesian Belief Network Models for Evaluating Final EIS Alternatives for Wildlife Viability[TWS]

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The Terrestrial Science Staff of the Interior Columbia Basin Ecosystem Management Project has developed "causal web" models relating key environmental correlates (KECs) of wildlife species, to potential population response under the Project's Final EIS alternatives. The models involve use of Bayesian belief networks (BBNs), which represent conditional probabilities of population response given environmental conditions at two scales of spatial resolution. The KECs were identified by use of literature and expert panels and formalized into a Species-Environment Relations database. The probabilities and BBN model structures were derived from literature and, where needed, expert judgment. The BBN models provide a consistent, testable framework by which to represent simple habitat relations of a wide array of species. Sensitivity analyses using entropy-reduction metrics identify controlling KECs that may be worthy of further study or monitoring. BBN species modeling represents a major step beyond using expert panels to evaluate population viability; it opens the "black box" of expert opinion by formally modeling the subjacent ecological relations.

Gap Analysis Models: a Conservation Tool for Predicting the Distribution of Amphibians and Reptiles in Montana[TWS]

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The goal of the Gap Analysis Program is to provide broad geographic information on the distribution and status of species and their habitats in order to provide land managers, planners, scientists, and policy makers with the information they need to make better-informed decisions. This goal is particularly relevant to the conservation of herptiles, which have experienced declines around the world and in Montana over the past few decades. Models for Montana's 14 amphibian and 17 reptile species were created by (1) reviewing distribution records in the Montana Natural Heritage Program's database and compiling all relevant literature on the species' habitat use and distribution in Montana and surrounding states and provinces, (2) constructing models within a database spreadsheet, and (3) applying the models in ARC/INFO using digital elevation models, land cover types derived from satellite images, and digital line graphs of hydrography. Amphibian and aquatic reptile models typically consisted of buffering hydrographic features into appropriate cover types (at appropriate elevations) by distances typical of the maximum migration the species is known to undergo. Terrestrial reptile models were based largely on turning on appropriate cover types at appropriate elevations. Models, modeling approaches, and model assumptions/caveats for each species were included as metadata for user reference. Predicted distribution maps, species accounts, and key references for each species represent the most comprehensive and up to date understanding of the distribution and habitat requirements of Montana's herpetofauna.

Comparison of Wildlife Mortality Between 2 Consecutive Winters with Contrasting Weather Conditions, Northwestern Montana[TWS]

Gene Miller
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Carcasses found (n = 71) during winter 1997-98 in the lower Clark Fork River drainage of northwestern Montana were examined and assessed for condition by bone marrow-fat index using visual and percent fat (dry/wet weight) rating methods. Species examined were bighorn sheep (*Ovis canadensis*) (n = 18), black bear (*Ursus americanus*) (n = 1), elk (*Cervus elaphus*) (n = 2), moose (*Alces alces*) (n = 1), mule deer (*Odocoileus hemionus*) (n = 5), and white-tailed deer (*Odocoileus virginianus*) (n = 44). For white-tailed deer, percent marrow-fat for both sexes combined (n = 20) during the first half of winter (Jan-Feb 98) was significantly higher from the second half of winter (Mar-May 98) (n = 15) ($P = 0.0004$). White-tailed deer percent marrow-fat was also significantly higher during the first ($P = 0.004$) and second ($P = 0.003$) halves of the 1997-98 winter than during the 1996-97 winter. For bighorn sheep, percent marrow-fat for the first half of winter (Dec 97-Feb 98) ranged from 77-93 percent (n = 5) compared to a range of 20-97 percent for the second half of winter (Mar-May 98)(n = 13). These data show a definite difference for physical condition of white-tailed deer subjected to nearly opposite extremes of winter weather. Poorer physical condition of bighorn sheep during the milder winter (1997-98) is suggested, but probably are a result of inadequate sample sizes. This report documents the seasonal, physical stress on a sample of wildlife in northwestern Montana comparing the effects of contrasting winter weather conditions during 2 consecutive years.

Reintroduction of Grizzly Bears into the Selway- Bitterroot Wilderness Areas of Idaho and Montana[TWS]

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There are 5 populations of grizzly bears (*Ursus arctos*) in the lower 48 states, three of these are small and precarious. Only the Yellowstone and NCDE populations are both reasonably large (>400 individuals each) and growing. Reestablishment of grizzlies in additional large areas of acceptable habitat is an identified component of the FWS recovery plan for grizzly bears. The largest remaining area of unoccupied grizzly habitat is the Selway-Bitterroot and Frank Church River of No Return Wilderness Areas of eastern Idaho and western Montana. This area encompasses some 5,500 square miles that is 97.5 percent USFS public lands, is bisected by only

one paved highway, and has no cattle or sheep grazing permits. Primary human uses of the area are compatible with grizzlies, river rafting, and hunting. FWS estimates that this area could ultimately support >200 grizzlies, a 20-30 percent increase over current lower 48 grizzly numbers. Surrounding the wilderness areas are additional areas of potential grizzly habitat into which bears introduced into the wilderness could connect with existing precarious populations in northern Idaho and north-central Montana. The Fish and Wildlife Service has undertaken an exhaustive public process effort leading to the recent completion of a final EIS for grizzly reintroduction. This FEIS is a compromise approach between those who would prefer no grizzlies and those who prefer a solution more dramatically tailored to grizzly habitat needs. I hope that professional biologists and grizzly advocates can quit arguing over details of the reintroduction plan and unite behind efforts to get some bears back on ground from which they've been missing for 40 years.

Endangered Species Act Review of the Lynx[TWS]

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The publication of the proposed rule to list the lynx in the contiguous United States under the Endangered Species Act has created questions and misperceptions about how animals and plants are added to the list of species protected under the Act and the consequences of listing. Using the lynx as an example, I describe the specific process the U.S. Fish and Wildlife Service must use in determining whether an animal should be listed and the policies and legal cases that provide guidance to the listing process. I review the lynx listing history, time frames for the listing decision, and flexible provisions of the Act. Finally, I summarize some of the Endangered Species Act's requirements and possible effects, should the lynx become listed.

Effects of Spotted Knapweed and its Biological Control Agents on Deer Mouse Ecology[TWS]

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We studied a spotted knapweed- (*Centaurea maculosa*) infested grassland of westcentral Montana to examine the effects of knapweed invasion and 2 gall fly biological control agents (*Urophora affinis* and *U. quadrifasciata*) on deer mouse (*Peromyscus maniculatus*) ecology. Stomach-content analysis indicated that gall flies were the primary food item in deer mouse diets for most of the year and comprised 85 to 90% of the diet during winter. Deer mouse stomach contents also revealed that wild-caught mice consumed on average up to 247 gall fly larvae/mouse/day, whereas feeding trials established that deer mice could depredate nearly 5 times as many larvae under laboratory conditions. Feeding trials showed that deer mice avoided depredating uninfested knapweed capitula while selecting capitula with the highest gall fly infestations. Deer mice selected microhabitats with moderately high

(31-45% cover) and high knapweed infestation (=46% cover) when gall fly larvae were present in knapweed capitula. After gall flies emerged and larvae were unavailable to deer mice, mice reversed habitat selection to favor native-prairie dominated sites with low knapweed infestation (0-15%) while avoiding high-density knapweed stands. Deer mice appear to select for high-density knapweed stands because they exploit gall fly larvae in knapweed-infested habitats. Invasion of native prairie by spotted knapweed and the release of gall flies as biological control agents for knapweed has altered deer mouse habitat selection, diet, and possibly demographics. Knapweed invasion of native grassland systems may disrupt small mammal community composition resulting in indirect effects which impact predator communities.

Private Efforts to Conserve Biological Diversity[TWS]

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Every year tens of thousands of species and attendant ecological interactions, fine-tuned by time and place, disappear at the hand of man. Losses are so severe that the redundancy and certainty of nature is being stripped away, exhausting the lives of millions of people. If trends continue, the world will soon be a more dismal place with silent springs and hot summers and little left to excite the senses less the weeds. Without doubt, the extinction crisis is one of humanity's most pressing problems. In response to the crisis, during June 1997 Ted Turner launched the Turner Endangered Species Fund and the Turner Biodiversity Divisions as private organizations dedicated to conserving biodiversity by ensuring the persistence of imperiled species and the habitats upon which they depend. We concentrate on carnivores, grasslands, plant-pollinator complexes, species with historic ranges that include Turner properties (14 parcels encompassing 1.5 million acres in six U.S. states and Argentina), and distribution of reliable scientific and policy information on biodiversity conservation. Our activities are based on the principles of conservation biology and we work closely with state and federal agencies, Universities, and private organizations. We operate on the belief that many minds wrapped around a problem is a certain route to success. In our endeavors, whether it is management of an extant population or restoration of an extirpated population, our goal is population persistence with little or no human intervention. We believe that self-sustaining populations of native species indicate a healthy or, at least, a recovering landscape.

Teaming With Wildlife: A Update[TWS]

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Non-game programs have traditionally been woefully underfunded; Teaming With Wildlife is an attempt to address this problem. Initially, the idea was to provide the states with approximately $350,000,000 annually from a small, federal excise tax on hiking, camping, and bird watching equipment (similar to what Pittman-

Robertson does with hunting equipment). Each state would receive their share of this money through a formula based on the size and population of the state. Every 3 dollars of federal money would have to be matched by 1 dollar from the state. While most conservation organizations supported this approach, it was strongly opposed by parts of the recreation industry. A new funding proposal would use a portion of the proceeds from the Outer Continental Shelf (OCS) oil and gas revenues to fund the program. Senate Bill 25 would allocate 7 percent of those revenues for state-run, non-game programs. A competing House proposal would allocate 10 percent of those revenues to non-game programs. Most other aspects of the original Teaming With Wildlife proposal are intact. Some environmentalists argue that this bill would encourage future off-shore drilling for oil and gas and therefore oppose the approach; others argue that sufficient safeguards are already in place to prevent this from occurring. I will discuss the discuss the merits of the OCS proposal and provide an update on it's current status in Congress.

Fair Chase, the North American Hunting Ethic and Professional Responsibility[TWS]

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The North American hunting community has an exceptional *collective hunter ethic.* It is an ethic of wildlife restoration and conservation that fits nicely within the Leopold definition of a land ethic. Teaching ourselves the substance of this collective ethic, our hunting heritage, is a positive way of addressing the need to improve individual hunter behavior. This heritage teaching approach is being used to addre s individual ethics by placing each hunter in the context of the achievement of all hunters. Making individuals proud to be hunters creates a positive learning environment where ethical choices can be addressed. This teaching method is part of the training hunter educators are receiving through seminars held by Orion the Hunters Institute all across North America. The menu of training opportunities now available reaches from material for entry level hunters to a graduate level course offering at Montana State University, *The History, Philosophy, and Ethics of the Hunt.* If ethical teaching is to be successful, resource managers will be challenged to contribute by providing hunting opportunities conducive to fair chase concepts that encourage ethical choices. In addition to managing wildlife population, consideration of the hunter's relationship with the individual animal will become part of the 21st Century management standard. Early evidence of this social need was seen in The Montana Hunter Behavior Advisory Council's findings. The council recognized a need to retool both land and wildlife managers so fair chase concepts and ethical hunting environments can become a part of the art of wildlife management.

ADAPTIVE MANAGEMENT AT GRAYS LAKE NATIONAL WILDLIFE REFUGE, IDAHO[TWS]

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Management tools currently in operational use by wildlife refuges of the Intermountain Region will be assessed for their efficacy in maintaining habitat for breeding waterbirds and other biotic resources. Twelve units, 32-70 ha each with a total of 600 ha (1483 ac.) of Grays Lake National Wildlife Refuge, were devoted to a multi-year, replicated field experiment to test four management regimes: continuous idle, fall burning/idle, fall cattle grazing, and summer cattle grazing/idle. Each treatment will be applied to three randomly-selected units during 1997-2000. Each unit will receive standardized and repeated monitoring for breeding bird use; nest success by waterbirds and sandhill cranes; small mammal abundance; predator community composition; and composition and production of vegetation. Preliminary results from 1997-98, pre-treatment years, are discussed. The Service expects to base its long-term management of Grays Lake meadows upon study results.

RABBIT AND HARE HUNTING AMONG MONTANA SPORTSMEN[TWS]

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The Montana Fish, Wildlife and Parks Nongame Program receives periodic inquiries regarding rabbit and hare hunting within the state. Rabbits and hares are classified as nongame species in Montana. In surrounding states, these animals are small game and considered valued game species. Little information exists regarding the hunting of lagomorphs in Montana. I initiated a survey to determine the interest and harvest levels among Montana sportsmen via a special rabbit survey coordinated with the annual Hunter Harvest Survey. A total of 1,408 hunters were interviewed. Eighty-five sportsmen (6%) responded positively when asked if they hunted or harvested rabbits during 1996. A majority of rabbit hunters stated they were hunting other game in combination with rabbit hunting (51%) while 41 percent were hunting specifically for rabbits. Most respondents who hunted rabbits in combination with other game were hunting deer and/or elk (41%) followed by upland game birds (36%). Carbon County was hunted most by those surveyed (13%), followed by Flathead County (7%), while Lewis and Clark, Madison, and Pondera tied at 6

percent of respondents. Sixty-eight percent of rabbit hunters surveyed harvested lagomorphs. Successful hunters generally harvested less than 3 rabbits (61%). Most rabbit hunters harvested cottontails (*Sylvilagus spp*) and/or jackrabbits (*Lepus spp*). It appears that interest levels in rabbit hunting are significant in Montana. An equivalent number of sportsmen hunt specifically for rabbits and hares as those that hunt waterfowl, and rabbit hunter numbers approach those that hunt turkeys in Montana.

High Reservoir Discharge and the Collapse of a Regulated River Food Chain[TWS]

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When populations of a species occupying the intermediate level of a food chain decrease, taxa at higher trophic levels should also decline, whereas species immediately below the intermediate level should increase. We conducted a retrospective investigation to test this hypothesis by analyzing a 13-year data set of a reservoir food chain. Kokanee salmon (*Oncorhynchus nerka*) were introduced into Hauser Reservoir, Montana during the late 1970's and the population peaked a decade later. The number of bald eagles (*Haliaeetus leucocephalus*) congregating at the reservoir to feed on kokanee during autumn migration was highest in 1991, the same year angler harvest of kokanee peaked. The concentration of bald eagles attracted thousands of eagle viewers each autumn. The kokanee population crashed in 1994. Heavy winter snow and subsequent high reservoir discharge over several years may have caused the decline. The number of migrant bald eagles that congregated in autumn, along with eagle viewers, declined significantly after the kokanee decrease. Angler harvest rates also plummeted. These declines supported the basic food chain hypothesis. Contrary to predictions, zooplankton did not increase following the demise of kokanee, a principal predator. Zooplankton densities were always very high and a eutrophic reservoir located upriver from Hauser Reservoir probably maintained these populations at levels where limiting factors other than predation operated. We discuss the management implications of the collapse of this food chain and recent efforts to augment the kokanee population.

Habitat Selection and Mortality of Mule Deer in the South Central British Columbia[TWS]

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Several regions of British Columbia (B.C.) have recently experienced seemingly sharp declines in mule deer (*Odocoileus hemionus*) populations. One hypothesis regarding this decline is that habitat modifications, brought about by resource extraction, have exacerbated predation pressure on mule deer. In response to this the Columbia Basin Fish and Wildlife Compensation Program in conjunction with the B.C. Ministry of Environment Lands and Parks, began radio collaring mule deer in February 1997. Deer in the Salmo-Creston region of south central B.C. were targeted, partially due to their overlap with mountain caribou (*Rangifer tarandus caribou*), another species believed to suffer from high predation pressures. We have radio collared 24 mule deer (22 females, and 2 males), 13 of which remain on the air. Moralities include three cougar predations, one bobcat predation, one unknown predation, one highway mortality, one death of natural causes, and three unknowns. One buck slipped his collar shortly after capture. Radio collaring of additional deer is ongoing. This project will produce basic habitat and population data (i.e. seasonal habitat use, survivorship, and recruitment), as well as an in-depth analysis of mule deer mortality. Analysis of radio telemetry and mortality data will test the hypotheses that: 1) deer use some habitats disproportionately to availability, 2) predation is disproportionately high in specific habitats, and 3) population recruitment is low due to high predation. Determining which forces have the greatest impact on mule deer populations, may allow managers to address the recent decline in deer numbers through better habitat, or predator management. Poster.

Minimum Population Estimate and Limiting Factors for North Cascade Grizzly Bears[TWS]

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The trans-border North Cascades grizzly bear population in northern Washington (WA) and southern British Columbia (BC) is classified as Threatened in the U.S. (US Fish & Wildlife Service 1993) and sensitive in adjacent BC (BC Ministry of Environment, 1995). This population has been protected on both sides of the international border for decades but has not recovered despite protection. How many grizzlies, if any, are on the US side is unknown. We must determine the number and sex ratio of grizzly bears present in the North Cascades to determine if the population has any chance of natural recovery. We will use DNA hair-snag methods to test several hypotheses within a 2,000 km2 area of the northernmost part of the US Cascades: 1) Are grizzly bears present in the North Cascades Ecosystem; 2) What is the minimum and estimated number of grizzlies in the North Cascades; 3) Are female grizzlies present and what are the minimum estimated numbers. This information will be used in conjunction with that obtained in BC on a 2,400 km^2 area just north of the border to determine minimum population size for a 4,200 km^2 trans-border region. Our DNA hair-snag data will also be used to test hypothesis 4) What is limiting population growth and recovery in the North Cascades (lack of bears, lack of females, inbreeding, lack of vertebrate food, sexually motivated infanticide). This information will be used to formulate a scientifically based recovery plan for the North Cascades Grizzly Bear Ecosystem. Poster.

Source-sink Dynamics of Passerines in the Greater Yellowstone[TWS]

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We studied the distribution of bird species diversity and abundance among multiple habitats from 1995-1998. Distributions were shown to be very heterogeneous in space with several habitats acting as hot spots for diversity and density. Habitats dominated by deciduous vegetation were the strongest hot spots. All of the hot spot habitats occur as relatively small patches and many hot spots are within or near sites of intensive human land use. Thus, reproductive success and population viability may be low in some hot spots. We studied nest success of multiple species in cottonwood (hot spot with intensive land use), aspen (hot spot with less intensive land use), and lodgepole pine (non-hot spot) to investigate possible source-sink status of populations in various habitats. We searched for and monitored nests of multiple species in each habitat during 1997-98. We successfully monitored 1,004 nests and obtained data for 18 species. Preliminary analyses indicate that for most species, reproductive output is lower in cottonwood habitat than it is in aspen or in lodgepole pine. This is due to lower nest survival and higher brood parasitism in cottonwood. Analyses of covariates of nest survival indicate that intensity of human land use near a site is inversely related to nest survival on a site. Preliminary results of population modeling suggest that cottonwood and some aspen stands may act as high-density population sinks and that many aspen stands may be important population sources.

Reestablishment of Carnivore Habitat Connectivity in the Northern Rocky Mountains[TWS]

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Habitat fragmentation is a major conservation issue facing large and mid-sized carnivores (grizzly bear, *Ursus arctos*; gray wolf, *Canis lupus*; wolverine, *Gulo gulo*; lynx, *Lynx canadensis*; fisher, *Martes pennanti*) in the Northern Rockies. Habitat Fragmentation has caused: 1. The isolation of carnivore populations; 2. The necessity for reintroduction and augmentation programs; and, 3. Highly restrictive land management practices. This has lead to both expensive and controversial management practices to conserve carnivore populations. Two primary factors have created habitat fragmentation. These are highway and railroad right-of-ways and development of narrow parcels of private lands. The authors have reviewed habitat fragmentation in the Northern Rockies and developed a proposal to reestablish or improve habitat connectivity. This proposal would also benefit other wildlife species, reduce wildlife mortality on highways and railroads and make highway travel safer for motorists by reducing vehicle collisions with wildlife.

ROCKS AND ICE REVISITED: AN ASSESSMENT OF THE GEOGRAPHICAL AND ECOLOGICAL DISTRIBUTION OF RESERVES IN THE UNITED STATES[TWS]

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Creation of a complete network of biological reserves in a country requires that the level of protection attained with existing reserves be known before new refuges are established. This knowledge can be used to further protect biodiversity with a minimum of duplication of past efforts and the most efficient filling of gaps in the reserve network. We present the results of a study in which we mapped the occurrence of biological reserves in different physical environments across the coterminous United States. We examined the occurrence of theses reserves by 500 meter elevation intervals, quantiles of soil productivity, five degree blocks of latitude and longitude, and ecoregions. Observed patterns of occurrence suggested uneven distribution within all these coarse filter features. The areas with the highest level of protection were those that were least productive and or least accessible. We discuss the implications of these findings for future siting of reserves.

THE STATUS OF GRIZZLY BEAR RECOVERY 25 YEARS AFTER LISTING[TWS]

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The grizzly bear was listed as a threatened species in 1975. In 1981 recovery actions got underway. Since that time significant progress has been made in the Yellowstone Ecosystem where the population is now increasing and reoccupying areas where it has been absent for 40 or more years. The reasons are directly related to reduced human-caused mortality with resultant increasing numbers of females having cubs. From 1996-98 more than 204 cubs were born in the Yellowstone area while only 18 bears were known to die from human causes. In the other ecosystems, recovery is not as clear as in Yellowstone. In the Northern Continental Divide Ecosystem in Montana, grizzlies have reoccupied the Rocky Mountain front from the Canadian border to Highway 200. Bears are moving farther and farther east on the prairie each year as populations increase in this area. The fact that most of this land is in private ownership complicates management in this area. The NCDE is almost 16 percent private land and these areas are the major conflict sites between bears and people. In the last 11 years, 61 percent of the human-caused mortalities have been on or within 1 km of private lands in the NCDE. The Cabinet/Yaak ecosystem has a small population. We have placed 4 young females in this area to augment this population. The numbers of bears in this area remains low, however, with most animals in the northern Yaak drainage. The Selkirk ecosystem is small in size, but animals are increasing in this area since recovery actions have been underway. The connection with Canadian habitat is important here as the bears go back and forth across the Canadian border. The North Cascades population is minimal at this time. It may well be that the remaining bears are concentrated along the US-Canada border, but data on the US side to verify this is minimal. The Bitterroot is the only large area south of Canada where bears do not currently exist but where there is

habitat and space capable of supporting a population. An EIS process is drawing to a close to restore grizzly bears to the Bitterroot using an innovative citizen management approach. The final decision on the Bitterroot will be made this year. The restoration of grizzlies in the Bitterroot will be one of the outstanding achievements of Rocky Mountain wildlife conservation if it is allowed to go forward.

Development of Fall Cattle Grazing Prescriptions to Improve Deer and Elk Forage[TWS]

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Cattle (*Bos taurus*) and wild ungulates have long been viewed as competitors. In the future the best method of preserving wildlife and cattle will be to manage them cooperatively. The objective of this project was to examine the use of fall cattle grazing to improve wildlife forage. We looked at the effects of four fall cattle grazing levels on elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*) and white-tailed deer (*Odocoileus virginianus*) forage. The hypothesis of this study is that fall cattle grazing will improve the quality of elk and deer forage the following spring and summer. The effects of fall grazing on wildlife forage were examined on the Blackfoot Clearwater Wildlife Management area in westcentral Montana. A randomized complete block design with five replications was used. Cattle were grazed in enclosures during the fall of 1997 and 1998. Grazing levels were 0 percent removal (control), 50 percent removal, 70 percent removal, and 90 percent removal. During spring and summer we measured plant species composition, plant diversity, dead plant material, green forb biomass, and green grass biomass to evaluate quality of elk and deer forage. Preliminary data from the first year of this two-year study suggests significant positive differences in wildlife forage due to cattle grazing intensity. Information generated will be useful in making management decisions on ranges that are important spring and summer wildlife habitat.

Off-site Impacts of Rural Subdivision on Wintering White-tailed Deer in Northwest Montana: Could Man's Best Friend Be Wildlife's Worst Adversary?[TWS]

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Impacts of rural subdivision are often considered at the project scale rather than in the greater context of the landscape. Impacts to wildlife and wildlife habitat extend beyond the boundaries of the actual development site. We demonstrate that off-site impacts to wintering white-tailed deer (*Odocoileus virginianus*) increase as the number of home sites increases. Between 1988- 97, white-tailed deer were systematically surveyed on public land using remotely-triggered cameras in a 29 km^2 grid. Incidental photographs of free-ranging domestic dogs (*Canis familiaris*) were obtained, starting in 1991. The number of septic permits, reflecting occupied home sites in a buffer of private land surrounding the survey area, was summarized for the

years 1974-1997. The number of permits issued varied annually, but the cumulative total increased significantly through time ($P < 0.000$). The average number issued per year increased from 3.2 in 1989-92 to 9.4 in 1993-97 ($P = 0.014$). Concurrently, the number of unique dogs photographed per unit effort (x100) increased from 0.21 in the period 1989-92 to 1.3 in 1993-97 ($P = 0.027$). Linear regression demonstrated that the total number of unique dogs photographed per year (TDOG) was significantly related to the cumulative number of septic permits in the buffer ($P < 0.029$). Dogs were photographed up to 2.5 km from the nearest home site. Some dogs were explicitly photographed chasing deer. Individual dogs were photographed in multiple years and on multiple occasions within a single year. One in particular was photographed on 6 occasions at 5 different sites in 15 days. Two of those sites were 3 km apart. The majority of dogs wore collars (88.5%) and were photographed during daylight (65.9%). Implications will be discussed.

Long Term Monitoring of Vegetation on Elk Range in Rocky Mountain National Park[TWS]

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A study of the condition and trend of vegetation was initiated in 1968 on the elk winter range in Rocky Mountain National Park. To monitor changes 45 transects were established on the east slope low elevation winter range and 17 transects on the higher elevation winter and summer ranges, including 5 in the Colorado River Valley. These transects consisted of 21 Daubenmire plots (20X50 cm) distributed along a 100 ft line to measure canopy cover and frequency of primary plant species. Shrub intercept was measured along lines 100 or 200 ft in length. Most transects were measured at 5 year intervals with the last reading in 1996. On the shrub/grass and grassland plots the vegetation appears to have remained stable in composition and cover. Results on the meadow types were not definitive but may reflect responses to changes in water table levels. Declines were apparent on aspen and willow transects but individual transects vary greatly in response to use by elk and/or habitat modification by beaver. On the alpine tundra transects the vegetation on upland sites appeared quite stable, but some declines are indicated for willow cover on Trail Ridge. Major declines in willow cover over the study period were noted on subalpine krummholz plots. Elk are probably a significant influence but weather conditions may also affect these sites. West side willow transects along the Colorado River bottom did not indicate any significant trends.

Diet Selection of Bighorn Sheep in Central Idaho[TWS]

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Rocky mountain bighorn populations in the Big Creek drainage of central Idaho experienced population declines, followed by years of low recruitment. It was unclear whether disease alone caused population declines or whether several interacting factors combined to lower disease resistance. Knowledge of diet composition was necessary to assess the nutritional status of local bighorns. The objective of this study was to determine and interpret the seasonal diet selection of the non-migratory portion of the population. Microhistological analysis of composite fecal samples was used to determine diet composition, and plant samples were analyzed for crude protein, digestibility, and macro and micro nutrients to examine forage quality. Graminoids made up the majority of the diet throughout the year. During spring green-up when protein content and digestibility of grasses were at peak levels, consumption of forbs and browse declined. However, forbs and browse provided important sources of nutrients, especially protein, at critical times of the year when grasses were low in nutritional value and digestibility. Non-migratory bighorns had developed flexible and dynamic feeding behaviors that allowed them to meet their nutritional needs while remaining in a relatively warm, dry environment. Managers should focus on providing a diversity of plant species in all forage categories. Invasions of exotic plant species that reduce biodiversity may negatively impact bighorn sheep populations.

Demographics, Movements, and Population Trends of Grizzly Bears in the Cabinet-Yaak and Selkirk Ecosystems of British Columbia, Idaho, Montana, and Washington[TWS]

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We investigated demographic values of 22 and 46 radio-collared female grizzly bears (*Ursus arctos*) and attendant offspring in the Cabinet-Yaak and Selkirk ecosystems, respectively. Data was collected from 1983-1998. Four mortalities of radio-collared animals or offspring were detected in the Cabinet-Yaak sample and 11 in the Selkirks. Estimated survival rates were 0.953 Å 0.238 for adult females, 0.913 Å 0.190 for subadult females, 1.0 Å 0.0 for yearlings, and 0.867 Å 0.20 for cubs in the Cabinet-Yaak. Estimated survival rates for the Selkirks were 0.933 Å 0.072 for adult females, 0.856 Å 0.200 for subadult females, 0.641 Å 0.297 for yearlings, and 0.870 Å 0.174 for cubs. We also report and compare trap success, reproductive parameters, causes of mortalities, and sex/age structure from these two areas. We calculated a finite rate of increase (74) during 1983-1998 for the Cabinet-Yaak and Selkirks. Adult female survival contributed the largest amount to the variance in 74 for the Cabinet-Yaak. Subadult female survival contributed the largest amount to the variance in the Selkirks. Data was partitioned to investigate timing and influences of mortalities on population growth. Male grizzly bears from both the Yaak and Selkirks moved into a common area in British Columbia, suggesting possible genetic interchange between recovery zones. We discuss the validity and implications of classification of these two ecosystems as one recovery area.

Distribution, Abundance and Status of the Timberline Sparrow in Montana: A Threatened Species?[TWS]

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The "Timberline" subspecies (*Spizella [breweri] taverneri*) of the Brewer's sparrow is a little- known songbird breeding in high elevation treeline habitats of the Canadian Rockies. Recent discovery of Timberline sparrows in Glacier National Park raises new questions about it's current distribution, abundance and biological status in the United States. Field surveys of Timberline sparrows in Glacier National Park in 1998 found approximately 50 breeding pairs in fifteen separate locations within the park. I will discuss subspecific identification, vocalizations, habitat associations, effective monitoring methods and plans for future research.

Bibliography on Motorized and Nonmotorized Recreation in Wildlife Habitat[TWS]

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The Montana Chapter of The Wildlife Society (TWS) is developing a comprehensive bibliography on motorized and nonmotorized recreation in wildlife habitat. A volunteer committee (Montana Chapter of TWS Committee on Recreation in Wildlife Habitat) is using the bibliography to prepare a document that identifies issues, impacts, and research needs and provides guidelines for resource managers. To date, the bibliographic database consists of approximately 2600 references compiled from literature searches of commercial and government databases and other recreation bibliographies. Presently, the bibliography includes key references that directly address aspects of recreation and disturbance to wildlife as well as more general papers that contain important biological/ecological species information. The bibliography will be partially annotated and contain the authors' abstracts and/or annotations by committee members. ProCite software is being used to construct the electronic bibliographic database that can be searched by wildlife groups (amphibians and reptiles, birds, carnivores, small mammals, ungulates), types of motorized and nonmotorized recreation, as well as by species, vegetation, soil, water, laws and policy, and other keywords. The final version of the bibliography, including detailed instructions and explanations of keywords, will be available to the public via an internet web site (linked to The Montana State Library, The Wildlife Society, and Montana Fish, Wildlife and Parks) by September 1999. Upon completion, all hard copies of papers accumulated during this project will be held in repository at The Montana State Library for public use. Poster.

Effects of Forestry Roads and Cutting Units on Grizzly Bear Habitat Use in the Selkirk Mountains Grizzly Bear Ecosystem[TWS]

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We investigated effects of forestry on grizzly bear (Ursus arctos) habitat use in the Selkirk Mountains of northern ID, northeastern WA, and southern BC from 1985-1991. We hypothesized that bears would avoid open, restricted, and closed forestry roads in that order. We also hypothesized that grizzlies would avoid managed cutting units (clearcuts and young forests) and prefer unmanaged units (natural openings and old forests). We used chi square goodness of fit and log-linear models to analyze habitat use for 11 bears (5F, 6M) in an area containing both open roads (public use allowed) and closed roads (no public use allowed) and 11 bears (7F, 4M) in an area containing restricted roads (forestry use only). Four of 5 females and 3 of 6 males avoided open roads and 3 of 5 females and 0 of 6 males avoided closed roads. No bears avoided restricted roads. Our results are inconsistent with the hypothesis that bears avoid open, restricted, and closed roads in that order. Zero of 5 females and 1 of 6 males avoided ($P<0.05$) clearcuts and 5 of 5 females and 3 of 6 males preferred openings in the open road area. No bears avoided clearcuts and 2 of 7 females preferred openings in the restricted road area. Four of 5 females and 2 of 6 males avoided young forests but 2 of 5 females and 2 of 6 males also avoided old forests in the open road area. Two of 7 females preferred and 1 of 7 avoided young forests but 6 of 7 females and 2 of 4 males avoided old forests in the restricted road area. The "apparent" avoidance of young forests in the open road area was due to avoidance of associated open roads. Our results are inconsistent with the hypothesis that bears avoid managed units (clearcuts and young forests) and prefer unmanaged units (old forests). Forestry activities alone (restricted roads, clearcuts, young forests) had no apparent negative effect on grizzly bear habitat use. Human recreational use (open roads) had the only observed negative effect on bear habitat use. We recommend that open roads not be intermixed with closed roads and that open roads be converted to restricted use whenever possible.

Overview of Terrestrial Science Assessments for the Interior Columbia Basin Ecosystem Management Project[TWS]

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The Interior Columbia Basin Ecosystem Management Project (ICBEMP) is a multi-resource, multi-disciplinary effort to develop an ecosystem-based strategy for managing National Forest and BLM lands within the 145-million acre Interior Columbia River Basin (Basin). Terrestrial science assessments of the ICBEMP, which consist of a myriad of publications, databases, reports, and computer maps, provide a compelling basis for ecosystem-based management of the Basin's plant and animal species. Three terrestrial science publications are of particular interest to managers and biologists: (1) the terrestrial component assessment ("Terrestrial Ecology of the Basin," by Marcot et al. [1997]), which synthesized a wealth of knowledge regarding the ecology of plant and animal species and communities in the Basin; (2) the analysis of source habitats and road effects ("Source Habitats for Terrestrial Vertebrates of Focus in the Interior Columbia Basin," by Wisdom et al. [in press]), which evaluated habitat trends and road effects for selected species of viability concern; and (3) the analysis of ecosystem management alternatives on terrestrial species viability ("Historical and current status of terrestrial species and the effects of proposed alternatives," by Lehmkuhl et al. [1997], which assessed effects of proposed alternatives of the ICBEMP's Draft Environmental Impact Statements on terrestrial species viability. Findings from these publications, each of which is available as a general technical report from the USDA Forest Service Pacific Northwest Research Station in Portland, are the basis for three of our presentations. In addition, our last presentation describes on-going work regarding the use of Bayesian belief network models to evaluate viability effects for selected species as part of the final Environmental Impact Statement and Record of Decision. The composite of these terrestrial science assessments will form the basis for critical land management decisions in the Basin, and as such, resource managers and biologists in the Basin will benefit from a strong working knowledge of this work.

Longitudinal Studies of Hantavirus in Deer Mice in Western and Central Montana[TWS]

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The summer (1994) following the occurrence of the first two human Hantavirus cases In Montana which occurred in 1993, we initiated a longitudinal study of the ecology of deer mice *(Peromyscus maniculatus)* and Hantavirus. The objectives were to determine the geographic distribution of infection in rodents, describe the relationships between deer mouse population dynamics and infection, and to try to determine how the virus is maintained in the deer mouse population. As of November 1998, we had captured 6,342 rodents 10,992 times. Of 20 species of rodents, deer mice, meadow voles *(Microtus pennsylvanicus)*, red backed voles

(*Clethrionomys gapperi*), sagebrush voles (*Lagurus curtatus*) and yellow pine chipmunks (*Tamias amoenus*) were found to be seropositive for antibodies against Hanta type viruses. We found infected animals everywhere we trapped. Preliminary data comparing population density versus infection rates and numbers of infections are presented. Clues to the maintenance of the virus in deer mouse populations include differences in infection rates among animals of differing ages, sexes and breeding condition.

Road Effects and Source Habitat Trends for Terrestrial Vertebrates of Concern in the Interior Columbia Basin[TWS]

Michael J. Wisdom, Richard S. Holthausen, Barbara C. Wales, Danny C. Lee, Christina D. Hargis, Victoria A. Saab, Wendel J. Hann, Terrell D. Rich, Mary M. Rowland, Wally J. Murphy, and Michelle R. Eames
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We assessed habitat trends and summarized knowledge about species-road relations for 91 species of terrestrial vertebrates that were of viability concern within 145 million acres of public and private lands in the Interior Columbia Basin. Our assessment was conducted as part of the Interior Columbia Basin Ecosystem Management Project. Our results indicated that habitats for species associated with old-forest structural stages, with native grasslands, or with native shrublands have undergone strong, widespread decline. Implications of these results for managing old-forest structural stages include the potential to (1) conserve habitats in areas where decline in old forests has been strongest; (2) use silvicultural manipulations in mid-seral forests to accelerate development of late-seral stages; and (3) accommodate fire and other disturbance regimes in all forested structural stages to hasten development and improvement in the amount, quality, and distribution of old-forest stages. Implications of our results for managing rangelands include the potential to (1) conserve native grasslands and shrublands that have not undergone large-scale reduction in composition of native plants; (2) control or eradicate exotic plants on native grasslands and shrublands where invasion potential or spread of exotics is highest; and (3) restore native plant communities, using intensive range practices, where potential for restoration is highest. Our analysis also indicated that >70 percent of the 91 species are affected negatively by one or more factors associated with roads. Comprehensive mitigation of road effects will require a substantial reduction in the density of existing roads as well as effective control of road access in relation to management of livestock, timber, recreation, hunting, trapping, mineral development, and other human activities.

Why Focus on Wilderness?[TWS]

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For many people, watching and searching for signs of wildlife contributes immensely to the value of their wilderness experience. Hiking a wilderness trail imagining that a grizzly bear awaits at every turn, hearing the first birds sing in the spring, and searching the forest understory for snakes and salamanders are heart-filling experiences for many wilderness visitors. Wildlife species also contribute to the functioning of wilderness ecosystems, through actions such as seed dispersal, germination, and fertilization. Many wildlife species could not persist in the face of human development without broad expanses of wilderness, and if wilderness areas are too small, species such as the wolf, grizzly, and wolverine disappear from the landscape. Because the persistence of many wildlife species depends on the presence of wilderness, and areas outside wilderness are undergoing increasing developmental pressure, conservation biologists question whether the current distribution of wilderness will allow for the long-term viability of native wildlife species. Questions about the amount and distribution of wilderness needed for wildlife conservation are based on an assumption that wilderness in itself is sufficient refuge for species adversely affected by development. However, there are many threats to wildlife within wilderness, including recreation, pollution, and altered disturbance regimes. While wildlife management is one of the more complex and controversial aspects of overall wilderness administration, it receives relatively little attention. Being explicit about the contribution of wilderness to wildlife conservation, and the threats within and around wilderness, can help biologists and wilderness managers identify gaps in the conservation of wilderness-dependent species.

Effects of Prescribed Fire on Sage Grouse Habitat[TWS]

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Sage grouse nest success and chick recruitment are influenced by tall grasses for nesting cover and broad-leaved forbs for chick and pre-laying female nutrition. Fire suppression and other land uses may reduce understory herbaceous cover by increasing associated shrubs. Prescribed burning may be an effective way to enhance food and cover for sage grouse. The effects of prescribed fire on shrubs, grasses, forbs, and arthropods in Wyoming big sagebrush habitat were examined at Hart Mountain National Antelope Refuge, OR. Eight similar plots, u 400 ha in size, were sampled before fire in 1997 and after fire in 1998. Four plots were randomly selected for treatment, and burned in September of 1997. Prescribed burning removed sagebrush cover from 35 percent of treated plots and created 29Å 11.11 edges per linear km. Shoot density of sagebrush individuals was 235 percent greater along burn edges. Prescribed fire reduced percent cover and frequency of tall grass and perennial bunchgrasses. However, perennial bunchgrass density was similar between treatments. Overall, grasses were likely reduced in size, but not number of individuals. Prescribed fire increased percent cover and frequency of forbs, especially annuals. Ant abundance was also increased by fire. Of 8 sage grouse food species studied, > numbers of flowers (5 species), extended flowering periods (6 species), longer succulence (all species), yet lower frequency score or density (3 species) were observed in burned plots. Sagebrush absence within burned areas will reduce nesting cover for sage grouse. However, increased sagebrush growth may increase nest cover along edges. Greater ant abundance, forb cover, flowering, and length of time available may positively affect nutrition of pre-laying female, and young sage grouse.

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