Final Report

The Potential Economic Impact on the Economy of Southeastern Wyoming from Designation of Critical Habitat for the Preble's Meadow Jumping Mouse

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EXECUTIVE SUMMARY *(Final Report September 15, 2004)*

Introduction

The purpose of this report is to identify and analyze the potential impact on the economy of Southeastern Wyoming from designation of critical habitat for Preble's Meadow Jumping Mouse (PMJM). This report is a follow up to a preliminary report that was submitted on May 16, 2003. This final report expands on the economic implications of PMJM for agriculture and communities in the region.

PMJM was listed as a threatened species in May, 1998. In July, 2002 as a result of a lawsuit filed by several private conservation groups and individuals, the U. S. Fish and Wildlife Service (the Service) proposed designating critical habitat in Wyoming and Colorado. A final designation was scheduled for June 4, 2003. The proposed critical habitat in Wyoming included approximately 237 miles of rivers and streams and over 20,000 acres of land. Approximately 77 percent of this land is privately owned and approximately 94 percent is currently used for agricultural production. On June 23, 2003 the Service designated 125 miles of rivers and streams and 10,540 acres of critical habitat in Wyoming. Under the final designation, critical habitat in Wyoming was reduced by about one-half. Much of the private land is hay meadows, producing critical winter-feed for ranches in the region. Under sections 7, 9 and 10 of the Endangered Species Act (the Act) some or all of this production could be affected. This report differs from the Service's Draft Economic Analysis of Critical Habitat Designation for Preble's Meadow Jumping Mouse (Industrial Economics, Incorporated 2003) in that it considers potential effects on jobs and income resulting from actions associated with PMJM.

The State of Wyoming's position continues to be that convincing scientific evidence of the existence of PMJM, as a subspecies, has not been provided. A DNA study of the mouse, conducted by the Denver Museum of Science and Nature appears to support this position. The State submitted a petition to the Service based on this study to review the status of the mouse in December of 2003. The Service agreed to review the listing status. A decision is expected by December 2004. However, since the Service has designated critical habitat, and is apparently moving forward with a recovery plan, an economic analysis of the economic impact of PMJM on Southeastern Wyoming may still be warranted.

Procedures

As a first step in evaluating the economic impact of PMJM on the economy of Southeastern Wyoming, "listening" sessions were held in each of the five counties in the region. This was an opportunity for local landowners, businessmen, and county officials to indicate their concerns regarding the efforts to protect PMJM. The University Cooperative Extension Service in each county coordinated these listening sessions. The information from these sessions served as the starting point for the analysis.

The second step in the analysis was to evaluate the potential impact of PMJM on agricultural operations in the region. The Draft Economic Analysis and some of the

language in the Service's Critical Habitat Designation leave open the possibility of extending protective measures for species protection to a larger land area. Factors considered in this part of the analysis included effects on economic viability of agricultural operations and the potential for a Federal nexus among producers in the region. The analysis of economic viability was based on Economic Research Service's Commodity Cost and Returns Budgets for cow-calf operations in the Northern Great Plains. Information on the potential for a Federal nexus among agricultural producers in Southeastern Wyoming was obtained from various Federal government reports and agencies.

Step three in the analysis was to evaluate the economic impact of the changes in agricultural production on the economy of communities in Southeastern Wyoming. Because agriculture is linked to other sectors of the region's economy, a change in agriculture will have a ripple effect throughout the local economy. An IMPLAN model of the five-county region was developed to estimate the economic impacts of PMJM on total (direct and secondary) jobs and income in the region. Due to time constraints and the uncertainty associated with the how the PMJM program might be administered and the effects on agricultural production, the preliminary report considered only a worst case scenario of elimination of irrigation and a shift to dry land agriculture in Southeastern Wyoming.

Following submission of the preliminary report, the authors worked on refining their analysis at the firm level. That is, understanding the impact of critical habitat designation on a ranch in the region. To this end, a computer model was adapted to see the effects on profitability of different amounts and types of land put under protection and withdrawn from productive use. The model estimated the value of a mile of PMJM habitat of two different land types to the ranch and the effects on profitability should this land be withdrawn from production.

Results

The results of the listening sessions were startling. Anger, frustration, confusion and distrust were some of the sentiments felt at the sessions. Landowners and community leaders present were unanimous in feeling that the process appeared to by-pass some of the fundamental tenants of the American way of life. Many of the participants felt that the process and particularly the ESA was an assault on their property rights. At times the sessions became emotionally charged. The researchers also gathered information on which production practices would continue and which would be curtailed and how profitability would be affected.

Analysis of the USDA-ERS budgets showed that if ranchers are forced to cease hay production in order to protect PMJM habitat and instead must purchase hay, then average operating profit falls from $12.75 per cow to -$30.08 per cow with the probability of negative operating profit doubling from 33.3 percent to 66.7 percent. If transportation costs are factored in, then operating profits decline further to -$60.08 and the probability of negative operating profit goes to 100 percent.

An IMPLAN model of the five county region of Southeastern Wyoming was used to estimate the impact of critical habitat designation on the regional economy. The Service's Draft Economic Analysis notes that: "…Some incidental take of individual mice is inevitable during normal farming and ranching operations in the mouse's range." This suggests that, under Section 9 of the Act, a large part of the agricultural sector in Southeastern Wyoming could conceivable be affected by protection of PMJM. Given the current uncertainty regarding recovery efforts for PMJM, it is difficult to estimate the actual economic impact that the mouse will have on agriculture in the region. Despite the current lack of certainty, it is possible to estimate the economic importance of irrigated agriculture in the region that could be affected by PMJM. This could provide an indication of the economic importance of the sector that could be most impacted by protection of PMJM and also provide an upper limit on the potential economic impacts of PMJM on the regions economy.

The model estimated that if irrigation were to cease in Southeastern Wyoming due to PMJM, then the value of production of agriculture would decrease $177 million (-80 percent) per year. Agricultural employment was estimated to decrease by 3,000 jobs (-90 percent). Additionally, agricultural labor earnings are estimated to decrease by $75 million (-90 percent).

As another measure of the impact of critical habitat designation, this project used a computer simulation to evaluate the cost to the landowner of a mile of critical habitat on either a mile of sub-irrigated pasture (riparian zone) or a mile of hay meadow. The results show that one mile of sub-irrigated pasture would have an estimated cost of $2,271 ($25.96 per acre) per year, and the per mile cost increases with each mile of additional mile of sub-irrigated pasture on the ranch. On average, one mile of critical habitat would reduce ranch profitability about 6 percent per year.

When hay meadow is considered, the estimated cost per mile was significantly higher. The model shows that a mile of irrigated hay meadow reduced ranch profits by $7,163 ($81.90 per acre) per year. This would reduce ranch profitability nearly 20 percent per year. Again, these per unit costs increase with each additional mile on the ranch. With three miles of irrigated hay meadow critical habitat withdrawn from the ranch, the income for the ranch would fall below the U.S. Census Bureau's definition of poverty for a family of four.

As a policy scenario, the project built a simulation scenario that would cancel the model ranch's 500 aum U.S. Forest Service summer grazing lease. Although the ranch does have deeded summer pasture available, the USFS lease helps to maximize the ranch's resources by allowing enough additional herd size.

The model showed that canceling the USFS lease would reduce ranch profits by $4,586 per year. This would reduce ranch profitability by nearly 12 percent per year.

For the third part of the project, transferability, the researchers evaluated the process used in this project for applicability to future threatened and endanger species. It was decided that the process could be readily adapted to other species. However, the data used in the analysis appears to be highly specific to the species analyzed. So shifting analysis from one species to another is more difficult than first appears. This is due to the different habitat requirements of different species and their affect on agricultural operations. For example, the habitat requirements for PMJM are significantly different from that of the Colorado Butterfly plant, so although ranch profitability can be analyzed for both species, they affect profitability in different ways because they may effect the management of the ranch in different ways.

Conclusions

Most of the economic impact of PMJM in Southeastern Wyoming will be felt by agricultural production. Analysis of USDA-ERS budgets showed that if ranchers are forced to cease hay production in order to protect PMJM habitat and instead purchase hay, the average operating profit would become negative and the probability of negative operating profits would approach 100 percent. It is doubtful that many ranching operations could remain viable under this scenario.

The number of Federal nexuses in the region is likely to be significantly higher than reported in the Service's Draft Economic Analysis since Federal government reports show that nearly 50 percent of the commercial agricultural operations in the region receive government payments. The uncertainty surrounding the Federal nexus issue has many producers in the region apprehensive about participating in these programs.

Computer modeling at the firm level shows that the effect of removing land from production can have a significant impact on ranch profitability even at relatively modest levels. And the type of land removed is as important as the amount due to productivity and timing concerns.

Protection of PMJM has the potential to significantly impact the economy of Southeastern Wyoming. While protection may not completely eliminate irrigated agriculture, it could have a significant impact on an important industry in the region. Much will depend on if and how the Service decides to implement and administer future recovery programs.

Figure 1. Potential critical habitat for PMJM, Horse Creek, Wyoming.

I. INTRODUCTION

In May 1998 the Preble's meadow jumping mouse (PMJM) was listed as a threatened species by the U.S. Fish and Wildlife Service (the Service) under the Endangered Species Act (the Act). PMJM occupies shrub habitat adjacent to streams along the Front Range of the Rocky Mountains in Colorado and Southeastern Wyoming. At the time of listing, the species range in Wyoming was thought by the Service to be confined to portions of five counties (Albany, Converse, Goshen, Laramie, and Platte).

In July 2002, as a result of a lawsuit filed by several private conservation groups and individuals, the U.S. Fish and Wildlife Service proposed designating critical habitat for PMJM in Wyoming and Colorado. A final designation of critical habitat was required by June 4, 2003. The proposed critical habitat included approximately 237 miles of rivers and streams and 20,054 acres of land in Wyoming (50CRF- Part 17). The proposed habitat in Wyoming spanned four counties (Albany, Converse, Laramie, and Platte). Table 1 summarizes the distribution and ownership of the proposed habitat in Wyoming. Approximately 77 percent of the proposed habitat in Wyoming is on private land ("other" ownership is assumed to refer primarily to privately owned lands) while less than 20 percent is federal land.

Table 1. Ownership of proposed critical habitat for Preble's Meadow Jumping Mouse in Wyoming, by county.

County	Federal (Acres)	State (Acres)	Other (Acres)	Total (Acres)
Albany	2,323	265	3,334	5,921
Converse	279	0	279	279
Laramie	1,225	242	8,937	10,403
Platte	11	148	3,292	3,451
Wyoming	3,836	655	15,561	20,253

Source: 50 CFR Part 17, July 17, 2002

The Service's Draft Economic Analysis of Critical Habitat Designation for PMJM (Industrial Economics, Incorporated 2003) estimated that almost 19,000 acres (approximately 94 percent) of the proposed habitat in Wyoming is currently in agricultural use (7,500 acres in hay production and 11,500 in livestock grazing).

On June 23, 2004 the Service designated 125 miles of rivers and streams and 10,540 acres of land as critical habitat in Wyoming (50CRF – Part 17). This was about one-half of the area originally proposed for designation. Of the seven original habitat units proposed, four were excluded. Table 2 shows the estimated percent ownership of PMJM critical habitat by class in each habitat unit. However, the potential impact of the PMJM extends beyond the area designated as critical habitat. Under the Endangered Species Act the mouse is protected wherever it occurs regardless of designation and Federal agencies are required to consult on any action they take that might affect the species at any

location where it might be present. The Service did not rule out future expansions of critical habitat if the mice were found elsewhere.

Table 2. Estimated percent ownership of PMJM critical habitat by class.

Unit	BLM	Private	State	USFS	Water	Total
NP1- Cottonwood Creek	0.42%	75.80%	4.39%	19.39%	0.00%	100%
NP3-Chugwater Creek	0.29%	94.43%	4.98%	0.00%	0.31%	100%
SP1-Lodgepole Creek	0.00%	60.98%	0.03%	38.99%	0.00%	100%
Total	0.29%	88.29%	4.46%	6.74%	0.23%	100%

Source:WYNDD GIS data layer
Note: Total acreages are not consistent with acreage values released by USFWS

The purpose of this report is to identify and analyze the potential impact on the Southeastern Wyoming economy from listing and designation of critical habitat for PMJM under section 7 of the Endangered Species Act. Due to the difficulty in differentiating between impacts and concerns that result from section 7 (which considers adverse modification of critical habitat) and section 9 (which prohibits destruction or take) and section 10 (which allows for incidental take), both the impacts of section 7 and sections 9 & 10 are considered in the analysis. This approach is similar to that taken in the Service's Draft Economic Analysis of Critical Habitat Designation for the PMJM (Industrial Economics, Incorporated 2003, page 1-6) "… Two types of costs are discussed in the analysis: (1) costs that are a direct result of the protection provided by section 7 of the Act; and (2) costs that result from actions by stakeholders pursuant to sections 9 and 10 of the Act to avoid take of the PMJM." This approach is also supported by case law in terms of co-extensive costs (New Mexico Cattle Growers Association vs. U.S. Fish and Wildlife Service, 248 F.3d 1277).

This report differs from the Service's Draft Economic Analysis in that it considers potential effects on jobs and income in Southeastern Wyoming resulting from actions associated with PMJM. On the other hand, the Service's report focuses primarily on the potential economic cost associated with consultations between the Service, Federal management agencies and third parties regarding PMJM. This report focuses on the economic impacts to landowners and communities from protection of PMJM. Both perspectives are important considerations in the decision-making regarding PMJM.

The Department of Agricultural and Applied Economics, College of Agriculture, University of Wyoming prepared this report at the request of the Governor's Office of the State of Wyoming in cooperation with the Albany, Converse, Goshen, Laramie, and Platte County Commissioners. The State of Wyoming's position continues to be that convincing scientific evidence of the existence of the PMJM, as an identifiable subspecies has not been provided. Recent DNA testing seems to support the State's position that the PMJM should not be classified as a separate subspecies of the meadow jumping mouse. On March 26, 2004, the Service announced a 90-day finding for a petition to delist the PMJM. This finding was in response two petitions, one from the Office of the Governor of the State of Wyoming, and one from Coloradoans for Water Conservation and Development. However, since the PMJM is currently still listed and

since the Service has designed critical habitat, an economic analysis of the economic impact of PMJM on Southeastern Wyoming may be still warranted.

This research is part of a three-part project that goes beyond PMJM to build a more general methodological framework for economic analysis of threatened and endangered species.

> **Part I:** Preliminary analysis- This included economic analysis of the affected area using existing data, focus groups, GIS techniques, and IMPLAN modeling. Due to the time constraints, the GIS portion was still in progress.
>
> **Part II:** Refining the analysis- Once the preliminary report was completed, work continued on the analysis with additional information that was developed under the time frame for the preliminary report. This included not only the GIS information, but also, more detailed analysis of the economic impact as more information regarding PMJM became available.
>
> **Part III:** Testing Transferability- Upon completion of the analysis of the economic impact of PMJM, the researchers evaluated the applicability of the methodology developed for PMJM to another species in the study area that could potentially be listed.

II. BACKGROUND INFORMATION

Economic Importance of Agriculture

Because the majority of the land affected by PMJM habitat in Wyoming is in agricultural use in rural parts of Southeastern Wyoming, the information in this section will focus on agriculture. Southeastern Wyoming is defined, in this report, as the five-county region including Albany, Converse, Goshen, Laramie, and Platte counties.

As noted in the Service's Draft Economic Analysis (Industrial Economics, Incorporated 2003), agriculture is the dominant economic activity in rural Southeast Wyoming. The U.S. Department of Commerce estimates that gross agricultural income for Southeastern Wyoming totaled $457 million in 2000 (Table 3). Cash receipts for livestock was the largest contributor (77 percent), followed by cash receipts for crops (12 percent), other farm related income (7 percent), and government payments (5 percent). Goshen ($176 million) and Laramie ($111 million) had the highest gross agricultural income among the five-counties. Altogether, gross agricultural income in the five counties represented 41 percent of the total agricultural income in the state in 2000. In terms of government payments, Southeastern Wyoming accounted for 61 percent of the state's total with $21 million in payments.

Although government payments are a small part of the gross agricultural income in Southeastern Wyoming, they are not an insignificant amount. Over the last 10 years these government payments have amounted to $180 million to the region (Table 4). This source of income could be reduced if concerns about Federal nexus due to PMJM and other threatened and endangered species discourage participation in Federal programs.

Table 3. Gross agricultural income for Southeastern Wyoming, 2000.

County	Cash Receipts Livestock ($000)	Cash Receipts Crops ($000)	Government Payments ($000)	Other Farm Related Income ($000)	Gross Agricultural ($000)
Albany	$37,687	$1,491	$24	$4,357	$43,559
Converse	$34,061	$1,495	$493	$4,828	$40,877
Goshen	$135,039	$24,844	$8,582	$7,308	$175,773
Laramie	$76,925	$16,151	$7,827	$9,803	$110,706
Platte	$66,806	$10,590	$4,051	$4,927	$86,374
SEWYO	$350,518	$54,571	$20,977	$31,223	**$457,289**
	76.7%	11.9%	4.6%	6.8%	100.0%
Wyoming	$794,711	$159,380	$34,302	$124,273	**$1,112,666**
SEWYO %	44.1%	34.2%	61.2%	25.1%	41.1%

Source: U.S. Department of Commerce, REIS, 1969-2000

Table 4. Government payments to agriculture in Southeastern Wyoming, 1991-2000.

Year	Albany County ($000)	Converse County ($000)	Goshen County ($000)	Laramie County ($000)	Platte County ($000)	Total SEWYO ($000)
1991	$109	$1,903	$5,363	$6,987	$3,532	$17,894
1992	$209	$2,113	$5,357	$5,961	$3,300	$16,940
1993	$203	$2,019	$7,366	$7,271	$3,829	$20,688
1994	$176	$2,214	$5,720	$5,875	$3,063	$17,048
1995	$176	$1,610	$4,650	$4,981	$3,125	$14,542
1996	$30	$923	$5,178	$5,732	$3,078	$14,941
1997	$44	$712	$5,241	$5,595	$3,115	$14,707
1998	$1	$417	$7,658	$7,400	$3,544	$19,020
1999	$44	$894	$9,434	$8,878	$4,443	$23,693
2000	$24	$493	$8,582	$7,827	$4,051	$20,977
Total	$1,016	$13,298	$64,549	$66,507	$35,080	**$180,450**

Source: U.S. Department of Commerce, REIS, 1969-2000

Agriculture is also an important source of employment in Southeastern Wyoming, particularly in rural parts of the region. Zip code level data from the 2000 Census of Population and Housing indicates that agriculture is the number one employer in rural areas of Southeastern Wyoming employing 18 percent of the civilian population 16 years or older (Table 5). Agriculture is the number one employer in the rural areas for all counties except Platte were it is number five out of eighteen categories of employment.

Agriculture is less important in urban areas of the region (Laramie, Douglas, Torrington, Cheyenne, and Wheatland) with an overall ranking of 13 out of 18 categories and employing 3 percent of the work force. The exception is Wheatland in Platte County where agriculture ranks number one employing 14 percent of the workforce in the Wheatland zip code area. Of the 36 zip code areas in Southeastern Wyoming, agriculture ranks number one in 50 percent and among the top 3 in nearly three-fourths of the areas.

Table 5. Agricultural Employment in Southeastern Wyoming, 2000 Employed Civilian Population (16 years and older)

County	Percent in Agriculture Rural Areas	Agriculture Rank in Rural Areas	Percent in Agriculture Urban Areas	Agriculture Rank in Urban Areas
Albany	26.3%	1 of 18	2.6%	12 of 18
Converse	50.0%	1 of 18	5.8%	9 of 18
Goshen	22.2%	1 of 18	8.5%	4 of 18
Laramie	16.6%	1 of 18	1.1%	16 of 18
Platte	9.2%	5 of 18	14.0%	1 of 18
SEWYO Total	**17.6%**	**1 of 18**	**3.0%**	**13 of 18**

Source: 2000 Census of Population and Housing

Table 6. Annual Average Earnings in Southeastern Wyoming, 2000

County	Livestock Production SIC 02	All Jobs	Livestock Production Percent
Albany	$29,629	$23,574	125.7%
Converse	$21,404	$26,202	81.7%
Goshen	$21,857	$20,344	107.4%
Laramie	N.A.	$25,935	N.A.
Platte	$20,925	$24,483	85.5%
SEWYO	**$25,741**	**$24,755**	**104.0%**

Source: Wyoming Department of Employment, 2002

One of the concerns with the agricultural sector in Wyoming is the perception of low wages being paid to employees. However, as shown in Table 6, annual wages for the major agricultural production activity in Southeastern Wyoming, livestock production, were actually slightly higher than the average for all sectors in the region ($25,741 vs. $24,755). In Albany and Goshen Counties the annual wages for livestock production significantly exceeded the county average. Average annual wages for livestock production in Converse and Platte are somewhat lower than the county average, probably due to the presents of higher paying energy sector jobs. While some sectors of agricultural production, other than livestock production, may be somewhat lower paying, agricultural employment often includes housing for the employee and his family, the use of a vehicle, and other tangible benefits beyond the wage itself. If these fringe benefits are considered, the total earnings for agricultural employees is often comparable to other sectors in the local economy, particularly in the rural areas of the region where agricultural operations tend to be located.

Agriculture and Open Space

The agricultural industry has traditionally been viewed strictly as a producer of food and fiber. However, agriculture also provides another important product—open space. Out of economic necessity, most commercial agricultural operations in Southeastern Wyoming cover large areas of land and thus agriculture contributes substantially to maintaining open space in the region. Open space provides landscapes, lifestyles, and wildlife habitat that are highly valued in Wyoming and elsewhere.

Though the missions of state and federal agencies differ, the lands they manage are protected from development to varying degrees. Therefore much of the concern about maintaining open space in the West has focused on private lands where landowners face greater development pressures. Unlike Western Wyoming, most of the land in Southeastern Wyoming is privately owned (Table 7). Region-wide, over three-fourths of the land base is in private ownership. This ranges from about two-thirds in Albany County to over 90 percent in Goshen and Laramie Counties.

Agriculture is the dominant use of private land in Southeastern Wyoming (Table 7). Overall, agriculture use represents over 96 percent of the private land in the region and accounts for more than 93 percent of the private land in each of the five counties. Thus what happens to agriculture has important implications for open space in Southeastern Wyoming. The American Farmland Trust (AFT) has estimated that over 394,000 acres of prime ranchland in Southeastern Wyoming could potentially be converted to residential development over the next 20 years (AFT 2002). Other types of agricultural land in the region also have the potential to be converted to other uses.

Table 7. Landownership in Southeastern Wyoming, 2000

County	Total Land (Acres)	Public Land (Acres)	Private Land (Acres)	Percent Private Land	Agricultural Land (Acres)	Percent Private in Agriculture
Albany	2,755,136	934,582	1,820,554	66.1%	1,699,516	93.4%
Converse	2,742,486	763,617	1,978,869	72.2%	1,942,630	98.2%
Goshen	1,426,028	115,897	1,310,131	91.9%	1,288,669	98.4%
Laramie	1,718,912	180,848	1,538,064	89.5%	1,430,253	93.0%
Platte	1,323,557	266,713	1,056,844	79.8%	1,044,852	98.9%
SEWYO	**9,966,119** (1)	**2,261,657** (1)	**7,704,462** (1)	**77.3%**	**7,405,920** (2)	**96.1%**

Sources: (1) 2000 Equality State Almanac, Wyoming Department of Adm. & Info.
(2) 2000 Annual Report, Wyoming Department of Revenue

The conversion of agricultural land to residential development can also be costly to county government. While property tax revenues tend to increase with these conversions, the operating and maintenance costs for county government tend to increase even more. Table 8 shows that average net loss to county governments from conversion of agricultural land to residential development in Southeastern Wyoming is -$6.83 per acre annually. Depending on the size of the operation, conversion of an entire agricultural

operation represents a significant annual cost to county government. Thus the loss of open space due to conversion of agricultural land has important fiscal implications for local government.

Table 8. County Government Costs of Conversion of Agricultural Land

County	Annual Change in County Revenue*	Annual Change in County Costs*	Annual Net County Revenue*	Annual Net Revenue Per Acre	Average Size of Operation (Acres)	Annual Net Revenue Per Unit Conversion
Albany	$809	$992	-$183	-$5.23	9,044	-$47,287
Converse	$1,989	$2,257	-$268	-$7.66	10,308	-$78,930
Goshen	$2,039	$2,301	-$262	-$7.49	2,370	-$17,741
Laramie	$1,439	$1,626	-$187	-$5.34	4,154	-$22,194
Platte	$2,255	$2,551	-$296	-$8.46	4,062	-$34,353
Average	$1,706	$1,945	-$239	-$6.83	5,988	-$40,921

*Based on conversion of 35 acres of agricultural land to one rural residence
Source: Coupal, McLeod, and Taylor, 2002

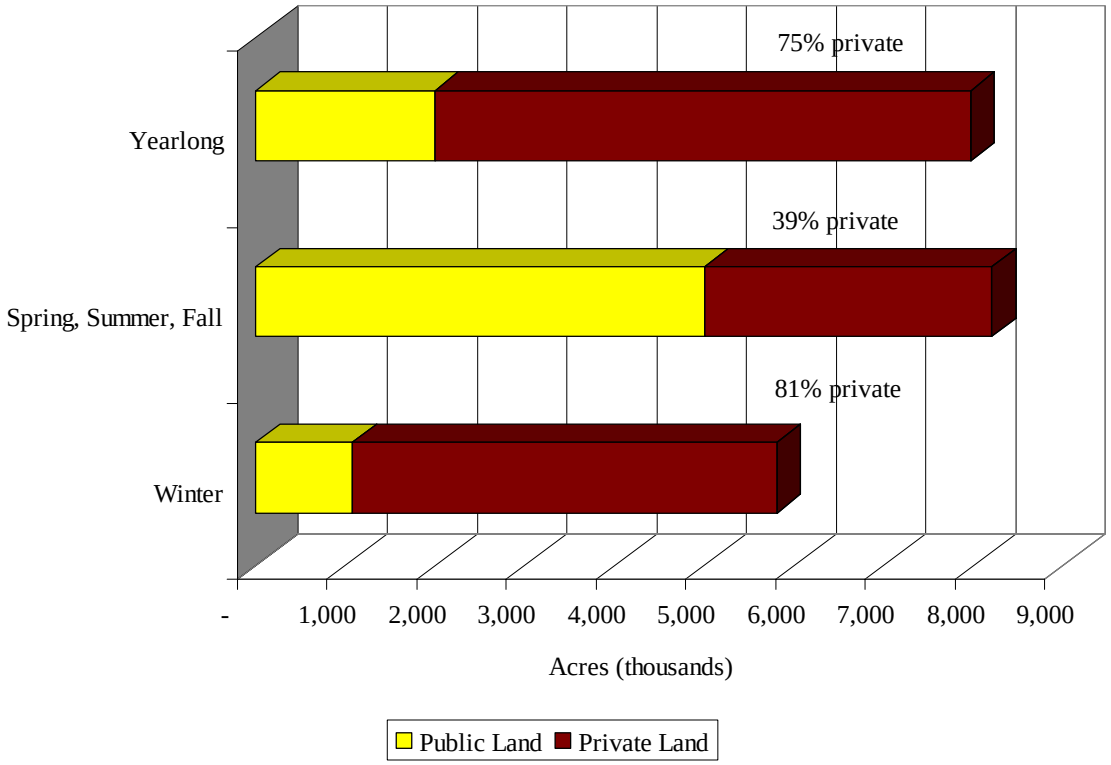
Wildlife and Southeast Wyoming's Undeveloped Areas

Along with threatened and endangered species such as PMJM, agricultural lands are an important source of habitat for other species. There is a body of evidence that points to a linkage between agriculture and big game populations. This section evaluates the role that undeveloped and agricultural areas in southeast Wyoming play in providing habitat for important economic species for the State. The focus is on the six major big game species: pronghorn (Antilocapra americana), elk (Cervus elaphus), moose (Alces alces), big horn sheep (Ovis canadensis), mule deer (Odocoileus hemionus), and whitetail deer (Odocoileus virginianus). These species on a statewide basis generate over $120 million in hunter expenditures (Coupal, Feeney, Lieske, Beauvais; forthcoming).

Viability of these species is highly dependent upon large undeveloped tracts of private land. Research on the links between development, agriculture and wildlife has been studied by various researchers in the West. Vogel (1989) found that housing developments in deer habitat can have an important and negative impact on deer populations. Mitchell, Knight, and Camp (2002) found that increased road densities and human populations of subdivided ranches reduced mobility of many species and reduced the overall available habitat.

This analysis uses Wyoming Game and Fish Department seasonal range GIS data and the BLM land ownership GIS data to estimate acreages of public and private lands with each seasonal range type. Seasonal range categories were divided into three types for each species: Winter (WIN), Spring-Summer-Fall (SSF), and Year-Long (YRL). The ranges were then aggregated to get an overall acreage level accounting for overlapping ranges.

Figure 2. Seasonal range, public and private: Southeastern Wyoming



Southeastern Wyoming has an abundance of private land in all the counties, especially Laramie, Platte and Goshen. As such, big game ranges are highly dependent upon undeveloped private lands in the area. Albany and Converse Counties, though predominantly private, have large areas of public lands. It is these public lands that carry much of the hunting and wildlife watching activities, but it is the private lands that to a certain degree support the herds that allow these activities. Overall, there are almost 22 million acres of seasonal range in Southeastern Wyoming, with 63 percent privately owned. Of the 22 million acres, 26 percent are classified as winter range, 37 percent is classified as SSF range and 36 percent classified as yearlong range (Appendix Table H).

The availability of private seasonal range is an important contribution to the undeveloped areas in this region. Figure 2 summarizes the acreages and relative sizes of aggregate wildlife range types and public and private ownership. Winter range has a higher proportion of private lands (81 %) as wildlife herds come down from publicly owned higher elevation areas. Conversely, SSF range has a lower proportion of private lands (39%) during these seasons because higher elevation areas are opened for foraging. Year-long range is also predominantly private (75%) because of the preponderance of lower elevation areas.

The results show the importance of both private and public lands to the area's wildlife and the economic importance to the local economy. Policies that affect land use in the region need to take into account all species and their economic importance.

Description of Agriculture in the Region

The Service's Draft Economic Analysis (Industrial Economics, Incorporated 2003) notes that the most prevalent type of agricultural operation in the region involves irrigated hay production in support of livestock operations. At lower elevations irrigated row crops and dry land winter wheat production are also economically important. Irrigation water in the area typically comes from surface water diversions from the North Platte River or its tributaries. Groundwater is also used in some locations. Not noted in the Draft Economic Analysis was the substantial amount of cattle feeding in Platte and Goshen Counties, which is also dependent on irrigated crop production for much of its feed requirements. Table 9 summarizes average agricultural production for Southeast Wyoming between 1996 and 2001 based on January 1 inventories for livestock and harvested acres for cropland.

The Service's Draft Economic Analysis notes that a typical moderately sized ranching operation in the region might have 400 brood cows and that the limiting factor in the size of the cattle herd is usually the amount of winter feed that can be produced from irrigated hay meadows. The Draft Analysis also indicates that the average beef cow consumes two to three tons of hay during the winter and that the average annual yield from irrigated meadows in Southeastern Wyoming ranges from one to two tons of hay per acre.

Table 9. Average Agricultural Production in Southeastern Wyoming, 1996-01

Type	1996-2001 average
I. Livestock	Number of head
Cattle and calves	451,667
Breeding Sheep	86,167
II. Crop land	Harvested acres
Hay production	283,000
Dry land winter wheat	146,250
Corn for grain	44,733
Corn for silage	15,583
Dry beans	14,867
Sugar beets	12,917
Oats	6,950
Barley	6,633

Source: Wyoming Agricultural Statistics, Various Years

Uncertainty of Regulatory Effects of PMJM on Agriculture

One of the problems with evaluating the economic implications of PMJM is the uncertainty regarding the effects of protection of PMJM on agricultural production in the region. The Service's Draft Environmental Assessment (USFWS December 2002) indicates substantial overlap between primary constituent elements for PMJM and agricultural operations in Southeastern Wyoming including:

- Riparian areas along rivers and streams (which are also used for livestock grazing and stock water).
- Adjacent floodplains and vegetated uplands with limited human disturbance (including hayed fields, grazed pastures, and other agricultural lands that are not plowed or disked regularly)
- Areas that provide connectivity between and within populations (including along ditches and canals).

However, the Draft Economic Analysis (Industrial Economics, Incorporated 2003) notes that:

- The proposed critical habitat designation for PMJM will only affect private landowners in Wyoming if a Federal nexus exists with respect to their farming or ranching operations (page 5-1).
- Agricultural activities typically do not involve a Federal nexus (page 5-3).
- Even if a landowner's agricultural operation involves a Federal nexus, agricultural activities in Wyoming do not typically result in "adverse" modifications of critical habitat (page 5-1).

The Service also seems to recognize that irrigation associated with agricultural production is often responsible for creating and maintaining Preble's habitat in Southeastern Wyoming. For example:

- "Continued uses of water will generally maintain conditions under which Preble's currently exist. In some locations, Preble's exists only because of human manipulation of water flows (USF&WS Special Rule Announced for Preble's Meadow Jumping Mouse, page 2, 2001)."
- "Impacts to streams and riparian habitats from diversion of water will vary…Flows in some streams may increase species habitat or actually create habitat in areas where it would not have existed naturally (USFWS Record of Compliance, 2000)."
- "If ditches are not maintained they would at some point no longer be used to convey water. Without water, habitat for the Preble's along ditches would cease to exist (USF&WS Environmental Assessment for a Proposed 4(d) Rule on the Preble's Meadow Jumping Mouse, 2000).

This notion is supported by Skinner and Hiller (1996), who confirm the contribution of agriculture to riparian areas in Wyoming. They noted that in the semi-arid western United States:

- "What the public perceives as natural wetland habitat in Wyoming and in the West, along larger steams in the basin and foothills regions, is not really natural at all."

- "In summary, agriculture, livestock grazing, and water development must be given their fair share of credit for building and maintaining riparian zone resources."
- "Because of water development for agriculture, riparian zones now exist where none existed before."
- "…because of agriculture, the quality and extent of riparian wetlands are far higher than before settlement."
- "As streams were fully developed for diverting spring runoff, the result was that historical stream channels lost their braided appearance and narrowed to a single channel. Wide historical channels became riparian zone floodplains supported by irrigation return flows into a much smaller stream. Because this new configuration does not have as much conveyance capacity as in the past, over-bank flooding often occurs during spring runoff. This action further supports the floodplain riparian zones of today."

On the other hand, statements in various government documents associated with the listing of PMJM may raise concerns regarding the effects on agricultural production in the region:

- "Conversion of native riparian ecosystems to commercial croplands and grazed rangelands was identified as the major threat to Preble's existence in Wyoming (Clark and Stromberg 1987, Compton and Hugie 1993) (50 CFR Part 17, 2002, page 47157)."
- "However, the designation, or proposed designation, of critical habitat may affect private entities with no Federal nexus, and therefore no section 7 responsibilities under the Act (Draft Economic Analysis, Industrial Economics, Incorporated 2003, Fn, page 5-1)."
- "For these reasons, all should understand that critical habitat designations do not signal that habitat outside the designation is unimportant or may not be require for recovery. Areas outside the critical habitat designation will continue to be subject to conservation actions that may be implemented under section 7(a)(1) of the Act, and the regulatory protections afforded by section 7(a)(2) jeopardy standard and the section 9 take prohibition, as determined on the basis of the best available information at the time of the action (50 CFR Part 17, 2002, page 47159)."
- "…the Service anticipates including conditions to minimize take in all future consultations associated with grazing leases on Federal lands, such as restrictions on the number of AUM's within riparian areas or the construction of fencing with water gaps to keep herds out of riparian areas (Draft Economic Analysis, Industrial Economics, Incorporated 2003, page 5-9)."
- "Without the rule (4d), section 9 would prevent all harvest of hay on the affected acres (i.e., the worst case), and landowners would receive no income from these lands (USFWS Record of Compliance, 2000)."

The proposed designation of critical habitat, under Conservation Issues also mentions changes in the timing and abundance of water, control of noxious weeds, and the use of

pesticides and herbicides as concerns associated with the protection of Preble's (50 CFR Part 17, 2002, page 47157). Restrictions on any or all of these could also significantly affect agricultural production in the region.

The Service's Interim Survey Guidelines for Preble's Meadow Jumping Mouse (1999) indicates that:

> "A project occurring in poor or marginal habitat but having potential to disrupt a travel corridor (such as construction of a road crossing a creek) is a concern. In such cases it may be desirable to survey higher quality habitat nearby rather than, or in addition to, surveying the immediate project site. The question of secondary impacts from proposed projects must also be considered. Projects removed from potential Preble's habitat that have the potential to adversely impact the habitat may also require a survey. For example, a residential or commercial development far uphill from a creek supporting potential Preble's habitat may significantly increase runoff or otherwise impact the hydrology and the habitat present on the creek. In such instance, presence of Preble's within the secondary impact area should be determined."

This may suggest that regularly plowed croplands and irrigation ditches with little or no vegetation, even though they are poor habitat, may be subject to restrictions if they are located near Preble's habitat.

Because of the uncertainty associated with protection of the Preble's, many landowners in Southeastern Wyoming are concerned that designation of critical habitat could:

> "(1) Result in a loss of discretion in their land management practices; (2) reduce or restrict irrigation ditch maintenance activities to the point that they would be unable to divert sufficient irrigation water; and/or (3) severely restrict or possibly end grazing and haying activities in critical habitat areas. These landowners fear that excessive restrictions on grazing, haying, and ditch maintenance activities would force them to reduce the size of their livestock herds, and in some cases may force them out of business (Draft Economic Analysis, Industrial Economics, Incorporated 2003, page B-1)."

These concerns relate beyond section 7 (designation of critical habitat) to sections 9 (prohibits take) and 10 (incidental take) of the Endangered Species Act. The Draft Economic Analysis notes "Section 9 and 10 of the Act apply to all landowners with PMJM on their property regardless of whether a Federal nexus exists or whether their property is located with critical habitat (page B-1)." The Draft Analysis further notes "Because the PMJM inhabits riparian areas in or surrounding irrigation ditches and hay fields, some incidental take of individual mice is inevitable during normal farming and ranching operations in the mouse's range (page B-1)." As a result the effects of

protection of the Preble's are much more widespread and significant than just the designation of habitat under section 7 of the Act.

The discussion above shows that uncertainty regarding future regulation for the protection of PMJM is creating mixed signals, at the very least, for landowners in the region. The effects on agriculture from PMJM remain unclear. In the final critical habitat designation the Service notes that:

- "While some aspects of irrigated hayfields are undoubtedly beneficial to the Preble's, overall effects on Preble's populations are likely complex and have not yet been studied (USFWS 50 CFR Part 17 – page 54)".
- "The Service has adjusted the discussion of grazing and water management to indicate that these activities, under certain management scenarios, may be consistent with Preble's conservation. However, the Service still views both grazing and water management as threats to the Preble's (USFWS 50 CFR Part 17 – page 89)".

Federal Nexus

The regulatory effects of critical habitat designation under section 7 of the Act are triggered by activities conducted, authorized, or funded by a Federal agency. This is sometimes referred to as a Federal nexus. Section 7 of the Act requires Federal agencies to confer with the Service on any action that is likely to result in the destruction or adverse modification of proposed critical habitat regardless of whether the action is physically located on public or private land. Activities that require consultation include (50 CFR Part 17):

- Any activity that results in development or alteration of the landscape of a unit.
- Any activity that results in changes in the hydrology of the unit.
- Any sale, exchange, or lease of Federal land that is likely to affect habitat.
- Any activity that detrimentally alters natural processes in a unit.
- Any activity that leads to the introduction, expansion, or increased density of exotic plants or animal species.

Federal agencies whose involvement could require consultation include (50 CFR Part 17):

- Department of Defense
- Forest Service
- Department of Energy
- Bureau of Land Management
- Corps of Engineers
- Federal Energy Regulatory Commission
- Bureau of Reclamation
- Federal Highway Administration
- Federal Communication Commission

- Federal Emergency Management Agency
- Fish and Wildlife Service
- Other Federal Agencies

The Draft Economic Analysis (Industrial Economics, Incorporated 2003) lists three specific types of agricultural activities that may involve a Federal nexus and be subject to section 7 consultations:

1. Agricultural operation improvements funded through the Federal Farm Service Agency (FSA).

2. Conservation activities funded by the Farm Service Agency and/or Natural Resource Conservation Service (NRCS).

3. Grazing permitted by the U.S. Forest Service and Bureau of Land Management on Federal lands.

The FSA provides technical and fiscal assistance to farmers and ranchers under the Farm Bill. This assistance includes helping agricultural operators conserve land and water resources, providing credit to new or disadvantaged farmers and ranchers, helping farmers and ranchers recover from disasters, and stabilizing farm income. Currently there is uncertainty regarding which FSA funded programs may create a Federal nexus (Industrial Economics, Incorporated 2003).

The NRCS provides cost-share and other Federal assistance to private ranchers and farmers for the institution of environmentally friendly land use practices (Industrial Economics, Incorporated 2003). Typical conservation activities on Wyoming farms and ranches include grassland restoration, wetland restoration, and riparian restoration and enhancement. Due to concerns regarding creation of a Federal nexus, the Service's ongoing activities to designate critical habitat may have caused some landowners to not participate with the Service and the NRCS on conservation projects (Industrial Economics, Incorporated 2003). "Reduced cooperation could result in lower-quality land management, environmental degradation, and increased risks to native plants and wildlife (Industrial Economics, Incorporated 2003)". If this occurs it would result in an environmental and economic loss to society. Even if other landowners not affected by the mouse use the available NRCS funding, the funding may not be going to the areas in greatest need of assistance. So there could still be an environmental and economic loss to society.

The Draft Economic Analysis indicates that, as long as the landowner does not request an increase in the stocking rates for the grazing permit, the Forest Service does not anticipate initiating consultations with the Service for re-permitting activities. The BLM anticipates four formal consultations on grazing allotment activities over the next 10 years at a cost of $59,000 to $98,000. However, under the Potential Impacts of Section 9 on Grazing Activities on Federal Lands, the Draft Economic Analysis notes:

> "While the USFS and BLM do not expect any project modifications associated with future consultations on grazing permits and leases, the Service anticipates including conditions to minimize take in all future consultations associated with grazing leases on Federal lands, such as restrictions on the number of AUMs within riparian areas or the construction of fencing with water gaps to keep herds out of the riparian areas (Industrial Economics, Incorporated 2003)."

Overall there appears to be a high level of uncertainty between the Service, Federal management agencies and landowners about what constitutes a federal nexus. The Service's final critical habitat designation notes that:

> "In general, actions on Federal lands, and actions on non-federal lands that are funded or permitted by a Federal agency have a Federal nexus. An exception exists in cases where the Federal agency involved has not discretionary involvement or control over the actions in question…The determination of whether a Federal nexus exists for a given activity should be made on a case by case basis and largely rests with the Federal agency involved (USFWS 50 CFR Part 17 – page 37)."

Habitat Conservation Plans (HCPs)

Under section 10 of the Act, a landowner or local government may develop an HCP in order to obtain an incidental take permit for their property. The HCP attempts to balance potential harmful effects that a proposed activity may have on the species, while allowing the otherwise lawful activity to proceed. The purpose of the HCP is to ensure that the effects of incidental take are adequately minimized and mitigated. To date, no county-level or individual HCPs have been implemented in Wyoming and the Service feels that it is unlikely that any will be developed over the next 10 years in Wyoming. The costs associated with the development of an HCP and the cost associated with any activity restrictions recommended by the Service to minimize take of PMJM have been cited as the major reasons for not developing these plans (See Text box, page 17).

Section 4(d) Special Rule

The Endangered Species Act prohibits "take" of listed species, which is defined as killing, harming, harassing, trapping, or wounding of an animal, regardless of whether the act was intentional or not. However, Section 4(d) of the Endangered Species Act allows the Service to prepare a special rule that defines the conditions under which unintentional take of a threatened species would be exempted from the provisions of the Act. Because PMJM is listed as threatened rather than endangered, it is eligible for the special rule. In 2001 and 2002, the Service adopted special regulations under 4(d) for PMJM. These regulations were implemented to provide landowners time to prepare a Habitat Conservation Plan (HCP) and apply for an incidental take permit in order to comply with section 9 of the Act. These special regulations were scheduled to expire on May 21,

The Laramie County Experience

The only attempt to complete an HCP in Wyoming uncovered by the researchers was in Laramie County (Cheyenne). Laramie County's experience is a good example of the difficulties in developing an HCP. In December 1998, Laramie County started to develop an HCP to help ensure that it had a voice in the process of critical habitat designation not only for PMJM, but in anticipation of future threatened and endangered species that could potentially be found within its boundaries. What resulted was thousands of dollars and hundreds of man-hours expended, but no HCP.

On average, ten people attended monthly meetings from 1999 through 2000 and then bi-monthly meetings in 2001. Meetings were held in the evening from approximately 7:00pm to 10:00pm (an estimated 810 hours contributed). Attendance was voluntary, and participants were not compensated for their time. The lone exception was a consultant who was paid a total of $13,438 to facilitate the meetings. This report conservatively values the time of those in attendance at $30 per hour since they were mostly salaried employees. Table 10 assumes 9 people since the consultant's fees are listed separately. The county expended $3,750 on GIS services in development of a website for the project.

Table 10. Estimated cost of HCP attempt by Laramie County.

Category	Item	Est. Cost
Est. man-hours	Approx. 30, 3-hr meetings, 9 people @$30/hr	$24,300
County funds	Consultant fees	$13,438
Paid staff hours	GIS work (staff) Approx 50 hours @$75/hr	$3,750
	Total	**$41,488**

Laramie County received two grants for the project. $25,000 was received from the governor's National Resource Policy Fund and $25,000 was received from the Wyoming Department of Transportation (WyDot). No money was expended from either of these pools. The consultant was paid from county funds. The county had anticipated using the grant money for mapping, and preparing an EIS once the HCP was approved.

The County entered into the process to take some of the uncertainty out of events for local residents, particularly landowners and developers. After three years, the process slowly ground to a halt. Monthly committee meetings became bi-monthly in 2001. Finally, in December, the county sent USFWS a list of questions in order to clarify its position. They included a 60-day deadline for responses. The committee decided to discontinue the HCP process in February 2002 because they felt the response was inadequate.

In spite of all that transpired, one participant still felt that HCPs are good tools that can be effective to advance local goals. He said that if the opportunity to complete an HCP arose again, that he would certainly consider it.

2004. At that time landowners would no longer be exempt from section 9 prohibitions against take, and agricultural operators in Southeastern Wyoming would feel the full force of section 9 of the Act. However, on May 20, 2004 the Service permanently extended the special regulations for PMJM.

The special regulations (commonly referred to as the "4d rule" or just "4d") exempt the following activities from the general take provisions provided they are conducted in accordance with the requirements specified in the regulations:

- Rodent control within 10 feet of or inside any structure. Since PMJM is not generally found in structures the mortality associated with trapping near structures would be insignificant.

- Ongoing agricultural activities provided there is no increase of impacts or further encroachment upon Preble's habitat. Situations where Preble's populations coexist with ongoing agriculture may provide valuable insight into habitat conditions and specific types of grazing and farming practices that are compatible with the species. Ongoing agricultural activities are considered those activities in place at the time of the 1998 listing of PMJM. Crop rotations consistent with past pattern would be exempt from take. However, the ability to document past use may be important. Examples of agricultural activities not exempt from take would include returning Conservation Reserve Program land to agricultural production, a change in existing grazing practices, or a change in mowing practices such as mowing closer to the stream if these activities would adversely impact Preble's habitat.

- Maintenance and replacement of existing landscaping and related structures and improvements. Because minimal take is associated with these activities, they are not expected to adversely affect Preble's conservation and recovery efforts.

- Existing uses of water associated with the exercise of perfected water rights. Continued uses of water will generally maintain conditions under which Preble's currently exist. Take associated with new water development is not exempt, however. The exemption does include maintenance of existing water wells that provide sources for water right usage.

- Noxious weed control activities, when conducted in accordance with State laws regarding control of noxious weeds and with Federal law relating to pesticide labeling. The Service believes this exemption will help conserve and recover Preble's because noxious weeds are displacing desirable vegetation on which Preble's depends for survival.

- Ongoing ditch maintenance activities that result in the annual loss of no more than ¼ mile of riparian shrub habitat within any 1 linear mile of ditch, and that are conducted in conformance with certain Best Management Practices as defined in the amendments. This exemption is designed to provide relief to those who must

maintain active ditches, and to assure that currently existing Preble's habitat along ditches remains functionally intact and viable. The following maintenance activities are not exempt under the regulations: 1) Replacement of existing infrastructure with components of substantially different materials and design. 2) Construction of new infrastructure or movement of existing infrastructure to new locations.

Figure 3. PMJM designated critical habitat, Lodge Pole creek, Wyoming.

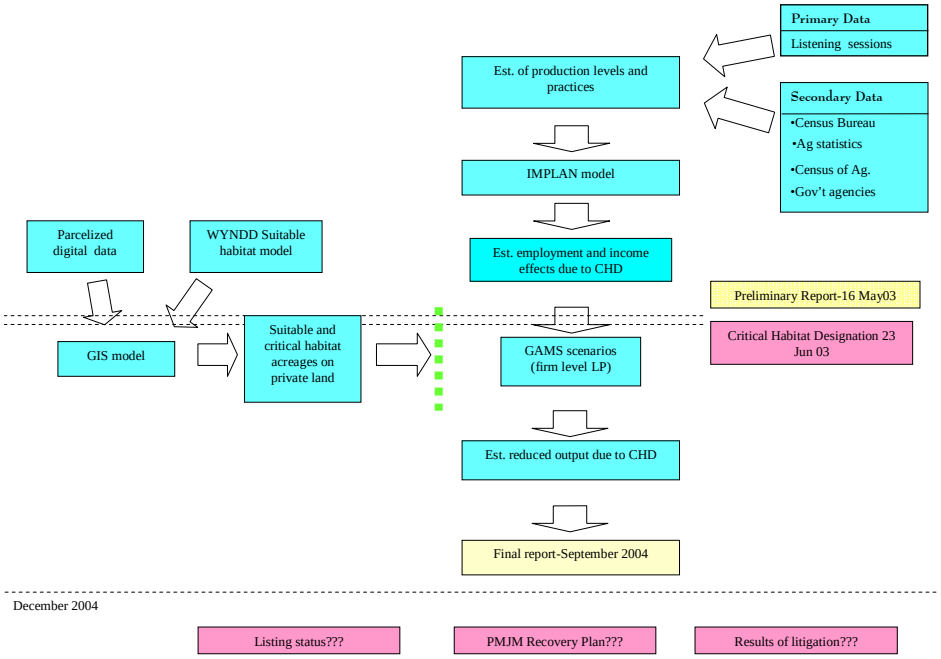
Although section 4(d) regulations somewhat shield agricultural production in Southeastern Wyoming from the full impact of the listing of PMJM, they still place restrictions on agricultural production in the region. Under 4(d), ongoing agricultural activities are exempt only if the impacts and encroachment upon Preble's mouse habitat do not increase. In addition, take associated with new water development is not exempt. As a result a landowner considering modifications to his agricultural operation that might result in incidental take would have to either submit an application to the Service for an incidental take permit (including an HCP) or forgo the modifications to avoid violating Section 9 of the ESA. Also, under the 4(d) regulations ongoing ditch maintenance can result in the loss of no more than 0.25 miles of riparian shrub habitat within any one linear mile of ditch. This restriction could have a significant negative effect on hay production in the region due to reduced irrigation efficiencies. These restrictions could

severely limit the landowner's ability to adjust his agricultural operation to meet changing conditions, especially in times of drought.

III. PROCEDURES

Figure 4 shows a flow chart detailing the procedures used in this project along with the dates of important associated deadlines. As a first step in evaluating the economic impact of PMJM on the Southeastern Wyoming economy, "listening" sessions were held in each of the five counties in the region. This was an opportunity for local landowners, businessmen, and county officials to indicate their concerns regarding the efforts to protect PMJM. The University Extension Educator in each county coordinated these "listening" sessions (See Table 12). The information from these sessions served as the starting point of the analysis.

Figure 4: Flow chart of project methodology and events.



The second step was to evaluate the potential impact of PMJM on agricultural operations in the region. Factors considered in this part of the analysis included effects on economic viability of agricultural operations and the potential for a Federal nexus among producers in the region. The analysis of economic viability was based on Economic Research Service's Commodity Cost and Returns Budgets for cow-calf operations in the Northern Great Plains. These budgets have the advantage of allowing comparison over time using budgets based on the same methodology. Currently, ERS budgets are available for 1996 through 2001. Information on the potential for a Federal nexus among agricultural producers in Southeastern Wyoming was obtained from various Federal government reports and agencies.

Step three was to evaluate the economic impact of the changes in agricultural production on the economy of communities in Southeastern Wyoming. Because agriculture is linked economically to other sectors of the region's economy, a change in agriculture will have a ripple effect throughout the local economy. An IMPLAN model of the five-county region was developed to estimate the economic impacts of PMJM on total (direct and secondary) jobs and income in the region. Due to the uncertainty associated with the how the PMJM program might be administered and the effects on agricultural production, a range of scenarios is considered in this portion of the report.

Firm Level Analysis

Step four in the research was to evaluate profitability at the firm level. The preliminary report showed that the people most likely to be directly impacted by critical habitat designation would be agricultural producers. This view is based on the location of designated critical habitat and the potential for additional critical habitat based on the WYNDD suitable habitat model. It was decided that the best approach would be to use a computer simulation (model) of a southeastern Wyoming ranch to test the effect of critical habitat designation on ranch profitability. A model originally developed by Dr. Alan Torell (University of New Mexico) and Dr. Larry Van Tassel (Idaho State University) was obtained and modified for the productivity conditions of southeastern Wyoming.

A Mile of Habitat

In order to adapt the model, an appropriate measure had to be found to evaluate the effect initiated by a policy change. The service has designated critical habitat for PMJM as 110 meters from the edge of either side of a stream (for stream orders 1 and 2. Larger stream have been given a 120 meter boundary). This measure is rather difficult to use as a meaningful value from an economic perspective. Therefore, the researchers translated the 110 meter measurement into an area to see what the value of habitat per linear mile of stream would be and how its withdrawal from the ranchstead would affect profitability.

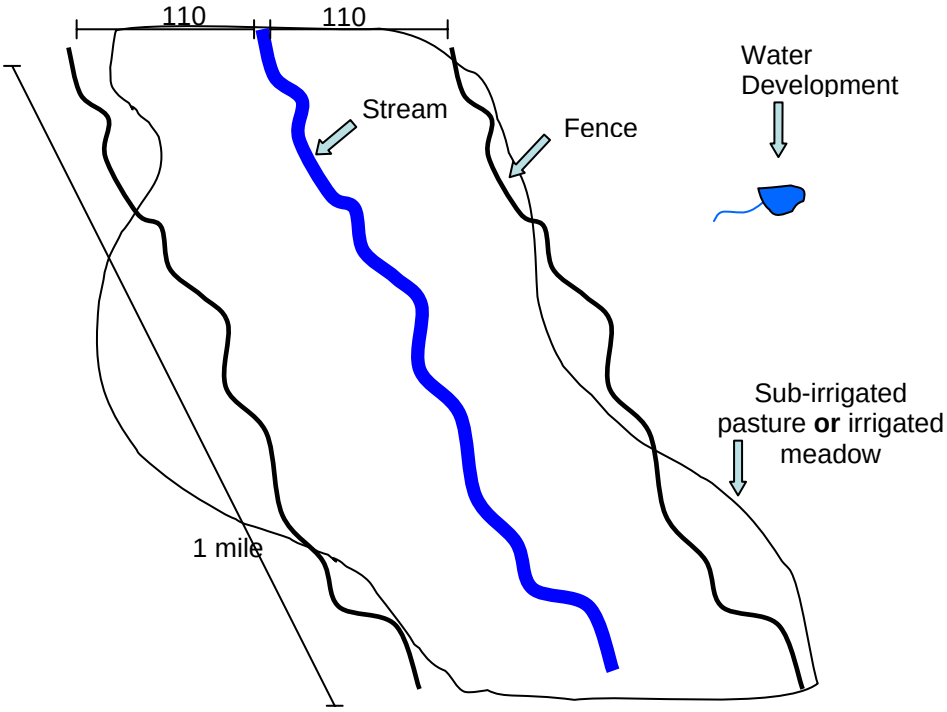
Figure 5 shows the results of a conversion of 110 meters to a linear mile of stream and an area in English units (acres). An explanation of the conversion process can be found in Appendix Table I.

Figure 5 brings up an important point, the shape of hay meadows in this region. Due to the geographic location of the ranches, adjacent to the Laramie range, many of the creek bottoms tend to be narrow. These ranches were homesteaded in the 19th century and the construction of some of the irrigation ditches (and their accompanying water rights) date

from this period. The technology of the time meant that ditched had to very nearly follow the contours of the land. Consequently, many of the hay meadows in the region tend to be long and narrow, following the creek bottom (See Figure 6). This means that often most

of an operations hay meadow is located within 110 meters of a stream and that these operations could potentially be significantly impacted by PMJM protection policies.

Figure 5. Hypothetical view of a linear mile of PMJM habitat.



Linear programming model description

The base simulation used in this project is a linear programming model built in the GAMS (General Algebraic Modeling System) software format. GAMS is an optimization program for solving simultaneous equations. For this project, a hypothetical, model ranch was developed for southeastern Wyoming. It was modeled on the concept of being a typical ranch for the region, large enough to be a primary occupation for the operator and supporting a family of four persons with no additional outside labor resources. It consists of 4,160 aums of pasture land (which is assumed to include both dry upland pasture and sub-irrigated creek bottoms) and 575 acres of hay meadow. Ranch resources, both land and livestock are detailed in Table11.

A Monte Carlo simulation was used for the cattle prices to simulate the effects of the cattle cycle. The model simulates 40 years of production, with 100 iterations per year for a total of 4,000 iterations. This helps to minimize the effect of fluctuating livestock prices when a policy change is made in the model. Hay grown on the ranch can either be sold or fed to livestock. All parameters are set to reflect the type of production practices prevalent in Southeastern Wyoming.

Figure 6. Aerial photo from Southeastern Wyoming showing USFWS policy buffer.

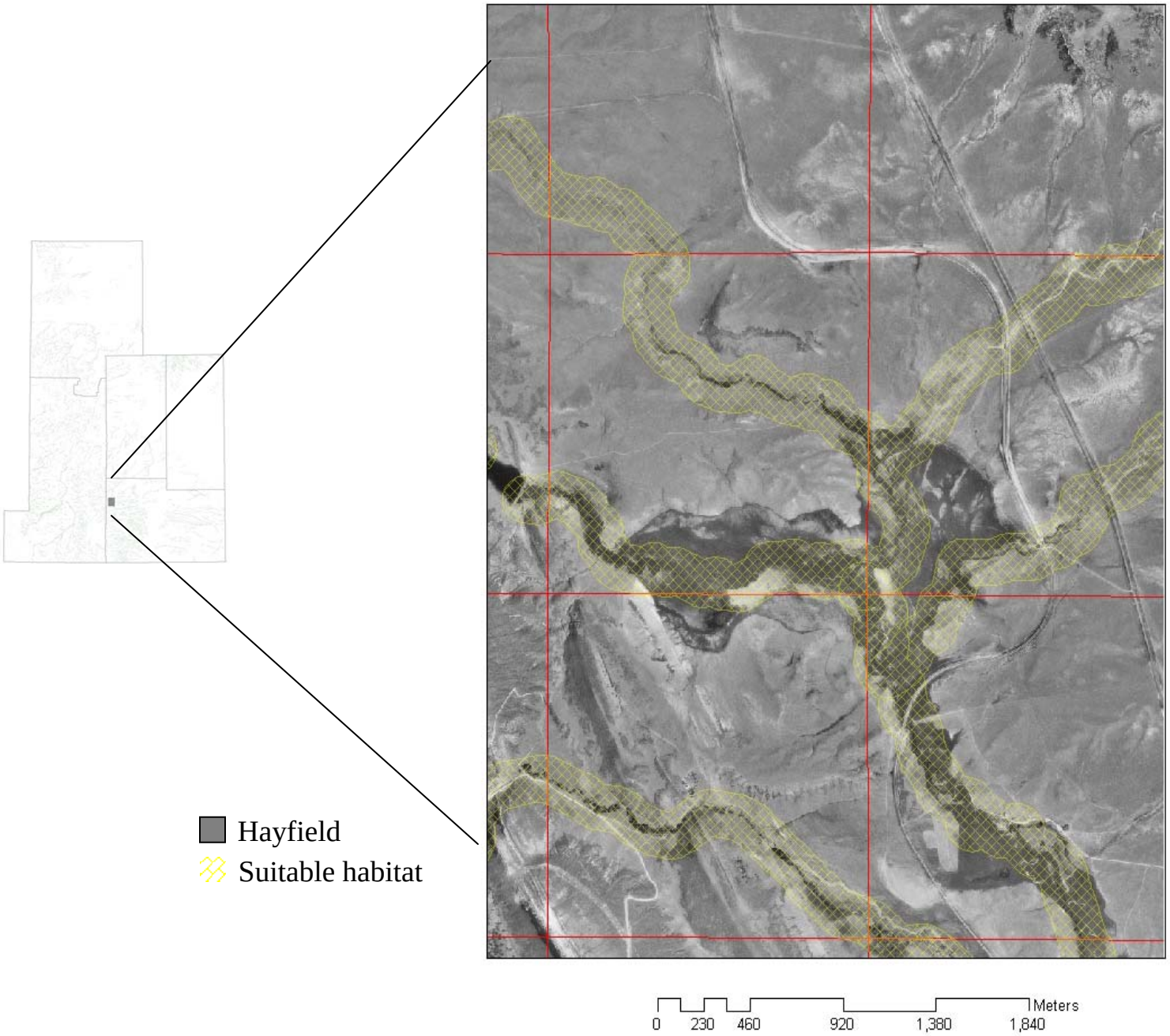


Table 11. Ranch resources

Resource base	Units	Productivity assumptions
Land		
Deeded pasture land	4,160 aum's	.52 to 1.34 aum's/acre
Hay meadow	575 acres	1.5 tons/acre, 862 tons per year
Forest Service lease	500 aum's	Mid-June to mid-September
State lease	300 aum's	Summer pasture
Livestock		
Mother cows	430 head	
Bulls	22 head	

The base model assumes that the ranch is operating at full capacity. Gross returns of the model ranch over a 40 year analysis period average $188,948 per year, while net returns average $39,423 per year. The main revenue source for the ranch is the sale of approximately 232 head of steer calves and 137 head of heifer calves per year.

Once the base model was set, the researchers introduced withdrawals of either irrigated hay meadow or sub-irrigated pasture land to simulate the effects of land taken out of production due to PMJM habitat protection. The withdrawals were accompanied by an additional fixed cost to pay for construction and maintenance of fencing of the riparian habitat and new water developments that would be required on pasture land (See Appendix Table J). In all, 16 versions of the model were created including the base model, withdrawal models for one to six miles each of sub-irrigated pasture and irrigated meadow. Separate versions of the model were built for sub-irrigated pasture and irrigated meadow to reflect not only the differing levels of productivity of the land classes, but the time differential for land use. That is, sub-irrigated pasture would normally be grazed, early in the season and then again in the fall. Whereas irrigated meadow is hay meadow that is harvested in the summer to be fed in the winter. The time differential becomes important to profitability. It has long been recognized in Wyoming that herd size is largely dependent on the amount of hay that can be produced. Indeed, several of the producers at the listening sessions stated that the hay meadows where the "heart" of the ranch.

Two separate simulations were also developed as alternatives for decision makers. One of the policy options available is the elimination of grazing on Forest Service lands in the area. Due to the presence of habitat on Forest Service land and the potential difficulties in fencing, elimination of grazing seems a logical alternative. As a policy scenario, the project built a simulation that would cancel the model ranch's 500 aum U.S. Forest Service summer grazing lease. Although the ranch does have deeded summer pasture available, the USFS lease helps to maximize the ranch's available resources by adding summer grazing land that allows enough additional herd size to maintain family income.

Another scenario was the elimination of 10 percent of the hay production on the ranch. Given the amount of riparian area in southeastern Wyoming devoted to hay production and the importance of hay production to the ranch operation, this scenario is instructive in showing the impact on profitability.

IV. RESULTS

Listening Sessions

The project held meetings in each of the five counties in Southeast Wyoming to assess landowner and community perception of PMJM critical habitat listing. These meetings were set up and advertised by the local University Extension Educators. Paul Kruse, an attorney working for the affected counties, acted as moderator and assisted with these sessions. Table 12 shows the location and date of each meeting. The meetings were described as "listening sessions" where local landowners and interested citizens were invited to give their views on the mouse. The purpose was two-fold. First, the researchers needed to know first hand how PMJM has and will affect landowners and local businesses. Specifically, which production practices would continue and which would be curtailed. How the profitability for these enterprises would be affected and what the alternatives were. Secondly, the researchers wanted to obtain a clear understanding of the emotional response these people have toward the mouse, and how it would influence their decisions.

The results of the listening sessions were startling. Anger, frustration, confusion and distrust were some of the sentiments felt at the sessions. Landowners and community leaders present were unanimous in feeling that the process appeared to by-pass some of the fundamental tenants of the American way of life. Many of the participants felt that the process and particularly the ESA was an assault on their property rights, since most of the proposed habitat is on private land. At times the sessions became emotionally charged. In one instance, after an explanation of how a federal nexus would allow USFWS to access private property, one county commissioner stated that if this were so than Wyoming should "secede from the Union".

Table 12. Project listening sessions

County	Location and date	Coordinator
Albany	Albany County Fair Grounds- 25 March 2003	Brett Moline
Converse	Converse County building-12 February 2003	Frank Henderson
Goshen	Bear Creek Community Center- 10 April 2003	Wayne Tatman
Laramie	Laramie County Extension Office- 04 April 2003	Phil Rosenlund
Platte	Platte County Fairgrounds- 13 March 2003	Dallas Mount

Other participants became emotional as they described how three and four generations of their family had settled and improved the land, creating and sustaining habitat for a creature that they did not even know existed, only to feel that they were being told that now they could no longer participate in that way of life due to the federal government's attempt to "save" the mouse.

Frustration was expressed that there was a lack of understanding within the federal government as to the role that agriculture plays in creating and sustaining mouse habitat and open space in general. It was suggested that those producers who are good stewards of the land by creating and sustaining mouse habitat will bear most of the cost for the "social welfare". Many of the participants voiced the opinion that they would be unable to sustain their enterprises, should the 4(d) rule expire.

Another result of the sessions was that it became clear that there was a significant amount of misinformation and lack of information at the community/landowner level. Considerable time at each of the sessions was devoted to informing participants of the status of the process and the basics of the Act.

A deep distrust of the process was felt by many of the participants. This was evidenced by those who would not accept federal drought assistance or participate in other Federal programs for fear of triggering a federal nexus. Some participants felt that values from outside their communities (which they do not hold) were being imposed upon them. In other words, because of outside interests, private landowners felt that they will have to bear the cost of preserving the species at their own expense and without compensation. Local people expressed frustration that the existence of their communities, enterprises, and lifestyles is threatened by critical habitat designation and the listing of the mouse in general. They believe that this is unwelcome and needless change, imposed upon them by the federal government (see text box, page 24). They felt that should the full force of the Act come into effect, their lives would be detrimentally impacted by changes in the local economy. These changes would not only affect their livelihoods, but the culture of the region as well.

The feeling that habitat designation is an assault on property rights was expressed numerous times in the sessions. Many noted the high percentage (77 percent) of the proposed critical habitat for the mouse in Wyoming on private land. Add to this the federal nexus issue, the perceived differences in values, and the lack of information about the process and one can begin to understand the feelings of landowners.

The subject of noxious weeds came up in several of the sessions. A number of participants who were either county weed and pest employees or ranchers felt strongly that whatever administrative decisions are made in regard to the mouse, control of noxious weeds must continue. This is especially true for leafy spurge. These individuals stated that it is not possible to exclude certain areas, especially highly productive riparian zones, from weed control. The county weed and pest is the first and sometimes the last line of defense against some invasive species. Should there be no control of these species in certain areas, then the whole region would be in jeopardy from infestation. These same individuals pointed out that change in the ecological balance due to lack of weed control could be detrimental to the mouse habitat.

Different Values
The difference in values between listening session participants and the Services Draft Economic Analysis may be reflected by Section 8.0, "Potential Benefits of Critical Habitat Designation" which states:

> "The primary goal of the Act is to enhance the potential for species recovery. Thus the benefits of actions taken under the Act are primarily measured in terms of the value the public places on species preservation…such social welfare values may reflect both use and non-use (i.e. existence) values. For example, use values might include the potential for recreational use of a species should recovery be achieved. Non-use values are not derived from direct use of the species, but instead reflect the utility the public derives from the knowledge that a species continues to exist" (Industrial Economics, Incorporated 2003) page 8-2

So while landowners view themselves as the stewards of the land, the Act and hence the Service is seen to be attempting to impose the collective views of "the public" on private property. Additionally, participants saw little "recreational use" of the species. Instead, many of them expressed the view that ulterior motives are at work, both in the Federal government and private conservation groups.

The listening sessions were the starting point for the project. They gave the researchers valuable insight into not only how the land is used, but how the people using the land feel about PMJM and critical habitat designation. The listening sessions also showed that there is a considerable amount of distrust of the process and agencies involved as well as misinformation and lack of information at the local level.

Listening sessions were also held with various State agencies (Office of the Governor, Wyoming Department of Agriculture, Wyoming Game and Fish, and State Historical Preservation Office) and U.S. Fish and Wildlife personnel involved with PMJM in Wyoming to get their perspective on the issues.

Figure 6. PMJM habitat, Lodge Pole Creek, Wyoming.

Economic Viability of Agriculture

Costs and returns production tables (budgets) for the Northern Great Plains from the U.S. Department of Agriculture's Economic Research Service (ERS) were used to estimate the effects of reduced production capacity due to PMJM. These tables were used because they are the only region-wide annual estimates of costs and returns and they include most of the range of PMJM.

Table 13 summarizes cow-calf costs and returns per bred cow for the Northern Great Plains from ERS budgets. Between 1996 and 2001 operating profits (value of production – operating costs) have ranged from -$106.26 per cow in 1996 to $76.49 per cow in 2000. The average for the time period was $12.75 per cow with a 33.3 percent probability of negative operating profit (see appendix tables).

Like most agricultural operations, cow-calf operations in the Northern Great Plains have not been able to cover all economic costs between 1996 and 2001 resulting in a negative economic profit (value of production – operating costs – fixed costs) ranging from -$530.64 per cow in 1996 to -$421.04 in 1999. The average for the time period was -$462.96 per cow with a 100 percent probability of negative economic profit. Fixed costs include the opportunity costs of unpaid operator labor, capital recovery cost of machinery and equipment, opportunity cost of land, taxes and insurance and general ranch overhead.

Voices of Southeastern Wyoming

Economics serves a vital function in quantifying the magnitude of the effects of critical habitat designation. However, there is another, unquantifiable portion of this project and that is how local residents feel about having the mouse in their "backyard". These are the people who will bear the cost of designation, not only from the potential loss of income, devaluation of their property or loss of the associated community services, but in an emotional sense from a loss of control over their lives. For the most part, these people feel powerless in the face of forces beyond their control. This is what they have to say.

"Endangered species is no different than drought."—landowner

"Platte County can't take a lot more"— bank president

"If 4d disappears, we're in trouble."—landowner

"We're here [Wheatland] because of the Irrigation District"—economic developer

"How can we promote our community if we can't take care of what's here?"—economic developer

"This feels like the dust bowl, people just leave. The school is already suffering from dis-enrollment."—economic developer

"It would shut us down completely."—landowner

"It's all or nothing in agriculture".—landowner

"It's a farce. It's about gaining control of the water so they can gain control of the land."—landowner

"Without hay, we might as well give up."—landowner

"A quarter of the ditches [cleaned per year] doesn't do you any good."— landowner

"This takes the heart right out of your operation."—landowner

"That would completely devastate the assessed valuation of the county" —landowner

"The meadow is the heart of the ranch" —landowner

"We've been taken away from…taken away from…."—landowner

"We should secede from the Union." —county commissioner

"Us stakeholders are the ones that take it in the shorts." —landowner

"I don't care if I ever see a mouse." —landowner

The failure to cover all economic costs by cow-calf operations may be at least partially offset by appreciating land values. Between 1996-98 and 1999-01, the average selling price per animal unit for ranches in Southeastern Wyoming increased by more than 40 percent from $2,372 to $3,333 (Table 13). So while ranching has only provided limited current returns in recent years there has been substantial asset appreciation.

Table 14 summaries the cow-calf costs and returns per bred cow if the rancher was forced to buy hay rather than raise his own. The ERS budgets estimate that 89 percent of harvested forage costs for cow-calf operations in the Northern Great Plains are from homegrown harvested forages. This scenario considers the effect on profitability for the cow-calf operation if the rancher is forced to cease hay production to protect PMJM and instead must purchase hay. The hay prices used in the analysis were taken from the Wyoming Agricultural Statistics for the appropriate years. They include: $76.50 per ton in 1996, $85.00 per ton in 1997, $76.00 per ton in 1998, $65.00 per ton in 1999, $84.50 per ton in 2000, and $109.00 per ton in 2001. Hay prices in 2001 are substantially higher due to drought. Under this scenario average operating profit falls from $12.75 per cow to -$30.08 per cow and the probability of negative operating profit doubles from 33.3 percent to 66.7 percent. Negative economic profit increases under this scenario.

The hay prices used in the above analysis are based on average prices received by farmers and ranchers in Wyoming. If ranchers were forced to buy hay there would most likely be transportation charges on top of the price of the hay. This would be particularly true if the rancher was forced to buy hay from outside his immediate locality. Assuming a $15 per ton transportation cost, the price of hay becomes: $91.50 per ton in 1996, $100.00 per ton in 1997, $91.00 per ton in 1998, $80.00 per ton in 1999, $99.50 per ton in 2000, and $124.00 per ton in 2001. Table 14 summarizes cow-calf costs and returns if transportation costs are considered in the cost of purchasing hay. Under this scenario, average operating profit fall to -$60.08 per cow and the probability of negative increases to 100 percent. It is doubtful that many ranching operations could remain economically viable under this scenario if it were to continue for an extended period of time.

Table 13. Cow-Calf Production Costs and Returns Per Bred Cow Northern Great Plain, 1996-2001

Base Budget

	1996	1997	1998	1999	2000	2001	Average 1996-01	Prob. Neg.
Value of Production	$361.70	$446.42	$432.47	$468.45	$525.01	$527.72		
Operating Costs	$467.96	$483.29	$419.84	$408.50	$448.52	$457.17		
Operating Profit	**-$106.26**	**-$36.87**	**$12.63**	**$59.95**	**$76.49**	**$70.55**	**$12.75**	**33.3%**
Fixed Costs	$424.38	$464.82	$471.68	$480.99	$499.05	$513.32		
Economic Profit	**-$530.64**	**-$501.69**	**-$459.05**	**-$421.04**	**-$422.56**	**-$442.77**	**-$462.96**	**100.0%**

	1996-98	1999-01
Average AU Sale Price	$2,372	$3,333

Table 14. Effect on budget by purchasing rather than growing hay.

	1996	1997	1998	1999	2000	2001	Average 1996-01	Prob. Neg.
Value of Production	$361.70	$446.42	$432.47	$468.45	$525.01	$527.72		
Operating Costs	$485.13	$509.66	$461.35	$448.22	$499.04	$538.87		
Operating Profit	**-$123.43**	**-$63.24**	**-$28.88**	**$20.23**	**$25.97**	**-$11.15**	**-$30.08**	**66.7%**
Fixed Costs	$424.38	$464.82	$471.68	$480.99	$499.05	$513.32		
Economic Profit	**-$547.81**	**-$528.06**	**-$500.56**	**-$460.76**	**-$473.08**	**-$524.47**	**-$505.79**	**100.0%**
Price Per Ton of Hay	$76.50	$85.00	$76.00	$65.00	$84.50	$109.00	$82.67	

Table 15. Effect on budget by purchasing and transporting it rather than growing hay

	1996	1997	1998	1999	2000	2001	Average 1996-01	Prob. Neg.
Value of Production	$361.70	$446.42	$432.47	$468.45	$525.01	$527.72		
Operating Costs	$515.13	$539.66	$491.35	$478.22	$529.04	$568.87		
Operating Profit	**-$153.43**	**-$93.24**	**-$58.88**	**-$9.77**	**-$4.03**	**-$41.15**	**-$60.08**	**100.0%**
Fixed Costs	$424.38	$464.82	$471.68	$480.99	$499.05	$513.32		
Economic Profit	**-$577.81**	**-$558.06**	**-$530.56**	**-$490.76**	**-$503.08**	**-$554.44**	**-$535.79**	**100.0%**
Price Per Ton of Hay	$91.50	$100.00	$91.00	$80.00	$99.50	$124.00	$97.67	

Sources: Economic Research Service, USDA; Wyoming Farm, Ranch, and Rural Markets; and Wyoming Agricultural Statistics, Various Years.

*Assumes two tons of hay per bred cow

During the listening sessions, ranchers indicated that riparian areas were also important for protection of their livestock herds during the winter months. Depending on the severity of the winter, they estimated that the death loss for calves could approach 40 to 50 percent during severe winters and could average 20 percent if they were unable to use the riparian areas during the winter months due to PMJM. They also felt that the inability to use riparian areas during the winter months would substantially increase feed cost since livestock would have to eat more to survive the increased exposure to the elements. Ranchers felt that feed cost could increase by perhaps as much as 100 percent if they were unable to use riparian areas in the winter. This would further increase operating costs for the ranching operation beyond just the cost of buying rather than growing hay.

The emphasis on the importance of riparian zones to agricultural producers in the region cannot be overstated. Several participants referred to the creek bottoms and associated hay meadows as the "heart" of their operations (see text box, page 24). As discussed in this and the following sections, the riparian zones are critical for winter forage production and shelter for livestock. Since the riparian zones are the most productive and valuable ground on many ranches, any alteration to their productive capacity could have significant affect on the viability of the enterprise.

Conversion to Stocker Operations

One alternative suggested for ranching in the region has been the conversion from cow-calf to stocker operations. With a stocker operation the rancher would purchase yearling cattle in the spring, graze them on summer range and sell them in the fall. In this manner, the rancher would avoid the need for hay production since there is no livestock to maintain during the winter months. In addition, the rancher could avoid the use of riparian areas by grazing the uplands in the summer.

Unfortunately, there are several problems with this scenario. One is an apparent lack of profitability for this type of enterprise. Production budgets from the University of Idaho for 1998, 2000, and 2002 (Table 16) indicate that operating profits for the three years for which budgets are available ranged from negative -$49.26 in 1998 to $6.88 in 2002. The average for three years of budgets is -$16.23 with the probability of negative operating income of 66.7 percent. Although this is a rather short time frame in which to evaluate, the information that is available suggests that stocker operations have tended not to be very profitable enterprises in recent years.

Table 16. Stocker Cattle Production Costs & Returns Per Head, Idaho: 1998, 2000, and 2002

	1998	2000	2002	Average 1998-2002	Probability Negative
Total Receipts	$561.78	$604.99	$604.99		
Operating Costs	$611.04	$611.30	$598.11		
Operating Profit	**-$49.26**	**-$6.31**	**$6.88**	**-$16.23**	**66.7%**

Source: University of Idaho Cooperative Extension Service

There are also other concerns with stocker operations. One is that fencing may be required to keep livestock away from riparian areas. The Custom Rate Guide for Farms/Ranch Operations in Wyoming, 2000-02 indicates that the average cost for wooden braces, steel/wooden posts, with four barb wires on smooth to rolling terrain was about $6,800 per mile (University of Wyoming, Cooperative Extension Service, 2003). At this rate it would cost more than $3.2 million just to fence both sides of the 237 miles of rivers and streams included in the proposed critical habitat designation for PMJM. Under the final critical habitat designation the costs would be about half this amount. This amount does not include the costs of cross fencing and water gaps that would need to be installed to exclude the riparian areas. While it would be cheaper to use electric fences to exclude riparian areas, these types of fences are only temporary in nature.

Another concern is the availability of stock water. In many cases, the rivers and streams are the primary source of water for livestock. If the riparian areas were fenced, then alternative source of water would need to be developed. Information provided by ranchers at the listening sessions indicated that stock water development would cost between $4,000 and $6,500 per site and that one site would be required for every one mile of fenced stream. Using an average of $5,250 per site it would cost nearly $2.5 million to provide stock water along both sides of the 237 miles of rivers and streams

included in the proposed critical habitat designation for PMJM. Under the final critical habitat designation the costs would be about one-half this amount. This amount does not consider stock water already developed outside of riparian areas. These levels of expenditures would appear to be difficult to justify given the lack of profitability in stocker operations.

Figure 7. Typical Southeastern Wyoming grass lands, near Lodge Pole Creek.

Federal Nexus

One of the factors that could influence the economic impact of PMJM in Southeastern Wyoming is the number of Federal nexuses that exist with agriculture in the region. Conceptually, a Federal nexus could exist whenever there is a government payment involved. A Federal nexus could also exist due to USFS and BLM grazing permits. Finally, a Federal nexus could exist due to farm ownership and operating loans from the USDA Farm Services Agency. This latter category is difficult to quantify due to the confidential nature of the information and is not included in this report.

The 1997 Census of Agriculture reports the number of agricultural operations receiving government payments for counties in Wyoming. For the counties in Southeastern Wyoming, nearly fifty percent of the operations with sales of $10,000 or more received some form of government payment in 1997 (Table 17). The percentage ranged from less than 5 percent in Albany County to nearly 70 percent in Goshen County. The category "Farms with Sales of $10,000 or more" was selected to focus more on commercial agricultural operations. The Census estimates suggest that at a maximum there were 773 agricultural operations in the region with sales of $10,000 or more that have a potential for a Federal nexus as a result of receiving government payments. If all operations are

considered, regardless of their farm sales, the total increases to 994 agricultural operations. Since these operations may participate in more than one government program, they may have multiple Federal nexuses.

One of the possible sources of a Federal nexus specifically mentioned in the Service's Draft Economic Analysis (Industrial Economics, Incorporated 2003) is Federal grazing permits. The 1997 Census of Agriculture reports the number of agricultural operations holding grazing permits for counties in Wyoming. For the counties in Southeastern Wyoming more than 26 percent of the operations with sales of $10,000 or more held grazing permits (Table 18). The percentage ranged from nearly 50 percent in Albany County to less than 10 percent in Goshen County. Most of these operations hold multiple grazing permits with the majority being from the BLM and USFS. Grazing permits tended to be associated with larger landowners in the region. As a result agricultural operations with grazing permits accounted for nearly 45 percent of the total land in farms in the region (Table 18). The Census estimates suggest that at a maximum there were 419 agricultural operations in the region with a potential for a Federal nexus as a result of holding grazing permits. These operations represent over 3.6 million acres of land in agricultural use.

Table 17. Agricultural Operations with Government Payments, 1997 Farms with Sales of $10,000 or More in Southeastern Wyoming.

County	Total Units	Units w/ Government Payments	Percent w/ Government Payments
Albany	197	9	4.6%
Converse	234	52	22.2%
Goshen	510	350	68.6%
Laramie	365	227	62.2%
Platte	294	135	45.9%
SEWYO	**1,600**	**773**	**48.3%**

Source: 1997 Census of Agriculture, Wyoming State and County Data

Table 18. Agricultural Operations with Grazing Permits, 1997 Operations with Sales of 10,000 or More in Southeastern Wyoming

County	Total Units	Units w/Grazing Permits	Percent w/Grazing Permits	Total Land in Farms	Grazing Permits Land in Farms	Percent w/Grazing Permits
Albany	195	97	49.7%	1,763,654	1,032,367	58.5%
Converse	236	113	47.9%	2,432,747	1,457,977	59.9%
Goshen	510	85	16.7%	1,208,860	260,152	21.5%
Laramie	366	34	9.3%	1,520,186	390,942	25.7%
Platte	293	90	30.7%	1,190,225	496,508	41.7%
SEWYO	**1,600**	**419**	**26.2%**	**8,115,672**	**3,637,946**	**44.8%**

Source: 1997 Census of Agriculture, Wyoming State and County Data

Another possible source of a Federal nexus specifically mentioned in the Service's Draft Economic Analysis (Industrial Economics, Incorporated 2003) is the USDA Farm Service Agency (FSA). In order to estimate the number of agricultural producers potentially affected in this manner, individual FSA county offices in the region were contacted. The results of this effort are presented in Table 19. The data is shown in two ways. "All program participants" refers to the number of producers in any program sponsored by FSA. Since a producer may be involved with several programs this number estimates the total number of potential Federal nexuses within the county in terms of FSA. "Individual Operators" represents the number of producers that may be affected in a given county, regardless of how many programs they are enrolled in. Although Table 19 is incomplete, it does indicate that there are a substantial number of potential Federal nexuses through the FSA in Southeastern Wyoming. As previously noted in the background section, currently there is uncertainty regarding which FSA funded programs may actually create a Federal nexus.

Table 19. Participants in Farm Service Agency Programs Southeastern Wyoming, 2002

County	All Program Participants	Individual Operators
Albany	400	153
Converse	Not Reporting	Not Reporting
Goshen	1,700	Not Reporting
Laramie	1,150	Not Reporting
Platte	960	581
Total Reporting	**4,210**	**734**

Source: Farm Service Agency, County Offices

The Conservation Reserve Program (CRP) is one of the programs administered by the FSA. Table 20 indicates that in 1993 (latest available data) there were 659 CRP contracts in Southeastern Wyoming, primarily in Goshen, Laramie, and Platte Counties. These contracts covered nearly 218,000 acres and represented more than $8.3 million in annual payments. As noted in the background section on the Rule 4(d), CRP land appears to represent a Federal nexus.

Table 20. The Conservation Reserve Program in Southeastern Wyoming, 1993

County	Contracts	Acres	Annual Payments
Albany	0	0	$0
Converse	14	4,156	$160,298
Goshen	201	69,105	$2,671,682
Laramie	255	91,056	$3,441,121
Platte	189	53,400	$2,079,141
SEWYO total	**659**	**217,717**	**$8,352,241**

Source: Farm Service Agency Website

The Natural Resource Conservation Service (NRCS) is another possible source of a Federal nexus specifically mentioned in the Service's Draft Economic Analysis

(Industrial Economics, Incorporated 2003). Table 21 indicates that in 2002 there were 93 NRCS contracts in Southeastern Wyoming representing over $3.3 million in government payments for conservation practices. These contracts also represent potential Federal nexuses.

The above information appears to indicate that there is significant potential for a high number of Federal nexuses associated with agriculture in Southeastern Wyoming with regards to PMJM. The exact number will depend on how the PMJM program is administered. Several landowners during the listening sessions mentioned that they had either withdrawn from or were not participated in Federal programs because of a concern for the potential for a Federal nexus regarding PMJM and other endangered or threaten species. It was not possible to quantify the exact extent to which this is occurring in Southeastern Wyoming. But this subject is of concern regarding possible impacts on the resource base (soil, water, noxious weeds) due to conservation programs that may be neglected out of concern of triggering a federal nexus. Several participants in the listening sessions noted the difficulty in obtaining guidance on what constitutes a Federal nexus from the Service.

Table 21. Natural Resource Conservation Service Programs Southeastern Wyoming, 2002

County	Contracts	Amount
Albany	1	$56,072
Converse	5	$92,793
Goshen	34	$1,815,104
Laramie	18	$286,736
Platte	35	$1,038,017
SEWYO total	**93**	**$3,288,722**

Source: Natural Resource Conservation Service, State Office

Economic Importance of Irrigated Agriculture

Protection of PMJM could significantly impact irrigated agriculture in Southeastern Wyoming. As note in the Service's Draft Economic Analysis, "Because the PMJM inhabits riparian areas in or surrounding irrigation ditches and hay fields, some incidental take of individual mice is inevitable during normal farming and ranching operations in the mouse's range (Industrial Economics, Incorporated 2003)." This statement would seem to indicate that without the 4(d) rule much of the irrigated agriculture in Southeastern Wyoming could be in violation of section 9 of the Endangered Species Act if the mouse is present because:

- Over 70 percent of the harvested irrigated land in Southeastern Wyoming was in hay production in 2002 (Wyoming Agricultural Statistic, 2002).

- Most irrigation in the region involves the use of ditches.

- Due to concerns with secondary impacts, regulations regarding the timing and abundance of water, control of noxious weeds, and the use of pesticides and herbicides could have an impact on irrigated agriculture located away from potential Preble's habitat if it has the potential to adversely affect habitat.

Disruption of irrigated agricultural production is of particular concern in Wyoming since the State's water law specifies that either intentional or unintentional non-use of water for its appropriated use during any five successive years results in forfeiture of all water rights (Wyo. Stat. Ann. &41-3-401)

Due to the livestock sectors dependency on forage production from irrigated cropland and concerns regarding the effects of livestock grazing in riparian areas, the only part of agriculture in Southeastern Wyoming that might not conceivably be affected by PMJM is dry land farming.

Given the current uncertainty regarding recovery efforts for PMJM, it is difficult to estimate the actual economic impact that the mouse will have on agriculture in the region. Much of the biology and ecology for PMJM is still not well understood (Draft Environment Assessment, USFWS 2002). Until these traits are better categorized and a recovery plan developed, it is difficult to be specific about the potential economic impact. This uncertainty is further complicated by 4(d) rule regulations. While the Service's permanent extension of the 4(d) rule reduces the impact of PMJM on agriculture in the region, it does not totally eliminate them. Despite the current lack of certainty, it is possible to estimate the economic importance of the various aspects of irrigated agriculture in the region that could be affected by PMJM. This would provide an indication of the economic importance of the sector that could be the most impacted by conservation of PMJM and also provides an upper limit on the potential economic impacts of PMJM on agriculture in the region.

This analysis was based on an IMPLAN model of the five-county region. IMPLAN is an economic impact assessment modeling system that allows users to develop local level input-output models that can estimate the economic impacts of economic changes in a particular community or region. The five-county region consisted of the five Wyoming counties included in the initial listing of PMJM (Albany, Converse, Goshen, Laramie, and Platte). Because suitable habitat has been predicted in the Laramie Basin and Snowy Range - west of known Preble's occurrence (Keinath 2001) - all irrigated agriculture in Albany County was considered in the analysis.

The analysis considered the four major irrigated crops produced in the region: 1) hay production, 2) corn production (both grain and silage), 3) sugar beet production, and (4) dry bean production. The region also produces small quantities of barely and oats, but these were considered as auxiliary activities associated with other agricultural production. Approximately 80 percent of hay production and all corn production were assumed to be inputs to livestock production, which was then exported from the region. It was assumed that sugar beets were exported from the region as processed sugar through the sugar beet refinery at Torrington. It was assumed that approximately 20 percent of hay production

and all dry bean production were exported from the region as cash crops. To assess the economic impact of irrigation, the estimated current economic impacts with irrigation were compared to the estimated economic impact without irrigation. For irrigated hay production the without-irrigation use was assumed to be dry land hay production. For corn, sugar beet, and dry bean production the without-irrigation use was dry land winter wheat production. The difference between the with- and without-irrigation scenarios was considered to be the economic impact of irrigation in the region. A six-year average (1996-2001) from the Wyoming Agricultural Statistics was used to estimate production levels by crop. This was done to account for annual variations in production levels. More details on the production estimates can found in the appendix tables.

Table 22 summarizes the economic impact of irrigated agriculture in Southeastern Wyoming. Value of production for agriculture is estimated to decrease by $177.2 million per year from $220.5 million with irrigation to $43.3 million without irrigation. The $177.2 million loss represents over 21 percent of the value of production for all agricultural commodities in Wyoming in 2000 (Wyoming Agricultural Statistics 2002). Nearly fifty percent of this loss was due to the decrease in hay production ($85.4 million).

Employment (both direct and secondary) is estimated to decrease by 3,000 jobs from approximately 4,000 jobs (Table 23) with irrigation to approximately 1,000 jobs without irrigation. Approximately 70 percent of the total lost jobs would be in agriculture with the rest coming in other sectors of the region's economy. Nearly 64 percent of the job loss was due to the decrease in hay production. Total employment in the agricultural sector would decline by 75 percent under this scenario.

Table 24 estimates labor earnings (both direct and secondary) could to decrease by $75.7 million per year from $81.1 million with irrigation to $8.3 million without irrigation. Approximately 60 percent of the total lost labor earnings would be in agriculture with the rest coming from other sectors of the region's economy. Nearly 72 percent of the labor earnings loss was due to the decrease in hay production. Labor earnings in the agricultural sector would decline by 95 percent under this scenario. Average earnings per job for all sectors would decline from $21,190 with irrigation to $8,624 without irrigation.

Table 22. Value of production, irrigated agriculture in Southeastern Wyoming

	Value of Production W/Irrigation	Value of Production W/O Irrigation	Change	Percent change
Hay Production	$122,516,662	$37,144,458	-$85,372,204	-69.7
Corn Production	$57,709,019	$4,208,579	-$53,500,440	-92.7
Sugar Beet Production	$34,721,982	$899,798	-$33,822,184	-97.4
Dry Bean Production	$5,594,749	$1,035,635	-$4,559,114	-81.3
Total	**$220,542,412**	**$43,288,470**	**-$177,253,942**	**-80.4**

Table 23. Agricultural Employment in Southeastern Wyoming

	Employment W/Irrigation	Employment W/O Irrigation	Change	Percent change
Hay Production	2,778.8	870.7	-1,908.1	-68.7
Corn Production	767.8	67.2	-700.6	-91.3
Sugar Beet Production	319.5	14.4	-305.1	-95.5
Dry Bean Production	101.6	16.5	-85.1	-83.8
Total	**3,967.7**	**968.8**	**-2,998.9**	**-90.1**

The loss of irrigation in Southeastern Wyoming could also have significant implications for agricultural land values in the region (Table 25). For the period 1999-2001, the average sale price reported for irrigated land (meadow and cropland) in Southeastern Wyoming was $1,171 per acre (Wyoming Farm, Ranch, and rural Land Markets: 1999-2001, University of Wyoming 2003). During this same time period the average sale price reported for dry land (range and cropland) in Southeastern Wyoming was $534 per acre. Assuming comparable land types, this suggests that without irrigation the average value of irrigated agricultural land in the region would decline by over $637 per acre. This means that without irrigation the 349,000 plus acres of irrigated land in the region (Wyoming Department of Revenue 2000) would decline in value by $211.9 million (Table 25). This would represent a significant loss to landowners in the region, especially since many agricultural producers depend on land values to finance the continuation of their operation. This estimate does not consider the effects of the lack of irrigation on the value of other types of agricultural land in the region or the value of the land if it were to go into an alternative use. Nor does it consider the value of water should it become possible to purchase water separately from the land similar to Colorado.

Table 24. Agricultural labor earnings in Southeastern Wyoming

	Labor Income W/Irrigation	Labor Income W/O Irrigation	Change	Percent change
Hay Production	$61,605,412	$7,183,970	-$54,421,442	-88.3
Corn Production	$13,262,850	$801,962	-$12,460,888	-94.0
Sugar Beet Production	$8,033,204	$171,460	-$7,861,744	-97.9
Dry Bean Production	$1,175,414	$197,345	-$978,069	-83.2
Total	**$84,076,880**	**$8,354,737**	**-$75,722,143**	**-90.1**

Table 25. Irrigated agricultural land values in Southeastern Wyoming

	Land Value W/Irrigation	Land Value W/O Irrigation	Change	Percent change
Irrigated Land	**$408,803,126**	**$196,895,784**	**-$211,907,342**	**-51.8**

The loss of irrigation in Southeastern Wyoming could also have significant implications for the tax base of local governments in the region. The average assessed valuation for irrigated land in the region was $52.62 per acre in 2000 (Wyoming Department of Revenue 2000). The average assessed valuation for dry land and waste and bogs in the region was $11.67 per acre in 2000. Assuming that there is a procedure to change tax

classifications, this suggests that without irrigation the average assessed valuation of irrigated land in the region would decline by $40.95 per acre. This means that without irrigation the assessed valuation on the 349,000 plus acres of irrigated land in the region would decline by $14.3 million (Table 26). The decrease in assessed valuation is a particular concern in Southeastern Wyoming where the per capita assessed valuation is only 40 percent of the state average.

Table 26. Assessed valuation, irrigated agriculture in Southeastern Wyoming

	Assessed value w/irrigation	Assessed value w/o irrigation	Change	Percent change
Total agricultural land	**$18,439,354**	**$4,155,316**	**-$14,284,038**	**-77.5**

The answers to these and other questions will determine how the PMJM recovery effort is administered in the region and in turn the economic impact. It does appear that the PMJM has at least the potential to significantly impact agricultural operations and the economy of communities in Southeastern Wyoming. While it may not completely eliminate irrigated agriculture in the region, it could have a significant impact on an important industry in the region depending on how future recovery programs are implemented and administered.

Cost of Compliance

Table 27 summarizes the estimated administrative costs to third parties from each consultation with the Service regarding the PMJM (Industrial Economics Incorporated 2003). These are the costs a third party such as an agricultural producer would have to bear for each consultation on PMJM. These costs are in addition to the costs to the Service and any Federal Agencies that are involved. They do not include the cost of project modifications as a result of the consultation.

The Draft Economic Analysis estimates that the total economic costs if the proposed critical habitat is implemented in Wyoming would be $10.3 million to $13.5 million over 10 years or $508.57 to $666.57 per acre. Agriculture would represent $561,000 to $600,000 of the 10 year total or $56,100 to $60,000 per year. Again, no estimates of project modification costs are provided.

Table 27. Estimated Third Party Costs Per PMJM Consultation*

Type of consultation	Low estimate	High estimate
Technical assistance	$600	$1,500
Informal assistance	$1,200	$8,500
Formal consultation	$8,500	$12,900

Source: Draft Economic Analysis of Critical Habitat Designation for the Preble's Meadow Jumping Mouse.

***** Assumes third party bears the cost of biological assessments

During the listening sessions in affected southeastern Wyoming counties the researchers heard numerous examples of costs actually or potentially incurred because of PMJM. The following are some examples that have been documented for both agriculture and other activities in Southeastern Wyoming:

- Since 1999 True Ranches has spent nearly $110,000 due to PMJM including travel expenses, trapping, and personnel time (Personal communications, True Ranches). They estimate that their ranches contain 753 acres of proposed critical habitat. If these costs are extrapolated to the 15,561 acres of private land in Wyoming proposed for critical habitat, total cost to Wyoming landowners could approach $2.3 million.

- The current cost of ditch maintenance is approximately $34,800 per year for the Wheatland Irrigation District (Industrial Economic Incorporated, 2003). If burning activities on the ditches were reduced by 50 percent, following the expiration of the 4(d) Rule, it is estimated that the cost of ditch maintenance would increase by nearly 250 percent to $86,200 per year (Industrial Economic Incorporated, 2003). If no burning is permitted on the ditches following the expiration of the 4(d) Rule, it is estimated that the cost of ditch maintenance would increase by over 400 percent to $144,900 (Industrial Economic Incorporated, 2003). The Wheatland Irrigation District irrigates approximately 54,000 acres. If these costs are extrapolated to the 349,000 plus acres of irrigate land in Southeastern Wyoming, total ditch maintenance costs would increase from $224,911 per year to $557,107 per year with 50 percent burning and to $936,683 per year with no burning following the expiration of the 4(d) Rule.

- As previously noted it could cost landowners more than $3.2 million to fence the 237 miles of rivers and streams included in the proposed critical habitat designation for PMJM in Wyoming. It could also cost nearly $2.5 million to provide stock water if these riparian areas were fenced. Under the final critical habitat designation the costs would be about half this amount.

- Laramie County spent $41,488 on an unsuccessful attempt to develop a county HCP for PMJM. This amount included the value of over 810 hours of volunteer time and 50 hours of paid staff time.

- The City of Douglas spent $48,653 on additional operation and maintenance expenses as a result of delays in the repair of a break in a water main under the North Platte River relate to PMJM (internal memo, City of Douglas, 1999).

- In Colorado, the total cost of developing and implementing four HCPs is estimated to have ranged from $2,577,000 to $2,618,000 for an average of $644,250 to $654,500 per HCP (Industrial Economic, Incorporate, Addendum to Economic Analysis of Critical Habitat Designation for the Preble's Meadow Jumping Mouse, June 2003 – page 4).

These examples illustrate some of the potential costs that may accrue to firms and communities in Southeastern Wyoming as a result of PMJM. In many cases, these costs would be in addition to the consulting costs listed in Table 27.

Linear Programming Model Results

The linear programming model allowed the researchers to ask "what if" questions at the firm level. Specifically, how much does a mile of sub-irrigated pasture or a mile of irrigated hay meadow cost a landowner, on an annual basis, if he/she were no longer able to use that land due to a policy decision by the Service to protect PMJM? Or how would ranch profitability be affected by the cancellation of the ranches summer grazing on USFS land?

Tables 28 through 30 detail key findings from the sub-irrigated pasture models. "Ranch profits" represents the average, undiscounted, annual returns to land and management over the forty year run of the model. The "Base" column is the ranch without any PMJM habitat withdrawn from production. The other columns estimate the effects on ranch profits for the number of miles indicated of sub-irrigated pasture withdrawn from production. "Cows" represents the average number of head of breeding cows in the herd. And "Alfalfa purchased" represents the average annual number of tons of alfalfa purchased. Note that even without any land withdrawn from production, the ranch purchases some alfalfa. This is because under normal conditions, the rancher buys some of this type of feed for replacement heifers. The results indicate that as the number of miles of sub-irrigated habitat increases, the number of head of cows the rancher can support decreases. Also, the amount of purchased alfalfa decreases with herd size. Note that the ranch is still producing the same amount of grass hay from its irrigated meadows and selling this hay to try and offset the lower number of cattle it is able to carry.

Table 29 shows the percent change from the base model for each successive mile of habitat that the ranch might have. Notice that ranch profits decrease about 6 percent for every mile of this type of habitat withdrawn from production. The rate of decrease also appears to be increasing so it is likely that should there be more than 6 miles of habitat withdrawn from production that there would be an even larger decrease.

Table 28. Linear programming model results, sub-irrigated pasture.

	Base	1 Mile	2 Miles	3 Miles	4 Miles	5 Miles	6 Miles
Ranch profits	$39,423	$37,152	$34,754	$32,170	$29,443	$25,898	$22,328
Cows (head)	430	424	417	408	398	382	366
Alfalfa purchased (tons)	94.5	85.7	79.7	78	76	73	70

Table 30 shows the dollars per unit cost of withdrawn land resources in dollars per mile and dollars per acre. Here the costs increasing at an increasing rate is even more apparent. For example, a ranch with just one mile of habitat withdrawn is estimated to have ranch profits reduced by $2,271 per year, on average, from $39,423 to $37,152. The cost per acre of the 87.45 acres withdrawn would be $26.95 per acre. However, if the ranch had 6

miles of habitat withdrawn from production, the cost per mile would increase to $28.49 and the per-acre cost would increase to $32.58. Ranch profits would decrease over 43 percent from $39,423 to $22,328.

Table 29. Linear programming model results, percent change from base model, sub-irrigated pasture.

	Base	1 Mile	2 Miles	3 Miles	4 Miles	5 Miles	6 Miles
Ranch profits	0	-5.76	-11.84	-18.40	-25.31	-34.31	-43.36
Cows (head)	0	-1.40	-3.02	-5.12	-7.44	-11.16	-14.88
Alfalfa purchased (tons)	0	-9.31	-15.64	-17.46	-19.58	-22.75	-25.93

Table 30. Linear programming model results, per unit cost of sub-irrigated habitat

	Base	1 Mile	2 Miles	3 Miles	4 Miles	5 Miles	6 Miles
$/mile of habitat	--	$2,271	$2,334	$2,418	$2,494	$2,705	$2,849
$/acre of habitat	--	$25.96	$26.69	$27.64	$28.53	$30.93	$32.58

The pattern of the results for irrigated meadow is similar, yet more pronounced. As several ranchers in the listening sessions stated, “the hay meadows are the heart of the ranch”. This is borne out in the model. Whereas withdrawal of some of the sub-irrigated pasture constrained the operation in the number of head it could graze in the spring and fall, it experienced a somewhat modest herd reduction of about 15 percent (and not so modest profit reduction of over 43 percent) with six miles of habitat. In the case of irrigated meadow, however, the operations ability to feed cattle through the winter is significantly constrained with just one mile of habitat. Table 31 shows the model results. One mile of irrigated meadow withdrawn decreases average annual ranch profits over 18 percent from $39,423 to 32,260. Herd size decreases almost 4 percent and the number of tons of alfalfa purchased jumps 84 percent. Why the increase? The hay meadow supplies winter feed for the animals. By withdrawing this type of acreage, the ranch can no longer winter the same number of animals that it could before. Plus, unlike the withdrawal of sub-irrigated pasture, where even with a reduction in carrying capacity, an alternative product (hay) can still be sold. When hay meadows are withdrawn, there are no alternative products to sell when the means of production is no longer available. So herd size and profitability both suffer. The reason alfalfa purchases continue to increase is that the model is trying to maximize ranch income, so it will try to keep herd size up by buying hay to feed the herd even as the profits from the enterprise decline.

Table 31. Linear programming model results, irrigated meadow.

	Base	1 Mile	2 Miles	3 Miles	4 Miles	5 Miles	6 Miles
Ranch profits	$39,423	$32,260	$24,978	$17,673	$10,071	$2,056	-$6,253
Cows (head)	430	413	404	395	384	367	349
Alfalfa purchased (tons)	94.5	174	287	395	502	596	690

Table 32 shows the shows the percent change from the base model for each successive mile of habitat that the ranch might have. Ranch profits decrease about 18 percent for

every mile of this land class withdrawn from production. The rate of decrease also appears to be increasing so it is likely that should there be more than 6 miles of habitat withdrawn from production that there would be an even larger decrease.

Table 32. Linear programming model results, percent change from base model, irrigated meadow.

	Base	1 Mile	2 Miles	3 Miles	4 Miles	5 Miles	6 Miles
Ranch profits	0	-18.17	-36.64	-55.17	-74.45	-94.78	-115.86
Cows (head)	0	-3.95	-6.05	-8.14	-10.70	-14.65	-18.84
Alfalfa purchased (tons)	0	84	204	318	431	531	630

Table 33 shows the dollars per unit cost of withdrawn land resources in dollars per mile and dollars per acre measures. Here again, the costs increasing at an increasing rate can be seen. For example, a ranch with just one mile of irrigated meadow habitat withdrawn is estimated to have ranch profits reduced by $7,163 per year, on average, from $39,423 to $32,260. The cost per acre of the 87.45 acres withdrawn would be $81.90 per acre. However, if the ranch had 6 miles of habitat withdrawn from production, ranch profits would decrease over 116 percent from $39,423 to -$6,253 (an annual loss). The cost per mile would increase to $7,613 and the per-acre cost would increase to $87.05. In other words, the ranch would no longer be profitable.

Table 33. Linear programming model results, per unit cost of irrigated meadow.

	Base	1 Mile	2 Miles	3 Miles	4 Miles	5 Miles	6 Miles
$/mile of habitat	--	$7,163	$7,222	$7,250	$7,338	$7,473	$7,613
$/acre of habitat	--	$81.90	$82.59	$82.90	$83.91	$85.46	$87.05

It is interesting to note that the U.S. Census Bureau lists the threshold for poverty for a family of four (with two children under the age of 18) at $18,660 (2003). By this measure, with a little under three miles of irrigated meadow habitat withdrawn, the family would be below the poverty line, assuming one family per ranch.

In addition to the per mile scenarios, two other scenarios were developed in GAMS to help decision makers assess the economic impact of PMJM protection on agricultural producers. As a policy scenario, the project built a simulation that would cancel the model ranch's 500 aum U.S. Forest Service summer grazing lease. Although the ranch does have deeded summer pasture available, the USFS lease helps to maximize the ranch's available resources by adding summer grazing land that allows enough additional herd size to maintain family income.

Table 34 shows that canceling the USFS lease would reduce ranch profits by $4,586 per year and herd size by 64 head of mother cows. This would reduce ranch profitability by nearly 12 percent per year and herd size by almost 15 percent. An important point to note is the temporal nature of the reduction. For although the ranch has some summer grass available, the Forest Service lease allows the ranch the capacity to use all of its hay meadow resources. In the absence of the Forest Service lease, the model automatically

sells the surplus hay to try and make up for the lack of summer grass since it is less profitable to try and feed hay during the summer months. Results depend on how dependent the ranch is in USFS grazing for summer forage.

Table 34. Linear programming results for No USFS and 10 percent hay reduction scenarios.

	Base	No USFS lease	10 % hay reduction
Ranch profits	$39,423	$34,837	$35,606
Cows (head)	430	366	417
Alfalfa purchased (tons)	94	70	137

Finally, a scenario was developed that reduced hay production by 10 percent. The model has 575 acres of hay meadow which produces 863 tons of grass hay per year. Reducing production by 10 percent would reduce meadow acreage to 518 acres, cutting 87.5 tons off of production. Ten percent seems like a small amount, but the hay meadows provide valuable winter feed for cattle. It has long been recognized in Wyoming that herd size is dependant on the amount of winter feed available. Table 34 shows that a 10 percent reduction in hay production decreases ranch profits by $3,817 per year and herd size by 17 head of mother cows. The model tries to compensate for the loss of hay production by buying an additional 43 tons of alfalfa.

V. Suitable Habitat and Potential Economic Impacts of PMJM

This chapter extends the baseline analysis presented earlier by identifying specific acres that are potentially affected by the listing of the Preble's Meadow Jumping Mouse (PMJM). We use the results of the Interim report on the status of Preble's Meadow Jumping mouse (Beauvais, 2003), and then use county land use parcel data to identify particular uses for potential economic and fiscal impacts.

The Status Report summarizes a GIS-based modeling effort to identify areas where there is a higher likelihood of finding PMJM. The report contents are presented in appendix K. Suitable habitat estimates are based upon known positive trappings collected by Wyoming Natural Diversity Database (WYNDD). Trappings were located on proposed critical habitat designation and elsewhere in the region. This database was used to estimate PMJM suitable habitat. The chapter proceeds with a discussion of the conceptual framework for analyzing the potential impacts based upon suitable habitat and a presentation of the results.

Estimation of Suitable Habitat in Southeastern Wyoming

The Status Report identifies land that is suitable to PMJM based upon 158 positive trappings and 51 negative trappings in southeast Wyoming. Figure 8 presents the positive trappings (red dots) and negative trappings (blue crosses) with proposed designated critical habitat (red lines). Successful and non-successful trappings of PMJM.

Figure 8. Successful and non-successful trapping sites of PMJM

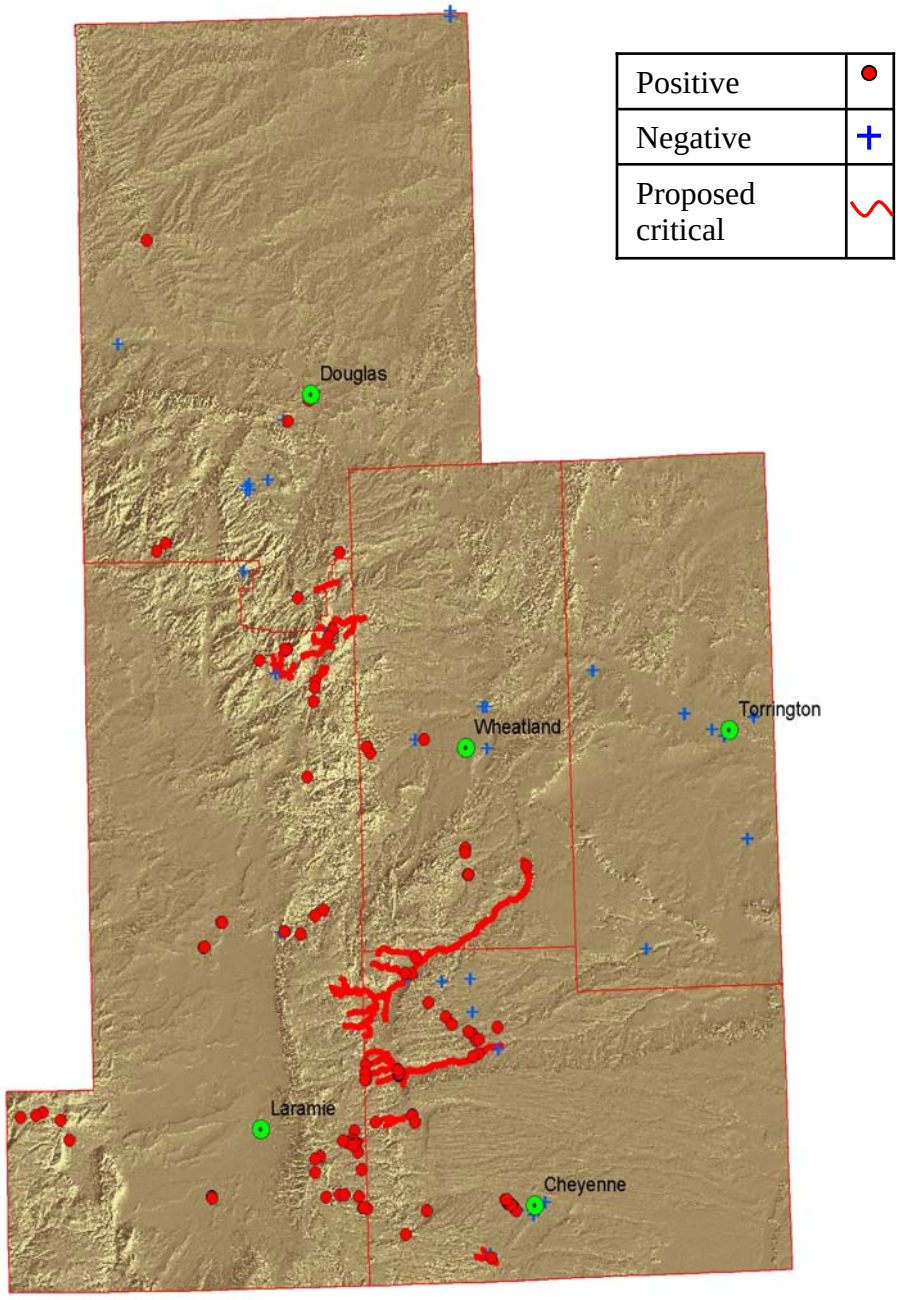
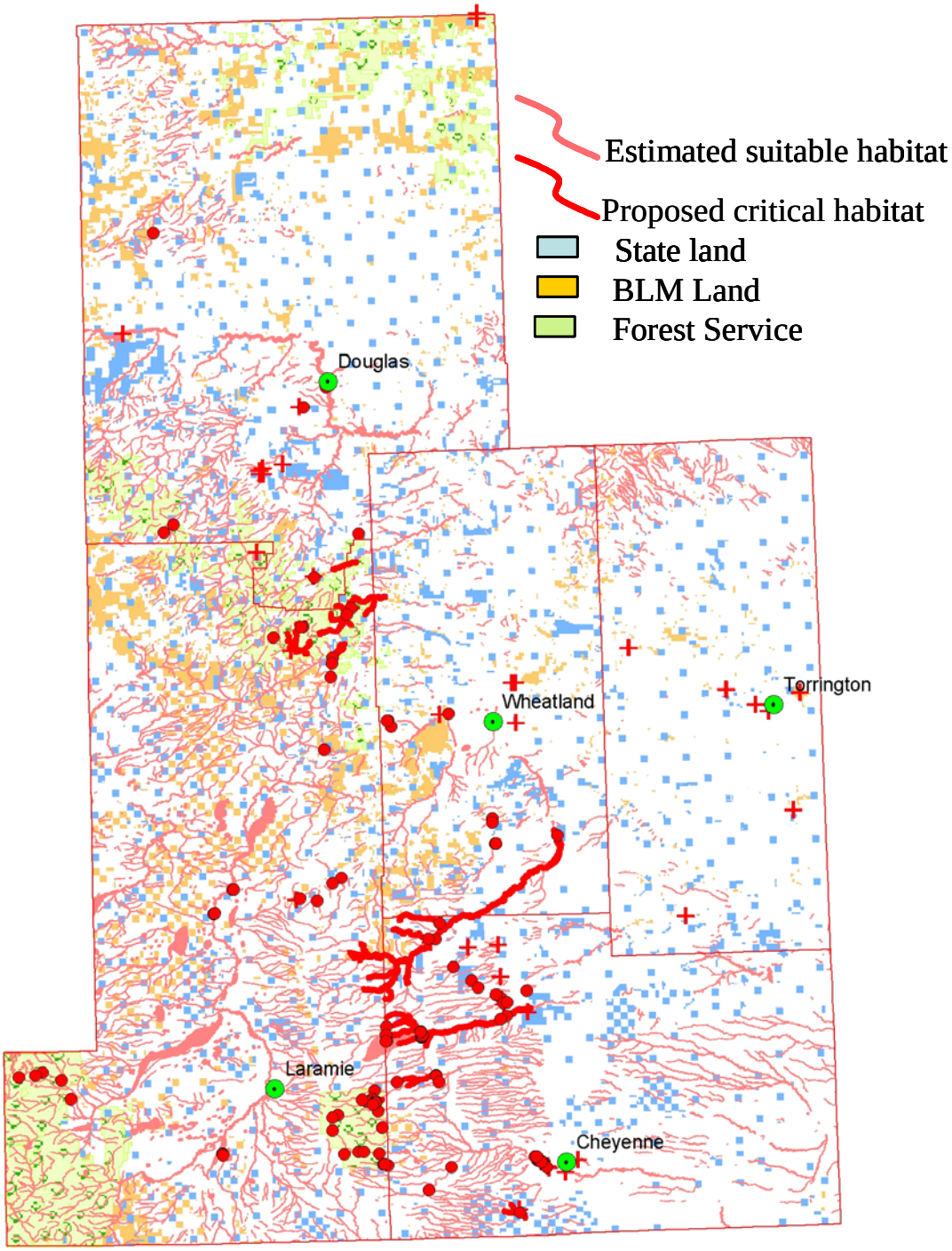


Figure 9. Estimated suitable habitat for PMJM in Southeastern Wyoming.



The model by Beauvais (2003) was used to provide a predictive range of suitable habitat from a robust statistical model of environmental conditions at positive points. Explanatory variables include ecological indicators, frost-free days, elevation, and soil. The output of the statistical model is put into a geographic information system (ESRI

2001) to spatially extrapolate across all five counties in southeast Wyoming. Mapping results are presented in Figure 9. *It is important to remember that the modeling does not predict whether the habitat is occupied, but only that the habitat is suitable for the species and it could be occupied.* Only actual testing in these areas would provide more conclusive information on occupancy.

The mouse inhabits riparian areas so suitable habitat represents a buffer around the selected drainage systems. Biological buffers applied by the WYNDD interim report differ from the Service's buffers. The differences are presented in Table 35. The analysis adjusted the buffer size to be consistent with USFWS buffer sizes.

Table 35. Suitable habitat stream buffers from the Interim report and the USFWS.

Stream Order	Interim report buffer size (meters)[a]	U.S. Fish and Wildlife Buffer size (meters)[b]
1 and 2	40	220
3	60	240
4	90	240
5	120	240
6	150	240
7	210	240

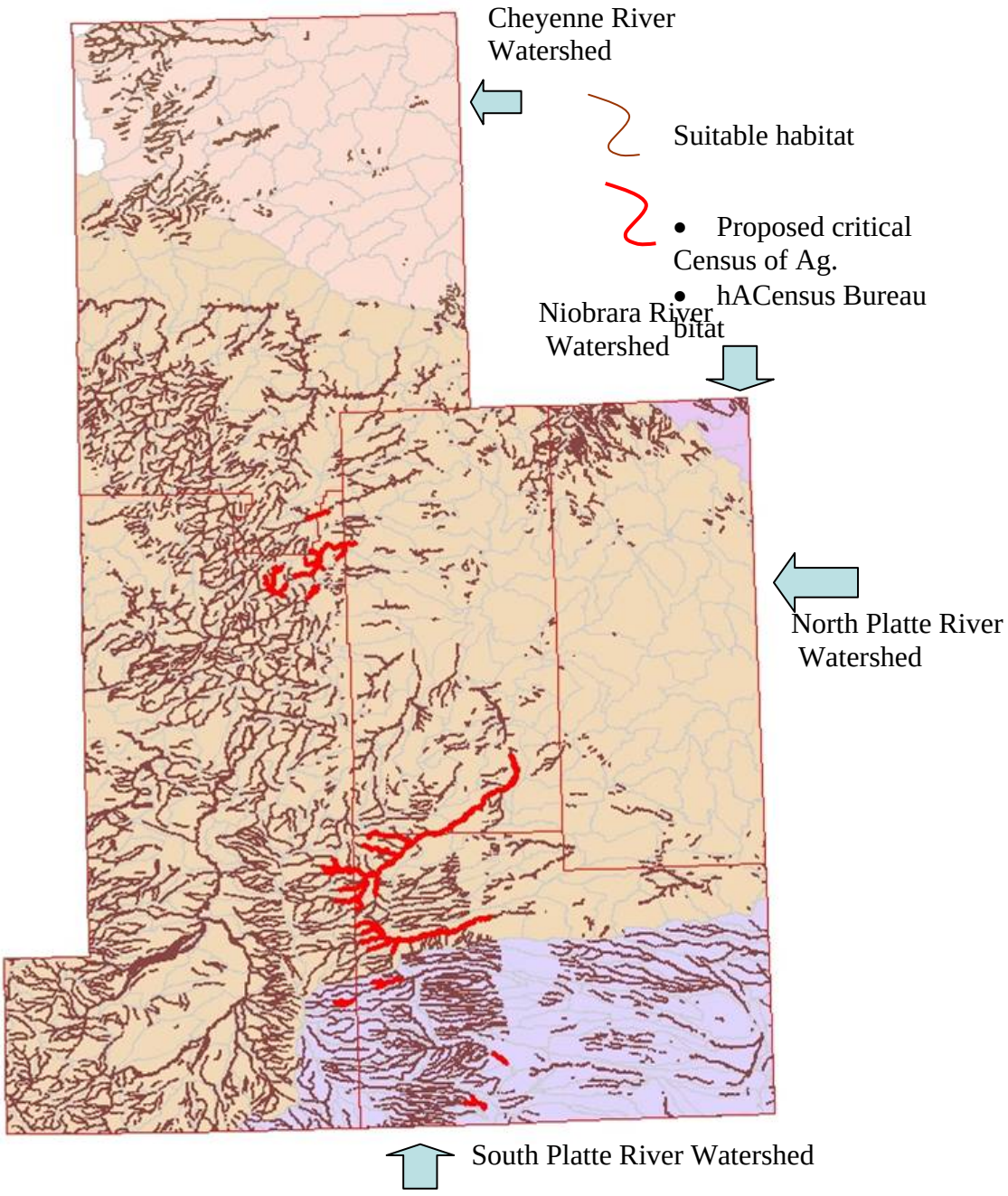
[a]Beauvais (2003); [b]USFWS (2002)

Suitable habitat is located in four of the major watersheds that intersect southeastern Wyoming: North Platte, South Platte, Cheyenne, and Niobrara (Figure10). The North Platte is the largest with 76.6 percent of the suitable habitat. The South Platte is the next largest with 17.8 percent of the suitable habitat. The Cheyenne River watershed and Niobrara both comprise small proportions of the suitable habitat.

Table 36. Suitable habitat by major watershed in Southeastern Wyoming.

	Acres of suitable habitat	Pct of total
Cheyenne watershed	43,966	5.3%
North Platte	637,785	76.6%
South Platte	147,959	17.8%
Niobrara River	3,115	0.4%
Total	832,825	100.0%

Figure10. Suitable habitat by major watershed.



Suitable habitat in southeastern Wyoming totals approximately 832,825 acres, (see Table 37). Albany County has the highest proportion of their land base identified as suitable habitat with 288,246 acres. Converse County has the next highest acreage level with 165,600 acres. Goshen County has the least with 76,266 acres. Likewise Albany County also has the highest quantity of suitable habitat on public land with 101,195 acres.

Table 37. Estimated acreage of suitable habitat in Southeastern Wyoming.

	Total Private	Public Lands	Total potentially affected lands
Albany	173,221	101,195	274,416
Converse	153,653	29,573	183,226
Goshen	140,823	2,521	143,344
Laramie	49,427	13,231	62,658
Platte	160,298	8,883	169,181
Total	677,422	155,403	832,825

Land Use Estimates

The next step in evaluating the impact of designation based upon suitable habitat is to estimate the land use occurring on the private lands covered by suitable habitat. This required the use of digital parcel maps and assessor data from county offices. GIS parcel coverages with land use data are overlaid with suitable habitat coverages to estimate acreages of rangeland, cropland, waste and bog, and residential. The analysis does not extend to residential and commercial parcels. It is assumed that these parcels are used more intensively, and are less relevant to mouse habitat.

From the parcel databases and location of suitable habitat, 677,422 acres of agricultural land can be classified as suitable habitat (Table 38). Another 177,291 acres are classified as waste and bog. The analysis includes waste and bog since this category can include land types ranging from alkali flats to highly productive riparian areas. Finally 155,403 acres of suitable habitat are located on public land. The total land area covered by suitable habitat then is 832,825 acres. Albany County has the largest component with 173,221 acres of private land and 101,195 acres of public lands.

Laramie County has the smallest amount of suitable habitat, with 49,427 acres of private land and 13,231 acres of public lands. The data suggest that expansions of critical habitat will have differing impacts across counties. Mitigation strategies will need to be evaluated based upon the type of land and the public/private ownership characteristics.

A more detailed analysis of land classification and suitable habitat is based upon Department of Revenue agricultural land classes are presented in Table 39. These classifications relate to assessed valuation formulas generated by the State of Wyoming Department of Revenue to assist local assessors in property tax estimation, (Wyoming State Department of Revenue, 2003). Laramie County has the lowest amount of land covered under suitable habitat, but has a higher value mix, with irrigated lands being a dominant part of the mix. Albany County, Converse County, and Goshen County all have relatively higher proportions of rangeland.

Table 38. Estimated acreage of suitable habitat by land classification, southeastern Wyoming.

	Range	Crop	Waste and Bog	Total Private	Public Lands	Total potentially affected lands
Albany	122,606	19,826	30,789	173,221	101,195	274,416
Converse	93,218	20,222	40,213	153,653	29,573	183,226
Goshen	73,568	22,637	44,618	140,823	2,521	143,344
Laramie	-	19,324	30,103	49,427	13,231	62,658
Platte	127,099	1,631	31,568	160,298	8,883	169,181
Total	416,491	83,640	177,291	677,422	155,403	832,825

Table 39. Estimated acreage of suitable habitat on private agricultural land in Southeastern Wyoming based upon land use classification.

	Albany	Converse	Goshen	Laramie	Platte	Total
Irrigated agriculture II	0	18,996	0	6,667	7,696	33,359
Irrigated agriculture III	0	0	435	12,689	11,628	24,752
Irrigated agriculture IV	0	0	950	1,717	0	2,667
Irrigated agriculture V	0	0	246	1,564	0	1,810
Dry land crops II	0	1,226	0	0	0	1,226
Dry land crops III	0	0	0	0	0	0
Dry land crops IV	16,723	0	0	0	0	16,723
Dry land crops V	3,103	0	0	0	0	3,103
Range I	1,562	93,218	0	17,652	0	112,432
Range II	39,599	0	1,237	4,484	0	45,320
Range III	81,445	0	125,862	51,432	0	258,739
Range IV	0	0	0	0	0	0
Range V	0	0	0	0	0	0
Waste and bog	30,789	40,213	31,568	44,618	30,103	177,291
Total	173,221	153,653	160,298	140,823	49,427	677,422

Average buffer perimeter length and average acreage are estimated in Table 40. On a per section of land basis, suitable habitat buffer perimeters on private land average 3,718 meters in total length. The standard deviation is 2,431 meters. The maximum perimeter length per section is 17,185 meters. Average acres and standard deviation of acres per section are 77 acres and 63 acres, respectively.

Suitable habitat of the Preble's Meadow Jumping Mouse estimates total over 832,825 acres in southeastern Wyoming, with 677,422 acres on private land and 155,403 acres on public land. The overwhelming majority of the land potentially impacted is agricultural

land. Perimeter lengths which relate to fencing costs are substantial and average approximately 3,718 meters per section with a standard deviation of 2,431 meters. (This large standard deviation suggests a high variability in perimeter length across land sections.)

Table 40. Average perimeter length and acreage of suitable habitat per section of land.

	Average perimeter (meters)	Average acreage (acres)
Mean	3,718	77
St. dev	2,431	63

The pattern of potential impact from the listing of the Preble's Meadow Jumping Mouse can be quite complex depending upon the location of the habitat and the overall quantity of land scrutinized. The above analysis attempts to put some sideboards on the size and complexity of the scope of long run management. This information can then be used to model mitigation strategies by explicitly parameterizing spatial attributes.

Combining Results: Valuation Estimates

Combining the results from the linear programming model with the Geographic Information Systems (GIS) information results in an estimated annual valuation range for critical habitat and suitable habitat for southeastern Wyoming. Linear programming results for dollars per acre of habitat from Tables 30 and 33 (pages 48 and 49) were averaged to establish a single estimate for each of the land classes. These averages were multiplied by the acres of private land designated as critical habitat and estimated acres of suitable habitat. The results, shown in Tables 41 and 42, are an estimated range of costs that could be incurred by landowners in the region due to the protection of PMJM. The lower bound is represented by all land as sub-irrigated pasture and the upper bound is represented by all land as irrigated hay meadow.

Table 41. Range of estimated annual costs for PMJM critical habitat (private land).

Land class	**$/acre** (average value)	**Acres**	**Estimated value**
Irrigated meadow	$84.48	11,227	$952,662
Sub-irrigated pasture	$29.27	11,227	$330,071

Table 41 estimates a range of $330,071 to $952,662 per year as a cost to private landowners for the critical habitat designated by the Service. This is based on 11,227 acres of critical habitat. Please note that this figure differs from the 10,532 acres figure provided by the Service in the critical habitat designation. The discrepancy between these two figures could not be resolved in the data.

Table 42 estimates a range of $19,828,142 to $57,228,611 per year as a cost to private landowners in the region for suitable habitat acreage, as estimated by the WYNDD model. This value is based on 677,422 acres of private land. Again, suitable habitat does not guarantee the presence of PMJM, just the conditions likely to support it.

Table 42. Range of estimated annual costs for PMJM suitable habitat (private land).

Land class	$/acre (average value)	Acres	Estimated value
Irrigated meadow	$84.48	677,422	$57,228,611
Sub-irrigated pasture	$29.27	677,422	$19,828,142

VI. TRANSFERABILITY

The third goal of this project was to evaluate the transferability of the methodology used to another potential endangered species. Specifically, the researchers would like to develop a methodological template that could be applied to future threatened and endangered species in Wyoming. Such a template would not only cut down on the time it takes to accomplish an economic impact study, but help to set a standard of comparison for economic impacts to the regional economy from different species.

The flow chart shown in Figure 4 (page 25) shows the process used in this project. There are three major components in the process. The first is the gathering of data, such as the listening sessions and the secondary data used to build the base line scenario. Model building is the second component and finally the results. This is a standard approach to a research problem. Where the researchers wanted to break new ground was in the use of GIS and the digitized parcel data to get a more detailed and accurate look at the land area and usage of the land. It was hoped that by having accurate land use data, that the results would more accurately reflect the real world situation. The results were mixed since the availability of such data across multiple counties was not consistent and the data layers used by government agencies were often not publicly available or different from what the researchers could obtain. The researchers feel that it is only a matter of time before these issues will be resolved as the use of GIS continues to expand.

The use of listening sessions, though time consuming, was a valuable first step for several reasons. Not only were the researchers able to gain an understanding of the problem and valuable information from people with first hand experience dealing with the mouse, but they were also able to give those individuals with the most to loose a voice in the process. A voice that they felt they otherwise did not have. Several producers came to the sessions feeling that the issue had been “studied to death” and that it was not possible to be heard in the bureaucracy. These same people left the sessions with some sense that something was being done that could possibly assist them in maintaining their way of life.

Another component of the project that shows promise of transferability is the use of a linear programming model to simulate the firm level affects of a policy decision. In this case, a model that shows the affects of a policy decision on the profitability of

agricultural producers appears to be readily adaptable throughout the state. Other models could be built to simulate affects on small businesses in other sectors if the need arises. The use of this type of model is not new in attempting to answer policy questions, but the use of this type of model in conjunction with GIS data and an input–output model is new when used to address endangered species issues (to the best of our knowledge). This could be because the amount of private land involved in the issue is larger than has been seen with other endangered species.

This process of evaluating firm level affects and then translating them to the regional level through established input-output modeling seems to work well when used for individual firms. However, this process would become much more complicated if different types of firms were involved. That is, with PMJM the affects are on a fairly homogenous industry (cattle ranching). Whereas, trying to model the affects from several different types of firms at the same time, say ranching, residential construction and oil and gas production would increase the complexity and thus be more difficult to measure.

The main obstacle however, appears to come from the species themselves. Because each species has different habitat or at least utilizes habitat differently, it will have differing levels of impact on different activities at different times of the year. This would necessitate gathering different types of data for each individual species studied.

For example, PMJM and the Colorado Butterfly Plant (also listed as a threatened species) both occupy riparian habitat in southeastern Wyoming. And yet management practices intended to promote one species may actually harm the other. The Colorado Butterfly Plant tends to benefit from periodic disturbances such as fire, flooding and grazing "that maintain short vegetative cover or early seral conditions" (Natureserve 2004). In the absence of these natural processes "development of management strategies involving mowing, brush removal and integrated pest management for weed control have been recommended to maintain and improve Colorado Butterfly Plant habitat…" (Natureserve 2004). Contrast this with PMJM which prefers "heavily vegetated, shrub dominated riparian habitats" (USFWS, 2004). Interestingly, the Service designated critical habitat for the Colorado Butterfly Plant on August 6, 2004 that coincides with some land considered suitable habitat for PMJM.

What this means is that some activities (such as grazing or the use of herbicides) that could be built into a model to estimate the impact on profitability for one species would not work (or even be harmful or illegal) for another species. So from the standpoint of transferability, the procedures may transfer, but not the data and that researchers will be required to understand the habitat requirements for each new species and gather the appropriate data before launching into the model building phase. This is not a "show stopper" for the analysis but means that a cookie-cutter approach will not work and that more time and money may be required to accomplish the project.

Overall, the researchers feel that the methodology used in this project could be transferred to another species in Wyoming. Though each species has different habitat requirements and affects the economy differently, by gathering the appropriate species

specific data a comparable study could be accomplished. The use of digital parcelized data and firm level analysis to measure economic impacts and translate them to the regional level should get better as the use of GIS data layers becomes more wide spread and easy to use.

VII. IMPLICATIONS FOR NATIONAL ENVIRONMENTAL POLICY

Whatever the USFWS decides in December regarding the listing status of PMJM, it will have served as a watershed species in terms of pointing the way toward future listings and de-listings under the ESA. Indeed, for some, PMJM is motivation for ESA reform. This is due to both biological and geographic aspects surrounding the issue. On the biological side is the issue of what constitutes a distinct species and how much research is required to determine its uniqueness and scarcity. Even the scientists involved have been debating what standards to use, so further litigation is likely.

On the geographic side, the mouse's native range, along the fast growing Front Range of the Rocky Mountains, has increased the visibility of the controversy, fueling some visceral feelings on both sides of the debate. Caught in the middle are the agricultural producers of Southeastern Wyoming who have PMJM habitat on their land. Away from the rural residential developments of Colorado, these producers feel that their livelihoods are threatened by a species many of them did not even know existed and that their operations, by some accounts, have created and sustained mouse habitat. One thing that sets the PMJM debate apart in Wyoming is the amount of private land that has been designated at critical habitat for the mouse. Private land that may be the sole means of support for some landowners. Since the ESA does not provide for compensation, the door is open for charges by landowners that the federal government is "taking" their land.

ESA requires that the agency use "best available science" to identify the suitability of a species to come under the protection of the Act. However, very often the research question that the science was based upon differs from the policy question that USFWS is confronted with. If the research question did not directly address the range and the biological distinctness of the species, the agency is forced to take the position of the petitioner as opposed to the "science". Safety-first rules dictate such an interpretation.

To address this issue some have proposed that the State and USFWS follow a modification of the guidelines set forth by the Council for Environmental Quality. Petitions for listing could be evaluated by a scientific review panel to address whether the science sufficiently addresses the questions that agency has to operate on, namely: Is this species a distinct species or subspecies, and does the scientific record really address its actual range. If the review panel thinks the scientific record exists then the listing proposal could proceed. Otherwise there should be more field research on those topics specifically.

VIII. SUMMARY AND CONCLUSIONS

Most of the economic impact of PMJM in Southeastern Wyoming will be felt by agricultural production. Approximately 88 percent of the critical habitat is on private land. Because agriculture is the predominant economic activity in rural parts of the region, administrative action to protect PMJM is a concern in Wyoming. Additionally, agriculture is the prime provider of open space in the region and an important resource in terms of landscapes, lifestyle, and wildlife habitat. A major part of agriculture in the region involves livestock and irrigated crop production. Both of these could be affected by PMJM.

As a part of this project, a series of "listening" sessions were held in the affected Wyoming counties to assess landowner and community perceptions regarding PMJM. Anger, frustration, confusion, and distrust were the most frequent sentiments expressed at these sessions. Frustration was expressed that there was a lack of understanding as to the role that agriculture plays in creating and sustaining mouse habitat. It was also clear that there was a lot of misinformation and lack of information regarding the mouse at the community/landowner level.

Analysis of USDA-ERS budgets showed that if ranchers are forced to cease hay production in order to protect PMJM habitat and instead purchase hay, the average operating profit would become negative and the probability of negative operating profits would approach 100 percent. It is doubtful that many ranching operations could remain economically viable under this scenario.

One of the factors that could influence the economic impact of PMJM in Southeastern Wyoming is the number of Federal nexuses that exist with agriculture in the region. Federal government reports indicate that nearly 50 percent of the commercial agricultural operations in the region receive government payments, which could mean that they have a Federal nexus regarding PMJM and other endangered species. In addition agricultural operators holding grazing permits, which would also represent a Federal nexus, control 45 percent of the agricultural land in the region.

Protection of PMJM could significantly impact irrigated agriculture in Southeastern Wyoming. Depending on how the program is administered, the only part of agriculture in the region that might not conceivably be affected by PMJM is dry land farming. Loss of irrigated agriculture due to PMJM would significantly affect the economy of Southeastern Wyoming. It would also significantly reduce land values and assessed valuation for agricultural land in the region. Of course, this is a worst-case scenario representing an upper limit to the potential impact from the mouse. However, it does appear that PMJM has at least the potential to significantly impact agricultural operations and the economy of communities in the region.

As another measure of the impact of critical habitat designation, this project used a computer simulation to evaluate the cost to the landowner of a mile of critical habitat on either a mile of sub-irrigated pasture (riparian zone) or a mile of hay meadow. The results show that one mile of sub-irrigated pasture would have an estimated cost of $2,271

($25.96 per acre) per year. This would reduce ranch profitability by 6 percent per year. This cost increases with each additional mile of sub-irrigated pasture on the ranch.

When hay meadow is considered, the estimated cost per mile was significantly higher. The model shows that a mile of irrigated hay meadow reduced ranch profits by $7,163 ($81.90 per acre) per year. This would reduce ranch profitability by nearly 20 percent per year. Again, this cost increases with each additional mile on the ranch. With three miles of irrigated hay meadow critical habitat withdrawn from the ranch, the income for the ranch would fall below the U.S. Census Bureau's definition of poverty for a family of four.

As a policy scenario, the project built a simulation that would cancel the model ranch's 500 aum U.S. Forest Service summer grazing lease. Although the ranch does have deeded summer pasture available, the USFS lease helps to maximize the ranch's resources by adding summer grazing land that allows enough additional herd size to maintain family income. The model showed that canceling the USFS lease would reduce ranch profits by $4,586 per year. This would reduce ranch profitability by nearly 12 percent per year.

An additional scenario showed the impact of a 10 percent reduction in hay production on ranch profitability. Loosing 10 percent of hay meadow production due to protection of PMJM would reduce average profitability by $3,817 per year (9.7 percent) and reduce herd size by 17 head of mother cows. This scenario illustrates the importance of the hay meadows to the feed base of the operation.

GIS analysis of suitable habitat for PMJM shows a total of over 832,825 acres in Southeastern Wyoming, with 677,422 acres on private land and 155,403 acres on public land. The overwhelming majority of the land potentially impacted is agricultural land. Perimeter lengths which relate to fencing costs are substantial and average approximately 3,718 meters per section with a standard deviation of 2,431 meters. (This large standard deviation suggests a high variability in perimeter length across land sections.)

The pattern of potential impact from the listing of PMJM can be quite complex depending upon the location of the habitat and the overall quantity of land scrutinized. In order to give decision makers some estimate of the potential economic impact on the region from both critical and suitable habitat, the researchers combined results from the linear programming model and the GIS analysis. The results showed a range of impacts from about $330,000 to $950,000 per year on critical habitat, and from about $20,000,000 to $57,000,000 per year for the suitable habitat in the region.

For the third part of the project, transferability, the researchers evaluated the process used in this project for applicability to future threatened and endanger species. It was decided that the process could be readily adapted to other species. Though each species has different habitat requirements and affects the economy differently, by gathering the appropriate species specific data a comparable study could be accomplished. The use of digital parcelized data and firm level analysis to measure economic impacts and translate

them to the regional level should get better as the use of GIS data layers becomes more wide spread and easy to use.

Finally, the PMJM controversy has some important implications for national environmental policy. The Denver Museum of Science and Nature's DNA study has put the mouse in a unique position. This is the first time that a threatened or endangered species' distinctiveness has been scientifically challenged on this level.

Additionally, the amount and type of private land designated as critical habitat has a high proportion of private land, land that is productively being used by small family businesses (ranches) that play a key role in the rural economy of Southeastern Wyoming. That critical habitat has the potential to significantly impact these operations and the regional economy, without compensation from the federal government could have significant legal, political and economic repercussions.

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X. APPENDICES

Appendix Table A: Cow-calf production costs and returns per bred cow, Northern Great Plains-base budget

	1996	1997	1998	1999	2000	2001	Avg	Prob.Neg.
Gross Value of Production								
Steer Calves	$95.82	$131.05	$130.90	$143.94	$167.21	$164.47		
Heifer Calves	$59.75	$81.70	$81.21	$89.33	$103.87	$102.05		
Yearling Calves	$96.99	$109.82	$101.19	$109.87	$118.68	$120.78		
Yearling Heifers	$28.37	$32.37	$29.53	$31.86	$34.18	$35.06		
Other Cattle	$80.77	$91.48	$89.64	$93.45	$101.07	$105.36		
Total Value of Production	$361.70	$446.42	$432.47	$468.45	$525.01	$527.72		
Operating Costs:								
Feeder Cattle	$28.00	$33.81	$31.14	$34.41	$38.15	$38.24		
Feed:								
Concentrate & Other Feed	$22.07	$22.53	$20.26	$18.03	$18.19	$19.58		
Supplemental Feed	$48.02	$42.98	$33.15	$31.34	$33.16	$37.40		
Harvested Forages	$135.83	$143.63	$110.49	$90.28	$118.48	$136.30		
Cropland Pasture	$8.36	$8.98	$7.10	$7.74	$7.72	$7.61		
Private Pasture	$114.13	$121.45	$108.17	$114.75	$115.72	$114.82		
Public Land	$8.77	$9.59	$6.20	$7.16	$6.93	$6.53		
Total Feed Costs	$337.18	$349.16	$285.37	$269.30	$300.20	$322.24		
Other:								
Veterinary and Medicine	$14.29	$14.73	$15.38	$15.70	$16.37	$14.95		
Bedding and Litter	$0.21	$0.21	$0.22	$0.22	$0.23	$0.24		
Marketing	$6.12	$6.37	$6.63	$6.78	$7.02	$6.36		
Custom Operations	$28.32	$29.33	$31.08	$31.68	$32.92	$29.66		
Fuel, Lube, and Electricity	$21.86	$16.41	$16.44	$16.40	$16.39	$16.38		
Repairs	$20.51	$21.62	$22.69	$23.30	$24.07	$21.46		
Interest on Operating Inputs	$11.47	$11.65	$10.89	$10.71	$13.17	$7.64		
Total Other Costs	$102.78	$100.32	$103.33	$104.79	$110.17	$96.69		
Total Operating Costs	$467.96	$483.29	$419.84	$408.50	$448.52	$457.17		
Allocated Overhead:								
Hired Labor	$0.57	$0.64	$0.65	$0.68	$0.71	$0.75		
Unpaid Family Labor	$289.55	$302.94	$309.71	$319.50	$325.93	$331.60		
Capital Cost Recovery	$50.78	$76.71	$74.76	$73.16	$82.26	$88.72		
Charge for Land	$2.72	$2.79	$2.89	$3.37	$3.42	$3.12		
Taxes & Insurance	$31.51	$31.59	$32.40	$32.49	$33.42	$33.81		
General Overhead	$49.25	$50.15	$51.27	$51.79	$53.31	$55.32		
Total Allocated Cost	$424.38	$464.82	$471.68	$480.99	$499.05	$513.32		
Total Costs	$892.34	$948.11	$891.52	$889.49	$947.57	$970.49		
GVOP - Operating Costs	($106.26)	($36.87)	$12.63	$59.95	$76.49	$70.55	$12.75	33.3%
GVOP - Total Costs	($530.64)	($501.69)	($459.05)	($421.04)	($422.56)	($442.77)	($462.96)	100.0%

Source: USDA-ERS

Appendix Table B: Cow-calf production costs and returns per bred cow, Northern Great Plains-replacement hay budget

	1996	1997	1998	1999	2000	2001	Avg.	Prob. Neg.
Gross Value of Production								
Steer Calves	$95.82	$131.05	$130.90	$143.94	$167.21	$164.47		
Heifer Calves	$59.75	$81.70	$81.21	$89.33	$103.87	$102.05		
Yearling Calves	$96.99	$109.82	$101.19	$109.87	$118.68	$120.78		
Yearling Heifers	$28.37	$32.37	$29.53	$31.86	$34.18	$35.06		
Other Cattle	$80.77	$91.48	$89.64	$93.45	$101.07	$105.36		
Total Value of Production	$361.70	$446.42	$432.47	$468.45	$525.01	$527.72		
Operating Costs:								
Feeder Cattle	$28.00	$33.81	$31.14	$34.41	$38.15	$38.24		
Feed:								
Concentrate & Other Feed	$22.07	$22.53	$20.26	$18.03	$18.19	$19.58		
Supplemental Feed	$48.02	$42.98	$33.15	$31.34	$33.16	$37.40		
Harvested Forages	$153.00	$170.00	$152.00	$130.00	$169.00	$218.00		
Cropland Pasture	$8.36	$8.98	$7.10	$7.74	$7.72	$7.61		
Private Pasture	$114.13	$121.45	$108.17	$114.75	$115.72	$114.82		
Public Land	$8.77	$9.59	$6.20	$7.16	$6.93	$6.53		
Total Feed Costs	$354.35	$375.53	$326.88	$309.02	$350.72	$403.94		
Other:								
Veterinary and Medicine	$14.29	$14.73	$15.38	$15.70	$16.37	$14.95		
Bedding and Litter	$0.21	$0.21	$0.22	$0.22	$0.23	$0.24		
Marketing	$6.12	$6.37	$6.63	$6.78	$7.02	$6.36		
Custom Operations	$28.32	$29.33	$31.08	$31.68	$32.92	$29.66		
Fuel, Lube, and Electricity	$21.86	$16.41	$16.44	$16.40	$16.39	$16.38		
Repairs	$20.51	$21.62	$22.69	$23.30	$24.07	$21.46		
Interest on Operating Inputs	$11.47	$11.65	$10.89	$10.71	$13.17	$7.64		
Total Other Costs	$102.78	$100.32	$103.33	$104.79	$110.17	$96.69		
Total Operating Costs	$485.13	$509.66	$461.35	$448.22	$499.04	$538.87		
Allocated Overhead:								
Hired Labor	$0.57	$0.64	$0.65	$0.68	$0.71	$0.75		
Unpaid Family Labor	$289.55	$302.94	$309.71	$319.50	$325.93	$331.60		
Capital Cost Recovery	$50.78	$76.71	$74.76	$73.16	$82.26	$88.72		
Charge for Land	$2.72	$2.79	$2.89	$3.37	$3.42	$3.12		
Taxes & Insurance	$31.51	$31.59	$32.40	$32.49	$33.42	$33.81		
General Overhead	$49.25	$50.15	$51.27	$51.79	$53.31	$55.32		
Total Allocated Cost	$424.38	$464.82	$471.68	$480.99	$499.05	$513.32		
Total Costs	$909.51	$974.48	$933.03	$929.21	$998.09	$1,052.19		
GVOP - Operating Costs	($123.43)	($63.24)	($28.88)	$20.23	$25.97	($11.15)	($30.08)	66.7%
GVOP - Total Costs	($547.81)	($528.06)	($500.56)	($460.76)	($473.08)	($524.47)	($505.79)	100.0%

Appendix Table C: Cow-calf production costs and returns per bred cow -replacement hay with transportation

	1996	1997	1998	1999	2000	2001	Avg.	Prob. Neg.
Gross Value of Production								
Steer Calves	$95.82	$131.05	$130.90	$143.94	$167.21	$164.47		
Heifer Calves	$59.75	$81.70	$81.21	$89.33	$103.87	$102.05		
Yearling Calves	$96.99	$109.82	$101.19	$109.87	$118.68	$120.78		
Yearling Heifers	$28.37	$32.37	$29.53	$31.86	$34.18	$35.06		
Other Cattle	$80.77	$91.48	$89.64	$93.45	$101.07	$105.36		
Total Value of Production	$361.70	$446.42	$432.47	$468.45	$525.01	$527.72		
Operating Costs:								
Feeder Cattle	$28.00	$33.81	$31.14	$34.41	$38.15	$38.24		
Feed:								
Concentrate & Other Feed	$22.07	$22.53	$20.26	$18.03	$18.19	$19.58		
Supplemental Feed	$48.02	$42.98	$33.15	$31.34	$33.16	$37.40		
Harvested Forages	$183.00	$200.00	$182.00	$160.00	$199.00	$248.00		
Cropland Pasture	$8.36	$8.98	$7.10	$7.74	$7.72	$7.61		
Private Pasture	$114.13	$121.45	$108.17	$114.75	$115.72	$114.82		
Public Land	$8.77	$9.59	$6.20	$7.16	$6.93	$6.53		
Total Feed Costs	$384.35	$405.53	$356.88	$339.02	$380.72	$433.94		
Other:								
Veterinary and Medicine	$14.29	$14.73	$15.38	$15.70	$16.37	$14.95		
Bedding and Litter	$0.21	$0.21	$0.22	$0.22	$0.23	$0.24		
Marketing	$6.12	$6.37	$6.63	$6.78	$7.02	$6.36		
Custom Operations	$28.32	$29.33	$31.08	$31.68	$32.92	$29.66		
Fuel, Lube, and Electricity	$21.86	$16.41	$16.44	$16.40	$16.39	$16.38		
Repairs	$20.51	$21.62	$22.69	$23.30	$24.07	$21.46		
Interest on Operating Inputs	$11.47	$11.65	$10.89	$10.71	$13.17	$7.64		
Total Other Costs	$102.78	$100.32	$103.33	$104.79	$110.17	$96.69		
Total Operating Costs	$515.13	$539.66	$491.35	$478.22	$529.04	$568.87		
Allocated Overhead:								
Hired Labor	$0.57	$0.64	$0.65	$0.68	$0.71	$0.75		
Unpaid Family Labor	$289.55	$302.94	$309.71	$319.50	$325.93	$331.60		
Capital Cost Recovery	$50.78	$76.71	$74.76	$73.16	$82.26	$88.72		
Charge for Land	$2.72	$2.79	$2.89	$3.37	$3.42	$3.12		
Taxes & Insurance	$31.51	$31.59	$32.40	$32.49	$33.42	$33.81		
General Overhead	$49.25	$50.15	$51.27	$51.79	$53.31	$55.32		
Total Allocated Cost	$424.38	$464.82	$471.68	$480.99	$499.05	$513.32		
Total Costs	$939.51	$1,004.48	$963.03	$959.21	$1,028.09	$1,082.19		
GVOP - Operating Costs	($153.43)	($93.24)	($58.88)	($9.77)	($4.03)	($41.15)	($60.08)	100.0%
GVOP - Total Costs	($577.81)	($558.06)	($530.56)	($490.76)	($503.08)	($554.47)	($535.79)	100.0%

Appendix Table D: Hay production and use in Southeastern Wyoming

With Irrigation					Per Unit	Total
Type	Number of Head	Tons Per Head	Tons of Hay	Percent	Value of Production	Value of Production
Beef Cows	199,233	2.0	398,466	67.7%	$525.01	$104,599,317
Sheep - Ewes	71,257	0.5	35,629	6.0%	$127.48	$9,083,842
Feedlot Cattle	167,000	0.3	50,100	8.5%	N.A.	N.A.
Export Sales	N.A.	N.A.	104,538	17.8%	$84.50	$8,833,503
	(1)	(2)			(3)	
	Acres of Cropland	Tons of Hay/Acre				
Total Production	283,000	2.1	588,733			$122,516,662
	(1)	(1)				

Without Irrigation						Per Unit	Total
	Acres of Cropland	Tons of Hay/Acre	Tons of Hay	Tons of Hay/Cow	Number of Beef Cows	Value of Production	Value of Production
Dry land Hay	283,000	0.5	141,500	2.0	70,750	$525.01	$37,144,458
	(1)	(2)		(2)		(3)	

Sources:
(1) 1996 - 2001 average, Southeast Wyoming, Wyoming Ag. Statistics, Various Years
(2) Estimated
(3) Beef Cow = 2000 Cow/Calf Budget, Northern Great Plains, ERS, USDA
Sheep - Ewes = 2000 Idaho Range Sheep Budget, University of Idaho
Hay = 2000 Average Price Received by Farmers, Wyoming Ag. Statistics, 2002

Appendix Table E: Corn production and use in Southeastern Wyoming

With Irrigation	Acres of Cropland	Bushels of Corn/Acre	Total Bushels of Corn	Bushels of Corn/Head	Number of Feedlot Cattle	Per Unit Value of Production	Total Value of Production
Corn for Grain	44,733 (1)	130.3 (1)	5,828,710	73 (2)	79,845	$722.76 (3)	$57,709,019

Without Irrigation (Includes Corn for Silage)	Acres of Cropland	Bushels of Wheat/Acre	Total Bushels of Wheat	Per Unit Value of Production	Total Value of Production
Winter Wheat	60,416 (1)	25.8 (1)	1,558,733	$2.70 (4)	$4,208,579

Sources:
(1) 1996 - 2001 average, Southeastern Wyoming, Wyoming Ag. Statistics, Various Years
(2) Estimated
(3) 2000 Idaho Cattle Feedlot Budget, University of Idaho
(4) 2000 Average Price Received by Farmers, Wyoming Ag. Statistics, 2002

Appendix Table F: Sugar beet production and use in Southeastern Wyoming

With Irrigation	Acres of Cropland	Tons of Beets/Acre	Total Tons of Beets	Per Unit Price	Value of Production (Beets)	Value of Production Beets/Sugar	Value of Production (Sugar)
Sugar Beet Processing	12,917 (1)	17.7 (1)	228,631	$32.50 (2)	$7,430,504	21.4% (3)	$34,721,982

Without Irrigation	Acres of Cropland	Bushels of Wheat/Acre	Total Bushels of Wheat	Per Unit Value of Production	Total Value of Production
Winter Wheat	12,917 (1)	25.8 (1)	333,259	$2.70 (2)	$899,798

Sources:
(1) 1996 - 2001 average, Southeastern Wyoming, Wyoming Ag. Statistics, Various Years
(2) 2000 Average Price Received by Farmers, Wyoming Ag. Statistics, 2002
(3) IMPLAN 2000 for Southeastern Wyoming

Appendix Table G: Dry bean production and use in Southeastern Wyoming

With Irrigation

	Acres of Cropland	Cwt of Beans/Acre	Total Cwt. of Beans	Per Unit Price	Value of Production
Dry Beans	14,867 (1)	22.4 (1)	333,021	$16.80 (2)	$5,594,749

Without Irrigation

	Acres of Cropland	Bushels of Wheat/Acre	Total Bushels of Wheat	Per Unit Value of Production	Total Value of Production
Winter Wheat	14,867 (1)	25.8 (1)	383,569	$2.70 (2)	$1,035,635

Sources: (1) 1996 - 2001 average, Southeastern Wyoming, Wyoming Ag. Statistics, Various Years
(2) 2000 Average Price Received by Farmers, Wyoming Ag. Statistics, 2002

Appendix Table H: Seasonal Ranges of the Major Big Game Species in Southeastern Wyoming

	Total Seasonal Range		
	Winter	Spring, Summer, Fall	Yearlong
Pronghorn	3,024,544	465,386	4,638,432
Elk	1,115,818	771,557	183,990
Bighorn Sheep	57,747	175,962	10,765
Mule Deer	2,468,384	6,182,722	6,011,139
Whitetail Deer	858,554	2,728,716	4,225,071
Aggregate	5,810,472	8,203,905	7,970,097

	Private lands		
	Winter	Spring, Summer, Fall	Yearlong
Pronghorn	2,498,452	321,776	3,807,022
Elk	668,220	334,605	123,354
Bighorn Sheep	36,508	62,843	2,480
Mule Deer	1,479,544	4,741,051	4,784,511
Whitetail Deer	737,033	2,050,354	3,660,043
Aggregate	4,725,668	3,199,781	5,974,174

	Percentage private		
	Winter	Spring, Summer, Fall	Yearlong
Pronghorn	82.6%	69.1%	82.1%
Elk	59.9%	43.4%	67.0%
Bighorn Sheep	63.2%	35.7%	23.0%
Mule Deer	59.9%	76.7%	79.6%
Whitetail Deer	85.8%	75.1%	86.6%
Aggregate	81.3%	39.0%	75.0%

Appendix Table I: Conversion process for policy boundary to acres

A. **Subirrigated pasture**		Units	B. **Irrigated meadow**	
1 mile equals	1609.344	meters	1 mile equals	1609.344
110m X 2 (sides)	220	meters	110m X 2 (sides)	220
total area	354055.7	meters ^{2}	total area	354,055.7
10,000sq-m equals 1ha	35.40557	hectares	10,000sq-m equals 1ha	35.40557
2.47ac equals 1ha	87.45175	acres	2.47ac equals 1ha	87.45175
total grass enclosed	87.45	acres	total grass enclosed	87.45
est. aum's from grass	1.335	aum/ac	est. aum's from grass	4.47
Total aum's enclosed	116.75	aum's	Total aum's enclosed	390.91
value of an aum	$13.75		tons per acre	1.5
Total annual cost to ranch	**$1,605.29**		$ per ton	$91.89
Total 40-yr cost	**$64,211.45**		Total cost to ranch	**$12,053.91**
			40-yr cost to ranch	**$482,156.50**

Appendix Table J. Fencing and water development cost estimates.

		labor	$64.00	$/hour ==>two persons and equipment, no materials*
		days of maintenance	0.4	per year**
4-wire, barbed wire fence*	$6,800	hours of maintenance	3.2	hours
X2 for both sides of stream	$13,600	total labor cost	$204.80	
water development (1 per mile)	$5,250	total materials cost	$40.00	***
maintenance	$12,352.00	Total annual costs	$308.80	fencing maintenance labor and materials estimate
Total	$31,202	Total 40yr cost (maint)	$12,352.00	

*source: 2000-02 custom rates guide

**assume 1 day of maintanance by two persons for every five miles of fence

***assume $100 of materials for every day of maintenance

Appendix K:

PREBLE'S MEADOW JUMPING MOUSE

(*Zapus hudsonius preblei*)

IN WYOMING: STATUS REPORT, JULY 2003

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1 July 2003

INTRODUCTION

The management of Preble's meadow jumping mouse (*Zapus hudsonius prebeli*) is a high priority for natural resource professionals in southeast Wyoming and north-central Colorado. It is currently listed as Threatened under the U.S. Endangered Species Act (ESA; USDI 1998), and discrete units of critical habitat necessary for the subspecies' recovery will soon be designated by the USDI Fish and Wildlife Service (USFWS; USDI 2003). New land use regulations designed to enhance recovery within critical habitat units have the potential to alter traditional uses of natural resources throughout the subspecies' range.

Clearly the main scientific controversy surrounding the conservation and management of jumping mice in southeast Wyoming is whether or not the species meadow jumping mouse, *Z. hudsonius*, and the subspecies Preble's meadow jumping mouse, *Z. h. preblei*, are distinct and valid taxa here. Unfortunately there are no straightforward criteria with which to evaluate the validity of within-genera taxa. It has long been recognized that biological diversity at this level exists as a continuum, with gradations (as opposed to quanta) of difference between individuals, populations, and races. The traditional taxonomic system forces the identification of artificially discrete units along that continuum. In this context, no single trait can adequately partition the continuum, necessitating a "weight of evidence" approach that considers multiple traits (e.g., morphology, genetics) to define within-genera taxa (DeWeerdt 2002).

This report is a to-date summary of scientific information on the morphology, genetics, ecology, and biogeography of *Zapus* in southeast Wyoming, and is organized in a way

that should inform "weight of evidence" evaluations of species and subspecies occupying the region. It is intended as an update of a similar report completed in July 2001 (Beauvais 2001), and is one of several reports on rare plants, rare animals, and important vegetation communities produced by the Wyoming Natural Diversity Database (WYNDD). This research and service unit of the University of Wyoming serves as a central clearinghouse of scientific information on the biota of Wyoming, and distributes this information to all interested parties in order to facilitate appropriate management of natural resources.

BACKGROUND KNOWLEDGE OF *Zapus*

Genus *Zapus* - **North America supports 2 genera of jumping mice: *Napeozapus* and *Zapus*. Only the latter occurs in the state and vicinity of Wyoming (Hall 1981, Whitaker 1999a, Whitaker 1999b, Cranford 1999, Gannon 1999; Figure 1). A similar genus, *Eozapus*, occupies eastern Asia (Krutzsch 1954).**

Species *Zapus hudsonius* - The genus *Zapus* includes 3 species. Two of these, the western jumping mouse, *Z. princeps*, and the meadow jumping mouse, *Z. hudsonius*, occur within the state and vicinity of Wyoming (Figure 1; Figure 2). The more common and westerly-distributed *Z. princeps* generally occurs along streams and in mesic upland vegetation in montane and subalpine zones, occasionally ranging into foothills and even prairie zones along stream courses. The more easterly-distributed *Z. hudsonius* is rarer in this region, occurs in riparian zones in prairie and foothills environments, and occasionally ranges into montane areas along stream courses (Quimby 1951, Krutzsch 1954, Long 1965, Armstrong 1972, Whitaker 1972, Hall 1981, Clark and Stromberg 1987, Fitzgerald et. al. 1994, Cranford 1999, Whitaker 1999a).

Subspecies *Zapus hudsonius preblei* - E.A. Preble made the first scientific collection of *Z. hudsonius* in this region at a site near present day Loveland, Colorado, in 1899 (Preble 1899). Early specimens of *Z. hudsonius* from southeast Wyoming and northern Colorado were classified as *Z. h. campestris* (e.g., Warren 1910, Cary 1911). This trinomial is currently reserved for the Bear Lodge meadow jumping mouse, a separate subspecies now thought to occur only in the Black Hills region (Whitaker 1999a; Figure 2). Krutzsch (1954) first described the subspecies *Z. h. preblei* in southeast Wyoming and northern Colorado.

Mammalogists currently recognize 5 subspecies of *Z. hudsonius* in the vicinity of Wyoming (Whitaker 1999a, Hafner et al. 1981, Morrison 1992; Figure 2). Only *Z. h. preblei* and *Z. h. campestris* are thought to occur in the state (southeast and northeast corners, respectively). Three subspecies (*Z. h. intermedius*, *Z. h. campestris*, *Z. h. pallidus*) are regarded as contiguous (i.e., interbreed regularly along the boundaries of their respective distributions) and essentially represent the westernmost extent of the continuous distribution of *Z. hudsonius* in the United States (Hall 1981, Whitaker 1999a). The remaining 2 subspecies, *Z. h. preblei* and *Z. h. luteus*, are thought to be Pleistocene relicts completely isolated from each other and other *Z. hudsonius* subspecies (Hafner et al. 1981, Jones 1981, Morrison 1992, Hafner 1997; Figure 1, Figure 2).

CURRENT MANAGEMENT AND CONSERVATION STATUS

Concern over the viability and persistence of *Z. h. preblei* began as early as September 1985 when the USFWS placed the taxon in Category 2 status, which indicated that at that time a proposal to list under the ESA may have been appropriate but conclusive biological information to support such a proposal did not yet exist. This was followed by 20 other official USFWS decisions over the next 18 years, as documented in the Federal Register (see: https://ecos.fws.gov/species_profile/SpeciesProfile?spcode=A0C2). These decisions include the Final Rule to list as Threatened in May 1998 (USDI 1998), Proposed Special Regulations in August 2001, and Notice of Availability of a Draft Habitat Conservation Plan in February 2003 (USDI 2003).

The current status of *Z. h. preblei* as Threatened under the ESA precludes it from receiving other special designations from federal land management agencies in Wyoming, such as the USDA Forest Service (Region 2) and the USDI Bureau of Land Management (Wyoming State Office). Although each of these agencies maintains a Sensitive Species list to help guide management actions (e.g., USDA Forest Service 1994, USDI Bureau of Land Management 2001), each list specifically excludes taxa already listed under ESA because those taxa are automatic and pre-determined management priorities.

Zoologists at WYNDD have ranked *Z. h. preblei* as G5 T2 S1, with a Wyoming Contribution Score of Very High. Importantly, these designations are predicated on the assumption that the subspecies is valid, identifiable, and distributed throughout lowland riparian systems in north-central Colorado and southeast Wyoming as currently understood by the USFWS:

G5 = The full species *Z. hudsonius* is demonstrably widespread, abundant, and secure with a very low probability of extinction from its entire range.

T2 = The subspecies *Z. h. preblei* is rare and imperiled with a high probability of extinction from its entire range.

S1 = The subspecies *Z. h. preblei* is rare and imperiled with a very high probability of extinction from the state of Wyoming.

Wyoming Contribution Very High = The subspecies *Z. h. preblei* is a native, resident taxon with a small continental range and a high percentage of that range within the state of Wyoming; thus Wyoming populations of *Z. h. preblei* contribute very highly to the rangewide persistence of the taxon.

Hafner et al. (1998) classified *Z. h. preblei* as “Endangered” under the system used by the International Union for Conservation of Nature and Natural Resources.

MORPHOLOGY

Morphology: Genus *Zapus* - The following generally describes individuals of both *Z. hudsonius* and *Z. princeps*. A small rodent with hind legs much longer than forelegs. The tail is longer than the body, sparsely haired, and darker above than below. Eyes are midway between the nose and the ear. Ears are dark but edged with white. There are 18 teeth, with upper incisors having distinct grooves on their outer faces. Cheek pouches are absent. Fur on the back is yellow olive-brown with scattered, long, black-tipped hairs

which create a faint dorsal stripe. The sides are light yellow-brown, and the belly is white to light buff. Young tend to have softer, lighter fur than adults. Adult pelage appears rather coarse (Long 1965, Armstrong 1972, Clark and Stromberg 1987, Fitzgerald et al. 1994, USDI 2002).
The general appearance of jumping mice is relatively unique; it is difficult to confuse them with other rodents in Wyoming. The extremely long tail and large hind feet are especially good characters for recognizing jumping mice. Woodland jumping mice (*Napeozapus insignis*) are very similar in appearance, but do not occur within ca. 500 mi of Wyoming (Figure 1).

Morphology: Species *Zapus hudsonius* - The following dimensions are in addition to the above description of individuals in the genus *Zapus*. Adult measurements: total length 180-220 mm; head and body length <89 mm; tail 115-136 mm; hind foot 28-31 mm; ear 11-16 mm; weight 12-22 g (Clark and Stromberg 1987, Compton and Hugie 1993). In addition, incisive foramina <4.6 mm; palatal breadth at last molariform tooth <4.2 mm; condylobasal length usually <20.3 mm; and maxillary toothrow usually <3.7 mm (Whitaker 1972).

When specimens from distant sites are compared, known *Z. hudsonius* are on average smaller in several gross body dimensions than known *Z. princeps* (e.g., Hall 1981, Jones 1981, Schorr 2001). For several years it was thought that total body length and other gross dimensions were reliable indicators of species identity within the suspected range of *Z. h. preblei* (e.g., Clark and Stromberg 1987). However, it has since become clear that there is substantial overlap in these measurements between purported *Z. hudsonius* and purported *Z. princeps* from this region. This, coupled with essentially indistinguishable pelage and body shape, has lead most mammalogists in the region to conclude that no external morphological character can be used to classify specimens from here into 2 distinct taxa.
Using multivariate analysis techniques, Conner and Shenk (2001) compared precisely-measured skull dimensions of *Zapus* specimens from low elevations (purported *Z. hudsonius*) to those of *Zapus* specimens from high elevations (purported *Z. princeps*) in northcentral Colorado and southeast Wyoming. At a sub-millimeter scale, low-elevation skulls were significantly and consistently smaller than those from high elevations. Also, known *Z. hudsonius* typically possess an anterior median tooth fold (Kilngener 1963), and many of the low-elevation *Zapus* with small skulls identified by Conner and Shenk (2001) also had this character. These results support the contention that there are 2 *Zapus* taxa in the region that are separated by skull size and elevation in a manner predicted by general knowledge of *Z. princeps* and *Z. hudsonius*.
However, some data suggests that this separation is less apparent in the North Platte and extreme northern South Platte river basins than in areas to the south. Conner and Shenk (2001) documented a steady decline in the size of high-elevation *Zapus* skulls when moving north from Colorado into southern Wyoming; i.e., although still statistically significant, the elevation-dependent difference in skull dimensions was less in Wyoming than in Colorado. Furthermore, some *Zapus* specimens recently captured at mid-elevations (ca. 7200') in the North Platte River basin in Wyoming have large skulls, suggesting *Z. princeps*, but also possess an anterior median tooth fold, suggesting *Z. hudsonius*. Preliminary analyses of other recently-captured specimens from southeast

Wyoming indicate that individuals with large skulls and no tooth folds (suggesting *Z. princeps*) were captured within a few meters of individuals with small skulls and present tooth folds (suggesting *Z. hudsonius*; C. Meaney and C. Jones, personal communication; Denver Museum of Nature and Science).

Morphology: Subpecies *Zapus hudsonius preblei* - Compared to *Z. h. campestris* and *Z. h. pallidus*, *Z. h. preblei* is described as slightly smaller and duller in color, with a less distinct dorsal band and fewer black-tipped hairs (Krutzsch 1954).
As discussed above, there are no external morphological characters that can reliably classify specimens of *Zapus* from southeast Wyoming to species. Therefore, for live specimens that cannot be resolved to species, it is unreasonable to expect external morphology to reliably indicate subspecies; i.e., uncertainty at the species level would propagate to the subspecies level.
Even for prepared specimens tentatively classified as *Z. hudsonius*, external morphology is likely to be an inexact indicator of subspecies because distinctions at this level are qualitative and usually require subjective evaluation; e.g., ochraceous upper parts for *Z. h. preblei* versus "brighter ochraceous (and more blackish) upper parts" for *Z. h. campestris* (Long 1965). Although some *Zapus* from Wyoming and surrounding states may match the description of a particular subspecies quite well, most are likely to span the descriptions of 2 or more of the 5 subspecies in the region. This is probably especially true in and near areas where the subspecies co-occur and interbreed (e.g., the contact zone between *Z. h. campestris*, *Z. h. pallidus*, and *Z. h. intermedius* in northwest South Dakota; Figure 2).
Krutzsch (1954) first established the subspecies *Z. h. preblei* in southeast Wyoming and northcentral Colorado based on comparisons of precisely-measured body dimensions of prepared museum specimens. In a subsequent re-analysis using a larger sample of specimens, Jones (1981) concluded that although *Z. hudsonius* in this area were geographically isolated, there was insufficient morphological evidence to support their subspecific status, or indeed the subspecific status of any *Z. hudsonius* population.

GENETICS

Genetics: Genus *Zapus* - At this time there is no significant debate among mammalogists over the validity of the genus *Zapus*. It is generally accepted as a distinct and biologically-meaningful taxon and thus its genetic distinction from similar genera will not be fully explored here. It is assumed that *Napeozapus* is the genus most closely allied with *Zapus*, and thus would show the most similar genetic patterns. As discussed above, *Napeozapus* does not occur within ca. 500 mi of Wyoming (Figure 1).

Genetics: Species *Zapus hudsonius* - Genetic analyses have shown *Z. hudsonius* to be a unique and identifiable species that is relatively easily distinguished from similar species, especially when specimens from distant sites are compared. Hafner et al. (1981) used to genetic analyses to identify and distinguish *Z. hudsonius* from nearby *Z. princeps* in Arizona and New Mexico. Wunder and Harrington (1996; as cited in Schorr 2001) were similarly successful in using genetic patterns to resolve *Z. hudsonius* from *Z. princeps* in the South Platte River Basin in Colorado.

Riggs et al. (1997) used mitochondrial DNA to analyze the genetics of *Zapus* along the Southern Rocky Mountain front in Colorado and southeast Wyoming. Their main conclusion was that *Zapus* specimens from low elevations that were suspected to be *Z. h. preblei* formed a relatively homogenous genetic group. However, the northernmost samples in the study, including several from southeast Wyoming, were more closely allied with *Z. princeps*; these samples could not be reliably assigned to species. The general consensus among regional mammalogists is that *Z. hudsonius* X *Z. princeps* hybridization in extreme northern Colorado and southeast Wyoming is the most parsimonious explanation for such results (Hafner 1997, Riggs et al. 1997, Pague and Grunau 2000, Schorr 2001). Hybridization between related species in areas of co-occurrence is well known for other vertebrates (see examples in Pague and Grunau 2000, Hafner 1997). Krutzsch (1954) stated that *Z. hudsonius* X *Z. princeps* hybridization did not seem to occur in other areas of sympatry, such as British Columbia, but his conclusion was informed by morphological comparisons only without any genetic information.

Genetics: Subspecies *Zapus hudsonius preblei* **- Hafner et al. (1981) and Riggs et al. (1997; see also Hafner 1997) used genetic analyses to support subspecific status of *Z. h. preblei* as distinct from other *Z. hudsonius* subspecies, based on specimens form the South Platte and Arkansas river basins. However, as outlined above, genetic tests were unable to conclusively assign subspecies, or even species, identity to specimens from southeast Wyoming. New genetic studies, with the intent of resolving both the species- and subspecies-level distinctions of *Zapus* in this region, are underway (Ramey et al. 2002).**

ECOLOGY

Ecology: Genus *Zapus* - All members of *Zapus* and *Napeozapus* show strong affinities for heavily-vegetated habitats in proximity to open and flowing water (Whitaker 1972, Whitaker 1999a, Whitaker 1999b, Cranford 1999, Gannon 1999). *Napeozapus* prefer forested and woodland habitats and are rarely found elsewhere; in contrast, *Zapus* commonly occupies grass- and forb-dominated wetlands as well as wooded sites. Fungi may be more important in the diet of *Napeozapus* than *Zapus*, with the latter genera depending more on seeds and vegetation.
Members of both genera hibernate for approximately half the year (Whitaker 1999b).

Ecology: Species *Zapus hudsonius* - The general life history of *Z. hudsonius* has been described by several authors (e.g., Long 1965, Armstrong 1972, Whitaker 1972, Clark and Stromberg 1987, Fitzgerald et al. 1994, Whitaker 1999a), as has similar information for *Z. princeps* (e.g., Long 1965, Armstrong 1972, Clark and Stromberg 1987, Fitzgerald et al. 1994, Cranford 1999). The major distinction between the 2 species in this region appears to be elevation of occurrence: the distribution of *Z. princeps* is primarily montane, whereas that of *Z. hudsonius* is centered on prairie. Both species are strongly associated with riparian habitats. However, *Z. princeps* is known to range relatively frequently into uplands in montane and subalpine areas, whereas *Z. hudsonius* rarely strays from riparian zones in prairie environments (but see discussion of *Z. hudsonius* upland forays in Shenk and Sivert 1999, Ryon 1999, Schorr 2001). It is difficult to know

whether this stems from an intrinsic biological difference between the taxa or is simply due to the fact that high elevation uplands are more mesic than prairie uplands.

Aside from elevation of occurrence, *Z. princeps* and *Z. hudsonius* are ecologically very similar in this region, although it must be recognized that there is a relative paucity of comparative field studies. There is no indication that these species diverge in life history traits to any substantial degree; with the currently limited knowledge base, it appears that within-species variation in most ecological traits may be as great as between-species variation.

Ecology: Subspecies *Zapus hudsonius preblei* - The basic ecology of *Z. h. preblei* has been outlined by several authors (see USDI 2002). All purported subspecies of *Z. hudsonius* in Wyoming and surrounding states are strongly associated with riparian habitats. It is assumed that *Z. h. campestris*, *Z. h. pallidus* and *Z. h. intermedius* range more into uplands than either *Z. h. preblei* and *Z. h. luteus*, but that this may be a function of climate (uplands are more mesic and heavily-vegetated in the Black Hills and central Great Plains relative to the Rocky Mountain front) rather than intrinsic differences in the subspecies' biology. Variations in food habits, hibernacula, reproductive characteristics, and other traits may all similarly vary with geography. As is the case with full species of *Zapus*, there is a general lack of field studies that compare subspecies. Current information suggests no great degree of ecological divergence between subspecies.

BIOGEOGRAPHY

Biogeography: Genus *Zapus* - Genera immediately ancestral to *Zapus* and *Napeozapus* are known from North American sites dating to the early Pliocene. *Zapus* in its current form has been relatively widespread in North America since the early Pleistocene, when the continent was occupied by at least *Z. hudsonius* and 2 other, now-extinct species. *Napeozapus* is thought to have achieved its current form in the mid-Pleistocene. Diversification of early *Zapus* into the 3 extant species likely occurred during repeated geographic isolation of eastern and western groups during Pleistocene glaciations. The eastern isolate generated *Z. hudsonius*, whereas the western isolate generated *Z. trinotatus* and *Z. princeps* (Krutzsch 1954). The current interglacial has allowed *Z. hudsonius* and *Z. princeps* to come into close contact, including broad zones of sympatry in the northern U.S. and southern Canada and narrower zones of sympatry along the Rocky Mountain front in New Mexico, Colorado, and Wyoming (Figure 2). Such "re-contact" between the 2 species is assumed to have occurred during earlier interglacial periods as well, alternating in cycle with isolation during glacial periods.

Biogeography: Species *Zapus hudsonius* - During the late Pleistocene (ca. >10,000 years ago) the eastern slope of Southern Rocky Mountains and adjacent lowlands supported more cool and mesic grassland suitable for *Z. hudsonius*, presumably leading to larger and more widespread populations of the species here. At this time *Z. princeps* was probably isolated to the west of the Rocky Mountains in the Great Basin and adjacent regions. The warming and drying of the western United States during the early Holocene shifted mesic grassland, and thus the main center of occurrence of *Z. hudsonius*, to the north and east; *Z. h. campestris* now occupies the periphery of this shifted range (Figure 2).

However, pockets of suitable habitat remained along the Southern Rocky Mountain front, allowing disjunct populations to persist here. Through the combined forces of founder effect, genetic drift, and adaptation, these disjunct populations are thought to have diverged to the subspecies level and now exist as *Z. h. luteus* and *Z. h. preblei* (Hafner et al. 1981, Jones 1981, Morrison 1992, Hafner 1997). The Holocene climatic amelioration presumably also allowed *Z. princeps* to move east onto the Rocky Mountains to its present position (Figure 2).

It is generally accepted that *Z. princeps* occurs at higher elevations than *Z. hudsonius* in Colorado and Wyoming. The former species is thought to primarily occupy subalpine and montane zones, with peripheral extensions into foothills and possibly even prairie environments along riparian corridors. In contrast, *Z. hudsonius* is thought to primarily occupy prairie riparian environments, with peripheral extensions into the foothills and montane zones along riparian corridors. This pattern obviously suggests zones of *Z. princeps* X *Z. hudsonius* co-occupation along mountain-front riparian systems.

Zones of co-occupation are likely to be rather narrow along the Front Range of Colorado, where the abrupt mountain front and high terminal elevations can be expected to sharply divide prairie and montane biota. Some areas of likely sympatry between *Z. hudsonius* and *Z. princeps* along the Front Range are currently being studied (e.g., Trout Creek, Douglas County, Colorado; Schorr 1999).

Importantly, the biogeographic situation changes rather markedly in the extreme northern South Platte River basin (ca. Cache La Poudre River and points north) and North Platte River basin. A large area of sympatry between *Z. hudsonius* and *Z. princeps* in northern Colorado and southeast Wyoming has been suspected, if not conclusively demonstrated, by mammalogists for quite some time (e.g., Long 1965, Armstrong 1972). The major mountain range here, the Laramie Mountains, has a rather gradual east slope (leading to much interdigitation of prairie, foothills, and montane biota), a low crest (<7500' in many places), and is bisected by a major river system (Laramie River) that connects large areas of mixed grass prairie on either side of the range. These factors suggest that the zone of co-occupation may be quite broad along the Laramie Mountains and that this range is not a western barrier to *Z. hudsonius*. Since 1998 the USDA Forest Service and other field workers have captured several suspected *Z. hudsonius* between 7500 - 8500 ft elevation in the Laramie Range (WYNDD, unpublished data).

Also, 4 capture locations to the west of the Laramie Range in Wyoming bear mentioning in this context:

1. A *Zapus* specimen captured in the Snowy Range (southwest Albany County, Wyoming) in the 1970's was originally identified as *Z. hudsonius*, but then was subsequently relabeled *Z. princeps* based on the relatively high elevation of the capture location. However, preliminary results using the methods of Conner and Shenk (2001) suggest that this specimen may in fact be *Z. hudsonius* (C. Jones, Denver Museum of Nature and Science, personal communication). It is assumed that the specific identity of this specimen is currently being investigated more thoroughly.

2. In summer 2000, WYNDD zoologists captured several *Zapus* on the floor of the Laramie Valley (central Albany County, Wyoming; ca. 7200'). These individuals were taken from a cottonwood-willow riparian corridor bordered by mixed grassland, several

miles from the nearest montane forest; such habitat suggests *Z. hudsonius* rather than *Z. princeps.* It is assumed that the specific identity of these specimens is currently being investigated with methods of Conner and Shenk (2001), and that tissue from these specimens will be included in ongoing genetic analyses (Ramey et al. 2002).

3. In summer 2002 WYNDD zoologists captured several *Zapus* spp. along the Laramie River ca. 30 mi north of the town of Laramie, Wyoming (ca. 7100'). These individuals were taken in a grass- and willow-dominated riparian corridor bordered by mixed grassland, several miles from the nearest montane forest; such habitat suggests *Z. hudsonius* rather than *Z. princeps.* Preliminary results using the methods of Conner and Shenk (2001) suggest that some of these specimens may be *Z. hudsonius*; oddly, others in this group (which were all captured within several meters of one another) appear to be *Z. princeps* (C. Meaney and C. Jones, Denver Museum of Nature and Science, personal communication). It is assumed that tissue from these specimens will be included in ongoing genetic analyses (Ramey et al. 2002).

4. In summer 2002 WYNDD zoologists captured several *Zapus* spp. at Hutton Lake National Wildlife Refuge, ca. 12 mi southwest of the town of Laramie, Wyoming. These individuals were taken in a grass- and reed-dominated wetland bordered by mixed grassland, several miles from the nearest montane forest; such habitat suggests *Z. hudsonius* rather than *Z. princeps.* Preliminary results using the methods of Conner and Shenk (2001) suggest that some of these specimens may be *Z. hudsonius* (C. Meaney and C. Jones, Denver Museum of Nature and Science, personal communication). It is assumed that tissue from these specimens will be included in ongoing genetic analyses (Ramey et al. 2002).

If further analyses continue to suggest that some of these specimens are *Z. hudsonius*, the suspected range of the species in southeast Wyoming may need to be extended west to include the drainage basins of the Upper Laramie River, Little Laramie River, Rock Creek, and possibly Medicine Bow River.

Biogeography: Subspecies *Zapus hudsonius preblei* - The uncertainty regarding the species-level taxonomy of *Zapus* in southeast Wyoming makes it difficult to accurately portray distributions of subspecies here. As currently understood, presumed *Z. h. preblei* have been documented in both the North Platte and South Platte river basins of Wyoming, with collection sites as far north as the town of Douglas, west to the town of Boxelder, and east to the vicinity of Slater (Figure 3). The crest of the Laramie Mountains is generally regarded as the western boundary of *Z. h. preblei* in Wyoming. However, as discussed above, this may be untenable and further analyses may show the western boundary of *Z. h. preblei* farther to the west in Wyoming.
It is generally accepted that *Zapus* in southeast Wyoming are geographically isolated from populations to the north (*Z. h. campestris*) and east (*Z. h. pallidus*) because the intervening shortgrass prairie is too dry and sparsely-vegetated, even on the borders of streams, to provide suitable habitat (Figure 2). However, there have been very few surveys for *Zapus* in these intervening areas. Also, habitat suitability for *Zapus* has been increasing in these areas over the past century, largely due to the westward progression of

gallery forests (Choate and Reed 1986, Knopf 1986, Knopf and Samson 1996), and both Choate et al. (1991) and Frey (1992) have demonstrated recent westward expansions in the ranges of *Z. h. intermedius* and *Z. h. pallidus*. These trends suggest increasing likelihood of connectivity between *Zapus* in southeast Wyoming and populations to the north and east. Connectivity between these populations could have 2 major management implications: (1) increased effective population size and genetic diversity, possibly reducing the risk of local extinction, and (2) erosion of any unique genetic and morphological characters currently maintained in the populations.

In summer 2000, *Zapus* surveys were performed on the USDA Forest Service Thunder Basin National Grassland on streams in the headwaters of the Cheyenne River. No *Zapus* were found (T. Byer, USDA Forest Service, personal communication). In summer 2002, *Zapus* surveys were performed at 6 sites in Goshen County, Wyoming, again with no *Zapus* captured. These efforts lend direct support to the geographic separation of *Zapus* in southeast Wyoming from *Z. h. campestris* and *Z. h. pallidus*. More such surveys are needed in these areas to corroborate these initial findings.

It is important to note that separation between *Z. hudsonius* subspecies is also an issue in southern Colorado where *Z. h. preblei* and *Z. h. luteus* approach each other. Indeed, this is another area where *Z. princeps* come into close contact, and possibly sympatry, with *Z. hudsonius*. The issues of range overlap, potential hybridization, and taxonomic clarity explored above for *Zapus* in southeast Wyoming may have parallels in southern Colorado.

Predictive range map for *Zapus* spp. in southeast Wyoming: In an effort to contribute more information to the debate over the distribution of *Zapus* in southeast Wyoming, WYNDD zoologists produced a predictive range map for the taxon using points of known occurrence ("positive points") and points of suspected absence ("negative points").

The basic concept behind predictive range mapping is to first identify and model the environmental conditions at positive points, then identify other locations in the area of interest that also have those specific conditions. The modeling algorithm used here was the Classification and Regression Tree (CART) procedure within the S-Plus (Professional Release 1) statistical package. This procedure contrasts the values of environmental variables at positive and negative points to build a robust statistical model of environmental conditions at positive points. Then, by linking this output to the ArcView geographic information system (Environmental Systems Research Incorporated, Relands, California), the model was spatially extrapolated across all 5 counties in southeast Wyoming (Figure 4). Details of the modeling and mapping procedures are presented in Appendix A, and results are presented in Figure 4.

It is important to note that this map portrays the predicted distribution of *Zapus from relatively low elevations in southeast Wyoming*. It cannot be said to portray the predicted distribution of *Z. hudsonius* or *Z. h. preblei*, because the current confusion over the taxonomic identity of *Zapus* species and subspecies in the region precludes such certainty in the input data. Nevertheless, these results support the notion that the range of low-elevation *Zapus* in southeast Wyoming spans the Laramie Mountains and in fact covers much of the Laramie Valley. Also, much of extreme eastern Wyoming appears

unsuitable for the taxon. Similar results were obtained by Keinath (2001) in his predictive range mapping effort.

SUMMARY

Based on current knowledge of the morphology, genetics, ecology, and biogeography of *Zapus* in northcentral Colorado and southeast Wyoming:

1. *Zapus hudsonius preblei* appears to be a valid and identifiable taxon in the South Platte River basin (south of the Cache La Poudre River) and Arkansas River basin in Colorado. *Zapus* at low elevations here are consistent morphologically and genetically with *Z. hudsonius*, and additional genetic evidence indicates an identifiable within-species unit consistent with *Z. h. preblei*. The biogeographic history of the region indicates that *Zapus* here may have been derived from past *Z. hudsonius* populations and may have remained isolated from the main center of occurrence of *Z. hudsonius* for several thousand years, setting the stage for subspeciation. There is likely some limited sympatry with low elevation *Zapus* to the south (*Z. h. luteus*) and high-elevation *Zapus* (*Z. princeps*) to the west. Any hybridization stemming from this sympatry is probably limited and apparently has not reduced the morphological or genetic uniqueness of *Z. h. preblei*, apparently the most abundant form in the area, to any great degree.

2. *Zapus hudsonius preblei*, as defined above for areas in Colorado, may occur at low elevations in the northern South Platte River basin (north of the Cache La Poudre River) and North Platte River basin in Wyoming, but there is substantial confusion between this form and *Z. princeps*. Some *Zapus* here are consistent morphologically with *Z. hudsonius*, others are more consistent with *Z. princeps*, and still other individuals show morphological characteristics of both species. Similarly, genetic tests appear to detect a mixture of *Z. hudsonius* and *Z. princeps* in individuals from this region. Biogeographic history indicates that *Zapus* here may have been derived from past *Z. hudsonius* populations and may have been isolated from the main center of occurrence of *Z. hudsonius* for several thousand years, setting the stage for subspeciation. However, current patterns in landform and vegetation clearly indicate a mixing of montane and prairie biota that would produce a relatively large area of sympatry between *Z. hudsonius* and *Z. princeps*. The clearest interpretation of this information is that southeast Wyoming supports some *Z. princeps*, some *Z. h. preblei*, and a relatively large group of hybrids between the 2 species.

The 1998 listing of *Z. h. preblei* has stimulated many *Zapus* surveys and specimen collections in southeast Wyoming. Collected specimens have been sent to various analytical labs, most commonly the Denver Museum of Nature and Science (Denver, Colorado), where they undergo a series of analyses and tests. The results of these tests are not always made widely available, nor are they organized in a discrete summary showing the results of all tests on all collected specimens. Such a summary for all specimens collected in southeast Wyoming (ideally, from throughout the entire suspected range of *Z. h. prebeli*) would substantially improve our understanding of *Zapus* taxonomy and distribution in the region.

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APPENDIX [to interim report]

APPENDIX A: PREDICTIVE RANGE MAP FOR *Zapus* spp. IN SOUTHEAST WYOMING

To inform the debate over the distribution of *Zapus* in southeast Wyoming, WYNDD zoologists produced a predictive range map for the taxon using points of known occurrence ("positive points") and points of suspected absence ("negative points"). The basic concept behind predictive range mapping is to first identify and model the environmental conditions at positive points, then identify other locations in the area of interest that also have those specific conditions. The modeling algorithm used here was the Classification and Regression Tree (CART) procedure within the S-Plus (Professional Release 1) statistical package. This procedure contrasts the values of environmental variables at positive and negative points to build a robust statistical model of environmental conditions at positive points. Then, by linking this output to the ArcView geographic information system (Environmental Systems Research Incorporated, Relands, California), the model was spatially extrapolated across all 5 counties in southeast Wyoming (Figure 4). A more thorough description of the procedure is given in Fertig and Thurston (2002) and Fertig et al. (2002).
For this model, the initial set of positive points included all 158 locations where individual *Zapus* have been observed (typically trapped) in Albany, Converse, Platte, Goshen, and Laramie Counties in Wyoming. The initial set of negative points included 51 locations where *Zapus* were trapped for, but not found, in the same 5 counties. Both positive and negative data are on file at the Wyoming Natural Diversity Database (University of Wyoming, Laramie, Wyoming). These data required several filtering steps prior to statistical modeling in order to produce an unbiased model of suitable environmental conditions:

Biogeographic filter: From the initial dataset we excluded:

- Positive points above 8500' elevation on the Snowy Range in southwest Albany County. Although the distribution of *Zapus* species has not yet been resolved for southeast Wyoming, these high-elevation areas are generally accepted as supporting only *Z. princeps* and no *Z. hudsonius*. Therefore, these points were removed to minimize the influence of *Z. princeps* on the final model and map.

- Positive points in Carbon and Natrona counties. These areas are outside the scope of the project and likely support many *Z. princeps*. These points were removed to minimize the influence of *Z. princeps* on the final model and map.

- Positive points labeled with "unmappable" precisions. These points could not be reliably mapped, and thus could not be reliably attributed with environmental variables.

- Two negative points in the Cheyenne River basin, northeast Converse County and southern Weston County (these were the only 2 points in these areas). These areas are

outside the scope of this project, and are generally accepted as outside the range of *Z. hudsonius* and approaching the range of *Z. h. campestris*.

Spatial filter: Because the positive and negative points were collected opportunistically and did not result from an even application of sampling effort across the study area, the spatial pattern of the points is an artifact of sampling distribution rather than a true reflection of *Zapus* distribution. Unless this clustering is accounted for, the resulting model will be unjustly biased towards heavily-sampled environments. To minimize the influence of heavily-sampled sites, we eliminated one point from each pair of points (either positive or negative) that were within 2000m of each other. In cases where we had to choose between a positive point and a negative point, we eliminated the negative point. In cases where we had to choose between 2 positive or 2 negative points, we eliminated the point with the coarsest mapping precision. In cases where we had to choose between 2 positive or 2 negative points with the same mapping precisions, we eliminated the point with the oldest date-of-observation.

The post filtering dataset consisted of 53 positive and 21 negative points. After exploring these data spatially and statistically, we selected 5 environmental variables to enter into the CART analysis: elevation, mean annual precipitation, mean annual temperature, number of frost days per year, and primary landcover type as identified by the Wyoming Gap Analysis project (Merrill et al. 1996). Note that initial attempts at using more and finer-scale variables (e.g., mean April temp, max July temp, etc.) produced results qualitatively similar to the final results, except that the results were not as immediately interpretable based on species life history. Thus the final variable set was chosen as producing the most parsimonious and biologically meaningful model. Note also that models including topographic slope and aspect as predictors produced results very similar to the final results, except that there was a much more fine-grained, "salt-and-pepper" structure to areas of predicted *Zapus* presence. It was decided that our positive and negative occurrence data were not mapped to a fine enough precision to allow valid use of slope and aspect, so these variables were eliminated.
The final CART model identified 3 combinations of environmental variables that predict presence of *Zapus* in southeast Wyoming. A total of 91% of the positive points were in areas that fit these descriptions, and 91% of the negative points were in areas that did not fit these descriptions.

SUITABLE ENVIRONMENT 1. Number of frost days greater than 189.9, and land cover types of forest-dominated riparian, shrub-dominated riparian, mixed grass prairie, limber pine woodland and scrub, lodgepole pine, and human disturbed. 67.9% of the positive model points occurred in this environment.

SUITABLE ENVIRONMENT 2. Number of frost days greater than 189.9, land cover types of ponderosa pine and xeric upland shrub, and elevation greater than 1998 m. 11.3% of the positive model points occurred in this environment.

SUITABLE ENVIRONMENT 3. Number of frost days less than 189.9, elevations between 1419 m and 1822.5 m, and land cover types of forest-dominated riparian, shrub-

dominated riparian, and human disturbed. 11.3% of the positive model points occurred in this environment.

After mapping this final model we eliminated all polygons of predicted presence that were less than 10,800 m^2 (3 contiguous 60m x 60m grid cells) in size. This spatial "smoothing" was intended to eliminate most of the very small and extremely isolated areas of predicted presence that are unlikely to support *Zapus* on their own.
Finally, because low-elevation *Zapus* in this area are riparian obligates, the smoothed output was intersected with a layer of riparian zones to more accurately restrict areas of predicted presence to riparian habitats. The riparian layer was created by buffering permanent streams, intermittent streams, ponds and other hydrologic features by certain distances to represent the general extent of riparian vegetation. Buffer distances for these features were as follows:

Hydrologic feature		Buffer width (m)
Stream - Strahler order	1	40
2	40	
3	60	
4	90	
5	120	
6	150	
7	210	
Reservoir		90
Lake or pond		90
Wide river		300
Marsh or wetland		0
Ephemeral wash		0

It is important to note that our final map portrays the predicted distribution of *Zapus from relatively low elevations in southeast Wyoming*. It cannot be said to portray the predicted distribution of *Z. hudsonius* or *Z. h. preblei*, because the current confusion over the taxonomic identity of *Zapus* species and subspecies in the region precludes such certainty in the input data. Nevertheless, these results support the notion that the range of low-elevation *Zapus* in southeast Wyoming spans the Laramie Mountains and in fact covers much of the Laramie Valley. Also, much of extreme eastern Wyoming appears unsuitable for the taxon.