Intermountain Journal of Sciences

(ISSN 1081-3519)

Vol. 9, No. 1 - 2003

IJS

INTERMOUNTAIN JOURNAL OF SCIENCES

The Intermountain Journal of Sciences is a regional peer-reviewed journal that encourages scientists, educators and students to ubmit 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 ciences are welcome.

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

Initial funding was provided by the co-sponsor organizations. Long-term funding will be derived from page charges assessed authors, sponsoring organizations or agencies at $45 per printed page upon acceptance of each manuscript and from annual ubscriptions: student $6; regular member $15; patron member $25; library $25· life member $150; and, sustaining subscriber $2,500.

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

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ISSN #1081-3519

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

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

Three hard copies of the submitted manuscript, with copies of the "Guidelines and checklist for IJS referees" attached are forwarded to the appropriate Associate Editor. The Associate Editor retains one coy of the manuscript and guidelines for his/her review, and submits a similar package to each of two other reviewers. A minimum of two reviewers, including the Associate Editor, is required for each manuscript. The two other reviewers are instructed to return the manuscript and their comments to the Associate Editor, who completes and returns to the EIC a blue "Cover Form" and all manuscripts and reviewer comments plus a recommendation for publication, with or without revisions, or rejection of the manuscript. This initial review process is limited to 30 days.

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

Acceptance

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

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

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

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

Abstracts

Only abstracts from the annual meetings of the sponsoring organizations will be published in IJS. Other submissions of abstracts shall be considered on a case-by-case basis by the Editorial Board. Sponsoring organizations shall collect abstracts, review them for subject accuracy, key or scan them onto a 3.5" diskette, and submit the diskette and hard copy of each abstract to the EIC on or before November 1. Each abstract shall be reviewed by the EIC to assure proper grammar, compliance with IJS "Guidelines for Abstracts Only" and for assignment to the appropriate discipline section. All abstracts will be published in the December issue only.

Commentary

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

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

Literature Cited

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

Send all manuscripts to: Editor-in-Chief, P.O. Box 3014, Bozeman, MT 59772-3014

Trappers in Wyoming: Opinions on Trends in Mammalian Predator Populations, Motivations for Trapping, and Methodologies

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Abstract

Wyoming trapper numbers have declined 58 percent since the peak in 1979 ($P < 0.001$). In an effort to preserve the collective knowledge of long-term trappers and hunters of furbearers, predators, and trophy game species, i.e., mountain lion (*Felis concolor*) and black bear (*Ursus americanus*) , we surveyed 522 trappers and houndsmen by mail to assess their attitudes and opinions on methodologies used for trapping, motivations for trapping, and population trends for various furbearers, predators, and trophy game species in the state. Most trappers listed recreation (79%) as their primary motivation to trap, but income from fur sales (67%) and reduction of livestock losses (54%) also were important motivators. Steel traps were the primary method of taking furbearers and were used by 89 percent of trappers. Common methods also included snares (48%) and calling and shooting (47%). Predators were taken primarily by calling and shooting (83%), steel traps (79%), and snares (58%). Using hounds (74%) was the most common method used to harvest mountain lions. Mountain lions, coyotes (*Canis latrans*), raccoons (*Procyon lotor*), river otters (*Lutra canadensis*), and black bears were all reported to have increasing population trends during the last two decades. Only two species, jackrabbits (*Lepus* spp.) and lynx (*Lynx Canadensis*), were thought to be decreasing. Our respondents wanted management actions taken to increase all species of Wyoming's fully-protected furbearers, i.e. lynx, wolverine (*Gulo gulo*), river otter, fisher (*Martes pennanti*), gray fox (*Urocyon cinereoargenteus*), and swift fox (*Vulpes velox*) as well as bobcats (*Felis rufus*). They also supported actions that would decrease populations of coyotes, spotted skunks (*Spilogale putorius*), and mountain lions. Trapping and hunting are important pursuits in Wyoming with >30 percent of the population participating in one of these activities. As legislative restrictions further curtail trapping and hunting, other strategies will be required to address management of furbearers, predators, and trophy game species.

Key words: furbearer, human dimensions, mail survey, predator, trapping, trappers, Wyoming

Introduction

Trapper participation is rapidly declining throughout the U.S. and Canada (Siemer et al. 1994, Daigle et al. 1998, Manfredo et al. 1999, Reed 1999). Additionally, hunting of mountain lions (*Felis concolor*) and black bears (*Urus americanus*)—defined as trophy game in Wyoming—also is declining due to increased legislative restrictions in several western states, e.g., outlawing the use of hounds, bait, and spring bear seasons. Many wildlife managers believe that trappers play an important role in regulating nuisance species (Will 1992, Conover 2001), quantifying the economic value of wildlife (Samuel and Bammel 1981, Will 1992), and are a useful source of information to assess population trends for select species (Landwehr 1982, Gotie et al.

1984, Will 1992, Majors et al. 1996). Whereas motivation for trapping participation is complex and not well understood (Todd and Boggess 1987), reasons for declines in trapper numbers are usually attributed to market declines, i.e., low fur prices, increasing public intolerance of trapping and subsequent increased legislative restriction, increased urbanization of youth, and less dependence upon fur products for the fashion and garment industry (Will 1992, Siemer et al. 1994, Daigle et al. 1998). Although fashion trends and demographic shifts are beyond the influence of natural resource managers, regulatory controls are not.

To illustrate the importance that intolerance to trapping and using hounds to pursue bears and mountain lions will have in the future, we only have to examine opinions of wildlife resource managers. Muth et al. (1998) surveyed 4000 members of The Wildlife Society, American Fisheries Society, North American Wildlife Enforcement Officers' Association, and the Society for Conservation Biology and found that 46 and 57 percent, respectively, favored outlawing leg-hold traps for trapping furbearers and the use of dogs for hunting bear. Trappers and houndsmen may soon be forced to abandon their pursuits in light of increased legislation and decreasing demand for their products. For the manager, subsequent problems involved with this abandonment include 1) fewer options for managing potential nuisance species, e.g., beaver (*Castor Canadensis*), coyote (*Canis latrans*), and mountain lion, 2) loss of information needed to effectively manage furbearer and predator populations, e.g., harvest reports, catch per unit effort statistics, and demographic data for species, 3) increased costs associated with management, e.g., increasing nuisance complaints, and 4) loss of positive values associated with harvest programs.

Trapper numbers in Wyoming have declined 58 percent ($r^2 = 0.699$, $P < 0.0001$) since 1979 when trapper numbers peaked (Fig. 1). Lion and black bear hunter numbers have steadily increased during the same period although black bear hunting has recently declined due to increased restrictions regarding baiting. Concurrent with trapper declines, mean trapper age has risen to the point where many trappers are retiring from trapping or dying (Wyoming Game and Fish Department, Cheyenne, WY, unpubl. rep.). Since trappers are explicitly tied to their resource, many wildlife managers feel that trappers are a good source of qualitative data regarding animal populations (Landwehr 1982, Gotie et al. 1984, Will 1992, Majors et al. 1996), especially over long term, e.g. 10-50 years.

Across the United States, and the West in particular, there is a tendency to blame reduced game populations, e.g., mule deer (*Odocoileus hemionus*), pronghorn antelope (*Antilocapra Americana*), and sage grouse (*Centrocercus urophasianus*), on increasing predator populations (Ballard et al. 2001). Thus, long-term trends in predator populations could be useful to develop cause and effect hypotheses as well as to assist with management objectives for both furbearers and predators and their prey. Long-term population trends for predators, furbearers, and trophy game (Table 1) are limited in Wyoming; the only data that exist since 1978 are harvest reports (Wyoming Game and Fish Department 1978-1998). Since trapper and houndsmen success is inherently tied to population trends, we felt that these individuals would be a good source of information for long-term trends in furbearer and predator populations. Houndsmen are those individuals that use hounds in the pursuit of mountain lions, black bears, and bobcats although use of hounds for bear hunting is currently illegal.

Our objectives were to 1) develop long-term population trend data (>20 yrs) for select furbearers, predators, and trophy game species in Wyoming, 2) determine what trappers and houndsmen felt should be the future population trends for certain species, 3) quantify the importance of various methods and motivations for hunting and trapping predators, furbearers, and trophy game, 4) collect specific information regarding incidental take of

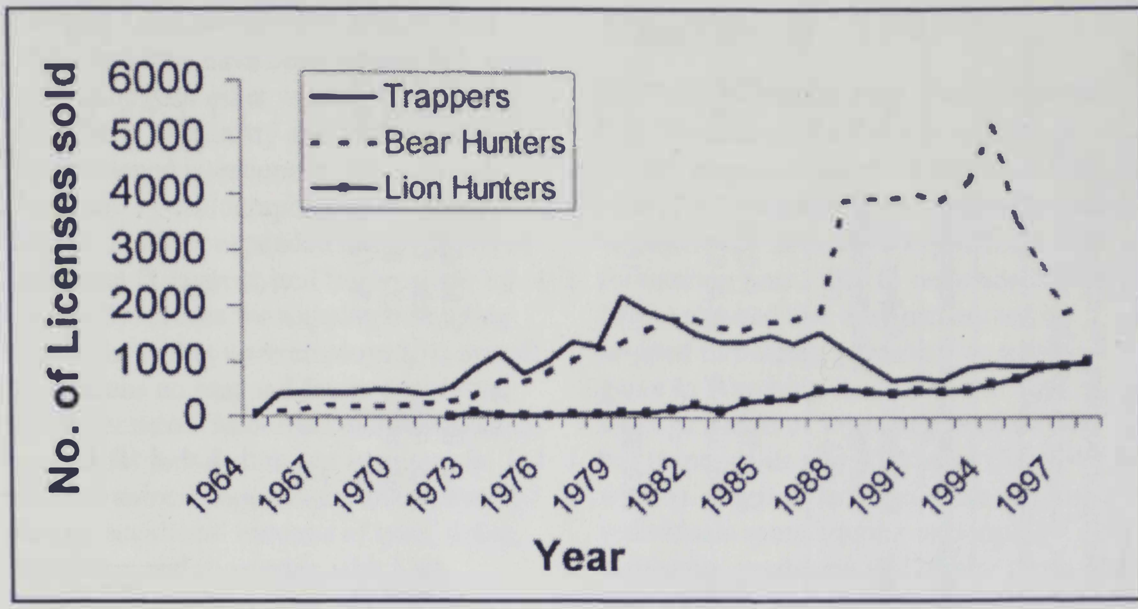

Fig. 1. Total number of resident trapping, black bear, and mountain lion hnting licernses sold in Wtyoming since 1964, the first year licenses were required for trapping and black bear hunting. Mountain lions were classfied as predators (unlimited harvest) prior to 1973.

lynx (*Lynx Canadensis*), fisher (*Martes pennanti*), wolverine (*Gulo gulo*), and river otter (*Lutra canadensis*), and 5) survey the "long-term" trappers and houndsmen in Wyoming before their knowledge, attitudes, and opinions are lost.

Methods

We define furbearers, predators, and trophy game under the regulations set forth by the Wyoming Game and Fish (WGF) Commission (Table 1). Furbearers are those species that primarily are harvested for their fur value, have strict harvest regulations, and are primarily taken by trapping methods. Predators are those species considered pests within the state, regardless of their biological or economical importance, and their take is not restricted. Predators, e.g., coyote and red fox (*Vulpes vulpes*), primarily are taken through trapping, but several species are aerial hunted; all are hunted using firearms. Trophy game species in Wyoming include grizzly bears (*Ursos arctos*), black bears, and mountain lions. State or federal laws regulate their take, and only black bears and mountain lions currently may be hunted. Although we were not interested in grizzly bears that have ongoing status and management programs, we were interested in trends for several protected nongame species that may be taken incidental to legal trapping (Table 1) but for which there is no open season.

We surveyed 522 individuals using a 6-page, 14-question mail survey (Appendix A). We derived our survey list from WGFD's list of licensed trappers ($n = 466$) and houndsmen ($n = 86$) during 1996-1998. Some overlap occurred between the two groups, so we censored 30 houndsmen that also possessed trapping licenses. We further restricted our mailing list to only include trappers and houndsmen that had been residents for ≥10 years and had purchased a trapping and/or trophy game (black bear or mountain lion) license during 1996 and 1997. After receiving a completed survey we further restricted our sample to include only those people that had hunted or trapped furbearers, predators, and trophy game species for >10 years. Since our two groups overlapped, and we feel that members from both of these groups have developed opinions on wildlife numbers, we lumped their responses and treated them equally.

Mail surveys can be a useful technique to identify trends in furbearer populations

Table 1. Past trends, future-desired trends, and reasons listed for changes in past populations for each species. Past trends and future-desired trends are listed as the percentage of respondents indicating that there has been or should be a negative (-), neutral (0), or positive (+) change in the population in which *n* is the total number of respondensts/305 that expressed an opinion. Reasons given for changes in populations (increases : decreases) are percentages of respondents listing that reason for the increase or decrease. Percentages do not sum to 100 due to rounding error (trend data) or because >1 selection could be made (reasons for increases or decreases).

	Trend				Reasons given for increases or decreases				
Species	Past trend (%) - : 0 : +	*n*	Future-desired trend (%) - : 0 : +	*n*	Habitat (%)	Density of prey (%)	Regulated harvest (%)	Federal or state regulations (%)	*n* + : -
Trophy Game									
Mountain Lion	3.6 : 9.2 : 87.5	258	51.2 : 33.2 : 14.8	263	26.6 : 11.1	33.0 : 11.1	61.5 : 77.7	42.1 : 22.2	221 : 9
Black Bear	10.8 : 31.9 : 56.8	221	20.0 : 52.3 : 27.7	227	27.5 : 21.7	8.1 : 13.0	40.3 : 30.4	22.6 : 6.1	124 : 23
Furbearers									
Bobcat	47.0 : 28.0 : 24.3	277	3.5 : 39.7 : 56.8	265	26.5 : 23.6	30.9 : 29.9	30.9 : 33.1	16.2 : 14.9	68 : 127
Badger	12.9 : 58.1 : 28.6	248	29.5 : 58.1 : 12.4	240	—[a]	—	—	—	—
Beaver	20.9 : 39.6 : 38.7	232	23.3 : 58.2 : 18.5	240	—	—	—	—	—
Pine marten	20.2 : 66.2 : 13.4	91	1.2 : 48.8 : 50.0	167	—	—	—	—	—
Mink	31.9 : 51.9 : 15.2	142	36.2 : 26.8 : 36.9	195	—	—	—	—	—
Predators									
Coyote	3.2 : 21.5 : 74.9	287	64.4 : 31.4 : 4.2	269	33.1 : 50.0	44.8 : 30.0	6.6 : 10.0	16.5 : 10.0	212 : 10
Red fox	15.2 : 26.8 : 47.5	270	39.9 : 45.2 : 14.9	257	34.0 : 36.6	41.2 : 41.5	6.5 : 2.4	8.5 : 7.3	153 : 41
Raccoon	4.6 : 28.8 : 65.8	249	45.1 : 44.3 : 10.7	252	42.3 : 33.3	21.5 : 25.0	3.7 : 16.7	3.7 : 8.3	163 : 12
Jackrabbit	57.9 : 33.2 : 8.9	244	11.2 : 49.7 : 42.1	231	22.7 : 35.8	13.6 : 13.9	0.0 : 4.4	4.5 : 1.5	22 : 137
Protected (no open season)									
River otter	11.5 : 28.9 : 57. 7	55	5.2 : 38.3 : 59.2	160	—	—	—	—	—
Pine marten	20.2 : 66.2 : 13.4	91	1.2 : 48.8 : 50.0	167	—	—	—	—	—
Mink	31.9 : 51.9 : 15.2	142	36.2 : 26.8 : 36.9	195	—	—	—	—	—
Wolverine	30.0 : 43.3 : 26.7	31	4.9 : 31.0 : 64.1	147	—	—	—	—	—
Pine marten	20.2 : 66.2 : 13.4	91	1.2 : 48.8 : 50.0	167	—	—	—	—	—
Mink	31.9 : 51.9 : 15.2	142	36.2 : 26.8 : 36.9	195	—	—	—	—	—
Spotted skunk	10.1 : 43.4 : 45.5	103	52.4 : 35.9 : 11.6	170	—	—	—	—	—

—[a] Sample sizes were < 40 for these species so reasons for declines or increases are not reported.

(Hoinville and Jowell 1978, Majors et al. 1996), and they have been successfully used in Wyoming for other wildlife issues (Berg et al. 1983, McKinstry and Anderson 1999). We developed questions to focus on each objective: 1) demographics of the survey sample, 2) effort expended in the pursuit of predators, furbearers, and trophy game by county, 3) reasons for trapping or hunting and methods that were employed, 4) overall perceptions on past and future population trends for select furbearers and predators, 5) reasons for past declines or increases in selected animal populations, and 6) specific data on accidental harvests of lynx, fisher, wolverine, and river otter, which are protected under Wyoming law and cannot legally be taken.

Our survey methods generally follow those recommended by Dillman (2000) and Filion (1978, 1980) and included 1) using agency (WGFD) sponsorship with the first cover letter and University of Wyoming sponsorship with the second letter (Fox et al. 1988, Gendall et al. 1995, Faria and Dickinson 1996), 2) a promise of anonymity for all respondents (Filion 1978, Faria and Dickinson 1996), 3) use of both altruistic and egoistic appeals (Filion 1978, Gendall et al. 1995) to motivate our respondents, 4) use of first-class postage for both the outgoing survey and the return envelope (Filion 1978, Fox et al. 1988), 5) highly structured closed questions with either dichotomous (yes, no), multiple choice, or check list answers (Filion 1978, Fox et al. 1988), 6) a "reward" consisting of reporting the results of the survey to both the Wyoming Trappers Association and *The Trapper and Predator Caller*, a national magazine for trappers (Fox et al. 1988, Faria and Dickinson 1992, Green 1996), and 7) a follow-up survey, mailed 3 weeks later, for non-respondents (Hammitt and McDonald 1982, Fox et al. 1988, Dillman 2000). Recognizing the importance of non-response bias, we attempted to identify and quantify it by randomly sampling 10 percent of non-respondents using a telephone survey and questions designed to identify reasons for non-response.

Results

Survey Returns and Nonresponse

We received 313 of 522 surveys for an overall response rate of 60 percent. Thirty-nine (7.5%) surveys were undeliverable due to incorrect addresses or expiration of the forwarding time. Of 313 respondents, 305 (97%) claimed that they had hunted or trapped furbearers, predators, or trophy game in Wyoming for >10 years. The average length of Wyoming residency for our respondents was 43.2 years (SD=14.7, *n*=303). Average length of time that these individuals spent hunting or trapping furbearers, predators, and trophy game was 23.1 (SD=16.3, *n* =273), 26.0 (SD=13.2, *n*=285), and 16.5 (SD = 13.5, *n*=200) years, respectively. The number of trappers and trophy game hunters actively trapping or hunting within each decade was skewed toward the last three decades but the sample included trappers and houndsmen in each decade (Table 2).

We attempted to contact 21 individuals for which we did not receive a response. We could not locate correct phone numbers for 24 percent of the non-respondents, another 48 percent could not be located after we made three attempts to contact them (mid AM, early PM, and mid PM), and 14 percent indicated that they had only purchased a trapping license to trap single nuisance species, e.g., beaver and badger (*Taxidea taxus*). The remaining 14 percent said that they had never received the original or follow-up survey. After back checking the license database with their correct address, we found errors in the address information in the database, probably due to transcription errors from the original license information obtained from license agents.

Motivations for Trapping and Methods

Seventy-nine percent (*n*=241) of respondents reported that recreation was a major factor in motivating them to trap or hunt predators, furbearers, and trophy game. Other factors included money from the sale

Table 2. Number of participants/305 who hunted or trapped furbearers, predators, and trophy game in each decade.

	Decade								
	1910	1920	1930	1940	1950	1960	1970	1980	1990
No. of participants	1	3	12	20	65	154	233	257	275

of furs (66.7%), a way to help reduce livestock losses (54.4%), a means to reduce populations of nuisance species (primarily coyotes and beaver; 40.1%), a component of the respondent's work (32.4%), and provision of food (8.3%).

Steel traps, including both leg-holds and Conibears, were the most popular method for harvesting furbearers (89% of trappers used them), but many also used snares (48%) and calling and shooting (47%) (Table 3). Calling and shooting (83%), steel traps (79%), and snares (58%), were all important methods for taking predators. Trophy game species were primarily killed using hounds (74%) and calling and shooting (28%).

Past Trends and Future-Desired Trends

Although >125 respondents commented on past and future trends for all species (Table 1), we received <40 responses on reasons why the past trends have occurred for pine marten, river otter, lynx, fisher, wolverine, swift fox, and gray fox. Due to the low response rate for these species, we excluded them from that portion of the analyses. Respondents reported several species to be increasing, which included mountain lion, coyote, red fox, raccoon, river otter, and black bear (Table 1). Changes in regulations and harvest governing the take of mountain lions and black bears were the principal reasons given for a perceived increase in these two species (Table 1) although respondents also felt habitat was important for increases in black bears. Respondents reported an increase in the density of prey as the primary reason coyote numbers may have increased, and changes in habitat were the main responses given for perceived increases in raccoons (*Procyon lotor*). Only jackrabbits (*Lepus* spp.) and lynx were thought to be decreasing. Change in habitat was listed as the primary reason for the decrease in these species, although respondents also believed that changes in federal or state regulations negatively impacted lynx populations.

Most respondents wanted to see coyote, spotted skunk (*Spilogale putorius*), and

Table 3. Percentage (%) of total respondents ($n = 305$) reporting the use of certain methods to take furbearers, predators, and trophy game. Percentages sum to > 100 since respondents could select > 1 method for each species group.

Species group	Steel trap[a]	Snares	Aircraft[b]	Calling and shooting	Denning[c]	Pursuit with dogs[b]	Box traps	Poisons[b]
Furbearers	89.0	48.4	3.9	47.2	3.5	20.5	11.8	0.4
Predators	78.6	57.5	20.4	82.9	33.9	27.9	19.3	19.6
Trophy Game	6.1	5.2	0.9	27.8	4.3	73.9	1.7	0

[a] Includes leg-hold traps and Conibear traps
[b] Some methods may currently be illegal for certain species, but may have been a legal method of take in the past (e.g. aircraft for lions, pursuit with dogs for bears, and poisons for lions, bears and predators).
[c] Consists of removing adults and young from den and killing them

mountain lion populations reduced (Table 1). Interestingly, most trappers (> 60% for each species) wanted to see increasing populations of all the protected nongame species (except spotted skunk), which include lynx, wolverine, river otter, fisher, gray fox (*Urocyon cinereoargenteus*), and swift fox (*Vulpes velox*). They also wanted to see increased populations of bobcat, a furbearer of substantial economic value.

Discussion

Response Rates and Recall Bias

Other researchers believe response rates approaching 60 percent adequate to identify opinions in populations of fairly homogeneous publics (Hammitt and McDonald 1982, Dolsen and Machlis 1991). Although our response rate was adequate, we realize that non-response bias may have affected our survey. However, our survey of non-respondents indicated that they did not respond due to 1) not receiving the survey, or 2) feeling that the survey did not pertain to them since they had purchased their license to trap only a few nuisance animals. We may have improved our response rate through use of a cash incentive or a donation to the Wyoming Trapper's Association for each survey returned (Filion 1978, Faria and Dickinson 1992, Green 1996).

Atwood (1956), in one of the best known studies on response errors and recall bias and later supported by others, (MacDonald and Dillman 1968, Wright 1978, Mazurkiewicz et al. 1996) showed that waterfowl harvests were exaggerated by as much as 168 percent in follow-up mail surveys when compared to check station results. Sen (1973) examined recall bias across two periods (2 and 4 months) within the same season and found that lengthening the recall period from two 2-month periods to a single 4-month period resulted in higher estimates of waterfowl harvests (+13%) and hunting days (+46%). Internal-forward telescoping, i.e., for a specific time interval respondents may tend to report events closer to the time of questioning than in reality (Filion 1980) also could have been a factor in our survey. There seems to be a tendency for people to remember "the good ol' days" regardless of the actual facts. However, our results seemingly contradict remembrance of better years past since most respondents felt that predator and furbearer populations were increasing. Our respondents also reported declines for several species, including jackrabbits, which, interestingly, are classified as a predator in Wyoming and are not considered of special importance by many people within the state (M. McKinstry, personal observations). We realize that our respondents may have biased their results depending upon success rates and or local population trends in species that were not indicative of statewide trends. However, we felt that soliciting opinions throughout the state and by giving equal weight to each opinion minimized the bias. Regardless of actual trends in population levels, perceived trends can be important to wildlife managers and are often used as another piece of information to make decisions.

Trapping Participation

Despite societal, biological, economical, and ecological benefits from trapping, most citizens in the U.S. do not support trapping (Andelt et al. 1999). An opinion poll on trapping in Wyoming has not been done, and while the results would undoubtedly be different from Colorado due to our proportionally higher rural population, Colorado's citizens banned recreational and commercial leg-hold traps, snares, and poisons by a margin of 52 to 48 percent in 1996 (Cockrell 1999, Manfredo et al. 1999). Trapping in Wyoming is increasingly under criticism, especially in communities, e.g., Jackson and Cody, where people are more likely to have moved from outside of the region and where they have a greater opportunity to observe wildlife in park-like settings (Reed 1999). Many states are undergoing dramatic changes in trapping regulations and face severe restrictions, if not outright banning, of trapping methods (Andelt et al. 1999, Cockrell 1999). Coupled with reductions in fur prices, demographic shifts in human populations (e.g., greater urbanization of population), less reliance on wild furs, and alternative choices for recreation, many trappers are quitting or reducing their efforts (Armstrong and Rossi 2000, Batcheller et al. 2000). Additionally, young people are not being recruited to the ranks of trappers in numbers that they once were. With decreasing trappers and increasing legislative restrictions, wildlife managers will face increasing problems with nuisance wildlife, reduced alternatives for dealing with endangered species-both capturing endangered species and reducing predation risks for endangered species, and a lack of biological data, e.g., age and sex of bobcats, from trapping harvests that can be used for demographic information to make management decisions (Armstrong and Rossi 2000, Conover 2001).

While Wyoming has never had a large number of trappers, they have contributed significantly in managing nuisance animals and providing information useful in managing furbearers, predators, and trophy game. Wildlife managers will need to consider these changes in trapping and hunting participation in order to effectively deal with management concerns of these species.

Species' Trends

Many members of the public and biologists within WGFD feel that several species of predators have been increasing over the last several decades. Notable among these have been coyotes, mountain lions, and avian predators, e.g., golden eagles (*Aquila chrysaetos*). Our respondents also felt that mountain lions, coyotes, red foxes, river otters, raccoons, and black bears have increased during the time that they have trapped or hunted them. Since our questions were not specific to a certain time period we do not have information on the time span over which these increases are thought to have taken place. Instead, our data represented trends from when the respondent first formulated a position on population data for these species. If the opinion was first formed when they began trapping and hunting these species, it is an average of 22.5 years ago.

The majority of respondents indicated that they would like to see increases in populations of all protected species with the exception of spotted skunks. They also felt that furbearer populations should be maintained at current levels. Since many trappers are motivated by monetary gain, and increasing populations of some species might mean increased trapping opportunities, it is interesting that many would like to see greater populations of protected species and stable populations for those that they harvest. This may emphasize the fact that many of them enjoy the recreational and aesthetic aspects of trapping and do not trap simply to earn money, which has been supported by others (Siemer et al. 1994, Daigle et al. 1998). Additionally, several trappers also commented that when animals are numerous and fur prices are high more people are drawn to trapping and these people are often untrained and unscrupulous. Our respondents may be separating themselves from these unethical behaviors, regardless of the monetary losses.

With the exception of mountain lions, black bears, and in some areas beavers, the species covered in our survey are not actively managed within Wyoming. These managed species have specific harvest quotas, and in the case of beaver have active introduction programs (McKinstry 2001, McKinstry et al. 2001). Forest management programs consider lynx, wolverine, pine marten (*Martes americana*) and fisher, but no programs address introductions, habitat improvement, or even extensive monitoring. Gray fox, swift fox, river otter, and spotted skunk are all protected from harvest but are only periodically or incidentally monitored. Furbearers are covered under harvest regulations set by the WGFD, but in reality few changes are made to manage their populations. Predators are not protected and may be taken throughout the year and by many different methods. As trapper numbers decrease and managing predators and furbearers becomes more contentious, biologists in Wyoming will need to consider alternative practices for managing these species including longer seasons for the few remaining trappers, incentives for trappers that might include economic or social motivations, greater emphasis on damage management and research to find solutions to damage and conflict issues, and active programs to monitor these animal's populations and demographics.

Conclusions

Our survey was useful in identifying perceived population trends in certain species that are not available using more traditional techniques. It also highlighted the importance of recreation and fur prices as motivators for trapping and reliance on steel traps for taking furbearers and predators in Wyoming. Use of hounds also was identified as the primary technique for harvesting mountain lions. A majority of trappers and houndsmen wanted to see increasing populations of fully protected species, bobcats, and jackrabbits; stable populations for most furbearers and black bears; and decreasing populations of mountain lions and predators. Wyoming, like many other states (Armstrong and Rossi 2000) is experiencing a severe decline in people who participate in trapping and hunting furbearers and predators. With reductions in agency budgets, increasing demands for other activities, and growing intolerance of trapping and predator control, programs aimed at furbearer and predator management will increasingly become more difficult to justify and fund. In the future wildlife managers in Wyoming will need to develop alternative methods for managing furbearers, predators and trophy game species that are not tied to regulated harvests.

Acknowledgements

This survey was first conceived by J. Lawson, Chief, Wildlife Division, WGFD and supported by many people within that agency. We thank B. Heath for the initial work on survey development and for later help in interpreting some of the results. V. Clingman, WGFD, assisted with the databases and provided helpful comments regarding the data. B. Heath, C. Anderson, G. Dusek, and two anonymous reviewers provided valuable suggestions to improve the manuscript.

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Received 8 August 2002
Accepted 6 February 2003

Appendix A. Questionnaire used for mail survey of trappers and houndsmen in Wyoming.

MAMMALIAN PREDATOR SURVEY

1) Have you ever trapped or hunted furbearing, predatory, or trophy game species in Wyoming? (Please refer to Table 1 for a list of furbearing, predatory, or trophy game species.)

❑ **YES** ❑ **NO**

List of furbearing, predatory, and trophy game species that are referenced in this survey. Species categorization does not necessarily follow Wyoming Game and Fish Department designations.

Furbearers	**Predators**	**Trophy Game**
Beaver	Coyote	Mountain Lion
Muskrat	Red Fox	Black Bear
Pine Marten	Porcupine	
Mink	Black-tailed Jackrabbit	
Badger	White-tailed jackrabbit	
River Otter	Western Spotted Skunk	
Mink	Eastern Spotted Skunk	
Bobcat	Raccoon	
Lynx	Gray Wolf	
Wolverine	Gray Fox	
Fisher	Swift Fox	

If you have <u>not</u> trapped or hunted furbearers, predators, or trophy game species in Wyoming please stop here and mail in the survey.

~Thank you

2) How many years have you been a resident of Wyoming?______________, ears

3) Please indicate the number of years you trapped or hunted furbearing, predatory, or trophy game in Wyoming.

I trapped or hunted **furbearing** species for __________ years.
I trapped or hunted **predatory** species for ___________, ears.
I trapped or hunted **trophy game** species for _________, ears.

4) Please indicate which counties and decades you trapped or hunted furbearing, predatory, or trophy game species in Wyoming (Follow the example provided in first line; please enter county name and place an "X" in the appropriate box).

County Name	1910-1919	1920-1929	1930-1939	1940-1949	1950-1959	1960-1969	1970-1979	1980-1989	1990-1998
Carbon					X	X	X	X	X

5) Please check all categories that describe why you participated in trapping or hunting furbearing, predatory, and trophy game species in Wyoming.

- ❑ **It was part of my work**
- ❑ **I did it for the money from fur sales**
- ❑ **I did it for recreation**
- ❑ **I did it to reduce livestock losses**
- ❑ **I did it to reduce populations of certain species (please list species)**

  ____

- ❑ **I wanted the meat for consumption**
- ❑ **Other, please specify**

  ____

6) Please check all methods that you have used to trap or hunt furbearing, predatory, and trophy game species in Wyoming.

	Furbearers	**Predators**	**Trophy game**
Steel and Snap traps (e.g. leg-hold, conibear traps).............	❑	❑	❑
Snares..	❑	❑	❑
Shooting from aircraft...........................	❑	❑	❑
Calling and shooting.............................	❑	❑	❑
Denning..	❑	❑	❑
Hunting dogs..	❑	❑	❑
Box traps (e.g. culvert, Hancock traps, etc.)........	❑	❑	❑
Poisons (e.g. M-44's, 1080, arsenic, etc).........	❑	❑	❑
Other (please specify) ______________________	❑	❑	❑

7) Please indicate each decade that you attempted to trap or hunt the following furbearing, predatory, or trophy game species in Wyoming. (Please place an "X" in each box that applies.)

	DECADE								
Species	**1910-1919** ⩒	**1920-1929** ⩒	**1930-1939** ⩒	**1940-1949** ⩒	**1950-1959** ⩒	**1960-1969** ⩒	**1970-1979** ⩒	**1980-1989** ⩒	**1990-1998** ⩒
Mountain lion.....	❑	❑	❑	❑	❑	❑	❑	❑	❑
Black Bear..........	❑	❑	❑	❑	❑	❑	❑	❑	❑
Lynx...................	❑	❑	❑	❑	❑	❑	❑	❑	❑
Bobcat................	❑	❑	❑	❑	❑	❑	❑	❑	❑
Coyote................	❑	❑	❑	❑	❑	❑	❑	❑	❑
Red fox...............	❑	❑	❑	❑	❑	❑	❑	❑	❑
Swift fox............	❑	❑	❑	❑	❑	❑	❑	❑	❑
Badger................	❑	❑	❑	❑	❑	❑	❑	❑	❑
Raccoon..............	❑	❑	❑	❑	❑	❑	❑	❑	❑
Spotted skunk.....	❑	❑	❑	❑	❑	❑	❑	❑	❑
Wolverine...........	❑	❑	❑	❑	❑	❑	❑	❑	❑
Beaver................	❑	❑	❑	❑	❑	❑	❑	❑	❑
Marten................	❑	❑	❑	❑	❑	❑	❑	❑	❑
Fisher..................	❑	❑	❑	❑	❑	❑	❑	❑	❑
Mink...................	❑	❑	❑	❑	❑	❑	❑	❑	❑
River otter...........	❑	❑	❑	❑	❑	❑	❑	❑	❑
Gray fox.............	❑	❑	❑	❑	❑	❑	❑	❑	❑
Jackrabbit...........	❑	❑	❑	❑	❑	❑	❑	❑	❑

8) **During the past 30 years (1968-98), do you feel the populations of the species listed below have increased, decreased, or remained stable in the areas you generally trapped or hunted these species. (Please mark one answer by putting an "X" in the appropriate box for each species.)**

Species	**Increased**	**Decreased**	**Remained table**	**No opinion**
Mountain lion	❑	❑	❑	❑
Black bear	❑	❑	❑	❑
Lynx	❑	❑	❑	❑
Bobcat	❑	❑	❑	❑
Coyote	❑	❑	❑	❑
Red fox	❑	❑	❑	❑
Swift fox	❑	❑	❑	❑
Badger	❑	❑	❑	❑
Raccoon	❑	❑	❑	❑
Spotted skunk	❑	❑	❑	❑
Wolverine	❑	❑	❑	❑
Beaver	❑	❑	❑	❑
Marten	❑	❑	❑	❑
Fisher	❑	❑	❑	❑
Mink	❑	❑	❑	❑
River otter	❑	❑	❑	❑
Gray fox	❑	❑	❑	❑
Jackrabbit	❑	❑	❑	❑

9) **Please check all factors that you feel have contributed to increases or decreases in these species over the last 30 years?**

Habitat refers to both quality and quantity of habitat available to the animal; density of prey refers to the quantity of food available to the animal; regulated harvest refers to trapping or hunting season regulations established by the Game & Fish Department; and federal or state regulations refer to federal or state laws that affected how these animals could be harvested.

Mountain lion:	❑ habitat, ❑ density of prey, ❑ regulated harvest, ❑ federal or state regulations, ❑ other please specify_______________.
Black bear:	❑ habitat, ❑ density of prey, ❑ regulated harvest, ❑ federal or state regulations, ❑ other please specify_______________.
Lynx:	❑ habitat, ❑ density of prey, ❑ regulated harvest, ❑ federal or state regulations, ❑ other please specify_______________.
Bobcat:	❑ habitat, ❑ density of prey, ❑ regulated harvest, ❑ federal or state regulations, ❑ other please specify_______________.
Coyote:	❑ habitat, ❑ density of prey, ❑ regulated harvest, ❑ federal or state regulations, ❑ other please specify_______________.
Red fox:	❑ habitat, ❑ density of prey, ❑ regulated harvest, ❑ federal or state regulations, ❑ other please specify_______________.
Swift fox:	❑ habitat, ❑ density of prey, ❑ regulated harvest, ❑ federal or state regulations, ❑ other please specify_______________.
Raccoon:	❑ habitat, ❑ density of prey, ❑ regulated harvest, ❑ federal or state regulations, ❑ other please specify_______________.
Wolverine:	❑ habitat, ❑ density of prey, ❑ regulated harvest, ❑ federal or state regulations, ❑ other please specify_______________.
Pine Marten:	❑ habitat, ❑ density of prey, ❑ regulated harvest, ❑ federal or state regulations, ❑ other please specify_______________.
Fisher:	❑ habitat, ❑ density of prey, ❑ regulated harvest, ❑ federal or state regulations, ❑ other please specify_______________.
River otter	❑ habitat, ❑ density of prey, ❑ regulated harvest, ❑ federal or state regulations, ❑ other please specify_______________.
Gray fox	❑ habitat, ❑ density of prey, ❑ regulated harvest, ❑ federal or state regulations, ❑ other please specify_______________.
Jackrabbit:	❑ habitat, ❑ density of prey, ❑ regulated harvest, ❑ federal or state regulations, ❑ other please specify_______________.

10) **Would you like the populations of the species listed below to increase, decrease, or remain the same in the county(s) you generally trap or hunt furbearing, predatory, or trophy game species.**

Species	Increase	Decrease	Remain stable	No opinion
Mountain lion	❑	❑	❑	❑
Black bear	❑	❑	❑	❑
Lynx	❑	❑	❑	❑
Bobcat	❑	❑	❑	❑
Coyote	❑	❑	❑	❑
Red fox	❑	❑	❑	❑
Swift fox	❑	❑	❑	❑
Badger	❑	❑	❑	❑
Raccoon	❑	❑	❑	❑
Spotted skunk	❑	❑	❑	❑
Wolverine	❑	❑	❑	❑
Beaver	❑	❑	❑	❑
Marten	❑	❑	❑	❑
Fisher	❑	❑	❑	❑
Mink	❑	❑	❑	❑
River otter	❑	❑	❑	❑
Gray fox	❑	❑	❑	❑
Jackrabbit	❑	❑	❑	❑

11) **Have you ever intentionally or accidentally harvested a:**

Fisher	❑ **YES**	❑ **NO**
Wolverine	❑ **YES**	❑ **NO**
Lynx	❑ **YES**	❑ **NO**
River Otter	❑ **YES**	❑ **NO**

12) **If you answered yes to any part of question 11, please indicate the year, county, and drainage where you harvested a fisher, wolverine, lynx, or river otter.**

SPECIES	YEAR AND LOCATION OF HARVEST		
	YEAR	COUNTY	DRAINAGE
FISHER			
RIVER OTTER			
LYNX			
WOLVERINE			

13) Do you have records or diary of your trapping or hunting activities ?

❑ **YES** ❑ **NO**

14) If records exist, would you be willing to allow the Game & Fish Department to review these records for information on trends in these species numbers and distribution?

❑ **YES** ❑ **NO**

15) Please list the names and addresses of other people that could provide information on long-term trends in furbearing, predatory, or trophy game populations.

Name:____

Address:____

City, State, Zip:__________________________________

Name:____

Address:____

City, State, Zip:__________________________________

Thank you for completing the survey. If you have any further comments please write them in below. When finished please return the survey in the self addressed envelope and drop in any mailbox.

Additional comments:__________________________________

Relationship of Orientation on Internal Temperature of Artificial Bat Roosts, Southwestern Montana

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Abstract

This study experimentally investigated if bat houses, built using a basic design, would provide suitable temperatures for roosting bats in southwestern Montana. Specifically, we looked at the effects of orientation (east vs. south) on the internal roost temperature, which was then compared to published data on the physiological temperature required for bat maternity roosting sites. We observed no use of the artificial roosting sites. There was a trend for southern-oriented bat houses to have slightly higher daily temperatures and slightly higher maximum temperatures. We determined that the internal temperature of the roosts did not remain in the optimum range for maternity roosts during most days and months. Most temperature readings were well below the minimum value. Bat houses built using a basic design do not appear to provide suitable temperature requirements for reproductive female bats in southwestern Montana. The information gathered by this study will allow us to continue to develop recommendations for design and placement of bat houses in southwestern Montana.

Key words: bats, bat houses, artificial roost sites, temperature requirements.

Introduction

In recent years there has been a growing public interest in bats and bat conservation (Fenton 1997). Bats have low reproductive rates and specific roost requirements, making them particularly vulnerable to environmental change (Hill and Smith 1984). Large population declines in some bat species have been documented (Humphrey 1978, Tuttle 1979, and Richter et. al 1993). Providing artificial roosting sites, e.g., bat houses, is often recommended to help offset the loss of natural roosts and aid in bat conservation (Brittingham and Williams 2000). Bat houses are readily available commercially or can be constructed using published plans (Tuttle 1988, and Tuttle and Hensley 1993). However, putting up a bat house does not guarantee its use by bats. Numerous factors including house design, size, exposure to sunlight and habitat influence whether or not a bat house will be inhabited (Tuttle and Hensley 1993). Most of these factors influence the house's internal temperature, one of the most important factors affecting roost suitability (Williams and Brittingham 1997).

However, data on actual roost temperature requirements for bats is limited. Licht and Lietner (1967) found that individuals of three species of California bats began to move to cooler parts of the roost when temperatures approached 40 °C. Big brown bats (*Eptesicus fuscus*) left their maternity roost site when temperatures exceeded 33-35 °C (Davis et al. 1968). But little brown bats (*Myotis lucifugus*) have been found in maternity roost sites with temperatures up to 55 °C (Davis et al. 1965, Henshaw and Folk 1966). Tuttle (1988) lists the optimum temperatures for nursery colonies of larger bats such as big brown bats at 27-32 °C , with the range for smaller *Myotis* spp. being 32-43 °C.

The effects of several bat house designs and placement on internal roost

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temperature have been tested in the eastern United States (Brittingham and Williams 2000). Little work however, has been done in the western United States and virtually none in the northern Rocky Mountain states (Kiser and Kiser 1999).

Our specific objectives were to provide artificial roosting sites for bats at 3 different sites in southwestern Montana, determine which species and number of bats using these bat houses, test effects of two different placement orientations (east-facing vs. south-facing) on internal temperatures of the houses, and compare internal temperatures in our houses with optimum temperatures for nursery colonies (Tuttle 1988).

Methods

Bat House Construction and Placement

We constructed 14 bat houses using the "small economy bat house" plans of Tuttle and Hensley (1993). The dimensions of these houses were 67.3 cm X 60.9 cm X 6.4 cm (26.5" X 24" X 2.5"). All houses were painted black as recommended by Tuttle and Hensley (1993). We did not place a 1.27-cm (0.5-in) vent space in the front of the house because the plans indicated this may not be necessary in colder climates.

At the end of May 2001, we placed bat houses arranged in pairs at three sites in western Montana where foraging big brown bats and little brown bats are known to be present based on mist-net captures (Kuenzi, unpublished data). One house in each pair was oriented facing the south, the other facing east. We choose these two placements because bat houses oriented in a direction that has the maximum exposure to sunlight is recommended in cooler climates (Tuttle and Hensley 1993).

At the first site, Blacktail Creek walkway in Butte, Silver Bow County, we placed two pairs of bat houses in cottonwood trees along the creek. At the second site, Warm Springs Wildlife Management Area, Deer Lodge County, we placed three pairs of bat houses in cottonwood trees (*Populus* spp.) located along a large irrigation canal that contains water year round. At the final site, the Mount Hagan Wildlife Management Area, Deer Lodge County, we placed three pairs of bat houses on abandoned buildings located within 20 m of a small creek. Elevation at the three sites were as follows: 1554 m at Blacktail Creek; 1467 m at Warm Springs; and 1914 m at Mount Hagan. We visually checked all bat houses for the presence of bats approximately every 3 weeks from June through September 2001 and from April through July 2002.

Temperature Data

Temperature data were collected from 14 June through 30 September 2001, and from 1 April through 19 May 2002 using four Hobo temperature data loggers (Onset Computer Corporation, Bourne MA). Data loggers were placed inside two pairs of houses/site and were programmed to collect temperature data on an hourly basis. Data loggers remained at a site for at least 2 weeks before being moved to another site.

We averaged temperatures daily within each placement orientation (south, east) at a site. We also determined daily minimum and maximum temperatures for each orientation. Daily averages as well as daily minimum and maximum temperatures were then averaged within each month at a site.

We used paired *t*-tests (Sokal and Rohlf 1995) to determine if internal house temperatures differed with placement orientation. Paired t-tests were done for each site and time of data collection.

We performed all statistical analyses using JMP (SAS Institute 1996). Alpha of 0.05 was used in all statistical tests, and data are presented as $\bar{x} \pm 1$ standard error unless indicated otherwise.

To determine how the temperatures in our bat houses differed from the optimum range for big brown and little brown bat maternity colonies, we calculated the percentage of temperature readings that was less than the minimum range value, the percentage of readings that was above the maximum value, and the percentage of temperature readings that were within the range. We calculated these values at each site and recorded the time of data collection.

Results

We did not document any use of bat houses by bats during the course of this study. Internal temperatures in bat houses were highly variable on a daily basis with difference between minimum and maximum temperatures ranging from ~13 °C in April up to 30 °C in August (Table 1). We observed a trend for southern-oriented bat houses to have slightly higher daily temperatures and slightly higher maximum temperatures. However, the results of paired *t*-test comparisons show that southern-oriented bat houses had significantly higher temperatures in only 5 of 14 (35.7%) comparisons that we made (Table 2). In most cases there was no difference between temperatures in south versus east oriented houses and in July at the Blacktail Creek site, houses that faced east had significantly higher temperatures than the south-facing houses.

A high percentage of each month's temperature readings were below the optimal temperature range for both big brown bats and little brown bats (Table 3). The percentage of temperature readings within the optimal range for big brown bats varied from 0 in all houses during April up to ~35 percent for a south-facing house in September (Table 3). In general houses that faced east had a higher percentage of readings within the optimal range for this species. The percentage of monthly temperature readings within the optimal range for little brown bats was much lower ranging from 0 to 14.5 percent (Table 3). In general houses that faced south had a slightly higher percentage of readings within the optimal range.

Discussion

Big brown bats and little brown bats commonly forage in and around our three study sites (Kuenzi, unpublished data). Both species are known to use artificial roost sites (Williams and Brittingham 1997, Neilson and Fenton 1994) and both form maternity colonies usually by mid-May (Davis et al. 1968, Barbour and Davis 1969, Fenton and Barclay 1980, Kurta and Baker 1990). However, it has been suggested that in more northern regions maternity colonies may form somewhat later (Fenton and Barclay 1980). The amount of precipitation in the spring may also influence the exact timing of maternity colony formation (Grindal et al. 1992).

Temperatures in our bat houses were often below the optimal range for maternity colonies of both big brown bats and little brown bats. Granted that each day varied somewhat in temperature, but overall our artificial roosts did not remain in the range of optimal temperatures for more than an hour or two at a time. We doubt that maintaining suitable internal temperatures for such short periods would provide a viable environment for female bats with young.

Roost temperature at maternity sites has a strong influence on reproductive success. When ambient temperature is low many bat species can optimize energy and water savings by entering torpor, a reduction in body temperature. Although male bats regularly use torpor during spring and summer (Grinevitch et al. 1995), pregnant females who enter torpor delay parturition, which could leave their offspring with too short a season to acquire fat stores needed for winter survival (Rydell 1989). Therefore reproductively active females select roost sites that allow them to minimize their use of torpor and maximize growth rates of their young (Audet and Fenton 1988). In addition, very young bats do not thermoregulate, thus roost temperature is very important to their survival (Kunz 1987).

The main problem with our bat houses as suitable sites for reproductive females was low internal temperature; thus, greater exposure to sunlight may raise the internal roost temperature sufficiently. Bat houses at Warm Springs and Blacktail Creek were partially shaded by trees at least part of the day, therefore, mounting the houses in the open on poles would allow greater exposure

Table 1. Average daily temperature and average daily minimum and maximum temperatures ($\bar{x}$ ± 1 SE) inside bat houses by month at sites in southwestern Montana.

Month	Site	Orientation of bat house	Ave. daily temp.	Ave. daily maximum temp.	Ave. daily minimum temp.	Number of days
April	Warm Springs	South	6.2 ± 0.7	17.1 ± 0.9	-4.1 ± 0.7	30
		East	5.3 ± 0.7	16.5 ± 1.0	-3.2 ± 0.7	30
May	Warm Springs	South	10.3 ± 1.0	21.6 ± 1.5	-0.2 ± 0.8	22
		East	9.2 ± 0.9	19.9 ± 1.4	0.7 ± 0.7	22
June	Mt. Hagan	South	14.3 ± 1.2	31.1 ± 2.0	3.2 ± 1.1	19
		East	14.2 ± 1.3	29.2 ± 1.8	1.8 ± 1.1	19
July	Mt. Hagan	South	17.6 ± 0.9	32.5 ± 2.0	7.2 ± 0.7	17
		East	17.6 ± 0.9	34.0 ± 1.5	5.6 ± 0.7	17
July	Blacktail Creek	South	16.8 ± 0.7	28.0 ± 0.9	8.2 ± 0.3	14
		East	18.2 ± 0.8	34.9 ± 1.4	8.3 ± 0.4	14
August	Warm Springs	South	21.3 ± 0.3	40.4 ± 0.7	6.9 ± 0.6	31
		East	20.2 ± 0.3	34.4 ± 0.5	7.4 ± 0.5	31
September	Warm Springs	South	20.3 ± 0.3	36.9 ± 1.9	5.8 ± 1.7	4
		East	19.7 ± 0.3	36.0 ± 0.8	5.9 ± 1.8	4
September	Mt. Hagan	South	13.5 ± 0.5	35.9 ± 1.3	-0.1 ± 0.7	26
		East	13.3 ± 0.6	32.9 ± 1.4	-0.7 ± 0.7	26

to sunlight. However, bat houses at Mount Hagan were not shaded by trees and their internal temperatures remained low. In addition to increasing exposure to sunlight, mounting bat houses on poles has been recommended as a way to provide protection from mammalian predators (Tuttle and Hensley 1997). Insulating the houses might help to provide a higher and more stable internal temperature. Others have suggested that mounting houses directly on the side of occupied buildings also provides some degree of insulation (Tuttle and Hensley 1993).

Although this study did not find an internal roost temperature that was overly high to be a problem, as measures are taken to raise the internal roost temperature, this may become an issue. Williams and Brittingham (1997) found if the microclimate of one part of the bat house was too high, bats would move to a part of the bat house that had a cooler microclimate rather than abandoning the roost. Plans for

Table 2. Results of paired *t*-tests comparing internal temperatures of south versus east facing bat houses at three sites in southwestern Montana.

Month	Site	House pair number	*t*-value	*P*-value	Direction with higher temperature
April	Warm Springs	1	6.17	< 0.001	South
May	Warm Springs	1	7.32	< 0.001	South
June	Mt. Hagan	1	0.15	0.884	No difference
		2	-1.09	0.275	No difference
July	Mt. Hagan	1	-0.07	0.942	No difference
		2	-0.17	0.860	No difference
July	Blacktail	1	-5.87	< 0.001	East
		2	-8.79	< 0.001	East
August	Warm Springs	1	5.62	< 0.001	South
		2	5.82	< 0.001	South
September	Warm Springs	1	1.64	0.104	No difference
		2	0.54	0.590	No difference
September	Mt. Hagan	1	4.01	< 0.001	South
		2	-1.47	< 0.140	No difference

Table 3. Percentage of hourly temperature readings from bat houses in southwestern Montana that were below the minimum temperature value, above the maximum temperature value, and were in the range of temperature values for maternity roosting sites. Sample sizes are shown in parentheses.

Month	Site	Orientation of bat house	Pair	Percentage of readings below 27 °C	Percentage of readings above 32 °C	Percentage of readings between 27- 32 °C[1]	Percentage of readings between 32- 43 °C[2]	Percentage of readings above 43 °C
April	Warm Springs	South	1	100 (720/720)	0	0	0	0
		East		100 (720/720)	0	0	0	0
May	Warm Springs	South	1	95.4 (496/520)	0.2 (1/520)	4.4 (23/520)	0.2 (1/520)	0
		East		97.3 (506/520)	0.0	2.7 (14/520)	0	0
June	Mt. Hagan	South	1	85.2 (379/445)	7.4 (33/445)	7.4 (33/445)	7.2 (32/445)	0.2 (1/445)
		East		83.1 (370/445)	6.3 (28/445)	10.6 (47/445)	6.3 (28/445)	0
		South	2	88.3 (391/443)	6.1 (27/443)	5.6 (25/443)	6.1 (27/443)	0
		East		87.1 (386/443)	1.1 (5/443)	11.8 (52/443)	1.1 (5/443)	0
July	Mt. Hagan	South	1	82.0 (323/394)	8.9 (35/394)	9.1 (36/394)	8.6 (34/394)	0.3 (1/394)
		East		76.4 (301/394)	12.4 (49/394)	11.2 (44/394)	12.4 (49/394)	0
		South	2	81.5 (322/395)	7.6 (30/395)	10.9 (43/395)	7.1 (28/395)	0.5 (2/394)
		East		77.2 (305/395)	5.8 (23/395)	17.0 (67/395)	5.8 (23/395)	0
July	Blacktail Cr.	South	1	89.5 (280/313)	0.6 (2/313)	9.9 (31/313)	0.6 (2/313)	0
		East		75.1 (235/313)	10.5 (33/313)	14.4 (45/313)	10.5 (33/313)	0
July	Blacktail Cr.	South	2	94.9 (298/314)	0.3 (1/314)	4.8 (15/314)	0.3 (1/314)	0
		East		91.4 (287/314)	0	8.6 (27/314)	0	0
August	Warm Springs	South	1	73.8 (549/744)	14.1 (105/744)	12.1 (90/744)	12.5 (93/744)	1.6 (12/744)
		East		81.9 (609/744)	1.7 (13/744)	16.4 (122/744)	1.7 (13/744)	0
		South	2	61.2 (455/744)	11.8 (88/744)	27.0 (201/744)	11.6 (86/744)	0.3 (2/744)
		East		69.6 (518/744)	11.6 (86/744)	18.8 (140/744)	11.6 (86/744)	0
September	Warm Springs	South	1	73.3 (66/90)	14.5 (13/90)	12.2 (11/90)	14.5 (13/90)	0
		East		73.3 (66/90)	0	26.7 (24/90)	0	0
		South	2	60.7 (54/89)	4.5 (4/89)	34.8 (31/89)	4.5 (4/89)	0
		East		66.3 (59/89)	12.4 (11/89)	21.3 (19/89)	12.4 (11/89)	0
September	Mt. Hagan	South	1	85.3 (521/611)	8.8 (54/611)	5.9 (36/611)	8.3 (51/611)	0.5 (3/611)
		East		81.0 (495/611)	9.2 (56/611)	9.8 (60/611)	9.2 (56/611)	0
		South	2	82.8 (505/610)	9.3 (57/610)	7.9 (48/610)	8.5 (52/610)	0.8 (5/610)
		East		82.3 (502/610)	8.2 (50/610)	9.5 (58/610)	8.2 (50/610)	0

[1]These percentages represent the percentage of temperature readings in the optimal range for *E. fuscus*.
[2]These percentages represent the percentage of temperature readings in the optimal rang

the construction of bat houses with several internal chambers are available (Tuttle and Hensley 1993). Although these houses are more costly and difficult to construct they may provide a wider range of temperatures.

The temperatures provided by our roost sites were likely unsuitable, especially for reproductive females. The houses may provide suitable temperatures for male bats who can tolerate lower temperatures (Hamilton and Barclay 1994). However, we did not observe any bats using our houses. One explanation could be that bats have yet to discover the houses. Although occupancy in many successful houses occurs during the first summer season of placement, occupation of houses by bats sometimes takes several seasons (Tuttle and Hensley 1993). During the first summer of our study our bat houses may have been put up too late in the season (end of May). Although maternity colonies are forming at this time, individuals were likely looking for roosting sites earlier in the season. A final reason for the non-use of the houses in this study may be that suitable natural roosting sites are not limited in the study areas.

We plan to continue this study in several different ways, the first is to leave up the present houses and monitor them for another year or two. Next we plan on examining the temperatures and use of different house designs, such as multiple-chambered houses. We also plan to examine the effects of factors such as insulation and placing houses in a southeast orientation on internal temperature and occupancy rates.

Acknowledgements

We thank R. Douglass, K. Douglass, M. Cerise, S. Nyland, D. Tziakek, and K. Ball for their assistance. Funding for this study was provided by the Montana Tech Undergraduate Research Program and the Montana Audubon Society. Additional funding was provided by Brandon Legg Construction and Ace Hardware in the form of supplies for bat house construction.

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Received 29 January 2003
Accepted 17 April 2003

Factors Affecting Survival and Recruitment in Female Merriam's Turkeys

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Abstract
Merriam's turkeys (*Meleagris gallopavo merriami*) historically occurred in ponderosa pine (*Pinus ponderosa*) and Gambel's oak (*Quercus gambelli*) forests in the southwestern U.S. They have been successfully transplanted into a wide array of habitats outside their original range. Some introduced populations are more robust than those within the original range. Annual survival fluctuates widely, ranging from 30 to 76 percent for adults. Survival of subadult hens is typically lower than adults. Predation is the primary mortality factor and coyotes are the most common predator. Percent of females attempting to nest (nesting rates) ranges from ~30 to >90 percent for adults. Yearling females nest at lower rates, and within the historical range of Merriam's turkeys, nesting by yearling hens may be almost nonexistent. Management that would increase nesting by yearlings probably has the greatest potential to influence populations given the existing biological limitations to Merriam's turkeys. Nesting rates of adult and yearling hens is likely related to habitat quality or productivity, possibly nutrition-related. Since survival of poults is low, maintaining high-quality meadows with an abundant component of herbaceous vegetation and invertebrates might increase poult survival.

Key words: Merriam's turkeys, *Meleagris gallopavo merriami*, nesting, population characteristics, survival.

Introduction

Merriam's turkey (*Meleagris gallopavo merriami*) populations historically have experienced dramatic declines (Ligon 1946) and increases (Mosby 1975). Initial declines resulted from unregulated harvest, habitat degradation from timber and range management practices, and predation (Ligon 1946, MacDonald and Janzen 1967). Populations continue to fluctuate even in the presence of regulated timber harvest and improved land management practices. An understanding of the natural variation of vital rates among Merriam's turkey populations can provide resource managers with insight to a range of fluctuation expected, based on climate, harvest, and land management practices.

Historically, Merriam's turkeys were found in Colorado, New Mexico, Arizona, and west Texas (Schorger 1966). Their distribution was generally concurrent with ponderosa pine (*Pinus ponderosa*) and oak (*Quercus* spp.) forests of the southwest (Ligon 1946, McDonald and Janzen 1967). The current range of Merriam's turkeys extends beyond the historical range (Bailey 1980, Kennamer and Kennamer 1996), and some transplants outside the historical range of Merriam's turkeys have been highly successful, e.g., particularly the release of Merriam's turkeys in the Black Hills of South Dakota. Between 1948 and 1951, 29 Merriam's turkeys (sex ratios unknown) from Colorado and New Mexico were released in the Black Hills (Petersen and Richardson 1975). By fall 1952, the wild turkey population in the Black Hills was estimated at 1000 birds, and by 1960 the population was estimated at 5000 to 7000 birds. Merriam's turkeys were not native to the North Kaibab Plateau, Arizona, and subsequent introductions resulted in robust populations (Wakeling and Goodwin 1999). Success of the Merriam's turkey in the Black Hills led to subsequent transplants throughout the region including the ponderosa pine hills and buttes and deciduous woodlands of northeastern Wyoming, southeastern Montana (Jonas 1966), and western South Dakota. Substantial populations now occur in plains cottonwood (*Populus deltoides*), bur oak (*Q. macrocarpa*), and green ash (*Fraxinus pennsylvanica*) prairie-woodlands, and the ponderosa pine-covered buttes throughout the northern Great Plains. Deciduous woodlands in prairie and high desert regions are usually associated with streams and mesic north to northeast slopes in steep topography such as river breaks or foothills. Currently, distribution of Merriam's turkeys includes all of the contiguous U.S. north and west of the historical range (Stangel et al. 1992).

Given the broad array of habitats that Merriam's turkeys occupy, a similarly broad array of vital rates are expected. Parameters affecting populations of Merriam's turkey vary spatially and temporally. We summarize the available literature on nesting and survival of Merriam's turkeys. Despite many studies of Merriam's turkey populations and habitat, comparable data on population parameters is lacking among many of these studies. We obtained sufficient data from Arizona (*n*=201, 1987-1991, Wakeling 1991), Montana (*n*=74, 1988-1992, Thompson 1993), and South Dakota (*n*=119, 1986-1992, unpubl. data, Rocky Mountain Research Station) to calculate Kaplan-Meier survival (Parmar and Machin 1995) estimates for these areas.

Terminology and methods for estimates of nest parameters are not consistent among papers. For example, some papers calculate nesting rates as

$$\frac{\textit{nests found}}{\textit{\# of hens}}$$

whereas others used localization of movements by hens as evidence for initiation of a nest (e.g., Rumble and Hodorff 1993). Some papers calculate nest success as

$$\frac{\textit{nests hatched}}{\textit{nests found}}$$

although others calculate Mayfield (1975) nest survival rates. We refer readers to the original papers if methods for estimates are a concern. Here, we use nest success since it provides a slightly biased estimate of nest survival. The literature also does not clearly define terminology describing age of turkeys. We use "poults" for birds from hatching to fall, "subadults" for birds from fall up to the first nest season, and "yearlings" for birds in their first breeding season. At ~15 months of age, birds cannot be aged using plumage (Leopold 1943), and we refer to those birds as "adults." Hen success is defined as the proportion of hens that successfully hatch ≥1 egg during a nesting season (Cowardin *et al.*1985). Where practical, we applied these terms when interpreting findings from other studies. For ease of comparison, we provide a summary of values used in our paper in Table 1.

Survival and Mortality

Merriam's turkeys are physiologically capable of being long-lived. The oldest marked female in Arizona survived for >8 years (B. F. Wakeling, pers. obs.). However, annual survival of female Merriam's turkeys varied spatially and temporally. Kaplan-Meier survival rates for all radio-marked birds adjusted from 1 January to 30 December were 68 percent in South Dakota, 57 percent in Arizona, and 45 percent in Montana. In South Dakota annual survival of female Merriam's turkeys ranged from 33 to 76 percent. Annual survival of subadult females in Arizona ranged from 20 percent to 65 percent, whereas that of adult females ranged from 84 to 100 percent (Wakeling 1991). We did not calculate survival rates for each year of the study in Montana because sufficient data were not available. Survival of subadult females varied more than other vital rates measured and

Table 1. List of population metrics referenced in the text and for Merriam's turkeys that occur in the literature or in our data files.

Population metric		State[1,2]	Value[3]
Annual survival			
	♀ all ages	MT	45%
	♀ all ages	SD	33-76% ($\bar{x}$ = 68%)
	♀ all ages	AZ	57%
	♀subadult	AZ	20-65%
	♀adult survival	AZ	84-100%
Relative mortality accountable to predation		AZ, MT	80%
	Coyotes	AZ	65%
	Bobcat	AZ	13%
	Avian	AZ	22%
	Hunting	AZ	<10%
Fall harvest composition			
	Adult♀	AZ	30-40%
Hen mortality during nesting			
		SD (BH)	20%
		SD (C)	11%
Winter survival			
	Subadult♀	AZ	79%
	Adult♀	AZ	82%
Mortality during severe winter weather			
	Subadult♀ (Jan. – early Apr.)	AZ	90%
	Subadult♀ (<2 weeks after severe storm)	SD (BH)	100%
	Adult ♀ (Jan. – early Apr.)	AZ	38%
Nesting rates			
	Adult	SD (BH)	97%
	Adult	SD (C)	77%
	Adult	AZ	45%
	Adult	CO (WC)	100%
	Adult	CO (SC)	62%
	Adult	NM (SE)	75%
	Adult	NM (SC)	76%
	Adult	OR	100%
	Yearling	SD (BH)	73%
	Yearling	SD (C)	17%
	Yearling	AZ	0%
	Yearling	CO (WC)	96%
	Yearling	CO (SC)	8%
	Yearling	NM (SC)	11%
	Yearling	NM (SE)	8%
	Yearling	OR	25%
Nest survival			
	Adult	SD (BH)	36%
	Adult (*n* = 16) and yearling (*n* = 1)	SD (C)	44%
	Adult and yearling averaged	NM (SC)	31%
	Adult and yearling averaged	NM (SE)	40%
	Yearling	SD (BH)	23%
Renesting rate			
	Adult	SD (C)	13%
	Adult	AZ	18%
	Adult	NM (SE)	35%
	Adult	NM (SC)	27%

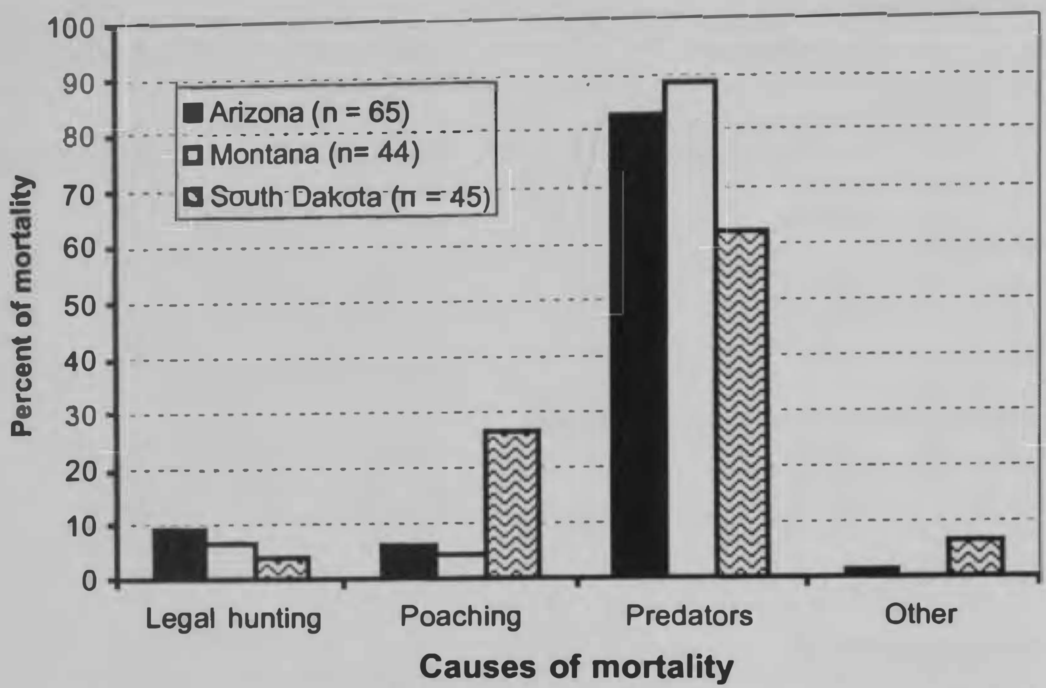
Table 1 (continued)

	Population metric	State[1,2]	Value[3]
	Adult (attempts/bird)	SD (BH)	1.18%
	Yearling (attempts/bird)	SD (BH)	0.57%
	Yearling	AZ	0%
	Yearling	NM (SE)	0%
Renest survival			
	Second nest	SD (BH)	35%
	Third nest	SD (BH)	67%
	All renests	AZ	50%
	Adult	NM	35%
Hen success (% of hens that ultimately hatch ≥1 egg)			
	Yearling	SD (BH)	24%
	Yearling	MT	25%
	Yearling	NM (SE)	4%
	Adult	SD (BH)	48%
	Adult	MT	50%
	Adult	NM (SE)	37%
Relative cause of nest loss			
	Birds	SD (BH)	35%
	Mammals	SD (BH)	26%
	Mammals	SD (C)	86%
Poult mortality			
	2 weeks	MO	50-75%
	8 weeks	WY	64%
	Hen:poult ratio	SD (BH)	>40%
	Hen:poult ratio	AZ	41-65%
	8 weeks	SD (C)	57%
	Complete brood mortality	SD(C)	35%

[1] (C) = south central South Dakota, (BH) = Black Hills South Dakota, (SE) = southeast New Mexico, (SC) = south central New Mexico.
[2] Merriam's turkey populations from Montana, Oregon, South Dakota, and Wyoming were all introduced.
[3] Expressed at percentage except as noted.

consequently had the greatest influence on populations in Arizona in which only adults nested (Wakeling 1991).

Predators accounted for the majority of mortality events for female Merriam's turkeys throughout their range (Fig. 1). However, the magnitude of predation as a mortality factor differed among populations (Wakeling 1991, Rumble and Hodorff 1993, Thompson 1993, Wakeling and Rogers 1998). Predation accounted for >80 percent of identifiable causes of mortality to female turkeys in Montana and Arizona. In Arizona, coyotes (*Canis latrans*) accounted for 65 percent of the predation events, bobcats (*Lynx rufus*) accounted for 13 percent, and avian predators accounted for 22 percent. Legal hunting accounted for <10 percent of mortality events among female turkeys. Hunter harvest appears directly related to population size (Wakeling 1991). Hunters harvested <3 percent of adult females during a week-long fall hunt, and modeling suggested that hunter harvest had no significant effect on subsequent populations. Fall turkey hunters in Arizona appeared to harvest the larger birds in fall flocks. The fall harvest comprised 30-40 percent subadult males, and 30-40 percent adult females. The proportion of adult females in the fall harvest increased when nesting occurred later, probably because they presented a larger and more preferred target for hunters than smaller subadults (R. W. Engel-Wilson, Ariz. Game and Fish. Dept., unpubl. data). We believe that

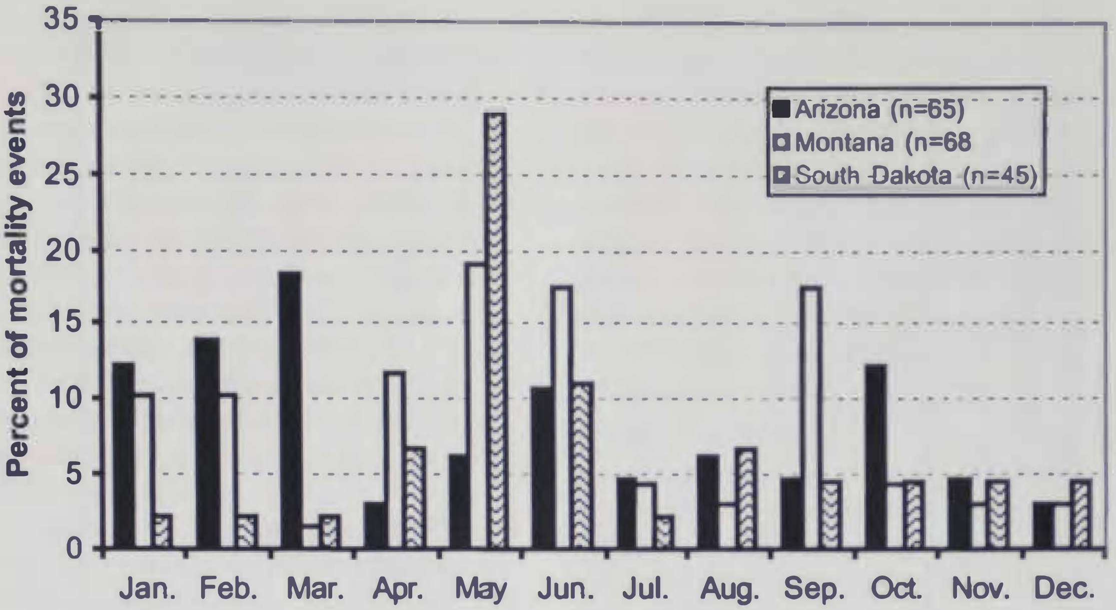


[1]Includes only identifiable causes of mortality. Other category includes disease and vehicles.

Figure 1. Causes of mortality to female Merriam's turkeys from Arizona (adapted from Wakeling 1991), Montana (adapted from Thompson 1993), and South Dakota[1].

limited fall turkey harvest has little overall effect on populations of Merriam's turkeys. Because winter survival among populations of Merriam's turkeys tends to be high and because adult females contribute more to the reproductive performance of some populations (Rumble and Hodorff 1993), recovery from population declines or growth of new populations might increase slightly in the absence of fall hunting.

Timing of mortality varied among areas, but there appeared to be regional similarities. The monthly frequency of mortality events in Montana and South Dakota were correlated ($r = 0.6$, $P = 0.04$). Correlations of monthly mortality events between Arizona and the former states showed nonsignificant negative correlations ($r \leq -0.12$, $P \geq 0.5$). Mortality events in Arizona increased from winter through early spring (Fig. 2), but declined during the nesting season. In Arizona, survival of yearling females was greater than adult females from nest initiation through fall (Wakeling 1991). These yearling females had low nesting rates and Wakeling (1991) attributed their greater survival to their not being encumbered with broods. Lutz and Crawford (1987) suggested that yearling females experienced comparatively high rates of predation and nest loss because they maintained higher levels of activity through the second week of incubation and displayed lower attentiveness to the nest. Increased mortality of female turkeys during late winter to spring is also the result of the cumulative effects of winter on the physiological condition of birds (Rumble and Anderson 1996*a*, Wakeling and Rogers 1995, 1996). Vulnerability to mortality of birds during nesting and brood rearing was evident in Montana and South Dakota. The onset of nesting corresponded with the period of greatest mortality in South Dakota. Predation during nest initiation or incubation was primarily by coyotes, red fox (*Vulpes fulva*), or raptors and may approach 20 percent of females (Rumble and Hodorff 1993). In south central South Dakota, female turkeys incurred 11 percent mortality from mammalian predators during nesting (Day 1988).



[1] Includes unidentified causes of mortality.

Figure 2. Monthly distribution of mortality events to female Merriam's turkeys in Arizona (Arizona adapted from Wakeling 1991), Montana (adapted from Thompson 1993), and South Dakota[1].

Weather conditions from previous summers can interact with predation, affecting survival of Merriam's turkeys the following spring. During summer 1988, drought reduced the production of ponderosa pine seeds, the preferred winter food of turkeys in the Black Hills (Rumble and Anderson 1996*a,b*). Consequently, winter diets comprised mostly grass seeds and kinnikinnick (*Arctostaphylos uva-ursi*) seeds (Rumble and Anderson 1996*a*). During a mild winter, Rumble and Anderson (1996*c*) documented 25 percent mortality of radio-marked females (all subadults) by predators within 2 weeks of a winter storm in March. Despite the small sample ($n = 4$), this resulted in 100 percent mortality of the radio-marked subadult females in the Black Hills that year. In another instance, anecdotal observations on the North Kaibab during fall 1996 indicated that acorns, the favored mast, were limited (Wakeling and Rogers 1995, 1996). Following several substantial winter snowfalls, mortality rates of female turkeys were high. Over-winter survival of subadult female survival was 10 percent compared to 62 percent among adult females (Wakeling and Goodwin 1999). During typical winters in Arizona, average survival of the respective age groups was 79 and 82 percent (Wakeling 1991). Ultimate factors affecting survival of Merriam's turkeys probably varies across their range and may often be unique. Available data did not allow us to identify the integrated effects of weather, habitat, and age of birds affecting survival of Merriam's turkeys.

Reproductive Parameters

Nesting rates of adult females vary markedly across the range of Merriam's turkeys (Lockwood and Sutcliffe 1985, Schemnitz et al. 1985, Lutz and Crawford 1987, Wakeling 1991, Rumble and Hodorff 1993, Flake and Day 1995). Nesting rates in some introduced populations exceed those from populations within the historical range. For example, in the Black Hills, nesting rates of adults averaged 97 percent (Rumble and Hodorff 1993), but in Arizona adult female nesting rates averaged 45 percent (Wakeling 1991). Nesting by yearling females within the historical range of Merriam's turkeys is normally

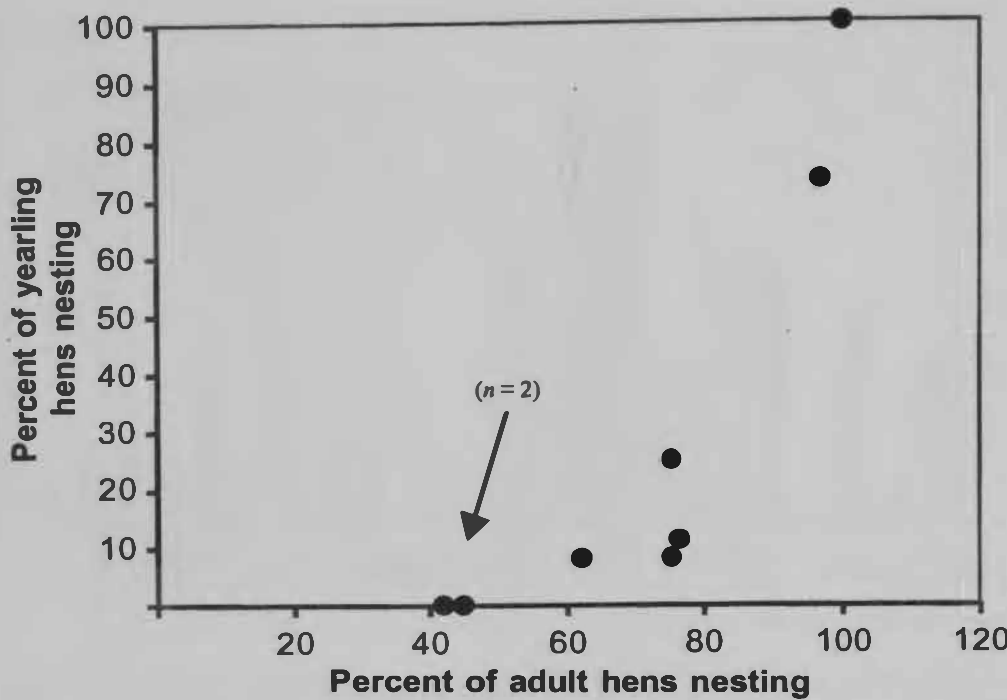


Figure 3. Scatterplot of adult and yearling Merriam's turkey nesting rates from nine studies.

nonexistent or limited (Schemnitz et al. 1985, Lockwood and Sutcliffe 1985, Hoffman 1990, Wakeling 1991, but see Hoffman et al. 1996). Nesting by yearling hens is also uncommon in some introduced populations (Lutz and Crawford 1987, Wertz and Flake 1988, Flake and Day 1995), while other introduced populations have substantial nesting (≤73%) by yearling females (Hengel 1990, Rumble and Hodorff 1993, Thompson 1993).

In a generic sense, quality of habitat or some component apparently affects nesting by yearling females and the likelihood for females to renest (Rumble and Hodorff 1993). Hoffman et al. (1996) summarized data from several studies that suggested a link between propensity for subadult females to nest and winter nutrition; populations in which subadult females weighed more than 3.9 kg demonstrated greater nesting effort than those that weighed less than 3.6 kg. In Arizona, some females lost up to 20 percent of their body weight during a relatively snow-free, but mast-limited winter, and there was a weak correlation between nesting rate and mast production (Wakeling 1991). Nesting rates of females are high in the central Black Hills (Rumble and Hodorff 1993) where ponderosa pine seed, the primary mast source (Rumble and Anderson 1996*a*), is usually dependable (Boldt and Van Duesen 1974). Wakeling and Rogers (1995) noted that nutritional deficiency of copper and selenium, which can affect nesting (Puls 1988), was evident in a turkey population with a low propensity for nesting.

There appears to be a relation between adult and yearling nesting rates for Merriam's turkeys. Data suggest that yearling nesting is low or nonexistent until adult nesting rate exceeds about 60 percent (Fig. 3).

Although survival of yearling nests (0.23) did not differ ($P = 0.18$) from that of adults (0.36) in the Black Hills, adults contributed more to annual recruitment of Merriam's turkeys in the Black Hills than yearlings (Rumble and Hodorff 1993). Adult females renested more (1.18 attempts/bird) often than yearlings (0.57 attempts/bird) and had greater (48%) hen success than yearlings (24%). Nest outcomes in southeastern Montana were strikingly similar to the Black Hills in which success of adult and yearling hens was 50 and 25 percent, respectively (Thompson 1993). In the Black Hills, renesting was correlated (r=0.96) with spring-summer precipitation (Rumble and Hodorff 1993). Of 15 adult females in south central South Dakota with unsuccessful nests, only 2 (13%) attempted to renest (Flake and Day 1995). In Arizona and New Mexico, only adults (18-35%) attempted to renest (Lockwood and Sutcliffe 1985, Schemnitz et al. 1985, Wakeling 1991).

Birds (35%) and mammals (26%) were the primary causes for failure of Merriam's turkey nests in South Dakota. Weather, e.g., late spring snow storms, can be an important factor affecting nest outcome. During some years, American crows (*Corvus brachyrhynchos*) accounted for complete loss of all first nesting attempts and 65 percent of total annual nest predation (Rumble and Hodorff 1993). Coyotes and, to a lesser degree, red fox were the primary mammalian predators in the Black Hills. In south central South Dakota, 17 of 39 (44%) of nesting attempts hatched and 86 percent of nest losses were attributed to mammalian predation (Flake and Day 1995). Probable nest predators included coyotes and black-billed magpies (*Pica pica*). American crows or black-billed magpies were primary nest predators in Montana (Thompson 1993).

In the southwestern U.S., nesting outcomes differed from those in northern latitudes. Only adults nested in Arizona where nest success averaged 68 percent (Wakeling 1991). Most nest losses in Arizona resulted from mammalian predation, although ravens (*C. corax*) were noted predators of nests (Wakeling et al. 1998). Renesting by females in Arizona was 18 percent of which only half were successful (Wakeling et al. 1998). In southeastern New Mexico, nest success averaged 31 percent for first nests and 55 percent for renests for an average hen success of 35 percent (Lockwood and Sutcliffe 1985).

Multiple microhabitat characteristics at the nest site influenced the outcome of nesting in Arizona; successful nest sites had greater horizontal screening and overhead cover (Wakeling et al. 1998). Rumble and Hodorff (1993) reported greater survival rates of third nest attempts than first or second attempts in the Black Hills; third nest attempts had greater horizontal screening and more vegetative cover than earlier nest attempts.

Poult Survival

We are unaware of a suggested level of reproductive success for maintaining populations of Merriam's turkey. Data on poult survival are limited and extrapolation beyond the areas where these studies were conducted must be done cautiously. Glidden and Austin (1975) suggested that poult survival should exceed 20 percent for maintaining eastern turkey (*M. g. silvestris*) populations, depending on nesting success, nesting rates for yearlings and adults, and renesting effort.

We can reasonably expect poult mortality for Merriam's turkey from hatch to August to vary from 60 to 70 percent; however, additional data are needed that quantify the effect of complete brood loss on these estimates. Mortality rates of eastern turkey poults vary from 50 to 75 percent during the first 14 days post hatch (Vangilder 1992). The period of highest poult mortality occurs while flightless—usually 7-9 days post hatch—when dietary protein requirements for growth are high. However, we have observed flightless poults 12 to 14 days post hatch when availability of invertebrates was low (M. Rumble, personal observation). Mortality of eastern turkey poults occurs primarily in the first 2 weeks post hatch with minimal losses thereafter (Vangilder 1996). All complete brood losses of Merriam's turkey in south-central South Dakota occurred ≤2 weeks post hatch (Flake and Day 1995). Predation accounts for about 80 percent of mortality of eastern turkey poults (Speake et al. 1985). Mortality of Merriam's turkey poults during the first 8 weeks post hatch averaged 64 percent in Wyoming (Hengel

1990). Based on personal observations, we conclude that predation and weather are important contributors to early mortality of Merriam's turkey poults. In the Black Hills, poult mortality estimates from late summer hen:poult ratios and average clutch size are >40 percent (unpubl. Pittman-Robertson Rep. W-95-R-31, South Dakota Department Game Fish and Parks 1998). In Arizona, brood surveys suggested poult mortality rates from 41 to 65 percent by August (Wakeling 1991). Brood surveys underestimate poult mortality; they do not account for entire brood losses because unsuccessful females and those with complete brood loss use habitats where they are less likely to be observed (Shaw and Mollohan 1992, Hoffman et al. 1993, Mollohan et al. 1995). In south-central South Dakota, poult mortality estimates from radio marked females ≤8 weeks post hatch was 57 percent including 35 percent complete loss of broods. (Flake and Day 1995).

Population Modeling

Because of the number of factors involved, modeling is useful for estimating vital rates necessary for sustaining turkey populations. Modeling successfully identified probable factors that limit populations of eastern turkeys in Wisconsin (Rolley et al. 1998). Demographic modeling suggested that greater survival of subadult females (Wakeling 1991) or adult females (Wakeling and Rogers 1998) in Arizona could potentially increase Merriam's turkey populations. Nonetheless, Wakeling and Rogers (1998) speculated that managers could more successfully increase nesting rates of yearling females through habitat manipulation than increase survival rates by controlling predators. Because of an apparent relationship between nesting and nutrition or food availability, habitat manipulation directed at improving body condition of females through improved abundance and distribution of food would likely improve nesting rates of Merriam's turkeys (e.g., Wakeling 1991, Wakeling and Rodgers 1995, Hoffman et al. 1996).

Summary and Conclusions

The likelihood that adult or yearling Merriam's turkeys attempt to nest varies spatially and temporally, probably in relation to population density or physiological condition of females at the onset of nesting. Food availability and nutrition may be the most direct link to nesting rates. In addition to installing food plots, silvicultural treatments are available to increase mast production of oak, pine and other mast producing species. Adult female Merriam's turkeys exhibit greater reproductive success than yearlings, i.e., after their second spring. In general, low reproductive output among yearling females results from low rates of success from the first nesting attempt with little or no likelihood of renesting. Renests have a greater chance of hatching, but renest rates are highly variable. Populations of Merriam's turkeys with a high percentage of nesting by yearling females are more resilient to population declines and nest loss than those in which yearling females are less likely to nest. Predators, weather, and habitat may interact to influence nesting success with coyotes, crows, ravens, and magpies being major nest predators.

Predation is the primary source of mortality to female Merriam's turkeys, most of which is attributed to coyotes. Merriam's turkeys commonly live 3-5 years and some >8 years. Because of their longevity, we hypothesize that mortality is only partially compensatory. Population models suggested that altering survival of adult females increases turkey populations in which yearlings do not nest. However, increased nesting by yearlings probably has the greatest potential to increase populations of Merriam's turkeys.

Survival of poults is generally quite low. While, low survival of poults is common among all subspecies of wild turkeys, indications are that some of the current Merriam's turkey range may lack high-quality brood habitat. Poults should be capable of flight in approximately 9 days. They occasionally remain flightless for >2 weeks, which suggests less than optimal growth and development. Growth and development of turkey poults is linked to invertebrate abundance, which in turn is linked to the abundance of herbaceous vegetation in meadows.

Most of the information on Merriam's turkey populations is from studies of habitat relations. Except for Arizona, studies with sufficient sample sizes from which to estimate cause-specific mortality rates are lacking. Consequently, we recommend that future studies address cause-specific nest losses and mortality rates to Merriam's turkeys. Similarly, data are lacking on rates of poult survival, causes of mortality, and measures of survival related to habitat quality. We believe the need for these studies encompasses most of the current range of Merriam's turkeys. We believe population sensitivity modeling could identify the limiting factors to Merriam's turkey populations.

Acknowledgements

We gratefully acknowledge the support of the Rocky Mountain Research Station, Arizona Game and Fish Department, South Dakota Agricultural Experiment Station, South Dakota Department of Game, Fish and Parks, National Wild Turkey Federation Grant-in-Aid Program, and Federal Aid in Wildlife Restoration funding for direct support of our research. We extend appreciation to several National Forests and State game agencies for their support of research on Merriam's turkeys that we included in this paper. H. G. Shaw, R. W. Hoffman, Dr. J. A. Crawford, and two anonymous review's provided valuable comments that greatly improved this manuscript.

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Received 23 September 2002
Accepted 14 March 2003

Repeal of Idaho's Prevailing Wage Law: An Economic Evaluation

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Abstract

We studied the effects of repealing Idaho's prevailing wage law, particularly on Idaho's construction trades employees, county and state economies, and state public works expenditures. We used trend and regression analyses as well as IMPLAN input–output modeling using data from a wide range of sources. We found a strong downward trend in average construction wages in Idaho for both union and nonunion jobs. Salary losses have since dramatically increased that lowered Idaho's national ranking for average earnings/construction worker. These trends implied that (1) construction wages in Idaho fell sharply since repeal of the prevailing wage law and relative to the rest of the nation, and (2) despite Idaho's rapid population and economic growth, repeal of the prevailing wage law may have exerted downward pressure on *all* wages in Idaho.

Key Words: prevailing wage laws, efficiency wage theory, unions, average wages, construction.

Introduction

In 1985, the Idaho legislature repealed Idaho's prevailing wage law. As a matter of public policy, legislation on the payment of prevailing wages to construction workers raises issues that include level of government expenditures, economic growth rates, economic well-being of employees, and potential shortages of qualified workers. These interrelated issues concern specific economic variables. Does a prevailing wage law affect the wages of all or just some construction workers? If prevailing wage laws change construction wages, what employment effects might we expect? What happens to construction-worker training programs and worker productivity when prevailing wages are paid? Are the costs of state and local public works projects higher or lower with prevailing wages? These among many more questions arise when legislative discussion focuses on prevailing wage laws. During 1999 the Center for Business Development and Research, University of Idaho, initiated an inquiry of the effects of repealing Idaho's prevailing wage law on Idaho's construction trades with funding from the North Idaho Central Labor Council.

Idaho's prevailing wage law, enacted in 1911 as a part of eight-hour workday legislation, was amended several times from 1911 to 1965. Efforts to repeal this law and to pass a state "right to work" law began in 1979, and by 1985 both of these legislative initiatives were successfully enacted. In repeal discussions, market economists argued that substantial savings on public construction costs would result. Several studies of the impacts of repeal have not found conclusive evidence that repeal has saved a significant amount of public funds.

Study Objectives

Past studies of the effects of prevailing wage laws in other states supported the hypothesis that this legislation increased wages in covered industries, i.e., industries whose employees are covered by unemployment compensation. Those results suggest that for the period of 1911-1985 wages in the building trades for Idaho's public works projects were above those in non-covered portions of the construction industry. In his studies, Philips (1995, 1998, 1999) found a substantial wage advantage to the existence of a prevailing wage law and a reduction in wages associated with the repeal of prevailing wage legislation. In his employee compensation regression analysis Philips used variables for trend rates of growth, regional location, and business cycles. Our hypothesis in this study is that the construction earnings effects of Idaho's prevailing wage law repeal will be consistent with Philips' findings.

For our second study objective we extend our analytical scope beyond that of Philips' study to estimate changes in county and state overall economic activity in terms of variation in trend growth rates for output, value added, earnings, and employment in all business sectors. We obtained estimates of the macroeconomic aggregates using Impact Analysis for Planning (IMPLAN) modeling techniques.

Our third objective was to determine if a decline occurred in the level of occupational maturity of construction workers relative to industry standards. Occupational maturity is measured by injury rates in the construction industry. The hypothesis is that construction firms will use lower-cost, inexperienced construction workers with a consequent increase in on-the-job injuries.

A fourth research objective was to test the hypothesis that declines in construction wages and productivity have resulted in higher total costs for public works projects funded by the State of Idaho. One justification for repealing prevailing wage laws is the belief that costs of public works construction projects would decline based on the assumption that wages could be reduced without comparable reductions in productivity. Efficiency wage theory links pay with labor productivity; specifically higher pay results in increased employee productivity. If the proponents of repeal were correct, repeal would lower pay rates without significant declines in productivity and result in lower public works project total costs. Philips presented evidence supporting his hypothesis that repeal of Utah's prevailing wage law would not lead to decreased public works project costs.

Although all objectives are analyzed, the focus of this paper, however, is primarily on the first objective.

Methods and Data Sources

Our research employed statistical trend and regression analyses, comparisons of predicted values with actual data, and IMPLAN input–output modeling of county and state income impact assessments using multiplier-based predictions. We measure a substantial portion of the economic impact on wages, earnings, and employment by deviations in the trends. In dynamic economies prices, allocation of resources, and overall growth constantly change. In trend analyses historical data are used to estimate underlying economic structures and links. We use trend analysis to predict what would have happened if the repeal had not occurred. Regression analyses identify underlying economic structures and links. Regression coefficients and the tests for statistical significance indicate which variables might best explain wage or employment level, how important those variables are, and how well the theory fits the facts. Using the regression equation, we predicted future wage and employment levels.

The IMPLAN input–output system is a technique for assessing the impact of economic changes on a regional economy, such as industry growth or decline. Originally developed by the USDA Forest Service, the IMPLAN modeling system incorporates the economic links within and among a region's industries, households, and export sectors. Using the multiplier analysis associated with this economic modeling system, we predict changes in the industries that constituted the region's economy. We state changes in terms of income, employment, and industry outputs.

We obtain the majority of the data for the project from federal and state government sources, including Regional Economic Information Systems (REIS) and other U.S. Bureau of Economic Analysis units, the Idaho Industrial Commission, the Idaho Department of Labor, and the U.S. Bureau of the Census.

Results

We present results by study objective. Our first objective was to apply Phillips' Study hypothesis to Idaho, which states that repeal of prevailing wage laws will cause a decline in real construction wages.

Objective One: The Phillips Study Hypothesis

Several approaches are utilized to examine the Phillips Study hypothesis as it applies to Idaho.

Approach 1: Increase in Sole Proprietors.—First we look at the increase in sole proprietor construction firms since repeal, a possible market response to declining construction incomes. Construction employment is observed over the course of the business cycle in the 1980s and 1990s. Employment fell from 1979 through 1983 and again in 1986 and 1987, but rose steadily from 1987-1999 (Fig. 1). An interesting aspect was the growing difference between covered employment, i.e., covered by unemployment compensation, and total employment, i.e., covered and uncovered employment (Fig. 1). Proprietorships are included in total, but not covered, employment and account for the difference in the two statistical series. Most likely, this growth correlated with economic expansion, but also may be explained partly by the increased number of construction workers establishing their own businesses (as contractors), possibly in response to the change in wages associated with the repeal. *County Business Patterns* data from the U.S. Bureau of the Census confirms this trend. From 1986 until 1997 the number of construction firms increased every year, with the exception of 1988. In 1986 there were 1869 construction firms, and by 1997 there were 5436—an increase of 191 percent.

We used regression analysis as illustrated below to estimate the degree to which repeal increased new construction firms:

$$Y = 4909 + 943X_1 - 375X_2$$
$$(3.92) \quad (2.01) \quad (-2.32)$$

in which Y = total number of construction firms, and X_1 = a dummy variable representing repeal, and X_2 = unemployment rate representing the business cycle. The *t*-statistics, shown under the coefficients, are significant at the 5-percent level. The adjusted R-squared is 0.43; thus, the model explains about 43 percent of the variation in the dependent variable. An estimated 943 more construction firms were created as a result of repeal of the prevailing wage law. The sign of the coefficient on unemployment is negative as expected given the inverse relationship between the unemployment rate and increased business activity in the construction sector. These variables provided strong statistical support to our hypothesis that individuals went into business for themselves, a form of occupational mobility.

Approach 2: Out-of-State Firms.—A second approach to confirming Phillips' hypothesis in Idaho was to examine the effect of the prevailing wage law's repeal on the participation of out-of-state firms in Idaho construction industries; we examined census data on commuting obtained from the 1980 and 1990 censuses. Fewer out-of state construction firms were taking bids in Idaho in 1990 than in 1980 (Table 1). The out-of-state firms working in Idaho paid more in 1990 than in 1980 after adjusting for inflation. Furthermore, more Idaho firms worked out-of-state in 1990 than in 1980, but their wages had fallen sharply, even on those projects conducted out-of-state. The commuting data suggest a change in

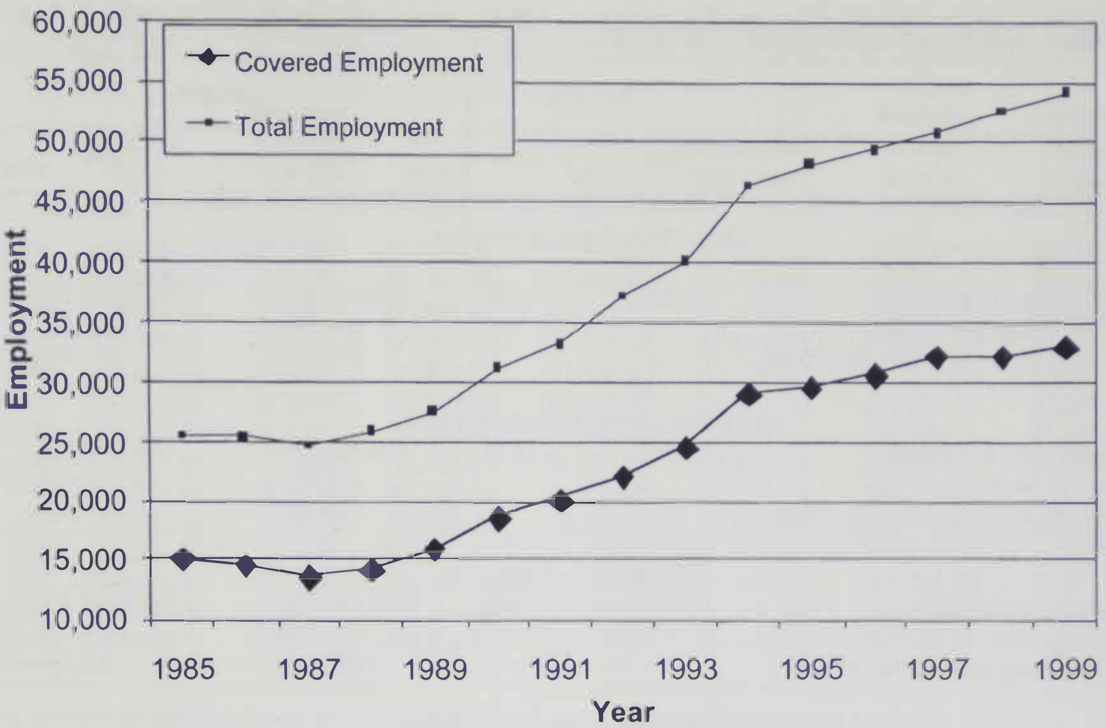

Figure 1. Covered and Total Construction Employment in Idaho, 1985-1999

behavior by Idaho firms engaged in construction projects within and outside the state. Some firms headquartered outside Idaho worked on projects within Idaho between the census years before and after the repeal of the prevailing wage law.

The employment and wage data from the 1980 and 1990 censuses indicated the number of workers employed by Idaho construction firms increased from 15,691 to 17,475. Using the wage and employment data, the average annual wage rose from $14,563 to $20,868. When these averages were adjusted for inflation, the real wages paid by Idaho firms on in-state projects fell 9.7 percent. The comparable data on employment and wages for Idaho firms working on projects outside Idaho showed that employment increased from 1245 to 1670, and the annual average real wage fell 22.0 percent.

The census-commuting data suggested that fewer out-of state construction firms were taking bids in Idaho, with employment at those firms declining from 472 to 325. However, for those out-of-state firms who worked on projects in Idaho, the data indicated they were paying 20.4 percent more in real wages in 1990 compared to 1980. Moreover, the annual average real wage paid by out-of-state firms on projects in Idaho were 24.5 percent higher than what Idaho firms paid on projects in Idaho and suggested that out-of-state firms had underbid Idaho firms on certain types of in-state construction projects even though out-of-state firms had higher labor costs. One possible reason for the bidding success of out-of-state firms was the level of labor skills that were no longer available in the Idaho labor force making it difficult for an Idaho firm to submit a bid. Alternatively, it may have been the case that the relatively higher-wage labor employed by out-of-state firms was sufficiently more productive to result in lower production costs for out-of-state firms.

Approach 3: Apply Statistical Parameters to Idaho.—The third approach in confirming the Phillips hypothesis to Idaho is to apply the statistical parameters of the Phillips Study to Idaho data. In the University of Utah economic study of the repeal of nine prevailing wage laws, Philips et al. (1995)

Table 1. Construction Firms, in 1980 and 1990

	Workers		Wages	
	1980	1990	1980	1990
Idaho Firms Working in Idaho				
Construction employees	15,691	17,475	$228,513,514	$364,664,853
Average wage per worker			$14,563	$20,868
Average wage per worker (in $1999)			$29,233	$26,408
Idaho Firms Working Outside Idaho				
Construction employees	1,245	1,670	$24,168,252	$40,107,252
Average wage per worker			$19,412	$24,016
Average wage per worker (in $1999)			$38,966	$30,392
Total Idaho Firms				
Construction employees	16,936	19,145	$252,681,766	$404,772,105
Average wage per worker			$14,920	$21,142
Average wage per worker (in $1999)			$29,948	$26,756
Out-of-State Firms Working in Idaho				
Construction employees	472	325	$6,829,564	$8,978,040
Average wage per worker			$14,469	$27,625
Average wage per worker (in $1999)			$29,044	$34,959

Source: U.S. Bureau of Economic Analysis REIS. *Journey to Work.* 1980 and 1990.

reported the results of their regression analysis using an extensive data set that included 27,778 observations of annual construction earnings, cross-classified by state and type of construction contractors, from 1975 through 1991. Using the statistically derived importance of their regression equation factors, Philips et al. reported estimated effects on annual earnings, employment, and tax revenues of the laws' repeals. Using data for the State of Idaho and the regression model's parameters, we estimated the impacts on average annual earnings, employment, and state tax revenues for 1986, the first year after the law's repeal, through 1999.

Results shown in Table 2 were derived from the Phillips regression model parameters applied to Idaho data. The model analyzes the effects in Idaho of prevailing wage law repeal on construction earnings, adjusting for regional differences in average earnings and normal growth trends. Average annual earnings of $33,005 was the estimated starting point from which $79 was subtracted because the average income level of Idaho's mountain state location is less than the national average (regional control variable). The next adjustment was to compensate for the economic impact on earnings of having had the prevailing wage law repealed (repeal variable). Income, or earnings level, also was adjusted for a secular or normal growth trend for the economy. In the Utah study, construction earnings or incomes were predicted to increase each year at the rate of $225/year. This increase would occur simply with the passage of time, most likely linked to productivity and price level changes. An unemployment rate adjustment was the last element in the explanatory equation, and it captured the effects of the business cycle experienced in Idaho.

In 1986 the predicted average annual earnings was $26,238.07, which is $6766.93 less than the starting point. The magnitude of the predicted "Lost Income" varied between $6337.62 and $8539.73 over the forecast period. The income loss shows

Table 2. Regression Model for Idaho, Based on Philips's Regression Equation, 1986–1999.

Year	Starting Point	Regional Control Variable	Repeal	Secular Trend	Unemployment Adjustment	Predicted Average Annual Income	Predicted Lost Income
1986	$33,005.00	($79.00)	($1,350.00)	($2,700.00)	($2,637.93)	$26,238.07	$6,766.93
1987	$33,005.00	($79.00)	($1,350.00)	($2,925.00)	($2,425.68)	$26,225.32	$6,779.68
1988	$33,005.00	($79.00)	($1,350.00)	($3,150.00)	($1,758.62)	$26,667.38	$6,337.62
1989	$33,005.00	($79.00)	($1,350.00)	($3,375.00)	($1,546.37)	$26,654.63	$6,350.37
1990	$33,005.00	($79.00)	($1,350.00)	($3,600.00)	($1,788.94)	$26,187.06	$6,817.94
1991	$33,005.00	($79.00)	($1,350.00)	($3,825.00)	($1,879.90)	$25,871.10	$7,133.90
1992	$33,005.00	($79.00)	($1,350.00)	($4,050.00)	($1,970.87)	$25,555.14	$7,449.87
1993	$33,005.00	($79.00)	($1,350.00)	($4,275.00)	($1,879.90)	$25,421.10	$7,583.90
1994	$33,005.00	($79.00)	($1,350.00)	($4,500.00)	($1,697.98)	$25,378.02	$7,626.98
1995	$33,005.00	($79.00)	($1,350.00)	($4,725.00)	($1,637.33)	$25,213.67	$7,791.33
1996	$33,005.00	($79.00)	($1,350.00)	($4,950.00)	($1,576.69)	$25,049.31	$7,955.69
1997	$33,005.00	($79.00)	($1,350.00)	($5,175.00)	($1,607.01)	$24,793.99	$8,211.01
1998	$33,005.00	($79.00)	($1,350.00)	($5,400.00)	($1,516.05)	$24,659.95	$8,345.05
1999	$33,005.00	($79.00)	($1,350.00)	($5,625.00)	($1,485.73)	$24,465.27	$8,539.73

a generally upward trend (Fig. 2). The downstream impacts of the lower income levels would have included lower levels of spending, a lower growth trend in state economic activity because of the lost spending, and a lowered level of taxes paid by construction workers.

Our regression model predicted associated employment changes with the repeal of prevailing wage law in Idaho. Substantial evidence suggests that prevailing wage laws are statistically correlated with higher wages; states without coverage by such legislation report lower wages. Because of the law's repeal, wages in the construction industry have been lower and employment should be higher. Market economists associate lower wages with higher levels of employment, rather than higher profitability for construction

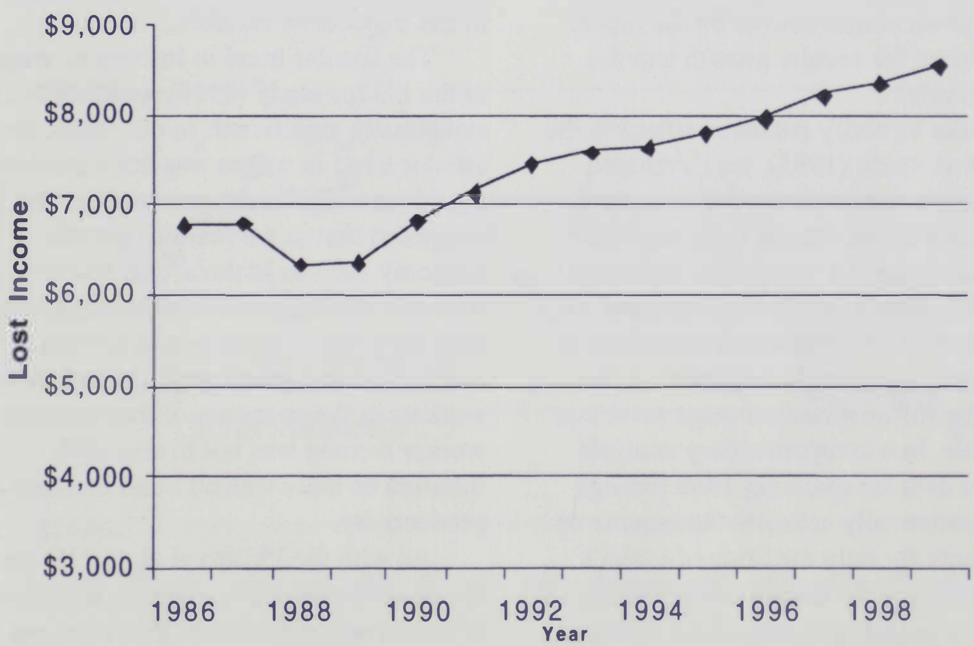

Figure 2. Average Lost Income per Job As a Result of the Repeal of Idaho's Prevailing Wage Law, 1986–1999

Table 3. Net Loss of Income and Employment Due to Repeal of the Prevailing Wage Law, in Idaho, 1999

	Direct	Indirect	Induced	TOTAL
Employee Compensation	$20,882,011	$4,663,837	$4,903,093	$30,448,942
Employment	1,251	270	292	1,813
Total Personal Income	$25,026,724	$6,386,074	$6,026,959	$37,439,757
Sales	$200,000,005	$18,756,705	$16,933,188	$235,689,898
Total Value Added	$43,342,292	$10,255,103	$10,293,006	$63,890,402

contractors. Our model's employment projections indicated that the average level of employment across the various components of the construction industry declined by 2.7 percent in 1986. Those components were viewed as either an industry or occupation class of construction workers, such as plumbers and pipe fitters. A recession in the Idaho economy was a major reason for this decline in employment. During the remainder of the forecast period, employment in construction was predicted to have been higher than it would have been without the repeal, except in 1990. The percent increases in employment from lower wages ranged from <0.1 percent in 1991 to 7 percent in 1988. Since 1995 percent increases in employment have fell between 4 and 6 percent. The employment gains associated with the lower wages caused by the repeal were adjusted for secular growth and the business cycle.

In order to verify results obtained in the Philips et al. study (1995), we developed and tested a comparable model for only the Idaho economy. Income or wage analysis in Philips' study used a very large, multistate data set that began in 1975 and spanned 16 years. Because of information contained in that data set, a regional component in the predicted state construction wage level was identifiable. In a complementary analysis we used a data set spanning 1969 through 1997 to statistically estimate the income or wage effects for only the State of Idaho's repeal of the act. To ensure comparability of the current results with that of the Philips study, we used the same explanatory variables, with the exception of the regional control variable. The explanatory power of the included variables in the Idaho equation accounted for two-thirds of the observed changes in construction wages or income. For our Idaho analysis the comparable starting point, or intercept term, was $33,283 or $278 more than the Philips study results below and shown for Idaho in Table 3.

$$Y = 33{,}283 + 37.1X_1 - 4{,}236X_2 - 265X_3$$
$$(16.5) \quad (0.55) \quad (-3.4) \quad (-1.09)$$

where Y = average construction wage, X_1 = secular trend variable, X_2 = dummy variable representing repeal, and X_3 = business cycle proxy as represented by the unemployment rate. The *t*-statistics, shown under the coefficients, are significant at the 5 percent level. The adjusted R-squared is 0.66, thus the model explains about 66 percent of the variation in the dependent variable.

The secular trend in income or wages in the Philips study (1995) was positive and statistically significant. In our study, the secular trend in wages was not statistically significant. This result was unexpected and suggested that in a dynamic, growth economy such as Idaho's, construction workers' earnings were not keeping pace with the general trend rate of growth in the earnings or income experienced by other workers in the economy. Either construction worker income was not in step with inflation or there was no trend increase in productivity.

As with the Philips et al. (1995) study the dummy variable measuring the impact of repeal was significant. However, we estimated impact of repeal at $4236, or three times larger than that found in Philips' multi-state analysis. The *t*-statistic for the dummy variable was -3. This larger figure suggested that in the case of Idaho's construction workers, repeal has had a much larger negative effect on wages than that experienced in other areas of the country. The small estimated difference associated with repeal found in the Philips estimates may have been attributable to the smaller wage or income impacts in other, larger states and overwhelmed the effects noted in Idaho. Clearly, repeal of the prevailing wage law was more important in explaining Idaho construction wage changes than it was in Philips' construction wage study.

The business cycle component explaining wage or income levels of Idaho's construction workers was measured by the state's unemployment rate. The estimated coefficient for the unemployment rate was a negative $265, or $38 less than the Philips' result; it implies that as the unemployment rate increased, the earnings of construction workers declined, an expected result but the variable was not significant. The *t*-statistic for the unemployment term was -1.09 as measured at the 5 percent level of significance. Rising unemployment rates generally mean less demand for workers and declining earnings; falling unemployment rates are associated with rising wages. Overall, results of our study consistently followed those, which provided further credibility to the statistical results. If there were a notable difference, it was in the effects of the time trend for earnings.

Approach 4: Changes in Real Wages.—Our fourth approach in testing the Phillips hypothesis was to examine differences in inflation-adjusted wages over time. To understand relative income changes for construction workers in Idaho as compared to national averages, we calculated their price-adjusted, or real, earnings from 1969 to 1997. The data presented in Figure 3 indicate Idaho construction workers received earnings below the national average through the 1970s, then the 1980s improved their position relative to the national average. Since repeal of the prevailing wage law in 1985, price-adjusted earnings of Idaho construction workers have shown a steady decline with the largest difference occurring in 1997.

To put this difference in earnings in

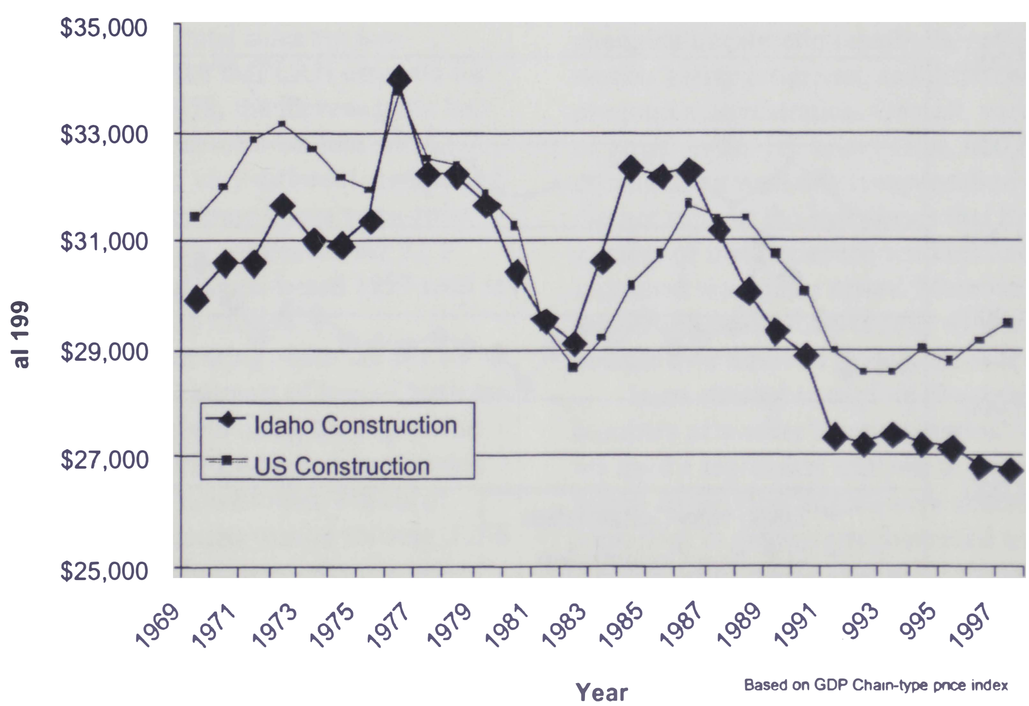

Figure 3. Real Construction Earnings Per Worker 1969-1997 U.S. and Idaho Averages (Base Year = 1992)

context, we calculated the real earnings of non-construction workers. The national non-construction workers' average earnings were consistently above those of Idaho's workers (Fig.4). The national trend showed a more rapid increase than that in Idaho. From a competitive perspective, Idaho most likely will begin to experience labor shortages in the construction industry because real earnings in other occupations and other parts of the country have been growing, although the real earnings of construction workers have been in decline.

A significant change in analysis occurred when we shifted our focus from average annual construction earnings to total earnings in Idaho. Using structures in the Philips study, we generated comparable estimates of the loss to state government tax revenues associated with the income loss realized by Idaho construction workers. The total construction earnings for 1999 were $1.63 billion, which was $37.8 million less than would have occurred without repeal of prevailing law. Throughout the period of 1985–1999 total loss of income for construction workers due to prevailing wage law repeal was larger than total incomes earned by the additional construction workers linked to the lower wages resulting from the repeal.

Employment in construction would have increased due to normal growth and the overall economic expansion. Total earnings for construction workers were lower than they otherwise would have been. Because of this earnings penalty or loss, retail businesses have lost sales, and the state has lost revenue from both sales and income taxes. Over this period the state lost a total of $25.4 million in taxes. In order for the state to compensate for the tax revenue lost since the repeal, our analysis suggested that savings on public works projects from changes in construction earnings would only have had to exceed $25 million. Effectively, government agencies would have had to save $1.8 million on average/ year on construction projects just to break even with the lost tax revenues.

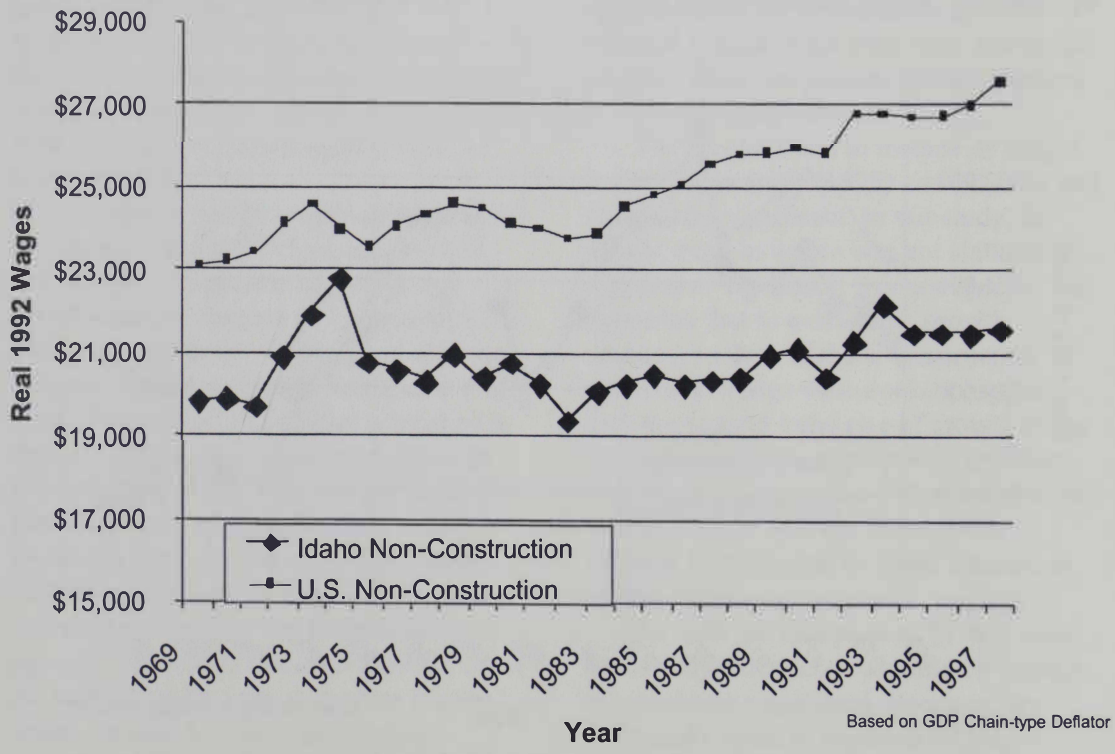

Figure 4. Non-Construction Earnings Per Worker Comparison — U.S. and Idaho

Objective Two: Lost Wages and Earnings on the Idaho Economy—IMPLAN

For our second study objective we extend our analytical scope to estimate changes in county and state overall economic activity in terms of the variations in trend growth rates for output, value added, earnings, and employment in all business sectors. The lost business sales associated with repeal retarded growth in the state's economy. Idaho's current business expansion would have been even more robust if it had enjoyed the higher level of sales lost due to the repeal. To check our estimates of the total tax effect of the repeal we generated an IMPLAN model of Idaho's economy to identify the overall effects of change in economic activity. The direct spending changes (first column of Table 3) from our IMPLAN estimates used a net income loss of $8540 per construction worker. The indirect and induced estimates were downstream effects of those changes and were the earnings, employment, sales, and output lost when businesses lost sales and cut back their level of operations. Using the proportions of income spent on sales, an average sales tax rate, and an average income tax rate, total sales tax loss associated with the IMPLAN estimate for 1997 was $575,458; the income taxes lost were $1.1 million; total tax loss was $1.7 million. Our two very different methods of estimating tax revenue losses were quite close in magnitude—compare our $1.7 million with the Philips-based 1997 total tax loss figure of $1.6 million.

What is interesting about the use of IMPLAN is the estimate of loss of business activity not obtained using the regression approach. The IMPLAN model estimated that, because of downstream effects of losses of construction worker income, $236 million in Idaho business sales never occurred. Furthermore, $64 million of Idaho's production of goods for the marketplace, as measured by value added, was lost. The lost taxes, lost business sales, lost production, and downstream jobs are the actual economic cost of the repeal.

As noted in our discussion of Figure 1, there have been a growing number of proprietorships in the construction industry, which suggested that individuals gaining experience in construction may have migrated away from traditional employment relationships. When wages decline in Idaho relative to the returns available in other states or for occupational choices, economic theory presumes that people will go where they can reap higher returns. This theory suggests that experienced construction employees may look elsewhere to maximize their returns, resulting in a less experienced workforce in Idaho's construction industry.

Objective Three: Decline in Occupation Maturity

We acquired data on construction industry injury rates to examine other aspects of the occupational maturity or experience level. We argue that less experienced workers have less expertise or human capital and are less productive. We attempted to estimate the effects of the repeal on occupational injury rates. The percentage of construction-based worker's compensation claims had a general downward trend (Fig. 5), reflected the national trend, and may have been due to changing construction methods, national worker safety programs, and differences in program administration. Overall, variations of gross on-the-job injury rates, as measured by worker's compensation claims, did not support the hypothesis that the number of inexperienced workers had increased workplace errors. Moreover, lost wages and medical costs (Fig. 6) were volatile over time and showed no clear trends.

In an attempt to explain changes in the numbers of worker's compensation claims, we used a regression analysis to determine which underlying factors were statistically important in determining observed trends. Because of overall volatility in the injury claims data, we adjusted the number of claims to an average claim rate, then examined Idaho's claim rate as compared to the nation's average claim rate. Due to several legislative factors and the institution of new methods of production, both the

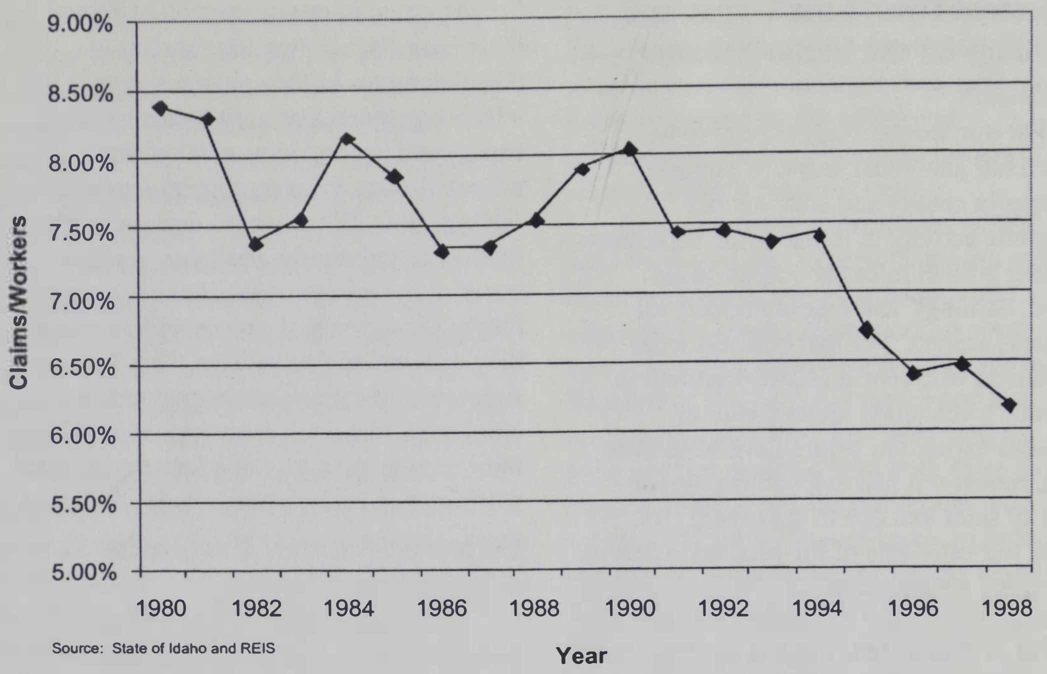

Figure 5. Worker's Compensation Claims—All Industries as a Percentage of Total Idaho Workers

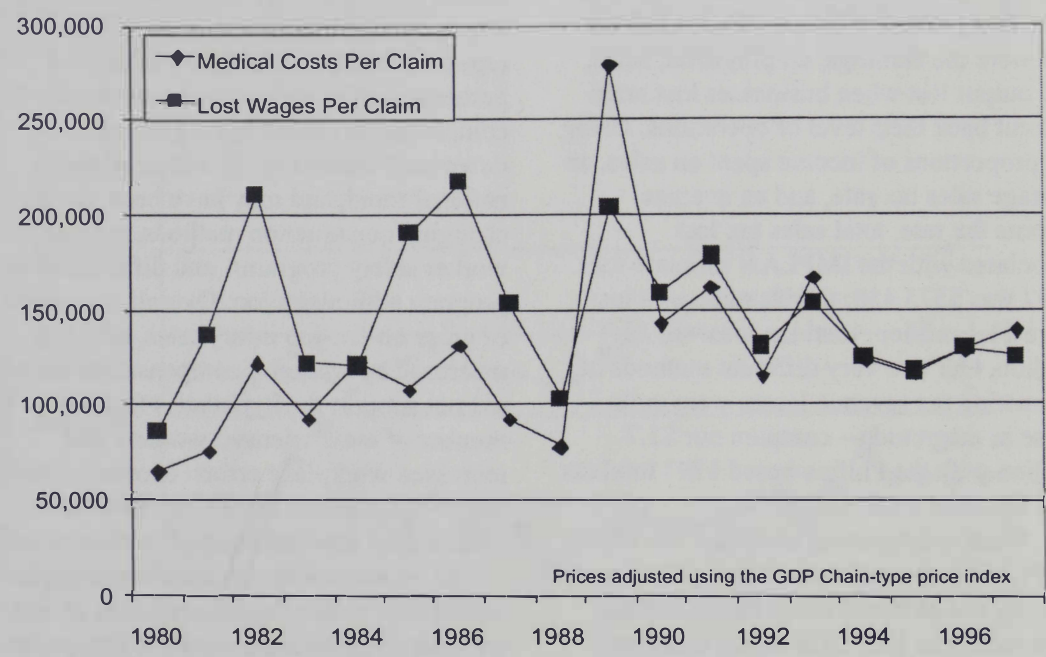

Figure 6. Real Lost Wages and MedicalCcosts Per Worker's Compensation Residential Construction Claim, 1980-1998 (1996 Dollars)

average claim rates for Idaho and the nation declined over the period addressed by our analysis. However, our statistical analysis indicated that Idaho's claim rate behaved differently than the nation.

The results of the regression equation appear below:

$$Y = 0.133 + 0.0145X_1 - 0.0051X_2 - 0.002X_3$$
$$(5.56) \quad (1.75) \quad (-1.94) \quad (-2.35)$$

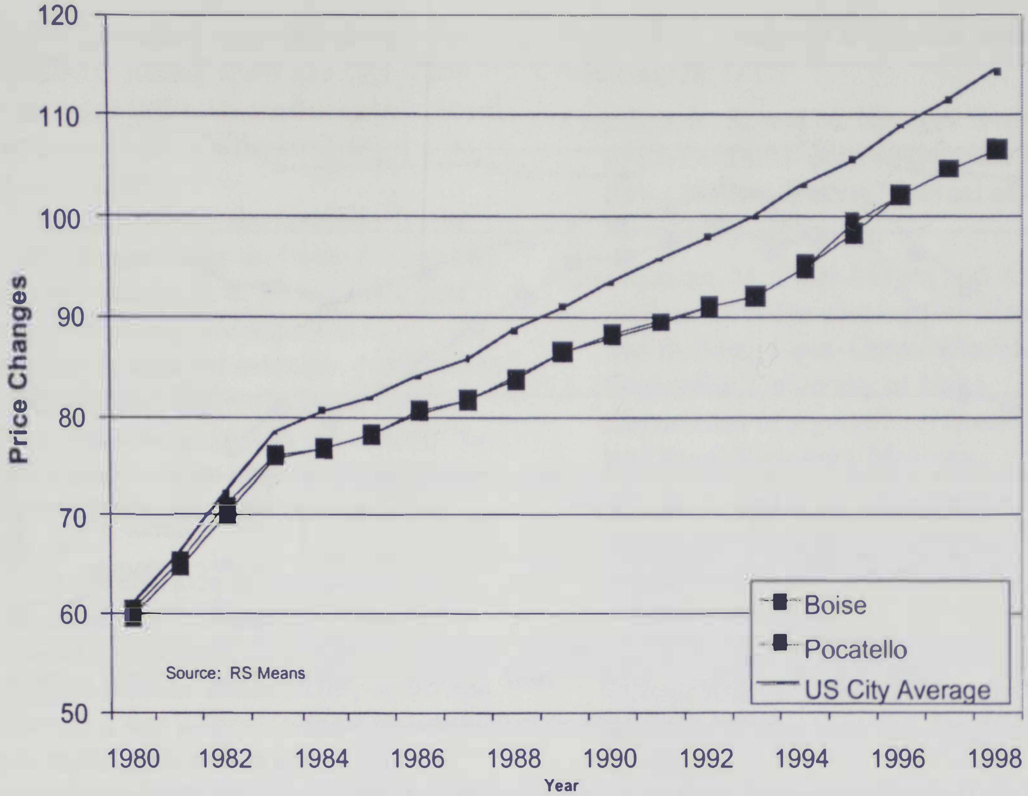

Figure 7. Idaho Construction Price Index Compared to US Average—1980-1997

where Y = injury claim rate, X_1 = dummy variable representing repeal, X_2 = business cycle proxy as represented by the unemployment rate, and X_3 = secular trend variable. The *t*-statistics, shown under the coefficients, are significant at the 5-percent level. The adjusted R-squared is 0.22, thus the model explains about 22 percent of the variation in the dependent variable

The largest coefficient, and thus most important factor in the statistical explanation of the difference in claim rates, was repeal of the prevailing wage law (X1). The magnitude and positive sign of this variable indicated that for those years without a prevailing wage law, Idaho's injury claim rate exceeded the nation's claim rate. The small, negative coefficient for the time trend suggested that the difference between Idaho's and the nation's injury claim rate was slowly shrinking. Possible or likely reasons for Idaho's claim rate approaching the nation's claim rate in the long term were compliance with statutes, and the diffusion of new construction technologies.

The negative coefficient for the unemployment rate (X_2) suggests that when Idaho's economy was slowing, there was a slight increase in the difference between the state's and the nation's claim rates. It may have been that shortcuts on job sites or the use of lower-priced labor were undertaken to keep construction costs down and profits up, and those shortcuts and low-wage labor caused a small increase in injury claim rates.

Objective Four: Declines in Worker Productivity Lead to Higher Costs

To test our hypothesis that there have been declines in construction worker productivity and consequently higher costs, we acquired R. S. Means construction price index information. One justification for repealing prevailing wage laws was the belief that costs of public works construction projects would decline because wages could be reduced without reduction in the overall productivity of the labor force. In several studies including Phillips

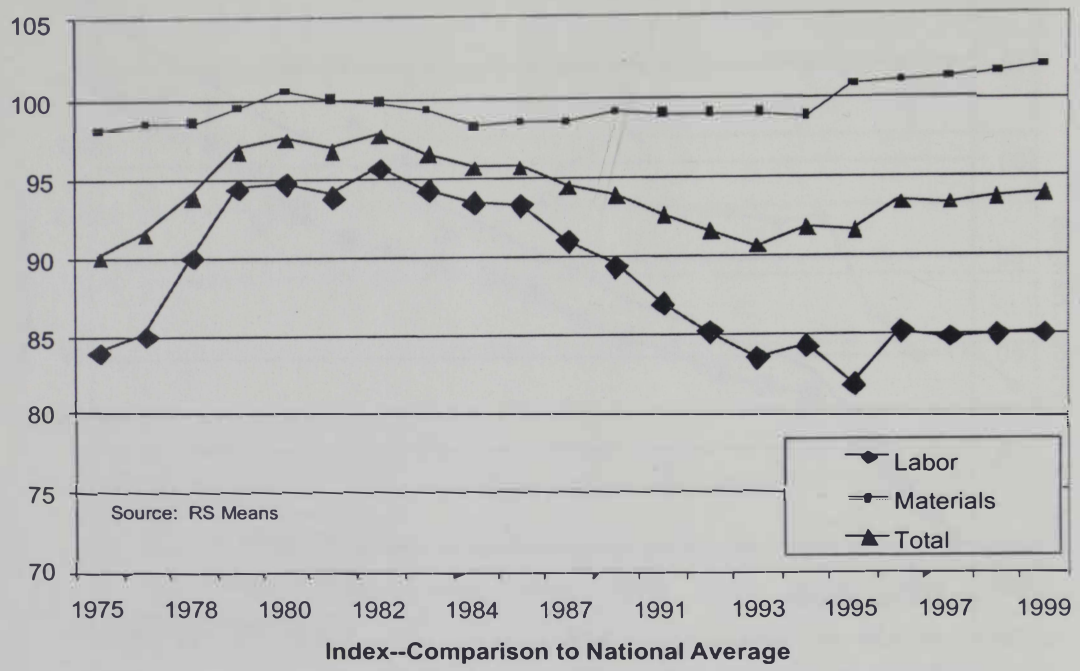

Figure 8. Boise Construction Price Index 1975-1999, as Compared to the National Average

et al. (1995), researchers were unable to detect a statistical relationship between school construction costs and prevailing wage laws, which meant that you could not predict lower construction costs with the repeal of a prevailing wage law.

Mainstream economic theories link pay with productivity in what is called the "efficiency wage hypothesis," specifically higher pay means higher employee productivity. If lower wages and productivity declined less than wages fell, there would have been a decline in overall project costs as purported by repeal advocates. One of the difficulties with using the construction index was that it is comprised of combined wage and productivity changes, and the two effects are inseparable in the information supplied.

Since the passage of the repeal in 1985, construction cost indices for Idaho cities seemed to parallel the national city average and suggested that there may have been a decline in wages, productivity, or both, and that little has changed since (Fig. 7).

Relative cost of construction materials showed a remarkable stability over the period from 1975 to 1999 (Fig. 8), suggesting that material costs in the Boise area have changed at the same rate as the nationwide city average. Relative costs of labor on Boise construction projects showed a slightly different pattern. Taking estimated wages and productivity of labor into account, the Boise's construction labor costs showed a sharp decline for the decade beginning shortly after the repeal. The deviation of trends noted in Figure 7 apparently was linked to a labor cost difference. The pattern strongly suggested initial cost savings associated with the repeal-based lower wages, and that wage increases and worker productivity declines were beginning to occur in the construction industry. The data displayed in Figure 8 clearly showed that Idaho real earnings declined for most of the 1990s and led us to conclude that, compared to national averages, productivity of construction workers in Boise was falling.

Conclusions

Our study statistically supported the hypothesis that prevailing wage legislation increased construction earnings although average lower wages were associated with repeal of prevailing wage legislation when compared to having never had such a law. We included IMPLAN modeling techniques to estimate change in the level of overall economic activity.

Our data clearly showed Idaho's real construction earnings declining for most of the 1990s and the R. S. Means labor cost component rising. We submit that, compared to national averages, productivity of construction workers in Boise was falling. We concurred with the result of the Philips study—there may not have been a cost savings to repealing the prevailing wage law.

On the cost side of the government revenue benefit–cost equation were tax revenues lost because construction workers were paid less and consequently spent less. Although it was difficult to find any benefit from repeal, cost was in excess of $1.8 million/year. Furthermore, the IMPLAN estimates clearly indicated losses of business sales, production, and jobs. Those losses to Idaho businesses and households slowed the rate of economic growth.

Using construction industry injury rates as an index of workers' experience, we found that repeal of the prevailing wage law a significantly explained Idaho's injury claim rate being higher than the nation's claim rate.

With the repeal of the prevailing wage law, a number of construction workers entered the construction industries as contractors (sole proprietorships). That is, construction workers quite likely established their own businesses in response to the decline in wages associated with the repeal.

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Received 19 August 2002
Accepted 30 April 2003

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Design and Layout ~ **Media Works, Bozeman, Montana**
Printing ~ **Kwik Kopy Printing, Bozeman, Montana**

Intermountain Journal of Sciences

Vol. 9, No. 1 - 2003

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