Wyoming Pocket Gopher (*Thomomys clusius*): A Technical Conservation Assessment

Prepared for the USDA Forest Service, Rocky Mountain Region, Species Conservation Project

August 31, 2006

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Peer Review Administered by
Society for Conservation Biology

Keinath, D.A. and G.P. Beauvais. (2006, August 31). Wyoming Pocket Gopher (*Thomomys clusius*): a technical conservation assessment. [Online]. USDA Forest Service, Rocky Mountain Region. Available: http://www.fs.fed.us/r2/projects/scp/assessments/wyomingpocketgopher.pdf [date of access].

ACKNOWLEDGMENTS

The authors would like to acknowledge the valuable assistance of Darby Dark-Smiley in early versions of this manuscript; Dr. James Patton (University of California at Berkley) and Dr. Cindy Ramotnik (University of New Mexico) for their assistance in locating study skins of *Thomomys clusius*; Rebekah Smith for her fine cover art and GIS help; and finally the late Dr. Charles Thaeler, without whom the world would not know this elusive creature.

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COVER ILLUSTRATION CREDIT

Wyoming pocket gopher (*Thomomys clusius*). Cover art by Rebekah Smith, Wyoming Natural Diversity Database. Used by permission.

Summary of Key Components for Conservation of The Wyoming Pocket Gopher

Pocket gophers are members of the family Geomyidae, species of which inhabit virtually all of the United States, a large area of southwestern Canada, and much of Mexico. They are powerfully built mammals that are strongly adapted to fossorial living, with small ears, small eyes, fur-lined cheek pouches used to carry food, and very strong front limbs with long nails used for digging. Although considered pests in some agricultural situations, pocket gophers are important in soil development (incorporating organic matter), soil aeration, and promoting water storage in soil during spring runoff.

The Wyoming pocket gopher (*Thomomys clusius*) is the only vertebrate animal that occurs exclusively in Wyoming; its known distribution is restricted to the south-central portion of the state. Almost nothing is known about the Wyoming pocket gopher. The entire assumption of its distribution, ecology, and status is based on a handful of museum records and anecdotal reports from over 30 years ago. It is a smallish pocket gopher that appears to occupy dry and gravelly ridges, as opposed to the valley bottoms with deeper soils that are typically associated with other species. The Wyoming pocket gopher is sympatric with other species of pocket gophers that look very similar (notably the northern pocket gopher [*T. talpoides*]), making it difficult to distinguish specimens to species. Therefore, although evidence of identity can be gained from geographic location, pelage characters, and morphology, reliable identification of this species involves chromosomal analysis (i.e., karyotyping to count chromosome number).

The Wyoming pocket gopher is listed as a species of management concern by the Wyoming State Bureau of Land Management, Region 2 of the USDA Forest Service, the Wyoming Game and Fish Department, and the Wyoming Natural Diversity Database; this demonstrates reasonable consensus that it is in need of conservation action. However, the actual status of Wyoming pocket gopher populations is unknown due to the extreme paucity of data. It is assumed to be rare and to have a very restricted distribution, but no one has extensively surveyed for pocket gophers in central Wyoming in at least the last 30 years, and there has *never* been a systematic survey for the Wyoming pocket gopher. Recent *ad hoc* efforts failed to document gophers at several historic localities, leading to speculation of population declines. The possibility of decline appears quite serious given that these pocket gophers are vulnerable to disturbance due to their highly limited distribution, limited dispersal ability, and uncertain ecology.

Immediate conservation action can be taken by limiting additional disturbance to areas containing known, active Wyoming pocket gopher burrow complexes. However, effective long-term conservation requires a better understanding of the species' distribution, ecology, and population status. For example, the habitat requirements of the species are vague and based largely on conjecture from incidental observations; so recommendations using this information are doomed to be similarly vague. Once such gaps are filled we can take the next logical steps to implement a conservation plan, namely habitat preservation and population monitoring.

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INTRODUCTION

Goal

This species conservation assessment was prepared in support of the Species Conservation Project by the USDA Forest Service (USFS), Rocky Mountain Region (Region 2). It addresses the biology, ecology, status, conservation, and management of the Wyoming pocket gopher (*Thomomys clusius*) throughout its current range, which falls entirely within the Region 2. Our goal is to provide a summary of published information and expert interpretation of this information that can be used by the USFS to develop conservation strategies and management plans. The Wyoming pocket gopher was selected for assessment because of its status as a sensitive species in Region 2 due to its rarity and potential sensitivity to disturbance.

Scope, Uncertainty, and Limitations

The reader should note the confusing taxonomic history of the Wyoming pocket gopher when reviewing this assessment, other literature, and reported specimen locations (see the Taxonomy section of this assessment for details). Most collections initially labeled as *Thomomys clusius* are no longer thought to be Wyoming pocket gophers, and some references to a subspecies of northern pocket gopher (*T. talpoides clusius*) may refer to the Wyoming pocket gopher while others would now be considered belonging to different subspecies of northern pocket gopher (likely *T. t. ocius*).

Partly because the Wyoming pocket gopher has a confusing taxonomic history and was only recognized as a species in the last 25 years, very little research has been conducted on the species and relatively little is known about most populations. Therefore, this assessment often makes reference to information developed for taxonomically and/or ecologically similar species in Region 2, particularly the northern pocket gopher (*Thomomys talpoides*). Such inferences are always noted in the text. Information was obtained from peer-reviewed literature, agency reports, and acknowledged experts. There is uncertainty in all scientific inquiries, and the data described in this assessment are no exception. Herein, the strength of evidence from research is noted, and alternative explanations of observational data and expert inference are provided when appropriate. Peer-reviewed literature represents the strongest set of data and is therefore used preferentially to draw conclusions regarding this species. Hypotheses and inferences are noted with appropriate qualifications. Where possible, when there is little or no quantitative research to back up specific ideas, expert opinion was obtained independently from several sources. As with all pieces of literature synthesized from disparate data, this assessment has some limitations. Since most data presented herein come from specific studies in restricted research areas, interpolation and extrapolation of these data must be done with caution. The information in this assessment should not be taken as definitive of the Wyoming pocket gopher in any particular area. Rather, it should be used as a guide to the range of biological parameters and behaviors possible for the species, which can then help to direct specific investigation to clarify the status of local populations as a prelude to major management action.

Web Publication and Peer Review

To make the information in this assessment accessible more rapidly than publication as a book or report, to facilitate its use by USFS personnel, other agencies, and the public, and to make revisions more efficient, this document will be published on the USFS Region 2 World Wide Web site (http://www.fs.fed.us/r2/projects/scp). A link to this publication will also be available on the Wyoming Natural Diversity Database Web site (http://uwadmnweb.uwyo.edu/wyndd). Assessments developed for the Species Conservation Project have been peer reviewed prior to release on the Web. Under the editorial guidance of Gary Patton (USDA Forest Service, Region 2), this report was reviewed through a process administered by the Society for Conservation Biology, employing two recognized experts on this or related taxa. Peer review was designed to improve the quality of communication and to increase the rigor of this assessment.

MANAGEMENT STATUS AND NATURAL HISTORY

Management Status

Federal Endangered Species Act

The U.S. Fish and Wildlife Service does not give any special status to the Wyoming pocket gopher at this time.

USDA Forest Service

Beginning in 2001, Region 2 of the USFS undertook a major revision of its sensitive species list, which was finalized in December 2003; this list subsequently underwent a minor revision in May 2005.

As of the last revision, the Wyoming pocket gopher was listed as a sensitive species in Region 2 (USDA Forest Service 2005, http://www.fs.fed.us/r2/projects/scp/assessments/index.shtml). Sensitive species are defined by the USFS as "those animal species identified by the Regional Forester for which population viability is a concern as evidenced by: (a) significant current of predicted downward trends in population numbers or density, and/or (b) significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution" (USDA Forest Service 1994). The Region 2 area in Wyoming includes the Bighorn, Black Hills, Medicine Bow, and Shoshone national forests and the Thunder Basin National Grassland. Based on known distribution, the Medicine Bow–Routt National Forest is the only National Forest System unit in Region 2 that possibly supports the Wyoming pocket gopher, but we are not aware of any known occurrences on USFS lands.

Bureau of Land Management

The Wyoming Bureau of Land Management (BLM) developed their sensitive species list in 2001 and assigned the Wyoming pocket gopher to that list. The BLM developed the list to "ensure that any actions on public lands consider the overall welfare of these sensitive species and do not contribute to their decline." The BLM's sensitive species management will include:

- ❖ determining the distribution and current habitat needs of each species
- ❖ incorporating sensitive species in land use and activity plans
- ❖ developing conservation strategies
- ❖ ensuring that sensitive species are considered in National Environmental Policy Act analysis
- ❖ prioritizing what conservation work is needed (Bureau of Land Management Wyoming 2001).

To date, however, no such action has been taken for the Wyoming pocket gopher, and the authors are not aware of plans to do so.

State Wildlife Agencies

The Wyoming Game and Fish Department classifies the Wyoming pocket gopher as NSS4 and includes it on a long list of species of concern under Wyoming's Comprehensive Wildlife Conservation Strategy (Wyoming Game and Fish Department 2005). In general, this ranking means that although populations appear to be restricted in distribution, the species' habitat does not appear to be declining, and there are no known sensitivities to human disturbance (Oakleaf et al. 2002). The primary issues identified by the conservation strategy regarding this species were a need for more information on its status, trends, and habitat use.

Natural Heritage Program

The Wyoming Natural Diversity Database (WYNDD) has assigned the Wyoming pocket gopher a rank of G2/S2 (http://uwadmnweb.uwyo.edu/wyndd/; Keinath et al. 2003). The G2 refers to a relatively high probability of global extinction, based primarily on the taxon's extremely small global range. The S2 rank refers to a relatively high probability of extinction from Wyoming, based largely on range restriction, but also considering apparently low range occupation, uncertain abundance trends, and moderate biological vulnerability. Further, WYNDD assigns a Wyoming Significance Rank of Very High to the Wyoming pocket gopher (Keinath et al. 2003), which reflects the extremely high contribution of Wyoming population segments to continental persistence of the species. Clearly, because the species is thought to occur only within the state of Wyoming (possibly extending slightly into northern Colorado pending further investigation), the fate of Wyoming populations is synonymous with the fate of the species as a whole.

Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies

To date, there are no management plans or conservation strategies pertaining explicitly to the Wyoming pocket gopher although one status assessment has been drafted with support of the Wyoming State Office of the BLM and WYNDD (Beauvais and Dark-Smiley 2005). With its listing on most major sensitive species lists in Wyoming (see above section on Management Status), there appears to be consensus among management agencies of the importance of conserving this species and some leverage to initiate such action. The tenants of such lists generally require that the agencies maintaining those lists consider the welfare of those species when developing land use and resource management plans and in planning project actions. This generally includes, but is not limited to:

- ❖ evaluating current distribution and status of sensitive species, including sensitive species concerns in NEPA analyses
- ❖ employing best management practices for conserving sensitive species
- ❖ monitoring the status of populations and/or habitat for sensitive species
- ❖ collaborating with other agencies to further exchange of information beneficial for conserving sensitive species (e.g., USDA Forest Service 1994, Bureau of Land Management Wyoming 2001, Wyoming Game and Fish Department 2005).

If such mandates are rigorously adhered to, there appear to be sufficient mechanisms by which conservation of Wyoming pocket gopher could be achieved. However, conservation will only be effective if the mandates are given institutional priority by the agencies in question, whereby collection of needed information is funded and the data from such research are allowed to influence management actions. The primary issue stated by most studies looking at this species is the lack of information on virtually all aspects of its biology and ecology (e.g., this report, Keinath et al. 2003, Beauvais et al. 2004, Wyoming Game and Fish Department 2005). Without such information, decisions regarding its conservation are not likely to be effective or enforceable. Unfortunately, given other issues of management concern, no efforts have been taken to date by any agency to resolve this lack of information. Thus, the mechanisms by which conservation can be achieved (at least on public lands) are in place, but their efficacy depends on the rigor with which responsible agencies implement them, which has yet to be determined.

Biology and Ecology

Description and systematics

Identification

Pocket gophers are powerfully built mammals, characterized by a heavily muscled head and shoulders that taper into relatively narrow hips and short legs (**Figure 1**). As typified by both the northern and Wyoming pocket gophers, they have small eyes and ears and fur-lined cheek pouches that open external to the mouth. Front feet are strong with claw-like nails used for digging (Verts and Carraway 1999).

The Wyoming pocket gopher is smaller and paler than other pocket gophers in its geographic range (**Table 1**), with a yellow cast to the pelage, especially in younger animals (Thaeler and Hinesley 1979, Clark and Stromberg 1987). Dorsal pelage is uniform in color, and the margins of the pinnae are fringed with whitish hairs (Thaeler and Hinesley 1979). Adults may attain the following dimensions: total body length 161 to 184 mm, tail length 50 to 70 mm, hind foot length 20 to 22 mm, ear length 5 to 6 mm, and a weight of 44 to 72 grams. There is no sexual dimorphism displayed in this species (Clark and Stromberg 1987).

Four species of pocket gopher occur in Wyoming: the Wyoming pocket gopher (*Thomomys clusius*), the northern pocket gopher (*T. talpoides*), the Idaho pocket gopher (*T. idahoensis pygmaeus*), and the plains pocket gopher (*Geomys bursarius*). The plains pocket gopher (*G. bursarius*) occupies only far eastern Wyoming; aside from this wide geographic separation, *G. bursarius* is easily distinguished from *T. clusius* by distinctive parallel grooves on the front surface of its protruding incisor teeth (Clark and Stromberg 1987). Characteristics separating the remaining three taxa are presented in **Table 1**. The ranges of *T. clusius* and *T. idahoensis pygmaeus* are close but likely do not overlap, leaving *T. talpoides* as the primary taxon of confusion. Despite some differences, the potential for confusing these two taxa in the field is high. The range of *T. clusius* lies almost entirely within the range of *T. talpoides*, but the two species are suspected to occupy different habitats (Thaeler and Hinesley 1979); *Thomomys clusius* prefers well-drained, gravelly soils on ridge tops while *T. talpoides* occurs in sandy soils proximal to watercourses (Patton *in* Wilson and Reeder 1993). Morphometric characteristics recorded in the field (e.g., weight, body length, hind foot length, pelage characteristics, gross skull morphology) can be helpful, but they are often not diagnostic due to overlap between species, especially in the presence of juvenile *T. talpoides*.

Pocket gophers appear to have extreme interpopulation chromosomal variation relative to other mammals, with proximate populations of the same species often exhibiting different karyotypes (e.g., Patton and Dingman 1968, Thaeler 1974a, 1974b, 1980). However, diploid chromosome count appears to be a distinguishing feature at the species level (e.g., Patton and Dingman 1968, Thaeler 1974a), which holds true for Wyoming pocket gophers (Thaeler and Hinesley 1979). Thus, given the difficulty of distinguishing gophers in the field (described above),

Figure 1a. *Thomomys clusius* (top) and *T. talpoides ocius* (bottom).

Figure 1b. *Thomomys clusius* (left).

Figure 1b. *Thomomys talpoides ocius*.

Figure 1. Photographs showing a) the dorsum of representative study skins of a probable Wyoming pocket gopher (currently *T. clusius*) and a northern pocket gopher (*T. talpoides ocius*), both collected from central Wyoming; and b) the ear and post auricular area of both species, with the darker coloration evident on the *T. talpoides* specimen. Photographs of *T. t. ocius* courtesy of Dr. James Patton and the Museum of Vertebrate Zoology, University of California, Berkeley (http://mvz.berkeley.edu). Photographs of *T. clusius* courtesy of Gabor Racz and Cindy Ramotnik, Department of Biology, University of New Mexico, Albuquerque.

positive identification of Wyoming pocket gopher requires karyotype analysis (i.e., a count of the number of diploid chromosomes). The Wyoming pocket gopher has a karyotype of 2n = 46 chromosomes while the northern pocket gopher has a karyotype of 2n = 48 and the Idaho pocket gopher has a karyotype of 2n = 58 (Thaeler 1972, Thaeler and Hinesley 1979). This is a straightforward procedure, but it does require some technical expertise and equipment and, under typical circumstances, cannot be accomplished in the field. Given appropriate time and funding, it is possible that further genetic research on the Wyoming pocket gopher

Table 1. Characteristics of *Thomomys clusius* and similar pocket gophers near its range. Data were drawn largely from **Thaeler and Hinesley (1979)**, **Clark and Stromberg (1987)**, and **Verts and Carraway (1999)**.

	Thomonys clusius	*Thomonys talpoides*	*Thomonys idahoensis pygmaeus*
Ecology			
Wyoming Range (see also **Figure 4**)	South-central Wyoming; encompassed within range of *T. talpoides*.	All of Wyoming, including the range of *T. clusius*.	Southwestern Wyoming; west of and probably disjunct from *T. clusius* range.
Habitat	Unknown vegetation associations, **possibly preferring greasewood. Dry, well-drained, sometimes gravelly ridges.**	Varied vegetation. **Loose soil with relatively few rocks, often in valley bottoms.**	**Shallow, stony soils.**
Field Characteristics			
Dorsal pelage	**Dorsal pelage uniform in color, paler than other gophers, and having a yellow cast.**	Darker coloration than *T. clusius*. **Fur is brown to yellow-tan.**	Darker coloration than *T. clusius*. **Yellowish to dark-brown fur.**
Contrasting pelage	No post-auricular dark patch. No difference in color between cheeks and dorsal part of head.	Post-auricular dark patch (small blackish patches around ears). **Grayish cheeks and sides contrast with pale-brown mid-dorsal fir.**	No post-auricular dark patch.
Pinnae	Fringe of white hair on margins of the pinnae.	Dark-colored hair along margins of pinnae.	Unknown
Body size	Smaller overall than others. Body length: **~128 mm (112-134)** Total length: **~173 mm (161-184)** Hind foot: **20.7 mm (20-22)**	Larger overall than *T. clusius*.| Body length: **usu. >140 mm (131-157)** Total length: usu. **>200 mm (165 - 253)** Hind foot: **~26 mm (23-33)**	Slightly larger overall than *T. clusius*. Body length: **97-153 mm** Total length: **167-203 mm** Hind foot: **21-22 mm**
Adult weight	**~58 g (44-72)**	**~90 g (63-**180)	**~53 g (46-63)**
Lab Characteristics			
Diploid chromosomes	**46**	**48, 56**	**56**
Skull characteristics	Dorsal surface of rostrum depressed.	**Dorsal surface of rostrum in same plane as cranium and inter-orbital region.**	Dorsal surface of rostrum in same plane as cranium and inter-orbital region.
Baculum	**10.4 - 13.8 mm**	**12.3-22.6 mm**	**17.8 - 20.0 mm**

could develop genetic markers capable of distinguishing it from related species, thus eliminating the need for highly invasive karyotype analyses, but the feasibility of this is highly speculative.

Taxonomy

Pocket gophers comprise the family *Geomyidae*, within which there are currently six recognized genera: *Cratogeomys* (eight species), *Geomys* (nine species), *Orthogeomys* (11 species), *Pappogeomys* (two species), *Thomomys* (nine species), and *Zygogeomys* (one species). Species of the genus *Thomomys* have recently been allocated to two subgenera based on chromosome number and molecular characters (Wilson and Reeder 2005): *Megascapheus* (four species) and *Thomomys* (five species, including the Wyoming pocket gopher and its close relative the northern pocket gopher).

The placement of the Wyoming pocket gopher in this scheme has changed somewhat over time, and the name *clusius* has been variously applied at both the species and subspecies level to pocket gophers whose range centered roughly on southern Wyoming. The type specimen was collected in 1857 by Dr. W. A. Hammond about 18 miles southwest of Rawlins, Wyoming, but it was not described until 18 years later (Coues 1875), when it was given the name *Thomomys clusius*. After that, it was sometimes referenced as a subspecies of the northern pocket gopher (*T. talpoides clusius*) until Thaeler and Hinesley (1979) clarified its taxonomy and range boundaries by conducting karyotype analyses. These analyses also showed that specimens assumed to be *T. clusius* in earlier publications (e.g., Bailey 1915, Long 1965) were in fact *T. talpoides*. Even after the terminology was solidified and a reasonable estimate of range was formed through the work of Thaeler and Hinesley (1979), some authors persisted using the subspecific classification of *T. t. clusius* (mainly Hall 1981). *Thomomys clusius* is now widely recognized as a unique species (Wilson and Reeder 2005) whose range is more-or-less completely encompassed by the range of *T. talpoides* (**Figure 2**, **Figure 3**, **Figure 4**). Its distinctiveness is mainly based on the unique karyotype of 2n = 46, with support from the more pale and yellowish pelage and generally small size (Thaeler and Hinesley 1979).

The reader should note this confusing taxonomic history when reviewing literature and specimen locations, since most collections labeled as *Thomomys clusius* are no longer thought to be Wyoming pocket gophers. Further, some references to *T. talpoides clusius* may refer to the Wyoming pocket gopher while others would now be considered belonging to different subspecies of northern pocket gopher, likely *T. t. ocius*.

Distribution and abundance

According to Miller (1964), the general distribution of the Geomyidae family in North America is limited only by suitable soils, but particular species may also be limited by climatic factors or other factors associated with altitude and latitude. Pocket gophers of the genus *Thomomys* can be found in much of the central and southern Rocky Mountains, and from the Pacific coast in Washington to Minnesota and Manitoba in the central plains (Tryon and Cunningham 1968, Hall 1981). However, the Wyoming pocket gopher is known to occur only in Sweetwater and Carbon counties in Wyoming (**Figure 3**, **Figure 4**), although there is some indication (pending further investigation) of occurrences in northern Colorado (Clark and Stromberg 1987, Wyoming Natural Diversity Database 2003). In comparison, the Idaho pocket gopher is found in southwestern Wyoming (Lincoln, Uinta, and Sublette counties) and adjacent portions of Idaho; the northern pocket gopher occurs throughout Wyoming and adjacent states in virtually all vegetation types underlain by loose soil; and the plains pocket gopher occupies true grasslands of the Great Plains including far eastern Wyoming (Clark and Stromberg 1987). It is important to recognize that all *Thomomys* in this region are undersampled, and additional field inventory may dramatically alter the limits of known range for any taxon, including the Wyoming pocket gopher.

As its range is currently defined, the Wyoming pocket gopher appears to occur primarily on multiple-use lands managed by the U.S. BLM; these lands are extensively intermixed with parcels of private land. Little, if any, of this species' supposed distribution falls on lands managed by the USFS (**Figure 4**). However, this may be an artifact of the lack of field inventory, and it is possible that survey efforts could document the species on National Forest System lands. The highest probability of such occurrence would likely be in lower elevations of the Medicine Bow – Routt National Forest (Region 2) near Rawlins and Saratoga, Wyoming, but the possibility also exists for the species to occur on lands administered by the Ashley and Wasatch national forests (Region 4) of southwestern Wyoming.

No information exists on the abundance of the Wyoming pocket gopher in any portion of its restricted range. No one has surveyed extensively for pocket gophers within this species' range in at least the last 30 years, and there has never been a systematic

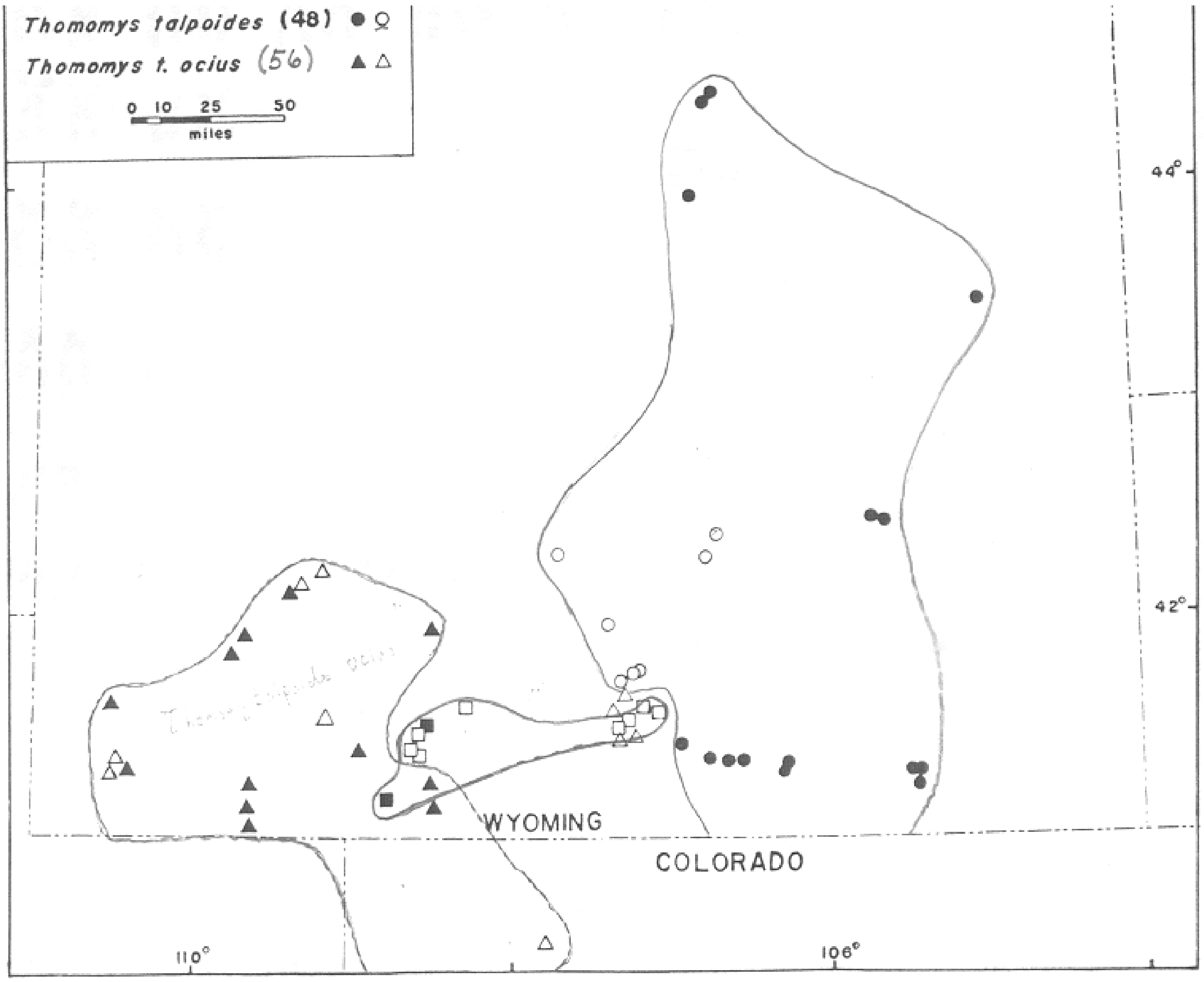

Figure 2. Karyotype map adapted from Thaeler and Hinseley (1979; Copyright American Society of Mammalogists, Journal of Mammalogy, by C.S. Thaeler, Jr. and L.L. Hinseley. Reprinted by permission of Alliance Communications Group, a division of Allen Press, Inc.) showing the distribution of samples analyzed in their study and the differences in chromosome number among taxonomic groups of *Thomomys* in central Wyoming. Open symbols represent localities where chromosome material was examined and closed symbols represent localities were it was not examined. Legend in upper left provides a species key to symbology, with chromosome count (2n) noted in parentheses.

survey of the Wyoming pocket gopher. The entire assumption of this species' distribution is based on a handful of museum records and anecdotal reports from about 30 years ago (**Figure 4**). Given this paucity of information, in the summer of 2005 the Wyoming Natural Diversity Database revisited some locations of former occurrence. Each site was searched for the presence of gopher mounds, and sites with mounds were trapped using Victor EasySet Gopher traps (http://www.victorpest.com/). Only one site of 17 sites showed evidence of recent gopher activity. Of the remaining 16 sites, half showed no evidence whatsoever of gophers, and the rest had only scattered mounds and collapsed tunnels that probably had not been used for several seasons (**Figure 5**). Moreover, no gophers were captured at any site, despite about 500 trap days expended at sites where mounds were witnessed (Wyoming Natural Diversity Database unpublished data). Since the effort expended was minimal and not uniform, such *ad hoc* surveys cannot be used to make a definitive determination of Wyoming pocket gopher status. However, they suggest that this species is likely quite rare. They also suggest that the gophers could be absent from many areas where they were heretofore presumed present, raising the disturbing possibility of a population decline since the mid-1900's. Mostly, the 2005 survey results highlight the need for a thorough, systematic survey for Wyoming pocket gophers throughout their known range.

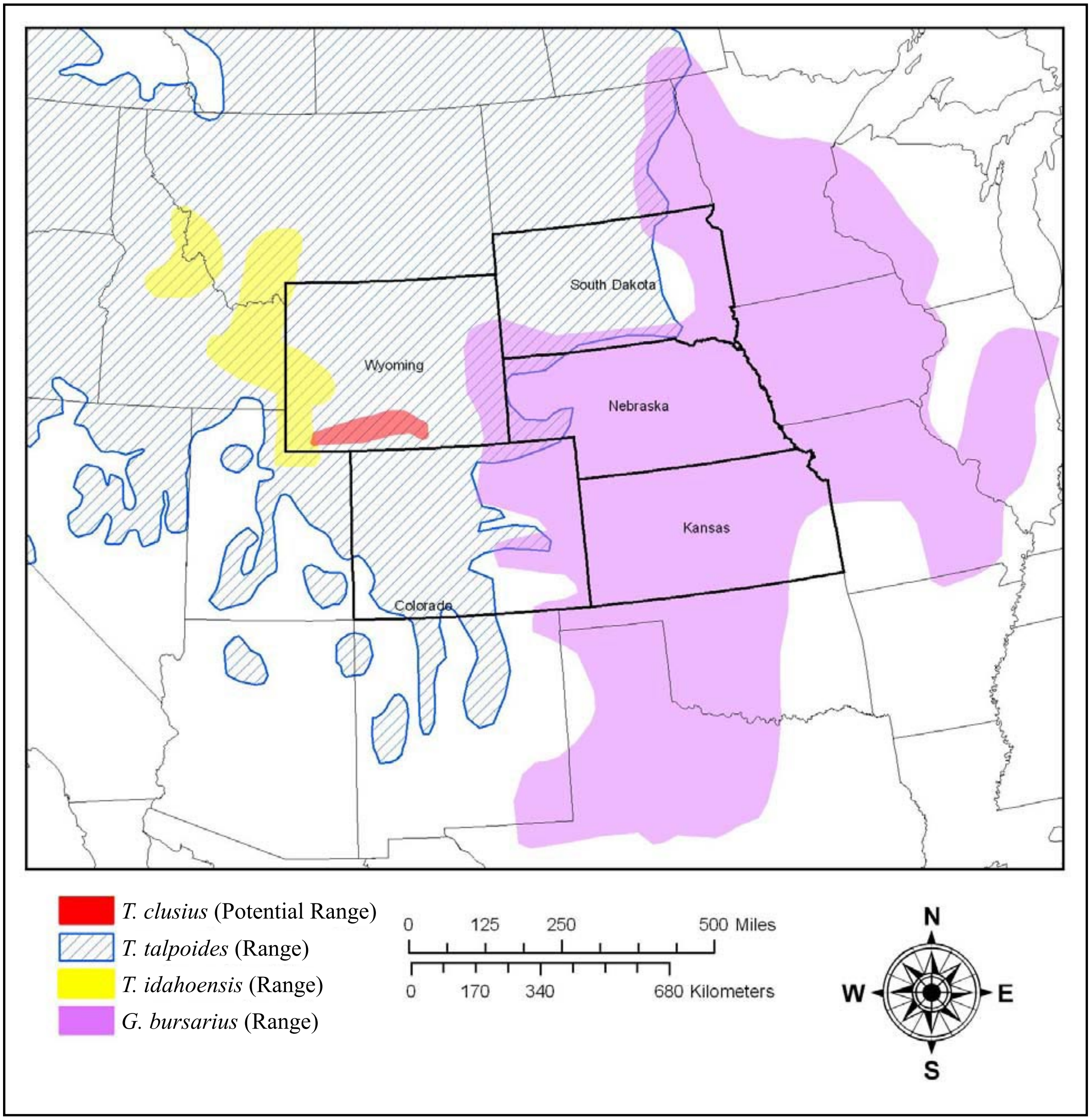

Figure 3. Regional ranges of *Thomomys clusius* and similar species.

Habitat

Apparent habitat requirements

Pocket gophers are strongly fossorial, living most of their lives in burrow systems and underground tunnels. Based on the very limited information base, the Wyoming pocket gopher appears to segregate from northern pocket gophers by preferentially occupying dry, gravelly, shallow-soil ridge tops rather than deeper soiled swales and valley bottoms (Clark and Stromberg 1987). Many existing capture locations are from greasewood (*Sarcobatus* spp.) communities on the edges of eroding washes (Thaeler and Hinesley 1979, Clark and Stromberg 1987). However, this information is predominantly the result of inference from specimen tags and anecdotal accounts rather than from actual habitat studies. Moreover, it is not known if such accounts represent actual habitat preference by Wyoming pocket gophers since unknown biases could be masked by such *ad hoc* reports. For example, documented specimen locations could represent a biased geographic sample, Wyoming pocket gophers could be more readily captured in marginal habitats, or there may

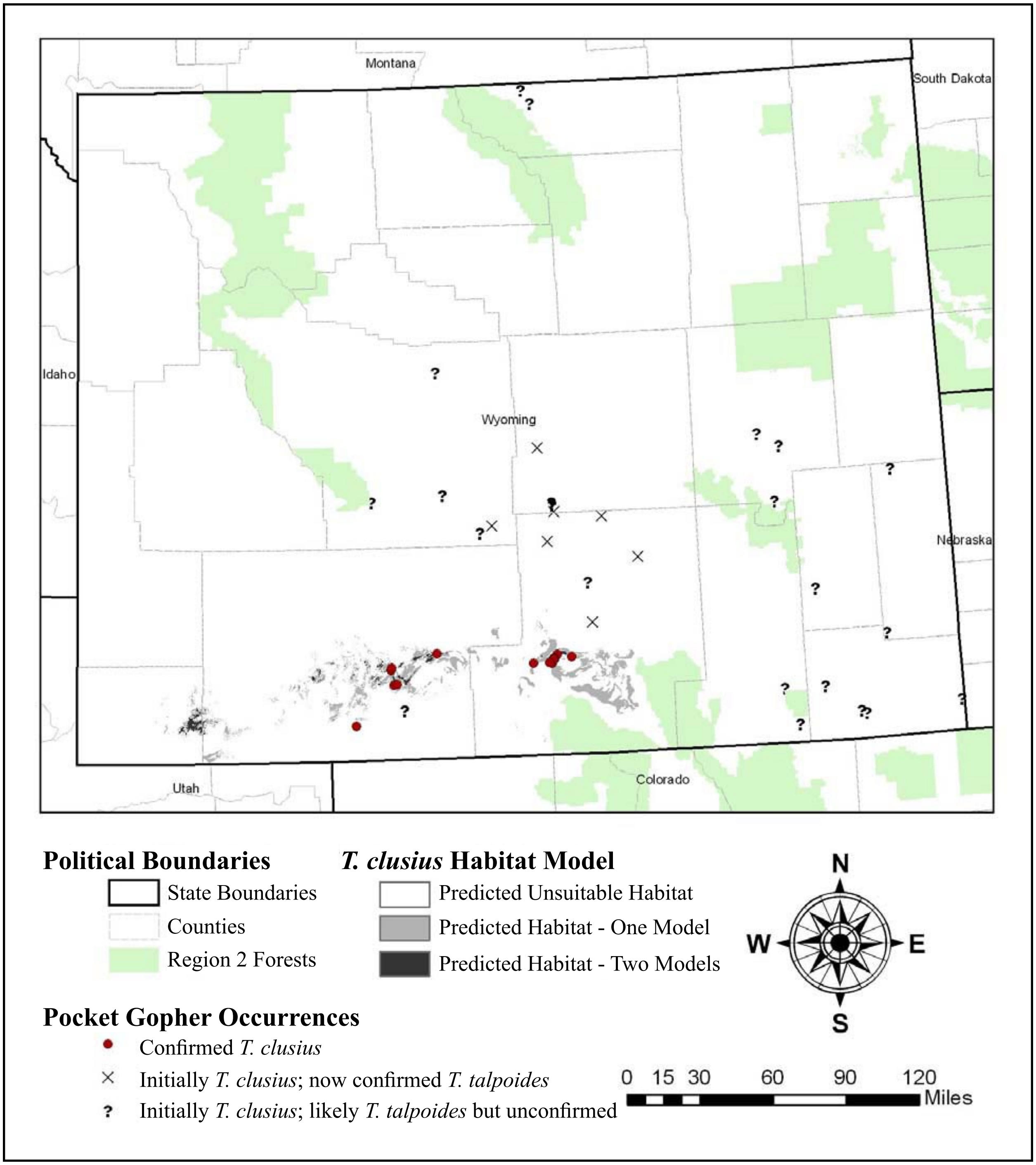

Figure 4. Documented locations of *Thomomys clusius*; the known global range of the taxon falls completely within the state of Wyoming. Red circles indicate the approximately 14 unique capture locations of the 22 pocket gopher specimens positively identified as Wyoming pocket gopher. Other symbols indicate locations of specimens initially believed to be Wyoming pocket gophers, but then reclassified to other species by Thaeler and Hinseley (1979) (X's), or currently thought to be *T. talpoides* and accompanied by insufficient evidence for positive identification (?'s). Habitat models were developed using the known capture locations and available statewide environmental data (see Appendix). All data on file at the Wyoming Natural Diversity Database, University of Wyoming, Laramie, Wyoming.

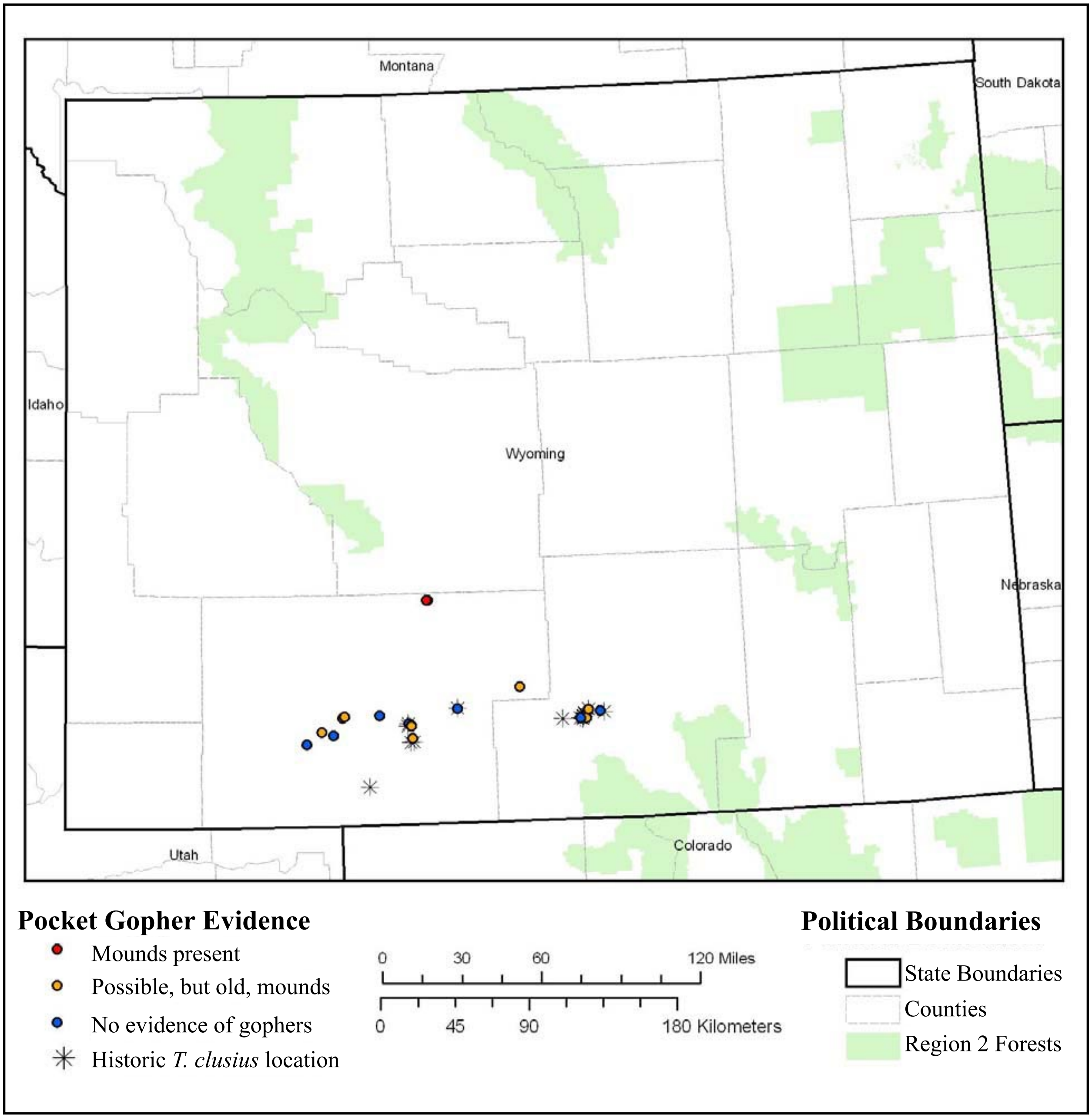

Figure 5. Map of summer 2005 survey locations for *Thomomys clusius* and preliminary results (WYNDD unpublished data). Relatively fresh mounds were only found at one location, which was outside the historic range of *T. clusius* (red dot). All other survey areas (n = 16) showed either scattered old mounds (i.e., collapsed tunnels not likely used this season) or no evidence of gopher presence, even at historic locations where museum specimens were formerly collected.

have been unaccounted for competitive exclusion from preferred habitats by other species of pocket gophers. In any case, the above habitat description should be viewed as hypothetical.

Beyond this, nothing is known regarding the habitat affinity of the Wyoming pocket gopher. In the absence of data, we can draw some basic inferences on habitat use from the northern pocket gopher, but we must realize that such comparisons are tenuous and useful mainly to inform further investigation. In general, pocket gopher habitat appears to be limited by two factors: the presence of a soil layer deep and tractable enough to hold burrow systems and enough herbaceous plants to form a food base. Northern pocket gophers are very adaptable and occur across much of the western

United States at various elevations, vegetation types, and soil types (Miller 1964, Tryon and Cunningham 1968, Clark and Stromberg 1987, Verts and Carraway 1999). They apparently prefer deep and tractable soils, but they also occupy heavily compacted soils and shallow gravels (Miller 1964) that are more reminiscent of suspected Wyoming pocket gopher habitat.

In some regions, pocket gophers appear to preferentially occupy habitat dominated by "mima mounds" (i.e., circular to oval mounds each 4 to 30 meters in diameter, up to 2 meters higher than the surrounding soil, and occurring at various densities on the order of 25 to 50 mounds per hectare; Cox and Hunt 1990, Knight 1994). There is ongoing debate whether burrowing mammals, typically gophers, caused these mounds through their diggings or inhabit mounds that previously existed in the landscape due to other processes, such as post-glacial cycles of freezing and thawing that cause differential soil development based on substrate characteristics (e.g., Hansen 1962, Knight 1994, Verts and Carraway 1999). No one has reported whether the Wyoming pocket gopher is preferentially found in habitat reminiscent of mima mounds. Although such mounds are much less common in the range of Wyoming pocket gophers than in the deeper soils of eastern Wyoming, this is a possibility worthy of investigation.

Pocket gophers use burrow systems consisting of a network of feeding tunnels connected to a smaller and deeper system of chambers that are used for nesting and food storage (Miller 1964). In general, pocket gopher tunnels vary from 6 inches to a foot below the surface of the ground and are 1.5 to 3 inches in diameter, depending on the size of the gopher (Bailey 1915). Unlike ground squirrels and many rodents, which have regular tunnel openings, the surface tunnels of pocket gopher burrows are kept plugged with loose soil (Clark and Stromberg 1987). Pocket gopher burrow systems are typically found in areas with large herbage yields of succulent forbs with fleshy underground storage structures, such as alfalfa fields (Reid 1973). However, it is assumed that because such cultivation is relatively rare in southern Wyoming and occurs primarily in valley bottoms occupied by northern pocket gophers, such habitats do not substantially influence populations of Wyoming pocket gophers.

Movement, territoriality and area requirements

Given their fossorial nature, once pocket gophers establish territories and burrows, they move very little over the course of their entire lives, except for minor alterations of territory boundaries (Bailey 1915, Miller 1964, Reichman et al. 1982). Moreover, the long distance movement and dispersal capabilities of pocket gophers are limited since they stay underground most of the time, foraging above ground only at night or on overcast days (Verts and Carraway 1999). Also, despite their considerable tunneling capability, the energetic costs of burrowing are high enough to be a physiological limitation to movement (Vleck 1979). Vaughan (1963) recorded distances dispersed by northern pocket gophers and valley pocket gophers (*Thomomys bottae*) when they were released into unfamiliar habitat. He found that over the course of a year northern pocket gophers moved much farther from the release area (mean of 13 individuals = 785 m; range 50-2590 m) than valley pocket gophers (mean of 18 individuals = 198 m; range 0-900 m). This demonstrates that, although movement of both pocket gopher species was very restricted, there is substantial interspecies variation in dispersal. This variation could be attributed to either (or both) innate interspecies' differences in propensity for dispersal or variable restrictions on dispersal caused by the different environments used by the two species. If the main restriction on dispersal is environment (admittedly a large assumption) and if we consider that northern pocket gophers appear to occupy areas with looser soils that are presumably more amenable to long-distance movements than the gravelly ridge-top soils occupied by Wyoming pocket gophers, then we can hypothesize that Wyoming pocket gophers could be more restricted in their movements than northern pocket gophers. In this case, the figures presented above likely represent the upper limit of Wyoming pocket gopher dispersal. All speculation aside, in the absence of additional information, it is reasonable to assume that the dispersal distances recorded by Vaughan (1963) represent bounding estimates for the dispersal capabilities of Wyoming pocket gophers. Pocket gophers are active year-round, and some have suggested that longer-distance dispersals may occur beneath the snow (Marshall 1941, Vaughan 1963). This does not seem likely for the Wyoming pocket gopher since the dry ridges presumed to be its preferred habitat have generally low snow accumulation due to low winter precipitation and wind scouring that tends to deposit existing snow in depressions.

The territory of a pocket gopher is essentially equivalent to the extent of its active burrow complex. Pocket gophers such as the northern pocket gopher generally defend against intrusion into their burrow system by other gophers (Tryon 1947, Verts and Carraway 1999), but during the breeding season territoriality appears to be somewhat relaxed (Hansen and Miller 1959, Miller and Bond 1960). The defense and maintenance of a territory usually involve some form of aggressive behavior or display. Once a pocket gopher establishes a territory and has lived in its burrow for one breeding season, it tends to remain in that burrow for life, with only minor boundary changes (Miller 1964). Many animals alter their tolerance of neighbors in response to resource availability; home ranges often are smaller and closer together in resource-rich areas than resource-poor areas. However, Reichman et al. (1982) found that pocket gophers in his northern Arizona study area altered burrow length but did not change territory spacing to compensate for differences in forage production. Despite defense of their burrows, burrow systems of valley pocket gophers (particularly those of reproductive males) are generally configured to contact numerous other territories, presumably to facilitate finding mates (Reichman et al. 1982), which is assumed to hold true for other species.

The home ranges of the Wyoming pocket gophers are assumed to be similar in size and nature to those of the northern pocket gopher, which are very small. Banfield (1974) documented the home range of the northern pocket gopher to be 0.015 hectares. In Utah, density estimates for populations of northern pocket gophers in early summer were 5.3 to 16.9 per hectare (2 years) in meadow, 2.1 to 14.4 per hectare (3 years) in aspen, 6.3 per hectare (1 year) in fir, and 0.4 per hectare (1 year) in spruce (Andersen and MacMahon 1981). During a 3-year study at 3,020 meters in subalpine parks in Colorado, densities of northern pocket gophers in early summer were 6.2 to 12.4 per hectare and 14.8 to 34.6 per hectare in late summer; much of the variation in late summer was attributed to differences in survival of young (Vaughan 1969). Howard and Childs (1959) observed that male territories in a population of valley pocket gophers averaged 0.025 hectares and were considerably larger than those of females and sub-adult males. Reichman et al. (1982) confirmed this assessment, noting that reproductive males had longer burrow systems, greater home ranges, and a greater number of neighbors than either females or non-reproductive individuals.

Landscape pattern

Considering that very little information is known regarding pocket gopher habitat use in general, it is hard to say what may constitute a suitable landscape pattern for Wyoming pocket gophers. Miller (1964) stated that "soil depth and texture, and interspecies competition are clearly the most critical factors in both the geographic and habitat distributions of pocket gophers". Also, population density and body size of pocket gophers is related to food quantity and quality (Smith and Patton 1988). For example, because fields of alfalfa produce more and more consistently available food than fields of annual cereals, they support more and larger pocket gophers (Reid 1973). This likely occurs because gophers in these resource-rich areas can thrive in smaller burrow systems than in resource-poor areas, although the spacing and arrangement of individual territories likely does not change with resource availability (Reichman et al. 1982).

In this context, a suitable landscape for Wyoming pocket gophers may be loosely defined as a dry upland with gravelly, yet still tractable, soils (i.e., which presumably favors Wyoming pocket gophers over northern pocket gophers; see the above section on Apparent habitat requirements) and relatively high productivity of grasses and forbs (i.e., high food availability). Given relatively small home ranges (see previous section), the continuous area of such habitat capable of supporting a local population of pocket gophers may be relatively small, perhaps on the order of tens of hectares. However, long-term persistence of gophers would likely depend on larger areas of such habitat arranged in patches of sufficient proximity to allow dispersal between patches. Since no supporting information exists, the necessary scale and arrangement of such a landscape are conjecture.

Reproduction and survivorship

Breeding behavior and phenology

Studies of reproduction of the Wyoming pocket gopher are lacking, but presumably, its reproductive biology closely resembles that of the northern pocket gopher. Northern pocket gophers are solitary creatures, except during the breeding season (Miller 1964). Male northern pocket gophers are polygamous, exploring the burrows of females living next to them, but females will only permit the males to remain in their burrow during the breeding season (Miller 1964). Very little is known regarding the courtship practices of pocket gophers. Sex ratios for adult pocket gophers are generally close to 50:50, but estimation of sex ratios may be biased depending upon when sampling is done in the annual population cycle (Reid 1973).

The precise phenology of reproduction is unclear, but the breeding season of northern pocket gophers in Colorado is thought to extend from mid-March to mid-June (Hansen 1960). Vaughan (1964, 1969) claimed that it occurred in May or June at elevations of 3,020 meters and noted that most litters in Colorado were probably born in June. Pregnant northern pocket gophers have been captured in June in Sweetwater County, Wyoming, which is near the range of the Wyoming pocket gophers, but they were captured as late as July in the Black Hills (Clark and Stromberg 1987). The northern pocket gopher is thought to have a gestation period of 19 to 20 days (Reid 1973). Young are born hairless into subterranean nests within the burrow system, their eyes open at about 26 days of age, and they are weaned by 35 to 40 days of age (Andersen 1978, Chase 1982). Young northern pocket gophers can appear above ground as early as June (Armstrong 1987), but they often remain with the mother for 6 to 8 weeks (Criddle 1930). Clark and Stromberg (1987) indicated that young in Sweetwater County disperse from maternity burrows in early June, but this could occur much later, perhaps even late July, if females are still pregnant in June. It takes about 180 days for newborns to reach near-adult weights (Reid 1973), at which point young of the year can only be distinguished from adults by the size of their reproductive organs (Hanson and Reid 1973).

Fecundity and survivorship

No data are available regarding the fecundity of the Wyoming pocket gopher, so the best one can do is assume general similarity with the closely related northern pocket gopher. Litter size of northern pocket gophers is highly variable (averaging 4 to 6 young in Wyoming; Wirtz 1954, Tryon and Cunningham 1968, Andersen 1978, Verts and Carraway 1999). Studies in Colorado suggest similar litter sizes that are likely influenced by habitat, averaging 6.4 young in irrigated alfalfa fields and 4 to 5 young in native forb-grass rangelands (Hansen 1960, Reid 1973). It has been suggested that some female northern pocket gophers may produce more than one litter per year, based largely on the synchronous capture of pregnant females and juveniles in the same burrow systems (Burt 1933, Miller 1946). However, Hansen (1960) found no evidence of more than one annual litter per female in the Rocky Mountain region, and Miller (1964) suggested that this only occurred in southern climates. It is therefore unlikely that multiple litters would occur in Wyoming pocket gopher populations. Young northern pocket gophers are able to reproduce in the calendar year following their birth (Moore and Reid 1951). The proportion of females that produce litters every year can vary greatly (Verts and Carraway 1999). In a study conducted in Utah, 62.5 to 100 percent bred annually during a 4-year period, and differences among the years were not significant (Andersen and MacMahon 1981). Wight (1930) reported that 79 percent of 112 females collected from mid-March to mid-April were found to be reproductively active.

Very little is known generally regarding survivorship and mortality in pocket gophers, much less for Wyoming pocket gophers in particular. As with many small mammals, individual pocket gophers often do not live more than two breeding seasons, typically surviving 18 to 20 months in the wild; however, they are capable of living longer, perhaps up to 5 years under favorable circumstances (Reid 1973, Clark and Stromberg 1987). Lechleitner (1969) stated that about 75 percent of a breeding population of northern pocket gophers were yearlings, and only 25 percent were two years or older. In a 4-year study of northern pocket gophers in Utah, annual survival rates were 0.27, 0.18, 0.23, and 0.70, with weekly survivorship greater in summer than winter (Andersen and MacMahon 1981). In Colorado, Hansen (1965) studied an introduced population of northern pocket gophers in a controlled exclosure; mortality was approximately 10 percent per month from June through September and approximately 13 percent per month from September through June. Sixty-three percent of the study population survived the summer, but only 17 percent survived the winter. One of the very few studies investigating natal pocket gopher mortality occurred in Oregon, where pocket gophers (then classified as *Thomomys quadratus*) were repeatedly trapped within individual burrow systems (Wight 1930). This resulted in an average of 2.8 young being captured, which was well below the mean natal litter size of 6.3, causing the author to suggest that young pocket gophers experienced heavy mortality or dispersed before sampling occurred. Howard and Childs (1959) also stated that sub-adult pocket gophers appeared to be exposed to unusually heavy mortality as they were forced to live in marginal habitats. Moreover, although Wight (1930) and Howard and Childs (1959) did not study species closely related to the Wyoming pocket gopher, the results suggest the possibility of high juvenile mortality.

Population demographics

Even less is known about the demographics of pocket gopher populations than other aspects of their biology and ecology. Other than coarse scale habitat availability, it is unclear what limits the structure and growth of populations. The extremely varied diets of various pocket gopher species have led to the conclusion that food is seldom a limiting factor in pocket gopher distribution, but the nature and amount of vegetation may affect local population densities (Miller 1964).

There is not enough known about pocket gophers in general, and Wyoming pocket gophers in particular, to confidently assess the spatial dynamics of populations. This issue, however, is intriguing given the apparent karyotypic differences within the same genus, wherein morphologically and geographically proximate species or sub-species can have radically different chromosome numbers (see Taxonomy section above). Such cellular divergence is likely facilitated by the limited dispersal ability of pocket gophers and a resultant high rate of inbreeding for some species (Patton and Dingman 1970). All these factors (e.g., low dispersal ability, high inbreeding, and high variation over small geographic area) suggest that pocket gophers could have an easily disrupted metapopulation structure wherein local populations are readily isolated over relatively short distances. The magnitude of these distances, however, is unknown. This is particularly important for small and isolated taxa, such as the Wyoming pocket gopher, where isolation may also raise the risk of local extinction. Although the management implications of this situation are unclear, it would likely mean that continuity of suitable habitat would be an important component in the conservation of pocket gopher populations.

Food and feeding habits

As with most other aspects of Wyoming pocket gopher biology, food habits have not been studied. Roughly speaking, diet is assumed to be similar in variety and opportunistic composition to other pocket gophers in the region, with a general reliance on roots, shoots, and leaves of forbs, and a lower utilization of grasses and other plants (Ward and Keith 1962, Clark and Stromberg 1987). In general, pocket gophers are strictly herbivorous (Reid 1973), eating roots and tubers while underground and, to a lesser extent, harvesting surface vegetation occurring near burrow entrances (Verts and Carraway 1999). A large part of their diet throughout the year is comprised of belowground plant material (i.e., roots, tubers, bulbs, corms), but it appears that in summer they tend to include green plants and aboveground material to a greater extent than in winter (e.g., Aldous 1951, Reid 1973). For example, the summer diet of northern pocket gophers in one subalpine habitat in Colorado consisted of 87 percent forb leaves, 12 percent roots, and 1 percent grasses (Vaughan 1974). In another location in Colorado, their summer diet consisted of 93 percent forbs, 6 percent grasses, and 1 percent shrubs, with 74 percent of this material being aboveground plant parts and 26 percent roots (Verts and Carraway 1999). Ward and Keith (1962) also reported that forbs occurred in northern pocket gopher diet disproportionate to their occurrence in the environment, representing over 92 percent of stomach contents but only 42 percent of site biomass. Tietjen et al. (1967) experimentally confirmed the importance of forbs to northern pocket gophers, as gophers forced to eat a larger dietary proportion of grasses lost body mass.

In general, pocket gophers can subsist on a very wide variety of plant species, but they have a strong preference for forbs. It makes sense that the relative consumption of specific species of forbs is likely different for Wyoming pocket gophers than for other pocket gophers, simply because they inhabit a different environment with different vegetation. The overwhelming preference by other gophers for forbs, however, provides strong evidence that forbs are likely to be an important component of Wyoming pocket gopher diet. The northern pocket gopher probably eats most species of succulent plants within its range, but it is capable of selecting plants with higher levels of protein and fat from those available (Tryon and Cunningham 1968). Alfalfa fields are known to provide large amounts of high quality, succulent vegetation to pocket gophers in Colorado (Reid 1973). In a shortgrass prairie region of Colorado, northern pocket gophers consumed 67 percent forbs, 30 percent grasses, and 3 percent shrubs; the major components of the diet included prickly pear (*Opuntia polyacantha*) (49.9 percent), needle-and-thread grass (*Stipa comata*) (12.1 percent), red globe-mallow (*Sphaeralcea coccinea*) (10.3 percent), bluestem wheatgrass (*Agropyron smithii*) (10.1 percent), blue grama (*Bouteloua gracilis*) (3.0 percent), and fourwing saltbush (*Atriplex canescens*) (2.5 percent) (Vaughan 1967). At elevations between 2,750 and 3,050 meters in Utah, the species consumed most frequently and in the greatest amounts were dandelion (*Taraxacum* spp.), penstemon (*Penstemon rydbergii*), sweet sage (*Artemisia discolor*), meadowrue (*Thalictrum fendleri*), and slender wheatgrass (*Agropyron trachycaulum*) (Aldous 1951).

Pocket gophers tend to change their diet seasonally in response to habitat conditions and the availability and nutritional quality of food (Reid 1973). A summer preference for aboveground plant parts was found in Colorado's shortgrass prairies, where 70 percent of foods consumed by northern pocket gophers were from above ground (Vaughan 1967). In winter, diet is assumed to shift more toward belowground forage, unless sufficient subnivean space is available in which case aboveground components of forbs and grasses may be supplemented by woody material (Verts and Carraway 1999).

The northern pocket gopher normally forages in underground burrows, but it occasionally forages above ground, in close proximity to a burrow entrance, at night or on overcast days. Some experts have suggested that pocket gophers rarely forage above ground beyond where they can reach by keeping their hind feet in the burrow entrance, suggesting that virtually all aboveground vegetation is taken in the immediate vicinity of entrance mounds (Aldous 1951). Many of the plants cut by gophers, particularly above ground, are not immediately consumed, often being cut into small pieces and carried in the cheek pouches back to the burrow where they are either consumed, stored for winter, used for nest building, or taken into runways and later pushed to the surface (Aldous 1951, Verts and Carraway 1999). Pocket gophers generally cache food collected in late summer. In Utah, five food caches of northern pocket gophers collected in late summer contained an average of 380 g of stored food items (Aldous 1945).

Community ecology

As a group, pocket gophers have been widely recognized for their impacts on the ecosystems they inhabit. These effects primarily result from their extensive tunneling activity, which can affect soil formation, hydrology, and nutrient flows, and their consumption of belowground plant biomass, which can alter the competitive interactions of plants and thereby influence vegetation patterns and aboveground herbivory. Like other "ecosystem engineers" (e.g., beavers, prairie dogs), their activities can drive ecosystem function, making them important to native ecosystems while simultaneously causing them to be labeled as pests in many areas where they occur in abundance and coincide with humans. For example, due to potentially detrimental impacts on agricultural production, such effects have been studied for pocket gopher species occurring in agrarian landscapes. Such a discussion, although interesting, is not directly pertinent to this assessment, particularly since no such investigation has studied the impact of Wyoming pocket gophers and since the purported habitat of this species is sufficiently different than that of studied species to make comparisons rather tenuous. Readers interested in such information might consult the following literature: McDonough (1974), Tilman (1983), Hobbs and Mooney (1985), Huntly and Inouye (1988), Borchert et al. (1989), Davis et al. (1995), and Wolfe-Bellin and Moloney (2000).

Predation

Pocket gophers are preyed upon by a number of birds and mammals, but it is suspected that natural predation is not a factor limiting pocket gopher distribution and abundance (Chase et al. 1982). This hypothesis is logical since gophers evolved with natural predators, making it unlikely that such predation would play a role in population declines unless accompanied by other extenuating circumstances. Such extenuating circumstances might include increased predation from generalist predators whose distributional expansion has been facilitated by human alteration of the landscape (e.g., feral cats, coyotes, raccoons). Also, in the event that Wyoming pocket gopher populations become small and/or isolated, even natural predation events could cause a marked population decline (e.g., Wilcove 1985, Sinclair et al. 1998).

Documented predators of pocket gophers include gopher snakes (*Pituophis catenifer*), rattlesnakes (*Crotalus viridis*), long-tailed weasels (*Mustela frenata*), coyotes (*Canis latrans*), bobcats (*Lynx rufus*), martens (*Martes americana*), badgers (*Taxidea taxus*), foxes, skunks, and numerous owls (Criddle 1930, Young 1958, Vaughan 1961, Hansen and Ward 1966, Marti 1969, Clark and Stromberg 1987, Bull and Wright 1989).

Interspecific interactions

Species of pocket gophers are generally distributed so that their ranges do not overlap (Bailey 1915, Vaughan 1967, Thaeler 1968a). However, given that the Wyoming pocket gopher's range is completely subsumed within that of the northern pocket gopher, it is possible that sympatry could exist. However, the species are thought to exclude one another from particular environments in a classic competitive exclusion manner based on differential habitat preferences and requirements (i.e., soil type and depth) (Miller 1964). Given its highly restricted distribution, if populations of Wyoming pocket gophers are found to be declining, competition with northern pocket gophers could become a limiting factor in their persistence. This is, of course, very speculative, as no studies have been published that suggest this.

Parasites and disease

Parasites and/or disease have not been shown to limit pocket gopher populations and are thus not suspected to be a factor in the conservation of Wyoming pocket gophers. Pocket gophers carry a typical complement of endoparasites and exoparasites, most of which have been documented incidentally to other research. Lists of such are presented by Verts and Caraway (1999), Chase et al. (1982), Reid (1973), and Miller and Ward (1964). Although most parasitic infestations appear to be minor and non-lethal, the northern pocket gopher has been found to be infested with warbles of the botfly, sometimes severely enough to cause mortality and occasionally involving 25 to 37 percent of local populations (Richens 1965a).

Conservation and Management of The Wyoming Pocket Gopher in Region 2

Extrinsic Threats and Reasons for Decline

Abundance and trends

Virtually nothing is known regarding the actual abundance of the Wyoming pocket gopher within its range, and even the boundaries of its range are questionable. Therefore, all published statements estimating the prevalence of this species are conjecture, and more information is needed for a confident assessment. For example, Clark and Stromberg (1987) stated that it may be abundant within its range, but their analysis included locations currently believed to be occupied by northern pocket gophers rather than Wyoming pocket gophers (e.g., **Figure 4**). There are now only 14 known locations where specimens of the Wyoming pocket gopher have been documented, representing 21 captured and positively identified individuals. The Wyoming Game and Fish Department used this information to list the Wyoming pocket gopher as an uncommon resident (Oakleaf et al. 2002), while WYNDD currently categorizes the abundance of the Wyoming pocket gopher as rare and possibly declining (e.g., see Keinath et al. 2003, **Figure 5**, and the previous section on Distribution and abundance).

The Wyoming pocket gopher has an exceedingly small global range, essentially being endemic to one or two counties in Wyoming, with a possible small extension into northern Colorado (**Figure 3**, **Figure 4**). Given the overall lack of field inventory, the bounds of this range are not well defined. Even if additional field efforts document significant range expansions and moderate or high abundances within that range, the overall population of Wyoming pocket gophers is still likely to be very small.

Population trends of Wyoming pocket gophers are essentially unknown across both the historical and recent periods. Recent *ad hoc* evidence, however, suggests a possible decline based on an absence from historic locations (see above section on Distribution and abundance). Similarly, very little is known about habitat trends for this species. A small amount of habitat may have been lost to urbanization and other disturbances such as road and pipeline construction, but a substantial amount of generally undisturbed habitat probably remains. It is likely that remaining available habitat has been fragmented and/or degraded by these same processes, as well as vegetative shifts caused by grazing, drought, and global climate change, but we have no information to support or refute this hypothesis.

Intrinsic vulnerability

A variety of biological factors can make animals intrinsically susceptible to disturbance. These factors include narrow distribution, habitat specificity, restrictive territoriality and area requirements, susceptibility to disease, lower dispersal capability, high site fidelity, and low reproductive capacity. After reviewing available information (summarized below), Keinath et al. (2003) considered the intrinsic vulnerability of Wyoming pocket gophers to be moderate. This was due to their highly limited distribution, their limited dispersal ability, and the uncertainty surrounding many aspects of their biology (e.g., habitat use).

Small mammals with restricted distributions and/or narrow habitat requirements are more vulnerable than others to habitat loss (Hafner 1998). Since the habitat requirements of the Wyoming pocket gopher are so poorly understood, it is not clear how restrictive they are. It appears to be an upland species dependent on habitat that is not uncommon in southern Wyoming (i.e., ridges with gravely, loose soils in sparse shrubland). However, the paucity of information requires extreme caution when interpreting habitat patterns, as they may be responding to subtle factors of soil texture or vegetation that are not apparent based on scant available information. Moreover, their highly restricted distribution and apparently low abundance suggest that this could be the case. Until we learn otherwise, it makes sense to interpret their habitat use conservatively/ Therefore, for purposes of estimating intrinsic vulnerability, we assume that they have some, as yet undefined, habitat requirements that restrict their occurrence and make them potentially vulnerable to disturbance.

Given their fossorial existence, and the fact that dispersal capabilities of other species of pocket gophers are rather limited (Vaughan 1963), we can assume that the Wyoming pocket gopher is similarly restricted. Because of this limit, it may be relatively easy to fragment suitable habitat, as relatively small habitat disturbances could be a movement barrier.

Very little information exists to make further determinations of vulnerability for Wyoming pocket gophers. If we consider them similar to northern pocket gophers, other biological factors do not seem to predispose them to harm from disturbance. In general, pocket gophers can persist in fairly small areas (Banfield 1915, Ingles 1952, Howard and Childs 1959), so it is not likely that area requirements are a major limiting factor. Neither does the literature suggest that disease is a major factor in pocket gopher persistence, although research is sparse. The northern pocket gopher shows somewhat lower fecundity than other small mammals, but in the absence of major neonatal mortality, it does not appear restrictive. For example, the northern pocket gopher is able to reproduce one calendar year after birth, has a gestation of only 19 to 20 days, and has a relatively long breeding season (March to June), but it generally produces only one litter of four to seven young per year (Moore and Reid 1951, Verts and Carraway 1999).

Anthropogenic impacts

Several studies have demonstrated that livestock grazing reduced the abundance of pocket gophers (e.g., Hansen 1965, Turner et al. 1973, Hunter 1991, Stromberg and Griffen 1996) while some studies suggested increased gopher abundance with grazing (Phillips 1936, Richens 1965b) until grazing became heavy, whereupon gophers virtually disappeared (Phillips 1936). Consequently, there is no conclusive answer as to how cattle grazing affects pocket gopher populations, but the weight of evidence suggests that heavy grazing pressure is likely to reduce the prevalence of pocket gophers. However, when making this statement one should consider that none of these studies was conducted in or near the range of the Wyoming pocket gopher. Thus, although it is likely that cattle grazing could negatively affect populations, ultimate relevance is speculative. Also, the causative mechanism for negative impacts is unclear. Authors have suggested different hypothetical causes, but none have formally been studied. Stromberg and Griffen (1996) suggested that negative impacts of grazing on gopher populations occurred because cattle reduced the shallow-rooted biomass that was available to gophers, presumably through removal of the aboveground portions of those plants. This idea was supported by data from Hunter (1991), who found significantly lower vegetative cover on grazed plots (with few gophers) than ungrazed plots (with more gophers). Phillips (1936) suggested that light grazing by domestic livestock actually increased forb diversity on rangeland, which resulted in more gopher activity, but that gophers virtually disappeared in overgrazed pastures due to the increasing "imperviousness" of soils. This is clearly an area in need of further research.

Northern pocket gophers are greatly affected by agricultural development and associated pest control practices, wherein native vegetation is converted to agricultural fields and subsequent efforts (e.g., poisoning, trapping) are aimed at eliminating pocket gophers from fields (e.g., Tietjen 1973). It is not only application of pesticides targeted at gophers that can have a negative impact, but herbicides used to control weeds have been shown to impact populations of northern pocket gophers through their effect on the species' natural food sources (e.g., Miller 1964, Tietjen et al. 1967, Reid 1973). Hansen and Ward (1966) found that litter size was smaller for gophers inhabiting rangeland sprayed with 2,4-D herbicide than untreated rangeland, and Tietjen et al. (1967) showed decreased body mass in gophers that were forced to increase the proportion of grass in their diets due to a herbicide-caused reduction in forb cover. However, such impacts are unlikely on the dry and gravelly uplands of southern Wyoming, where public land predominates and broadcast herbicide application is assumed to be minimal.

A more likely threat is soil disturbance and compaction due to increased petroleum exploration and extraction. In this context, increased road density that accompanies petroleum development may be more of a threat than the construction of well pads and pipelines, since it would fragment habitat, which could impede population persistence (see the section on Population demographics). Fragmentation due to road construction has been cited as a factor in a petition to list a subspecies of northern pocket gopher (*Thomomys talpoides macrotis*), as threatened under the Endangered Species Act (CNE et al. 2003). Authors of the petition claim road construction from municipal development reduces dispersal corridors, creates barriers to finding mates, and increases exposure to edge effects, thereby separating populations and leading to inbreeding and loss of gene flow within individual populations. Given the already noted propensity of pocket gopher populations to become isolated and inbred, this is not an unreasonable scenario and could become a concern if road construction increases within populations of Wyoming pocket gophers.

Invasion of noxious weeds (.e.g., cheatgrass [*Bromus tectorum*]) is generally enhanced by human disturbance of native landscapes (e.g., overgrazing, road construction, recreation, land development), and such vegetative conversion has been shown to limit populations of other burrowing herbivores (e.g., Slobodchikoff et al. 1988, Knapp 1996). Studies have not explicitly investigated effects on pocket gophers, but it is likely that non-native vegetation could alter or restrict their populations, particularly if the invasive species are not palatable to gophers. The authors do not see this situation as likely to be a current threat to Wyoming pocket gophers, but there is no information to support this hypothesis and it is therefore something to keep in mind as the status and ecological relationships of this species are clarified.

Stochastic events

Wyoming pocket gophers have a very small global range, and random events, such as environmental catastrophes, are a particular threat to geographically restricted populations. Three categories of stochastic events have been noted in the literature, environmental, demographic, and genetic; these can act synergistically on small populations to cause potentially dramatic declines (e.g., Brussard and Gilpin 1989, Miller et al. 1996, Vucetich and Waite 1998).

1. Environmental stochasticity refers to random events influencing all individuals in a given population, such as weather events, fires, disease outbreaks, or unusual predation events. Environmental events can have a substantial impact on even relatively large populations, but small or geographically restricted populations are in far more danger of becoming extinct from such events.

2. Demographic stochasticity represents events influencing individual birth and death rates, such as random variability in the sex ratio of offspring. Demographic events are generally not important in large populations, but they can be significant in extremely small populations where one individual represents a substantial proportion of the population.

3. Genetic stochasticity refers to variability in random recombination in the gene pool of a particular species and is generally not a problem in normal, heterozygotic populations. However, in very small and/or isolated populations, it can result in loss of fitness due to inbreeding depression and the resultant expression of deleterious alleles (e.g., Lacy 1997).

Of these three types of stochasticity, only environmental events are likely to be of current import to Wyoming pocket gopher populations. In the event that populations decrease to the verge of extinction, demographic and genetic stochasticity could become major concerns. Howard and Childs (1959) ascribed weather and its influence on food and cover as a dominant factor in determining annual populations of pocket gophers. Although extreme climatic events can affect pocket gopher populations, their overall effects are not well understood. Vaughan (1967) observed that pocket gophers are more abundant in years of normal or above-normal moisture and lower in years of below-normal precipitation, suggesting a potentially negative impact from prolonged drought. This effect can be extended to include impacts from global climate change if it results in a general desiccation of habitat within the range of the Wyoming pocket gopher. Runoff from melting snow and high groundwater tables can force temporary redistribution of pocket gophers (Reid 1973). Harsh winters and late spring/ early fall freezes can also affect pocket gopher populations (Reid 1973), probably mostly by increasing juvenile mortality.

Management of the Wyoming Pocket Gopher in Region 2

As discussed in the Distribution and Abundance section of this assessment, the Wyoming pocket gopher is not currently known to occur on USFS lands. However, since its distribution is predicted to be proximate to some units of Region 2 (**Figure 4**), it is possible that this is an artifact of limited sampling effort and that this species could occur on peripheral portions of some forests. Thus, much of the management direction noted in subsequent sections does not have immediate implication for the USFS unless the first element noted below (i.e., Range-wide Inventory) uncovers populations of Wyoming pocket gophers that fall under USFS jurisdiction.

Conservation elements

Given the virtual absence of information on the Wyoming pocket gopher's life history and status, primary conservation elements are filling in these data gaps. Until information is in hand, it is difficult and speculative to develop a complete list of conservation elements. Thus, the first two elements listed below should be considered of highest priority, and their results should inform a re-evaluation of the remainder, which are tentative in nature.

1. Range-wide Inventory: Basic field inventories are most needed to elucidate the distributional limits, habitat preferences, and population status of the Wyoming pocket gopher. As discussed above, pocket gopher surveys conducted broadly across southern Wyoming will be the most efficient way to inform management of this species as well other forms in the region. In addition, surveys should be extended into northern Colorado, especially near the Upper Laramie River watershed and points west, to determine if the Wyoming pocket gopher occurs there.

2. Determination of Habitat Requirements: Following basic surveys, studies are necessary to determine what constitutes high-quality habitat for the Wyoming pocket gopher (i.e., habitat capable of supporting viable, long-term populations). This should include evaluation not only of the specific habitat components promoting occupation by the species (e.g., vegetation, soil structure), but also of what constitutes a landscape mosaic capable of supporting gophers in the face of future disturbances (e.g., connectivity of local populations). Further, as part of this habitat evaluation, the responses of Wyoming pocket gophers to soil and vegetation disturbing actions (e.g., road and pipeline construction, grazing) should be investigated so that wise multiple-use decisions can be made.

3. Habitat Preservation: Once the current distribution and habitat use of this species is clarified, managers need to evaluate the potential threats to those areas and mitigate those threats to insure the continued viability of populations. Conservation priority should be placed on areas with relatively high abundances of Wyoming pocket gophers and offering contiguous (i.e., non-fragmented) suitable habitat. The quantitative extent of such decisions depends entirely upon the results of elements 1 and 2 above.

4. Population Monitoring: Once a good estimate of distribution, abundance, and habitat use is obtained (elements 1 and 2), a monitoring program can be developed to track changes in populations relative to other land-use practices. This is critical to the management of the species because without it managers will not know the status of Wyoming pocket gophers, much less understand how that status is changing over time.

Tools and practices

Inventory and monitoring

There are generally two methods used to inventory pocket gophers. One involves counting "visible sign" of pocket gophers (i.e., mounds and diggings) and using abundance of such sign to index abundance of the animals themselves. This method applies mainly where populations are small, where burrow systems are sufficiently separated to be recognized as belonging to individual pocket gophers, and where species identification is known or unimportant (Reid 1973). Thus, this method would only work in areas where one is certain that all gopher mounds are caused by Wyoming pocket gophers and not northern pocket gophers. For areas with much gopher activity, it is often best to use only fresh mounds, which can be done by conducting an initial pass through an area and raking down all mounds and then conducting surveys in subsequent days wherein only freshly excavated mounds are recorded (J. Patton personal communication 2006). In addition, mound counts are less accurate during the breeding season because individual burrow systems are not discrete during this time (i.e., territoriality is less, young are still in their natal burrow, and/or young are dispersing). Finally, a correlation between number of mounds and number of gophers has never been estimated for this species, so accurate populations estimates necessitate such a study be conducted prior to interpretation of mound counts.

The second method of inventorying pocket gophers is to directly trap them using various live and/or kill traps (see Proulx 1997 for a discussion of various traps). This is the most accurate method for estimating abundance and yields specimens that can be analyzed in detail and classified to species, but it requires considerable time and effort (Reid 1973).

Trapping should be routinely used in environmental assessments to determine Wyoming pocket gopher distribution. Ideally, pocket gophers would be trapped in as many environments and settings as possible across southern Wyoming, with detailed habitat data collected at trapping sites. This will be the best way to confirm habitat preferences of Wyoming pocket gophers, and to increase understanding of the factors that separate them from northern pocket gophers and Idaho pocket gophers. From a conservation standpoint, live trapping (e.g., Howard 1952, Proulx 1997) is preferable to kill trapping, particularly for small populations, because specimens can be returned to the population. However, the only method currently available for positive identification of Wyoming pocket gophers is karyotype analysis (see the above section on Identification), which requires the animal to be killed. Thus, until other methods of identification become available, a limited amount of kill-trapping should accompany live-trapping efforts to insure that gophers being sampled are indeed Wyoming pocket gophers. Since gophers are considered a pest in many areas, a variety of reasonably cheap and effective kill traps are available (e.g., the Macabee Gopher Trap from the Macabee Gopher Trap Company of Los Gatos, California or the Victor Easy-Set Trap from Victor Professional Products of Lititz, Pennsylvania).

There is disagreement on the best time to conduct surveys. Reid (1973) suggests that trapping sessions be conducted in the early fall, after the young of the year have been born but before they have dispersed, thus maximizing the local population numbers. Other researchers suggest conducting surveys shortly after snow melt during the spring "green-up" because gophers are much more active (i.e., soil is moist and they are reconstructing burrows and finding mates) during this period than later in the summer and fall when breeding is complete and soils become dry and less friable (J. Patton personal communication 2006). Speaking from personal experience, the landscape where Wyoming pocket gophers occur is rugged and difficult to traverse in spring due to poor road conditions and inconsistent snowpack, making extensive spring sampling problematic. The authors currently believe that it is more important that the timing of surveys be spatially and temporally consistent when comparing sites or making trend estimates; one should not compare abundance recorded in the spring with that recorded in the fall.

Only after inventory is virtually complete and we have a basic understanding of the species' biology can a monitoring program be fully developed. Conceptualization and implementation of monitoring plans can be found in numerous synthesis documents (e.g., Davis 1997, Thompson et al. 1998, Noon et al. 1999, National Park Service Inventory and Monitoring 2000, Kirk 2004, Thompson 2004, USGS Patuxent Wildlife Research Station 2006). Primary considerations include the following (specific suggestions for which can be found in the above documents):

- ❖ clearly defining the scope and goals of the monitoring program
- ❖ allotting funds and institutional infrastructure for conducting a valid monitoring program
- ❖ assessing the extent of survey possible with existing funds and expertise
- ❖ identifying and prioritizing key areas to monitor
- ❖ ensuring that survey effort (i.e., sample size) is large enough to observe population trends
- ❖ ensuring that survey methods are applied consistently and regularly across sites
- ❖ providing mechanisms by which ongoing results of a monitoring program can change management action (and insuring the institutional support necessary for enforcing these mechanisms).

Preserving habitat

Given the incredible lack of knowledge regarding the Wyoming pocket gopher, it is very difficult to suggest how habitat should best be conserved; we do not even have a good understanding of what suitable habitat is. In the absence of specific habitat information, one can identify (through inventory) where gophers currently occur and minimize disturbance to those areas, for example by doing the following:

1. Given their fossorial nature, we can be relatively confident that disturbance to upland soils, particularly compaction of such soils, in areas of known occupation will be detrimental to gophers and should be avoided. Activities potentially compacting soils, including but not limited to road construction, extractive industries, and cattle grazing, should thus be

limited, and their impacts should be closely monitored in areas deemed otherwise suitable for Wyoming pocket gophers.

2. Given their low dispersal ability and propensity for inbreeding, an effort should be made not to further fragment existing populations; for instance, by avoiding placement of roads (especially paved, graded, or high-traffic roads) that would bisect known areas of occupation.

3. Given their likely dependence on native forbs, it would be beneficial to control activities that alter the vegetation structure at known areas of occupation. In this regard, consideration should be given to grazing regimes and stocking levels as well as development (e.g., petroleum exploration or extraction) that could lead to either a reduction in forb cover and/or introduction or expansion of invasive weeds.

4. If populations of Wyoming pocket gophers are found to be small, consideration should be given to minimizing human-facilitated predation. For example, man-made perches promoting breeding and foraging of raptors (e.g., power lines, storage tanks, fence poles) could artificially increase predation pressure on pocket gophers. Similarly, increased human presence and the associated generation of refuse could attract generalist predators (e.g., raccoons, feral cats and dogs) that have the potential to negatively affect pocket gophers. Under this situation, managers should attempt to eliminate such pressure in areas of known Wyoming pocket gopher occurrence.

5. Given that the distribution of the Wyoming pocket gopher is completely encompassed by that of the northern pocket gopher (**Figure 3**), the potential exists for competitive exclusion from suitable habitat by one of these species. If inventory, monitoring, and habitat investigations suggest that the Wyoming pocket gopher is in danger of extinction, and encroachment by northern pocket gophers is identified as a factor either endangering their persistence or limiting their recovery, then the conservation of the Wyoming species may require restricting the northern species. Since this is purely hypothetical and there are many potential technical hurdles associated with restricting one species of pocket gopher from an area while promoting another, this course of action should not be considered unless studies suggest a clear and pressing need.

Beyond preserving areas were gophers are currently found, consideration should be given to conserving a landscape that promotes future persistence of current populations and provides for dispersal and/or establishment of new populations. Relatively small areas (ca. 1 ha) are probably adequate (although marginal) for supporting small, local populations. However, the limited dispersal capabilities of gophers suggest that such populations could suffer from over-utilization of local resources, reduction in fitness from inbreeding, and relatively small and seemingly minor disturbances could lead to their complete extirpation. In this context, and without further information, long-term viability may be best served by minimizing the above-noted disturbances across large and inter-connected upland forms (i.e., large ridges, mesas, and plateaus that are not dissected by permanent streams). This would allow populations of Wyoming pocket gophers to establish something approaching a meta-population that would be more robust in the face of individual disturbance events. Unfortunately, the optimal extent and form of such a landscape cannot be recommended without further knowledge of the species' biology, as noted under the Conservation Elements and Biology and Ecology sections of this assessment.

Information Needs

Given the extreme lack of information regarding Wyoming pocket gophers, resolving key information needs is an integral part of the conservation and management of the species and has been explicitly addressed in previous sections, notably Conservation elements and specific topics under Biology and Ecology. Please refer to those sections for elaboration.

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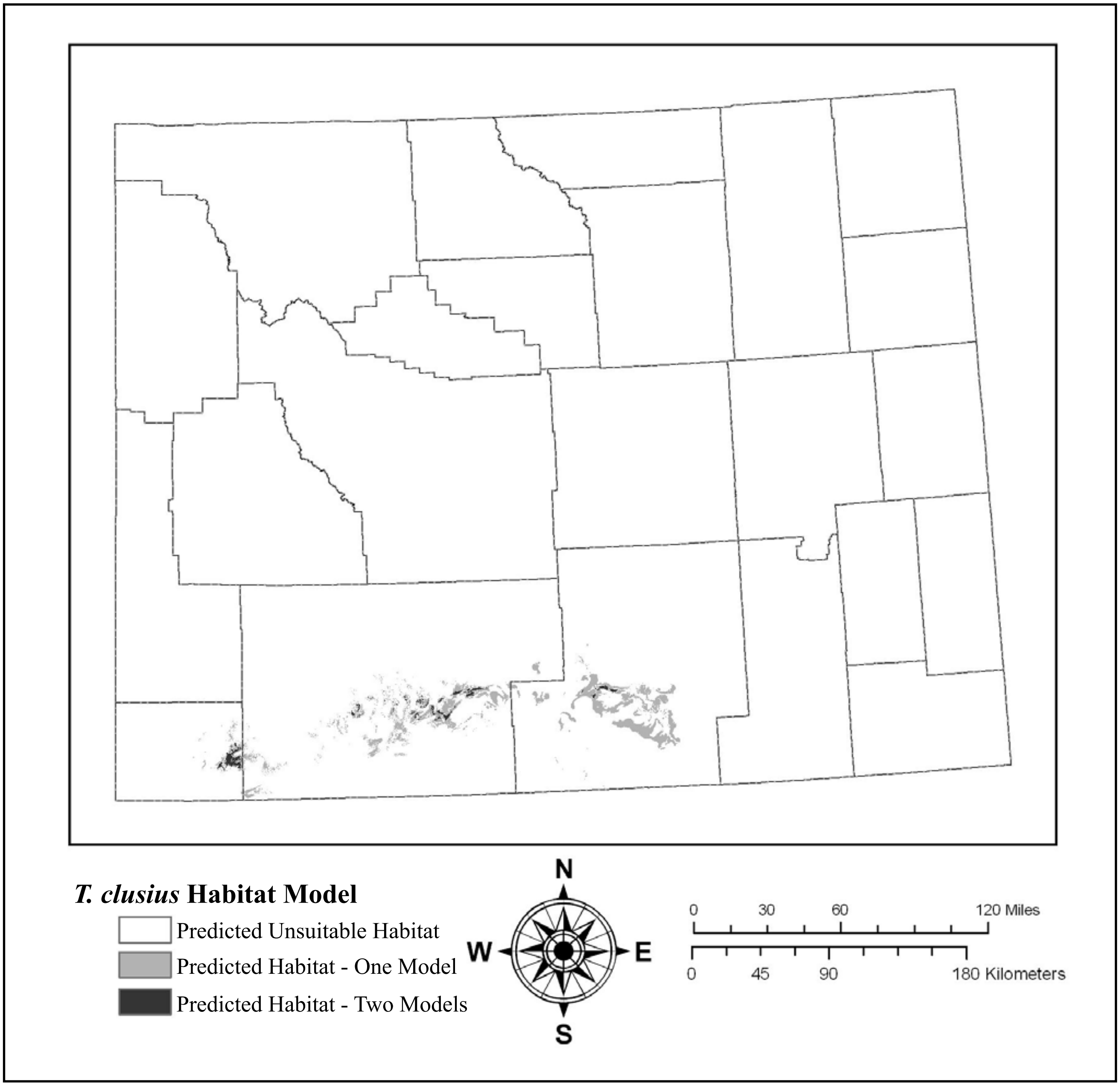
Appendix

Predictive Distribution Model for Wyoming Pocket Gopher

Doug Keinath and Rob Thurston, Wyoming Natural Diversity Database
University of Wyoming, Laramie, Wyoming

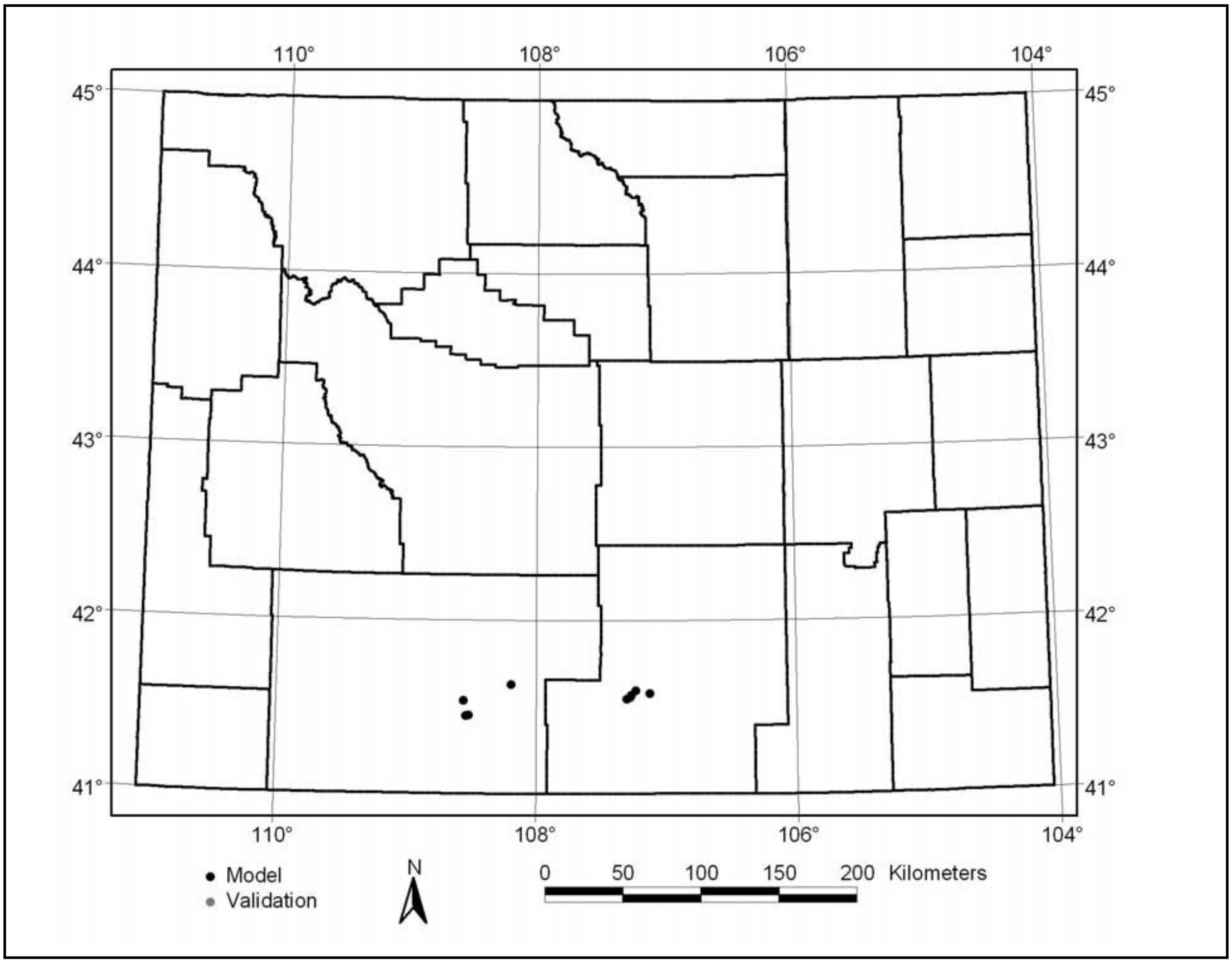


Summary and Interpretation

This predictive distribution model for Wyoming pocket gopher (*Thomomys clusius*) was created by overlaying two models derived from separate statistical approaches; classification and regression trees (CART) and the DOMAIN environmental similarity method. The areas where these models converge should be considered the area of most likely occurrence or absence. Those areas predicted as positive by only one model might be considered possible, but less likely, areas of potential distribution if they are geographically proximate to areas of positive model convergence. Details of the inputs and outputs of each model are presented in the following pages.

Insufficient occurrence points were available to validate the models using an independent dataset. Validation using the modeling points can be used to estimate model quality (as done below), but these results should be interpreted with caution because they tend to provide an inflated estimate of model quality. Moreover, given the very small sample size on which models were based (only 9 points of known occurrence met the criteria of the modeling routines), the output should be viewed as an hypothesis of *Thomomys clusius* distribution pending further field investigation.

Known Distribution in Wyoming



Modeling Notes

Filter criteria for occurrence data
- Identified: Y
- Precision: M or S
- Year: 1960 or after
- Season: None
- Minimum point to point distance: 1600 m

Numbers of points after filtering

	Model	Validation	Total
Known Positive	9	0	9
Known Negative	15	6	21
Pseudo Negative	858	290	1148
Total	882	296	1178

The similarity grid was created using the DOMAIN algorithm and the data layers, training points, and program options specified below.

Data layers: elev, slope, t9, tfa, p1, p9, domsys16, sand, clay

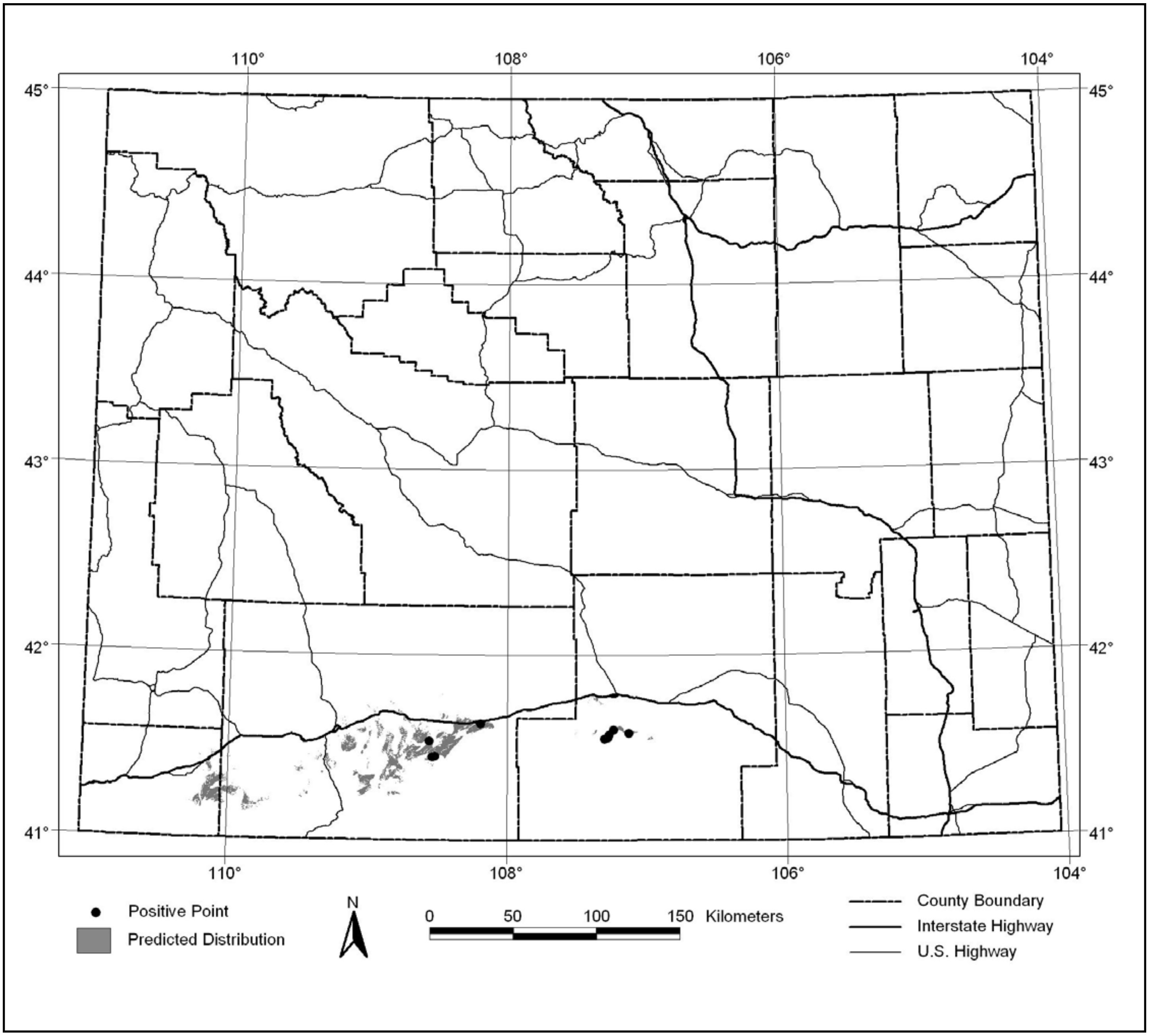
Training points: 9 positive model points

DOMAIN options
- Use Points: Yes
- Use Transects: No
- Complete Categorical Dissimilarity: No
- Average closest [2] points: Yes
- Compute Distance: No
- Compute Similarity: Yes

Binary model grid (1/0 = predicted positive/ negative)
- Similarity threshold: 9122
- Positive model points included by threshold: 90%

Since there were no positive validation points, receiver operating characteristic (ROC) analysis could not be applied to the confusion matrix generated from the validation data set to select an optimal threshold. In this situation, the threshold was set to include 90% of the positive model points.

Predicted Distribution in Wyoming



Classification Rates

Model Points

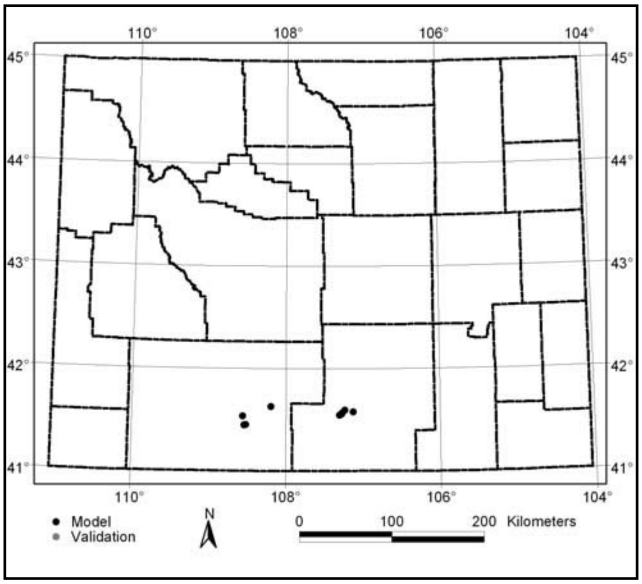
	Predicted Positive	Predicted Negative		
Known Positive	8 / 9 88.9%	1 / 9 11.1%	Total Correct	875 / 882 99.2%
Known and Pseudo Negative	6 / 873 0.7%	867 / 873 99.3%	Total Incorrect	7 / 882 0.8%

Validation Points

	Predicted Positive	Predicted Negative		
Known Positive	0 / 0	0 / 0	Total Correct	296 / 296 100.0%
Known and Pseudo Negative	0 / 296 0.0%	296 / 296 100.0%	Total Incorrect	0 / 296 0.0%

Area of Predicted Distribution: 1,102 km^2 (0.44% of WY)

Known Distribution in Wyoming



Classification Tree Used in Model Building

Modeling Notes

Filter criteria for occurrence data
- Identified: Y
- Precision: M or S
- Year: 1960 or after
- Season: None
- Minimum point to point distance: 1600 m

Numbers of points after filtering

	Model	Validation	Total
Known Positive	9	0	9
Known Negative	15	6	21
Pseudo Negative	858	290	1148
Total	882	296	1178

Tree model parameters
- Independent variables: ELEV, SLOPE, ASPECTNS, RELIEF16, T9, TFA, TFS, P1, P9, R2, R4, H3, CONTAG16, DOMSYS16, SAND, CLAY, ROCKDEP
- Minimum number of observations before split: 1
- Minimum node size: 2
- Minimum node deviance: 0.01
- Minimum percent for pruning: 0.0

Since there were no positive validation points, the optimal model was determined by applying receiver operating characteristic (ROC) analysis to the confusion matrix generated from the model data set. This method plots model sensitivity (true positive rate) against the commission error rate (false positive rate) and selects an optimal model by explicitly accounting for the prevalence of positive points (p = 0.010) and relative cost of false positive versus false negative errors (FPC/FNC = 0.20).

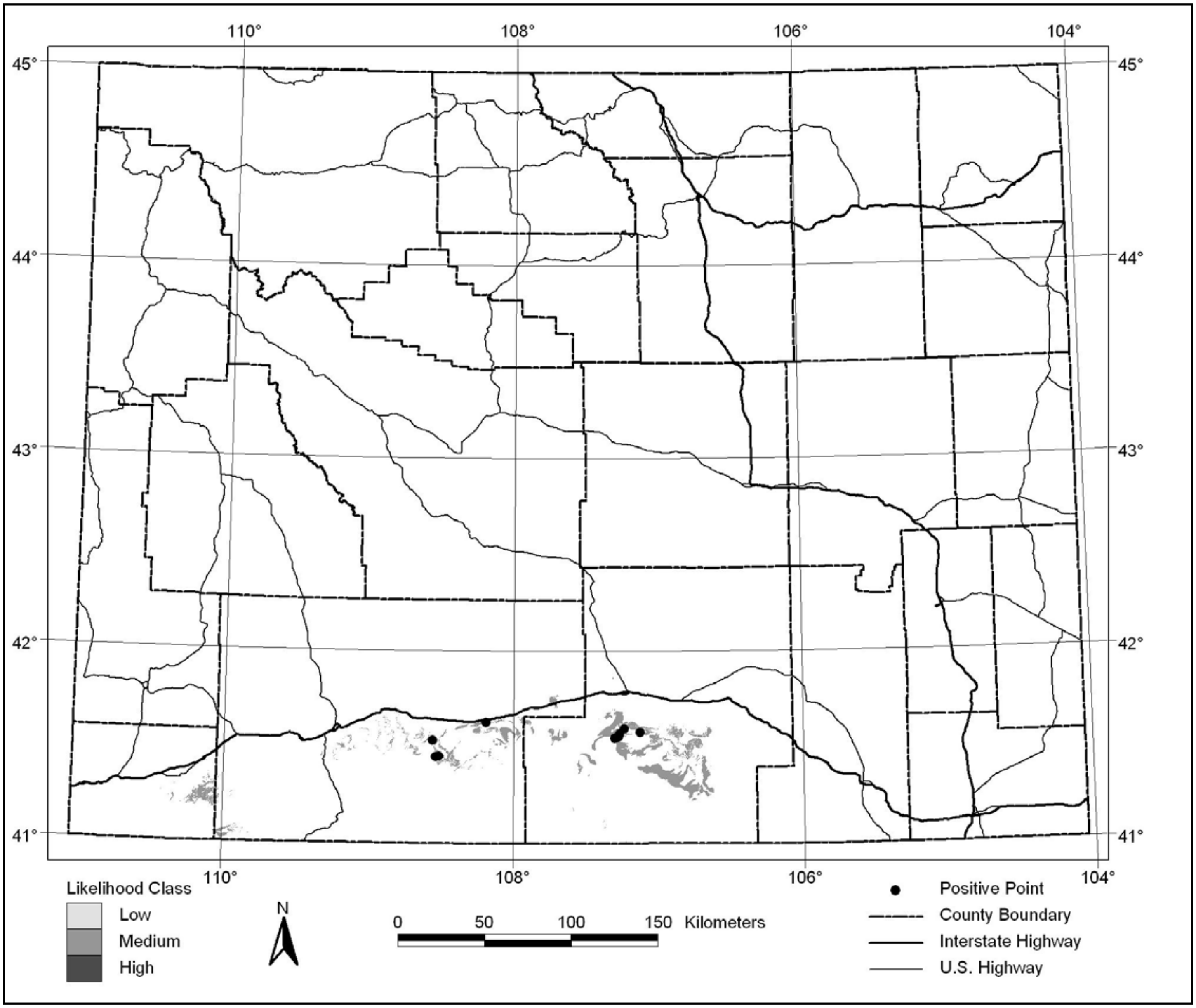
Classification Tree Output

Node_Num) Node_Def Node_Size (Num_No,Num_Yes) (Pct_No,Pct_Yes) Node_Type
1) root 882 (873,9) (100,100) Yes
2) R2<2653.5 665 (665,0) (76.2,0) No*
3) R2>2653.5 217 (208,9) (23.8,100) Yes
6) TFA<2169.5 97 (88,9) (10.1,100) Yes
12) P9<338.5 50 (41,9) (4.7,100) Yes
24) TFS<96.5 20 (20,0) (2.3,0) No*
25) TFS>96.5 30 (21,9) (2.4,100) Yes
50) CONTAG16<9896 21 (12,9) (1.4,100) Yes
100) ELEV<2162.5 17 (12,5) (1.4,55.6) Yes
200) P9<311.5 9 (9,0) (1,0) No*
201) P9>311.5 8 (3,5) (0.3,55.6) Yes
402) ELEV<2060 2 (2,0) (0.2,0) No*
403) ELEV>2060 6 (1,5) (0.1,55.6) Yes
806) SLOPE<385 5 (0,5) (0,55.6) Yes*
807) SLOPE>385 1 (1,0) (0.1,0) No*
101) ELEV>2162.5 4 (0,4) (0,44.4) Yes*
51) CONTAG16>9896 9 (9,0) (1,0) No*
13) P9>338.5 47 (47,0) (5.4,0) No*
7) TFA>2169.5 120 (120,0) (13.7,0) No*

Path Composition and Likelihood

Yes Path	Node List	% of Positive Points	Likelihood Class
a	806, 403, 201, 100, 50, 25, 12, 6, 3	55.6	Medium
b	101, 50, 25, 12, 6, 3	44.4	Medium

Predicted Distribution in Wyoming



Classification Rates

Model Points

	Predicted Positive	Predicted Negative		
Known Positive	9 / 9 100.0%	0 / 9 0.0%	Total Correct	882 / 882 100.0%
Known and Pseudo Negative	0 / 873 0.0%	873 / 873 100.0%	Total Incorrect	0 / 882 0.0%

Validation Points

	Predicted Positive	Predicted Negative		
Known Positive	0 / 0	0 / 0	Total Correct	293 / 296 99.0%
Known and Pseudo Negative	3 / 296 1.0%	293 / 296 99.0%	Total Incorrect	3 / 296 1.0%

Area of Predicted Distribution: 1,330 km^2 (0.53% of WY)

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