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IJS

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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.

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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 manuscript submitted to the *Intermountain Journal of Sciences*" (Dusek 1995). This cover letter must also include a statement by the author that thi paper ha 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.

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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

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Behavior of Nesting Lewis' Woodpeckers in the Laramie Range, Southeastern Wyoming

Stanley H. Anderson
Kathleen A. Linder

Abstract

Little data exist on the behavior of nesting Lewis' Woodpeckers (Melanerpes lewis), *particularly in areas where it is not a year long resident. We examined behavioral characteristics of this migratory bird that nested in clumps of ponderosa pine* (Pinus ponderosa) *in southeastern Wyoming during the 1993-1994 breeding seasons. We divided the breeding season into three periods defined as prenesting, incubation, and nestling. We found period difference ($P < 0.05$) in foraging behavior, time spent out of sight of the nest, time spent in the nest cavity, and perching. Birds spent more time foraging and perching during the nestling period as opposed to the incubation period ($P < 0.05$). We found no significant time of day differences. Period effects were found for vegetation gleaning (1993) and hawking (1994). Eleven of the 30 nests active in 1993 were reused in 1994.*

Key words: Lewis' Woodpecker, *Melanerpes lewis*, behavior, habitat, incubation, foraging

Introduction

Lewis' woodpeckers are cavity nesters that either excavate a new nest cavity, reuse the same cavity from the previous season, or use a natural or deserted cavity of another woodpecker (Bock 1970, Harju 1978, Bent 1992). The birds frequently utilize snags or partially living trees that are left after a forest fire (Linder and Anderson 1997). The pair is monogamous with both sexes assisting in the incubation of the eggs (Ehrlich et al. 1988). The young are fledged 28-34 days after hatching (Bock 1970, Ehrlich et al. 1988). In the northern part of their range (this study) Lewis' woodpeckers are seasonally migratory. They are territorial during the breeding season and are intolerant of conspecifics as well as other potential competitors (Bock et al. 1971, Hadow 1973).

This species has a unique foraging strategy compared to most other woodpeckers (Bent 1992). They spend 60-76 percent of their time catching insects on the wing (hawking), with the remainder spent primarily gleaning the ground and in brush. Only a small proportion of time is spent gleaning and probing snags (Jackman 1975, Sousa 1982, Raphael and White 1984). These behavior patterns may be an adaptation to burned habitats in which the birds nest.

Initial seasonal behavior changes had not been previously quantified for this species which was migratory in this portion of its range. This paper quantifies behavioral characteristics of Lewis' woodpeckers during the breeding season in the northern part of their range where such information is generally lacking. We used time budget analysis to quantify changes in behavioral patterns throughout the day

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and through the breeding season as young fledged. We also documented the incidence of territoriality and reuse of nesting cavities during the two year study.

Study Area

The study area, which contained scattered clumps of ponderosa pine, was located in the Laramie Range of southeastern Wyoming. Two large sites known to support Lewis' woodpeckers were selected. Both sites contained large burns of greater than 1250 ha. Fires eliminated much of the tree canopy and ground cover in some sections while leaving other tracts undisturbed.

The Tunnel Road Area (42° 0'N,105° 30'E), encompassing 6216 ha, ranged in elevation from 1890 m to 2347 m; approximately twenty-one percent had been burned (1295 ha) in 1974. The Palmer Canyon Area (42° 07'N,105° 22'E) encompassed 3885 ha with elevations of 1615 m to 2412 m. Approximately forty-one percent of this site had been burned (1590 ha) in 1986.

The average annual precipitation in the study area was 18.8 cm. The average summer temperature was approximately 47° C and ranged from 28.8° C in May to 57.6° C in July.

Methods

Nest Search Strategy

Fieldwork spanned the time birds arrived in early May to late August in both 1993 and 1994. A systematic (transect) search of each area was conducted by vehicle or foot using 1:24,000 United States Geological Survey (USGS) topographic maps as a guide. Nest searches could be conducted during all daylight hours due to the Lewis' woodpeckers conspicuous and distinctive behavior.

Once located, an adult woodpecker was continuously observed for 40 minutes or until it entered a cavity. If we were unable to locate a potential nest cavity within 40 minutes, we marked the area on a topographic map and returned to survey it at a later date. We assumed nests to be active if we saw an adult feeding, excavating, or remaining in the cavity for longer than two minutes, or heard the sounds of young. We flagged confirmed nests and plotted them on maps for periodic revisits.

Behavioral Observations

During 1993, we chose every fifth nest found, for a total of five confirmed active nests, to make behavioral observations. For each sampling period, we continuously watched a nest for one to three hours. When practical, we recorded the type and length of all behavior patterns for both adults (Table 1). During 1993, we recorded a total of 115 observation hours.

Table 1. *Behavior patterns recorded for Lewis' woodpeckers in southeastern Wyoming.*

Major	**Foraging**
Foraging	Vegetation Gleaning
Perching	Ground Gleaning
In Nest	Hawking
Copulation	Chiseling
Out of View	Direct Flight
Territory	
Perching	**Territorial**
On Nest Tree	Intraspecific
Nearby Tree	Interspecific
Looking into Nest	Calling
Exiting Nest	Drumming

During 1994, we selected every sixth active nest found to observe for a total of four. We also watched two of the nests observed in 1993, to provide a source of comparison between years. We spent a total of 206 hours observing behavior in 1994 in a manner similar to 1993. During 1994, however, we made one hour observations at varying times and were offset by one time period each sampling day. For example, if we observed a particular nest at 0800 one day, it would be observed at 0930 the next day. We documented nest site reuse in the second field season by relocating all previously occupied nests to determine whether those sites were reoccupied.

Analysis

We quantified behavioral changes among periods in the breeding eason, times of day, and years from data gathered from behavioral ob ervations on five nests in 1993 and six nests in 1994. During the breeding season, we defined three periods: prenesting (15 May-10 Jun.), incubation (10 Jun. -10 Jul.), and nestling (11 Jul. -10 Sep.). We divided the time of day into morning from 0600-1100, mid-day from 1100 -1500 and afternoon from 1500 - 2000.

We used this information to quantify the percent of time woodpeckers engaged in specific behavioral patterns. We classified behaviors into the following categories: foraging, perching, in nest, out of view, copulation, and territoriality (first level) (fable 1). We broke foraging, perching, and territoriality down further into second level behaviors (fable 1). Time spent in the nest included such behaviors as excavation, incubation, and feeding during early stages of the nestling period.

MANOVA was used for repeated measures (SAS 1985) to determine whether first level categories of behaviors differed across seasons, across times of day within seasons, or across times of day between seasons. We then evaluated the percent time foraging, percent time perching, and percent time spent in territorial behaviors. This level of anaysis showed the percentage of individual behaviors that made up the first level categories for differences across years, seasons, and times of day. We used alpha levels at $P < 0.05$ and mean values (percent of time) for both levels of analysis. In the 1993 field season, we did not obtain any observations for the prenesting period. Thus we only used the periods of incubation and nestling/ fledgling in the analysis.

RESULTS

There were no time of day effect or time of day between periods ($P > 0.05$) for the first level behavior classifications of Lewis' woodpeckers (table 2). We found effects ($P < 0.05$) in time spent foraging, time spent in the nest cavity, out of sight of the nest cavity, and perching between periods during both years (fable 3). Percent time spent in the nest cavity and out of sight of the nest tree were higher ($P < 0.05$) in the incubation and nestling periods. In 1994, percent time perching was ($P < 0.05$) higher in the prenesting period.

Time of day effects in individual foraging behaviors were not significant ($P > 0.05$), but we found some difference<; between periods (fable 4). Vegetation gleaning was higher ($P < 0.05$) in the 1993 incubation season. Hawking in 1994 was lower (P - 0.013) in the nesting period while direct fhght was higher ($P < 0.05$) during foraging in the 1994 nestling period.

We found no time of day effects ($P < 0.05$) for individual perching behaviors out of total percent time perching. One significant period by time of day ($P < 0.05$) interaction occurred for perching away from nest tree in 1994. In 1993, time spent looking in the nest cavity was higher ($P < 0.05$) in the incubation period, and in 1994, it was higher m both the prenesting and incubation period than in the nestling period. Time spent in the nest cavity in preparation for exit was higher ($P < 0.05$) in the incubation period than in either the prenesting or nestling period during both years.

There were no time of day effects ($P < 0.05$) or period by time of day interactions appeared for percent time spent in territorial behaviors out of total time spent in territorial activities, but we documented one seasonal effect. In 1994, calling represented a higher ($P < 0.05$) percent of the total time in territorial behaviors in the prenesting and nestling season than in the incubation season.

Table 2. *Percent of time spent in each behavior classification by Lewis' woodpeckers near nests.*

Year	Behavior type	Prenesting			Incubation			Nestling		
		Morn	Midday	Afternoon	Morn	Midday	Afternoon	Morn	Midday	Afternoon
1993	Foraging				4	5	6	9	9	13
	Perching				12	23	19	24	28	31
	In Nest				33	27	24	10	5	3
	Feeding				0	0	0	1	1	2
	Copulation				0	0	0	0	0	0
	Out of Sight				51	44	49	55	56	51
	Territory				1	0	1	1	1	1
1994	Foraging	3	6	4	4	4	4	9	10	11
	Perching	24	27	28	15	20	14	22	23	22
	In Nest	27	24	22	40	36	37	6	7	6
	Feeding	0	0	0	0	0	0	1	1	1
	Copulation	0	0	0	0	0	0	0	0	0
	Out of Sight	43	42	45	41	40	44	61	59	59
	Territory	3		1	0	0	0	2	1	1

Table 3. *Percent time spent in primary behavior type during prenesting, incubation and nestling periods in 1993 and 1994.*

	Prenesting	Incubation	Nestling
1993			
Foraging*		5	10
Perching*		18	28
In Nest*		28	6
Copulation		<1	0
Out of View*		48	54
Territory		1	1
1994			
Foraging*	5	4	10
Perching*	26	16	22
In Nest*	24	38	6
Copulation	<1	<1	0
Out of View*	44	41	59
Territory	1	<1	

* Significant at $P < 0.05$.

Table 4. *Percent of time spent in foraging activities by Lewis' woodpeckers during prenesting, incubation and nestling periods in 1993 and 1994.*

	Prenesting	Incubation	Nestling
1993			
Vegetation Gleaning*		10	2
Ground Gleaning		10	7
Hawking		26	31
Chiseling		18	30
Direct Flight		36	30
1994			
Vegetation Gleaning	0	1	<1
Ground Gleaning	6	7	14
Hawking*	56	52	22
Chiseling	22	22	17
Direct Flight*	16	8	47

* Significant at $P < 0.05$.

Discussion

Behavioral patterns did not differ throughout the day during any period in the breeding season. In southeastern Wyoming, several behavioral differences in Lewis' woodpeckers corresponded with breeding periods. Time spent in the nest varied from 23 percent during the prenesting period to a maximum of 40 percent during incubation with a minimum of seven percent during the nestling period.

As expected for adults feeding young, percent time spent foraging increased in the nestling period. There were differences in time spent gleaning vegetation in 1993 and direct flight foraging in 1994. The reasons remain unclear, but we speculate that variability in insect availability between periods of the breeding season and between years contributed to these differences. We would expect woodpeckers to spend more time gleaning and hawking during years of low insect availability. Decreased availability of flying insects during the incubation period of 1993 may have resulted in more time spent gleaning vegetation for terrestrial insects. Direct flight foraging, involving prolonged flights, probably would increase when flying insects are abundant.

The woodpeckers we observed spent an average of 62 percent of their foraging time flycatching, either hawking or direct flight. In 1994, percent time flycatching out of total percent time foraging was 72 percent in the prenesting period, 60 percent in the incubation period, and 69 percent in the nestling/fledgling period. These values were within a range reported by Bock (1970) and Jackman (1975) although they did not distinguish between breeding periods or behaviors that made up "flycatching." Others have reported that foraging time also was spent gleaning on the ground and in brush, while only a small proportion of time was spent gleaning and probing snag (Sousa 1982, Raphael and White 1984). Bock (1970) reported that Lewis' woodpeckers spent 32 percent of their foraging time gleaning on the ground and in vegetation. Our results from 1993 indicated that they spent 20 percent of their time gleaning the ground and vegetation during incubation and nine percent in the nestling period. In 1994 these behaviors occupied six percent of the prenesting period, eight percent in the incubation period, and 14 percent in the nestling period. Bock (1970) also reported that 10 percent of their foraging time was in bark gleaning, whereas we did not observe bark gleaning as a frequent foraging behavior. We observed frequent use of food stores in or near nest trees. Chiseling was rarely associated with bark gleaning and was mainly associated with food stores near nests.

Our 1994 data suggested that the woodpeckers spent more time perching during the prenesting and nestling periods than in the incubation period. They spent more time out of sight of the nest during the nestling period than in the prenesting or incubation periods. We suspect food demands of the nestlings resulted in increased foraging time over a larger foraging area.

Several studies have suggested that territorial behavior should increase during times of low food abundance and high area competition accompanied by a greater risk of cuckoldry and predation (Biermann and Robertson 1981, Knight and Temple 1986, and Moller 1990). Our data are insufficient to support this idea, but insect abundance in the Laramie Range seemingly increased with time throughout the nesting period. Such an increase suggests that higher competition for food should have occurred in the prenesting period. Competition for nesting areas and the risk of cuckoldry also should have increased during the prenesting period when adults were establishing territories. This idea holds that territoriality would again increase due to increased parental investment and the probability of predation as nestlings near fledging (Boucher 1977, Andersson et al.1980). Bock et al. (1971) reported that drumming only occurred during the prenesting period. We also observed drumming during the nestling/fledgling period.

Bock (1970) suggested that Lewis' woodpecker show strong nest fidelity and his banding studies showed evidence for permanent pair bonds and nest site fidelity for individual pairs. Eleven of the 30 (36%) active nests in 1993 were used in 1994. We do not know if the same pairs reoccupied these nests in consecutive years as our birds were not banded.

In summary, our results indicated that the Lewis' Woodpecker migrated into southeastern Wyoming in early to mid-May and begin prenesting activities. We found that the birds' different behavior patterns were similar throughout the day during each period (prenesting incubation and nestling). Foraging and perching near or inside the nest, as well as out of view of the nest varied by period. In 1993 the birds spent more time gleaning in the vegetation during the incubation period. In 1994, hawking declined in the nesting period while flying directly to the nest increased. Observed variation of behavioral patterns depended on food availability.

Acknowledgments

We appreciate the assistance of the many landowners who allowed us on their land and assisted us with data collection. The U.S. Forest Service provided maps and aerial photographs of the area. Funding was provided by the Wyoming Game and Fish Department and the Wyoming Cooperative Fish and Wildlife Research Unit. Linda Ohler was of great assistance in preparing the manuscript.

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Kenneth L. Hamlin

Survival and Home Range Fidelity of Coyotes in Montana: Implications for Control

Abstract

Survival and home range characteristics of coyotes (Canis latrans) *were examined in the Missouri River Breaks of Montana during 1976-1992. Mean annual survival was greater* (P = 0.05) *for coyotes captured as adults (0.70-0.76) than those captured as juveniles (0.42). I attributed this difference to social status of individual coyotes and related habitat use. Survival of nomad-disperser adults (0.35-0.42) did not differ* (P>0.20) *from coyotes captured as juveniles. Survival of denning coyotes (0.82-0.85) was greater than either those captured as juveniles or nomad-disperser adults* (P<0.002). *Survival in this heavily exploited coyote population was similar to that reported for lightly exploited coyote populations. One male coyote lived for a minimum of 13.5 years. Three individual denning coyotes used the same home range for at least 5 years. Coyote populations increased despite fur prices ranging from $40-150 (in effect, a high bounty). High survival of an effective predator of mule deer on this area (denning coyotes) suggested that a general bounty system would not increase survival of deer.*

Key Words: Coyotes, *Canis latrans*, survival, longevity, home range fidelity, predation, coyote control, bounties, mule deer, *Odocoileus hemionus*.

Introduction

Concurrent with the mid-1990s decline in many mule deer *(Odocoileus hemionus)* populations in Montana, hunters have focused their interest on predation and its effect on deer populations. Requests to control predators, including coyotes, to increase survival of game animals have been made by hunters (Hamlin and Erickson 1996) and through them, by legislators. These requests have suggested direct control by government agencies and establishment of bounty systems funded by an earmarked increase in hunting license fees. For example, the Fish and Wildlife Conservation Predator Control Program (HB404) was introduced in the 55th (1997) Montana Legislative Session but died in Committee.

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Previously, a decline in mule deer populations in the mid-1970s occurred in Montana and throughout the western U.S. coincident and subsequent to a ban on use of compound 1080 (sodium monofluoracetate) and other toxicants for predator control on public lands by Executive Order No. 11643 (Connolly 1978). Controversy surrounding these events resulted in considerable research on coyotes and predation throughout the western U.S. Studies in Montana included those reported by Schladweiler (1980), Hamlin et al. (1984), Pyrah (1984) and Hamlin and Mackie (1989).

Information collected in the Missouri River Breaks (MRB) of Montana during these earlier studies is pertinent to current discussion and decisions about control of coyote populations to increase survival of mule deer populations. Some of the information presented here was reported earlier by Pyrah (1984) but his paper concentrated on social distribution and population estimates. Data on the fate, longevity, and movements of an additional seven coyotes were determined after that reported by Pyrah (1984). This provided the opportunity to report information on coyote longevity and home range fidelity not previously available and to discuss implications of that information to efficacy of coyote control to increase deer survival and hunting opportunity.

Study Area

Capture and marking of coyotes was conducted on or near a timbered 250 km² area in the MRB about 40 km northeast of Roy, Montana. This area was previously described by Mackie (1970), Hamlin et al. (1984) and Hamlin and Mackie (1989). Description of a larger coyote study area that included some plains habitat was provided by Pyrah (1984).

The MRB are a 6-15 km wide band of heavily dissected uplands that occur on both sides of the Missouri River in north-central Montana. Drainages become wider and deeper as they approach the river and are interspersed with open ridges extending toward the river from the rolling plains beyond the MRB. These ridgetops are dominated by big sagebrush (*Artemisia tridentata*) and wheatgrasses (*Agropyron spp.*). Side slopes of drainages are dominated by ponderosa pine (*Pinus ponderosa*), Douglas fir (*Pseudotsuga menziesii*) and Rocky Mountain juniper (*Juniperus scopulorum*). Climate is semiarid.

Livestock grazing was the major commercial land use, though recreational pursuits, including hunting, fishing, wildlife observation and sight-seeing also were major land uses. During this study, coyote pelts had substantial economic value and coyote hunting and trapping were major commercial land uses. The majority of land in this area is under Federal ownership and administered by the USDI, Fish and Wildlife Service, Charles M. Russell National Wildlife Refuge (CMRNWR) and the USDI, Bureau of Land Management.

Methods

Thirty-seven coyotes were trapped, marked and released during 1976-1979 (Pyrah 1984). Twenty-three adult coyotes ($\geq$ 1-year-old) captured during 14 April - 10 July, 1976-1979 were equipped with radio-transmitter collars. Three radio-transmitter collars and 11 observation collars were placed on juvenile ($\leq$ 1-year-old) coyotes captured from 29 September - 16 October 1978 (Pyrah 1984). Aerial relocations of instrumented coyotes were made at an average interval of two weeks from a PA-18 Piper Super Cub aircraft during the life of the transmitter. Occasional relocations also were made from the ground (Pyrah 1984). Numbers of adults and pups were recorded for all visual observations of marked coyotes. Juvenile coyotes with observation collars provided information only on date and location of death when reported by hunters and trappers. More detailed descriptions of field methods were provided by Pyrah (1984).

Fate and date of death were determined for 17 of 23 adult and 11 of 14 juvenile coyotes. One adult was censored from analysis because death occurred within three days from probable capture-related injuries. One adult died prior to 1 October so was not included in the analysis that compared survival of adults to juveniles captured during autumn.

One adult coyote was trapped by a fur trapper aware of the study and released when he observed the radio-transmitter collar. For purposes of this analysis, that coyote was considered dead on the day he was trapped by the fur trapper.

Fate and date of death were undetermined for six adult coyotes after their transmitters ceased functioning or they dispersed beyond search range. Last relocations of those six coyotes were made from 54 to 2,356 days after capture. Because all but three deaths of the 16 other non-censored adult coyotes occurred after their transmitter ceased to function or they dispersed beyond search range, a method was devised to include these six coyotes in some of the analysis.

I calculated composite (weighted) mean annual survival using coyote death data as "band return" data in a cohort life table (Eberhardt 1969). Cohorts analyzed were those captured as adults and those captured as juveniles; specific ages were not used. The end product was average annual survival over the lifetime of the cohort. Survival rates and longevity were calculated by three different methods: 1) only those coyotes with a known date of death were used; 2) the six adult coyotes with unknown dates of death were assigned a death date on the last day a radio-relocation was made; and 3) each of the six coyotes of unknown fate was assigned a date of death based on the average date of death of all known fate coyotes that lived at least as long as that coyote. For example, Coyote N's transmitter functioned for 1,625 days. Known-fate coyotes that lived at least 1,625 days, lived from 1,626 to 4,489 days and an average of 2,703 days. Coyote N was assigned a longevity of 2,703 days after capture.

Method 1 does not provide maximal use of information. Method 2 underestimates longevity because 13 of 16 known fate adult coyotes lived longer than their transmitter functioned. Method 3 includes estimated data, but may be nearest to actual values.

To facilitate equal comparisons of longevity between autumn captured juveniles and spring-summer captured adults, starting date for comparative analysis was set at 1 October. Because of small samples and non-normal distributions, statistical tests of comparative longevity were made with nonparametric Mann-Whitney U test (Zar 1984). Home range plots were made only for three coyotes that survived at least four denning seasons (minimum of 1,333 days of radio-transmitter contact). Perimeters of annual home ranges were established using the minimum convex polygon method (Mohr 1947). Age and social category were assigned as described by Pyrah (1984). These social categories were: den pairs (breeders), supernumary den adults (nonbreeders), nomads, and dispersers. Juveniles were a temporary nonbreeder social category.

Results and Discussion

Annual Survival

From 1 October, first year survival of adults was 0.67, 0.57 and 0.76 by Methods 1, 2 and 3, respectively. For juveniles (0.5 - 1.5 years), first year survival was 0.55 (6/11). Similar estimates of composite (averaged over their lifetime) mean annual survival rates were produced by all three methods (Table 1), but Method 2 produced minimal and Method 3 maximal estimates as expected. A substantial difference in mean annual survival between coyotes captured as adults and those captured as juveniles was observed (Table 1), but the difference appeared to be related to social status rather than age. Mean annual survival rates for adults in the nomad-disperser social category (0.35-0.42) were essentially the same as for coyotes captured as juveniles (0.42) (Table 1). Adult coyotes associated with dens had approximately twice the mean annual survival rates (0.82 - 0.85) as either nomad-disperser adults or coyotes captured as juveniles.

Expressed as average number of days survived after 1 October, survival of adults with known dates of death (Method 1) did not differ (Mann Whitney U=110, $P = 0.17$) from survival

Table 1. *Composite annual survival rate and average days of survival by age and social category for coyotes captured during 1976-1979 in the Missouri River Breaks, Montana*[a]

Age and Social Category[b]	Annual Period: 1 October to 1 October			Year starting date of capture		
	Annual Survival Rate					
	Method 1[c]	Method 2[d]	Method 3[e]	Method 1	Method 2	Method 3
Adults	0.72 (15)(39/54)[f]	0.70 (21)(49/70)	0.76 (21)(68/89)	0.72 (16)(41/57)	0.71 (22)(53/75)	0.77 (22)(72/94)
Juveniles	0.42 (11)(8/19)			0.42 (11)(8/19)		
Nomad Disperser Adults	0.39 (8)(5/13)	0.35 (11)(6/17)	0.42 (11)(8/19)	0.40 (9)(6/15)	0.37 (12)(7/19)	0.45 (12)(10/22)
Den Adults	0.83 (7)(34/41)	0.82 (10)(44/54)	0.85 (10)(55/65)	0.83 (7)(35/42)	0.82 (10)(46/56)	0.85 (10)(56/66)
	Average Number of Days Survived					
	Beginning 1 October			Beginning date of capture		
Adults	1,061 (15)[g]	988 (21)	1,313 (21)	1,132 (16)	1,079 (22)	1,387 (22)
Juveniles	355 (11)			355 (11)		
Nomad-Disperser Adults	319 (8)	279 (11)	374 (11)	420 (9)	365 (12)	454 (12)
Den Adults	1,908 (7)	1,767 (10)	2,142 (10)	2,047 (7)	1,904 (10)	2,282 (10)

[a] Composite annual survival for juveniles is for the category of coyotes captured as juveniles. It is an estimate of mean annual mortality throughout their life span. First year mortality (age 0.5-1.5) is reported in text.

[b] Adults = $\geq$ 1 year old at capture. Juveniles = <0.5 years old at capture. Social category as described in Pyrah (1984).

[c] Method 1 = only coyotes with known fate and date of death used.

[d] Method 2 = six adults with unknown fate and date of death included as deaths when radio transmitter ceased functioning.

[e] Method 3 = six adults with unknown fate and date of death included with average adjusted date of death as described in Methods Section.

[f] Annual survival rate (number of coyotes)(composite number of survivals/composite number of opportunities to survive).

[g] Mean number of days survived (number of coyotes)

of coyotes captured as juveniles. The difference was significant (Mann-Whitney U=167, P = 0.05) when Method 3 was used to calculate adult survival. Survival of adults associated with dens was different than for nomad-disperser adults whether only known date of death was used (Method 1, Mann-Whitney U=54, P = 0.002) or adjusted dates of death were included (Method 3, Mann-Whitney U = 127, P <0.001). Survival of adults associated with dens differed from survival of coyotes captured as juveniles (Mann-Whitney U=75, P<0.001) although survival of nomad-disperser adults was not different from survival of coyotes captured as juveniles (Mann-Whitney U = 53, P >0.20).

Mean annual survival of coyotes with stable social status associated with den areas within timbered breaks habitat (0.82 - 0.85) was as high as any reported. Andelt (1985) reported annual survival of 0.68 for radio-transmitter collared adult coyotes on a Texas study area lightly exploited by humans. Annual survival there was 0.82 for residents (equivalent to denning coyotes in the MRB) and 0.51 for transients (equivalent to nomads in the MRB). Similarly, for another lightly exploited coyote population in south Texas, Windberg et al. (1985) found that annual survival of radio-transmitter collared adults ($\geq$ 1.5 - years) ranged from 0.68 to 0.70 and annual survival for juveniles (0.5 - 1.5 - years) was 0.42. In Maine, Harrison (1992) reported annual survival for radio-transmitter collared juveniles (0.5 - 1.5 - years) was 0.47 for dispersers and 0.74 for residents. Survival rates for these relatively lightly exploited coyote populations (0.68-0.70, all adults) were almost identical to those I report (0.70-0.77 all adults, Table 1) for a population subjected to relatively heavy harvest pressure by humans. I did not find published information on survival of instrumented coyotes for other heavily exploited populations.

Estimates of annual survival for adult coyotes based on age structure were 0.61 in Iowa (Boggess 1975), 0.59 in Texas as calculated by Bogess 1975 from Knowlton 1972 and 0.55 in Montana, based on my calculations using age structure data in Schladweiler (1980) and the equation of Chapman and Robson (1960). Nellis and Keith (1976) estimated adult coyote survival ranging from 0.58 - 0.64 from tag return data in Alberta. All these survival rates are from at least moderately exploited populations and are slightly lower than those reported here for the MRB. Use of age structure data to estimate annual survival may somewhat underestimate survival because it truncates maximal age and does not account for lesser vulnerability to harvest of older, experienced and socially stable coyotes.

Lack of stable, breeding social status often resulted in dispersal to non-timbered habitat with little topographic relief, and a lower life expectancy. Few juveniles were accepted into breeding units on this area (Pyrah 1984) which resulted in dispersal, nomadism and low survival. One of three radio-transmitter collared juveniles was a den supernumerary (extra adult) during its first year (Pyrah 1984). It dispersed in late July and was shot in December at 1.5-years-old. Social status at time of death for juveniles marked with observation collars was unknown, but most had dispersed from the area where marked. Coyotes first captured as juveniles probably were less likely to end up in timbered breaks habitat than coyotes that were established denning adults when captured.

A minimum of 85 percent of 27 deaths of coyotes were human-caused; 67 percent were shot and 18 percent were trapped. One of these wa trapped in a control action by the U.S. Fi h and Wildlife Service after it had disper ed from the area. Eighty-one percent of coyotes were taken from October through February; 59 percent were taken from December through February.

Longevity

Juvenile coyotes lived an average of about one year (x= 355 days; range, 76-793 days) after capture on 1 October (Table 1). Longevity of adult coyotes in the nomad-disperser social category was similar to coyotes captured as juveniles (range 160-910 days) (Table 1). Adults in a stable, breeding social unit (denners) lived an average of six years after capture or 5.5 years after 1 October of the year of capture (range 614-4,624 days) (Table 1).

Greatest longevity observed was for an adult male captured by a fur trapper 4,624 days after initial capture. This coyote, a minimum of 1-year-old at initial capture, was a minimum of 13.5-years-old at death. Canine teeth were recovered from two other radio-transmitter collared adult coyotes at death and they were aged by tooth cementum layers (Linhart and Knowlton 1967) as 9.5-and 12.5-years-old. The oldest wild coyotes reported elsewhere were a 14.5-year-old female in Colorado and a 13.5-year-old male in Texas (Knowlton 1972).

Home Range Fidelity

Few studies continued long enough or had coyotes survive long enough to determine fidelity to home range. Others have reported coyotes occupying the same home range for periods of 3-4 years (Camenzind 1978, Bowen 1982, Andelt 1985).

Two coyotes in the denner social category in the MRB occupied the same home range for five years (Female C and Male M), (Fig. 1). Another coyote (Male L) occupied the same general area for at least five years, but a shift occurred after three years to an overlapping adjacent area (Fig. 1). The fate of the female mate of L was unknown because she was not marked with a radio-transmitter collar. She might have died and male L found another mate in the adjacent area. When male L occupied his new adjacent home range (Fig. 1), another denning pair used the original denning area in 1983. Although home range area was stable through the years for these denning coyotes, den sites changed (Fig. 1). All three coyotes were killed outside their traditional den areas (Fig.1).

Death occurred for most denning coyotes after they left the original denning area. Five coyotes that were originally one of a denning pair became nomads. Four of these were shot or trapped outside their original den area and fate of the other was unknown. Two of these coyotes had feet damaged by trapping which may have made them less competitive in social conflicts and led to their shift to nomadism (Pyrah 1984). Older coyotes also might become less socially competitive and eventually be forced from their den area, increasing their risk of death. Final fate of three of ten coyotes that remained denners was unknown and location of death for another was unknown. Of the other six, three were slightly outside their traditional home range at death, one each was shot and trapped within their home range and one appeared to have died a natural death within its home range. It appeared that coyotes in the MRB maintained strong fidelity to home range as long as they remained socially competitive members of denning pairs.

Implications for Coyote Control

Coyotes have been killed for years in the western U.S. because of their real and perceived depredations on domestic animals and wildlife. Control efforts were by individuals, through state and local bounties, and by direct government programs such as the Federal Animal Damage Control Program (ADC) (Connolly 1978). In Montana, state bounties on coyotes were in place in the late 1800s. In 1929 the Montana Fish and Game Department had 14 employees solely dedicated to predator control (Smith 1929). Additionally, 11 hunters were employed by the Federal Government and 13 by the Montana Livestock Commission (Smith 1929). A brochure published by the Montana Fish and Game Department ca. 1927 entitled "Sportsmen's Dollars Destroy Coyotes" above a picture of "a month's catch of coyotes and other predatory animals . . ." extolled the program as follows: "The Fish and Game Department of Montana is rendering service to this great Treasure State in ways and to an extent few of its people realize. The cut on the title page of this folder shows what just one man in the employ of the Department accomplished for the protection not only of the game in which our sportsmen are interested, but also for the protection of the livestock, poultry and songbirds; $42,943.46 were expended by the Department during the years 1925 and 1926 in the destruction of these common enemies of domestic and wild life (sic). This fund is created by the setting aside of 25c from each hunting and fishing license for this purpose. . ."

Although millions of coyotes were killed in Montana and the Western U.S. during the last hundred years, of the control measures used, only toxicants were effective in reducing coyote populations (Cain et al. 1972). The most effective toxicant, Compound 1080, may have been relatively effective in reducing coyote populations where it was intensively used in northwestern states (Wagner 1972, Hamlin and

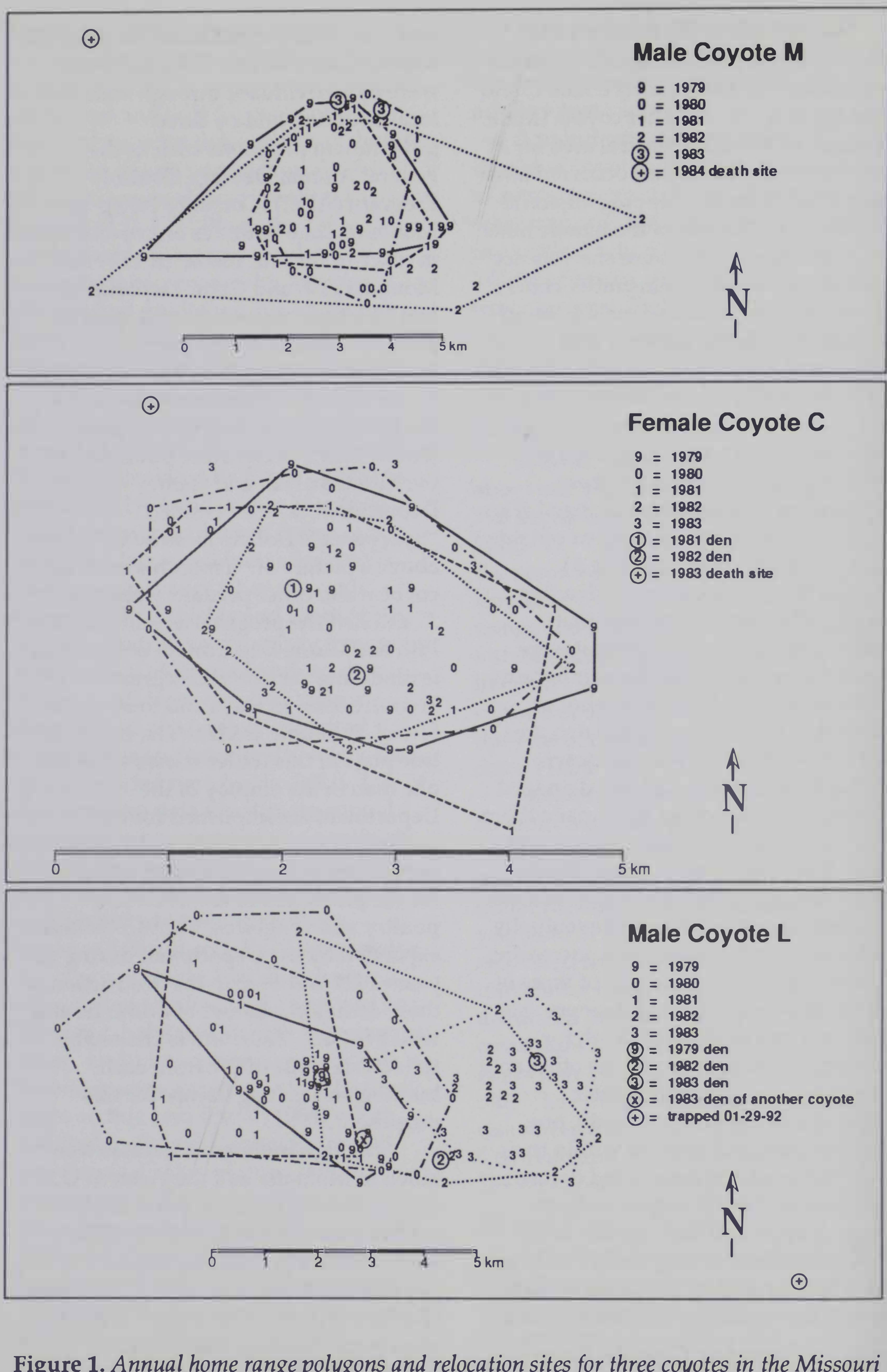

Figure 1. *Annual home range polygons and relocation sites for three coyotes in the Missouri River Breaks, Montana, 1979-1983. Known den sites and death sites included. Letter designations for coyotes are those used by Pyrah (1984).*

Mackie 1989). The use of toxicants for predator control on public lands was banned in 1972 (Connolly 1978) because of increasing public distaste for government killing of predators and the deaths of many nontarget mammals and birds.

There are two general approaches to predator control: 1) overall reduction of numbers on the assumption that depredation losses correlate directly with predator abundance and 2) selective control of the depredating individual or local populations (Connolly 1978). Bounty programs, government hunters, and toxicants are examples of the first approach, and except for the use of toxicants, have generally been unsuccessful. Latham (1951) summarized numerous studies and concluded that the bounty system failed for a variety of social, economic, and ecological reasons. Connolly and Longhurst (1975) concluded that a simulated coyote population could survive an annual control kill of 70 percent. At a 75 percent level of control, the population still persisted for more than 50 years. This model assumed compensatory reproduction, however, and control could be achieved at lower kill levels if compensatory reproduction did not operate or did so at a lower level.

It should be noted that generalized reductions in numbers of coyotes or long-term reduction in numbers is not necessary to reduce some depredations. Reductions in coyote numbers or removal of individual coyotes immediately prior to the time of birth for livestock or game may reduce losses of newborns in small areas (second approach). This approach to concentrate selective control on severe problem areas is currently used by ADC. The goal now is not to control coyote numbers, but to selectively kill depredating individuals or local populations. This approach has evolved because of limited resources, public concerns, the withdrawal of toxicants as a tool, and probably because of some increased ecological knowledge.

Information presented here clearly indicates the ineffectiveness of a general bounty system or other methods of general hunting and trapping to control coyotes, particularly in secure habitats. Average statewide prices of coyote pelts from Montana fur dealer surveys (Giddings 1995) rose from $8.30 in 1971-72 to $37.12 in 1975-76, $54.00 in 1977 and 1978, and $80.95 in 1978-79. Coyote pelt prices remained between $42.53 and $66.22 during 1979-80 through 1987-88. Prices "crashed" in 1988-89 and averaged between $13.00 and $25.00 through 1994. Harvest estimates for coyotes generally coincided with pelt price level (Giddings 1995). Prices for coyote pelts from the study area and vicinity were generally higher than those reported above. Many of these "pale northern pelts" were sent to fur auctions in Canada, and during the peak of prices in 1977-82, prices often averaged over $100.00 per coyote pelt. This price incentive was substantially more than any bounty offered or proposed. The fur price incentive resulted in substantial trapping and hunting from the ground and intensive aerial hunting of coyotes from fixed-wing aircraft and helicopters. Shooting coyotes from the ground was the only legal form of coyote harvest on the CMRNWR, but illegal aerial hunting and illegal trapping occurred there.

Despite intense hunting and trapping, coyote populations on the MRB study area, especially within the timbered breaks habitat increased from 1977 through 1983-84 (Pyrah 1984, Hamlin and Mackie 1989). Survival of coyotes associated with dens in timbered breaks habitat was as high or higher than reported elsewhere, including protected populations on refuges. Fur harvest was limited almost entirely to dispersing juveniles and adult nomad-dispersers. These nomad adult coyotes were often old or injured coyotes, at a disadvantage in social competition or as predators of deer. Fur harvest did not exceed annual recruitment because the coyote population in timbered breaks habitat increased during the period of high pelt prices. Thus, harvest level based on fur price incentives was compensatory to other forms of mortality in timbered breaks habitat during 1977-1984.

Denning pairs and associated den supernumeraries (Pyrah 1984), were the coyotes most likely to effectively prey on deer fawns (Hamlin and Schweitzer 1979) and adults (Knowles 1976) and also were least vulnerable to harvest by fur hunters. Consequently, the coyote harvest that occurred was not likely to be effective in reducing coyote predation on deer in timbered breaks habitat. Predation rate on mule deer fawns was related to level of alternate prey populations but not to size of coyote population (Hamlin et al. 1984, Hamlin and Mackie 1989).

Fur harvest will remove the most easily trapped or shot coyotes with effort appropriate to an economic return. Assuming that toxicants are not a politically viable alternative in coyote control, only intensive hunting and trapping after the period of prime fur associated with intimate knowledge of denning areas are likely to effectively reduce local predation on deer or other game animals. It is unlikely that these conditions could be met except on a limited number of small areas. Targeted control efforts may be successful in some situations of depredations on domestic animals. They are less likely to be successful for widely dispersed wildlife populations. In either case, substantial knowledge about local coyote territories - denning areas and intensive effort beyond that resulting from fur price incentives will be necessary to reduce losses of game animals to coyote predation.

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Bird Abundance and Diversity Relative to Habitat Features of Laramie Plains Lakes, Wyoming

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Abstract

We determined relative abundance and diversity of bird species and habitat features on 13 lakes on the Laramie Plains, a high-elevation intermountain plain in southeastern Wyoming, during summer 1994. A total of 48 species of birds were observed from May to July. Relative abundance of birds observed on individual lakes increased with water surface area and area of hard-stem bulrush (Scirpus acutus) *along the shoreline. Diversity of bird species declined with increasing water surface area and the length of bare ground along the shoreline. Marsh-like habitat was most abundant around the shore of small lakes forming habitat for marsh birds and leading to greater overall species diversity compared to large lakes. Species richness of birds had a curvilinear relationship with water surface area and was greatest among intermediate-sized lakes. A mix of marsh-like habitat and bare ground along the shoreline provided habitat for marsh birds and shorebirds leading to high species richness among intermediate-size lakes. It appears that stabilization of water levels and resulting succession from playas to lakes with more marsh-like features has led to a greater abundance and diversity of birds associated with lakes on the Laramie Plains.*

Key words: Birds, waterfowl, lakes, Great Plains, Wyoming

Introduction

High-elevation intermountain plains are unique in that they provide lake and wetland habitat for birds amid mountainous terrain. A diversity of lakes and wetlands in close proximity to one another can provide habitat for an array of species of migrating and breeding birds. We studied the birds associated with lakes of the Laramie Plains, a high-elevation (2,200 m above mean sea level), intermountain plain between the Laramie Range and Medicine Bow Mountains in southeastern Wyoming. The high elevation results in a short growing season and wide variation in diurnal air temperatures (Knight 1994). The Laramie Plains are on the periphery of the Central Flyway (Linduska 1964) and attract a variety of waterbirds.

The most common natural wetland type in the semi-arid landscape of the Laramie Plains was the playa lake. Playa lakes are shallow, oval depressions with a clay or fine sandy loam hydric soil formed by wind erosion (Mitsch and Gosselink 1993). Typically, sources of water included precipitation (especially runoff from snowfall), surface runoff, and groundwater discharge. As a result, playa lakes have fluctuating water levels and are often dry by late summer. Although most of the Laramie Plains

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lakes originated as playa lakes, irrigation and construction of small dams have raised water levels to stabilize fluctuations and enhance macrophyte growth in many lakes. Consequently, many lakes now have marsh-like shorelines. Thus, the habitat diversity among the lakes has increased over that which occurred naturally. Most research on playa lakes has focused on migratory waterfowl (Stormer et al. 1981) and little is known about use of these lakes by other kinds of birds.

We describe relative abundance and diversity of birds observed on 13 lakes and their associated wetland areas on the Laramie Plains during summer of 1994, and evaluate associations between habitat features and relative abundance, species diversity, and species richness of birds among lakes.

Study Area

Numerous lakes occur on the Laramie Plains in southeastern Wyoming and we chose 13 representative lakes with water surface areas of 5.0 - 308.4 hectares for study. Maximum distance between study lakes was 30 km.

The climate of the Laramie Plains is continental with annual precipitation of 12-25 cm (Ostresh et al. 1990). Average daily temperatures in July range from a high of 27° C to a low of 9° C (Martner 1986). Average annual wind speed is 20.6 km/h with prevailing westerly winds (Martner 1986). On the Laramie Plains, evaporation rates are greater than precipitation rates with a potential evapotranspiration rate of 51 cm annually (Martner 1986). The landscape is primarily rangeland with some areas of irrigated meadows.

Weather and geology contribute to saline water in Laramie Plains lakes. Soils on the Laramie Plains are influenced by weathering of marine cretaceous shales (Knight 1994). The saline soils in this region often contain high concentrations of sodium, gyp um (hydrated calcium sulfate), and other salts. Thus, the combination of high evaporation rates, low precipitation, and saline soils can re ult in salinities of lentic waters exceeding 30 mS/cm.

We classified the study lakes according to the salinity criteria of Cowardin et al. (1979). Ten lakes were oligosaline (0.8-8.0 mS/cm at 25° C): Alsop, Caldwell, Carroll, Gelatt, George, Hoge, Meeboer, Mortenson Lake A, Mortenson Lake B, and Rush. Dominant submerged aquatic plant in these lakes were chara *(Chara spp.)*, sago pondweed *(Potamogeton pectinatus)*, and water milfoil *(Myriophyllum sp.)*, and the dominant emergent plant was hard-stem bullrush but chair-maker's rush *(S. americanus)* was common. Two lakes were mesosaline (8.1-30.0 mS/cm), Hutton and Twin Buttes. The dominant submerged aquatic vegetation in the e two lakes was ditch-grass of the sea *(Ruppia maritima)* with patches of sago pondweed, and there was no emergent vegetation. Bamforth Lake was hypersaline (> 60.0 mS/cm) and was devoid of emergent and submergent vegetation.

Upland areas around all the lakes were dominated by grasses, such a foxtail barley *(Hordeum jubatum)*, bottlebrush squirrelltail *(Elymus elymoides)*, and inland saltgrass *(Distichlis spicata)*, and sedges *(Carex spp.)*. The outermost edges of the watersheds were marked by shrubland of greasewood *(Sarcobatus vermiculatus)* and big sagebrush *(Artemesia tridentata)*.

Most of the lakes were on public land. Four lakes (Alsop, Gelatt, Meeboer, Twin Buttes) had public acce for recreation. Eight lakes were on national wildlife refuges (Bamforth, Carroll, George, Hoge, Hutton, Mortenson Lake A, Mortenson Lake B, Rush) with limited public acce . Although the Mortenson lakes were located on a national wildlife refuge, they had restricted access. Caldwell

Lake was on private land. Cattle grazing occurred around the shoreline of all study lakes.

Methods

Surveys of birds were conducted by counting and identifying all birds seen from vantage points around lake perimeters where the entire lake could be observed with a 60 X spotting scope (Uresk and Severson 1988). Surveys were conducted weekly from 9 May to 5 July 1994 between 0630 and 1000 hours. Surveys lasted 15-60 minutes, depending on the size of the lake and bird abundance. Individual lakes were surveyed at different times during the observation interval to minimize potential bias associated with timing of surveys.

Relative abundance was defined as the total number of birds observed over all seven surveys. Diversity was described using the Shannon-Wiener diversity index (Margalef 1958). The index is computed as: $\sum_{i=1} (p_i)(\log_2 p_i)$ where s is the number of species and p_i is the proportion of the total sample belonging to ith species. Species richness was computed as the total number of species observed during the summer survey period.

The lakes were photographed from a fixed-wing aircraft at an altitude of 200 m above the water during July 1994. Photographs were taken with a 35-mm camera using 400 ASA color film. Aerial survey markers were placed at intervals of 100 m on the shoreline to provide a scale of distance on the photos. Water surface area, length of the shoreline, length of bare ground along the shoreline, length of shoreline occupied by hard-stem bulrush, and the area of the lake were features determined from 20 x 30 cm prints that were digitized. Shoreline development (Lind 1985), an index of shoreline sinuosity, was calculated as the length of the lake perimeter divided by two times the square root of the product of the lake surface area and π.

Water samples were collected during the morning of 23 May 1994 along the shoreline of each lake at a depth of 0.5 m. Water quality parameters were measured following standard methods (APHA 1985). Alkalinity and hardness were determined by volumetric titrations and expressed as mg/L $CaCO_3$. Specific conductance was measured with a conductivity bridge in umhos/cm at 25° C and the values were converted to mS/cm. The pH was measured with a meter.

Pearson correlation coefficients and multiple-regression analyses were used to determine relationships between the habitat features and variables describing the birds (relative abundance, Shannon-Wiener diversity index, and species richness). A significance level of $P \leq 0.05$ was used for inclusion of individual variables into regression models. Analyses were performed with STATISTIX 4.0 (Analytical Software 1992).

Results

We observed a total of 48 species of birds, including 16 waterfowl, 28 shorebirds and waders, three passerines, and one raptor (Appendix A). Relative abundance of birds at each lake (239-5,500 total birds observed), Sahnnon-Wiener diversity index (0.56-3.72), and species richness (12-36 species observed) varied among lakes (Table 1). Caldwell Lake had the highest species richness and the second highest relative abundance of birds. Mortenson Lake A had the lowest relative abundance of birds, yet the highest Shannon-Wiener diversity index. Bamforth Lake was excluded from statistical analyses because it had the largest surface area and was the only hypersaline lake (hardness = 341,555 mg/L).

Physical, chemical, and vegetative characteristics varied among lakes

Table 1. *Relative abundance, Shannon-Weiner diversity indices, and species richness of birds on the 13 lakes studied on the Laramie Plains in 1994*

Lake	Relative abundance[a]	Shannon-Weiner diversity index	Species richness
Alsop	602	3.62	31
Bamforth	5,500	0.56	12
Caldwell	4,034	2.86	36
Carroll	763	2.76	24
Gelatt	455	2.90	24
George	278	3.34	21
Hoge	981	3.57	31
Hutton	923	3.23	26
Meeboer	613	3.42	30
Mortensen A	239	3.72	25
Mortensen B	394	2.96	28
Rush	1,338	3.17	32
Twin Buttes	1,542	2.14	25

[a]Total number of birds observed over seven surveys from 9 May to 5 July 1994.

(Table 2). The 12 lakes were generally oval in shape as evidenced by the shoreline development index (1.0-1.7). The proportion of bare ground along the shoreline (3-100%), and proportion of shoreline vegetated by hard-stem bulrush (0-97%) were highly variable. The water chemistry parameters of alkalinity (55-517 mg/L), conductivity (0.7-16.6 mS/cm), hardness (292-17,672 mg/L), and pH (7.7-9.1) were variable and highly correlated.

Multiple-regression analysis identified significant relation of relative abundance of birds (total number of birds observed over all urveys), Shannon-Wiener diversity index, and species richness with physical and vegative habitat features, but no significant relations were observed with measures of water chemi try or shoreline development.

Regression analysis indicated that the relative abundance of birds varied with water surface area ($r^2 = 0.36$, $P = 0.040$), the area of hard-stem bulrush ($r^2 = 0.35$, $P = 0.043$), and both water surface area and area of hard-stem bulrush ($R^2 = 0.64$, $P = 0.010$) as independent variables:

ABUND = 418.7 + 14.4 WSA;

ABUND = 596.7 + 111.9 ABUL; and

ABUND = 94.9 + 13.1 WSA + 101.4 ABUL

where, ABUND = total number of birds observed over all surveys, WSA = water surface area (hectares), and ABUL = area of hard-stem bulrush (hectares).

Table 2. *Physical and biological features of the 13 lakes studied on the Laramie Plains in 1994.*

Lake	Water surface area (ha)	Shoreline development	Bare shoreline Length (m)	Bare shoreline %[a]	Shoreline of hard-stem bulrush Length (m)	Shoreline of hard-stem bulrush %[a]	Shoreline of hard-stem bulrush Area (ha)	Alkalinity (mg/L)	Hardness (mg/L)	Conductivity (m S/cm)	pH
Alsop	16.3	1.3	1,869	100	0	0	0.0	373	941	3.8	8.8
Bamforth	308.4	1.7	10,621	100	0	0	0.0	2,800	341,550	73.2	8.3
Caldwell	99.4	1.1	544	55	358	45	16.0	72	327	0.9	9.1
Carroll	15.4	1.1	322	41	0	0	0.0	344	1,104	3.3	9.1
Gelatt	14.4	1.7	62	6	131	47	8.8	96	1,267	2.4	8.3
George	5.7	1.1	108	12	210	69	10.4	77	792	1.8	8.0
Hoge	24.7	1.3	275	12	0	0	0.0	55	3,643	3.0	9.1
Hutton	22.3	1.0	100	6	0	0	0.0	517	17,622	15.8	8.5
Meeboer	91.4	1.7	86	15	75	5	0.8	358	2,128	4.4	8.9
Mortensen A	5.0	1.3	151	65	0	0	0.0	425	624	3.6	8.7
Mortensen B	38.3	1.2	104	4	268	20	1.8	232	292	0.7	8.7
Rush	26.5	1.6	47	3	407	97	6.8	174	742	1.5	7.7
Twin Buttes	134.8	1.5	6,026	100	0	0	0.0	363	17,672	16.6	8.3

[a]Percent of the total length of shoreline.

Regression models indicated that the Shannon-Wiener diversity index varied with water surface area ($r^2 = 0.37$, $P = 0.034$) and length of bare ground along the shoreline ($r^2 = 0.37$, $P = 0.034$):

SW = 3.40 - 0.00639 WSA; and

SW = 3.27 - 0.000159 LBARE

where, SW = Shannon-Wiener diversity index, WSA = water surface area (hectares), and LBARE = length of bare ground along the shoreline (meters). However, water surface area and length of bare ground along the shoreline were found to be positively correlated ($r = 0.65$, $P = 0.0216$).

A significant ($R^2 = 0.55$, $P = 0.027$) curvilinear relationship was observed between species richness and water surface area:

$$RICH = 21.71 + 0.3303\ WSA - 0.00225\ WSA^2$$

where, RICH = species richness and WSA = water surface area (hectares). The regression model indicated that lakes of intermediate size had higher species richness than small or large lakes.

When regression analysis was applied to individual species, the relative abundances of five species were observed to vary positively with the length of shore bare of vegetation, and the relative abundances of 15 other species were observed to vary positively with the length of shoreline with hard-stem bulrush or the area of hard-stem bulrush (Table 3).

Table 3. *Regression equations for signifcant relationship between relative abundance of individual bird species and the length (meters) of bare shoreline (LBARE), length (meters) of shoreline with hard-stem bulrush (LBUL), and area (hectares) of lake with hard-stem bulrush (ABUL). Relative abundance is the total number of a species seen over seven weekly surveys from 9 May to 5 July 1994.*

Species	Equation	r^2	*P*
	Species associated with bare shoreline		
American avocet	6.30 + 0.0223 LBARE	0.92	<0.001
Greater yellowlegs	- 0.09 + 0.0004 LBARE	0.91	<0.001
Spotted sandpiper	0.22 + 0.0008 LBARE	0.79	<0.001
Franklin's gull	- 0.21 + 0.0015 LBARE	0.98	<0.001
California gull	8.61 + 0.1524 LBARE	0.95	<0.001
	Species associated with hard-stem bulrush		
Pied-billed grebe	2.05 + 0.0548 LBUL	0.72	<0.001
	3.88 + 1.2869 ABUL	0.50	0.010
Eared grebe	- 33.85 + 58.3464 ABUL	0.46	0.015
Western grebe	- 0.32 + 0.9375 ABUL	0.43	0.021
Snowy egret	- 0.05 + 0.0011 LBUL	0.35	0.044
Black-crowned night-heron	- 3.36 + 0.1154 LBUL	0.61	0.003
	- 1.40 + 3.2249 ABUL	0.61	0.003
White-faced ibis	- 3.39 + 0.1129 LBUL	0.61	0.003
	- 0.17 + 2.8042 ABUL	0.48	0.013
Green-winged teal	0.16 + 0.2481 ABUL	0.47	0.014
Ruddy duck	4.68 + 0.1323 LBUL	0.41	0.025
	6.08 + 3.9234 ABUL	0.46	0.016
Northern harrier	- 0.12 + 0.1225 ABUL	0.56	0.005
Sora	- 0.06 + 0.1065 ABUL	0.56	0.005
American coot	13.80 + 0.3171 LBUL	0.56	0.005
	20.07 + 8.6124 ABUL	0.52	0.008
Black-necked stilt	- 0.44 + 0.8812 ABUL	0.66	0.001
Forster's tern	- 1.29 + 0.1522 LBUL	0.44	0.020
Black tern	- 0.02 + 0.0236 LBUL	0.38	0.034
Yellow-headed blackbird	24.18 + 1.0061 LBUL	0.74	<0.001
	74.60 + 19.1218 ABUL	0.34	0.048

DISCUSSION

Variation in relative abundance of birds among lakes on the Laramie Plains was related to water surface area of individual waters similar to what has been observed among lakes and wetlands in other areas. In northeast Wyoming, 30 species of migrating birds were identified on 80 man-made wetland ponds and water surface area was the single habitat variable associated with abundance (McKinstry 1993). Relative abundance of birds increases with water surface area of ponds in northern Wyoming (Svingen 1991) and wetlands on the Northern Great Plains (Uresk and Severson 1988). Similarly, relative abundance of birds also increases with water surface area of marshes in Iowa (Brown and Dinsmore 1986).

Our analysis indicated that the relative abundance of birds also was related to the area of hard-stem bulrush. Associated with increases in the area or hard-stem bulrush were increases in marsh-like habitat and the vertical diversity of vegetative habitat used by birds (Wiens 1983). Water level stabilization and resulting succession from playa to more marsh-like habitat among lakes on the Laramie Plains apparently resulted in a more abundant bird community.

Our data suggest a negative relationship between water surface area and species diversity, as well as between the length of bare shoreline and species diversity. However, we also found a significant positive correlation ($r = 0.92$, $P < 0.001$) between water surface area and length of bare shoreline. The functional relationship to species diversity probably occurs through greater habitat diversity (Wiens 1983) as the length of bare shoreline decreases. As with the relative abundance of birds reduction of bare shoreline and development of more marsh-like habitat apparently resulted in a more diver e bird community among lakes on the Laramie Plains.

Species richness was highest among lake of intermediate size and lowest among the smallest and large t lakes. This probably was a function of greater habitat diversity among intermediate-size lakes than among mall and large lakes. Small lake tended to have little or no bare shoreline, were ringed with marsh-like vegetation, and a relatively high abundance of marsh birds. Large lakes had predominantly bare shorelines, little marsh-like habitat, and an abundance of shorebird . Intermediate-size lake had marsh-like habitat and bare shorelines that provided habitat for marsh and shorebirds.

The relation hip between the relative abundance of individual species and the amount of bare shoreline or marsh-like habitat further supports an observed relationship between species diversity and species richness. Among the 48 species observed among the Laramie Plains lakes, the relative abundance of five species that are generally described as shorebirds were positively related to the length of bare shoreline, whereas 15 species that are generally associated with marshes were positively related to the shoreline length or area with hard-stem bulrush. While 16 waterfowl species were observed among the lakes, only two were related to habitat features, but waterfowl contributed substantially to species diversity and species richness. The negative relationship between lake size and species diversity probably resulted as a function of a large number of marsh birds associated with high amounts of marsh-like habitat around smaller lakes. Similarly, the high species richness of intermediate-size lakes may have resulted from the mix of marsh-like and bare shoreline habitats allowing both mar h and shorebird species to use these lake .

No temporal trends in relative abundance of individual bird species on the 12 Laramie Plains lakes were observed from May to July 1994. Breeding bird counts during May and early June have considerd birds counted at that time as summer residents rather than migrants (Brewster et al. 1976, Ruwaldt et al. 1979, McKinstry 1993). Our data suggest that birds observed on the Laramie Plains were summer residents that probably breed there. The only exception was Wilson's phalarope for which we observed the maximum number was observed in early May after which numbers decreased.

The Laramie Plains lakes provide habitat for a diverse array of bird species. The semi-arid Laramie Plains were devoid of surface water except for ephemeral playa lakes, but irrigation and construction of small dams has stabilize water levels and enhance wetland habitat for birds in many of the playa lakes. However, the nature of the soils and high evapotranspiration rates may adversely affect water quality (Dickerson 1993). Management should focus on maintaining a wide array of habitats among playa lakes altered by stabilizing water levels to provide habitat for a diversity of game and nongame birds.

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Appendix A. *Total number of each species of bird observed during all seven surveys on 13 lakes on the Laramie Plains from 9 May to 5 July 1994.*

Common name	Scientific name	Number
Pied-billed grebe	*Podilymbus podiceps*	104
Eared grebe	*Podiceps nigricollis*	2,196
Western grebe	*Aechmophorus occidentalis*	38
American white pelican	*Pelecanus erythrorhynchos*	125
Double-crested cormorant	*Phalacrocorax auritus*	152
Great blue heron	*Ardea herodias*	15
Snowy egret	*Egretta thula*	11
Cattle egret	*Bubulcus ibis*	1
Black-crowned night-heron	*Nycticorax nycticorax*	129
White-faced ibis	*Plegadis chihi*	123
Canada goose	*Branta canadensis*	1,863
Green-winged teal	*Anas crecca*	13
Mallard	*Anas platyrhynchos*	57
Northern pintail	*Anas acuta*	8
Blue-winged teal	*Anas discors*	8
Cinnamon teal	*Anas cyanoptera*	42
Northern shoveler	*Anas clypeata*	46
Gadwal	*Anas strepera*	114
American wigeon	*Anas americana*	183
Canvasback	*Aythya valisneria*	163
Redhead	*Aythya americana*	218
Ring-necked duck	*Aythya collaris*	5
Scaup spp.	*Aythya marila, A. affinis*	513
Bufflehead	*Bucephala albeola*	6
Common merganser	*Mergus merganser*	9
Ruddy duck	*Oxyura jamaicensis*	248
Northern harrier	*Circus cyaneus*	4
Sora	*Porzana carolina*	4
American coot	*Fulica americana*	625
Black-bellied plover	*Pluvialis squatarola*	1
Killdeer	*Charadrius vociferus*	269
Black-necked stilt	*Himantopus mexicanus*	7
American avocet	*Recurvirostra americana*	330
Greater yellowlegs	*Tringa melanoleuca*	2
Lesser yellowlegs	*Tringa flavipes*	1
Solitary sandpiper	*Tringa solitaria*	1
Willet	*Catoptrophorus semipalmatus*	5
Spotted sandpiper	*Actitis macularia*	10
Whimbrel	*Numenius phaeopus*	1
Common snipe	*Gallinago gallinago*	14
Wilson's phalarope	*Phalaropus tricolor*	592
Franklin's gull	*Larus pipixcan*	12
California gull	*Larus californicus*	<7000
Forster's tern	*Sterna forsteri*	205
Black tern	*Chlidonias niger*	34
Red-winged blackbird	*Agelaius phoeniceus*	77
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*	1,748
Brewer's blackbird	*Euphagus cyanocephalus*	120

Richard B. Keigley

Interpretation of a Lichen Lower Limit on Streambanks

Abstract

The vertical zonation of vegetation on a streambank provides a record of the hydrologic conditions existing at that location. Using data from nine USGS stream gauge stations, this study assessed the correspondence between the lower distribution limit of the lichen Xanthoria elegans *and three stream discharge parameters: 1) peak flood discharge, 2) number of days submerged, and 3) date of exposure on receding of annual flooding. The lower limit did not correspond with mean peak flood discharge or number of days submerged. At stations where the lower limit occurred greater than 40 cm above mean low water, the* Xanthoria *lower limit corresponded best with the stream level occurring in late-June and may document a minimum growing season necessary for the establishment of* Xanthoria. *Ice may prevent the establishment of* Xanthoria *lower than 40 cm above mean low water. The lower limit of lichen growth has been used to interpret the legal boundary of high water along streambanks. The lower limit of* Xanthoria *in this study did not correspond with mean peak discharge or mean period of submergence and so, would be a poor indicator of high water level.*

Key words: growing season, peak flood, submergence, zonation, *Xanthoria elegans*

Introduction

It may sometimes be necessary to estimate the discharge characteristics of ungauged streams (Leopold and Skbitzke 1967). For example, ownership boundaries may be defined by stage height, such as mean low water and ordinary high water. Flood stage height may also influence the design of bridges, roads, and trails.

Channel cross-section morphology has been used as evidence of bankfull stage height on ungauged streams (Riley 1972, Knighton 1984). The lower limit of mosses, lichens, herbs, and forbs has also been cited as evidence of flood stage (Leopold and Skbitzke 1967, Idaho Supreme Court 1978-1979).

Lichens on rocks along streambanks often grow in vertical zones (Hale 1967, Rosentreter 1984, 1992). The occurrence of *Dermatocarpon reticulatum* Magn. corresponded with mean high water, while *Verrucaria* spp. occurred below low water (Rosentreter 1992). The lower limit of the lichen *Parmelia conspersa* (Ehrh. ex Ach.) Ach. corresponded with a flood recurrence interval ranging from 1.14 - 1.37 years (Gregory 1976). The vertical zonation of lichen communities implies that different lichen species record different discharge parameter .

Along some stream segments in northwest Wyoming and southwest Montana, *Xanthoria elegans* (Link) Th. Fr. forms a conspicuous orange band on bedrock and large boulders close to stream level. Within local reaches, the *Xanthoria* zone is truncated at a uniform elevation above low water level, thus suggesting a correspondence with some stream stage height.

The purpose of this study was to determine how stream discharge controls the lower limit of *Xanthoria*. I tested for correspondence between the

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Xanthoria lower limit and three parameters: 1) mean peak discharge, 2) number of days submerged, and 3) date of exposure on receding of the annual flood.

Methods

I made observations at nine U.S. Geological Survey stream gauge stations in northwest Wyoming and southwest Montana (Table 1). At each station, I used a level to determine the height of the *Xanthoria* lower limit relative to the station's staff gauge (hereafter referred to as the "*Xanthoria* staff gauge height"). The *Xanthoria* staff gauge height was used to locate the lower limit with respect to minimum and maximum stream discharge levels.

Using the minimum daily discharge for each year of record (U.S. Department of the Interior 1963 - 1993), I calculated the mean minimum discharge for each station. From respective rating curves, I determined the elevation of the *Xanthoria* lower limit above mean low water.

Using the peak daily discharge for each year of record, I calculated a mean peak annual discharge for each station (D_{peak}). From respective rating curves, I determined the discharge that corresponded with the *Xanthoria* staff gauge height measured at each station (D_{Xanth}). Where the *Xanthoria* lower limit corresponded with mean peak annual discharge, $D_{peak} - D_{Xanth}$ would equal zero. For each station, I tested for that condition by t-test ($P < 0.05$).

From inspection of annual discharge records (U.S. Department of the Interior 1963 - 1993), I determined the number of days each year that flow exceeded the discharge indicated by the respective station's *Xanthoria* staff gauge height. Log transformation of the data failed to make the variances homogeneous. By Kruskal-Wallis ANOVA I tested the hypothesis that *Xanthoria* was submerged an equal number of days at all stations.

I similarly determined the mean Julian day at which discharge fell below that indicated by the *Xanthoria* staff gauge height at a given station. By ANOVA I tested the hypothesis that *Xanthoria* was exposed on the same day at each station. A post hoc comparison between gauge stations was made by Tukey honest significant difference for unequal sample size.

Results and Discussion

The vertical distribution of *Xanthoria* at Shields River and Soda Butte Creek was different from that at other

Table 1. *Gauge stations. YNP is Yellowstone National Park. N describes the number of years for which there were data during the period 1963-1993. Station numbers correspond with USGS gauge station description (Department of the Interior 1963-1993).*

Station name and location	Station number	N	Mean peak discharge (cms)	Mean minimum discharge (cms)	Figure labels
Big Creek near Emigrant, MT	06191800	7	11.3 ± 1.5	0.5 ± 0.0	BC
Gallatin River near Gallatin Gateway, MT	06043500	26	143.0 + 8.1	7.2 ± 0.3	GL
Gardner River near Mammoth, YNP	06191000	19	33.8 ± 2.3	2.1 ± 0.1	GR
Gibbon River near West Yellowstone, MT	06037000	7	17.7 ± 2.9	1.9 ± 0.0	GB
Lamar River near Tower Falls Ranger Station, YNP	06188000	12	218.3 ± 9.7	2.1 ± 0.2	LA
Shields River near Livingston, MT	06195600	15	60.1 ± 8.1	1.6 ± 0.1	SH
Soda Butte Creek near Lamar Ranger Station, YNP	06187950	5	33.2 ± 2.3	0.4 ± 0.0	SB
Yellowstone River at Corwin Springs	06191500	31	479.5 ± 21.7	18.7 ± 0.8	YC
Yellowstone River near Livingston, MT	06192500	31	564.1 ± 27.6	26.5 ± 1.1	YL

locations. Similar to other locations, cover percent diminished from about 50% to near zero over a vertical distance of a few centimeters. At other locations, *Xanthoria* was absent below this point. But at Shields River and Soda Butte Creek, scattered thalli occurred downward an additional 0.7 and 0.6 m, respectively, suggesting that colonization has occurred in response to fluvial adjustment. If, at the time of this study, *Xanthoria* had not fully colonized down to the new lower limit, then the *Xanthoria* staff gauge heights measured at Shields River and Soda Butte Creek would be higher than the true (future) lower limit gauge heights.

The *Xanthoria* lower limit ranged from 0.40 to 1.89 m above mean low water (Fig. 1). The lower limit occurred at a greater elevation at stations with high magnitude of seasonal fluctuation in discharge (see Table 1 for discharge comparisons).

The difference between peak discharge and the discharge corresponding to the *Xanthoria* gauge height (i.e., $D_{peak} - D_{Xanth}$) ranged from -0.2 to 176 m^3s^{-1} (Fig. 2). At five of the stations I rejected the hypothesis that $D_{peak} - D_{Xanth} = 0.0$ ($P < 0.05$). The variability between stations suggests that the *Xanthoria* lower limit is not an accurate indicator of mean peak flood stage height.

The mean periods of submergence ranged from 1 to 38 days (Fig. 3). I rejected the hypothesis that *Xanthoria* was submerged an equal number of days at all stations ($H = 61.7$; $P < 0.0001$). The variability between stations suggests that period of submersion is not a significant factor determining the lower limit elevation above stream level.

The mean date of exposure on receding of flood water ranged from Julian day 142 (May 22) to Julian day

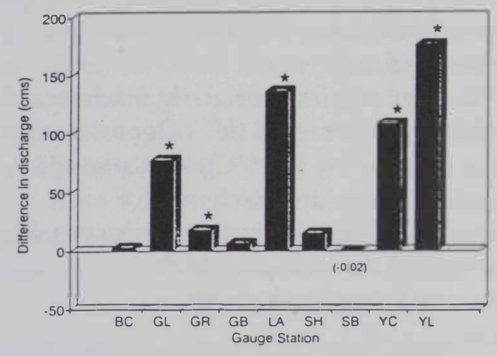

Figure 2. *The difference between mean peak discharge and the discharge indicated by the stage height at the Xanthoria lower limit. An asterisk denotes stations in which by t-test the difference did not equal 0.0 at P < 0.05.*

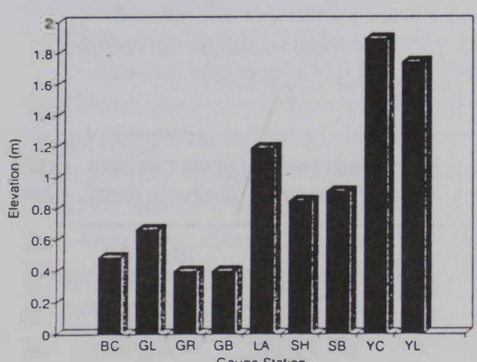

Figure 1. *Elevation of the Xanthoria lower limit above mean low water. Figure labels and sample sizes are described in Table 1.*

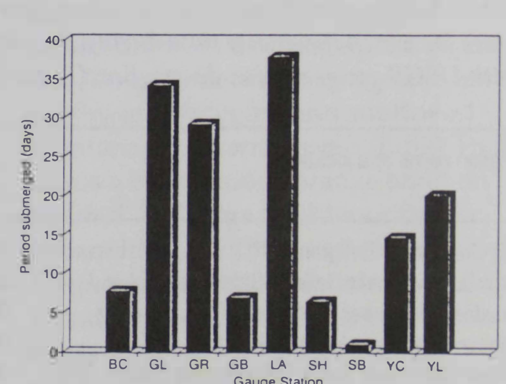

Figure 3. *The mean annual period of submergence of the Xanthoria lower limit differed between stations (P < 0.0001).*

181 (June 30; Fig. 4). I rejected the hypothesis that *Xanthoria* was exposed on the same day at all stations (N = 9, $P < 0.001$). At eight of the stations, the mean date of exposure did not significantly differ ($P < 0.05$). At these stations, exposure date ranged from Julian day 156 (June 5) to Julian day 181 (June 30).

Among that group of eight stations, Shields River and Soda Butte Creek had the earliest dates of exposure (Julian day 165 and 156, respectively). If the gauge height of the *Xanthoria* lower limit was overestimated at those stations (due to incomplete colonization), exposure of the future (true) lower limit would occur later than the dates presently indicated. At the remaining six stations, the mean dates of exposure were within six days of one another (Julian day 175 - 181).

The absence of lichens below a lower limit could be produced by: 1) the removal of established lichens by floods, or 2) the inability of lichens to colonize closer to stream level. Gregory (1979) reported that the lichen limit of *Parmelia* spp. represented discharge levels that were exceeded at least once per year and that some four to five annual inundations would result in lichen removal. Gregory appears to attribute the development of the lower limit primarily to lichen removal.

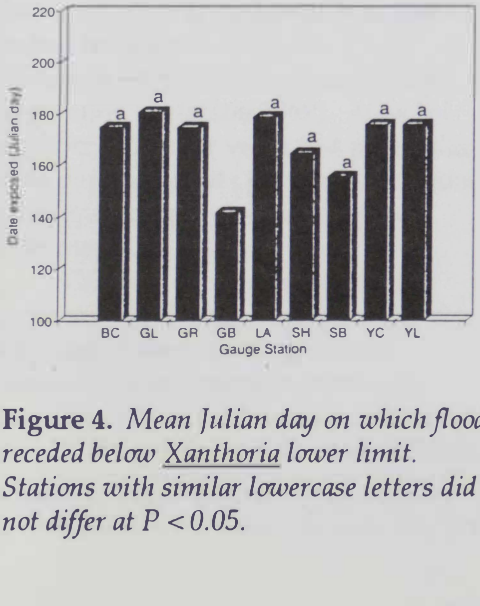

Figure 4. *Mean Julian day on which floods receded below Xanthoria lower limit. Stations with similar lowercase letters did not differ at P < 0.05.*

My study suggests that lichen removal plays a minor role in the development of the *Xanthoria* lower limit. Among the 9 gauging stations, the mean period of lichen submergence at the lower limit varied from 1-38 days. If lichen removal was the dominant factor for lower limit development, one would expect less variability between sites.

My study suggests that the *Xanthoria* lower limit may form primarily due to an inability to colonize lower than a certain elevation above stream level. Of the three parameters investigated, mean date of exposure on receding flood was most consistent between stations. I speculate that *Xanthoria* may be limited by a minimum length of a warm-temperature growing season. Based on the similarity of dates from six stations and the potential for incomplete colonization at Shields River and Soda Butte Creek, late June may mark the beginning of a critical period for *Xanthoria* growing close to stream level.

With an exposure date of Julian day 142 and no evidence of colonization, Gibbon River is anomalous to other sites. To be consistent with an exposure date ranging from Julian day 175 - 181, *Xanthoria* at Gibbon River would have to grow closer to mean low water stage than the 40 cm that was measured. I speculate that colonization closer to mean low water may be limited by ice formation.

In combination with other evidence, the lower limit of lichen growth has been used to legally interpret the elevation of "ordinary high water" (Idaho Supreme Court 1978-1979). But my study indicates that the *Xanthoria* lower limit would be a poor high water indicator. Among the 9 study sites, there was considerable variation between the lichen lower limit and both mean peak discharge and mean period of submergence.

The *Xanthoria* lower limit provides a benchmark for documenting changes in stream discharge and channel morphology. Within local reaches, the uniformity of the lower limit elevation above stream level is evidence that the lower limit forms in response to some stream discharge characteristic. I speculate that length of growing season is the responsible factor. Colonization below the lower limit is easily detected and is evidence of a change in stream condition.

Acknowledgments

I thank Wayne Hamilton, NBS Greater Yellowstone Field Station, and Roger Rosentreter, BLM Idaho State Office, for their comments.

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The Influence of Hunting on Deer Proximity to Roads

Melissa A. Sartor

Abstract

I tested the null hypothesis that hunting does not influence the average distance of white-tailed deer (Odocoileus virginianus) *from roads. Ten radio-collared, adult female white-tailed deer were located daily beginning 12 days prior to the opening day of the Montana general firearm season and ending 14 days after opening day. Four deer occurred on land that was hunted; six did not. Hunted deer stayed significantly further from roads during the hunting season ($\bar{x}$=540 m) than just prior to the season ($\bar{x}$=210 m). Non-hunted deer were closer to roads during the hunting season ($\bar{x}$=180) than before ($\bar{x}$=270). Distances of deer to forest openings between the two time periods were not significantly different for either group. I concluded that the hunted deer perceived and responded to intensive road-based hunting pressure, while the non-hunted deer did not.*

Key words: distribution, forest openings, hunting pressure, *Odocoileus virginianus,* roads, white-tailed deer

Introduction

Hunter distribution and deer movements under intensive hunting pressure are often examined. Deer hunter distribution is generally influenced by road and trail access (Johnson 1943, Peterson 1969, Thomas et al. 1976). Stenlund et al. (1952) and Fuller (1988) reported that most hunters never go more than 0.8 km (0.5 miles) from a drivable road or trail , and very few hunt more than 1.6- 3.2 km (1-2 miles) from roads or trails. These distances vary with topography and vegetation (Peterson 1969). Also, the number of hunter visits to a particular area depends on its proximity to a foot-trail, and camping or parking area (Thomas et al. 1976).

White-tailed deer movement patterns can change in response to the opening of deer hunting season. Generally, movement increases as hunting pressure intensifies (Marshall and Whittington 1968, Root et al. 1988).

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Deer tend to remain within individual home ranges when subjected to heavy hunting pressure, although Root et al. (1988) reported that female white-tailed deer move greater distances and have larger home ranges in comparison to other times. Marshall and Whittington (1968) reported similar behavioral patterns. Deer well-adapted to the features of their home ranges likely resist displacement by maximizing use of escape cover (Kufeld et al. 1988), and by spending considerable time in habitats with relatively dense understory (Marshall and Whittington 1968, Swenson 1982, Kufeld et al. 1988, Root et al. 1988).

I have not found studies that directly address deer response to roads during hunting seasons. Certainly hunter success would be influenced by deer associating roads with hunting pressure. I examined the null hypothesis that hunting does not influence the distances that deer occur from roads. I compared distances to roads of hunted deer before the firearm season with distances during the season.

f=3.074, P=0.081) or deer type (f=3.421, P=0.066) on distance to nearest road. However, there was a significant interaction between type of deer (hunted/not hunted) and date (before/during the hunting season) (ANOVA, f=26.089, P<0.001). Deer on lands open to hunting responded by staying further from roads during the hunting season ($\bar{x}$=540 m) than just before ($\bar{x}$=210 m, t-test, P<0.001, Table 1). As a group, non-hunted deer were located closer to roads during the hunting season ($\bar{x}$=180) than just before ($\bar{x}$=270, t-test, P=0.043). Three hunted deer had locations significantly further from roads during the hunting season compared to before (t-test, P<0.05) whereas the fourth deer on hunted lands showed no significant difference (P=0.114). Two non-hunted deer had locations significantly closer to roads during the season (t-test, P<0.04); the remaining four showed no significant difference (t-test, P>0.19).

Distribution of the type of road hunted deer were located closest to was strongly skewed toward open roads for two individuals, closed roads for another, and was fairly evenly divided for the remaining deer. Given this small sample size, I did not statistically compare the mean distances of locations closest to open roads with locations closest to closed roads. The deer that occurred near both road types on average stayed similar distances from open and closed roads both before (220 m vs. 190 m) and during the hunting season (450 m vs. 400 m).

Minimum Distance to Nearest Opening

There was no significant interaction between deer type and date for minimum distance to nearest opening (ANOVA, f=0.404, P=0.526). The main effect of date was insignificant (ANOVA, f=0.602, P=0.493). However, the main effect of type of deer on the variation in distance was significant (ANOVA, f=22.643, P<0.001). Non-hunted deer were located closer to forest openings ($\bar{x}$=110) than hunted deer ($\bar{x}$=260 m), both before and during rifle hunting season (Table 2). I found no significant difference between mean distance to opening before versus during the hunting season for three hunted deer and five non-hunted deer (t-test, Table 2). Locations for deer number 4 were closer to openings during the hunting season (t-test,

Table 1. *Mean distances to nearest road for hunted and non-hunted deer before vs. during the hunting season, and significance of t-tests performed with data from individual deer.*

	DISTANCE TO ROAD						
	BEFORE SEASON			DURING SEASON			
Deer #	n	mean(m)	std.dev.	n	mean(m)	std.dev.	P-value
unte							
1	10	220	150	8	330	170	0.114
2	10	130	180	12	180	80	0.043
3	11	250	210	10	360	230	0.05
4	11	240	180	10	1310	1260	0.006
total	42	210	180	40	540	770	<0.001
not hunted							
5	12	220	210	12	190	160	0.371
6	14	200	220	9	210	160	0.971
7	12	200	190	12	210	130	0.489
8	13	350	250	13	130	120	0.039
9	12	330	220	13	160	160	0.017
10	12	290	200	13	200	200	0.193
total	75	270	220	72	180	150	0.043

Table 2. *Mean distances to nearest forest opening for hunted and non-hunted deer before vs. during the hunting season, and significance of t-tests performed with data from individual deer.*

	DISTANCE TO FOREST OPENING						
	BEFORE SEASON			DURING SEASON			
Deer #	n	mean(m)	std. dev.	n	mean(m)	std.dev.	P-value
unte							
1	10	280	270	8	380	270	0.279
2	10	190	370	12	80	110	0.836
3	11	230	270	10	260	200	0.568
4	10	460	510	6	280	310	0.029
total	41	300	360	36	220	230	0.931
not unte							
5	12	90	140	12	80	100	0.495
6	14	110	130	9	140	150	0.651
7	12	130	190	12	40	70	0.062
8	13	130	170	13	60	100	0.172
9	12	210	230	13	80	160	0.073
10	12	140	200	13	180	150	0 049
total	75	130	190	72	90	140	0.21

P=0.029). Locations for deer number 10 were further from openings during the hunting season (t-test, P=0.049).

Discussion

Deer in areas receiving hunting pressure were further from roads during the hunting season than prior to the season. On average, deer that roamed on non- hunted land showed a closer association to roads during the hunting season (Table 1). I am unable to explain this observation. Though the average air temperature was cooler after the opening day of the season (a difference of only 7°C with three sub-zero days), there was no distributional shift in elevation that could have resulted in shorter distances to the main Ninemile Road situated through the bottom of the valley. Deer were not displaced out of their usual areas by hunter activity on public lands adjacent to the private land. This closer association to roads could be due to random movements or sampling error. An average difference of 90 m where distances were measured in 50 m increments is probably not an accurate reflection of true change, especially because locations were estimated from triangulation polygons. Of much more dependable significance is the difference of 330 m between before and during season locations for hunted deer.

I found no difference between the two time periods in distance to forest openings (Table 2). Non-hunted deer were significantly closer to openings than were hunted deer. Deer in areas receiving hunting pressure perceived and responded to an increased threat, or at least annoyance, associated with both open and closed roads. They apparently either did not perceive forest openings as a potentially dangerous place to be in or near once the hunting season began, or they always stayed sufficiently far from openings for safety, perhaps utilizing them with darkness.

Deer number 4 was displaced to an area away from main roads with a lower density of primitive roads. Livezey (1991) reported similar observations with female Columbian black-tailed deer *(O. h. columbianus)*. Four of 15 collared individuals moved 0.6 - 2.5 km out of their usual home ranges and away from roads during a males-only hunting season.

Hunted deer tended to stay further from all roads. Whether deer actually associate roads with disturbance or only perceive the disturbance is unclear. Rost and Bailey (1979) and Perry and Overly (1977) reported road avoidance by mule deer and elk was greater along more heavily traveled roads. Whitmer and deCalestra (1985) reported a significant departure from the expected frequency of female Roosevelt elk *(C. e. roosevelti)* locations within 500 m of paved and 125 m of 8spur roads open to vehicular traffic. They found no differences for elk locations around spur roads closed to vehicles. In Ninemile, an average of 72 vehicles on weekends and 44 on weekdays traveled each of the main roads on every day of the first two weeks of the general firearms season. Also, many hunters utilize the easier walking travel and increased field of vision provided along roads closed to vehicle traffic; however, there are many times more miles of closed roads than roads open for vehicle travel in the Ninemile system. Because these closed roads are so extensive, I assume it is unlikely that on any given day hunters walked even half of the miles of closed roads.

Obtaining the results that I did while incorporating roads closed to vehicles leaves the possibility that the association is with roads, and not necessarily actual pressure from hunters using roads, because foot traffic on any closed road was undoubtedly much less than vehicle traffic on open roads. Conversely, humans on foot possibly have a greater impact than motorized vehicle travel on deer perception of danger. I have often (nearly exclusively not during the hunting season) observed deer in close proximity to roads watching motor vehicles drive by without retreating. Deer would almost always flee if the vehicle stopped and someone got out. Neff (1977) reported similar observations and suggested there is a four-point scale of impact by human activity with rapid and steadily moving vehicles on smooth roads being least disturbing. Car doors opening, persons disembarking, and human on foot constitute the highest level of disturbance.

If the observed distributional shift away from roads is only a result of avoiding actual hunters using roads, I would expect a decrease in avoidaince of closed roads past a given distance from the point of closure (assuming that most hunters walking closed roads do not venture past this distance). Because of small samples of marked deer, my data can not adequately test this prediction. If it is true and I were to exclude that portion of roads far from a gate or other closure, the difference between before and during season distance to road for hunted deer would be greater than what I report here.

A November 1995 inventory of Region 1 roads under US Forest Service jurisdiction (USFS Region 1 Engineering, unpubl. data) listed 58 percent of Lolo NF roads closed to motorized vehicle travel, and an average of 49 percent of roads closed in Region 1 forests. Given that the Lolo NF has a slightly higher proportion of closed roads than the regional average, deer response to roads in areas open and accessible to hunting should be similar to what I observed, and therefore these results may be considered for management of other white-tailed deer populations in the Northern Region.

For management purposes, it may be helpful to know that hunter distribution and area of high disturbance may affect deer di tribution; especially if deer learn where they are likely to encounter pressure, or associate pressure with a component of the landscape, and avoid these place . Areas with low road densities or tracts with more than 5 km (3 mile) between roads receiving hunting use likely serve a a daytime refuge for legally hunted deer, because as others reported, hunters will usually not walk half that distance from a road or trail (Stenlund et al. 1952, Fuller 1988).

It is conceivable that the security benefits of adjusting diurnal spatial distributions during the hunting season become lower when other phy iological and physical factors are present, such as the breeding season or early winter storms. The observations reported here may only hold true for female white-tailed deer, and further work should be conducted with male deer, especially during the breeding season.

Acknowledgments

I wish to thank Mike Jimenez and Dr. Robert R. Ream for giving me this opportunity. Also, thank you to Mike for sharing data, resources and advice. Others who made this project possible were Mike Hillis of the Lolo National Forest, my field assistants, and Dr. Daniel H. Pletscher for his generous advising. Finally, thank you to my reviewers for their helpful comments about the manuscript and suggestions for improvement.

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Angler Response to Harvest Regulations in Montana's Yellowstone River Paddlefish Fishery

Abstract

A written, 15-question survey of anglers snagging for paddlefish (Polyodon spathula) *was conducted at a popular fishing site on the Yellowstone River, Montana. Its purpose was to obtain opinions and preferences on specific regulations, including the reduction in the annual bag limit from two to one fish, catch-and-release fishing, and on the possible implementation of a harvest quota for the stock. Questionnaires were completed by 258 snaggers over the six-week (May 15-June 30) fishing season in 1994. Snaggers were split (30% for, 44% against) in their opinions on whether the reduction to a one-fish bag limit was justified, and whether the paddlefish stock would benefit from the reduced bag limit. Seventy-three percent of all respondents favored the opportunity to catch and release paddlefish. Support for a harvest quota was not strong but of the three quota options presented (Tag Limitation, Inseason Closure, and a Five-Year Quota), support was strongest for Inseason Closure (44%) followed by Tag Limitation (25%). Results of this questionnaire have been used in conjunction with stock assessments to reduce the bag limit and establish catch-and-release periods in the fishery.*

Key words: paddlefish, Polyodontidae, Montana, fisheries management, Yellowstone River, fishing

Introduction

Although paddlefish *(Polyodon spathula)* snag fisheries exist in several states (Combs 1986), more information is needed on attitudes of snaggers toward harvest regulations (Scarnecchia et al. 1996a). Since the early 1960s, the paddlefish fishery on the Yellowstone River has supported an important recreational fishery on the Yellowstone River, Montana (Robinson 1966; Scarnecchia et al. 1996b). The fishery is centered at Intake, Montana, at a low-head irrigation-diversion dam 27 km downriver from Glendive (Rehwinkel 1978). Over the period 1962-1993, between 500 and 5,000 paddlefish have been harvested annually at Intake (Scarnecchia et al. 1996b).

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A two-fish-per-person annual bag limit and mandatory retention regulations (i.e., prohibition of catch-and-release) were implemented in 1981 in response to concerns about mortality of mishandled, released fish (Elser 1986) and because of overcrowding of snaggers at the shoreline fishing sites. These regulations remained in effect until 1994 when an increase in mean age of the stock and an expanding fi hery for the same migratory stock in North Dakota prompted the enactment of a one-fish-per-person annual bag limit in Montana (Scarnecchia et al. 1996b).

Several regulatory option have been considered for the Montana fishery, including catch-and-release fishing in conjunction with the one-fish bag limit. Catch-and-release has been used succe fully in many fisherie for other species (Barnhart 1989), but has not been formally implemented anywhere for paddlefish. Release of snagged paddlefish is permitted, however, in other fisheries (Elser 1986), including the Missouri River in Montana above Fort Peck Dam. In addition, quotas on total catch were also considered as a harvest option. Quotas, often called Total Allowable Catches (TACs), have been used commonly and successfully in marine fisheries throughout the 1970s and 1980s (Gough 1993; Parsons 1993).

The concentration of paddlefish at Intake attracts numerous snaggers each May and June who can be surveyed regarding fishing regulations and management policies (Matlock 1991; Pollock et al. 1994). Our objective was to obtain information on attitudes and preferences of snaggers on three fishery management options: a one-fish bag limit, catch-and-release, and harvest quotas.

Methods

Sampling Assumptions and Limitations

A 15-item self-administered questionnaire was administered to snaggers daily at Intake throughout the entire 1994 paddlefish snagging season (May 15-June 30). Although our preference would have been to query only one person per fishing party, low participation in snagging throughout much of the season made it necessary to survey all snaggers encountered. More than 95% of the snaggers approached were willing to spend the 5-7 minutes needed to complete the questionnaire. Non-responses were less than 1.5% for each question.

Because of a recent reduction in the annual bag limit combined with poor fishing in 1994, some snaggers probably avoided Intake entirely, resulting in a somewhat less disgruntled, more conservation-minded pool of respondents than would have been polled otherwise. For our study, the population of interest was defined as those licensed anglers who actually snagged for paddlefish at Intake, not the larger number of persons who purchased licenses and tags but did not fish. Questionnaires were completed by 258 snaggers, or an estimated 49% of the estimated total number of paddlefish snaggers at Intake in 1994.

The Questionnaire

The first three questions sought information on the state of residence (Montana resident versus non-resident), age, and sex of the snagger. The next three questions sought information on their primary and secondary fishing sites, i.e., how often they snagged for paddlefish at Intake, in the Missouri River above Fort Peck Dam, or elsewhere. Three questions concerned the effects of reduced bag limit (from two to one fish per person per year); two of the three questions concerned effects on the paddlefish stock and on snagger participation and a third question asked if the reduced bag limit had been justified. One question assessed their attitude toward catch-and-release for the paddlefish fishery.

To insure that snaggers understood the three quota options, Tag Limitation, Inseason Closure and Five-Year Quota, we summarized the options briefly for them on the questionnaire before the pertinent questions on quota options. Under Tag Limitation, annual harvest would be limited in each state by limiting the number of tags sold. Under Inseason Closure, an annual quota would be set and an unlimited number of tags sold. The fishing season would be closed when the quota was reached. Under a Five-Year Quota, once the total quota had been reached, the fishery would be closed for the remainder of that five-year period. The Five-Year Quota could thus result in some years with no paddlefish snagging season.

The last two questions asked if snagger would prefer to have their quota divided as a two-fish or one-fish bag limit. Finally, snaggers were asked to write any comments at the end of the questionnaire.

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Site of Dye Solubilization in Surfactant Micelles

Abstract

Comparisons of visible spectra of fluorinated analogs of the dye Orange OT and two of its isomers in dodecane, in a pyridine/water mixture, in micelles of dodecylpyridinium bromide, and in micelles of cetylpyridinium chloride suggest that the solubilized dye molecules prefer an environment which is more polar than that of the micelle's hydrocarbon core. Comparisons of nuclear magnetic resonance spectra of the dyes in deuterated pentane, in a pyridine/D_2O mixture, and in micelles of dodecylpyridinium bromide lead to the same conclusion.

Key words: dyes, surfactants, micelles, visible spectra, NMR spectra.

Introduction

The ability of a surfactant to greatly increase the water solubility of a variety of substances is undoubtedly associated with its tendency to form micelles. In fact, this phenomenon is the basis for the employment of dyes in determining critical micelle concentrations (Mukerjee and Mysels 1971). At concentrations below its critical micelle concentration (CMC), a surfactant is present in solution primarily in the form of monomeric surfactant ions and counterions and has little influence on the solubilities of other solutes. Above the CMC, most of the surfactant added to a solution aggregates to form micelles which readily solubilize dyes. Micelles occur in various sizes and shapes. Those involved in the present study are spherical and have aggregation numbers between 70 and 140.

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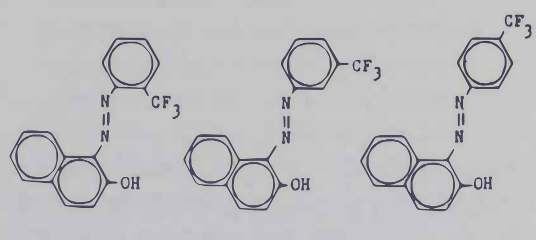
The primary goal of our research was to augment our knowledge of dye solubilization sites in micelles. According to Fendler and Fendler (1975), "Although no quantitative description of the mechanism of solubilization is available, a knowledge of the location of the solubilizate in the micelle is necessary for an understanding of micellar catalysis...The use of micelles in synthetic organic chemistry to alter the yields and reaction pathways has great potential." The possibility that micelles could serve as models for enzymes has stimulated considerable research (Hiemenz, 1986). Fendler and Fendler (1975) have warned, however, that "...ample evidence is accumulating which renders aqueous micelles to be relatively poor models for complex bioorganic interactions."

A number of investigators have used nuclear magnetic resonance (NMR) spectroscopy to investigate solubilization sites in micellar systems. Fendler and Fendler (1975) discussed and provided references for the initial research in this area. Lindman, Olsson and Söderman (1995) reviewed recent NMR studies of surfactant solutions. We decided to employ the technique in an attempt to learn something about the orientation in micelles of solubilized fluorinated analogs of Orange-OT isomers. The dyes have the following structures:



TOOT TOMT TOPT

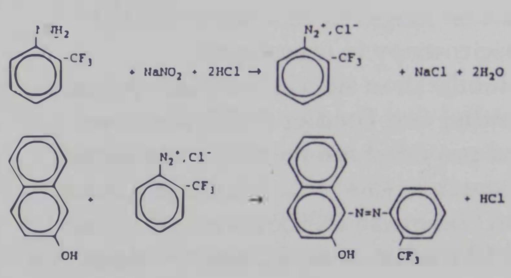
We also wanted to see what could be learned from visible spectrophotometry, a tool successfully employed by Jacobs, Geer and Anacker (1972) to gain information about the environment of the dyes Orange OT and dimethylaminoazobenzene in solutions containing micelles of tetradecylpyridinium chloride. Fendler and Fendler (1975) and Hiemenz (1986) provided references to some of the other investigations that used this technique to learn something about solubilization sites in micelles.

Experimental

Since 1-(α,α,α-trifluoro-2-tolylazo)-2-naphthol,

1-(α,α,α-trifluoro-3-tolylazo)-2-naphthol, and

1-(α,α,α-trifluoro-4-tolylazo)-2-naphthol, i.e., TOOT, TOMT, and TOPT, respectively, were prepared by similar procedures, we provide details for the preparation of only the first dye. The pertinent reactions are:



A solution containing 0.10 mole of 2-aminobenzotrifluoride (Aldrich), 25 ml of concentrated hydrochloric acid, and 40 ml of H_2O was prepared. To it were added 100 g of ice. Then 70 g more of ice and a solution containing 0.10 mole of $NaNO_2$ in 50 g H_2O were added with stirring. The resulting mixture was then added with vigorous stirring to a mixture of 100 g of ice and a solution containing 0.10 mole of β-naphthol (MCB), 40 g KOH and 100 ml H_2O. A yellow precipitate formed immediately. After about 45 minutes of continuous stirring, the reaction mixture was filtered. The solid obtained (crude TOOT) was washed with water and dried overnight at ~ 70°C. The TOOT was then recrystallized twice from ethanol and vacuum dried at 70°C. The TOOT, TOMT, and TOPT crystals prepared had melting points of 161-162, 172-173, and 143-143.8°C, respectively.

The dodecylpyridinium bromide monohydrate (DPB) was part of a batch prepared for earlier work (Jacobs, Geer and Anacker 1972). The cetylpyridinium chloride monohydrate (CPC) was purchased from Acros Organics, the pyridine and n-dodecane from Lancaster, the deuterium oxide and the deuterated n-pentane from Cambridge Isotope Laboratories, and the acetone from Fisher Scientific. Reagent grade sodium bromide and sodium chloride were obtained from Malinckrodt and Baker, respectively. Water used in solution preparation was distilled from alkaline permanganate. Pyridine/water mixtures were prepared by mixing equal volumes of pyridine and water. Solutions containing CPC were examined while several degrees above room temperature to prevent crystallization of the surfactant. In the NMR work, solutions of the dyes in deuterated n-pentane and in pyridine/ D_2O mixtures were saturated.

A Cary 219 spectrophotometer was employed to obtain visible spectra and a Bruker DRX500 MHz spectrometer tuned to ^{19}F was used in the NMR work. The NMR experiments were run at 300 K. Freon-113 was used as an external reference.

Results and Discussion

We used dye concentrations such that the likelihood that any micelle would contain more than one solubilized dye molecule was small. According to an earlier study (Anacker 1958), the CMC of CPC in 0.500 M NaCl is 4.7 x 10^{-5} M and the micelles in this medium have an aggregation number close to 136. This means that the micelle concentration in the CPC solutions (0.0600 M CPC, 0.500 M NaCl and ~ 1.03 x 10^{-4} M dye) used in our studies was (0.0600 - 0.000047)/136 M, i.e., 4.4 x 10^{-4} M. The ratio of dye molecules to micelles was therefore 1.03 x 10^{-4}/4.4 x 10^{-4} = 0.23. Using the CMC and aggregation number of DPB in 0.500 M NaBr from another study (Jacobs, Geer, and Anacker 1972), one calculates a ratio of 0.13 for the number of dye molecules to DPB micelles in the present work. Dye molecules experienced no overcrowding!

Visible spectra obtained in this research are displayed in Figures 1-3. Since a switch from DPB with twelve carbons in the hydrocarbon chain to CPC with sixteen carbons in the hydrocarbon chain had little effect on any spectrum, we can conclude that a dye molecule had considerable freedom in making a site selection within the micelle. Spherical CPC micelles have diameters of about 55 C (Anacker 1958). This is substantially greater than the maximum dimension possessed by any of the dyes.

Dye spectra obtained in the presence of surfactants have features (wavelength at which the absorption maximum occurs and its height relative to that of the adjacent and shorter wavelength shoulder) which resemble more closely those obtained in the pyridine/water mixture than those obtained with

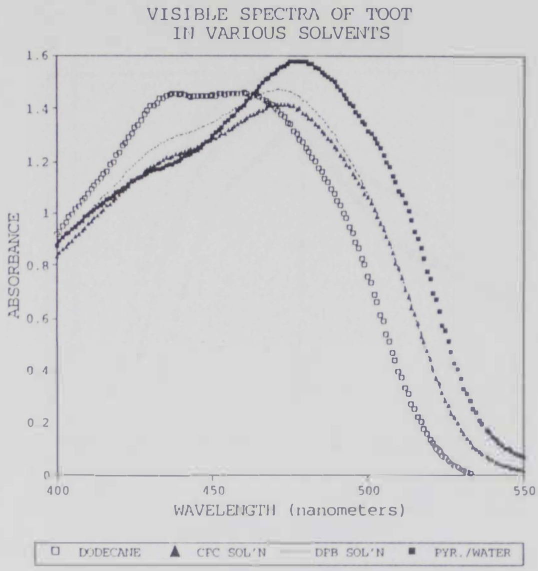


Figure 1. *Visible spectra of TOOT in dodecane, pyridine/water (50% each by volume), aqueous cetylpyridinium chloride solution (0.0600 M CPC, 0.500 M NaCl), and aqueous dodecylpyridinium bromide solution (0.0606 M DPB, 0.500 M NaBr). TOOT concentration = 1.024 x 10^{-4} M.*

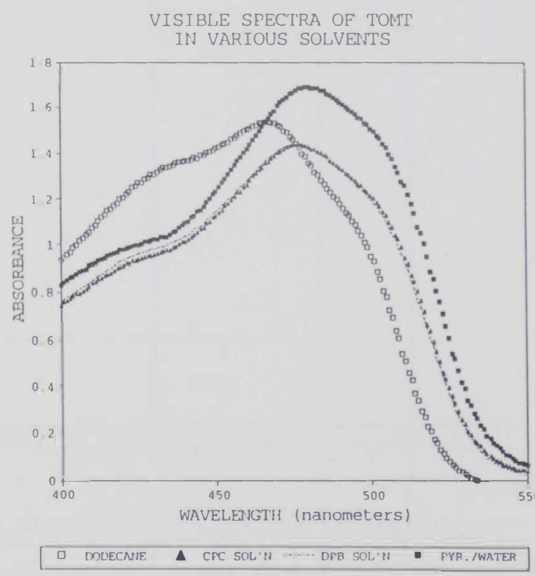


Figure 2. *Visible spectra of TOMT in dodecane, pyridine/water (50% each by volume), aqueous cetylpyridinium chloride solution (0.0600 M CPC, 0.500 M NaCl), and aqueous dodecylpyridinium bromide solution (0.0606 M DPB, 0.500 M NaBr). TOMT concentration = 1.037 x 10^{-4} M.*

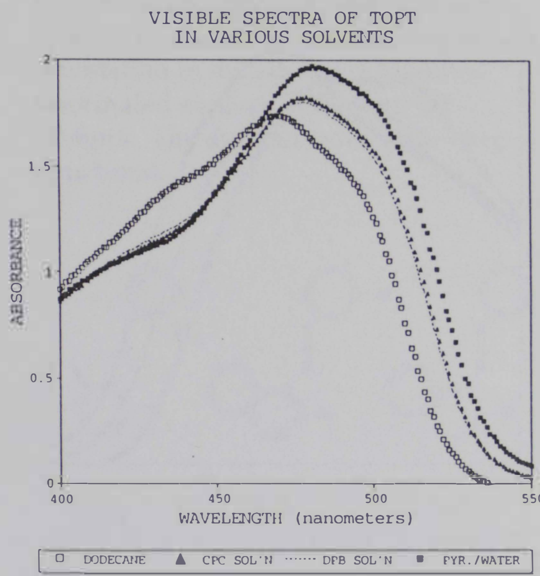


Figure 3. *Visible spectra of TOPT in dodecane, pyridine/water (50% each by volume), aqueous cetylpyridinium chloride solution (0.0600 M CPC, 0.500 M NaCl), and aqueous dodecylpyridinium bromide solution (0.0606 M DPB, 0.500 M NaBr). TOPT concentration = 1.036 x 10^{-4} M.*

dodecane. This was also the case in the earlier study (Jacobs, Geer, and Anacker 1972). If pyridine/water and dodecane can serve as crude models of the micelle's surface and interior, respectively, the spectra suggest that the dyes, or parts of them, reside in relatively polar environments. Since the dyes themselves are virtually water insoluble, their environments must also have some non-polar character.

NMR spectra obtained in this study make up Figures 4-6. Since the spectrum of a dye in a DPB/NaBr/D_2O solution more closely resembles that of the dye in a pyridine/D_2O solution than that of the dye in deuterated pentane, we again may conclude that when solubilized by a micelle, a dye's $-CF_3$ group experiences an environment that more closely resembles the micelle's surface than the micelle's interior.

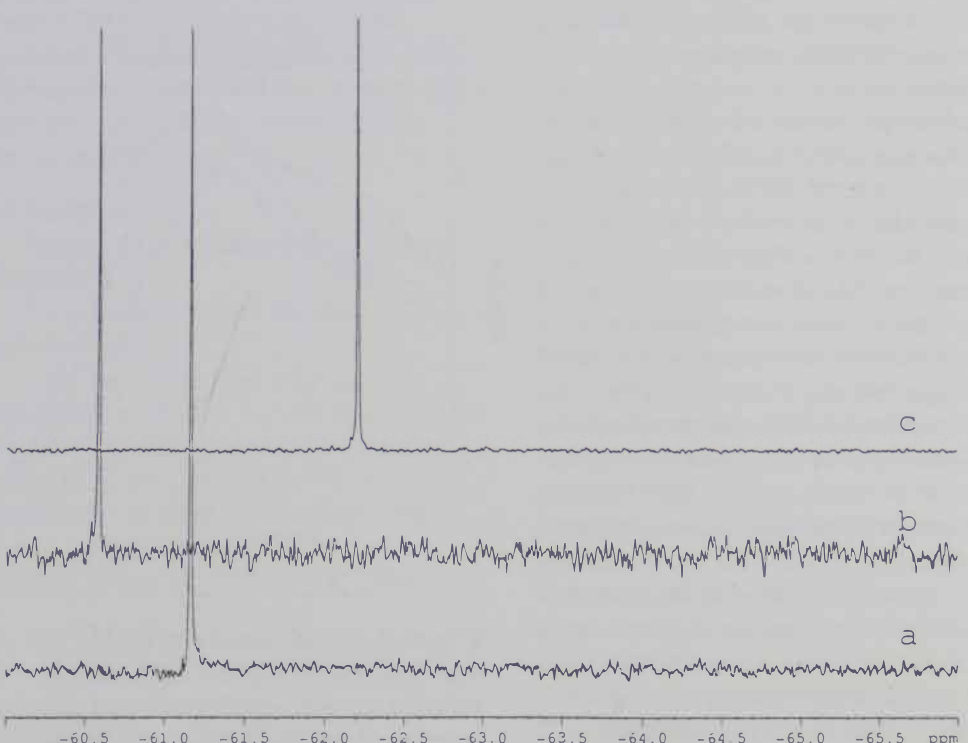


Figure 4. *NMR spectrum of TOOT in a) pyridine/D_2O (50% each by volume), b) aqueous dodecylpyridinium bromide solution (0.0573 M DPB, 0.478 M NaBr, 9.80 x 10^{-5} M TOOT), and c) pentane-d_{12}.*

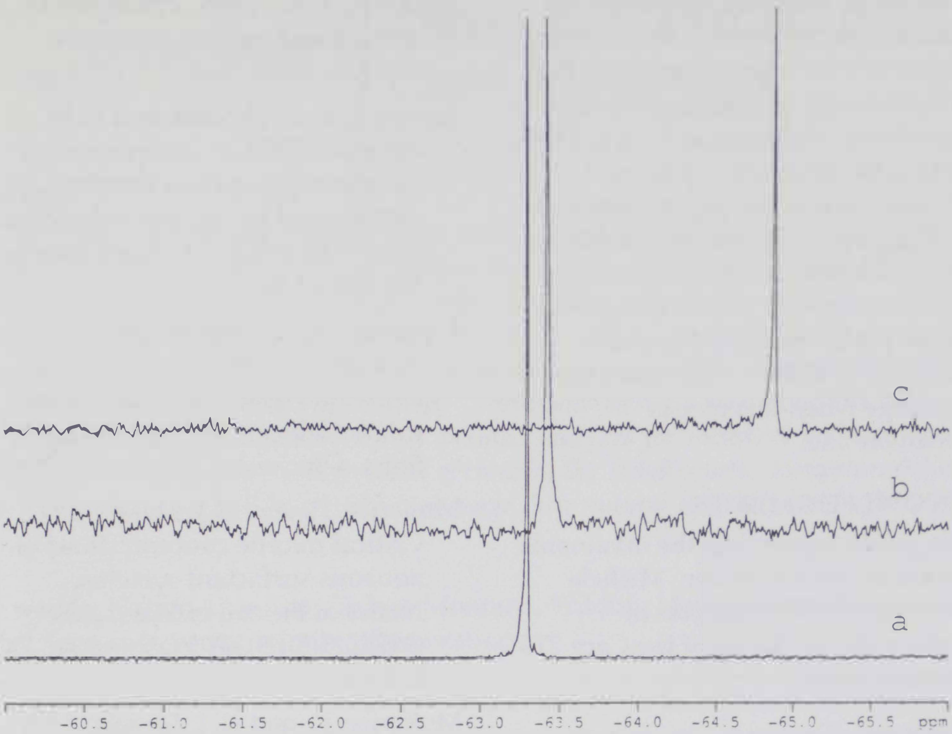


Figure 5. *NMR spectrum of TOMT in a) pyridine/D_2O (50% each by volume), b) aqueous dodecylpyridinium bromide solution (0.0631 M DPB, 0.486 M NaBr, 1.00 x 10^{-4} M TOMT), and c) pentane-d_{12}.*

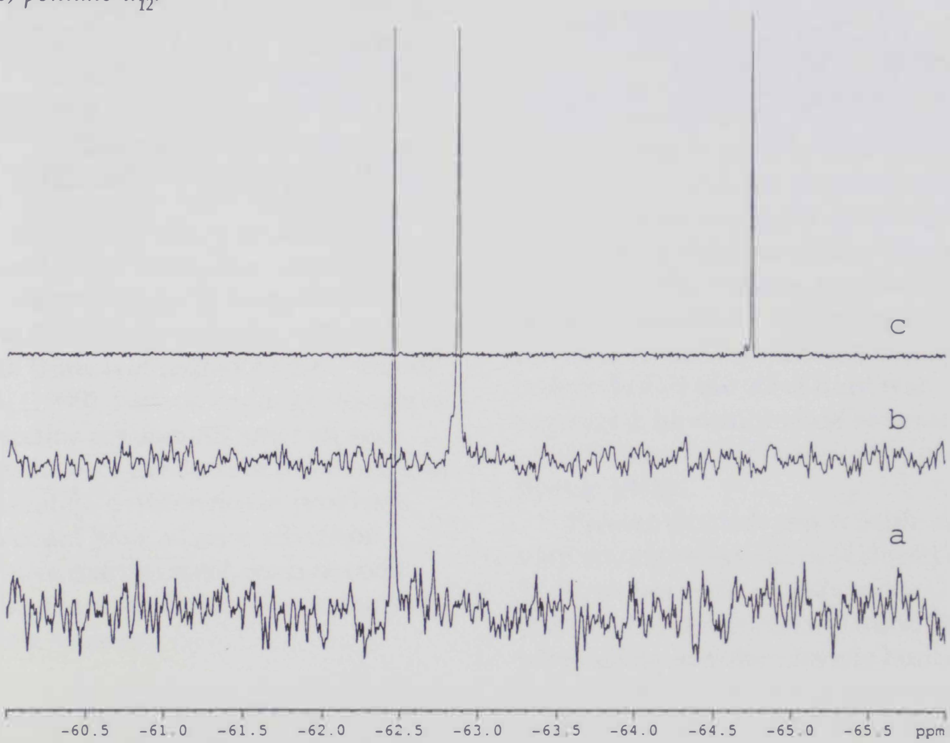


Figure 6. *NMR spectrum of TOPT in a) pyridine/D_2O (50% each by volume, b) aqueous dodecylpyridinium bromide solution (0.0635 M DPB, 0.500 M NaBr, 1.11 x 10^{-4} M TOPT), and c) pentane-d_{12}.*

One factor that may contribute to the tendency of the dyes to show some preference for the micelle surface is the mutual phobicity of hydrocarbons and fluorocarbons (Mukerjee and Yang 1976). According to Mukerjee and Mysels (1975), resistance to mixing of these two kinds of groups "reduces their tendency to micellize when attached to the same chain and causes the W-trifluoro group to sample predominantly the water-micellar core interface rather than the core average when this core is hydrocarbon-like."

ACKNOWLEDGMENTS

We greatly appreciate the invaluable assistance of Doreen Brown, Michele McGuirl, and Melanie Rogers in unraveling the mysteries of the Cary 219 spectrophotometer.

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Responses were summarized and analyzed with a Chi-Square statistic according to age (age 34 years and younger versus 35 years and older), sex and state of residence (Montana resident versus non-resident). For all questions, P=0.05 was required for statistical significance.

Results

Of the 258 snaggers who completed the questionnaire, 235 (91%) were male and 23 (9%) were female, 139 (54%) were younger than 35 years and 119 (46%) were 35 years or older, 154 (60%) were Montana residents and 97 (38%) were non-residents (2% unknown).

Most snaggers responding to questionnaires fished only at Intake (Table 1). More than one-fourth of the respondents had fished at Intake in each of the previous five years and most had fished there in more than one of the previous five years.

Table 1. *Number of years over the period 1990-1994 that respondent had snagged paddlefish a) at Intake, b) in North Dakota, and c) in the Missouri River above Fort Peck Dam.*

	Intake		North Dakota		Fort Peck	
Years fished during 1990-94	No.	%	No.	%	No.	%
None	NA	NA	227	88.0	230	89.1
One	87	33.8	10	3.9	17	6.6
Two	53	20.5	11	4.3	6	2.3
Three	28	10.9	7	2.7	3	1.2
Four	23	8.9	2	0.8	0	0.0
Five	67	26.0	1	0.4	2	0.8

NA= not applicable. All surveyed snaggers had fished at least once, i.e., the current year.

Snaggers were nearly equally split among all five response choices (Table 2) in their response to the statement "I would be less likely to return to Intake to fish for just one paddlefish than for two paddlefish." No significant differences were found according to age (P=0.33), sex (P=0.91), or state of residence (P = 0.14).

Slightly more snaggers agreed than disagreed with the conservation value of the bag limit reduction (Table 2). This split response occurred even though the rationale for the reduction in the annual bag limit from two to one fish had been presented at public meetings in eastern Montana. No significant differences were found in this response according to age (P=0.25), sex (P=0.93), or state of residence (P=0.26).

Table 2. *Percent responses to questions related to one fish bag limit and catch-and-release fishing. For responses, SD = strongly disagree, D= disagree, N = neutral, A=agree, and SA = strongly agree.*

Statement	Response (%)				
	SD	D	N	A	SA
I am less likely to return to Intake to fish for just one paddlefish than to fish for two paddlefish. (N = 256)	18	20	20	21	21
I think the paddlefish population will benefit from the reduced bag limit. (N = 257)	17	20	20	25	18
The reduction in catch from two to one fish is justified. (N = 257)	24	20	26	18	12
I would like to see some catch-and-release opportunities at Intake. (N =258)	8	7	12	21	52

Snaggers were split equally on whether the reduction from two fish to one fish was justified (Table 2). No significant differences were found in this response according to age (P=0.36), sex (P=0.99), or state of residence (P =0.08).

Seventy-three percent of the snaggers supported catch-and-release; only 15% did not favor some version of a catch-and-release regulation. Although all types of snaggers tended to support catch-and-release, support was significantly stronger among younger (<35 years) snaggers than older (35 or more years) snaggers (P=0.05).

Support for no quota option was strong, but snaggers most favored Inseason Closure (Table 3). No significant differences in response to the Inseason Closure option were detected by age (P=0.42), sex (P=0.96), or state of residence (P=0.94).

Table 3. *Percent responses to three quota options listed in Paddlefish Management Plan. For responses, SD = strongly disagree, D = disagree, N = neutral, A = agree, SA = strongly agree.*

Statement	Response (%)				
	SD	D	N	A	SA
If the number of snaggers and their expected catch exceeded Montana's quota, I would favor a lottery drawing for paddlefish tags [Tag Limitation](N = 251)	39	23	13	16	9
I would prefer that the season be closed each year when the quota is reached. [Inseason Closure] (N = 252)	25	14	17	26	18
I would prefer a five-year quota, even if it meant that the season might be closed entirely in some years. [Five-Year Quota] (N = 247)	49	22	15	8	6

Tag Limitation was the second choice; 25% of respondents agreed or strongly agreed with this option but more than 60% disagreed or strongly disagreed with it. No significant differences in response to Tag Limitation were detected by age (P=0.94), sex (P=0.35) or state of residence (P=0.59).

The Five-Year Quota option was preferred least; nearly half of the respondents strongly disagreed and 22% disagreed with it. Although no significant differences in response were detected by age (P=0.44) or sex (P=0.28), non-resident snaggers showed a much stronger and highly significant preference for this option than did Montana residents (P=0.01).

Snaggers were split on whether a two-fish or one-fish annual bag limit would be preferable under a quota system (Table 4). Thirty-eight percent of respondents agreed or strongly agreed with a one-fish limit under a quota system and 38% disagreed or strongly disagreed. No significant differences in response were detected by age (P=0.52), sex (P=0.35), or state of residence (P=0.46). Preference for a two-fish bag limit under a quota system was weaker than for a one-fish limit. Half (50%) of respondents disagreed or strongly disagreed with the two-fish bag limit under a quota system and only 29% agreed or strongly agreed. No significant differences in response were found by age (P=0.27), sex (P=0.94), or state of residence (P=0.41).

Table 4. *Percent responses to one-fish and two-fish bag limits under a hypothetical quota system. For responses, SD = strongly disagree, D = disagree, N = neutral, A = agree, SA = strongly agree.*

Statement	Response (%)				
	SD	D	N	A	SA
I would prefer to have Montana's quota divided up among snaggers so that each snagger's bag limit would be one fish. (N = 250)	21	17	24	26	12
I would prefer that Montana's quota be divided up among snaggers so that each snagger's bag limit would be two fish, even if it meant lower chances of successfully drawing for a tag. (N = 248)	28	22	21	19	10

The most common open-ended comments (total of 100 responses on 258 questionnaires) were recommendations for catch-and-release snagging (24 responses), a preference for a two-fish over a one-fish bag limit (19), and a preference for the one-fish bag limit (10).

Discussion

Although Inseason Closure was the preferred option if a quota were necessary, none of the three quota options received strong support. Inasmuch as respondents were split on whether the reduced bag limit from two to one fish was justified and if the reduction would help the paddlefish stock, it is understandable that they would resist any effort to establish quotas. Support for quotas may also be lacking because the processed-yield of paddlefish fillets is low (33.5%, including the less desirable red meat; Decker et al. 1991). For such intetjurisdictional fisheries, however, quotas have a history of success (Gough 1993). According to Parsons (1993), "Catch quotas were chosen as a primary regulatory instrument because it was easier to implement national allocations under a system of catch quotas than under a system of effort limitations." With the coexisting fishery in North Dakota for this stock (Scarnecchia et al. 19966), total harvest may be controlled best by allocating a quota of fish separately to each state.

The reason for the greatest support for the Inseason Closure option is probably a result of two factors. lnseason Closure would permit the purchase of paddlefish tags by all applicants, unlike tag limitation, and guarantee at least some fishing each year, unlike the Five-Year Quota. Although Tag Limitation is practiced for some big game mammals in Montana and other states, it has seldom been used for fish. A one-fish bag limit in combination with a tag drawing may not justify a trip to Intake.

From a management standpoint, several aspects of Inseason Clo ure would need to be addressed if it were implemented. Although it would be possible to monitor daily catches at Intake and at the Yellowstone-Missouri River confluence, which i the primary North Dakota fishing site, off-site harvest, now estimated post-season, would have to be estimated inseason. Second, the prospect of in ea on do ure induces fishermen to fish as early in the season as possible (Parsons 1993). Such a shift might create crowding problem , especially in years of more successful fishing and resulting higher demand for tags. Third, this option would shift catch and effort to earlier in the sea -on making comparison with past year less appropriate. Because the quality and consistency of the historical data base are important to stock assessment, it would be preferable if the fishery were not altered greatly in its seasonal pattern.

Under Tag Limitation, historical catch rates of tag holders could be used to estimate probable catch, and the appropriate number of tags could be sold. The crowding and stock assessment problems created under Inseason Closure would not occur.

Snaggers preferred a one-fish bag limit to a two-fish bag limit under a quota system (Table 4). These responses seem to contradict the common open-ended comment (19 responses) that suggested a return to a two-fish bag limit. Our interpretation of their respon-;es is that if the stock could withstand the pre-1994 management system of a two-fish bag limit, no quota and unlimited tag sales, this would be the preferred approach. With a quota, however, a latent concern is evidently that the quota will be so low that many people will not be able to obtain tags. Thus, the opportunity to catch and keep one fish might be preferable to not drawing a tag at all.

A combination of the one-fish bag limit enacted in Montana in 1994 and the low spring discharge in the Yellowstone River resulted in an all-time low catch and effort at the Intake fishery m 1994. This reduction in catch and effort raises the que tion of whether a quota, which is considered undesirable by snaggers (Table 3), would be necessary under present fishing interest and a one-fish bag limit.

The strong support (73% of respondents) for catch-and-release is interpreted as support for catch-and-release *in addition to* rather than *in place of* harvest. Since 1981, retention of snagged paddlefish on the Yellowstone River has been mandatory. In Montana, mandatory catch-and-release was first enacted in 1978 for trout (Salmonidae) on a stretch of the Madison River (Wells 1987); it has become common practice nationwide for warmwater, coldwater, and selected marine fishes since the 1980s (Barnhart and Roelofs 1977, 1987; Barnhart 1989).

Few of several thousand paddlefish landed at Intake during the period 1991-1994 and examined by us showed any overt signs of external damage from snagging. Some fish developed roundish, 1-3 cm diameter skin lesions, probably a result of sloughing of an imbedded hook. The most common form of damage was from boat propellers. Although other fish species have exhibited high stress levels, such as rainbow trout, *Oncorhynchus mykiss;* (Ferguson and Tufts 1992) and even disrupted spawning, as in smallmouth bass, *Micropterus dolomieui* (Kieffer et al. 1995) from hooking and handling, more information is needed on their potential effects on pre-spawning paddlefish.

Mandatory catch-and-release paddlefish snagging was enacted at Intake in 1995 for two six-hour periods per week during the May 15 to June 30 fishing season. At all other times, mandatory retention of paddlefish remained in force. Catch-and-release of each fish was monitored by trained state fishery personnel and excessive handling of paddlefish avoided. Snagged paddlefish were tagged immediately with jaw tags to provide information in the future on harvest rates and population abundances (Qualia 1987). In future years, effects of catch-and-release snagging will be evaluated through inspections of recaptured fish and with searches for dead or distressed paddlefish. Results from this study are being used in conjunction with fish stock assessments (Scarnecchia et al. 1996b) to set harvest regulations for the fishery.

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Lyle W. Allard

Tribal Fish and Wildlife Code Assessment

Abstract

The status of fish and wildlife codes on Montana Indian reservations was assessed. Information for this examination was developed by meeting with Tribal Resource Managers and legal/law enforcement personnel from each tribe. Six of the seven Native American reservations located throughout Montana were visited. Montana Tribal Fish and Wildlife Directors and their Conservation Officers were asked to discuss the fish and wildlife codes from the standpoint of effective management and enforcement. Variations were found among the codes of the reservations, including requirements for permits and fees for members and non-members, enforcement activities, and the disposition of cases by the Tribal courts. Recommendations are made for changes that will help tribes to manage their natural resources more effectively and efficiently.

Key words: Native American, Tribes, Montana, Wildlife Management, Criminal Codes, Law enforcement, Indian Reservations

Introduction

A review of fish and wildlife codes for Montana reservations was conducted to evaluate and/or compare effective codes with rudimentary or ineffective regulations found during a preliminary review with Tribal and USDI Fish and Wildlife Service personnel. The tribes are self-governing. State and federal agencies function in an assistence or advisory manner at the request of the tribes. The objectives of this study were to: 1) compare existing tribal fish and game codes with the USDI Bureau of Indian Affairs "model" code (1990), Federal endangered species protection regulations and fish and game laws of the State of Montana, and 2) identify deficiencies or problems that could have adverse effects on resource management, such as civil violations, fine schedules, and hunting/fishing seasons.

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Historically, the Native American culture depended upon fish and wildlife for subsistence. Several case studies of Native American culture, from periods between the early 1600's and the present, have described aboriginal techniques and methods of fish and wildlife management. Because there were no written game codes, tribal members were taught at a very early age by their elders to respect the wildlife resources. If tribal members abused this respect for wildlife, they were often severely punished. For example, if a member of the Crow Tribe harvested a buffalo before the tribal hunt wa organized, he would often be beaten, arms broken, or his lodge cut to pieces (Ewers 1955).

Present day fish and wildlife codes vary among reservations (Tables 1 and 2). Some reservations only allow enrolled tribal members to hunt. Some tribes allow non-members to hunt and fish, but those non-members are subject to the regulations of the reservation on which they are hunting or fi hing. A few reservations, such as the Ft. Belknap Reservation, issue special permits that allow non-members to hunt certain big

Table 1. *Summary of the application of reservation fish and game codes, state and Federal laws.*

Reservation	Tribal Code	State Laws	Federal Laws
Blackfeet	Tribal enrolled members within reservation Non-members Non-Indians	None	Bald Eagle Act Endangered Species (ES) Issues
Crow	No game codes No regulations on enrolled members	None	Bald Eagle Act Endangered Species (ES) Issues
Rocky Boy	Tribal enrolled members and non-Indian, non-members	None	Bald Eagle Act Endangered Species (ES) Issues
Northern Cheyenne	No game codes No regulations on enrolled members	None	Bald Eagle Act Endangered Species (ES) Issues
Fort Peck	Tribal members Non-members Non-Indians	None	Bald Eagle Act Endangered Species (ES) Issues
Flathead	Tribal members Non-members Non-Indians	Cross-deputization Non-members Non-Indians	Bald Eagle Act Endangered Species (ES) Issues
Ft. Belknap	Tribal members Non-members Non-Indians	None	Bald Eagle Act Endangered Species (ES) Issues

game species for a substantial fee, but require tribal guides to be present during the hunt. It provides jobs for tribal members and protects the game. Fishing is permitted with the proper permits on all Montana reservations, except the Crow Reservation.

Of the six reservations surveyed (Fig. 1), all have game codes addressing fish and wildlife resources within the reservation. The Northern Cheyenne Reservation, which was not visited, currently does not have a game code but allows limited recreational hunting and fishing by members.

Methods

Data were gathered from June to November 1996, using a questionnaire developed to seek information concerning tribal fish and wildlife programs on Indian Reservations in Montana. Several questions addressed the current status of fish and wildlife management programs, including game codes, law enforcement, training, and education needs. These questions were presented to key tribal personnel in an informal atmosphere to solicit information concerning the management of their fish and wildlife resources. The information was collected by on-site interviews, telephone interviews, and written correspondence. Twenty people were interviewed, including biologi ts, tribal game wardens, tribal council member , prosecuters, and judges. Two state fish and wildlife officials and two USDI Fish and Wildlife Service special agents were also interviewed.

Table 2. *Summary of major fish and game regulations within the reservation boundaries.*

Reservation	Regulation	Reservation Resident	Montana Resident	Out of State
Fort Belknap (Assiniboine & Gros Ventre Tribes)	Game Stamp	$2	$5	$5
	Fishing	$3 (kids free)	$15 (10 **Fish** per day)	$15 (10 **Fish** per day)
	Big Game	$10 per tag 1 Buck Deer 2 Doe Deer	**Buck Deer** - 5 tags $1000/ tag, if available 1 **Trophy Bull** - $4000 3 Bulls - $2500 **Pronghorn** 75 tags available Buck - $550 Doe - $50	**Buck Deer** - 5 tags $1000/tag, if available **1 Trophy Bull**- $4000 3 Bulls - $2500 **Pronghorn** 75 tags available Buck - $550 Doe - $50
	Upland Birds	Three of any combination daily $5	3 **Birds** - $55	3 **Birds** - $55
	Prairie Dogs	No limit - $5	No limit - $100 per season	No limit - $100 per season
Crow	Game Stamp	None	Not Available	Not Available
	Fishing	No fee, no limit	10 fish/day - $10	10 fish/day - $10
	Big Game	No fee, no limit	Not Available	Not Available
	Upland Birds	No fee, no limitq	Not Available	Not Available
Rocky Boy (Chippewa-Cree Tribe)	Game Stamp (incl. Fish)	$16 No limit on Fish	$16 No limit on Fish	$16 No limit on Fish
	Big Game	**Deer/Pronghorn** $5 / tag - one of each Elk - one tag $8	**Deer** - 15 tags available $1200 each Elk - 3 tags available $2000 each	**Deer** - 15 tags available $1200 each Elk - 3 tags available $2000 each
	Sportsman Package	one Deer, one Pronghonr One Elk - $15	Not Available	Not Available
	Upland Birds	3 bird limit daily - $5	4 bird limit daily $53 (3 days)	4 bird limit daily $53 (3 days)
Flathead (Confederated Salish and Kootenai Tribes)	Game Stamp	$6	$22	$65
	Fishing	$13, limits vary with species	$13, limits vary with species	$40, limits vary with species
	Big Game	Variable	Not Available	Not Available
	Upland Birds	$13, limits vary with species	$20, limits vary with species	$58, limits vary with species
Ft. Peck (Assiniboine and Sioux Tribes)	Game Stamp	No fee	$5	$5
	Fishing	No fee; 10 daily	$10; 10 daily	$20; 10 daily
	Paddlefish	No fee; no limit	Not available	Not available
	Upland Birds	No fee; no limit	$15; 3/day (cocks only)	$65; 3/day (cocks only)
	Waterfowl	$10, Federal Stamp	$15, Federal Stamp State regs. apply	$15, Federal Stamp State regs. apply

Table 2. *cont'd.*

Blackfeet (http://blackfeet.3Rivers.net)	Members	Non-Members
Game Stamp	No Fee	Conservation/Recreation permit for all non-members - $5. A prerequisite for all outdoor activity and all other permitting.
Fishing	No Fee	$45 seasonal; $25 - 3 day; $15 - 1 day; $10 boat stamp; $5 tube stamp; $5 Ice house
Big Game	$5 - standard 1 elk; 2 whitetail $1 each - Black Bear Mountain Lion, Pronghorn, Big Horn Sheep, Mountain Goat	No non-member hunting
Upland Birds	$35	
Waterfowl	Adopted Federal Flyway Regulations	

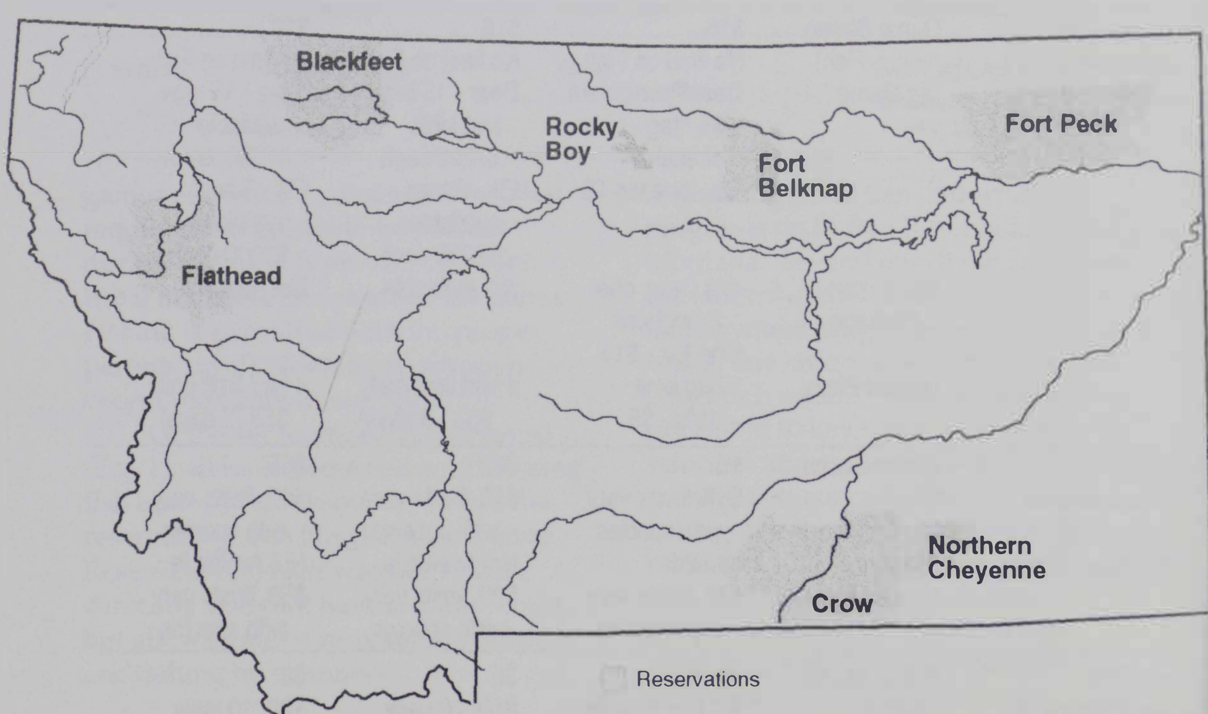

Figure 1. *Reservations in Montana visited for this study.*

Study Area

The Crow Reservation

The Crow Reservation, home to approximately 9,000 members of the Crow Tribe, is located in southeastern Montana and is the largest reservation with 2.3 million acres. The Crow Nation consists of tribal land, trust land, and fee land. There are currently no game codes in place. Tribal members can hunt and fish anytime. The reservation includes Yellowtail Reservoir on which non-Indian guides serve a non-Indian clientele.

Blackfeet Indian Reservation

This reservation, home to approximately 14,300 members of the Blackfeet Tribe, is located in northwestern Montana, adjacent to Glacier National Park. It consists of 1.5 million acres. Thirty-eight percent of this land is owned by non-Indians.

Game codes on the Blackfeet Reservation are well written and easy to understand. There is a well orgainized Fish & Wildlife Department where officers are well trained. The Department utilizes non-enrolled, consultant biologists from the surrounding universities. Some biologists are specialized in the management of a single species, such as the grizzly bear. Big game hunting is closed to non-Indians and non-members. Fishing on the Blackfeet Indian Reservation is offered to the public by permit only.

Fort Belknap Reservation

Approximately 5,100 members of the Assiniboine and Gros Ventre Tribes live on the Fort Belknap Reservation in north central Montana. This reservation contains 651,119 acres with 28,731 acres of tribal land located outside the eservation boundaries. The Fort Belknap Tribes actively manage their fish and wildlife resources, including 180 head of bison on >4000 acres of land, known as the Snake Butte Land. Only one or two buffalo are killed yearly by tribal members during spiritual ceremonies.

Fort Belknap has a dedicated Fish & Wildlife Department managing a game code that is clearly written and adequately enforced. The current regulations allow distribution of 300 big game hunting permits. These are to tribal members on a first come, first served basisfor $5 each. Tribal members can fish year round without a permit. For non-tribal members, general regulations allow permits for fishing, and hunting upland game birds and big game (antelope and deer only). Three buffalo hunting permits are issued to non-members per year.

Northern Cheyenne Reservation

This reservation, located in southeastern Montana, is home to approximately 6,500 members of the Northern Cheyenne Tribe. The reservation includes 444,157 total acres. There are 292,779 acres in tribally owned land and 140,013 acres in alloted land. The alloted land is tribally or individually owned. These lands may be held in trust by the federal government.

This reservation was not visited because there are no existing fish and wildlife regulations and no specific personnel with whom to contact.

Rocky Boy's Reservation

This reservation is located in northern Montana where approximately 4,600 members of the Chippewa-Cree Tribe live. This is one of two reservations in Montana that has been granted status as self-governing under P.L. 103-413. It also is the smallest reservation in Montana. Most reservations were established by treaties, but Rocky Boy was established by congressional action in 1916. The reservation land base consists of 107,613 total acres, and was the last reservation to be established within Montana.

The first tribal game codes were

- Close family ties between tribal members and leaders can result in cases being dismissed or being brought before the tribal council without game wardens being present.

Recommendations

A well-constructed management plan must be put into effect if any fish and wildlife program is to be successful. Based on my observations and standard wildlife management practices (Schemnitz 1980), I recommend the following general actions:

1. A well-defined game code should be written for all reservations by an intertribal commission. The game code regulations should apply to all of the reservations, providing consistent and equitable enforcement. Fines and/or punishment should be the same for a given violation, on each reservation. Also, law enforcement officers should be required to follow up and arrest violators who have not paid fines.

2. Better communication and cooperation are needed between the tribal council and governing bodies, the fish & wildlife department, and the court system. A task force could be organized to develop a procedure for interdepartmental communication.

3. Public support for game codes from surrounding areas, including non-Indian land owners within the reservation boundaries, would be helpful. To this end, game codes should be written and circulated throughout the reservation, nearby towns, and counties bordering the reservation.

4. Bring resource-oriented education into the school systems. Educating our youth early and helping them to understand the value of wildlife resources by example is very important.

5. Increased communication and cooperation are needed among the tribal fish and wildlife departments to share ideas and valuable information. Tribal governments along with state and federal agencies should work together for the benefit of the resource. The USDI Fish and Wildlife Service, Fisheries Assistance Office has begun a program to focus on intertribal communication needs. Each tribal fish and wildlife department would elect a representative to sit on panel along with state and federal officials.

6. Expand tribal budgets to allow increased law enforcement efforts and funding of other fish and wildlife resource management needs.

7. Coordinate training for tribal officers on proper techniques for collecting evidence and making arrests with state and federal agencies.

8. Establish closer coordination between tribal and state wildlife officers. Doing this on other reservations would provide the high level of law enforcement available on the Flathead Reservation.

A commission made up of Directors from Montana/Wyoming tribal fish and wildlife/resource departments, has been established. Their goals are to assist tribal governments with the prudent management of their vital natural wildlife, while working closely with state and federal agencies. This is a positive effort that may be the first step to a uniform Tribal Fish and Game Code.

Each reservation has the resources and the cultural commitment necessary for optimum fish and wildlife conservation. Proper management of the fish and wildlife resources on each reservation will provide future cultural, economic, and recreational benefits. Healthy wildlife popuiations will help ensure greater revenue from permit sales and tourism. To accomplish this, support from tribal leaders is critical. Training and education will also play a key role in conserving and protecting these vital resources. Professionally trained conservation officers will assist the court system in its effort to properly enforce wildlife laws, resulting in higher fines and punishment levied against violators.

A quote from Chief Sealth best summarizes the Indian's approach to natural resource management; " What is man without the beasts if all the beasts were gone, men would die from great loneliness of spirit. For whatever happens to the beast also happens to man, all things are connected."

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