Colorado Gunnison's and White-tailed Prairie Dog Conservation Strategy

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COLORADO GUNNISON'S AND WHITE-TAILED PRAIRIE DOG CONSERVATION STRATEGY

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For Wildlife-
For People

It is with pleasure that I sign the *Colorado Gunnison's and White-tailed Prairie Dog Conservation Strategy*. This strategy document forms the basis of future management decisions for these two species in Colorado through a public process that selects the top-priority actions for the nine Individual Population Areas (IPAs) described therein.

The Western Association of Fish and Wildlife Agencies has coordinated prairie dog conservation activities throughout the western United States, and this strategy is an outgrowth of that effort. The actions described in this strategy and the associated IPA Action Plans are aimed at providing for the continued existence of these two prairie dog species, thereby offsetting the need for either species to be listed under the federal Endangered Species Act.

Through the involvement of local and statewide stakeholders in the development of this strategy, the social and economic needs of Colorado's citizens have been incorporated. A workshop that included landowners, conservation organization members, scientists, and agency personnel was held in May of 2007 to formulate specific strategies. Continued involvement of these stakeholders has produced an approach that explicitly considers the needs of all concerned parties in developing local IPA plans for prairie dog conservation.

I hereby approve the *Colorado Gunnison's and White-Tailed Prairie Dog Conservation Strategy*.

SIGNED: Thomas E. Remington

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DATE: 7/9/10

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEGEMENTS

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I. EXECUTIVE SUMMARY

Concern about Gunnison's and white-tailed prairie dog populations, range-wide and in Colorado, stem from apparent declines in distribution caused by multiple factors, but most notably plague. Other factors affecting Gunnison's and white-tailed prairie dogs include agricultural conversion, energy and mineral development, poisoning, rangeland condition, recreational shooting, and urban development. Due to these declines and the immediacy and magnitude of factors negatively impacting the 2 species, both the Gunnison's and the white-tailed prairie dog were petitioned for listing under the federal Endangered Species Act in 2004 and 2002, respectively. Currently, the Gunnison's prairie dog is considered a Candidate species for listing in the "montane" portion of its range in Colorado and north-central New Mexico. The U.S. Fish and Wildlife Service found that white-tailed prairie dog listing was not warranted in a status review published on 1 June 2010.

The purpose of the *Colorado Gunnison's and White-tailed Prairie Dog Conservation Strategy* (or "*Colorado Conservation Strategy*" hereafter) is to propose a comprehensive list of conservation strategies that will be used by the Colorado Division of Wildlife to guide conservation efforts for both the Gunnison's and white-tailed prairie dogs at the state and local level. With appropriate management of these two species, it is anticipated that viable populations will be maintained throughout the state and that listing of the species under the federal Endangered Species Act will not be needed. Another goal of the strategy is to maintain healthy prairie dog-dependent ecosystems so that those other wildlife species commonly associated with prairie dogs are also protected. The *Colorado Conservation Strategy* described here is part of a range-wide effort identified in the Western Association of Fish and Wildlife Agencies Memorandum of Understanding for "Conservation and Management of Species of Conservation Concern Associated with Prairie Ecosystems."

This *Colorado Conservation Strategy* provides information on the biology and natural history of both species, an assessment of their historic and current status in Colorado, an issues analysis using the 5 listing criteria used by the U.S. Fish and Wildlife Service to determine whether a species should be protected under the Endangered Species Act, and a menu of conservation strategies to address each identified issue. To aid in evaluating impacts to prairie dog populations, a Population Viability Analysis and a Geographic Information System analysis were completed and are presented in the document. During development of this document, "Individual Population Areas" were defined to facilitate management of populations of prairie dogs that are physically separated from each other; and/or may face unique sets of management issues.

The Colorado Division of Wildlife recognizes stakeholder participation as critical in the development and successful implementation of this strategy because the majority of Gunnison's and white-tailed prairie dog populations reside on private lands and/or on lands managed by other state and federal agencies. Therefore, specific strategies outlined in the document were discussed and developed at a stakeholders' workshop in May 2007. Stakeholders at the workshop included agency personnel, prairie dog experts, private landowners, environmental organization representatives, concerned citizens, state, county, and city government representatives, recreational shooters, and energy company representatives.

Implementation of this *Colorado Conservation Strategy* will occur through 3- to 5-year action plans developed by local stakeholders within each Individual Population Area. These action plans will be developed through collaborative "rapid assessment" workshops that review issues and available strategies from the *Colorado Conservation Strategy* document and set priorities for immediate implementation. In addition to these local action plans, the Colorado Division of Wildlife will continue to manage Gunnison's and white-tailed prairie dogs at the state-wide level by conducting occupancy surveys to monitor long-term population trends, maintaining a seasonal shooting closure on public lands, continuing research on plague control and prairie dog genetics, and coordinating with other states and agencies to implement effective plague management protocols.

II. INTRODUCTION

A. Purpose

The purpose of the *Colorado Gunnison's and White-tailed Prairie Dog Conservation Strategy* ("*Colorado Conservation Strategy*" hereafter) is to propose conservation strategies that will be used to guide local action plan development for both species within their respective ranges in Colorado. Local action plans will be developed by the Colorado Division of Wildlife (CDOW) with the assistance of interested stakeholders, conservationists, private landowners, and other agency personnel. The implementation of local action plans will be tailored to address issues ranked as having high negative impacts on Gunnison's prairie dog (GUPD) and white-tailed prairie dog (WTPD) populations. Prioritized strategies will be implemented using cooperative efforts to alleviate negative impacts to help ensure long-term viability statewide, negating the need for protection under the federal Endangered Species Act (ESA).

B. Organization of the *Colorado Conservation Strategy* Document

The writing style used for the *Colorado Conservation Strategy* document generally follows that of the *Journal of Wildlife Management*, although English rather than metric measurements are used throughout. A LITERATURE CITED section and a GLOSSARY of terms used in the *Colorado Conservation Strategy* are included. The LITERATURE CITED contains references cited throughout the entire *Colorado Conservation Strategy* text, except that APPENDICES E, G, and H each have their own dedicated literature cited sections. Scientific names of organisms are not provided in the text if a common name exists; instead, all scientific names are listed in APPENDIX C (arranged alphabetically by common name). Acronyms are defined on their first use in the text, but a complete list of acronyms also is provided in APPENDIX D. Lists of figures and tables immediately follow the TABLE OF CONTENTS.

Four sections of text represent the foundation of the *Colorado Conservation Strategy* document. The CONSERVATION ASSESSMENT describes (1) current knowledge regarding GUPD and WTPD biology, distribution, abundance, and habitat; and (2) current status of Colorado GUPD and WTPD populations. The ANALYSIS summarizes the methods and findings of the population viability analysis (PVA) and Geographic Information System (GIS) mapping analyses used to assess the issues affecting prairie dogs. ISSUES & CONSERVATION STRATEGIES reviews the issues potentially impacting prairie dogs and their habitats and summarizes scientific and management literature. Immediately following the summary for each issue are conservation strategies designed to address impacts. IMPLEMENTATION PROCESS describes how the CDOW will ensure that conservation strategies identified in this document are translated into appropriate and effective on-the-ground actions to ensure the long-term viability of GUPD and WTPD populations.

C. Background

Range-wide

Five species of prairie dogs inhabit western North America, each with a different federal conservation status. The Mexican prairie dog (MEPD) is federally listed as endangered, and the Utah prairie dog (UTPD) is listed as threatened. The black-tailed prairie dog (BTPD) was placed on the Candidate Species list (species for which listing as threatened or endangered under the ESA is warranted but listing is precluded by other listing priorities) in 1999, but was removed from the list in 2004 (U.S. Fish and Wildlife Service 2004b). A new status review for the BTPD is currently being conducted by the U.S. Fish and Wildlife Service (USFWS).

The most recent petitions for listing prairie dogs under the ESA were for the WTPD in 2002 (Center for Native Ecosystems et al. 2002) and the GUPD in 2004 (Forest Guardians 2004). Following 2 years of review for each petition, the USFWS determined both petitions lacked substantial scientific information to warrant listing and negative 90-day findings were submitted (U.S. Fish and Wildlife Service 2004a, 2006). However, documents obtained under the Freedom of Information Act provided evidence that though USFWS biologists had originally recommended positive 90-day findings for both species, Julie MacDonald, the former Deputy Assistant Secretary for Fish and Wildlife and Parks at the United States Department of the Interior (USDI), ordered both findings be changed from positive to negative (Union of Concerned Scientists 2009). The USFWS has acknowledged this illegal interference. The Inspector General concluded that "the integrity of the process [was] potentially jeopardized" by Department of Interior employees in the GUPD decision (U.S. Department of the Interior 2008).

In 2006, a lawsuit was filed to challenge the USFWS's 90-day finding for GUPD with plantiffs citing the tampering with the 90-day finding by Julie McDonald. By court order, the USFWS agreed to complete a 12-month status review for the species by 1 February 2008 (U.S. Fish and Wildlife Service 2008). The 12-month finding issued by the USFWS determined that listing GUPD populations occupying "montane" habitat in Colorado (Gunnison, San Luis Valley, South Park, and Southeast populations; see Fig. 2.) and north-central New Mexico was warranted but precluded under the ESA. GUPD populations in "prairie" habitat (La Plata/Archuleta and Southwest populations; see Fig. 2) in Colorado, as well as those in Arizona, Utah, and New Mexico, did not warrant listing. The "montane" GUPD populations were added to the Candidate Species list and given a listing priority of 3 (listing priorities are from 1-12, with 1 being the highest priority, based on the magnitude of threats, the immediacy of the threats, and the taxonomic uniqueness of the species). The listing priority dictates the relative order in which the GUPD may become listed in relation to other species. Species ranked 1-3 are the first to be addressed. The highest ranking a species can receive is a 2. Only a monotypic genus can receive a priority level 1. Of the issues affecting GUPD populations, plague was considered the most significant.

A similar lawsuit was filed to challenge the 90-day finding for the WTPD. In a court settlement signed in February 2008, the USFWS agreed to conduct a formal status review to determine if the species is warranted for listing as threatened or endangered. As part of the settlement, the USFWS was required to initiate the status review by 1 May 2008 and, on 1 June 2010, published its finding that the WTPD was not warranted for listing.

In response to a petition to list the BTPD under the ESA in 1998, the 11 states located within BTPD range began a multi-state conservation effort by forming the Interstate Black-tailed Prairie Dog Conservation Team (BTPDCT), supported by the Western Association of Fish and Wildlife Agencies (WAFWA; Luce 2003). A multi-state approach was expected to be more effective in providing long-term conservation of this species than individual state planning efforts or federal listing under the ESA. The BTPDCT developed a rangewide Conservation Assessment and Strategy for the BTPD (Van Pelt 1999), which stated that conservation for all prairie dog species was needed. As a result, in March 2002, the BTPDCT was expanded to include GUPD and WTPD management.

In recognizing the need for GUPD and WTPD management, the state agencies in the ranges of these 2 species agreed to coordinate efforts and to form a GUPD and WTPD Working Group (GUWTWG) that would emulate, where possible, methods and expertise developed during the BTPD multi-state conservation effort. The first tasks completed by the GUWTWG were conservation assessments for both the GUPD and WTPD (Seglund et al. 2005, 2006). These multi-state conservation assessments evaluated the range-wide status of the species and identified factors potentially limiting conservation.

The GUPD and WTPD conservation assessments identified significant declines in occupied habitat for both GUPDs and WTPDs in certain population areas. These assessments documented areas that once contained thousands of acres of GUPDs (e.g., South Park, Colorado) but no longer included extensive prairie dog occupation, as well as sites within the WTPD range (e.g., the Little Snake area in northwestern Colorado) that had also seen obvious declines. In areas where changes were less extreme, however, population declines could not be accurately quantified due to (1) a history of incomplete and inconsistent surveys; (2) variable time periods between estimates at specific sites; (3) lack of completed exhaustive mapping surveys; and (4) lack of objective, standardized monitoring techniques to evaluate long-term population trends. In addition, information regarding the status of the prairie dog species was confined mainly to public lands because access restrictions inhibited field surveys on private and tribal lands. Until variation between mapping efforts can be understood and compensated for, mapping provides only a gross approximation of prairie dog occupied acres. These gross approximations are meaningful in areas that have experienced significant declines or increases such as those described above, but in areas where changes have been less extreme mapping occupied acreage cannot provide comparable results.

Although the GUPD and WTPD conservation assessments suggested declines in populations and occupied habitat, the GUWTWG concluded that listing of the GUPD and WTPD under the ESA was not justified. The conclusion was based on: (1) ongoing measures taken by states within the GUPD and WTPD ranges to manage and conserve the species by developing long-term monitoring protocols, instituting public land shooting closures (with the exception of Wyoming), and incorporating prairie dog management into their Comprehensive Wildlife Conservation Strategies (federally-mandated action plans that guide conservation of wildlife and wildlife habitat in each state); (2) the lack of quantifiable data to evaluate the status of the species on tribal and private lands; and (3) ongoing efforts by state and federal agencies to address many of the threats identified within the Conservation Assessments by enacting conservation measures such as rangeland improvements, invasive weed control programs, and plague research and monitoring. In addition, the GUWTWG committed to the development of a range-wide WTPD and GUPD conservation strategy that would provide management and administrative guidelines to assist in the development of state management plans for GUPDs, WTPDs, and associated wildlife species. This range-wide conservation strategy was completed in 2006 (Western Association of Fish and Wildlife Agencies 2006); an addendum, the Gunnison's Prairie Dog Conservation Plan, completed in 2007 (Western Association of Fish and Wildlife Agencies 2007).

Colorado

Colorado is home to 3 prairie dog species: the BTPD, GUPD, and WTPD. Although there are similarities among the species, each is unique in its habitat requirements, sociality, and conservation needs. In response to concerns over the viability of BTPD populations in Colorado, a grassland species conservation plan addressing the management of BTPDs and associated wildlife species was developed by the CDOW in 2003 (Colorado Division of Wildlife 2003a). The grassland species plan was developed using the best available science, stakeholder participation, and voluntary non-regulatory incentives.

As mentioned earlier, range-wide conservation efforts for GUPDs and WTPDs are underway and the *Colorado Conservation Strategy* is part of a rangewide effort identified in the WAFWA Memorandum of Understanding (MOU) for "Conservation and Management of Species of Conservation Concern Associated with Prairie Ecosystems" (APPENDIX A). One objective in the MOU was for each signatory state to develop a state-specific prairie dog management program and/or conservation plan. More specific guidance regarding objectives that states should use in their conservation plans is provided in the range-wide conservation strategy and its addendum (see excerpts APPENDIX B). The *Colorado Conservation Strategy* described here represents a coordinated effort by the CDOW, private landowners, interested stakeholders, non-governmental organizations (NGOs), scientific experts, federal agencies, and the Conservation Breeding Specialists Group of The World Conservation Union's Species Survival Commission (CBSG) to identify viable approaches for conserving and managing important GUPD and WTPD populations and habitats in Colorado.

Apparent declines in GUPD and WTPD populations and distribution in Colorado may be due to multiple factors, including (1) plague; (2) changes in rangeland conditions; (3)

historic poisoning campaigns; (4) agricultural and urban land conversion; (5) recreational shooting; and (6) energy development. There are also conservation concerns about wildlife species associated with GUPDs and WTPDs, such as burrowing owls (state threatened), ferruginous hawks (state species of special concern), black-footed ferrets (BFF; federally and state endangered) and mountain plovers (state species of special concern). Although the focus of the *Colorado Conservation Strategy* is to promote conservation of GUPDs and WTPDs, it is our hope that by appropriately managing the prairie dog ecosystem, we also are addressing the conservation needs of associated wildlife species.

Because many of the issues facing GUPDs and WTPDs conservation are similar, the *Colorado Conservation Strategy* is designed to address the needs of both species. In general, references to "prairie dogs" include information applicable to both species; species-specific information and recommendations are explicitly stated.

D. Goals

The goals of the *Colorado Conservation Strategy* process and document are to:

- Develop and implement conservation and management strategies designed to maintain viable GUPD and WTPD populations range-wide in Colorado to prevent the need to list these species under the ESA.
- Promote conservation not only of GUPDs and WTPDs, but of their habitats and of associated wildlife species.
- Identify and implement research that will help guide appropriate conservation and management measures for GUPD and WTPD populations.
- Increase stakeholder and other agency participation in GUPD and WTPD conservation and management efforts.

E. Management & Legal Authorities

The CDOW, a division of the Colorado Department of Natural Resources, has responsibility for the management and conservation of wildlife resources within the state's borders, including nongame, threatened, and endangered species, as defined and directed by state law (i.e., Colorado Revised Statutes, Title 33, Articles 1 and 2). GUPDs and WTPDs are currently classified as small game species under the Colorado Wildlife Commission Regulation #300 A.2.

Specifically, Title 33 Article 1-101, Legislative Declaration states: "It is the policy of the state of Colorado that wildlife and their environment are to be protected, preserved, enhanced and managed for the use, benefit and enjoyment of the people of this state and its visitors. It is further declared to be the policy of the state that there shall be provided a comprehensive program designed to offer the greatest possible variety of wildlife-related recreational opportunity to the people of this state and its visitors and that, to carry out such program and policy, there shall be a continuous operation of planning, acquisition and development of wildlife habitats and facilities for wildlife-related opportunities" (Colorado Revised Statutes 33-1-101 (1)).

Furthermore, Article 2-102, Legislative Declaration states: "The general assembly finds and declares that it is the policy of this state to manage all nongame wildlife, recognizing the private property rights of individual property owners, for human enjoyment and welfare, for scientific purposes and to ensure their perpetuation as members of ecosystems; that species or subspecies of wildlife indigenous to this state which may be found to be endangered or threatened within the state should be accorded protection in order to maintain and enhance their numbers to the extent possible; that this state should assist in the protection of species or subspecies of wildlife which are deemed to be endangered or threatened elsewhere; and that adequate funding be made available to the CDOW annually by appropriations from the general fund" (Colorado Revised Statutes 33-2-102).

This statutory language directs the CDOW to manage declining species that are at risk of being designated as threatened or endangered in Colorado at either the federal or state level, and to do so in a manner that involves private property owners, local stakeholders and affected communities, both in planning and in implementation. The CDOW's mission with respect to species conservation remains that of managing all wildlife to ensure their continued existence in Colorado's diversity of habitats and to preclude the necessity of protection via federal listing under the ESA. To accomplish this goal most effectively, the CDOW will emphasize multi-species conservation across landscapes, and to promote partnerships with private landowners and land management agencies and other interested stakeholders.

F. Mechanics of *Colorado Conservation Strategy* Development

Process & Public Participation

Background material was prepared to serve as an assessment of the (1) current status of the GUPD and WTPD in Colorado (CONSERVATION ASSESSMENT); and (2) issues facing the 2 species (ISSUES & CONSERVATION STRATEGIES). The range-wide conservation assessments (Seglund et al. 2005, 2006) served as the initial basis for these portions of the *Colorado Conservation Strategy*, which were supplemented with more recent Colorado-specific data and information.

To assist the CDOW in meeting the objectives outlined in the WAFWA conservation strategy and addendum (Appendix B), the CBSG was invited by the CDOW to design and conduct a series of workshops to produce a PVA and draft conservation strategies for GUPDs and WTPDs in Colorado. As a general principle, the CDOW believes that public involvement is essential to the implementation of effective, practical conservation actions. Given the issues at stake, strong stakeholder involvement is crucial to the success of any conservation efforts aimed at the GUPD and WTPD. Using this approach, CDOW believes strategies to protect these species can be promptly implemented while maintaining sustainable local communities and contributing to the long-term conservation of prairie dogs and their habitat.

The CBSG species experts and local stakeholder workshops were organized in the spring of 2007 to bring together the full range of groups that had a strong interest and/or knowledge in either (1) conserving and managing GUPDs and WTPDs and their habitats; or (2) recognizing the socio-economic consequences of implemented conservation strategies. One overarching goal in the workshops was to reach a common understanding of the state of scientific knowledge available and its possible application to the decision-making process for necessary management actions. The workshop process encouraged the development of a shared understanding across wide boundaries of training and expertise. This approach supported building of working agreements and instilling local ownership of problems, the decisions required, and their management during the workshop process. As participants appreciated the complexity of the problems, they took more ownership in the process as well as in the ultimate recommendations made to achieve workable solutions. Public involvement was seen as essential to the success of the management recommendations generated by the workshop.

Data Sources

The best available scientific data and expert input were used to determine species status and factors affecting prairie dog populations, and to identify strategies to reduce risks to populations. Data used included published literature, Environmental Impact Statements (EISs) for energy clearances on BFF habitat, and state and federal documents, papers, and reports generated by management agencies but not commercially published. From the information collected, temporal population changes and gross spatial changes in occupied habitat across the state were examined, current and historic management of prairie dogs within the state was evaluated, and a risk assessment was completed for the species based upon the 5 listing criteria used by the USFWS when evaluating a species' potential for listing under the ESA.

To aid in evaluating impacts to populations and resulting strategies that could be developed to help conservation efforts, a PVA and a GIS threats analysis were completed. The PVA is a tool for investigating current and future risk of GUPD and WTPD population decline or extinction. The need for and consequences of alternative management strategies were modeled to suggest which practices may be the most effective in managing prairie dog population. In addition, the overall range of the 2 species was defined using GIS data layers that included vegetation, slope, and elevation. A threats analysis was completed for urban and energy development to evaluate the percent of overall range potentially impacted by these issues. Ownership patterns for land comprising the statewide range of both species were also evaluated.

G. Local Action Plans

The *Colorado Conservation Strategy* will help guide GUPD and WTPD management in Colorado through the development of local action plans that contain the top-ranked issue(s) and prioritized strategies for implementation with timelines, costs, and responsible parties identified. The appropriate CDOW area biologist will be responsible for coordinating the implementation of strategies defined in the action plan, and will provide annual reports on actions implemented. Evaluation of these annual reports will allow those involved in the local action plan to adaptively manage prairie dogs and modify strategy implementation as needed based on successes and failures of respective efforts.

Occupancy modeling (MacKenzie et al. 2002) will be used as a response variable to evaluate the effect of range-wide management on long-term occupancy rates (Appendix E). Occupancy modeling is an objective and repeatable estimation technique that can be effectively used to evaluate long-term population trends of GUPDs and WTPDs. All states within the range of these 2 species have agreed, in the multi-state conservation plan, to implement an occupancy approach to monitor GUPD and WTPD population trends range-wide. Site-specific monitoring will be implemented to evaluate on-the-ground conservation efforts.

H. Stakeholder Considerations

The CDOW recognizes that stakeholder participation is critical in the implementation of the *Colorado Conservation Strategy* since a large portion of GUPD and WTPD populations exist on private lands and on lands managed by other state and federal agencies. The CDOW realizes that private land owners rely on private as well as federal properties for their livelihood and that at certain times, prairie dog conservation efforts and the need to manage properties may come into conflict. In addition, other agencies have stipulations for prairie dog management that may conflict with ideas and strategies developed in this document. Therefore, the CDOW needs to ensure that the implementation of conservation strategies does not impact the economic wellbeing of stakeholders or interfere with other agency mandates, but it must work with all parties to coordinate on strategy implementation to protect and maintain GUPD and WTPDs across the landscape. It has been shown that greater stakeholder involvement improves local participation and encourages innovative solutions, thus increasing plan effectiveness (Johnson 1999).

Stakeholders must understand the purpose of the *Colorado Conservation Strategy* is not to impose controls and regulations on their agricultural, economic, and recreational activities. The CDOW's only regulatory authority for species conservation is protecting species from pursuit, capture and harvest and to actively promote conservation efforts. The development of the *Colorado Conservation Strategy* is working toward a preventive conservation plan, aimed at avoiding the full implications and requirements of a federal species recovery plan. Our goal in this planning process is to identify voluntary steps we can take now, to avoid top-down regulatory action and land-use restrictions. Only if on-the-ground implementation of the strategies in this plan and associated benefits fail to materialize, or this conservation effort is pre-empted by a federal listing, will strict regulatory actions and controls be considered for either species.

I. Adaptive Management

Natural resource management benefits from an adaptive management approach that evaluates results of implemented strategies and reapplies learned solutions to the problem via an iterative process. Adaptive management generally follows 5 steps: (1) the problem is assessed (see CONSERVATION ASSESSMENT); (2) conservation or management strategies are designed to address the problem (see ISSUES & CONSERVATION STRATEGIES); (3) an action plan is developed to implement prioritized strategies (see IMPLEMENTATION PROCESS); (4) results of implementation are monitored and evaluated; and (5) the action plan is adjusted according to the results. This process can be repeated over several iterations to incrementally improve the effectiveness of ongoing conservation and management programs.

An adaptive management approach generates a better understanding of the system being managed, which leads to improved future decision-making and conservation (Taylor et al. 1997, Wilhere 2002, Williams 2003, Aldridge et al. 2004). It can "generate flexibility in institutions and stakeholders that allows managers to react when conditions change" (Johnson 1999), whether those conditions are biological, social, or both. Because the information required for optimal management of GUPD and the WTPD populations is currently unavailable, employing an adaptive management approach to conservation efforts will be crucial to successfully managing these species.

III. CONSERVATION ASSESSMENT

A. Biology & Life History

Several documents have been written summarizing the biology of both GUPDs and WTPDs. In 2005 and 2006, the WAFWA published conservation assessments for both GUPDs and WTPDs (Seglund et al. 2005, 2006). These documents summarized the ecology and life history of the subject species, in addition to assessing threats and status of each species within their respective ranges. Other written documents summarizing the ecology and life history of these species include petitions received by the USFWS to list them under the ESA (Center for Native Ecosystems et al. 2002, Forest Guardians 2004), the National Wildlife Federation's status review of GUPDs and WTPDs (Knowles 2002), and the U.S. Department of Agriculture's Forest Service (USFS) in the Rocky Mountain Region's WTPD Technical Conservation Assessment (Pauli et al. 2006a). Due to the large volume of work already available, an in-depth assessment of the biology and natural history of the 2 species will not be presented. Instead, a brief overview of the major life history characteristics will be discussed.

Species Description

GUPDs and WTPDs are diurnal, burrowing rodents found in western North America. The WTPD is the larger of the 2 species, with weights ranging from 1.4–3.7 pounds, and body length ranging from 12.4–15.7 inches. WTPDs are distinguished by the presence of a short, white-tipped tail, and distinct facial markings that consist of dark black or brown cheek patches that extend above the eye (Fitzgerald et al. 1994). GUPDs are smaller, weighing between 0.6–3.0 pounds, and measuring 11.8–15.4 inches long. The GUPD is darker overall, and has less striking facial markings than those exhibited by the WTPD (Fitzgerald et al. 1994). The GUPD has a gray-bordered tail tipped with white (Hollister 1916). In both species, males are typically heavier than females.

Taxonomy

The family Scuiridae is a successful and widespread mammalian group comprised of 49 genera and 262 species. Included in this family are tree and ground squirrels, chipmunks, marmots, and prairie dogs. As a group, prairie dogs diverged from ground squirrels about 2–3 million years ago (Clark et al. 1971, Pizzimenti 1975).

There are 5 extant species of prairie dogs, all of which inhabit North America and belong to the genus *Cynomys*. The genus has been divided into two subgenera, based on pelage color and tail length (Clark et al. 1971, Pizzimenti 1975). The GUPD, UTPD, and WTPD comprise the subgenus *Leucocrossuromys*. This group is distinguished by relatively short, white-tipped tails, weaker social organization, and less specialized dentition and morphology than the black-tailed forms (Pizzimenti 1975). Within the subgenus *Leucocrossuromys*, the GUPD is genetically, morphologically, and behaviorally distinct from the other 2 white-tailed species (Pizzimenti 1975). Species in the black-tailed subgenus, *Cynomys*, are the BTPD and MEPD. They have characteristic long, black-tipped tails, and are more specialized morphologically, behaviorally, and ecologically than members of the *Leucocrossuromys* subgenus (Pizzimenti 1975).

The *Cynomys* subgenus shows the greatest divergence from ancestral ground squirrel stock (Pizzimenti 1975). Within the subgenus *Leucocrossuromys,* there is some indication that the GUPD is less divergent from ground squirrels than the WTPD. The GUPD is smaller and its habitat resembles that of *Spermophilus* species inhabiting the central Rocky Mountains (Lechleitner 1969). Mound-building behavior is the least developed in the GUPD, intermediate development in the WTPD and most specialized in the BTPD (Lechleitner 1969). The GUPD also retains a chromosomal makeup more closely resembling that of other ground squirrels (Pizzimenti 1975, Goodwin 1995).

Some taxonomists divide the GUPD into 2 subspecies: the Gunnison's (*C. g. gunnisoni*) and the Zuni (*C. g. zuniensis*; Hollister 1916). *C. g. gunnisoni* is thought to be confined to the Rocky Mountain region of central and south-central Colorado and northern New Mexico. *C. g. zuniensis* ranges from extreme southeastern Utah, northwestern and west-central New Mexico and southwestern Colorado to the San Francisco Mountain Region and the Hualapai Indian Reservation in Arizona (Hollister 1916). Pizzimenti (1975) however, concluded that recognition of this subspecies was not warranted because the division by Hollister was primarily based on coloration and size incongruities. Pizzimenti's (1975) genetic analysis indicated relative homogeneity for chromosomes and serum proteins, and morphological analyses revealed essentially smooth geographic gradients for all characters across subspecific boundaries. Hafner et al. (2006) surveyed geographic variation in the mitochondrial DNA (mtDNA) throughout the range of the GUPD to evaluate the potential recognition of 2 subspecies. Although subspecies recognition should not be based only on mtDNA phylogeography, these data did provide support for past geographic isolation and subsequent genetic differentiation of *C. g. gunnisoni* apart from *C. g. zuniensis*. Currently, the CDOW recognizes a single species of GUPD in the state based on the Integrated Taxonomic Information System (http://www.itis.gov/).

The GUPD is genetically, morphologically and behaviorally distinct from the WTPD (Pizzimenti 1975). Genetic analysis conducted on populations of GUPDs and WTPDs in Delta, Montrose, and Ouray counties in Colorado, confirmed the genetic distinction of these 2 species (Pizzimenti 1975).

Life History

GUPDs and WTPDs are semi-fossorial mammals that depend on burrows to (1) protect them from inclement weather and predators; (2) provide refuge for bearing and rearing young; and (3) as hibernacula (Burns et al. 1989). A single prairie dog may use several burrows, and within active colonies there may be unused burrows. Burrow maintenance is generally confined to the spring when materials that collected in the burrow during the winter are removed (Clark 1977).

Both GUPDs and WTPDs cease above-ground activity during periods when they are unable to meet metabolic needs and cold weather taxes their energy budgets (Pizzimenti 1976a, Michener 1977, Bakko and Nahorniak 1986, Harlow and Menkens 1986, Rayor et al. 1987). Lack of precipitation, extreme daily temperatures and/or lack of forage and water appear to be the ultimate factors driving aestivation and hibernation. In Colorado, WTPD colonies have been reported to be active above ground from 7–9 months of the year, with sexes and age groups maintaining different activity periods (Tileston and Lechleitner 1966, Clark 1977). GUPD above-ground activity is variable in Colorado and is dependent on elevation; individuals that inhabit higher elevations remain underground for longer periods. Both species can hibernate from up to 5 months during the winter, and will aestivate during mid- to late summer (Hollister 1916, Tileston and Lechleitner 1966, Bakko and Brown 1967, Harlow and Menkens 1986).

Mating by both species occurs from mid-March to mid-May (Bakko and Brown 1967, Hoogland 1997). The breeding season may last 2-3 weeks, but individual female prairie dogs are sexually receptive for only a single day during this time period (Hoogland 1999). Males and females of both species may reproduce in their first spring (Rayor 1985, 1988, Cooke 1993, Hoogland 1996, 1999). However, in GUPDs the age of first reproduction for females depends on forage availability (Hoogland 1999) and, for males, on the number of older, breeding males in the population (Rayor 1985, 1988, Hoogland 1996). Both species predominantly employ a polygamous mating system with females mating with as many as 5 males (polyandry; Hoogland 1998).

Prairie dogs are born in the safety of their burrows and remain underground until weaning, at 4-7 weeks of age (Tileston and Lechleitner 1966, Clark 1977, Rayor 1985, Hoogland 1999). The probability of a female successfully weaning a litter varies tremendously and has been documented to fluctuate from as low as 20% to as high as 100% (Hoogland 2001, Pauli et al. 2006a). Research on WTPDs at Arapaho National Wildlife Refuge (AWR) in 2006 found that only 20% of 64 females at six study colonies weaned a litter (J. Hoogland, University of Maryland, personal communication 2009). This percentage was markedly lower than the percentages Hoogland had previously observed during his research as a graduate student at AWR in 1974 through 1976. Most of the unsuccessful females in 2006 never gave birth, but some gave birth and then lost their offspring at some point during lactation. In 2007 at AWR, 79% of females weaned a litter, in 2008 67% weaned a litter, and in 2009 37% weaned a litter. Hoogland (2001) has also studied reproduction of GUPDs in Arizona, and found that the probability of weaning a litter each year was approximately 82%.

The most recent research conducted by Hoogland on WTPDs at AWR (2006-2009) found that common litter sizes at juvenile emergence ranged from 4-6 young per female, with as many as 8 young reported. Hoogland (2001) studying reproductive output of GUPD in Arizona, found that at juvenile emergence, average litter size was 3.77. Hoogland (2001) noted factors that can enhance reproductive output, with body mass being the most important: heavy males were more likely to copulate and sire more offspring, and female maternal body mass correlated directly with litter size.

Little is known about the dispersal behavior of GUPDs and WTPDs. It is thought that dispersal occurs in fall prior to hibernation and in spring prior to the mating season (Travis et al. 1996). Dispersal distances have been recorded to be as short as 55 yards or as long as 4.8 miles.

GUPD offspring usually remain in their natal territory into their yearling summer and most GUPD females (95%) remain in their natal territory for life (Rayor 1988). Hoogland (1999) found that the majority of dispersing females moved to an adjacent clan, a distance ranging from 125–725 feet. Conversely, only 5% of males have been found to remain in their natal territory for more than 1 year, with 56% percent of dispersing males moving to an adjacent territory, a distance of 112–1,886 feet (Hoogland 1999).

At Shirley Basin, Wyoming, dispersal from WTPD natal dens did not always occur (Orabona-Cerovski 1991, Grant 1995). Orabona-Cerovski (1991) found that only 1% of all WTPD males dispersed more than 218 yards, with the majority moving less than 55 yards. The majority of juvenile WTPD females also moved less than 55 yards from their natal burrows, with most individuals not moving at all. Only 3% of females moved greater than 218 yards. Grant (1995) reported that none of his radio-collared WTPD juveniles dispersed from their natal areas. In Montana, Flath (1979) documented a dispersal distance of 1.5 miles of a single WTPD in the fall. In north-central Colorado, Cooke (1993) found that dispersal by both male and female juvenile WTPDs occurred in July and August. Dispersal distances ranged from 0.14–1.44 miles, with one female dispersing 4.8 miles.

Little work has been done examining home range sizes in different habitats and for different sex and age classes in either GUPDs or WTPDs. WTPD home ranges vary in size from 0.37–4.7 acres (Clark 1977, Cooke 1993). Rayor (1988) found that the area of individual home ranges in Colorado did not differ significantly between sites, sexes, or age groups, with median home range sizes of 0.17–0.2 acres recorded. In UTPDs, the size of the home range was thought to be inversely related to density (Wright-Smith 1978 *in* McDonald 1992).

Peak activity periods for both species are in the morning and late afternoon in the warmer summer months (Tileston and Lechleitner 1966, Fitzgerald and Lechleitner 1974).

Population Dynamics

WTPD populations are reported to fluctuate by more than 50% between consecutive years (Menkens 1987, Menkens and Anderson 1989). In most cases, variation in adult WTPD density (27–167%) was less than that reported for juveniles (124–348%; Menkens 1987). Variation in density between years and among habitats for both GUPDs and WTPDs is likely driven by local factors such as disease cycles, climate, and vegetation quantity and quality. Disease, especially the introduced pathogen *Yersinia pestis* responsible for plague, plays a role in amplifying prairie dog population fluctuations (see also "Disease" issue section). Hyper-productive environments (e.g., alfalfa fields) have been correlated with higher densities of prairie dogs (Crocker-Bedford 1976). Higher densities in limited areas may result in the prairie dogs denuding vegetation, ultimately resulting in lower prairie dog reproductive output. In addition, the invasion of non-native annuals, such as cheatgrass, can impact annual prairie dog population densities. These annuals can quickly increase in prevalence and become the single dominant vegetation. Such plants produce abundant spring vegetation during wet years, but have little production during drought years, and the resulting unpredictability in resources can affect prairie dog densities.

Social Structure

Cynomys species are known to be highly social, but variation exists among the 5 species in the degree of colonialism and social patterns. The WTPD is probably the least social species within the genus. WTPDs spend little time in social maintenance and most of their active time feeding (approximately 60%; Tileston and Lechleitner 1966, Clark 1977, Orabona-Cerovski 1991, Grant 1995). The social system of the WTPD has been classified as a single-family female kin cluster (Tileston and Lechleitner 1966, Michener 1983) and is composed of several reproductive females, occasionally 1 or 2 males of reproductive age, and dependent young (Cooke 1993). Females within a cluster are generally members of the same matriline (Cooke 1993).

In contrast, GUPDs maintain a more complex social system, with each colony subdivided into smaller territories occupied by social groups called clans (Slobodchikoff 1984, Slobodchikoff et al. 1988, Rayor 1988, Hoogland 1996). Clans vary from 2 to 19 individuals and may be composed of a single male and a single female, a single male and multiple females, or multiple males and multiple females (Slobodchikoff 2003). GUPD territories are used and defended by clans, and agonistic interactions with nonmembers do occur.

Habitat Requirements

Both GUPDs and WTPDs require deep, well-drained soils for development of burrows. Topography of inhabited areas is flat to gently rolling, with slopes generally less than 30% (Forrest et al. 1985, Collins and Lichvar 1986). GUPDs and WTPDs are found in relatively open plant communities with short-stature vegetation (Tileston and Lechleitner 1966, Clark 1977, Collins and Lichvar 1986, Menkens 1987, Orabona-Cerovski 1991).

GUPDs inhabit shortgrass and mid-grass prairies, grass-shrub habitats in low valleys, and mesic, high elevation sites (5,039–12,008 feet; Tileston and Lechleitner 1966, Pizzimenti and Nadler 1972, Pizzimenti and Hoffman 1973, Flath 1979, Fitzgerald et al. 1994, Davidson et al. 1999). Few studies have directly addressed habitat requirements of the GUPD (Wagner and Drickamer 2003). For studies that have been completed, common plant types on GUPD colonies include a diversity of shrubs, grasses, and forbs (Longhurst 1944, Lechleitner et al. 1962, 1968, Fitzgerald and Lechleitner 1974, Rayor 1985, Shalaway and Slobodchikoff 1988, Davidson et al. 1999, Bangert and Slobodchikoff 2000, Lorance et al. 2002). Total vegetative cover measured on GUPD colonies in Gunnison County, Colorado was 24% to 35% herbaceous, 9.5% to 25% shrub, and 39% to 66% bare ground (Rayor 1985).

In general, WTPDs inhabit xeric habitats at relatively lower elevations (3,772–8,500 feet) than do GUPDs (Fitzgerald et al. 1994). WTPDs are found in intermountain basins, open shrublands, semi-arid to arid shortgrass steppes, and agricultural lands (Pizzimenti 1976, Hall 1981, Clark and Stromberg 1987, Fitzgerald et al. 1994). A majority of WTPD habitat in Colorado occurs in areas that have high evaporation and low precipitation rates (Wolf Creek Work Group 2001, Knowles 2002). The majority of native plant communities within WTPD habitats have their main growing season from mid-April to the end of June (Wolf Creek Work Group 2001). Cool season plants that are able to use their stored winter moisture for growth dominate WTPD habitats that are generally dry from mid-June to mid-August. Late summer rains in August and September promote growth, making early fall another period when nutritious and abundant food sources are available to WTPD populations (Wolf Creek Work Group 2001).

Common vegetation associations on WTPD habitats are saltbush and sagebrush shrub communities that contain an understory of grasses and forbs (Kelso 1939, Gilbert 1977, Flath 1979, Forrest et al. 1985, Wolf Creek Work Group 2001, Knowles 2002). Saltbush associations occupy areas with fine-textured soils and are characterized by low growing widely spaced plants that vary in composition and density (Wolf Creek Work Group 2001). WTPD habitats in northwestern Colorado are dominated by shadscale, mat and Gardner's saltbush; and to a lesser extent, Wyoming big sagebrush, black greasewood, and rabbit brush (Gilbert 1977). Annual grasses (e.g. cheatgrass) and forbs dominate the herbaceous communities comprising much of the WTPD habitat in Colorado (Wolf Creek Work Group 2001).

Prairie dogs play an important role in the communities they inhabit. They are an important prey species for numerous avian and mammalian predators, including the endangered BFF. They create disturbances through their foraging and burrowing habits, which has resulted in them being considered keystone species. Their burrowing provides structural habitat for animals such as the burrowing owl and various small mammals (Miller et al. 1994), and dens and escape burrows for kit fox (Meaney et al. 2006). The resulting increase in bare ground caused by their foraging activity and colony development provides suitable nesting habitat for ground nesting bird species such as the mountain plover (Johnson-Nistler et al. 2004). Prairie dog colonies also attract many species of insects that may be important to different species using the area. Prairie dogs are known to affect a number of ecosystem-level functions by altering plant species composition and nutrient cycling rates (Whicker and Detling 1988).

BTPDs, the most widely-studied prairie dog species, are known to significantly alter their habitats. The limited amount of research conducted on GUPDs and WTPDs shows that their impact on the environment is less dramatic than that of BTPDs. For example, Grant-Hoffman and Detling (2006) measured vegetation cover, canopy height, species diversity, and nitrogen concentration on and off 6 GUPD colonies in southwestern Colorado. They found few vegetative differences between prairie dog colonies and non-colonies. However, Bangert and Slobodchikoff (2000) found that the presence of GUPD colonies increased habitat heterogeneity at the landscape level and that this heterogeneity is potentially important to a wide variety of animals. The magnitude of difference between the impact of BTPDs and that of GUPDs and WTPDs may be due to the vegetative communities they inhabit, as well as to the relatively limited above-ground activity of WTPDs and GUPDs (which can live up to 5 months underground). In addition, the impacts of GUPD and WTPD colonies on the landscape may be more muted due to the lower densities within their colonies, fewer social interactions, and because GUPDs and WTPDs do not actively "clip" vegetation to alter their surrounding habitat as do BTPDs.

Diet

GUPDs and WTPDs are primarily herbivorous, feeding extensively on grasses, forbs, sedges, and shrubs. Different types of plant species are consumed as plant phenology progresses. For example, WTPDs browse sagebrush during early spring, before other green forage is available, then select forbs as they develop in early summer, and finally, consume grass and sedge seed heads when they begin to flower (Tileston and Lechleitner 1966).

Rayor (1985) found that the primary foods consumed by GUPDs at 2 sites in Gunnison County, Colorado were borages, mustards, grasses, and some shrubs. Shalaway and Slobodchikoff (1988) found at their study sites in Arizona that, although there were dramatic differences in both plant species availability and use in colonies located < 12.4 miles apart, GUPDs maintained a consistent pattern of dietary selection for general types of plants: they fed on grasses and forbs when available and switched to seeds as the grasses and forbs died out, suggesting a seasonal shift in their diet.

Among 169 WTPD stomachs collected in Montana, Kelso (1939) found that saltbush, Russian thistle, winterfat and goosefoot were the most common items in the diet except during the months of April, July, August, and October when grasses dominated. Stockard (1930) examined 92 WTPD stomachs collected during the spring near Laramie, Wyoming and found that they contained weed and grass seeds, cactus roots and stems, sagebrush leaves, grasses and insects.

GUPDs and WTPDs inhabit arid, unpredictable environments with limited vegetation and short growing seasons. Because forage can become scarce and air temperature intolerable for these hyperthermia-prone species, GUPDs and WTPDs may spend up to 2/3 of their lives underground in burrows (Clark et al. 1971, Fitzgerald and Lechleitner

1974, Rayor 1988, Hoogland 1998). Consequently, fat reserves must be built during their active period and thus the availability of high quality forage during active periods is a crucial factor in survival and reproductive success (Beck 1994). High quality forage is considered necessary for reproductive females (who must double their daily energy requirements to support reproductive needs), and for accelerated ontogeny in juveniles (Crocker-Bedford and Spillett 1981). Rayor (1985) found that GUPD colonies located in habitats with higher quality vegetation had greater mass, accelerated sexual maturity, and earlier dispersal than prairie dogs in colonies located in lower quality vegetation sites.

B. Distribution

Accurate baseline data on occupied acres and status of GUPD and WTPD populations in Colorado is incomplete. In addition, there is an absence of historical information prior to, during, and after European settlement in the state. Knowles (2002) prepared a status review of both prairie dog species and stated that there was a need for state and federal agencies to make efforts to develop credible status reports on these species. Prairie dog populations, however, are very dynamic and do not lend themselves to being clearly understood without long-term, intensive study. Development of the *Colorado Conservation Strategy* has been based on the best scientific data available on distribution and occurrence of GUPDs and WTPDs. It has also been the impetus for the development of a long-term monitoring technique to evaluate prairie dog populations over time.

During development of the *Colorado Conservation Strategy*, "Individual Population Areas" (IPAs) were defined to facilitate management of areas of prairie dogs that (1) are physically separated from each other; and/or (2) may face unique sets of management challenges. A GIS habitat suitability model was developed (based on vegetation, slope, and elevation) for each prairie dog species) to model the "overall range". Expert opinions of local field biologists as well as known delineations of colonies were used to further refine this area and to define final boundaries of each IPA.

Gunnison's Prairie Dog

The current range of the GUPD (Fig. 1) includes the Colorado Plateau in southeastern Utah, southwestern Colorado, northern Arizona, and northwestern, west-central, and central New Mexico (Fitzgerald et al. 1994, Goodwin 1995, Knowles 2002). In Colorado, GUPDs are currently found in the southwestern and south-central portions of the state (Fig. 2). They occur in the San Luis Valley and South Park, along the Arkansas River Valley from Twin Lakes to Pueblo, westward into the upper Gunnison River drainage, in the Saguache and Cochetopa Park areas and in the four corners region (Capodice and Harrell 2003; Fig. 2). The range of the GUPD was thought to overlap that of the WTPD in the Uncompahgre River valley between Ridgeway and Olathe, and in the Cimarron River drainage (Lechleitner 1969, Armstrong 1972). Today the GUPD appears to be virtually extinct in the area of historic sympatry with the WTPD (Renner 2003a).

In central Colorado, GUPDs typically inhabit mountain parks, occurring at sites ranging in elevations from 5,997−12,000 feet (Pizzimenti and Hoffman 1973, Fitzgerald et al. 1994). In southwestern Colorado and adjacent areas, lower, more xeric habitats are used, with sites comparable to those inhabited by WTPDs further north (Armstrong 1972). There are 5 IPAs defined for GUPDs in Colorado: (1) Gunnison; (2) La Plata-Archuleta; (3) San Luis Valley; (4) South Park; (5) Southeast; and (6) Southwest (see also "Gunnison's Prairie Dog Individual Population Areas: Status and Distribution").

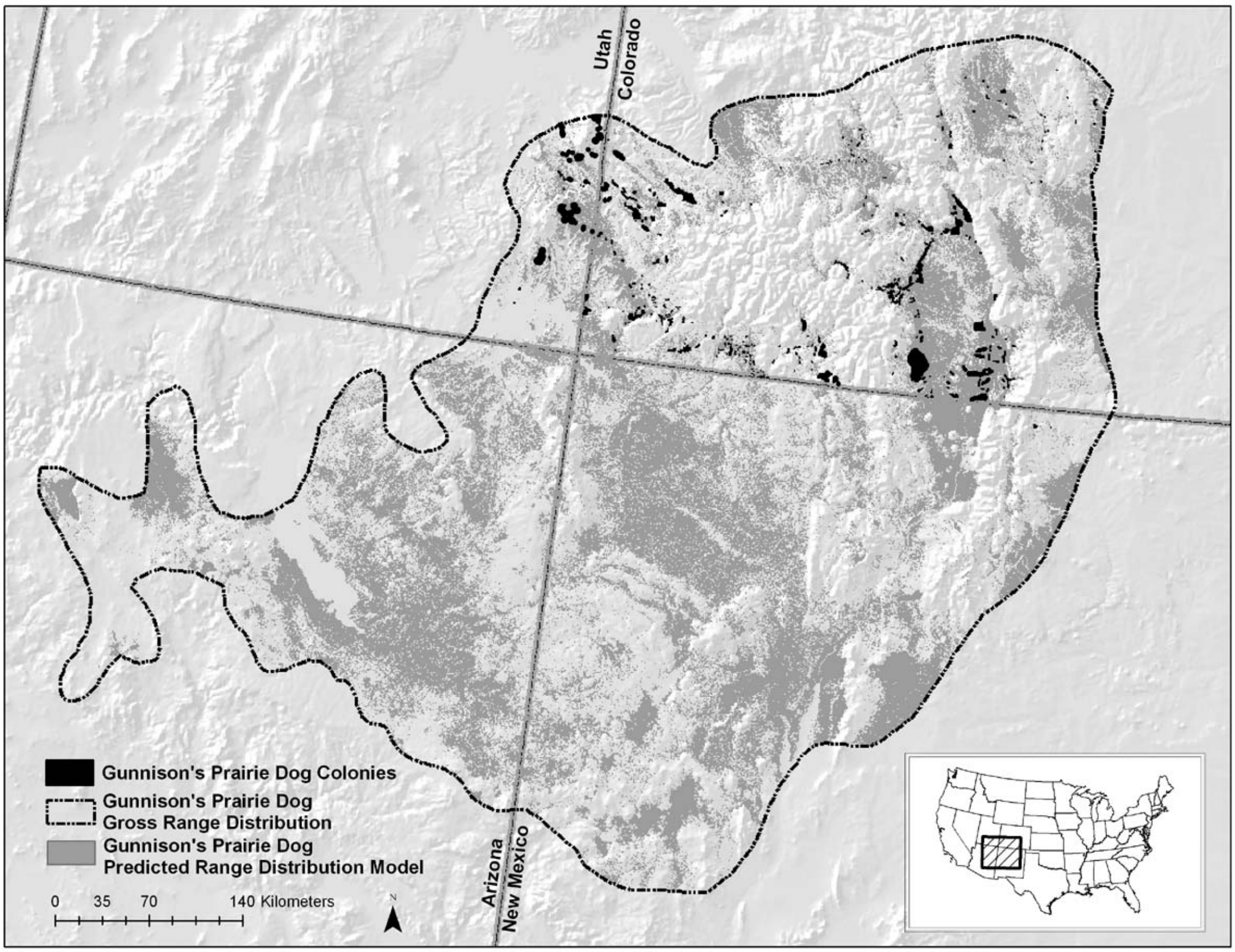


Fig. 1. Predicted range of Gunnison's prairie dog (GUPD) and identified colony distribution in Utah and Colorado as depicted in the multi-state GUPD conservation assessment (from Seglund et al. 2005).

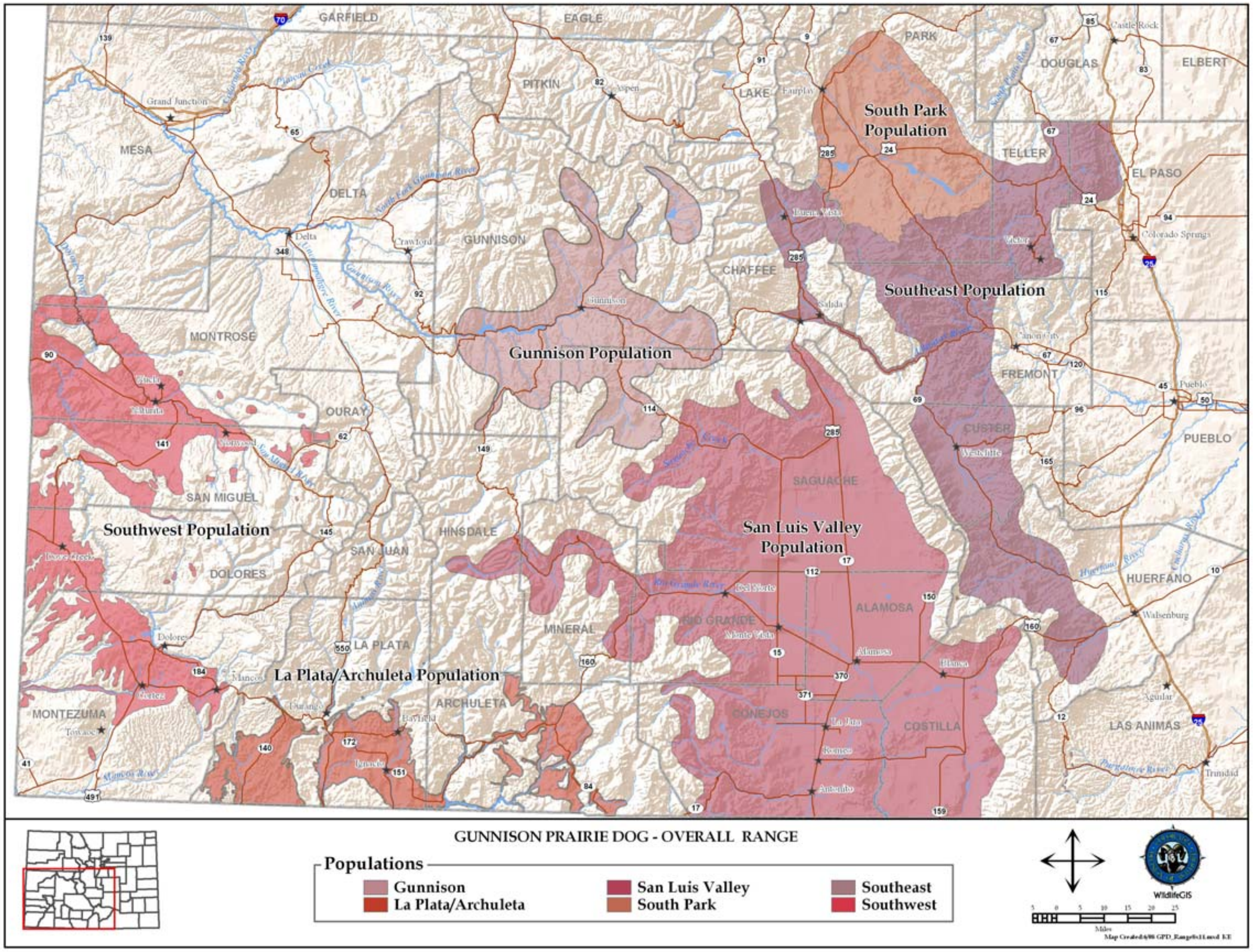


Fig. 2. Overall range of Gunnison's prairie dog in Colorado and associated Individual Population Areas.

White-tailed Prairie Dog

WTPDs inhabit intermountain basins, open shrublands, semi-arid to arid shortgrass steppes and agricultural lands of Utah, Montana, Wyoming and Colorado (Pizzimenti 1976a, Hall 1981, Clark and Stromberg 1987, Fitzgerald et al. 1994) (Fig. 3). In Colorado, WTPDs inhabit the northwestern and west-central portions of the state, primarily below 8,500 feet in elevation, although they occasionally occur up to and above 10,000 feet (Fitzgerald et al. 1994; Fig. 4). There are 3 IPAs defined for the current distribution of WTPD in Colorado: (1) Grand Valley-Uncompahgre Valley; (2) North; and (3) Northwest Colorado (see also "White-tailed Prairie Dog Individual Population Areas: Status and Distribution").

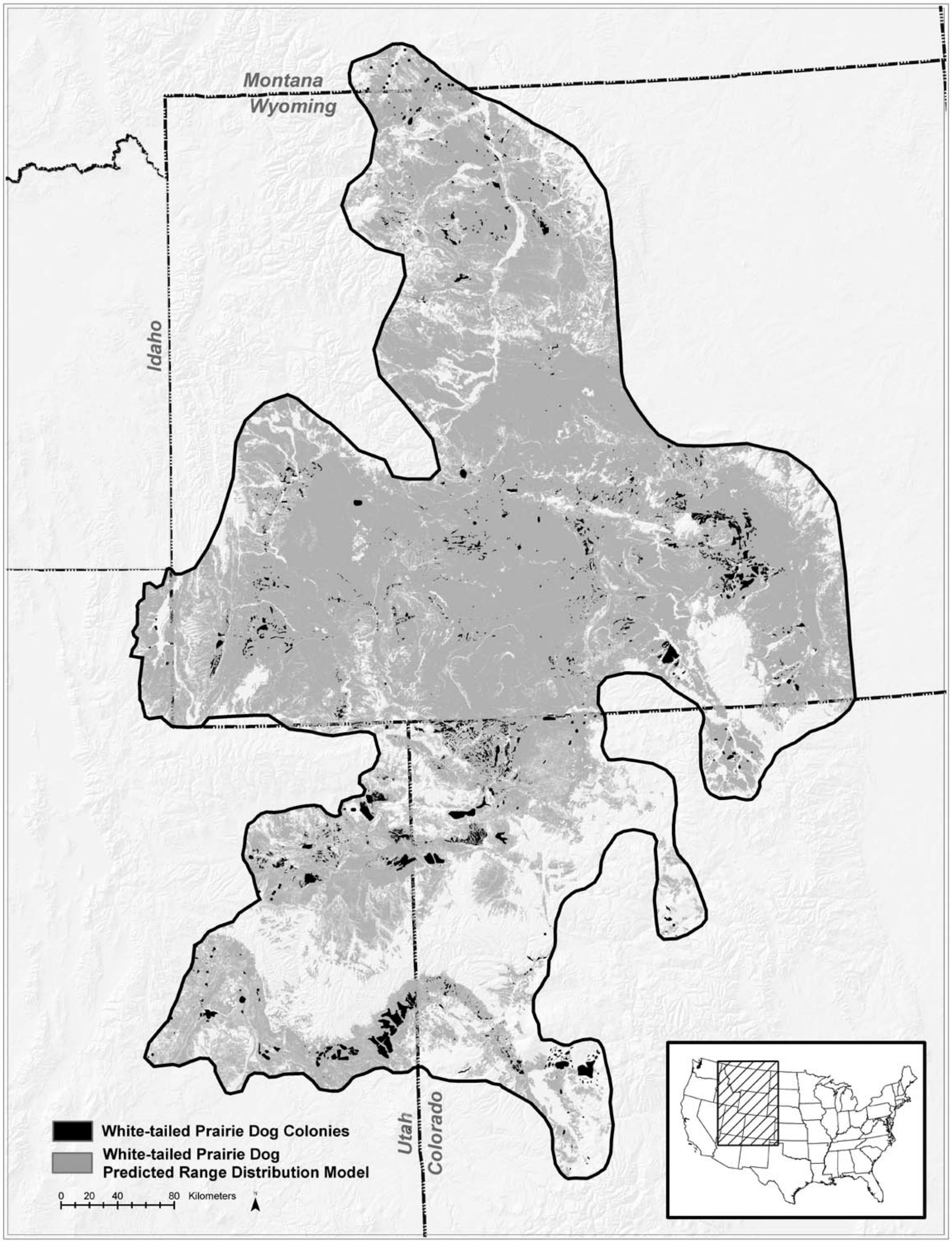


Fig. 3. Predicted range and identified colony distribution of white-tailed prairie dog (WTPD) as depicted in the multi-state WTPD conservation assessment (from Seglund et al. 2006).

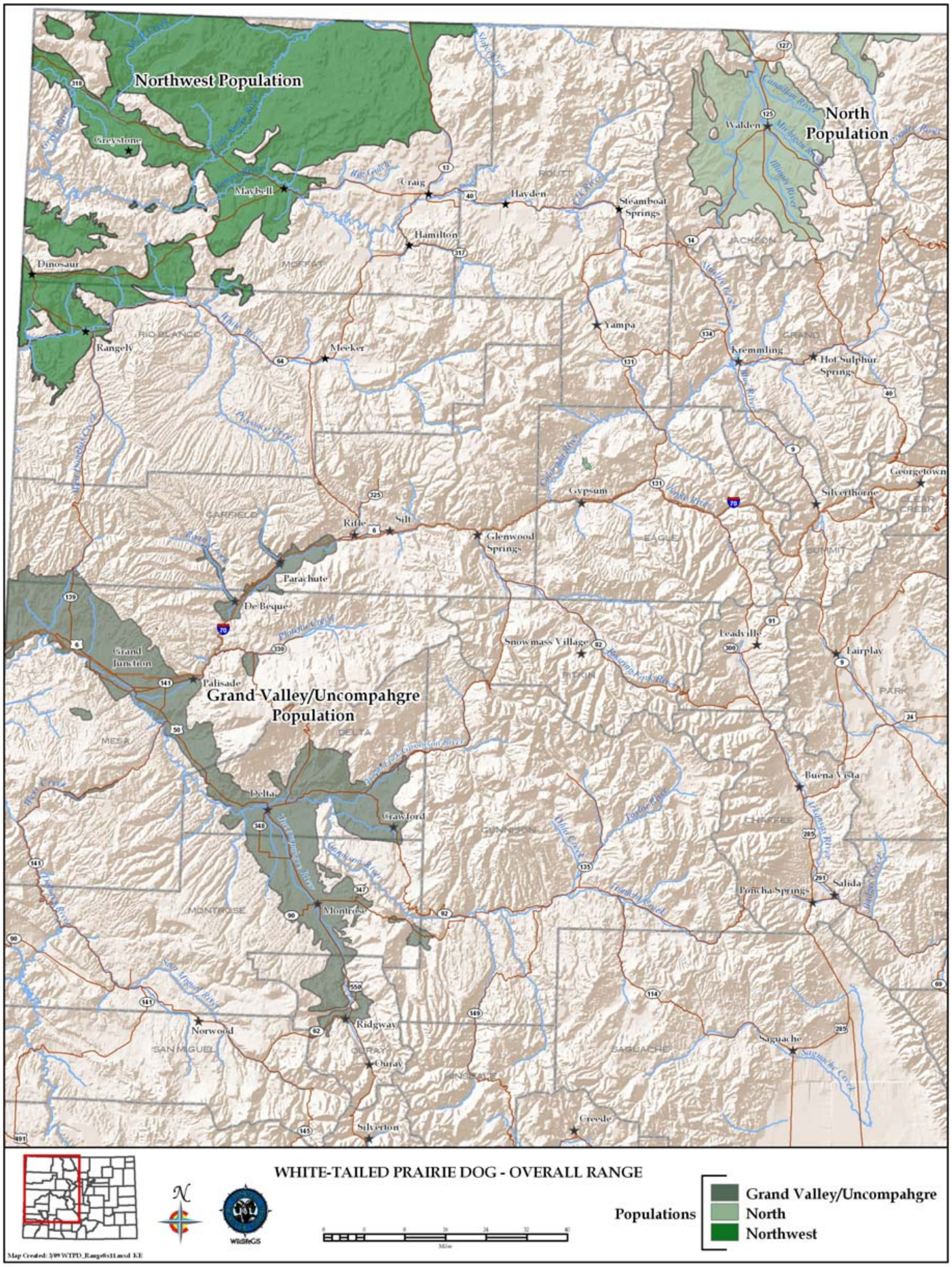


Fig. 4. Overall range of white-tailed prairie dogs in Colorado and associated Individual Population Areas.

C. Monitoring & Inventorying Gunnison's & White-tailed Prairie Dog Populations in Colorado

Historical Survey Efforts

Gunnison's Prairie Dog

Over the past 20 years, various efforts have been undertaken to document distribution and status of GUPDs in Colorado. Past surveys have been confounded by differences in effort, timing, and location, thus making comparisons of data among years difficult. Nevertheless, the best available data suggest that GUPD-occupied habitat on public lands in Colorado has been reduced, and in some areas this reduction has been dramatic (e.g., South Park). Recent surveys also indicate that GUPD colonies are small, with fragmented distribution. Though colonies that are small and widely distributed may persist, such low densities and scattered distribution will impede them from performing their evolutionary ecological function (Miller et al. 2000, Soulé et al. 2005, Proctor et al. 2006 *in* Miller et al. 2007).

The impacts of multiple factors including agriculture, changes in rangeland condition, urbanization, poisoning, and shooting may have collectively played a role in the decline of GUPD populations within the state. Plague, however, has had the largest negative impact on GUPD populations (Ecke and Johnson 1952, Lechleitner et al. 1968, Fitzgerald and Lechleitner 1974, Rayor 1985, Fitzgerald 1993; see "Disease" issue section), with historic poisoning also being a contributing factor (see "Poisoning" issue section). The majority of the GUPD overall range in Colorado occurs on private and tribal lands, which limits the ability of federal and state agencies to monitor and manage this species.

White-tailed Prairie Dog

In 1981, following the discovery of the last known wild BFFs on a WTPD colony in Wyoming, states within the historic range of this species initiated programs to identify and evaluate prairie dog habitat as potential BFF reintroduction sites. This specialized predator, a federally endangered species, is dependent on prairie dogs as a food source, and the significant loss of prairie dog colonies range-wide was identified as the main factor in the demise of BFF populations. This decline of BFF populations and contraction of its range can serve as a benchmark for measuring the loss of the ecological function of prairie dogs (Miller et al. 2007).

Evaluation of suitable BFF habitat is based on acreage and juxtaposition of prairie dog colonies, and prairie dog densities within these colonies (Forrest et al. 1985, Biggins et al. 1989, 1993). Within Colorado, 3 sites were evaluated for their potential as reintroduction sites: (1) Coyote Basin (CBMA); (2) Little Snake (LSMA); and (3) Wolf Creek (WCMA). All 3 sites are located in northwestern Colorado in Rio Blanco and Moffat Counties (see "Northwest Individual Population Area" and Fig. 13 for details). Results from the evaluations of BFF habitat suggest considerable, often unexplained fluctuations in Colorado WTPD populations.

The LSMA was the first area to be selected as a BFF reintroduction site in Colorado. However, a plague epizootic (an explosive outbreak of the disease which causes widespread mortality) caused a dramatic die-off of WTPDs in 1994 that precluded the area from further consideration. Fifteen years after this plague epizootic was first documented in the LSMA, WTPD numbers and occupied habitat remain severely depressed. Why this area has been unable to recover is unknown. Historic rodent control was significant in the White River Resource Area, but in the last 25 years, little (if any) WTPD or ground squirrel poisoning has taken place (U.S. Fish and Wildlife Service et al. 2001). Rodent control on Bureau of Land Management (BLM) lands in Moffat County has not been authorized since 1975, and large-scale eradication of WTPDs through poisoning no longer occurs (U.S. Fish and Wildlife Service et al. 1995).

Since evaluation of the WCMA and CBMA sites began, significant fluctuations in WTPD numbers have been recorded. Why these extreme fluctuations have occurred is unknown, but potential causes include plague and/or drought conditions. These fluctuations may stem from plague reemerging in these areas and infecting populations as soon as densities of WTPD become sufficient to increase transmission rates and spread the disease. Drought may also play a role, with its effects magnified due to poor range conditions.

Recent Survey Efforts

Inventory of the Distribution of Gunnison's & White-tailed Prairie Dog Colony Locations

In 2002, the CDOW began a statewide effort to document GUPD and WTPD distribution by interviewing field personnel from the CDOW, USFWS, USFS, and BLM (Colorado Division of Wildlife 2003b). Prairie dog colonies were identified and roughly mapped using the "best guess" of the observer onto 1:50,000 U.S. Geological Survey (USGS) county sheets (Appendix F). This mapping exercise was not exhaustive and not all colonies that occur in the state were documented. For example, many colonies located on private lands as well as in more remote areas were not identified. This effort, though not exhaustive, did provide the CDOW with a preliminary guide to the overall distribution of the GUPD and WTPD colonies in Colorado. After 2005, these maps continue to be periodically updated with one CDOW region per year re-evaluating colony status and adding any new colony locations not identified from previous mapping exercises. Because identification of colony locations is ongoing, some mapping is done in drought and some in wet years.

Monitoring & Inventorying Current Gunnison's & White-tailed Prairie Dog Populations in Colorado

The WAFWA's Conservation Plan (Western Association of Fish and Wildlife Agencies 2007) required the development and use of an objective, repeatable estimation technique to monitor the status of GUPD and WTPD populations. Previous techniques used to monitor prairie dog populations relied on mapping prairie dog habitat by delineating colony boundaries based on burrow distribution. However, GUPD and WTPD colony boundaries are often much more difficult to map as compared to BTPD colonies. These difficulties arise because GUPDs and WTPDs inhabit more varied habitat types, occur at lower densities, do not actively "clip" vegetation within colonies, and are more tolerant of shrub canopies (making detection of outermost burrows difficult). Because of these differences, mapping for these species can become subjective, with investigators using their best estimates to map colonies based on site topography and changes in vegetation communities. In practice, the objective is to map the outermost distribution of active burrows within a colony to document total occupied acreage. However, inactive areas within colonies are typically not assessed, resulting in mapped acreage that includes both active and inactive areas, resulting in an inaccurate estimation of true occupied habitat.

In 2002, Colorado embarked on an effort to develop an objective technique to monitor GUPD and WTPD populations statewide (Andelt et al. 2003a). Because aerial surveys, using line intercept methods, had been developed for estimating the area occupied by BTPDs (Sidle 2001), Andelt et al. (2003b) investigated aerial surveys as a potential estimation technique for GUPDs and WTPDs. Results indicated that the line intercept method significantly overestimated the area encompassed by GUPD and WTPD colonies compared to areas measured on the ground (Andelt et al. 2003b). In addition, estimates made along the same transects by different flight crews were variable, obscuring real differences in prairie dog colony area estimates. Due to these weaknesses, the line intercept method was abandoned as a viable technique to monitor and inventory GUPD and WTPD populations in Colorado.

A newer technique for monitoring GUPDs and WTPDs, called "occupancy modeling" (Mackenzie et al. 2002), has recently been implemented in Colorado (Andelt et al. 2009a). Unlike techniques that estimate acreages of occupied habitat, occupancy modeling: (1) yields measures of statistical precision and allows calculation of confidence intervals (CIs); and (2) can guide sampling design. Current results from this sampling strategy are promising for both species (Andelt et al. 2009a). This method will allow managers to detect population declines and to identify triggers within the natural biological variation of the respective species to initiate management action.

Colorado has completed 2 years of occupancy surveys for both WTPDs (2004 and 2008) and GUPDs (2005 and 2007). Results from the surveys found WTPDs occupying 24.1% (standard error [SE] = 12.8) in 2004, and 23.1% (SE = 2.1; Table 1) in 2008, of 47,710 0.25-km^2 plots (Andelt et al. 2005, 2009b). In 2005, GUPDs occupied 7.5% (SE = 1.3) and in 2007, they occupied 8.6% (SE = 1.1; Table 1) of 158,225 0.25-km^2 plots (Andelt et al. 2005, Andelt and Lukacs 2007).

For GUPDs, an extinction rate of 0.174 was estimated from 2005 to 2007 for the 11,938 plots that were estimated as occupied during 2005; GUPD went extinct from 2,073 plots (17.4% of 11,938). There was also an estimated colonization rate of 0.028 from 2005 to 2007: among the 146,287 plots that were estimated as unoccupied during 2005, GUPD colonized 4,156 plots (i.e., 2.8% of 146,287). Thus, the estimated change in occupancy rate from 2005 to 2007 was 1.142 (from 7.5% in 2005 to 8.6% in 2007; Table 1). The confidence intervals for our estimates of occupancy rates for 2005 (Ψ = 0.075, SE = 0.013, CI = 0.054 – 0.104) and 2007 (Ψ = 0.086, SE = 0.011, CI = 0.064 – 0.108) overlapped, indicating occupancy rates did not change significantly from 2005 to 2007. The next survey for GUPDs will be in the spring/summer of 2010.

An extinction rate of 0.289 was estimated for WTPDs from 2004 to 2008: for the 11,493 plots that were estimated as occupied during 2004, WTPDs were absent from 3,323 plots in 2008. WTPDs had a colonization rate of 0.087 from 2004 to 2008: for the 36,217 plots that were estimated as unoccupied during 2004, WTPDs colonized 3,152 plots. The estimated change in occupancy from 2004 to 2008 was –4.3% (Table 1). The confidence intervals for our estimates of number of plots occupied for 2004 (n = 11,492, SE = 6,091, CI = 3,564 – 26,476) and 2008 (n = 10,778, SE = 1035, CI = 9,293 – 13,181) overlapped, indicating occupancy rates did not change significantly from 2004 to 2008. The next survey for WTPDs will be in the spring/summer of 2011.

Table 1. Results of Gunnison's prairie dog (GUPD) and white-tailed prairie dog (WTPD) occupancy surveys conducted in Colorado: 2004–2008.

GUPDs

Parameter	Result	SE/ SD	95% Confidence Interval	
			Lower Bound	Upper Bound
2005 Occupancy (%)	7.5	1.3	5.4	10.4
2007 Occupancy (%)	8.6	1.1	6.4	10.8
Change in Occupancy	1.149			

WTPDs

Parameter	Result	SE/ SD	95% Confidence Interval	
			Lower Bound	Upper Bound
2004 Occupancy (%)	24.1	0.128	0.075	0.555
2008 Occupancy (%)	23.1	0.021	0.195	0.276
Change in Occupancy	–4.3			

The estimate of standard error and 95% confidence interval bounds for 2004 WTPD were estimated with a frequentist approach, whereas the standard deviation and the 95% credible interval bounds for 2008 WTPD were estimated with a Bayesian approach. Both approaches produce very similar estimates.

D. Gunnison's Prairie Dog Individual Population Areas: Status & Distribution

Gunnison Individual Population Area

General Description of Area

The overall range of the GUPD in the Gunnison Individual Population Area (GU IPA) encompasses 905,081 acres and includes parts of Gunnison and Saguache counties (Fig. 5). This IPA falls within the "montane" range of the GUPD as defined by the USFWS. GUPDs within this IPA are considered a candidate species for listing under the ESA.

The Upper Gunnison Basin is an intermontane basin situated at the eastern edge of the Colorado Plateau with elevations ranging from 7,100 feet to 12,700 feet. Uplands are moderate to steeply rolling and are dissected by permanent and intermittent stream drainages. Shallow eroded gulches are common on upland slopes and steep-sloped mesas occur in several parts of the Basin. The Upper Gunnison Basin is drained by the Gunnison River and its tributaries, the Lake Fork of the Gunnison, the East Rand Taylor Rivers, and Cochetopa, Tomichi, Blue, Cimarron, and Ohio Creeks. The Gunnison River originates at the town of Almont and flows southwesterly until being confined by Blue Mesa dam and forming Blue Mesa Reservoir, the largest body of water in Colorado.

Big sagebrush dominates upland vegetation and has a highly variable growth form depending on local site conditions. On dry south slopes, sagebrush is short and widely spaced and on wetter sites, it is tall and vigorous. Sagebrush rangelands below 8,500 feet are typically drier, less productive Wyoming big sagebrush communities with little understory. Higher elevation stands receive more moisture and contain more productive mountain big sagebrush communities with healthy understories. The majority of the bottomlands along stream corridors have been converted to hay and pastureland.

Land ownership in the GU IPA is 68% federal land, 30% private land, 2% state land (Table 2, Fig. 5). Land-use is primarily ranching and hay production, but residential subdivision development has been expanding out from the town of Gunnison during the past 25 years.

Table 2. Land ownership data for Individual Population Areas (IPAs) identified in the Gunnison's prairie dog (GUPD) and white-tailed prairie dog (WTPD) overall range in Colorado.

IPA[1]	**Land ownership in Acres (% of Total Area)**											
	Federal					**State**			**Other**			**Total**
	BLM	**NPS**	**USFS**	**USFWS**	**Other**	**CDOW**	**SLB**	**Other**	**Private**	**Tribal**	**Other**	
GUPD												
GU	345,974 (38)	27,274 (3)	248,366 (27)	0	7 (0)	7,803 (1)	5,100 (1)	20 (0)	269,759 (30)	0	780 (0)	905,081
LPA	5,741 (1)	0	35,055 (6)	0	0	1,796 (0)	7,407 (1)	0	388,602 (71)	110,430 (20)	11 (0)	549,041
SLV	510,578 (15)	66,802 (2)	809,763 (23)	83,768 (2)	963 (0)	10,479 (0)	180,200 (5)	340 (0)	1,767,213 (51)	0	57,898 (2)	3,488,005
SP	56,845 (8)	0	190,437 (27)	0	0	26,653 (4)	39,719 (6)	14,132 (2)	360,832 (52)	0	12,193 (2)	700,811
SE	297,186 (17)	5,984 (0)	226,335 (13)	0	14,560 (1)	11,551 (1)	84,270 (5)	9,020 (1)	1,059,298 (63)	0	5,403 (0)	1,713,607
SW	466,000 (42)	282 (0)	24,062 (2)	0	0	14,439 (1)	12,135 (1)	694 (0)	580,383 (53)	2,882 (0)	1,904 (0)	1,102,086
GUPD TOTAL	1,789,257 (21)	100,341 (1)	1,611,878 (19)	83,768 (1)	15,530 (0)	62,459 (1)	341,950 (4)	1,053 (0)	4,507,850 (52)	113,311 (1)	97,857 (1)	8,725,255
WTPD												
GVUN	299,715 (31)	128 (0)	258 (0)	143 (0)	774 (0)	4,395 (1)	1,481 (0)	1,510 (0)	646,267 (68)	0	3,030 (0)	957,702
NO	138,427 (31)	0	295 (0)	22,668 (5)	0	1,845 (0)	32,541 (7)	1,073 (0)	251,068 (56)	0	0	447,917
NW	1,055,259 (64)	7,219 (0)	0	11,774 (1)	0	12,264 (1)	115,977 (7)	0	454,631 (27)	0	530 (0)	1,657,653
WTPD TOTAL	1,493,401 (49)	7,347 (0)	553 (0)	34,585 (1)	774 (0)	18,504 (1)	149,999 (5)	2,583 (0)	1,351,966 (44)	0	3,560 (0)	3,063,272

[1] Key to abbreviations for prairie dog IPAs: GU = Gunnison; LPA = La Plata–Archuleta; SLV = San Luis Valley; SP = South Park; SE = Southeast; SW = Southwest; GVUN = Grand Valley–Uncompahgre; NO = North; NW = Northwest.

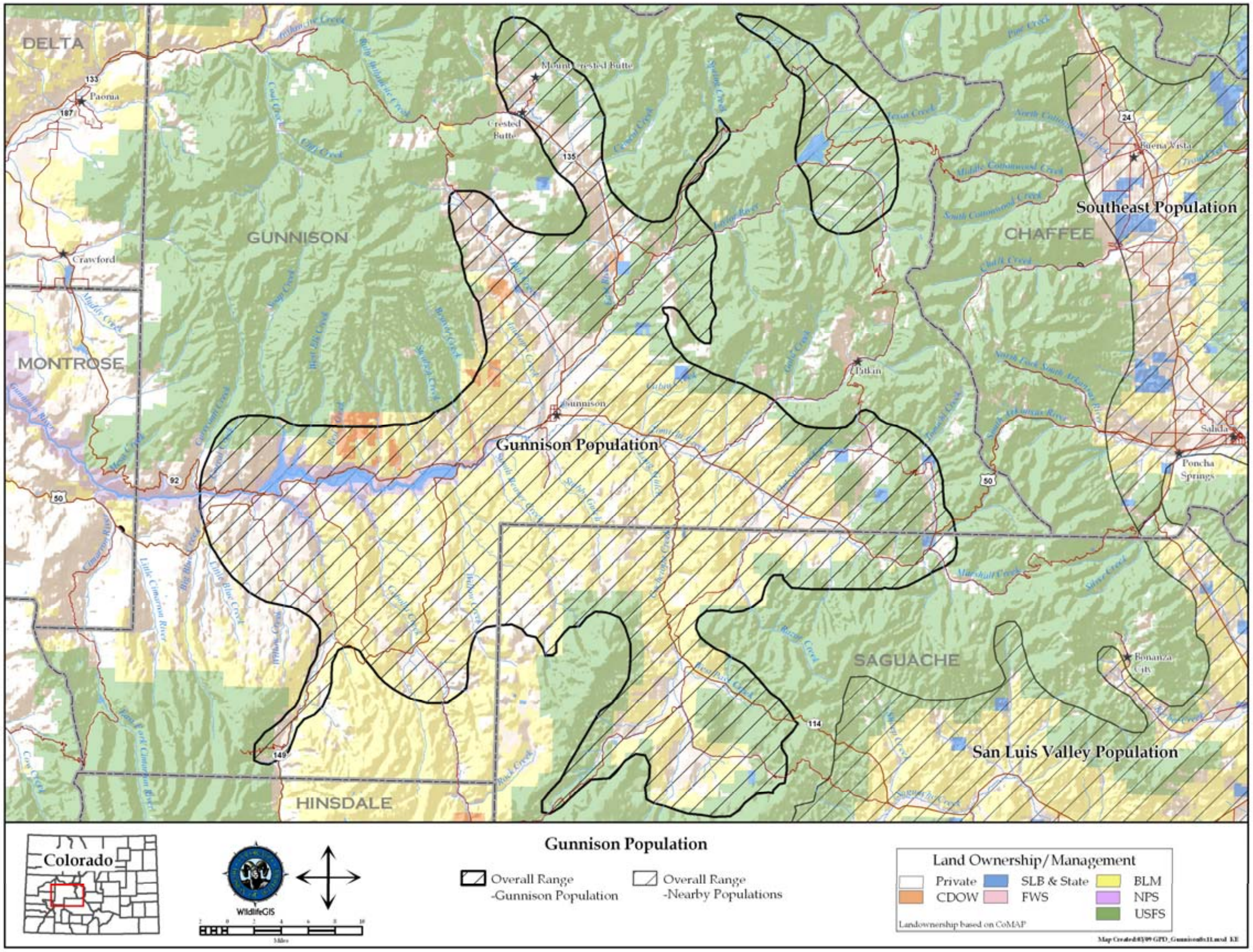


Fig. 5. Land ownership within the overall range of the Gunnison's prairie dog in the Gunnison Individual Population Area.

Population Information

GUPDs are found in the Gunnison Basin and Cochetopa Park areas (Capodice and Harrell 2003). In the GU IPA, they do not typically use irrigated bottomlands, due to the high water table, but are instead found in drier sagebrush areas and greasewood flats. Within these sites, prairie dogs inhabit those areas with low-growing, dispersed shrubs. Colonies throughout the Gunnison Basin are small and fragmented.

Historically, the Curecanti National Recreation Area (CURE), managed by the National Park Service (NPS), contained 9 GUPD colonies or colony complexes (T. Childers, National Park Service, personal communication 2009). These colonies experienced documented plague epizootics in 1971, 1981, 1992, 1996, 2005 and 2007. Recent plague outbreaks have resulted in the loss of 2 large, densely populated colonies (totaling approximately 114 acres) in 2005 and the loss of a sparsely populated 40 acre colony in 2007.

The NPS has not documented plague presence or plague outbreaks in two small colonies within the CURE since records began in the 1970s. These two colonies are isolated from the other CURE colonies on the east side of Gunnison River Canyon. Although plague seems to be fairly prevalent in the Gunnison Basin, these colonies have not yet experienced a plague outbreak. This may be due to the small size of these colonies or their geographic isolation.

Currently, 4 of the 9 historic GUPD colonies are active in CURE. As of 2007, the total acreage of known active and inactive colonies in CURE was estimated to be 182 acres, of which 28 acres were estimated to be occupied by active, seemingly healthy prairie dogs.

Other past inventory efforts included surveys included work by both the USFWS and the BLM. In 1990, the USFWS conducted surveys of GUPD distribution throughout Colorado (Finley 1991). Surveys were conducted by driving highways and roads and recording observations of prairie dogs. Finley (1991) documented 74 GUPD colonies (42 active) within 10 counties. Twenty-eight of the 42 active colonies contained fewer than 60 mounds or fewer than 30 individuals. The largest active colonies documented were in the Gunnison River drainage.

From 1979-1980 the BLM survey data indicated that GUPDs occupied 15,568 acres within 19 colonies in the Gunnison Field Office jurisdictional boundaries (Capodice and Harrell 2003). In 2000 to 2002, Capodice and Harrell (2003) revisited previously recorded occupied GPD colonies in Gunnison, and identified 279 acres within 5 previously measured colonies, in addition to 5 new active colonies on BLM lands. The results of this survey indicated a 50% reduction in active colonies since the 1979-1980 surveys (Capodice and Harrell 2003).

Issues

Plague has been implicated in the loss of several large prairie dog colonies on BLM land in the GU IPA. A large colony southeast of Gunnison that was very active in 2005 was totally devoid of prairie dogs in 2006 and 2007. Four other large colonies in the same vicinity were active in 2006, but by 2007 no prairie dog activity was observed. Plague is suspected as the cause, due to the complete elimination of prairie dogs and no sign of poisoning. Preliminary analysis of flea polymerase chain reaction (PCR) data has revealed evidence of *Y. pestis* DNA in flea pools from a small colony east of Gunnison in 2008. The colony subsequently died off by June of 2008. Two other colonies (one located on CURE properties) tested in the area did not have any positive flea pools.

Rayor (1985) described an outbreak of plague that spread through a 148-acre colony in CURE, west of Gunnison, in 1981. In less than 2 months, Rayor reported the loss of 1,000-1,500 prairie dogs. A few animals survived the disease and Cully (1989), who visited the area in 1986, noted that GUPDs were again abundant. As of 2007, the CURE staff estimated that 28 acres of occupied GUPD habitat existed within the National Recreation Area.

Population and corresponding development has increased within both the town of Gunnison and the county. Community planners are considering incentive and assurance programs for GUPDs and are working to keep development centralized around the town rather than diffusing development to rural areas. Recent development severely reduced one of the largest GUPD populations in the city. Individuals within the Gunnison area have proposed relocating GUPDs in response to development activities; however, suitable lands for relocation or translocation projects are currently limited and protocols for relocating GUPD and WTPD have not been developed.

Populations of GUPDs in the Basin are most abundant on private lands, probably due to high quality forage and deep soils. Poisoning on private lands is occurring in the GU IPA. The amount and location of poisoning efforts are unknown and impacts to populations are impossible to quantify. Lethal management using gas cartridges is allowed at select areas in the CURE where prairie dogs or their burrow systems cause harm to park infrastructure or put visitor safety at risk. Lethal management usually affects 20 or fewer burrows.

The GUPD and Gunnison sage-grouse (GUSG) coexist in the Gunnison Basin. This large landscape provides suitable habitats for both species. GUPDs may even facilitate the maintenance and enhancement of suitable habitats for the grouse by providing areas with early successional vegetation that is not dominated by mountain sagebrush communities. Suitable habitat may be a limiting factor in the Basin due to management changes resulting in dense, decadent sagebrush stands. Implementation of the GUSG Rangewide Conservation Plan in the Basin (Gunnison Sage-grouse Rangewide Steering Committee 2005) has included habitat treatments undertaken by government agencies and landowners to reduce sagebrush densities and improve understory vegetation. Some treatments completed for GUSG (such as the use of fire, or Lawson aerators) may unintentionally improve GUPD habitat, while others (such as mowing or a single-pass with a Dixie harrow) may not improve habitat for GUPDs. Although treatments may benefit GUPDs, conflicts may arise if prairie dogs move into treatment areas and suppress the herbaceous vegetation that the treatments were intended to enhance. However, the CDOW is unaware of any treatments for GUSG over the past 10 years that have been colonized by prairie dogs.

Current Conservation Efforts

GUPDs are protected from development and shooting on the CURE.

Seasonal shooting closure was instituted on public lands from 1 March – 14 June by the Colorado Wildlife Commission (CWC) in 2006.

The USFS considers the GUPD a Region 2 Sensitive Species. Conservation actions primarily consider the presence of GUPDs in project areas and recommendation of appropriate mitigation measures. USFS Districts do not give out the location of prairie dog sites to recreational shooters.

The CURE continues to monitor plague within their boundaries using the Centers for Disease Control (CDC) Procedure for Visual Evaluation of Prairie Dog Colonies for Plague in the Southwestern United States ((T. Childers, National Park Service, personal communication 2009). This procedure involves conducting a visual survey of colonies during periods when prairie dogs should be active and determining if a colony is healthy, dead, or has dead spots/zones. Fleas are only sampled from colonies exhibiting new dead spots/zones or that are completely inactive.

La Plata-Archuleta Individual Population Area

General Description of Area

The overall range of the GUPD in the La Plata-Archuleta Individual Population Area (LPA IPA) encompasses 540,041 acres. This IPA falls within the "prairie" range of the GUPD as defined by the USFWS. GUPDs within this IPA are not considered a candidate species for federal listing.

This IPA occurs in La Plata and Archuleta counties and lies mainly in the Navajo Section of the Colorado Plateau Province (Fig. 6). The landscape is less dissected topographically than many sections of this province. This area generally slopes southwest, with elevations along the northeastern boundary of the area approximately 8,000 feet and elevations along the state line approximately 5,900 feet.

The LPA IPA comprises 2 plant community zones: foothill and mountain. The dominant woody vegetation within the foothill zone includes piñon pine, Utah juniper, sagebrush, bitterbrush, and mountain mahogany. Associated grasses include Junegrass, blue grama, Indian ricegrass, and galleta. The mountain zone lies mainly in the eastern portion of the IPA and is generally described as pine-oak woodlands interspersed with grassland meadows. Common grasses include elk sedge, Junegrass, and mountain muhly.

In the southern and western portions of the IPA, agricultural use is common where deeper soils have developed on low gradient slopes. Agricultural uses include irrigated and non-irrigated croplands, pasture lands, and hay fields. In addition, Conservation Reserve Program lands exist predominately in the La Plata River drainage.

Land ownership in the LPA IPA is 71% private land, 20% tribal land, and 7% federal land (Table 2, Fig. 6).

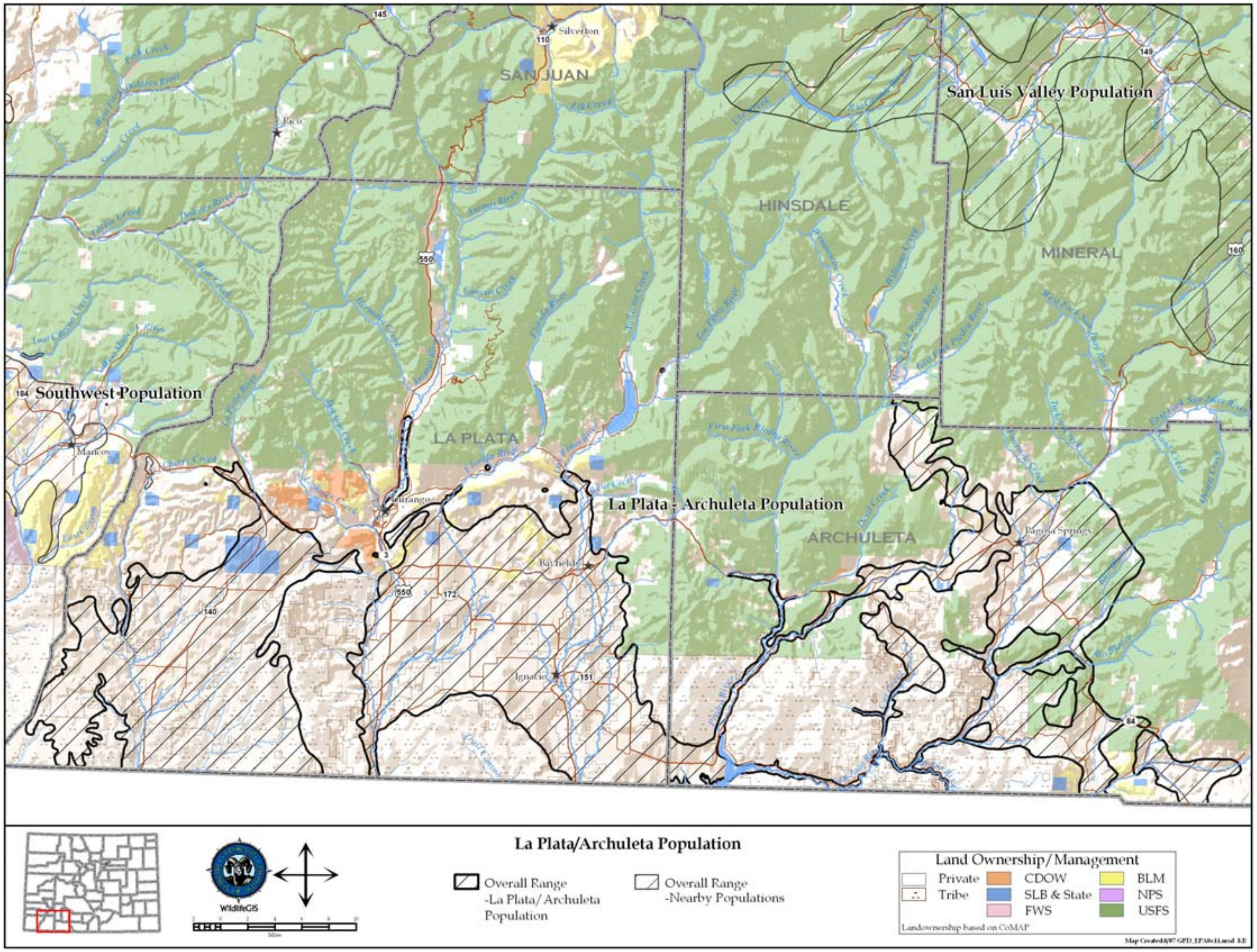


Fig. 6. Land ownership within the overall range of the Gunnison's prairie dog in the La Plata–Archuleta Individual Population Area.

Population Information

Currently, a large percentage of GUPD occupied habitat occurs on private lands. These lands tend to have soil types that support GUPDs. In addition, "improved" pastureland, both irrigated and non-irrigated, favors higher densities of GUPDs found on private lands, as compared to the more native arid landscapes.

Issues

The expansion of noxious weeds has been significant within the LPA IPA in recent years, with increasing acreages of knapweed, toadflax, jointed goatgrass, and bindweed. This trend is anticipated to continue.

Much of the LPA IPA lies within the boundary of the Fruitland outcrop. This coal formation has been the focus of extensive coal bed methane energy development in recent years. The 2006 Record of Decision for the Northern San Juan Basin Coal Bed Methane Project provides for an additional 185 new wells (Bureau of Land Management and U.S. Forest Service 2007). The GUPD is listed as a USFS Region 2 sensitive species and was analyzed in the Final Environmental Impact Statement (FEIS) biological evaluation (Bureau of Land Management and U.S. Forest Service 2006).

Plague in this area appears to occur every 4 to 7 years and may be limiting certain colonies. In addition, many colonies are located on private lands and lethal control of prairie dogs to protect agricultural crops is probably occurring in some areas.

Urban development is increasing in both counties comprising the IPA (see "Urban Development" under ISSUES & CONSERVATION STRATEGIES).

Current Conservation Efforts

The USFS considers the GUPD a Region 2 Sensitive Species. Conservation actions primarily consider the presence of GUPDs in project areas and recommend appropriate mitigation measures. USFS Districts do not give out the location of prairie dog sites to recreational shooters.

A seasonal shooting closure was instituted on public lands from 1 March – 14 June by the CWC in 2006.

San Luis Valley Individual Population Area

General Description of Area

The overall range of the GUPD in the San Luis Valley Individual Population Area (SLV IPA) encompasses 3,488,005 acres and is located within Alamosa, Conejos, Costilla, Rio Grande, and Saguache counties. This IPA falls within the "montane" range of the GUPD as defined by the USFWS. GUPDs within this IPA are considered a candidate species for listing under the ESA.

This IPA is located in southern Colorado in what has been called the highest, largest, mountain desert in North America (Trimble 2001). The Valley extends over 80 miles from north to south and 50 miles from east to west, with an average elevation of 7,500 feet. The valley is bounded on the north and west by the La Garita Mountains, on the west by the San Juan Mountains, on the north and east by the Sangre de Cristo Range, on the east by the Culebra Range, and on the south by the New Mexico state line (Fig. 7).

The habitat in the SLV IPA consists of shrublands, croplands, and meadows. The higher elevation shrub-grassland community occurs just below the piñon-juniper zone and is dominated by oakbrush, skunkbrush, and currant-rose. Grasses in this zone are dominated by blue grama, wheatgrass, and needle grass.

The lower elevation shrub community is dominated by alkali-resistant and hydrophyllic plants. Black greasewood and rabbit brush are the major shrubs found in this zone, although four-wing saltbush does occur. Grasses in this community include baltic rush, saltgrass, and various sedges and rushes.

Irrigated croplands occur on the valley floor and are the basis for the local area's economy. Cultivated crops include barley, wheat, oats, alfalfa, potatoes, vegetables, and grass and grain hay. Center pivot sprinkler systems (which began to be widely used in l975) have reduced farm labor demands, resulted in more efficient water use, and allowed production on marginal soils. Cropland comprises about 9% of the basin, while an additional 4.3% of the basin exists as irrigated hay meadow. Grazing is an important land use on public and private lands in the area.

The only surface water to leave the San Luis Valley is the Rio Grande River draining the southern end of the basin. The valley does have abundant ground water that supports considerable irrigation. Due to the high water table in the basin floor of the SLV IPA, prairie dog occupation is limited to the edges and slopes surrounding the area (Fig. 7).

Land ownership in the IPA is 51% private land, 42% federal land, and 5% state lands (Table 2; Fig. 7). The federal lands are administered by the USFS, BLM, NPS, and USFWS. State lands are administered by the State Land Board (SLB) and the CDOW.

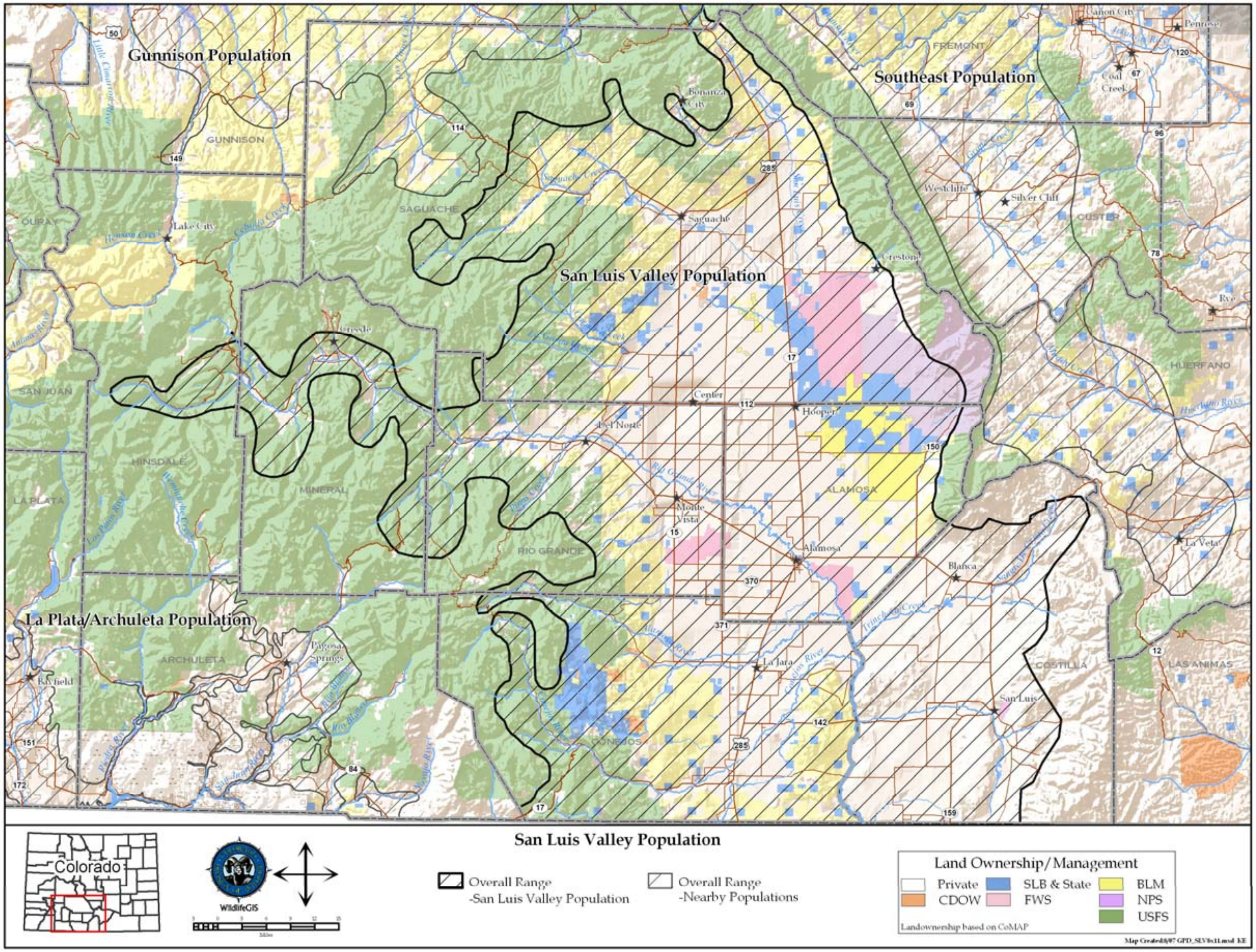


Fig. 7. Land ownership within the overall range of the Gunnison's prairie dog in the San Luis Valley Individual Population Area.

Population Information

Historically, GUPDs in Colorado were found in the SLV IPA (Capodice and Harrell 2003). In 1988, the Saguache BLM Field Office inventoried and mapped GUPD colonies in the San Luis Valley Resource Area to evaluate site potential for BFF reintroduction (BLM, unpublished data). These initial inventories covered the Punche Valley (5,763 acres) and Los Mogotes (59,520 acres). Two active colonies on 40 acres were mapped in the Punche Valley, and 8 colonies on 600 acres were mapped in Los Mogotes. During this survey, numerous prairie dog burrows were visible, but most were filled in with debris or were occupied by other species. This survey found that 0.9% of the San Luis Valley was occupied by GUPDs.

Fitzgerald (1991) expressed concern about the status of the GUPD in the San Luis Valley, indicating that plague and poisoning had eliminated some populations and overall populations were in poor condition in the area.

Issues

Cropland (90% irrigated) is a common land-use practice in the IPA. Prairie dog control is common in areas where agriculture and prairie dog occurrence overlap, but the extent of control activities is unknown.

Preliminary PCR analysis from CDOW surveys conducted in 2008 at Penitente Canyon in Saguache County revealed no evidence of plague (*Y. pestis)* DNA in flea pools collected off of GUPDs.

Solar energy development may become an issue in the San Luis Valley as the push for alternative energy sources continues.

Current Conservation Efforts

On the Rio Grande National Forest, conservation actions primarily involve considerations regarding whether the GUPD is present in project areas (Region 2 Sensitive Species status). USFS Districts do not give out the location of prairie dog sites to recreational shooters.

A seasonal shooting closure was instituted on public lands from 1 March – 14 June by the CWC in 2006.

South Park Individual Population Area

General Description of Area

The overall range of the GUPD in the South Park Individual Population Area (SP IPA) is 700,811 acres and occurs in Park County. South Park is a high intermountain grassland basin that occurs at an average elevation of 10,000 feet and encompasses the headwaters of the South Platte River. This IPA falls within the "montane" range of the GUPD as defined by the USFWS. GUPDs within this IPA are considered a candidate species for listing under the ESA.

The SP IPA has a short growing season, from mid-May to mid-September. Vegetation in the IPA consists predominantly of grasses and forbs (Fitzgerald and Lechleitner 1974). Grasses include muhly, fescue, wheat grass, and Junegrass. Forbs consist of fringed sage, senecio, and Indian paintbrush. Rabbit brush and big sagebrush are common shrubs in the area.

Land ownership in the SP IPA is 35% federal lands (including BLM, NPS, and USFS), 12% state lands (CDOW, SLB, state parks), and 52% private lands (Table 2, Fig. 8). Land-use practices within the SP IPA include livestock grazing, growing and harvesting of hay, and energy and mineral development (including sand and gravel mining, and oil and gas development).

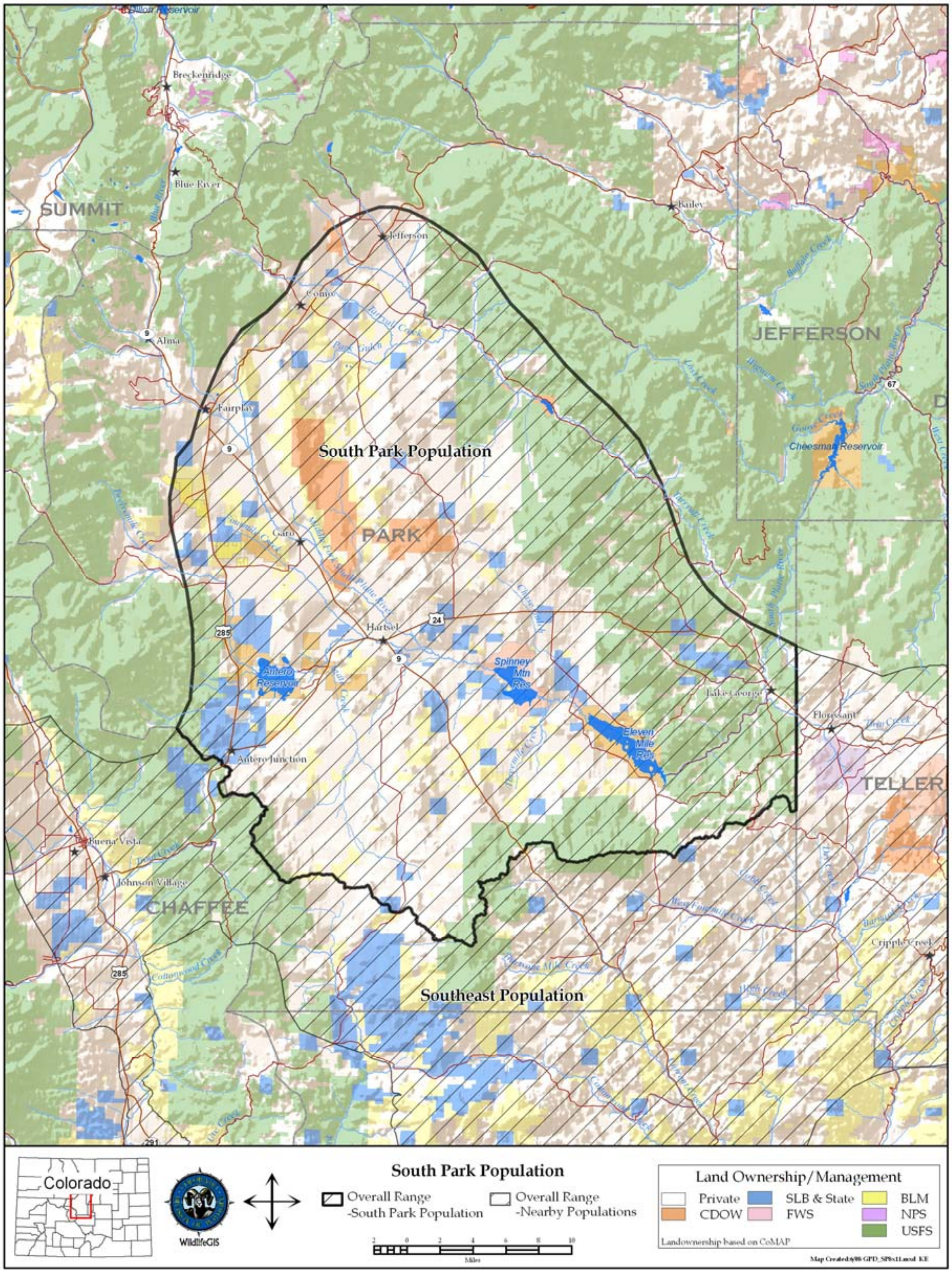


Fig. 8. Land ownership within the overall range of the Gunnison's prairie dog in the South Park Individual Population Area.

Population Information

Historically, GUPD distribution in South Park was continuous across the entire basin with an estimated density of $\geq$25 GUPDs per acre (Ecke and Johnson 1952). Prairie dog control was initiated in South Park in 1941, with strychnine and thallium used until 1947 (Ecke and Johnson 1952). These poisoning efforts were estimated to be less than 85% effective and areas were poisoned every year to maintain effectiveness. During 1945, workers poisoning the southeastern portion of the county found that over 240,000 acres had been eliminated due to plague (Ecke and Johnson 1952). In 1947, the Public Health Service crews began surveying the area and discovered that plague had spread 60 miles diagonally (southeast to northwest) across the county. And between 1947 and 1949, the entire population of prairie dogs on 915,000 acres was reduced to less than 5% of their original occupancy (Ecke and Johnson 1952). Today few GUPD colonies exist in South Park, with the estimated occupied area encompassing approximately 3,000 acres in the IPA (Colorado Division of Wildlife 2003b).

Fitzgerald and Lechleitner (1974) studied the biology of the GUPD in South Park from July 1965 to September 1966. During the research project a plague epizootic occurred, causing the main study colony to die off. Their study site was located 7.5 miles south from Fairplay, with the mapped portion of the study colony comprising 13.8 acres.

In 1990, the USFWS conducted surveys of GUPD distribution throughout Colorado (Finley 1991). Surveys were conducted by driving highways and roads and recording observations of prairie dogs. Finley (1991) noted that South Park was almost devoid of prairie dogs, but found a medium-sized colony (defined as having 21-60 mounds) near Hartsel, and other colonies in nearby Teller and Chaffee Counties.

Issues

Prairie dog control (strychnine and thallium) began in South Park in 1941, with the use of compound 1080 beginning in 1947 (Ecke and Johnson 1952). Poisoning may still be occurring since most of the IPA is under private ownership (Table 2). However, there are so few GUPDs in the IPA that poisoning is probably limited to ground squirrel control.

One rodent that has shown signs of recovery after the plague epizootic in 1947 is the Wyoming ground squirrel (WYGS; Ecke and Johnson 1952). The behavior of the WYGS to enter into an early hibernation and aestivation may account for the survival of this species over the GUPD. The WYGS was not as abundant or as widely distributed as the GUPD in Park County prior to the plague epizootics, but it has reappeared in areas that no longer maintain GUPD populations. The WYGS exists in habitats similar to GUPD and is known for its ability to invade new ranges rapidly (Ecke and Johnson 1952). Fleas common on this squirrel have been proven to be effective biological vectors of plague (Ecke and Johnson 1952).

Fitzgerald (1991) expressed concern about the status of the GUPD in South Park indicating that plague and poisoning had eliminated almost all of the populations there.

Finley (1991) thought that GUPD populations in South Park were below those reported in the years prior to plague.

Current Conservation Efforts

The USFS considers the GUPD a Region 2 Sensitive Species. Conservation actions primarily consider the presence of GUPDs in project areas and recommend appropriate mitigation measures. USFS Districts do not give out the location of prairie dog sites to recreational shooters.

A seasonal shooting closure was instituted on public lands from 1 March – 14 June by the CWC in 2006.

Southeast Individual Population Area

General Description

The overall range of the GUPD in the Southeast IPA (SE IPA) is 1,713,609 acres and occurs in Chaffee, Custer, El Paso, Fremont, Huerfano, and Teller counties. This IPA falls within the "montane" range of the GUPD as defined by the USFWS. GUPDs within this IPA are considered a candidate species for listing under the ESA.

The northern part of the SE IPA is composed of the Upper Arkansas Valley in Chaffee County, the area along the Arkansas Drainage into Fremont County, into the Waugh Mountain area on the north side of the river, and up onto the De Weese Plateau on the south side (Fig. 9). Teller County and the Rampart Range in El Paso County also contain prairie dogs. The southern part of the SE IPA is composed of the Wet Mountain Valley, Upper Huerfano Valley, and the Upper Cuchara Valley (Fig. 9). GUPDs occupy an elevation range between 6,000 and 9,000 feet in the SE IPA.

The occupied areas within the IPA are primarily located in flat mountain parks such as Maxwell Park in Chaffee County. These areas are used for haying, or for residential development. Isolated colonies of prairie dogs occur in some of the dry canyons off the Arkansas River in Fremont County. There are also scattered parks in the Thirty-nine Mile volcanic field that harbor prairie dogs. In the Wet Mountain Valley, prairie dogs commonly occur on rangeland adjacent to haying operations. A similar pattern occurs in the Upper Huerfano and Cuchara drainages.

Vegetation in occupied habitat in the IPA consists predominantly of grasses and forbs. Grasses include muhly, fescue, wheat grass, and Junegrass. Common forbs are fringed sage, senecio, and Indian paintbrush. Rabbit brush is a common shrub in the mountain parks where GUPDs occur within the IPA.

Land ownership in the SE IPA is 32% federal lands (including BLM, NPS, and USFS), 6% state lands (CDOW, SLB, state parks), and 62% private lands (Table 2, Fig. 9).

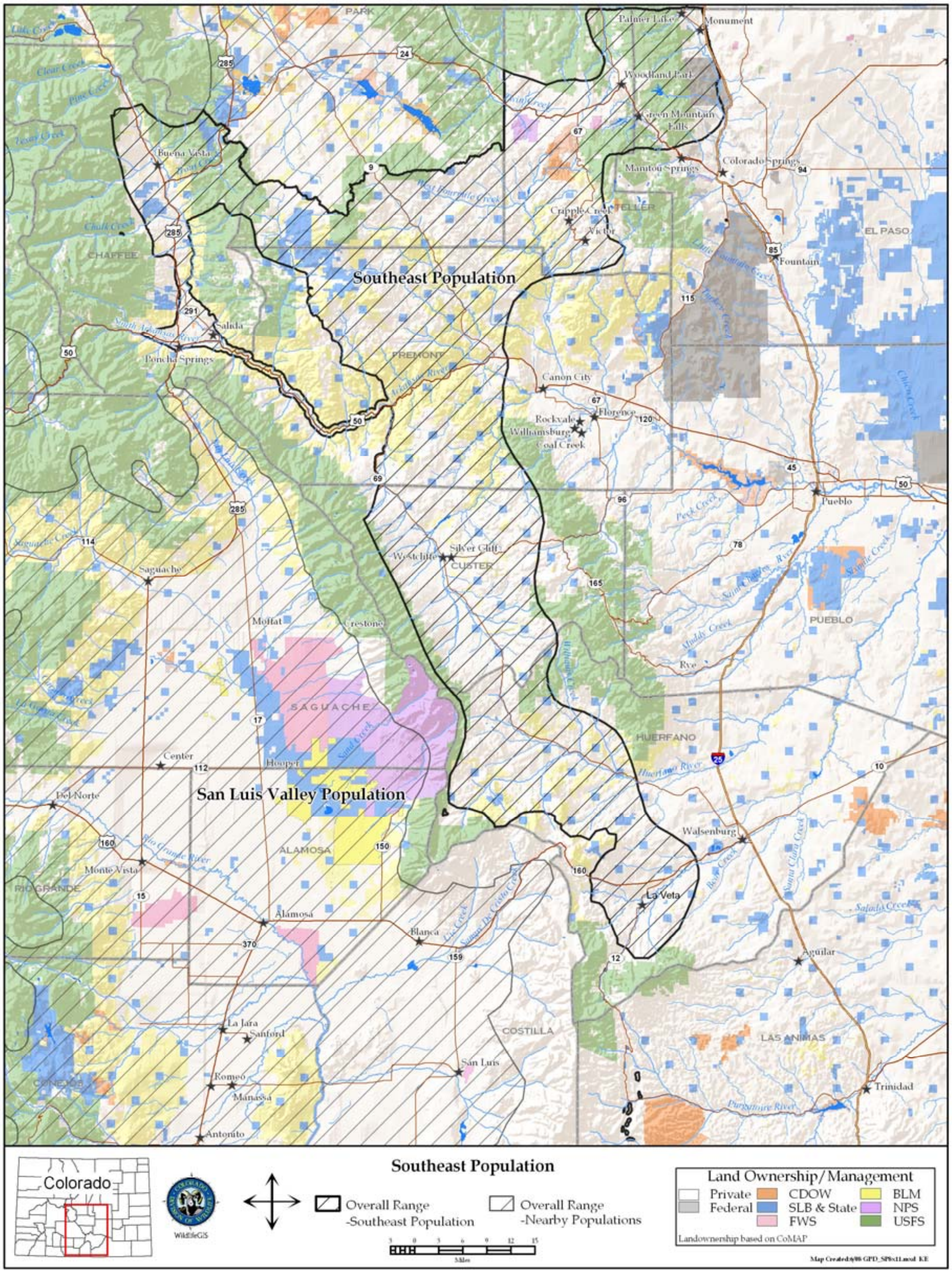


Fig. 9. Land ownership within the overall range of the Gunnison's prairie dog in the Southeast Individual Population Area.

Population Information

Historically, GUPDs were found along the Arkansas River Valley from Twin Lakes to Pueblo (Capodice and Harrell 2003). They are most abundant in the lower elevations, especially when associated with haying operations. Within native rangeland settings, colonies of prairie dogs in the IPA are small and widely distributed throughout mountain valleys and parks. The highest densities of colonies occur in the mountain valleys of the Upper Arkansas in Chaffee County, the Wet Mountain Valley in Custer County, and the Upper Huerfano drainage in Huerfano County.

Kartman et al. (1962) observed a complete die-off of a colony in Chubb Park, Chaffee County in 1959, due to plague. Lechleitner et al. (1962) also observed epizootic plague in an isolated colony in Chaffee County: in August 1958 the population was stable and healthy, but in 1959 a plague outbreak occurred and within 3 months the epizootic had spread 2 miles with prairie dogs absent from the area in 1960–1961. Fitzgerald (1991) found that prairie dog populations were extirpated from the extreme upper Arkansas River Valley.

CDOW biologists working in the Chubb Park area have not seen GUPDs there for at least 27 years (Randy Hancock, Buena Vista DWM, personal communication 2009) and there have been no colonies detected anywhere near Chubb Park. The only colonies found to be occupied are on the Arkansas Valley floor.

Issues

Poisoning is occurring on occupied habitat that occurs on private lands. The extent of control efforts is unknown. Plague also probably recurs in at least some parts of the SE IPA, but neither the extent nor the frequency of outbreaks is known.

Current Conservation Efforts

The USFS considers the GUPD a Region 2 Sensitive Species. Conservation actions primarily consider the presence of GUPDs in project areas and recommend appropriate mitigation measures. USFS Districts do not give out the location of prairie dog sites to recreational shooters.

A seasonal shooting closure was instituted on public lands from 1 March – 14 June by the CWC in 2006.

Southwest Individual Population Area

General Description Area

The overall range of the GUPD in the Southwest Individual Population Area (SW IPA) encompasses 1,102,086 acres and occurs in Dolores, Montrose, Montezuma, Ouray and San Miguel counties. Only those GUPDs that inhabit Montrose County fall within the "montane" portion of the range as defined by the USFWS. The rest of this IPA falls within the "prairie" range of the GUPD as defined by the USFWS. GUPDs within the "prairie' portion of the IPA are not considered a candidate species for federal listing.

The SW IPA includes portions of both the San Miguel and Dolores River watersheds and the eastern edge of the Colorado Plateau physiographic province, which consists principally of a gently sloping plain known locally as the Dolores Plateau (Fig. 10). This area generally slopes toward the southwest and is dissected by numerous deep canyons.

The areas within the IPA occupied by prairie dogs include high elevation mesas in the east (Iron Springs Mesa, Beaver Mesa), open mid-elevation parks in the center (Wrights Mesa, First, and Second Park), and broad low elevation valleys in the west and south (Gyp Valley, Paradox, and Dry Creek Basin). The quantity and quality of the habitat varies widely throughout the IPA based primarily on differences in precipitation and elevation.

Typical vegetation types in occupied areas are grass-dominated rangeland, sagebrush, salt desert shrub, and irrigated agricultural lands. The salt desert plant communities are found at lower elevations to the south and west and support grasses, shrubs, and forbs that are both drought and salt tolerant. Dominant shrubs include saltbush, sagebrush, and greasewood. Associated grasses include Indian ricegrass, alkali sacaton, and galleta. Non-native annual weeds such as cheatgrass can be abundant on depleted or disturbed sites. Plant communities of the foothill zone vary between grassland and shrub-dominated, depending upon fire occurrence. The dominant woody species within this zone include piñon pine, Utah juniper, sagebrush, serviceberry, and antelope bitterbrush. Grasses include Junegrass, *Stipa* spp., Western wheatgrass, and muttongrass.

In addition to native plant communities, agricultural operations exist on many of the deeper soil areas, particularly the reddish eolian soils covering the mesa tops. Agricultural use includes both irrigated and non-irrigated croplands, as well as pasture converted to introduced grasses and Conservation Reserve Program lands.

GUPDs occupy an elevation range between 6,000 and 9,000 feet in the SW IPA. They are most abundant at the lower elevations, especially when associated with irrigated agricultural operations (particularly alfalfa or grass hay fields). Within native rangeland settings, colonies of GUPDs in the IPA are small, occur at low densities, and are widely distributed.

Land ownership in the area mapped as GUPD overall range is 53% private, 44% federal, 2% state, and <1% tribal lands (Table 2, Fig. 10).

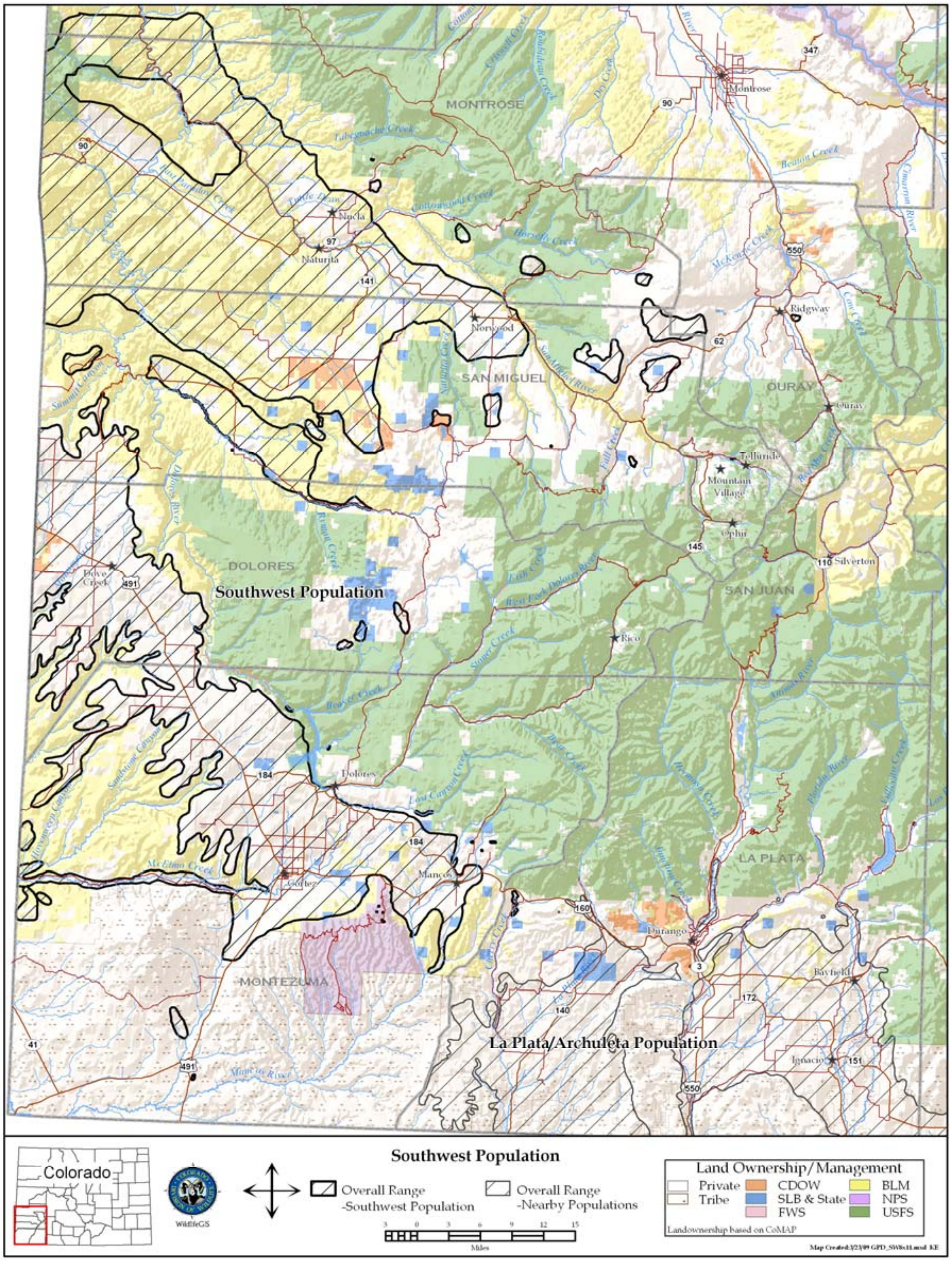


Fig. 10. Land ownership within the overall range of the Gunnison's prairie dog in the Southwest Individual Population Area.

Population Information

Historic information regarding GUPD populations does not exist for this IPA. GUPD densities are low to very low in the native rangeland areas. Converted sagebrush stands (generally crested wheat plantings) normally hold higher densities of GUPDs. When associated with irrigated agriculture, both populations and densities can become quite high, particularly in those areas which have been overgrazed or fallowed for any length of time.

Black sagebrush is the sage type most commonly used by GUPDs in the area, probably due to its generally low height and crown density. The more open grassland areas occupied by GUPDs often consist of converted semi-irrigated or dryland pastures that were once dominated by Wyoming sagebrush.

Land form and terrain features restrict the areas available for occupation by GUPDs in the SW IPA. In the east, the high elevation mesas are surrounded by thick forests of spruce-fir and ponderosa pine. In the west, the broad valleys and open parks are hemmed in by steep canyons or forests of piñon-pine and juniper. However, at the present time GUPDs can be found in nearly any habitat suitable for occupation (see "Habitat Requirements").

The only survey completed in the area was completed in 2003 in the southern half of Montezuma County by the NPS to evaluate GUPD occupancy (Coyler 2003). Surveys were completed along roads, on foot, and on horseback. From these surveys, 23 colonies on 608 acres were located in Mancos Valley, and 28 colonies on 539 acres were located in Montezuma Valley.

Issues

Plague may be a problem for this area, because periodic die-offs not associated with any poisoning or other control measures have been noted by local farmers and ranchers in the past. During the surveys in Montezuma County in 2003 (Coyler 2003), the major negative impact to populations of prairie dogs was plague. As described by Coyler (2003), "It appears populations build up, numbers get high per colony, and new colonies are formed up to 5 or more miles from core colonies. Then plague hits and colonies nearly die off with some completely dying out. Plague travels along drainages with neighboring drainages somewhat protected from epizootics. A few prairie dogs are usually able to survive the epizootic and within 2-3 years the population begins to rebuild." Plague appeared to impact Montezuma County in 1985, 1993, and 1999 (Coyler 2003).

Preliminary analysis of flea PCR data from CDOW 2008 surveys conducted in Dry Creek Basin and Hamilton Mesa (San Miguel County) revealed evidence of *Y. pestis* DNA in flea pools from 1 of 31 sampled prairie dogs. Both colonies remained active after sampling occurred and no large scale die-offs were detected. Both colonies were documented to have remained active in spring 2009.

During the early stages of settlement, large tracts of land in areas such as Wright's Mesa (Norwood/Redvale) and First/Second Parks near Nucla were cleared of piñon-juniper and converted to crops or rangelands. Once these areas were put under irrigation, prairie dogs likely increased within them. Currently, 270,440 acres (24%) of the SW IPA is in agricultural lands (see Table 14). Shooting, poisoning, and periodic flooding with irrigation are the most common control measures taken by landowners on private lands. Although sometimes effective on a local scale, these measures are not believed to be limiting the population as a whole.

Oil and gas development has increased within the SW IPA. Currently, 351,158 acres (32%) of the GUPD overall range within the SW IPA have been authorized for federal oil and gas leases (see "Energy & Mineral Development" under ISSUES & CONSERVATION STRATEGIES).

Although evidence is largely anecdotal, drought conditions during the last decade in southwestern Colorado also may be affecting overall GUPD population numbers. Conditions from 2001 and 2003 were particularly harsh. In native rangeland settings, CDOW biologists noted a complete absence of prairie dog activity during the summer of 2002. It was believed that drought conditions forced the remaining animals into a state of aestivation during this period. Since that time, GUPDs have reappeared in these habitats in numbers approximating pre-drought levels. Within irrigated or semi-irrigated croplands, GUPDs may have actually increased their numbers during this same time frame. A lack of irrigation water forced many farmers to fallow their croplands and the prairie dogs quickly colonized these areas.

Current Conservation Efforts

The USFS considers the GUPD as a Region 2 Sensitive Species. Conservation actions primarily involve considerations regarding whether the species is present in project areas. USFS Districts do not give out the location of prairie dog sites to recreational shooters.

A seasonal shooting closure was instituted on public lands from 1 March – 14 June by the CWC in 2006.

E. White-tailed Prairie Dog Individual Population Areas: Status & Distribution

Grand Valley-Uncompahgre Individual Population Area

General Description of Area

The overall range of the GUPD in the Grand Valley-Uncompahgre Individual Population Area (GVUN IPA) encompasses 957,702 acres. This population is located in west-central Colorado (Fig. 11) and extends along the Colorado River from western Mesa County (CO/UT border), eastward and southward onto the Uncompahgre Plateau to near Ouray in Ouray County, eastern Delta County, and to Cerro Summit in western Montrose County. In addition, a few scattered WTPD colonies remain near the town of Mesa and in the Roan Creek drainage near DeBeque. The GVUN IPA is geographically isolated and separated from the Northwest IPA by the Bookcliffs and the Roan Plateau on the north. This IPA overlaps somewhat with GUPD range in the very south end of its distribution (in the Ridgway area).

The climate is typified by hot summers and cool winters. Average precipitation is low (usually less than 10 inches), most of which falls as rain during occasional summer thunderstorms and as snow during the winter months. Much of the area occupied by WTPDs is described as "adobe badlands" and soils are typically alkaline.

The WTPD habitat in this IPA is classified as semi-desert shrublands (Fleischer and Emerick 1984). Greasewood, four-winged saltbush, and shadscale are the most common dominants of these shrublands. Invasive cheatgrass is now found throughout the area, with highest occurrence in the Grand Valley. Annual wheatgrass is also becoming highly prevalent in this area. Other herbaceous species include salt grass, blue grama, foxtail, kochia, whiteweed, galleta-grass, and Indian ricegrass (Fleischer and Emerick 1984).

Private lands make up the majority (68%) of the GVUN Area, the BLM manages 31%, and the remaining 2% is controlled by various other federal and local governments including the SLB (0.15%), other state-owned lands (0.62%), other federal lands managed by NPS, USFS, USFWS, Bureau of Reclamation (BOR; 0.14%), and areas owned by city and county governments (Table 2, Fig. 11). Of all the WTPD IPAs in Colorado, this IPA clearly has the highest proportion of WTPD overall range under private land ownership.

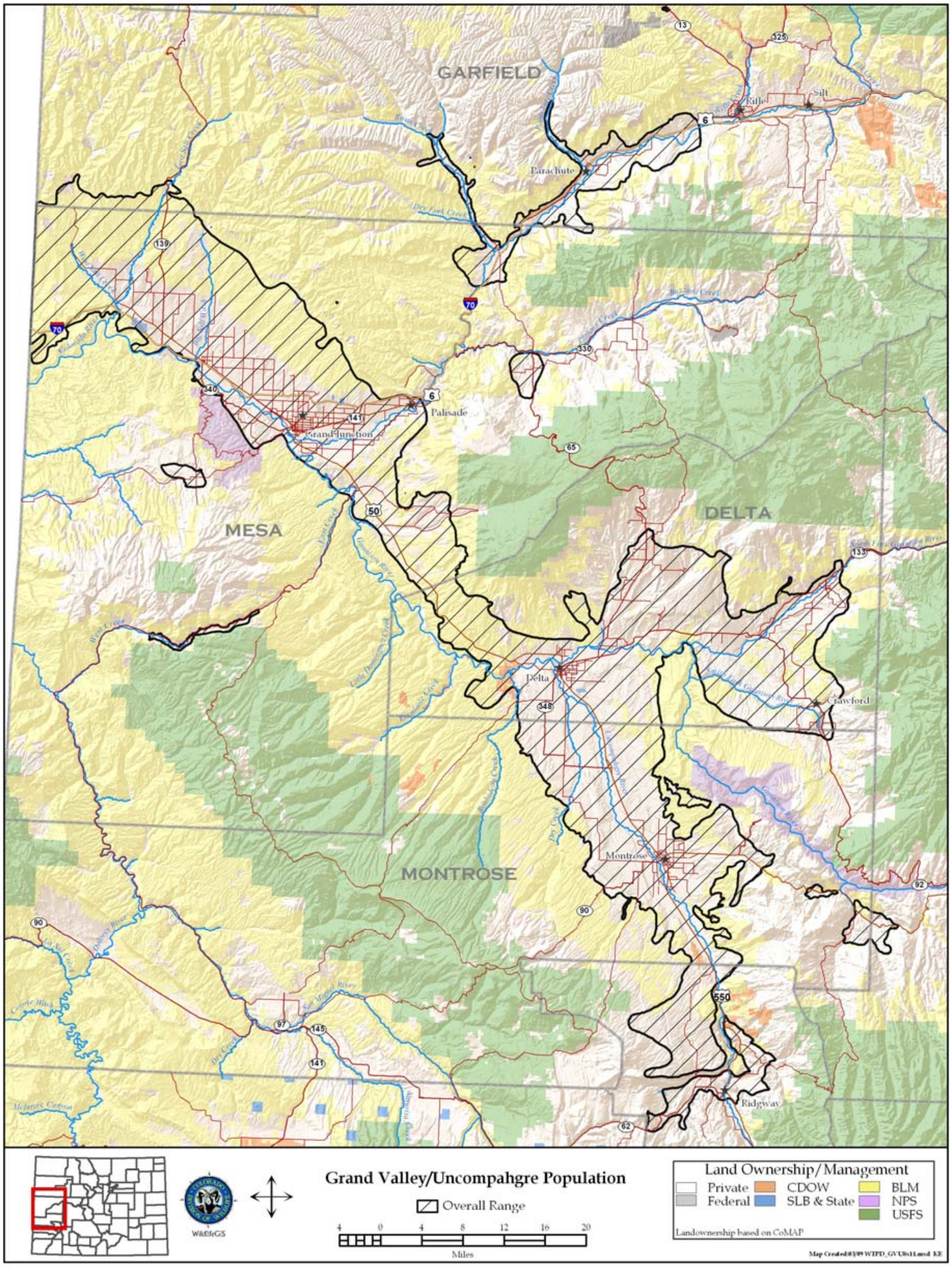


Fig. 11. Land ownership within the overall range of the white-tailed prairie dogs in the Grand Valley–Uncompahgre Individual Population Area.

Population Information

The Grand and Uncompahgre River valleys became important agricultural centers in the early to late 1900s (Pizzimenti 1975). Irrigation turned many xeric sage flats into lush productive farms and pastures, which presumably resulted in a positive population response by prairie dogs. Prairie dogs maintained scattered populations in these valleys and were often found in and around irrigated crops and pastures at high densities, due to the nutritious and plentiful forage (Pizzimenti 1975).

WTPD population trend data in the Grand Valley are lacking. Virtually no empirical data on the spatial distribution of WTPDs are available prior to the mid-1970s. Only rough inferences can be made from the existing knowledge on the spatial distribution and population trends. One can infer from the amount of housing development occurring in the Grand Valley that prairie dog colonies have become more fragmented, with reduced connectivity among existing population areas. For example, the population of WTPDs near the Whitewater area, south of Grand Junction, is nearly completely separated by urban development from the WTPDs located west of Grand Junction and Fruita. There are still vast acreages of suitable habitat that support low WTPD densities.

Information on prairie dog distribution and abundance in the Uncompahgre Valley is also very limited. The BLM office in this region has periodically been re-surveying colonies to evaluate their status. The last survey was completed in 2007, during which 59 known prairie dog colonies northwest of Montrose were visited and compared with distribution data collected from the mid-1990s. Approximately 17% of the colonies (10/59) showed signs of current prairie dog activity while the remaining colonies were abandoned or extirpated (Hunt 2007). The 10 active sites were all located north of the Gunnison River in Delta County. Prairie dog populations have declined since the first surveys completed in 1978 (Jones 2004), and data collected in 1995 and 2007 by the BLM confirm that this decline is continuing.

Issues

Loss of habitat from urban development is affecting WTPDs in the GVUN IPA. The Grand Valley area is experiencing explosive growth at this time due to housing needs brought about in large part by the increase in energy resource exploitation. The Delta-Montrose- Ridgway area is also experiencing a rapid increase in human population and associated conversion of rangelands and agricultural lands to urban settings.

Associated with the increased urban growth is also an increase in recreational uses of BLM lands in occupied WTPD range. Recreational uses impacting WTPDs include shooting, ATV/motorcycle activities, and disturbance from increased human and dog presence associated with hikers, mountain bikers, and horseback riders.

Oil and gas development in the DeBeque to Rifle portion of the GVUN IPA may have a significant impact on the remnant WTPDs that remain in this corridor.

Plague is also known to cycle through the GVUN area and has resulted in WTPD population die-offs. Due to a low precipitation regime in this area, drought periods that have occurred in the GVUN IPA have affected available forage for WTPDs, possibly impacting survival and reproduction.

Current Conservation Efforts

A group of volunteers has been relocating WTPDs in the Grand Valley since 2004. These volunteers are focusing on capturing WTPDs on private land sites that are being developed and moving them to areas on BLM lands that have been approved and identified as receiving areas. Based on past experience, survival of relocated prairie dogs may be relatively low, but some may survive and begin to reoccupy sites that have become devoid of WTPDs in recent years (most likely from plague events). Relocated prairie dogs are not protected from recreational shooters unless they are relocated during the seasonal shooting closure put in place by the CDOW (1 March–14 June).

BLM lands adjacent to and surrounding urban areas offer protection to WTPDs from urban development. Some of these BLM lands have special designations offering more restrictive protection than other BLM managed lands, such as a yearly closure to target shooting, motorized and non-motorized travel restrictions to designated routes only, and withdrawal from all forms of mineral entry, including oil and gas leasing. Lands managed by the NPS also offer protection from development and shooting, as well as restricted off-road motorized vehicle access. Some private lands have been preserved from rural development through conservation easements, but these easements have not been established for the goal of protecting WTPDs.

The USFS considers the GUPD a Region 2 Sensitive Species. Conservation actions primarily consider the presence of GUPDs in project areas and recommend appropriate mitigation measures. USFS Districts do not give out the location of prairie dog sites to recreational shooters.

A seasonal shooting closure was instituted on public lands from 1 March – 14 June by the CWC in 2006.

North Individual Population Area

General Description of Area

The overall range of WTPDs in the North Individual Population Area (NO IPA) encompasses 489,472 acres and occurs in Jackson and Larimer counties. North Park is an intermountain park on the east side of the Continental Divide and comprises the majority of Jackson County (Fig. 12). The park itself spans roughly 40 miles from south to north. North Park is surrounded by mountains, with the Park Range on the west, the Medicine Bow Mountains on the east, and the Rabbit Ears Range on the south. In Larimer County, WTPDs are located in the Laramie River Valley, bordered on the west side by the Medicine Bow Mountains (the Jackson, Larimer County line) and on the east side by the Laramie Mountains. The Wyoming state line is the northern border of both North Park and the Laramie River Valley.

North Park is relatively flat, sagebrush grassland with numerous wetlands interspersed with wide, willow-dominated drainages. North Park encompasses the headwaters of, and is drained by, the North Platte River, which flows north into Wyoming. The major drainages comprising the North Platte drainage in North Park are Grizzly Creek, the Illinois River, the Michigan River, the Canadian River, and the North Fork of the North Platte River. Elevations in Jackson County range from 7,800 feet at Northgate to 12,965 feet at Clark's Peak. The average elevation of the open, sagebrush-grassland park is 8,000 feet.

Habitat in the Laramie River Valley is montane, shortgrass prairie with scattered low density sagebrush. The valley is at a relatively high elevation of around 8,500 feet. Portions of the valley are farmed using irrigated and dryland agricultural practices. The Valley is drained by the Laramie River, which flows north into Wyoming.

The climate in the NO IPA is semiarid, characterized by short, cool summers followed by long, cold winters. The average frost-free season is only around 43 days from the end of June to early August. Precipitation ranges from approximately 25 inches at the edge of the forest in higher elevations to approximately 10 inches at Walden, with most of the precipitation coming in the form of snow.

Land ownership in the IPA is about 56% private land, 7% state land and 36% federal land (Table 2, Fig. 12).

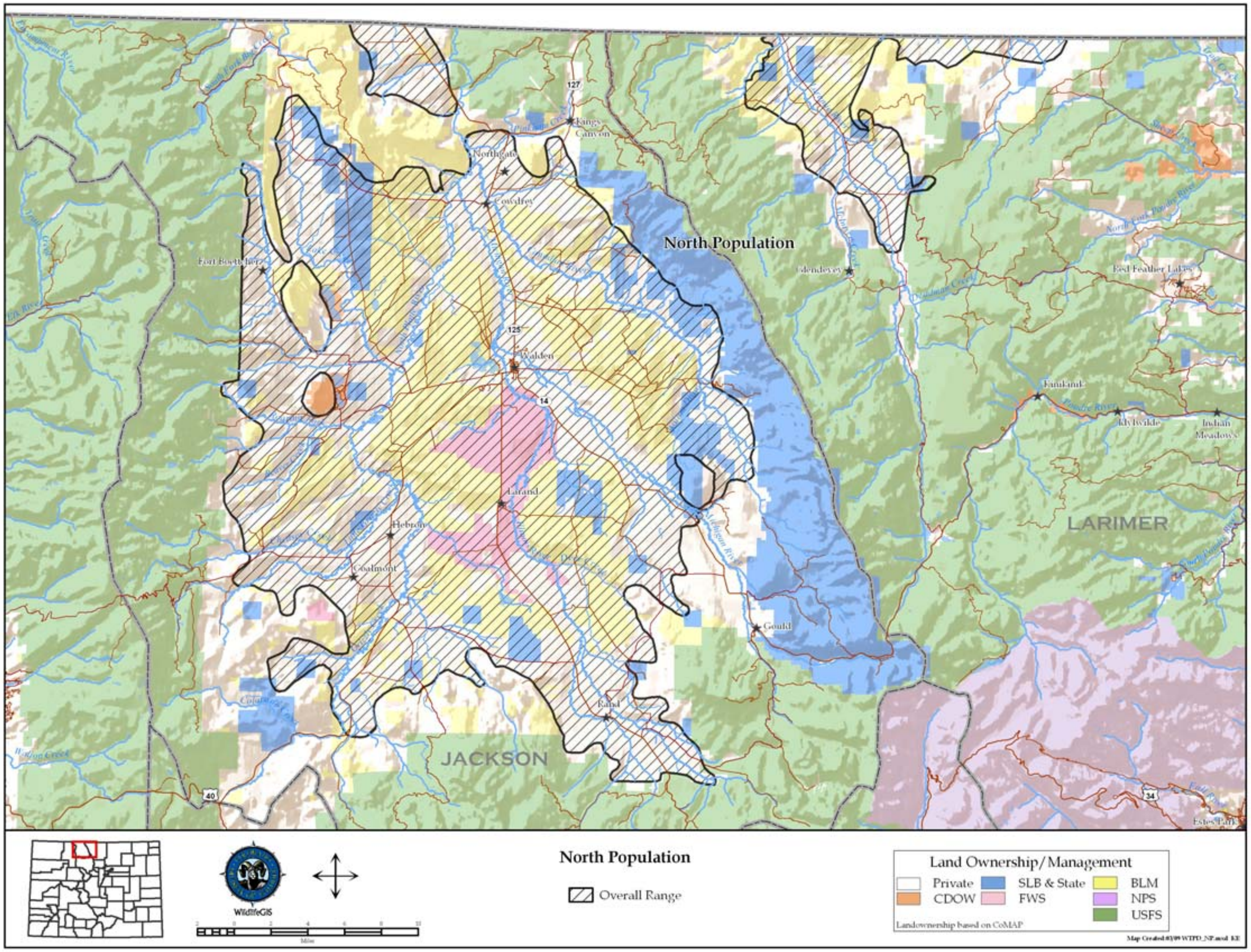


Fig. 12. Land ownership within the overall range of the white-tailed prairie dog in the North Individual Population Area.

Population Information

Historic information on the distribution and abundance of WTPDs in North Park and in the Laramie River Valley is spotty. One piece of information on the historic status of WTPD colonies in the Laramie River Valley is that 1 of the 7 BFF historical locations recorded in the WTPD range in Colorado (Anderson et al. 1986) occurred in this valley. This record suggests that historically, prairie dogs may have been abundant in some locations in order to sustain BFF populations. Today, there are only 2 known colonies of WTPDs (J. Jackson, CDOW District Wildlife Manager, personal communication 2009). Three colonies were known to occur 25–30 years ago, but one of these died off and has not been reestablished. One of the 2 colonies is contiguous with WTPD populations in Wyoming. Both colonies have apparently remained relatively stable over the past 20 years.

In North Park, WTPDs are found in isolated open pockets of suitable habitat, above wet meadow areas and outside of, and often on the edge of, sagebrush, greasewood, and other shrub communities. WTPDs appear to exist primarily on more barren and often alkaline areas relatively free of shrubs (although they are sometimes found scattered within shrub communities), and with overall lower vegetation. The 2 colonies in the Laramie River Valley occur near meadows and low sagebrush stands with understories of grass. Overall, the colonies in the IPA are small and dispersed, although densities of prairie dogs appear high in certain locales such as on the AWR.

Natural vegetation community juxtaposition and composition restricts areas available for use by WTPDs in North Park and the Laramie River Valley. Open and more barren areas above wet meadow water tables are the locales where WTPDs are found. Generally these areas are pockets on the landscape interspersed with thicker shrubs or broken up by wet meadow habitat.

Issues

According to Dean Biggins (USGS, personal communication 2009) plague is probably present in North Park, but he has not documented the disease there. Evidence at this point is circumstantial, but it does appear that plague has impacted WTPDs in North Park because: (1) there is documented plague north, south, east, and west of North Park; (2) there are literally thousands of acres of old mounds with scattered small active colonies, appearing much like other sites where plague has had serious impacts; and (3) the area is on the wet and high end of the spectrum for WTPDs, where plague seems to be more of a problem. Plague has not been recorded in WTPD study colonies at the AWR for the past 4 years (2006 to 2009; J. Hoogland, University of Maryland, personal communication 2009).

Current Conservation Efforts

Some of the highest density WTPD colonies are located on the AWR. The AWR Comprehensive Conservation Plan sets guidance for upland habitat objectives and requires that the refuge address the potential impacts to WTPDs from management decisions. Upland habitats are listed as an objective in the AWR Comprehensive Conservation Plan. WTPD populations are protected on the AWR from development, poisoning, and shooting.

In February 2006, Dr. John L. Hoogland, University of Maryland, began a long-term WTPD behavioral and demographic research project on 6 WTPD colonies at the AWR. All adults and juveniles are captured and marked each year. This behavioral study is based on the observations of marked individual WTPDs. Students enter 2-meter-high observation towers each morning at dawn before the WTPDs emerge from their burrows. Individuals are identified and observed (using binoculars) all day until they have all returned into their burrows at dusk. The information gathered allows estimates for key issues such as longevity, predation, overwinter mortality, immigration, litter size, annual and lifetime reproductive success, colony size, composition of clans, annual variation, infanticide, sexual dimorphism, and infestation by ectoparasites.

The USFS considers the GUPD a Region 2 Sensitive Species. Conservation actions primarily consider the presence of GUPDs in project areas and recommend appropriate mitigation measures. USFS Districts do not give out the location of prairie dog sites to recreational shooters.

A seasonal shooting closure was instituted on public lands from 1 March – 14 June by the CWC in 2006.

Northwest Individual Population Area

General Description of Area

The overall range of WTPDs in the Northwest Individual Population Area (NW IPA) encompasses 1,657,653 acres. This IPA is in the extreme northwestern corner of the state and includes Moffat and Rio Blanco counties (Fig. 13). Two primary areas contain the majority of WTPDs; these are Little Snake and Wolf Creek-Dinosaur-Rangely area. The Little Snake area is located completely in Moffat County, north of State Highway 318 and west of the Little Snake River (Fig. 13). The Wolf Creek area lies predominantly in southwestern Moffat County, about 18 miles northeast of Rangely (Fig. 13); about 10% of the area is located in northwest Rio Blanco County. Additionally, WTPDs extend across lands adjacent to Highway 40 to the Colorado-Utah state line; both east and west of the town of Dinosaur and along Highway 64 to Rangely, including the Rangely Oil Field and the Colorado side of Coyote Basin.

Elevations in the NW IPA range from approximately 5,300 to 8,000 feet, with the lower elevations occurring in the west portion of the IPA. The climate in the NW IPA is semiarid, characterized by low annual precipitation, extreme evaporation rates, and wide shifts in diurnal temperature. Average annual precipitation is approximately 9-15 inches, with the driest conditions occurring in midsummer (Wolf Creek Work Group 2001).

Most of the area within the NW IPA occupied by WTPDs consists of either the salt-desert shrub community or the big sagebrush community. Saltbush association occurs below 6,000 feet and is found on lower elevation foothill slopes, semiarid drainage bottoms, and alluvial deposits (Wolf Creek Work Group 2001). The salt-desert community consists of salt-tolerant semi-desert shrubs, grasses, and forbs. Dominant shrubs include Gardner's saltbush, mat saltbush, shadscale, big sagebrush, and winterfat. The sagebrush community is dominated by basin big sagebrush, Wyoming big sagebrush, and various species of rabbit brush and greasewood. Needle and thread grass, western wheatgrass, Indian rice grass, Sandberg's bluegrass, Salina and Colorado wildrye, and galleta are associated understory species, with cheatgrass invasions occurring in the area as well.

Current and historic land use in the area is primarily livestock grazing, with the exception of the 30,000-acre Coal Oil Basin (Colorado's largest oil field) located north and west of Rangely. First discovered in 1933, active development of the field was prompted by war demand in 1944. The field was fully developed at 40-acre spacing with 478 wells by 1949. Beginning in 1963, Chevron began infill drilling to improve oil recovery, and by 1984, a majority of the field had been drilled on 20-acre spacing. The field is still active, with considerable maintenance activity and expansion of the recovery process (Wolf Creek Work Group 2001). At any given time, prairie dogs may occupy about 7,000 acres of Coal Oil Basin (Wolf Creek Work Group 2001).

The majority (65%) of WTPD range in this IPA is under federal management, with the BLM managing the majority (98%) of the federal lands (Table 2, Fig. 13). The Wolf Creek–Dinosaur-Rangely area and Coyote Basin are managed by the BLM's White River Field Office, while the Little Snake Area is managed by the Little Snake Field Office. The NPS (Dinosaur National Monument) and the USFWS (Brown's Park National Wildlife Refuge) manage the remaining 2% of federal lands (Table 2). State-owned lands account for 8% of the overall range, with the SLB managing the majority of the state lands. Twenty-seven percent of the mapped overall range is in private ownership (Table 2, Fig. 13).

The majority of the WTPD overall range is either in high or medium potential for oil and gas development (see "Energy & Mineral Development" under ISSUES & CONSERVATION STRATEGIES). Both the BLM Field offices (Little Snake and White River) within this IPA are undergoing Resource Management Plan revisions to address oil and gas development and associated impacts to prairie dogs.

Both Wolf Creek and Coyote Basin are sites where BFFs have been released, beginning in 2001. Little Snake was scheduled for BFF release in the mid-1990s, but plague hit the population of WTPDs, dropping their numbers to a level too low to support a BFF reintroduction effort. WTPD populations in the Little Snake area have not yet recovered to the point where a BFF release would be reconsidered.

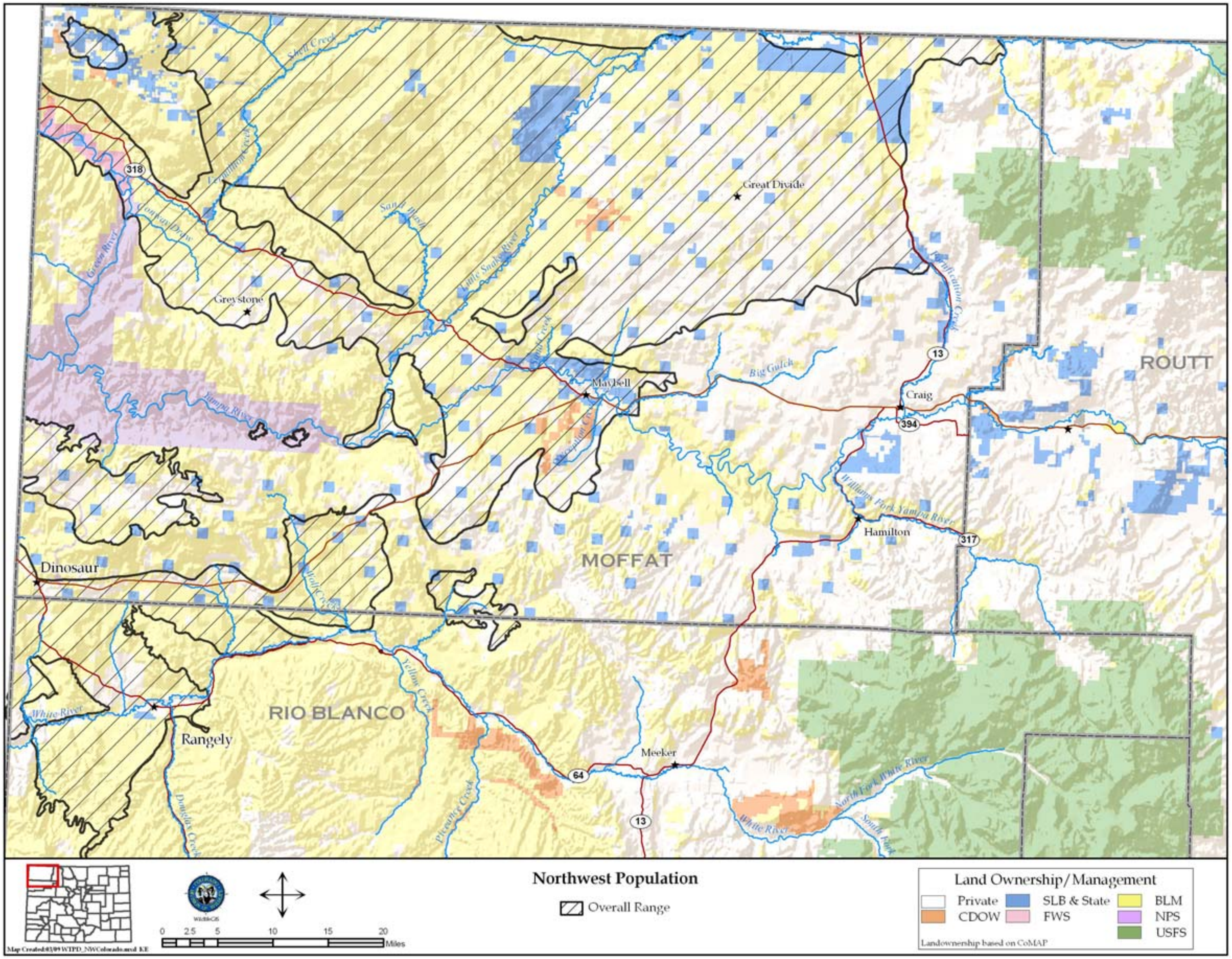


Fig. 13. Land ownership within the overall range of the white-tailed prairie dog in the Northwest Individual Population Area.

Population Information

The approximate historic range of the WTPD in northwest Colorado was documented by Ramaley (1910) and Cary (1911). Additional data on the distribution of this species based on museum records is presented by Armstrong (1972). These sources indicate that WTPDs once occurred in many areas where there are few, if any, remaining populations. Ramaley (1910) noted that WTPD colonies were common between Rifle and Meeker, between Meeker and Axial Basin, along Little Beaver Creek in the White River Valley, and up the White River to a point just below Buford. Cary (1911) documented WTPD colonies along the upper Little Snake River to near Honnold (Routt County), along the upper White River as far as the South Fork, throughout the Bear River (Yampa) region upstream to Egeria Park, and from Axial Basin across the lower passes of the Danforth Hills to Meeker. Locations of museum specimens reviewed by Armstrong (1972) corroborate these descriptions as well as documenting the presence of WTPD throughout western Moffat and Rio Blanco counties.

At various times since 1976, the BLM, USFWS, and CDOW have mapped and evaluated WTPD distribution and abundance within the NW IPA (Wolf Creek Work Group 2001). Since the earliest mapping and inventory efforts, it is apparent that prairie dog populations are in constant flux, subject to large, unpredictable, and often rapid fluctuations in densities and distribution (Wolf Creek Work Group 2001).

The WTPD population data in the NW IPA were collected over the years using similar, but slightly different techniques and approaches. Understanding that there are these differences, we present a summary of all the data available to give insight into population variation, major discernable trends, and the difficulty in assessing populations. The population information is presented separately for the Little Snake and White River BLM Field Office Areas.

BFF habitat evaluation data have been collected nearly every year since 2000 (and sporadically before that) using a transecting approach called the "Biggins Method" (Biggins et al. 1993). Using this method, an area of prairie dog colonies is mapped/delineated, and within that area, some part of the colonies is surveyed/sampled with transects, and prairie dog activity status and densities (using inactive/active burrow counts) are evaluated (Biggins et al. 1993). This evaluation method was designed to estimate, based on BFF energetics, the number of BFFs that an area could support. This number is called the Ferret Family Rating (FFR), where one "ferret family" consists of an adult female, her litter, and one-half of an adult male ferret. The minimum density of prairie dogs required to support a ferret family according to this model is 1.47 WTPDs per acre; areas supporting this minimum density of prairie dogs are considered "good habitat" for BFF.

Little Snake Field Office Area (specifically, the Little Snake BFF Management Area)

The Little Snake BFF Management Area (LSMA) is located in Moffat County and is bounded on the north by the Colorado-Wyoming state line and on the south by Colorado US State Highway 318 (Fig. 13). The vast majority of the prairie dogs in the Little Snake BLM Field Office Area are located within the LSMA (Bureau of Land Management 2007). Federal land represents 88% of the LSMA, 8% is state land, and 4% is private land (U.S. Fish and Wildlife Service et al. 1995).

Mapping of the Colorado section of the LSMA in 1989 identified 2 complexes: (1) the Hiawatha-Powder Wash complex (Complex A), comprising 98% of the mapped acres lying largely between the Little Snake River on the east and the Cold Spring Mountain-Middle Mountain highlands to the west; and (2) a much smaller complex located just south of Irish Canyon near Dinosaur National Monument (Complex B; Table 3; Patton 1989). Complex A contained 276 colonies on 76,601 acres and Complex B consisted of 14 colonies on 1,250 acres. Approximately 7% of the area mapped in 1989 was inactive due to some colonies recovering from a possible disease outbreak first suspected in 1983 when dramatic population declines were recognized by BLM biologists.

In 1990, BFF habitat surveys were conducted on 59,847 acres of Complex A (Table 3; Hyde 1990). For ease of mapping, Complex A was divided into 4 Sub-complexes: A1 (Little Snake) = 46 colonies on 13,002 acres; A2 (Vermillion) = 91 colonies on 19,380 acres; A3 (Powder Wash) = 18 colonies on 9,909 acres; and A4 (Hiawatha) = 71 colonies on 22,095 acres. Acres sampled within each Sub-complex varied: A1 = 34 colonies totaling 11,470 acres; A2 = 66 colonies totaling 18,272 acres; A3 = 14 colonies totaling 9,357 acres; and A4 = 44 colonies totaling 20,748 acres. Complex B was not surveyed. Thirteen of the 158 colonies sampled met the minimum criteria for good BFF habitat, having at least 10 active burrows per acre. The total area of good BFF habitat for the 4 sub-complexes combined was 14,381 acres.

In 1993 and 1994, BFF habitat surveys were conducted within the 4 Sub-complexes of Complex A to further examine population trends and distribution of WTPDs (Table 3; Albee 1993, Albee and Savage 1994). In 1993, a total of 360 transects were completed on 115 WTPD colonies covering 36,629 acres, 47% of the complex. Thirty-eight of the 115 colonies, or 22,557 acres, met the minimum criteria of good BFF habitat (29% of the complex). The 1993 surveys showed shifts in WTPD activity from the 1990 surveys. For example, colonies that had the highest numbers of WTPDs in 1990 had reduced activity in 1993, and other colonies that had low numbers of animals in 1990 had increased levels in 1993.

In 1994, only colonies that contained at least 763 WTPDs during the survey conducted in 1993 were sampled (Albee and Savage 1994). A total of 218 transects were completed on 32 colonies covering 17,514 acres, 22% of the complex. Thirteen of the 32 colonies comprising 8,408 acres, 11% of the complex, met the minimum requirement for good BFF habitat. Again, significant changes in activity were noticed with the most active colonies in 1993 almost completely devoid of activity in 1994, and colonies having little activity in 1993 appearing active.

The CDC in Fort Collins, Colorado confirmed plague in the LSMA from flea samples collected in 1994 and also found evidence of plague exposure in blood serum collected from coyotes in 1995 (Albee and Savage 1994, U.S. Fish and Wildlife Service et al. 1995). WTPD populations throughout the LSMA were severely impacted by plague and virtually disappeared after the 1994 surveys. Because of this, the area was dropped from consideration as a BFF reintroduction site, and surveys were discontinued until populations could recover to their pre-plague levels.

In 1999, occupied habitat in Sub-complexes A1 and A3 was remapped and transected to evaluate recovery rates and BFF habitat potential (Squires et al. 1999). This remapping resulted in identification of 41 colonies covering 1,816 acres; a decline of 92% in occupied habitat from 1990 when Sub-complexes A1 and A3 contained 64 colonies on 20,827 acres. The area of good BFF habitat in 1999 was 1,148 acres, with an estimated WTPD population of 5,064 (4.2-4.7 WTPDs per acre). Most of the burrows outside of the areas mapped as active revealed signs of collapse, indicating that they had not been occupied since the 1994 population decline.

In 2002, the active colonies in sub-complexes A1 and A3 were remapped and WTPD activity in other sub-complexes was informally assessed. From this effort there appeared to be little change from the 1999 survey, and what changes did occur were largely negative (Renner 2002a). In 2003, WTPD colonies in sub-complexes A2 and A4 were remapped and other areas informally assessed (Renner 2003). The 2003 survey showed modest improvement over the 2002 surveys; however, there was concern that this observed recovery might not continue due to the continued drought conditions causing significant numbers of sagebrush and saltbush to become dormant or die over large portions of the area (Renner 2003).

Windshield surveys (observations made while driving through WTPD habitat) by BLM personnel indicated that prairie dog numbers seemed to be increasing within the LSMA in 2004 and 2005 (Mike Albee, Bureau of Land Management, personal communication 2005). In 2006, BLM and CDOW personnel revisited and mapped a portion of A1 along the Little Snake River to see if prairie dogs had recovered enough to reinitiate discussions of a BFF release. In 1994, this Sub-complex included approximately 13,800 acres of prairie dogs; however, this mapping seemed to be very coarse as it included piñon-juniper areas and steep hillsides where prairie dog colonies were most likely never present (B. Holmes, Bureau of Land Management, personal communication, 2007). Mapping in 2006 identified 4,300 acres of active prairie dog colonies and, of the colonies mapped, all contained very few numbers of animals based on visual surveys. This led to the conclusion that the site had not recovered sufficiently to support a BFF reintroduction (Holmes 2006).

Table 3. White-tailed prairie dog (WTPD) population survey data for Little Snake Management Area (LSMA).

Year	Area within LSMA [a]	Survey Type	Results	Comments
1989	Complex A and Complex B	Biggins Method (Biggins 1989,1993)	• Complex A: 276 colonies on 76,601 acres • Complex B: 14 colonies on 1,250 acres • 7% mapped area inactive (plague?)	• 2 Complexes identified for future mapping (Complexes A and B) • Source: Patton 1989
1990	Complex A (Sub-complexes A1-A4)	Biggins Method	• A1: 34 colonies on 11,470 acres • A2: 66 colonies on 18,272 acres • A3: 14 colonies on 9,357 acres • A4: 44 colonies on 20,748 acres • 13/158 colonies are "good" BFF habitat [b] • Population estimate: 14,381 WTPDs	• 4 Sub-complexes identified in Complex A (A1 – A4) • Source: Hyde 1990
1993	Complex A (Sub-complexes A1-A4)	Biggins Method	• Surveyed 115 colonies on 36,629 acres • 38/115 colonies (22,557 acres) are "good" BFF habitat[2]	• Shifts in areas of WTPD activity from those in 1990 • Source: Albee 1993
1994 [c]	Complex A (only colonies with 1993 densities ≥ 763 WTPDs)	Biggins Method	• Surveyed 32 colonies on 17,514 acres • 13/32 colonies (8,408 acres) are "good" BFF habitat [b]	• Shifts in areas of WTPD activity from those in 1993 • Source: Albee and Savage 1994 • Plague detected in fleas
1999	Sub-complexes A1 and A3	Biggins Method	• 41 colonies in 1,816 acres; 92% decline from 1990 • 1,148 acres of "good" BFF habitat [b] • Population estimate: 5,064 WTPDs	• Source: Squires 1999
2002	Sub-complexes A1 and A3	Biggins Method	• Sub-complexes A2 and A4 informally assessed • Little change from 1999	• Source: Renner 2002a
2003	Sub-complexes A2 and A4	Biggins Method	• Sub-complexes A1 and A3 informally assessed • Modest improvement over 2002 results	• Continued drought a concern in population recovery • Source: Renner 2003
2006	Sub-complex A1 (a portion of it)	Biggins Method	• 4,300 acres active WTPD colonies • Many colonies have low densities (visually determined)	• Source: Holmes 2006

[a] See text for definition of Complexes and Sub-complexes
[b] "Good" BFF habitat is defined as at least 10 active WTPD burrows per acre.
[c] Evidence of plague exposure also detected in coyote serum samples in 1995. Area was dropped from consideration as a BFF introduction site. Surveys discontinued until 1999.

White River Resource Area (includes Wolf Creek, Coyote Basin, Coal Oil Basin, & Dinosaur Area)

The White River Resource Area (WRRA) includes sub-areas called Wolf Creek, Coyote Basin, Coal Oil Basin, and the Dinosaur Area. Most data collected prior to 1990 were not collected specific to any of these particular areas, so those data are presented in the following text as general WRRA data (although specific descriptions of data collection areas are provided when available). Data specific to Wolf Creek, Coyote Basin, and the Dinosaur Area, generally collected after 1990, are presented in the following subsections.

Gilbert (1977) surveyed for active WTPD colonies on approximately 239,683 acres in the west-central part of the WRRA (Table 4). Colonies were mapped on USGS topographic maps (1:24,000) and occupied habitat was calculated by hand. Eighty-two colonies encompassing 26,792 acres were mapped. Colony size averaged 326 acres, with the largest being 8,277 acres. Sixty-eight percent of the colonies were located on BLM lands, 28% on private lands, and 4% on state lands. Twenty-one belt transects (1,625 feet x 16.25 feet) were completed in 14 colonies to sample burrow density as an index to activity. The mean density of active burrows in colonies sampled was 27 per acre, with the number of active burrows exceeding inactive burrows in all but one of the colonies transected. Transecting was prematurely halted when Gilbert (1977) noted evidence of a possible plague epizootic within the study area.

A number of surveys were conducted in the WRRA in the 1980s. Almost all of the surveys found that WTPDs began to decline around 1985 with subsequent increases in population numbers by 1988. A summary of these surveys is provided below (see also Table 4).

A decrease in WTPD numbers was documented around Blue Mountain and Massadona during a long-term prey availability study conducted as part of a ferruginous hawk nesting mitigation study in Moffat and Rio Blanco counties (Stalmaster 1985, 1988; Table 4). WTPD densities were estimated annually by walking or driving established transects in April and June from 1982 to 1988 and counting the number of WTPDs seen along transects. The prairie dog densities observed along transects declined significantly from a high of 309 prairie dogs per square mile in 1983, to extreme lows of 20.8 and 23.4 prairie dogs per square mile in 1986 and 1987, respectively. By 1988, WTPD densities appeared to improve, with 135 prairie dogs per square mile documented.

In 1985, lands exhibiting past and present occupation by WTPDs were mapped by the White River Field Office in Meeker (E. Hollowed, Bureau of Land Management, personal communication 2003; Table 4). These surveys indicated that about 39,536 acres of occupied habitat occurred in an area roughly described as west of Pinyon Ridge, south of U.S. State Highway 40, and north and east of U.S. State Highway 64 in Moffat and Rio Blanco counties. In 1985, a presumed plague epizootic severely reduced (>75%) prairie dog densities in Divide Creek, Wolf Creek, and Coal Creek Drainages (Colorado Division of Wildlife 1986).

Chevron Oil Company conducted mapping surveys of WTPD colonies within Coal Oil Basin from 1985 to 1988 (Mariah Associates, Inc. 1986, 1987, 1988; Table 4). Surveys within this area resulted in 6,044 acres of occupied habitat being mapped with little apparent difference in occupancy between years. Burrow densities, however, were not estimated. WTPD populations appeared to maintain themselves throughout Coal Oil Basin from the mid- to late 1980s, whereas populations in other areas within the WRRA declined.

A decline in occupied WTPD habitat in the mid-1980s was also demonstrated during a pre-construction ecological study completed along a proposed route for the Craig-Bonanza transmission line in Utah and Colorado in 1988 (Bio/West Inc. 1988; Table 4). The survey was conducted to determine the amount of occupied habitat and activity status of WTPD colonies in an area extending from Bonanza, Utah north toward Dinosaur, Colorado and then east along US Highway 40 to Maybell, Colorado. A preliminary helicopter survey conducted in 1987 identified 30 colonies encompassing 15,080 acres, of which 6 were active on 5,120 acres (Department of Energy 1987). In the 1988 ground surveys, 28 of the previous 30 colonies were verified and an additional 7 colonies were mapped. All 35 colonies located were active, and total occupied habitat mapped in 1988 was 11,218 acres. These surveys again indicated that WTPD populations in the WRRA declined in the mid-1980s, but by 1988 were beginning to rebound.

One additional area was surveyed in the 1980s, but it was surveyed only 1 time and no data on trends were reported. The surveys occurred at 2 Known Recoverable Coal Resource Areas near Rangely, Colorado. The areas were surveyed for WTPDs in 1981 in response to prospective coal leasing activity by the BLM (McDonal et al. 1981). During the surveys, 14 WTPD colonies covering 8,947 acres were mapped, with private and state land holdings comprising < 28% of the prairie dog occupied area.

In 1991, a study was conducted in the Crooked Wash and Wolf Creek drainages of the WRRA to evaluate potential BFF reintroduction sites (Macdonald and Ellenberger 1991; Table 4). Mapping of most of the study area was completed in 1986-1989 by the BLM and USFWS (Patton 1989). The 1991 objectives were to complete the mapping of the WRRA, which consisted of the relatively small Crooked Wash Drainage, east of Wolf Creek, and to conduct transect (density) work for all the mapped colonies. Eighteen colonies were mapped for a combined area of 1,838 acres in Crooked Wash; colonies occupied just 6.1% of the 30,183 acre complex. Using the Biggins Method (Biggins et al. 1989, 1993), the Crooked Wash Complex yielded an estimated total of 1,445 acres of good BFF habitat.

In Wolf Creek, previous mapping (Patton 1989) yielded colonies with a total area of 30,182 acres; these occupied 50% of the 60,519 acre complex. In 1991 the Wolf Creek complex had a total area of 648 acres of good BFF habitat (MacDonald and Ellenberger 1991). MacDonald and Ellenberger (1991) stated that the Crooked Wash complex appeared to support proportionately more "good habitat" for a BFF reintroduction than did Wolf Creek. However, the report recognized that the previous mapping in Wolf

Creek (Patton 1989) was conducted prior to the development of the Biggins Method, which resulted in colony sizes being greatly inflated. Because a larger area was mapped than actually existed, it biased the results, showing fewer acres of good habitat.

Table 4. White-tailed prairie dog (WTPD) population survey data in the White River Resource Area (WRRA), 1977–1991. Data suggest that WTPD populations in most of the WRRA declined in the mid-1980s but began to rebound by the late 1980s. Populations in the Coal Oil Basin area of WRRA appeared to maintain themselves through the 1980s. More recent data for specific sub-areas within the WRRA are presented in Tables 5, 6, and 7.

Year	Area within WRRA [a]	Survey Type	Results	Comments
1977	West-central portion	• Map colony boundaries on 239,683 acres • Active burrow density	• 82 colonies on 26,792 acres • Average colony size: 326 acres • Mean burrow density: 27/acre	• Possible plague epizootic event beginning • Source: Gilbert 1977
1982–88	Blue Mountain and Massadona area	• Densities estimated: walking/driving transects	• 1983: 309 WTPDs/mi [b] • 1986: 20.8 WTPDs/ mi [b] • 1987: 23.4 WTPDs/ mi [b] • 1988: 135 WTPDs/ mi [b]	• Source: Stalmaster 1985, 1988
1985	Moffat and Rio Blanco Counties: west of Pinyon Ridge, south of US State Hwy 40, north and east of US State Hwy 64	• Occupied habitat mapping	• 39,536 acres occupied habitat • 75% decline in WTPD abundance in Divide Creek, Wolf Creek, Coal Creek Drainages	• Sources: E Hollowed, BLM, personal communication; CDOW 1986
1985–88	Coal Oil Basin	• Map colony boundaries	• Colonies covered 6,044 acres, similar in all 3 years	• 3 WTPD carcasses found in 1988, possibly due to plague • Sources: Mariah Associates, Inc. 1986, 1987, 1988
1987–88	From Dinosaur, CO east along US State Hwy 40 to Maybell, CO	• Occupied habitat and activity status Initial helicopter survey, ground surveys	• 1987 (helicopter survey): 30 colonies on 15,080 acres; 6 active colonies on 5,120 acres • 1988: 28 of 30 (1987 data) colonies verified; additional 7 colonies mapped; all 35 colonies active, on 11,218 acres	• Sources: Department of Energy 1987; Bio/West Inc. 1988)
1991	Crooked Wash and Wolf Creek Drainages	• Colony mapping (Biggins et al. 1989 method)	• 18 colonies on 1,838 acres • Good habitat [b]: 1,445 acres	• Source: Macdonald and Ellenberger 1991

[a] See text for more detailed descriptions of areas surveyed.
[b] "Good" black-footed ferret (BFF) habitat is defined as 1.47 prairie dogs per acre (Biggins et al. 1993).

Wolf Creek Management Area

The WCMA lies predominantly in southwestern Moffat County, about 18 miles northeast of Rangely with about 10% of the Management Area in Rio Blanco County; US Highway 40 crosses the northern portion of the Management Area between Massadona and Elk Springs (Fig. 13). Comprised primarily of federal land, this Management Area encompasses nearly one-half of the WTPD habitat found on BLM lands within the WRRA (Wolf Creek Work Group 2001).

The WCMA and the Colorado portion of Coyote Basin were selected to serve as BFF reintroduction sites and reintroduction was approved in the Record of Decision for the WRRA Management Plan, July 1997 (Wolf Creek Work Group 2001). Selection of the 2 areas was due to favorable land-use practices, land ownership pattern, and suitability of WTPD resources.

There are approximately 19,000 acres of active WTPD colonies currently distributed throughout the WCMA, although this figure fluctuates annually (Holmes 2008). Total occupied acreage was estimated at 16,800 acres in 2001. Colony sizes in 2008 ranged from 27 acres to 3,608 acres (Holmes 2008), but a plague epizootic that began in fall 2007 or spring 2008 has reduced current colony sizes significantly (Dan Tripp, CDOW, personal communication 2010).

The first WTPD mapping of the WCMA was completed in 1989. Both active and inactive colonies were delineated on topographic maps by an observer scanning colonies from an elevated vantage point. Remapping of the area in 1993 excluded areas of inactivity; thus, a decline in mapped occupied habitat occurred (Table 5).

Transecting (using the Biggins Method) within the WCMA began in 1989, conducted by the BLM and the USFWS, but was inconsistent until 2004, due to changes in personnel and different agencies conducting surveys. In 1993–94, surveys were conducted by the CDOW in an area from Pinyon Ridge on the east to Deserado Mine road on the west. In 2000, only the west side of the mapped area between Pinyon Ridge on the east and Coal Ridge road on the west was transected (colonies 1–13) by Utah State University (USU) and the BLM, and in 2001, the same agencies transected the east side of this area (colonies 14–26; B. Bibles, Utah State University, personal communication 2003; L. Renner, CDOW, personal communication 2003). The 2002 and 2003 surveys represented the first time that the entire mapped area was transected, with the CDOW transecting the east end (additional colonies were mapped on the east end in 2002, and these are reported separately for that year; Table 5) and USU and the BLM transecting the west. Because of discrepancies in data collection and protocol, data collected on the west and east sides are presented separately to illustrate population changes (Table 5).

In WCMA, like other areas within the WRRA, plague appeared to negatively impact the Management Area beginning on the east side in 1985 and progressed west to eventually affect the entire area (L. Renner, CDOW, personal communication 2003). Populations began to increase in the early 1990s and by 1993-94 they were thought to be near pre-plague levels (L. Renner, CDOW, personal communication 2003; Table 5).

Summary statistics, including measures of variation, were calculated for survey data collected at WCMA and Coyote Basin from 1997-2003 (survey techniques following 2003 don't allow the later data to be included in this summary). Survey data from the east side of Wolf Creek showed a relatively stable population from 2001 to 2003 with a coefficient of variation of 14% (Tables 5 and 6). The WTPD population on the west side of WCMA however, declined significantly after the 2000 surveys (Table 6), and the population estimate was highly variable (showing a coefficient of variation of 55%).

WTPD densities in WCMA increased from 2004 to 2006 (Table 5) and were thought to be associated with average or above-average precipitation in 2005 and 2006 that followed drought years in 2002 and 2003 (Holmes 2008). Two hundred and ninety transects were surveyed within the WCMA during 2004 (Belmonte 2004). Of the 19,188 acres surveyed, 5,515 acres; 29% were classified as "good habitat". Prairie dog density, within good habitat, was 2.8 WTPD per acre (Table 5). Again, comparisons with 2003 data are not possible due to the differences in collection techniques prior to 2004.

Transecting showed a substantial increase in prairie dog density in 2005 over 2004 (Table 5). Of the 19,188 acres surveyed, 5,564 acres, 50%, were classified as "good habitat" with an overall FFR of 36.1 compared to 19.6 in 2004 (Holmes 2008). Prairie dog density within good habitat was 2.8 WTPDs per acre (Table 5).

Results of transecting in 2006 showed a substantial increase in prairie dog density over the previous 2 years (Holmes 2008). Of the 19,188 acres surveyed, 14,199 acres, 74.1%, were classified as "good habitat" with an overall FFR of 64.1. In comparison, the FFR was 36.1 in 2005 and 19.6 in 2004 (Table 5). Including all transects in the analyses, estimated prairie dog density throughout Wolf Creek was 2.9 WTPDs per acre. Prairie dog density at individual colonies ranged from 1.59-4.38 WTPDs per acre, and the 2 colonies where most BFF were located had prairie dog densities of 3.77 and 3.88 WTPDs per acre.

Transecting in 2007 showed that prairie dog density in WCMA was down slightly from 2006, and this change could be accounted for simply by sampling error (B. Holmes, Bureau of Land Management, personal communication 2008). However, evidence of plague activity also was detected in late summer and fall 2007 (Griffin et al. 2010). In 2008, the population of WTPDs declined and the FFR went from 58.9 to 25.88 (Table 5). Plague activity continued through summer 2009 at WCMA, and transecting was not completed in 2009.

As the data validate, there have been wide fluctuations in prairie dog density in the WCMA. These fluctuations are most likely related to climatic conditions, disease, or a combination of both (Holmes 2008).

Table 5. Results of white-tailed prairie dog (WTPD) population surveys evaluating habitat suitability for black-footed ferrets (BFF) at Wolf Creek Management Area (WCMA). Shaded data are those collected for the entire sampling area (i.e., data for a comparable area).

Year Surveyed	Sampling Personnel	Sampling Area	Total Area Sampled			Good Habitat Area [a]				
			Ha (acres)	# WTPDs/ ha (acre)	Population Estimate	ha (acres) [b]	% of Total Area	# WTPDs/ ha	Population Estimate	FFR [c]
1989/90 [d]	BLM, USFWS	Entire area, active and inactive colonies	11,426 (28,234)	-	-	4799 (11,859)	42	6.3 (2.6)	30,102	-
1993-94	CDOW	Pinyon Ridge on east to Deserado Mine Road on west	6830 (16,877)	-	-	5942 (14,683)	87	7.4 (3.0)	43,967	-
2000	BLM, USU	West (Colonies 1-13)	3998 (9979)	4.9 (2.0)	19,719	2239 (5533)	56	7.7 (3.1)	17,274	-
2001	BLM, USU	East 1 (Colonies 14-26)	2823 (6976)	3.7 (1.5)	10,331	1,045 (2582)	37	7.5 (3.0)	7782	-
2002 [f]	BLM, CDOW, USU	Total Area [e] (Colonies 1-39)	5878 (14,525)	3.2 (1.3)	18,843	2234 (5520)	38	6.6 (2.7)	14,846	18.4
	BLM, USU	West (Colonies 1-13)	4050 (10,008)	1.8 (0.7)	7,266	729 (1801)	18	5.5 (2.2)	3922	-
	CDOW	East 1 (Colonies 14-26)	2840 (7,018)	2.9 (1.2)	8,212	852 (2105)	30	6.5 (2.6)	5554	-
	CDOW	East 2 (Colonies 27-39)	1828 (4517)	6.3 (2.6)	11,576	1,517 (3749)	83	7.2 (2.9)	10,924	-
2003 [f]		Total Area [d] (Colonies 1-39)	5878 (14,525)	3.4 (1.4)	19,968	2410 (5955)	41	6.8 (2.8)	16,564	21.9
		West (Colonies 1-13)	4050 (10,008)	2.3 (0.9)	9,214	932 (2303)	23	6.8 (2.8)	6275	-
		East 1 (Colonies 14-26)	2840 (7018)	5.9 (2.4)	10,754	1517 (3749)	83	6.8 (2.8)	10,289	-
2004 [f]		Total Area [e] (Colonies 1-39)	7765 (19,188)	2.7 (1.1)	21,112	2252 (5564)	29	7.0 (2.8)	15,485	19.6
2005 [f]		Total Area [e] (Colonies 1-39)	7765 (19,188)	4.3 (1.7)	33,309	3882 (9594)	50	6.9 (2.8)	27,615	36.1
2006 [f]		Total Area [e] (Colonies 1-39)	7765 (19,188)	7.2 (2.9)	52,650	5746 (14,199)	74	9.1 (3.7)	49,519	64.1
2007 [g]		Total Area [e] (Colonies 1-39)	7765 (19,188)	6.7 (2.7)	51,883	5358 (13,240)	69	8.6 (3.5)	47,082	58.9
2008 [g]		Total Area [e] (Colonies 1-26)	7881 (19,474)	3.37 (1.36)	26,545	2725 (6734)	35	7.58 (3.06)	20,646	25.88

[a] "Good" BFF habitat is defined as 1.47 prairie dogs per acre
[b] Estimated area of good habitat was determined by multiplying proportion of good habitat by colony size.
[c] FFR = Ferret Family Rating, where one "ferret family" consists of an adult BFF female, her litter, and one-half an adult male ferret.
[d] The 1989/90 data were derived from mapping that included all lands showing evidence of WTPD occupation, past and present; subsequent mapping was more selective and did not include inactive sites.
[e] In 2002 the entire area was transected, including additional colonies (#27-39) on the east side (East2) mapped by Renner in 2002b. In this and subsequent years, "Total Area" includes the entire area covered by colonies #1-39.
[f] Data from 2002-2006 are taken from Holmes 2008.
[g] Data from 2007and 2008 are from B. Holmes, BLM, personal communication 2008.

Table 6. Summary statistics for surveys evaluating suitability of black-footed ferret (BFF) habitat in management areas in Colorado from 1997–2007. Statistics were calculated for the entire sample area, and not just for areas of "good" BFF habitat.

BFF Management Area	**WTPD Population Estimate [a]**	**Standard Deviation [b]**	**Coefficient of Variation [c] (%)**	**Monitoring Period (years)**
Wolf Creek West (colonies #1-13)	28,519	16,038	56	6
Wolf Creek East 1 (colonies #14-26)	9,765	1,362	14	3
Wolf Creek Total (colonies #1-39)	32,961	16	48	6
Coyote Basin	3,003	2,179	72	9

[a] The average, or "mean" population estimate.
[b] A measure of the variability in the data; how widely spread the individual counts are around the average.
[c] A relative measure of variation in the population estimate, defined as the standard deviation divided by the mean population estimate.

Coyote Basin Black-footed Ferret Management Area – Colorado Side

The CBMA encompasses western Rio Blanco County and is located about 11 miles west-northwest of Rangely (Fig. 13). This site is contiguous with the Coyote Basin BFF Area in Utah and was selected as a logical expansion site for the Utah-Colorado Basin reintroduced BFF population. Colorado, Utah, and Wyoming share the same BFF experimental population area, but separate management plans were developed for Colorado and Utah. Coyote Basin, Utah was chosen to receive the first BFFs under this program. The CBMA in Colorado was intensively surveyed in 1997 and from 1999 to 2007 (Tables 6 and 7).

In the CBMA, WTPD populations have shown a very high level of dispersion in population estimates with a coefficient of variation of 72% (Table 6). The CBMA saw a doubling in prairie dog densities between 1997, when the population estimate for the CBMA was 3,132, and 2000 when the prairie dog population estimate was 6,666 (Table 7). Beginning in 2001, prairie dog populations began to decline in the CBMA, with a decrease in numbers of WTPDs to 1,055 during the 2003 surveys. By 2006, populations had had increased again to 2,653.

Table 7. White-tailed prairie dog (WTPD) population analysis determined from surveys evaluating habitat suitability for black-footed ferrets (BFF) at Coyote Basin Management Area, Colorado.

Year Surveyed	Total Area Sampled			Good Habitat Area [a]				
	ha (acres)	# WTPDs/ha	Population Estimate	Ha [b] (acres)	% of Total Habitat	# WTPDs/ha	Population Estimate	FFR [c]
1997	708 (1,750)	4.4 (1.8/acre)	3,132	370 (914)	52.2	6.8 (0.4/acre)	2,527	
1998	-	-	-			-	-	-
1999	529 (1,307)	10.4 (4.2/acre)	5,509	454 (1,122)	85.9	11.6 (1.1/acre)	5,260	
2000	529 (1,307)	12.6 (5.1/acre)	6,666	529 (1,307)	100	12.6 (5.1/acre)	6,666	
2001	529 (1,307)	6.7 (2.7/acre)	3,545	454 (1,122)	85.9	7.4 (3.0/acre)	3,355	
2002	529 (1,307)	7.0 (2.8/acre)	3,677	499 (1,233)	94.4	7.2 (2.9/acre)	3,604	
2003	529 (1,307)	2.0 (0.8/acre)	1,055	89 (220)	16.6	6.4 (2.6/acre)	571	0.7
2004	529 (1,307)	0.6 (0.2/acre)	308	0	0	0	0	0
2005	529 (1,307)	0.9 (0.4/acre)	483	0	0	0	0	0
2006	529 (1,307)	5.0 (2.0/acre)	2,653	239 (591)	45	9.1 (3.7/acre)	2,174	2.8
2007	529 (1,307)			261 (645)	49	6.0 (2.4/acre)	1,553	2.0

[a] Good" BFF habitat is defined as 1.47 WTPD/acre.
[b] Estimated area of good habitat was determined by multiplying proportion of good habitat by colony size.
[c] FFR = Ferret Family Rating, where one "ferret family" consists of an adult BFF female, her litter, and one-half an adult male ferret.

Dinosaur Area

High WTPD abundance was noted from windshield surveys in 2005 in the Dinosaur Area on the Colorado side of the state line. An effort began in 2006 to map prairie dog colonies in this area. Densities appeared to be higher than those in the WCMA. In 2007, some of these colonies were transected to discern prairie dog density. Results of this effort were encouraging and showed estimates ranging from 4.9-7.7 WTPDs per acre. Densities in the best WCMA habitat, ranged from 3.6-4.5 WTPDs per acre in 2006 and 2007 (B. Holmes, Bureau of Land Management, personal communication).

Issues

Both the White River and Little Snake BLM Field Offices are experiencing growth in oil and gas development, with current and projected activity exceeding the Reasonable Foreseeable Development scenario approved in 1997 (Bureau of Land Management 2006b). The vast majority of the overall WTPD range in this IPA has been leased for energy development. While scientific studies have not been conducted to examine the impacts of oil and gas activities on prairie dogs, it is likely that this development will affect prairie dog populations at some level (see "Energy and Mineral Development" issue section, for more information on implied effects).

Plague has been documented in the IPA, both in the WCMA and the LSMA. The WTPD populations in the WCMA managed to rebound to pre-plague levels before declining again in recent years, but the same has not occurred in the LSMA. Plague, both enzootic and epizootic outbreaks, remains a central concern in this IPA. Analysis of flea PCR data revealed evidence of *Y. pestis* DNA in flea pools from several colonies in the WCMA complex beginning in August 2007. Plague also was confirmed independently in carcasses of a desert cottontail rabbit and a prairie dog found in different parts of the WCMA complex in 2007 (Griffin et al. 2010).

Current Conservation Efforts

The NW IPA has the most intensive and high level monitoring of WTPD populations of any IPA due to management as a BFF release site. Intensive annual mapping of habitat conditions (i.e., WTPD populations) is projected to continue in WCMA, CBMA, and possibly now in the Dinosaur Area. If WTPD populations improve, mapping and transecting in LSMA will follow.

As part of ongoing obligations to support BFF reintroduction in northwestern Colorado, during 2007–2009 the CDOW developed in-house capacity for conducting large-scale plague surveillance in WTPD colony complexes. These approaches were to provide tools for identifying endemic plague foci and emerging plague epidemics in prairie dog populations to facilitate preventive management where warranted. For surveillance, fleas were collected by systematically swabbing WTPD burrows at four sites: WCMA, LSMA, CBMA, and Snake John Reef. Fleas were identified to species, pooled by burrow and species, and tested for presence of *Y. pestis* DNA using polymerase chain reaction (PCR; Griffin et al. 2010). In addition to burrow sampling, carcasses from prairie dogs and other mammals were collected or sampled opportunistically in the field and subsequently tested for evidence of plague.

Based on these recent PCR findings and the proximity of plague activity to the core BFF release area, prairie dog burrows over about 860 acres including parts of two prairie dog colonies on the eastern side of WCMA were dusted with deltamethrin in Sep–Oct 2008 in an effort to reduce flea populations and the potential impact of plague on populations of both prairie dogs and BFF. Dusting was a collaborative effort between the CDOW and the BLM. The treated area represented relatively high density WTPD habitat, with an average of about 40 total burrows per acre; all dusting was conducted via backpack/foot. The estimated cost was about $12 per acre (~$10,500 for the entire area treated) for dust and the labor needed to apply it in the field. Dusting of the east side of the WCMA complex resumed in early spring 2009 (Dan Tripp, CDOW, personal communication 2009).

By 2009, non-dusted colonies had experienced severe reductions in the WTPDs due to plague. The areas dusted in 2008 and 2009 appear to be free of plague (post dust application) and the WTPD populations in these areas appear to be stable (Dan Tripp, CDOW, personal communication 2009). Monitoring of WTPD and flea populations in these areas for the presence of plague is continuing.

Specific language to protect WTPD colonies has been proposed in the Little Snake RMP revision and in the White River RMP amendment. There is existing language in the current White River RMP specific to oil and gas development impacts on WTPD, as well as in the Wolf Creek Management Plan. The current (1997) White River RMP and 2001 Wolf Creek Ferret Management Plan adopted an array of management decisions that promoted maintenance or enhancement of WTPDs, with particular emphasis on accommodating abundance and distribution in the face of oil and gas development.

The USFS considers the WTPD as a Region 2 Sensitive Species. Conservation actions primarily involve considerations regarding whether the species is present in project areas. USFS Districts do not give out the location of prairie dog sites to recreational shooters.

A seasonal shooting closure was instituted on public lands from 1 March – 14 June by the CWC in 2006.

IV. ANALYSIS

A. Population Viability Analysis

Concepts & Principles

Population viability analyses can be useful tools for investigating current and future risk of GUPD and WTPD population decline or extinction. This risk analysis tool has been used for approximately 20 years by conservation biologists to predict the relative probability of extinction for a wildlife population under various management scenarios and to aid in decision-making for population management (Shaffer 1991, Boyce 1993, McCarthy et al. 2001, Reed et al. 2002). The need for, and consequences of alternative management strategies can be modeled to suggest which practices may be the most effective in conserving prairie dog populations. *VORTEX*, a simulation software package written for PVA, was used here as a vehicle to study the interaction of a number of prairie dog life history and population parameters, to explore which demographic parameters may be the most sensitive to alternative management practices, and to test the effects of selected management scenarios.

The PVA uses available population information to develop a model (a simplified representation of a real system) that simulates how the population functions (Shaffer 1991, Boyce 1993). The model can be used to project various future scenarios and predict resulting outcomes for the population. The model may incorporate many factors that affect the status of a population, such as environmental stochasticity (e.g., normal variation in weather and available food supply), demographic stochasticity (e.g., normal variation in breeding success and survival), catastrophes (e.g., drought, disease), genetic stochasticity (e.g., inbreeding, genetic drift), and interaction among these factors (Gilpin and Soulé 1986, Shaffer 1991). These factors enter the life of an individual as events that occur with particular probabilities, rather than with absolute certainty, at any given time (see Appendix G, "Population Viability Analysis Report").

PVA methods such as the *VORTEX* system are not intended to give absolute and accurate "answers" for what the future will bring for a given wildlife species or population. This limitation arises from two fundamental facts about the natural world: it is inherently unpredictable in its detailed behavior, and we will never fully understand its precise mechanics. Consequently, many researchers have cautioned against the exclusive use of absolute results from a PVA to promote specific management actions for threatened populations (e.g., Ludwig 1999, Beissinger and McCullough 2002, Reed et al. 2002, Ellner et al. 2002, Lotts et al. 2004). Instead, the true value of an analysis of this type lies in the assembly and critical assessment of available information on the species and its ecology, and in the ability to compare the quantitative metrics of population performance that emerge from a suite of simulations, with each simulation representing a specific scenario and its inherent assumptions about the available data and a proposed method of population and/or landscape management. Interpretation of this type of output depends strongly upon our knowledge of prairie dog biology in its habitat, the environmental conditions affecting the species, and possible future changes in these conditions.

Current Model

A PVA can be very useful in the decision-making process for managing species at risk, but only if used properly (Boyce 1993, Beissinger and Westphal 1998, Ellner et al. 2002, McCarthy et al. 2003). Thus, we contracted with the CBSG to develop a PVA for GUPDs and WTPDs in Colorado. Dr. Philip Miller of the CBSG used a simulation software program called *VORTEX* (Miller and Lacy 2003) to address a series of questions regarding prairie dogs in Colorado. The full report of this work is given in Appendix G. This section represents a summary of the key points regarding the analysis.

Specifically, this preliminary analysis addressed the following questions:

- Can a series of simulation models be built with sufficient detail and precision that describe the dynamics of GUPD and WTPD populations across Colorado with reasonable accuracy?
- What are the primary demographic factors that drive growth of GUPD and WTPD populations?
- How vulnerable are small, fragmented populations of GUPDs and WTPDs in Colorado to extinction under current management conditions? How small must a population become to increase its risk of extinction to an unacceptable level?
- What are the predicted impacts of plague on GUPD and WTPD populations in Colorado?
- What are the predicted impacts of current shooting practices on GUPD and WTPD populations in Colorado?
- What are the predicted long-term impacts of poisoning practices on GUPD and WTPD populations in Colorado?
- Can reasonable management practices be devised to reduce predicted impacts of these activities on GUPD and WTPD populations in Colorado?

VORTEX is a Monte Carlo model that simulates the effects of deterministic forces as well as demographic, environmental, and genetic stochastic events on wild populations. It is an individual-based model that follows the fate of each animal in a theoretical population as the individual encounters various life and environmental events during a given year. These events occur with a user-specified probability, and the model will run for a user-specified number of consecutive years. By following an entire population of individuals, it is possible to estimate relative population extinction risk and loss of genetic diversity within a specified time period.

Baseline Parameters & Simulations

In developing appropriate input datasets for our stochastic simulation models, we first held a 2-day experts workshop in Fort Collins, CO in February 2007. At this workshop we summarized our needs for the model and asked for input parameters from experts in the field of prairie dog biology and behavior, and plague ecology. We also referred to published field work reported in Hoogland (2001, 2007), Cully (1997) and Biggins (U.S. Geological Survey, personal communication 2007), with additional information coming from CDOW data on prairie dog biology and human activities around the state (CDOW unpublished data).

It is important to recognize that the simulated populations did not correspond to specific known colonies or complexes of GUPDs or WTPDs in Colorado. Moreover, these models were not spatially explicit, and consequently immigration and metapopulation dynamics were not simulated. Instead, these analyses focused on individual populations (colonies or demographically well-connected complexes), and were not intended to represent processes at larger geographic scales like IPAs or ranges of the 2 species as entire entities across the state. This population-level scale of resolution was regarded as most appropriate for answering relevant conservation and management questions in light of the extreme fragmentation of both species within their respective occupied Colorado ranges (see APPENDIX F).

The initial baseline simulation models were initialized with a total of 10,000 individuals. Subsequent models, designed explicitly to investigate the effects of small population size on extinction risk, were initialized with between 25 and 3,000 individuals. All population projections were simulated 500 times. Each projection extended to 50 years, with demographic information obtained at annual intervals.

Demographic parameters used in the GUPD and WTPD PVA included type of breeding system, age at first reproduction, age of reproductive senescence, a measure of reproductive success (production of weaned litters), sex ratio, mortality rates (including enzootic plague impacts), catastrophic plague events, and environmental carrying capacity (see details in Appendix G). Because there are no direct data on rates or effects of inbreeding in wild populations for GUPDs or WTPDs, we did not include inbreeding effects in this analysis. Because simulated populations were assumed to be closed, no immigration or emigration occurred.

Because of the difficulty in directly observing prairie dog litters immediately after birth, "reproduction" for model purposes was defined as the production of weaned litters. With this definition, data from Hoogland (2001, 2007) and Cully (1997) were modified to account for observations of higher reproductive output at low prairie dog densities. Specifically, species-specific parameters were used to define the percentage of adult female prairie dogs that successfully wean litters in the average year, as a function of density. Furthermore, as population density increased, the mean litter size at weaning was assumed to decrease (Table 8).

Table 8. Density-dependent reproductive parameters used in prairie dog simulation models. See Appendix G for additional information.

Species	Population Density		
	Low (N/K = 0.0)	**Medium (0.2 < N/K < 0.7)**	**High (N/K = 1.0)**
	Adult females weaning a litter (%)		
Gunnison's	100	82	40
White-tailed	100	67	40
	Mean litter size at weaning		
Gunnison's	4.6	3.8	1.8
White-tailed	6.0	5.47	2.8

Based on these data, adult female GUPDs were expected to produce smaller litters but have a higher percentage of weaned litters, while WTPD females produced larger litters but had a lower rate of weaning success.

In developing mortality rates, 2 alternative mortality schedules addressing sylvatic plague (and perhaps other diseases) acting as either enzootic or non-enzootic in the system were included (Table 9). In an enzootic scenario, plague operates at a relatively low level each year, thereby increasing average annual rates of mortality above a more benign non-enzootic scenario where disease does not play a major role in determining these long-term rates. These alternative mortality schedules resulted from discussions among species experts as to the causes of differing survival rates.

Table 9. Age-specific prairie dog annual mortality rates under alternative conditions of enzootic or non-enzootic sylvatic plague. SD= standard deviation. See Appendix G for additional details.

Age Class	% Mortality (SD)			
	GUPD		**WTPD**	
	Females	**Males**	**Females**	**Males**
Non-Enzootic				
0 – 1	52.0 (10.0)	55.0 (10.0)	52.0 (10.0)	55.0 (10.0)
1 – 2	33.0 (5.0)	35.5 (5.0)	33.0 (5.0)	35.5 (5.0)
2 – 3	31.0 (5.0)	48.0 (5.0)	31.0 (5.0)	48.0 (5.0)
3 – 4	13.5 (5.0)	60.0 (5.0)	13.5 (5.0)	60.0 (5.0)
4 – 5	100.0	100.0	100.0	100.0
Enzootic				
0 – 1	52.0 (10.0)	55.0 (10.0)	52.0 (10.0)	55.0 (10.0)
1 – 2	66.0 (5.0)	74.0 (5.0)	66.0 (5.0)	74.0 (5.0)
2 – 3	66.0 (5.0)	60.0 (5.0)	66.0 (5.0)	60.0 (5.0)
3 – 4	60.0 (5.0)	50.0 (5.0)	60.0 (5.0)	50.0 (5.0)
4 – 5	100.0	100.0	100.0	100.0

Baseline Model Results

Of the 4 scenarios (each species, enzootic and non-enzootic), the "most optimistic" model is the WTPD non-enzootic model. The "least optimistic" scenario is the GUPD enzootic model. Nevertheless, all 4 scenarios showed rather robust population growth dynamics (Table 10).

Table 10. Mean demographic performance across 500 iterations for 50-year baseline model projections for each demographic profile in the PVA. "Non-Enzootic" and "Enzootic" refer to alternative mortality schedules in the absence or presence of enzootic sylvatic plague, respectively, while "WTPD" and "GUPD" denote alternative descriptions of reproductive performance. See Appendix G for additional information on model construction. $\underline{r_s}$ (SD)= population growth rate (standard deviation); PE_{50}=probability of extinction at 50 years; N_{50} (SD)= mean population size at the end of the simulation (standard deviation).

Scenario	r_s (SD)	PE_{50}	N_{50} (SD)
Non-Enzootic WTPD	0.084 (0.199)	0.000	19,001 (1519)
Non-Enzootic GUPD	0.039 (0.203)	0.000	18,096 (1871)
Enzootic WTPD	0.055 (0.272)	0.000	17,666 (2537)
Enzootic GUPD	0.026 (0.274)	0.000	16,679 (2766)

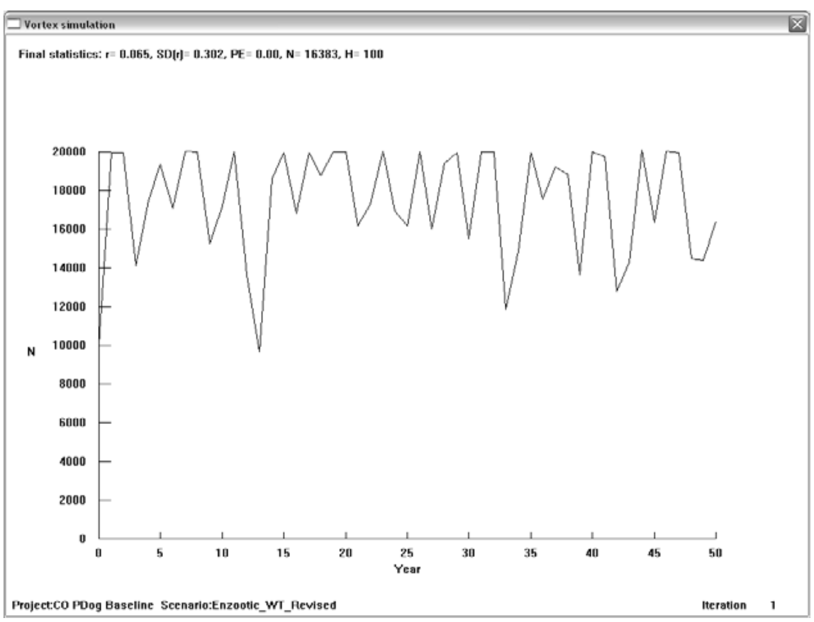


Fig. 14. Representative 50-year trajectory for a simulated WTPD population under conditions of enzootic plague mortality. Variation in population size through time in any single iteration, and average growth rate over many iterations of this dataset, were considered to be realistic in their portrayal of prairie dog population dynamics.

Variability in growth rate over the timeframe of the simulation, producing short-term fluctuations in population size of as much as 50%, seemed to be realistic when compared to field census and published data for actual prairie dog colonies or complexes (Fig. 14).

Thus, these 4 baseline models appeared to be good starting points for examining future risks among GUPD and WTPD populations for issues that may impact species persistence.

Demographic Sensitivity Analysis

During the development of the baseline input dataset, it quickly became apparent that a number of demographic characteristics of GUPD and WTPD populations were being estimated with varying levels of uncertainty. This type of measurement uncertainty, which was distinct from the annual variability in demographic rates due to extrinsic environmental stochasticity and other factors, could be considered a potential impairment to generating predictions of population dynamics with any degree of confidence. Nevertheless, an analysis of the sensitivity of models to this measurement uncertainty was used to identify priorities for detailed research and/or management projects targeting specific elements of the species' population biology and ecology.

To conduct demographic sensitivity analysis, a set of parameters from the model was identified whose estimates were considered uncertain. Minimum and maximum values for these parameters were developed, and for each parameter 2 simulations were constructed, with the parameter set at its prescribed minimum or maximum value and all other parameters remaining at their baseline values. The results of these alternative models were then compared to that of the initial baseline model.

The results of sensitivity analyses indicated that juvenile female mortality, mean litter size, and adult female breeding (weaning) frequency showed the greatest degree of response in terms of population growth rate to changes in those parameters and, hence, the greatest sensitivity (see Appendix G). These parameters can be targeted in subsequent conservation strategies for more detailed research and/or demographic management.

Impacts of Population Size on Gunnison's & White-tailed Prairie Dog Dynamics

To investigate the effects of small population size on extinction risk, subsequent models were initialized with between 25 and 3,000 individuals. Results of this analysis, in which population size was varied across a range of 25 to 3,000 individuals for each of the 4 baseline demographic profiles, indicated that GUPD and WTPD populations have the capacity for robust population growth in the absence of significant demographic disturbance from either natural or anthropogenic events. For brevity, Table 11 shows results from only one of the 4 demographic profile model sets: enzootic GUPD demographics, the "least optimistic" of the 4 profiles in terms of population growth potential. Even under this set of assumptions, all population growth rates were strong and, with the exception of the smallest population size showing a small (<1%) risk, there was no risk of population extinction among the scenarios.

Table 11. Output from models with different initial population sizes under the enzootic plague in Gunnison's prairie dog (GUPD) demographic profile. See Appendix G for additional information on model construction and output metrics. r_s (SD)= population growth rate (standard deviation); PE_{50}=probability of extinction at 50 years; N_{50} (SD)= mean population size at the end of the simulation (standard deviation); GD_{50}= gene diversity or expected heterozygosity of the population, expressed as a percent of the initial gene diversity of the population.

Initial Population Size	r_s (SD)	PE_{50}	N_{50} (SD)	GD_{50}
25	0.034 (0.324)	0.006	40 (9)	0.4748
50	0.031 (0.302)	0.000	80 (16)	0.6981
75	0.029 (0.291)	0.000	123 (24)	0.7918
100	0.028 (0.285)	0.000	163 (29)	0.8408
250	0.026 (0.275)	0.000	410 (72)	0.9324
500	0.026 (0.274)	0.000	818 (144)	0.9658
750	0.026 (0.274)	0.000	1229 (204)	0.9770
1000	0.025 (0.273)	0.000	1626 (285)	0.9827
2000	0.026 (0.273)	0.000	3305 (554)	0.9914
3000	0.025 (0.271)	0.000	4970 (824)	0.9942

Despite this negligible overall risk, it appeared that the smaller populations – in particular, those of no more than approximately 100 individuals – showed rather high rates of loss of genetic diversity (GD_{50} <0.85) during the course of the 50-year simulation. While inbreeding and its potential deleterious effects were not included in this model, there remains the possibility that such low levels of genetic variability in these small populations could lead to longer-term problems for populations that may otherwise show little or no demographic shortcomings in the short-term.

Impacts of Plague Epizootics on Gunnison's & White-tailed Prairie Dog Population Dynamics

Periodic plague epizootics that could have potentially very severe demographic impacts were included in the PVA. Catastrophes are singular environmental events that are outside the bounds of normal environmental variation affecting reproduction and/or survival.

The investigation of catastrophic or "epizootic" plague events began with a method of sensitivity analysis very similar to that discussed in more detail previously. A comparative analysis of the sensitivity of models to variation in either the frequency of epizootic plague or the severity of the epizootic event was conducted. Results indicated that the baseline simulation models were relatively more sensitive to changes in the frequency of plague epizootics in comparison to a similar proportional change in the severity of the same type of event. An increase in the frequency of epizootic plague led to a reduced ability of the simulated population to demographically rebound following the event. In contrast, if epizootics were relatively infrequent but more severe, the population, if not rendered extinct outright from an outbreak, retained the capacity to rebound from the event.

Plague epizootics were modeled to occur at intervals of 5, 10, or 15 years. In addition, plague severity was simulated at 2 different levels for a given epizootic (either 92% [range: 89% – 95%] or 99% [range: 98.5% – 99.5%] of the total population killed by the epizootic), and a function for variability in plague severity was included.

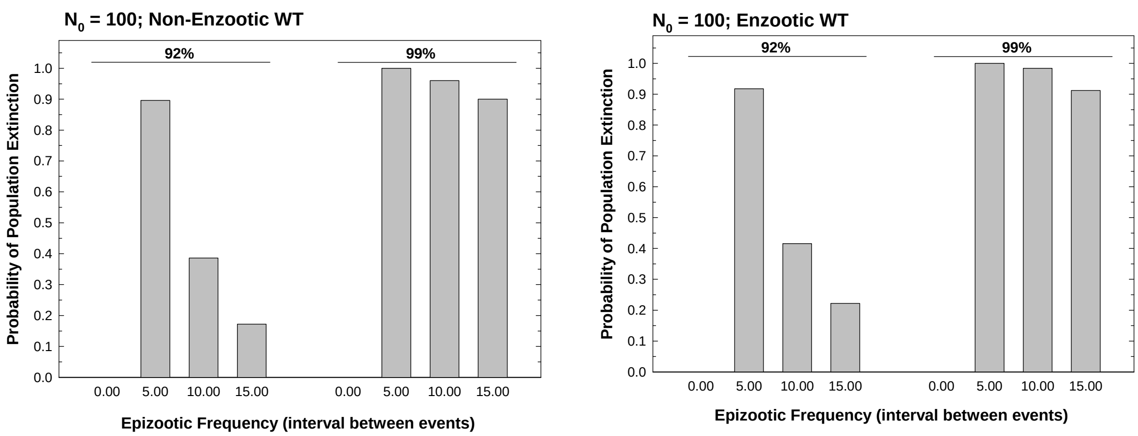


Fig. 15. Fifty-year extinction probabilities for a simulated population of WTPD in the presence of plague epizootics. Initial population size is 100 individuals. Epidemic frequency intervals are in years, and bars are grouped according to alternative assumptions regarding the severity of a given epizootic (92% or 99% of the population eliminated). GUPD models give very similar results and are therefore not reported here for clarity. See Appendix G for additional information on model construction.

This investigation of interactions between underlying plague-based mortality and the frequency and severity of plague epizootics (Fig. 15) led to the conclusion that

- When the severity of epizootic plague was relatively mild (i.e., 92% mortality), the frequency of epizootics was a major factor in determining the overall risk of prairie dog population extinction. More frequent plague epizootics led to much higher extinction risk.
- Very severe plague epizootics – those that eliminate about 99% of the population – led to very high extinction risks even when epizootics occurred relatively infrequently.
- The presence of enzootic plague affecting the underlying annual mortality rates did not appear to play a significant role in determining the fate of a population exposed to epizootic plague.

The results of these simulations were clear: epizootic plague, as represented here based on the best estimates of its demographic character, can be a critical factor in determining the long-term persistence of GUPD and WTPD populations. In addition, the underlying demographic profiles were also important factors in governing the risk to a given population. That is, those populations with poorer demographic performance were more vulnerable to extinction from plague epizootics than their more demographically vigorous counterparts.

An additional set of models was developed in which a specific level of plague management in a given prairie dog colony was assumed. This management was dusting colonies with chemicals that reduce the numbers of fleas in the colony and, hence, the rate of transmission of the infectious agent among prairie dogs. The efficacy of this dusting was simulated through a reduction of the severity of a given epizootic down to 80% (range: 77% – 83%) in the year that an epizootic was deemed to occur.

Simulation results indicated that the reduction in intensity of epizootics dramatically lowered the extinction risk of affected prairie dog populations (see Appendix G). Although the same general trends as in the absence of dusting were evident (lower baseline demographic performance and higher epizootic frequency leading to increased relative risk), the overall picture was considerably improved with the addition of simulated dusting as a method for imposing some measure of plague control.

Simulating the Impacts of Human Activity on Gunnison's & White-tailed Prairie Dog Populations

Additional PVA modeling was directed to determining the mechanisms through which specific human activities within prairie dog habitat may influence the two species' population dynamics into the future. The 2 primary activities investigated here were recreational shooting and poisoning.

Recreational Shooting

Four different levels of shooting-based mortality were simulated across all age classes of GUPDs and WTPDs, under current conditions of seasonal closure rules in effect 1 March – 14 June on public lands. Specifically, 5%, 10%, 15%, or 20% mortality was imposed across all age-sex classes, in addition to the baseline mortality rates discussed earlier.

To investigate the impact of removing the current seasonal closure rules, the same simulated additions to mortality were imposed while also decreasing the percentage of adult females that successfully weaned a litter. This is because shooting during the current closure season would lead to removal of pregnant females and dependent young of females from the population. In particular, 80% of the shooting mortality was estimated to occur during the time period of 1 March to 14 June; therefore, the reduction in the percentage of successful females was 80% of the specified increase in shooting mortality. For example, if shooting imposed an additional 10% increase in mortality, then there would be an 8% reduction in the percentage of adult females weaning a litter.

When the current seasonal shooting closure remained in place, nearly all scenarios except those with the highest levels of shooting-based mortality showed positive population growth and low to negligible risk of extinction (see Appendix G, Figs. 10 and 11). When the current seasonal shooting closure was retracted, all scenarios showed a decrease in growth rate and, if enzootic plague was present, an increase in the overall population extinction risk. However, the precise extent of this reduced demographic performance was clearly dependent on the underlying demographic profile. Therefore, the impact of shooting on prairie dog population persistence may be tied rather closely to the presence of low-level enzootic plague in these populations, particularly when they are small in size (i.e., < 250 individuals).

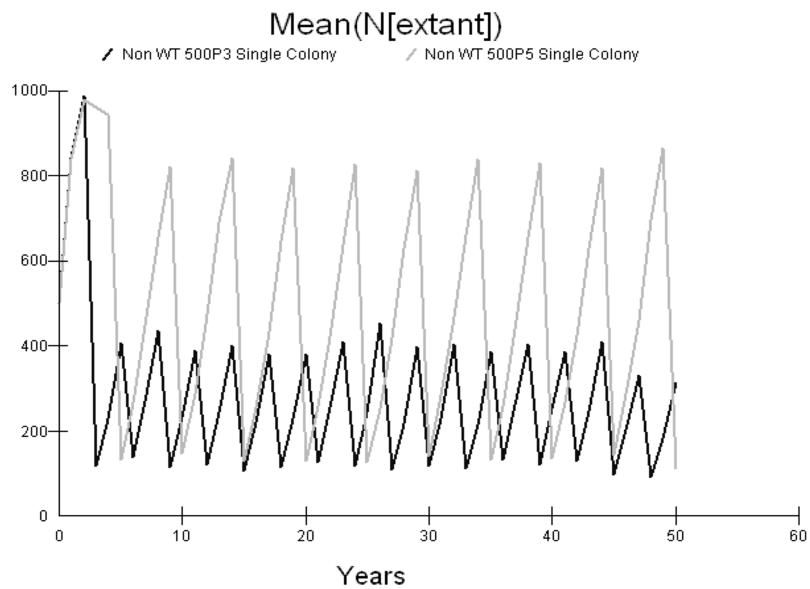


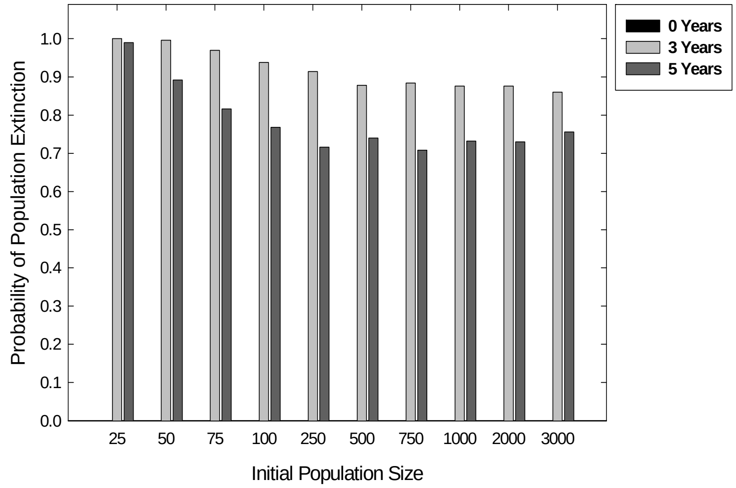
Fig. 16. Average extant size of a simulated prairie dog population with a non-enzootic white-tailed prairie dog (WTPD) demographic profile in the presence of periodic poisoning. The dark line indicates poison application every three years, while the light line indicates application every five years. Poisoning was assumed to be 85% effective, resulting in the elimination of 85% of the population during the year of application. Initial population size was 500 individuals. See Appendix G for additional information.

Poisoning

The application of various poisons can be an effective means of prairie dog population control. Information presented by experts in the field indicate that baited poisons are 75-85% effective, and fumigants could be as high as 95% effective. The use of these poisons was simulated by eliminating a total of 85% of a given simulated prairie dog population in the year of poison application. These poisons were also simulated at 2 different frequencies: either every 3 years or every 5 years. In the intervening years between poison application, demographic rates were assumed to be normal (baseline levels).

As expected, the periodic application of poison to prairie dog populations, assuming 85% efficacy of the agent, had dramatic effects on their long-term size trajectory (e.g., Fig. 16). Due to the underlying robust growth potential inherent in each of the four demographic profiles, less frequent poison application (in our case, every 5 years) afforded opportunity for the population to rebound, if still extant. However, even lower

Fig. 17. Probability of extinction over 50 years for simulated prairie dog populations of different initial size, and exhibiting a non-enzootic white-tailed demographic profile in the presence of periodic poisoning. Light gray bars indicate poison application every three years, while the dark gray bars indicate application every five years. Black bars, indicating no poison application (control), appear absent but merely represent a zero extinction risk in the absence of poison application.



frequency poison application led to very high risks of population extinction over the 50-year time period of the simulations (Fig. 17).

Conclusions

The analysis of Colorado prairie dog PVA can be summarized by returning to the original set of questions that provided the foundation for the PVA.

- *Can a series of simulation models be built with sufficient detail and precision that describe the dynamics of GUPD and WTPD populations across Colorado with reasonable accuracy?*

  The overall demographic analysis, combined with observations from the field, indicated that building such models was feasible. However, the absolute outcome predicted by any one modeling scenario should be interpreted with caution due to the inherent uncertainty in model input parameterization. A comparative analysis between models, in which a single factor (or at most two factors) was studied while all other input parameters were held constant, provided a more robust environment for evaluating alternative management scenarios and their effectiveness in increasing viability of the target species.

- *What are the primary demographic factors that drive growth of GUPD and WTPD populations?*

  The demographic sensitivity analysis indicated that models of prairie dog population dynamics were most sensitive to rates of juvenile female survival and adult female reproductive success (probability of weaning a litter and mean litter size). If appropriate and/or feasible, research and management efforts could be focused on these aspects of prairie dog biology in order to improve the persistence of selected populations in a conservation management context.

- *How vulnerable are small, fragmented populations of GUPDs and WTPDs in Colorado to extinction under current management conditions? How small must a population become to increase its risk of extinction to an unacceptable level?*

  Current simulations (and field observations) indicated that prairie dog populations, if free from natural or anthropogenic stressors, can show strong demographic dynamics. This outcome suggests greatly reduced risk of extinction for even the smallest populations on the landscape in the absence of other factors like plague, shooting, or poisoning.

- *What are the predicted impacts of plague on GUPD and WTPD populations in Colorado?*

  Plague epizootic events are a major threat to the future survival of prairie dog populations in Colorado, particularly in combination with other stressors present on the landscape. The models indicated that the frequency of such events was a critical factor in determining the long-term impacts; however, simulations that included a relatively modest reduction in the severity of plague epizootics, affected through flea dusting practices, suggested such approaches may yield a dramatic reduction in the long-term impacts of epizootics.

- *What are the predicted impacts of current shooting practices on GUPD and WTPD populations in Colorado?*

  Simulations suggested that lower rates of shooting-based mortality appeared to be sustainable in otherwise demographically robust (i.e., plague-free) prairie dog populations; however, populations appeared to become less stable when shooting was practiced during the primary reproductive period when pup production could be compromised.

- *What are the predicted long-term impacts of poisoning practices on GUPD and WTPD populations in Colorado?*

  Simulations suggested that current poisoning practices could reduce the long-term survival of even the largest prairie dog towns. This reduction in viability was, as expected, more acute when poisoning occurred more frequently.

- *Can we devise reasonable management practices to reduce predicted impacts of these activities on GUPD and WTPD populations in Colorado?*

  Overall, results from this analysis suggested that management practices currently proposed for prairie dogs such as flea dusting among prairie dog burrows, seasonal shooting closures, and restrictions in the geographic extent of poison use, would be expected to have measurable positive impacts on the long-term viability of prairie dog populations. Careful consideration of extent and scope of selected management options must occur so that conservation of an important prairie dog resource in Colorado can be achieved within an atmosphere of social, political, and cultural acceptance.

B. Geographic Information System Analyses

Geographic Information System analyses were undertaken to spatially map the overall range of the 2 prairie dog species. The overall range is an area that encompasses all known seasonal activity within the range of a population of prairie dogs.

To develop the overall range boundary, a GIS spatially-detailed model was developed to: (1) determine the number of acres comprising the overall range of the 2 species (see Table 2); (2) evaluate the extent of factors impacting GUPDs and WTPDs in Colorado; and (3) serve as a guide for conducting occupancy surveys. Although the model was produced to provide a more accurate, spatial depiction of the overall range of the GUPD and WTPD, not all areas located within the model's boundaries are biologically appropriate for prairie dog occupation. Limitations of the model stem from critical indicators of occupation not available in a digital, GIS format such as soil characteristics and detailed land cover information such as shrub density and shrub height. The model, therefore, most likely overestimates suitable habitat for the 2 species. The CDOW refined the model by using local biologist knowledge to identify areas appropriate for prairie dog occupation and removing areas identified as unsuitable for occupation.

The overall range boundary was used along with additional data layers, such as land ownership, urbanization, and oil and gas well locations, to facilitate analysis for the issues assessment.

<u>Overall Gunnison's Prairie Dog & White-tailed Prairie Dog Range</u>

The first step in producing the model was to separate specific habitat associations from those considered non-appropriate habitat. These associations were based on the literature and known species occurrences. Three input data layers were selected as indicators of potentially appropriate GUPD and WTPD habitat: (1) elevation range between 3,773 feet and 10,006 feet; (2) 0 to 20% slope; and (3) vegetation associations based on the Southwest Regional GAP Land Cover Classification (SWReGAP; Table 12).

Table 12. Vegetation classes used in the Overall Range model to depict suitable prairie dog habitat. Vegetation classes are from the Southwest Regional GAP Land Cover Classification 2005.

Agriculture
Colorado Plateau Mixed Low Sagebrush Shrubland
Inter-mountain Basins Big Sagebrush Shrubland
Inter-mountain Basins Greasewood Flats
Inter-mountain Basins Mat Saltbush Shrubland
Inter-mountain Basins Mixed Salt Desert Scrub
Inter-mountain Basins Montane Sagebrush Steppe
Inter-mountain Basins Semi-desert Grassland
Inter-mountain Basins Semi-desert Shrub Steppe
Inter-mountain Basins Shale Badlands
Invasive Annual and Biennial Forbland
Invasive Annual Grassland
Invasive Perennial Forbland
Invasive Perennial Grassland
Rocky Mountain Subalpine Mesic Meadow
Southern Rocky Mountain Montane-Subalpine Grassland
Western Great Plains Foothill and Piedmont Grassland

Both elevation and slope were derived from a 30-m Digital Elevation Model using the ArcGIS 9.2 (ESRI software). Landownership within the state was determined using the Colorado Ownership, Management, and Protection dataset (CoMAP v6; Wilcox et al. 2007), with landholders in the dataset including federal, state, local governments, universities, tribal governments, and private landowners. These data were used to develop the maps of the IPAs (Figs. 5 – 13; see also Table 2).

Agricultural Land

Lands designed as the "agricultural" vegetation class in SWReGAP were summarized for each IPA (Table 14). This vegetation class is defined as an aggregated landcover type that includes:

- Pasture/Hay: areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle, where pasture/hay vegetation accounts for greater than 20 percent of total vegetation
- Cultivated Crops: areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards, where crop vegetation accounts for greater than 20 percent of total vegetation; also includes all land being actively tilled.

Energy & Mining Development

Impacts to GUPDs and WTPDs due to energy and mining development were evaluated using GIS information from both the Colorado Oil and Gas Conservation Commission (COGCC) and the BLM. The analysis used federal lease data, oil and gas well locations, and resource potential data to evaluate (1) sites that have high potential for exploration and development; and (2) the amount of the overall range that may be impacted by federal oil and gas leases (Figs. 20–21, 24–26; Table 15).

Predicted Location of Future Housing

To evaluate the risk to prairie dog populations from increased urbanization, a Spatially Explicit Regional Growth Model (SERGoM v2) developed by Dr. David Theobald, Natural Resource Ecology Lab, Colorado State University (CSU), was used to depict the location and density of current and projected future private land housing units across Colorado. Although the current version of the model has not been published, the general procedure and rationale for a previous version of the model are described in Theobald (2005).

Future growth in housing units was based on Census Bureau county-level projections for population growth. This projected growth was apportioned to a projected number of new housing units using the county-level average persons per household, taken from 2000 census data. Growth in housing units was allocated spatially using a formula that considered recent (1990–2000) housing growth rates for a specific location and accessibility to the nearest urban core. Assumptions of this approach were: (1) future growth patterns will be similar to those found in the past decade; (2) people per household in the future will match that in the 2000 census data; (3) future growth is likely to occur nearby current high growth areas or "hot spots"; (4) housing units cannot occur on public land, water areas, etc.; (5) growth will be concentrated in areas closer (in terms of travel time, not just distance) to urban core areas over major roads; and (6) housing density will not decline over time (housing growth projections are additive to current housing densities).

Dr. Theobald's model and the resulting predicted housing density dataset was used in the GIS analysis to evaluate the potential acreage impacted by housing development to 2020 for each IPA (Tables 17 and 18, Figs. 27 and 28). For the analysis, housing densities were examined at less than 40 acres per unit, 40–80 acres per unit, and greater than 80 acres per unit. The designation of these housing classifications was based on the knowledge that prairie dogs are able to live around housing developments, but the probability of eradication due to disturbance, extermination, and removal of animals increase as housing density increases.

V. ISSUES & CONSERVATION STRATEGIES

In cooperation with the WAFWA's WTPD and GUPD Conservation Strategy, individual state management plans are addressing the 5 listing criteria used by the USFWS to determine if a species should be protected under the ESA. For each criterion, the state plans will summarize current status and management, evaluate current information, and develop conservation strategies. The 5 listing criteria and the items discussed in detail in the *Colorado Conservation Strategy* are:

A. Present or Threatened Destruction, Modification or Curtailment of Habitat or Range
  - Agricultural Conversion
  - Energy and Mineral Development
  - Rangeland Condition
  - Urbanization

B. Overutilization for Commercial, Recreational, Scientific or Educational Purposes
  - Recreational Shooting

C. Disease
  - Plague and Tularemia

D. Inadequacy of Existing Regulatory Mechanisms
  - Population Monitoring
  - Recreational Shooting

E. Other Natural or Manmade Factors Affecting its Continued Existence
  - Associated Species
  - Genetics
  - Poisoning
  - Population Reestablishment

In this section of the *Colorado Conservation Strategy*, we outline the issues encompassed within the 5 listing factors that could impact GUPD and WTPD populations in Colorado, and provide conservation strategies to address the issues; the strategies pertaining to each issue immediately follow the issue discussion. The issues are presented in alphabetical order and *not according to the priority ranking* of the issue as it relates to impacting prairie dog populations.

All issues with the exception of Associated Species, Genetics, Population Monitoring, and Population Reestablishment were discussed at a stakeholder's workshop (May 2007) with agencies, experts, stakeholders, and the CDOW. Summaries of the specific topics of concern identified by workshop participants are provided for the issues discussed at the workshop (Agricultural Conversion, Disease, Energy and Mineral Development, Poisoning, Rangeland Condition, Recreational Shooting, and Urban Development).

These discussions lead to the development (while at the workshop) of draft strategies designed to help alleviate potential negative impacts on GUPD and WTPD populations and maintain viable populations of both species statewide. The preliminary strategies were reviewed, consolidated, and supplemented by CDOW plan development staff following the workshop, resulting in the full list of strategies provided in this section.

A. Agricultural Conversion

Agricultural land conversion has resulted in the loss and fragmentation of native prairie dog habitat due to eradication efforts and development of barriers to movement. Today, prairie dog colonies are small, isolated and widely distributed across the agricultural landscape and though they may persist, low densities and scattered distribution preclude them from performing their ecological function (Miller et al. 2000, Soulé et al. 2005, and Proctor et al. 2006).

Background

Prairie dogs are often considered unwanted pests by farmers, who rely on agricultural lands for their livelihoods. Consequently, attempts have been made to eradicate prairie dogs through poisoning, shooting, and drowning. Thus, as more land was converted to agriculture historically, ever-increasing control efforts caused significant declines in all prairie dog species (Knowles 2002).

Today, prairie dog populations that inhabit agricultural land occur in small, widely distributed, isolated colonies. This fragmentation puts them at higher risk of extinction due to disease, environmental and demographic stochasticity, lower re-colonization rates due to the increase in barriers to movement (e.g., roads, fences, predators), and an increased risk of inbreeding. Fragmentation and loss of habitat can disrupt the entire ecological function of the prairie dog system, impacting not only prairie dogs but associated species.

Conversely, agricultural crops can be beneficial to prairie dogs by providing highly nutritious forage that can increase survival rates and litter sizes, resulting in prairie dog colonies exhibiting unnaturally high densities. For example, on native landscapes GUPD densities are thought to average 1-2 animals per acre. However, in agricultural fields, densities can exceed 28 GUPDs per acre (Longhurst 1944). Other researchers have found GUPD densities ranging from 2 to over 23 per acre in favorable habitat (Fitzgerald and Lechleitner 1974, Rayor 1985, Van Pelt 1995). For WTPDs, burrow densities also vary greatly from location to location, depending on site condition (0.3−118 per acre with a mean of 0.8−16.8 per acre; Tileston and Lechleitner 1966, Clark et al. 1986, Menkens 1987, Orabona-Cerovski 1991). A research study comparing UTPD densities in native habitat to those colonies occupying an alfalfa field found that UTPD densities were lower at sites not associated with agriculture (6.5 per acre) and significantly higher (14.6 per acre) at sites associated with alfalfa fields (Crocker-Bedford 1976). The differences in densities observed during the UTPD study were attributed to the variation in nutrition based upon quantity and quality of available forage.

Colorado

Prior to agricultural conversion of habitats in Colorado, many GUPD and WTPD populations occurred in habitats that provided deep soils and high quality forage, the same sites that agricultural producers coveted. But historical prairie dog densities were lower and distribution more contiguous across the landscape. Settlement of Colorado in the early 20th century saw rapid development of irrigated crops (Table 13). As the century progressed, alfalfa and hay crops began to dominate the landscape. Replacement of native arid landscapes with highly nutritious legume and grass crops allowed prairie dog colonies in these areas to reach artificially high densities. However, these areas also resulted in the creation of more widely distributed, small colonies due to active eradication efforts and development of barriers such as fences, irrigation, roads, and urban predators. Though GUPD and WTPD colonies are being maintained in this new biological arrangement, their ecological function has been impaired.

Table 13. Acres of land in agricultural production in counties within the Gunnison's prairie dog (GUPD) and white-tailed prairie dog (WTPD) overall range, including irrigated cropland, non-irrigated cropland, irrigated pasture and hayland, non-irrigated pasture and hayland (excluding rangelands; U.S. Department of Agriculture 2006).

County	Prairie Dog Species Present	Agricultural Acres 1910[1]	Agricultural Acres 1954	Agricultural Acres 2002
Alamosa	GUPD	Part of Saguache[2]	85,706	111,194
Archuleta	GUPD	16,095	21,930	26,676
Chaffee	GUPD	16,733	20,843	26,257
Conejos	GUPD	131,916	123,491	138,281
Costilla	GUPD	114,612	52,402	69,789
Custer	GUPD	27,080	22,365	30,781
Delta	WTPD	62,604	80,468	79,134
Dolores	GUPD	1,136	78,989	82,687
Eagle	WTPD	25,401	28,542	6,399
Fremont	GUPD	24,868	29,002	32,571
Garfield	WTPD	61,818	76,209	22,073
Gunnison	GUPD & WTPD	38,074	62,728	58,608
Hinsdale	GUPD	2,349	4,650	4,197
Huerfano	GUPD	28,631	36,732	60,191
Jackson	WTPD	74,737	103,527	44,248
La Plata	GUPD	41,390	93,734	111,609
Larimer	WTPD	177,525	192,512	139,895
Mesa	GUPD & WTPD	73,508	112,420	49,417
Mineral	GUPD	7,036	5,078	322
Moffat	WTPD	Part of Routt County[3]	107,947	40,370[4]
Montezuma	GUPD	31,112	122,749	118,994
Montrose	GUPD & WTPD	65,136	95,783	106,613
Ouray	GUPD & WTPD	14,612	16,029	15,342
Park	GUPD	46,205	32,745	45,649
Rio Blanco	WTPD	36,750	51,237	18,048[5]
Rio Grande	GUPD	115,890	122,999	110,868
Saguache	GUPD	217,102[5]	116,933	173,446
San Miguel	GUPD	19,130	20,047	21,708
Teller	GUPD	10,943	5,198	11,166

[1] The 1910 agricultural statistics do not provide total cropland acres, but has "improved land in farms".
[2] In 1910 Saguache County included the area currently known as Alamosa County.
[3] In 1910 Routt County included the area currently known as Moffat County.
[4] Non-disclosed total cropland acres. The amount shown is the total irrigated acres, plus wheat, oat, and estimated fallow acres.
[5] Non-disclosed total cropland acres. The amount shown includes the irrigated acres, plus the 1 non-disclosed, non-irrigated farm, sized 500-999 acres.

Geographic Information System Analysis Results

Within the state of Colorado, agriculture impacts 13.5% of the GUPD and 14.7% of the WTPD overall range (Table 14; see "GIS Analyses" section). Conversion of additional lands to agriculture is not currently occurring.

Table 14. Acres of agricultural lands within the overall range of Gunnison's prairie dog (GUPD) and white-tailed prairie dog (WTPD) in Colorado.

Population Area	Agricultural Lands (acres)	Overall Range (acres)	Agricultural Land in Overall Range (%)
GUPD			
Gunnison	59,198	905,081	6.5
La Plata/Archuleta	110,733	549,041	20.2
San Luis Valley	648,899	3,488,005	18.6
South Park	7,918	700,811	1.1
Southeast	78,158	1,713,607	4.6
Southwest	270,440	1,102,086	24.5
GUPD Total	**1,180,060**	**8,725,254**	**13.5**
WTPD			
Grand Valley / Uncompahgre	316,159	957,702	33.0
North	87,728	447,917	19.6
Northwest Colorado	47,473	1,657,653	2.9
WTPD Total	**451,360**	**3,063,272**	**14.7**

Stakeholder Workshop

The group assigned to the "Agricultural Conversion" and "Poisoning" issues at the stakeholder workshop identified the 2 following problem areas:

- "The co-existence of prairie dogs and agriculture present a challenge for one another. The challenges include: crop damage, equipment damage, disease, fear and a negative perception within the populous [*sic*]. [Note: most strategies for this issue are under 'Poisoning']."

- "Agricultural conversion has resulted in fragmentation with ground disturbances and land management differences on adjacent properties. This conversion has resulted in ecological impacts on prairie dogs and restricted or altered distribution."

Conclusion

Conversion of additional native prairie dog habitat to agricultural fields is currently limited in Colorado, but historical conversion was common and widespread. From a landscape-scale perspective, this historic conversion resulted in fragmentation and isolation of prairie dog populations. Fragmentation of prairie dog habitat is the primary concern caused by Agricultural Conversion. In addition, the continued use of toxicants and other lethal control techniques in agricultural settings needs to be monitored as part of ongoing GUPD and WTPD conservation efforts.

Agricultural Conversion - Conservation Strategies

ISSUE 1.1: The co-existence of prairie dogs with agriculture presents challenges, including their ability to cause (1) crop damage; (2) agricultural equipment damage; and (3) fear and a negative perception.

OBJECTIVE 1.1.1: Minimize the perceived negative effects of prairie dogs on agricultural lands.

STRATEGY 1.1.1.1: Develop alternatives to poisoning to protect croplands from prairie dog damage

STRATEGY 1.1.1.2: Create and identify funding sources for implementing available incentives (e.g., easements, fee title, management alternatives, depredation payments, incentive programs, Candidate Conservation Agreements with Assurances [CCAAs]) for landowners to maintain GUPD and WTPD colonies on private land.

STRATEGY 1.1.1.3: Educate landowners regarding the potential economic opportunity for harvest of prairie dogs by recreational shooters if agriculture is impacted by high densities of prairie dogs (see also "Recreational Shooting" strategies).

STRATEGY 1.1.1.4: Develop and implement an outreach program for landowners and local biologists regarding (1) GUPD and WTPD biology; (2) disease issues; and (3) importance of prairie dogs to the ecosystem.

ISSUE 1.2: Agricultural conversion has resulted in the fragmentation and isolation of prairie dog colonies, which has adverse long-term impacts to the maintenance of GUPD and WTPD populations.

OBJECTIVE 1.2.1: Minimize the adverse impacts on GUPDs and WTPDs of habitat fragmentation caused by current agricultural practices.

STRATEGY 1.2.1.1: Identify areas that could serve as corridors for GUPD and WTPD movement and colony reestablishment to minimize habitat fragmentation due to agricultural operations.

STRATEGY 1.2.1.2: Develop recommendations for agricultural practices that also address or recognize GUPD and WTPD habitat needs.

STRATEGY 1.2.1.3: Create new and use available incentives to fund cooperative agreements to develop movement corridors for prairie dogs.

B. Associated Species

Prairie dog populations have been reduced within the last century due to habitat conversion, eradication campaigns, and plague (Oldemeyer et al. 1993). It has been argued that the loss of prairie dogs across their range can impact ecological processes and affect biological diversity (Kotliar et al. 1999).

Background

Prairie dogs play an important role in the ecological communities they inhabit and many ecologists consider them a keystone species. GUPDs are known to affect a number of ecosystem-level functions by altering plant species composition and nutrient cycling rates (Whicker and Detling 1988). GUPD and WTPD burrows provide escape structures, dens, and nests for species such as burrowing owls, kit fox, and various small mammals (Miller et al. 1994, Meaney et al. 2006). Their colonies can attract many species of insects that are important to bird species using these systems. The resulting increase in bare ground caused by prairie dog foraging activities and colony development provides suitable breeding habitat for species such as the mountain plover that require open spaces and less cover for nesting (Johnson-Nistler et al. 2004).

BTPDs are the most widely-studied prairie dog species and are known to significantly alter their environments. The limited amount of research conducted on GUPDs and WTPDs shows that their impact on the environment is less dramatic than that of BTPDs. For example, Grant-Hoffman and Detling (2006) measured vegetation cover, canopy height, species diversity, and nitrogen concentration on and off 6 GUPD colonies in southwestern Colorado. They found few vegetative differences between prairie dog colonies and non-colonies. However Bangert and Slobodchikoff (2000), found that the presence of GUPD colonies increased habitat heterogeneity at the landscape level, and that this heterogeneity is potentially important to a wide variety of animals. The magnitude of difference between the impact of BTPDs and that of the GUPD and WTPD may be due to the vegetative communities they inhabit, as well as to the relatively limited above-ground activity of GUPDs and WTPDs (they can spend up to two-thirds of their life underground in burrows), lack of "clipping" behavior, lower colony densities, and fewer social interactions.

Prairie dogs are an important resource for a number of predators, including the endangered BFF, which depends almost exclusively on prairie dogs as prey. The BFF has been near extinction due to a decline in prairie dogs (Kotliar et al. 1999). Other species also depend on prairie dogs for food and at certain times and locations are known to specialize locally on them. For example, Ferruginous hawks that winter in Colorado feed primarily on prairie dogs and concentrate in areas with the highest prairie dog densities (Plumpton and Anderson 1997; Seery and Matiatos 2000). WTPDs are also thought to be important to the kit fox as a food source (Eussen 1999, Meaney et al. 2006).

Competition

The WYGS is a species that may gain a competitive advantage over prairie dogs when populations are reduced to sufficiently low levels after a plague epizootic. When prairie dog colonies are healthy, WYGSs probably have little, if any, competitive advantage. J. Hoogland (University of Maryland, personal communication 2007) documented 8 different WTPD females killing juvenile WYGSs in North Park, Colorado, where the 2 species co-occur. Because the prairie dogs killed and did not consume the carcasses, Hoogland suggested that the killings were in response to resource competition and that WTPDs held a competitive advantage over WYGSs.

D. Biggins (U.S. Geological Survey, personal communication 2007) observed that WYGSs resided on the periphery of WTPD colonies during his research in Meeteetse, Wyoming. However, after a plague epizootic resulted in a large die-off of WTPDs in the area, WYGS occurrence shifted from the periphery of colonies to within colony boundaries. Since the Meeteetse WTPD die-off, little recovery of the population has been documented (Seglund et al. 2006). Whether this is due to WYGSs now occupying the area, or due to some other factor, is unknown.

An additional example of WYGSs colonizing an area after a plague epizootic comes from South Park, Colorado, where plague decimated the GUPD population between 1947 and 1949 (Ecke and Johnson 1952). Today the area is still mostly devoid of prairie dogs, but WYGSs are now abundant in the area. Some local mammalogists suspect that WYGSs have extended their range in Colorado due to die-offs of prairie dogs from plague, and that WYGS presence might be preventing prairie dogs from repopulating their former colonies (Finley 1991). Hansen (1962, *cited in* Fitzgerald et al. 1994) reported that WYGSs had been extending their range in Colorado southward at a rate of 1.5 miles per year since 1930. Fitzgerald et al. (1994) felt that impacts of livestock grazing and reduction in prairie dog populations might account for the rapid spread of WYGSs.

Ground squirrels are susceptible to plague, but because of their smaller body size (Krasnov et al. 2006a), looser colonial nature, and extended hibernation period (Krasnov et al. 2006b), transmission rates may be reduced, resulting in WYGS populations perhaps being somewhat more resilient than prairie dog populations in the face of epizootic plague. After plague epizootics decimated GUPDs and most other rodents living in South Park, WYGSs were the first species to reappear in areas they had been absent from immediately following the disease outbreak (Ecke and Johnson 1952). Although WYGSs may be a source of infection to prairie dogs in areas where their populations overlap, there is no evidence that WYGSs serve as a true reservoir of plague in these systems.

Predation

Prairie dogs have evolved to be a prey species for many predators, including BFFs, hawks, eagles, badgers, and coyotes. Although prairie dogs are susceptible to predation by a wide array of species, predation is not believed to be limiting populations and is not currently believed to be a significant threat to the long-term viability of the 2 species. Only the BFF preys exclusively on prairie dogs. Other predators are known to utilize a wide array of prey species and are generally opportunistic prairie dog predators.

Because predation is not considered a risk to the viability of populations, no strategies were developed.

Conclusion

Although the effects of GUPDs and WTPDs on ecological processes and biological diversity may be more muted that those reported for BTPDs, their role in maintaining the integrity of the shrub-steppe and grassland ecosystems is no less important. Efforts to conserve large blocks of healthy, contiguous occupied prairie dog habitat are thus needed to maintain healthy prairie dog ecosystems and those species associated with such systems.

Infiltration of WYGSs into prairie dog colonies impacted by plague may prevent re-colonization of the area by prairie dogs resulting in a loss of occupied habitat. More research is needed to better understand the mechanism driving this interaction between prairie dogs and WYGS so that appropriate conservation strategies for both species can be developed.

Although GUPDs and WTPDs are susceptible to predation by a large number of species, predation is not believed to be limiting populations and is not currently believed to be a significant threat to the long-term viability of the species.

Associated Species - Conservation Strategies

ISSUE 2.1: There is a need to protect and maintain healthy prairie dog ecosystems, for the conservation of GUPDs, WTPDs, and associated species.

OBJECTIVE 2.1.1: Implement conservation strategies to protect the prairie dog ecosystem and associated species.

STRATEGY 2.1.1.1: Work with public land agencies and other affected stakeholders to identify management emphasis areas (MEAs) (within the GUPD and WTPD IPAs) where intensive management can focus on landscape scale conservation for the entire prairie dog ecosystem. These MEAs will balance the long-term conservation needs of prairie dogs and associated species with other land uses that may occur.

STRATEGY 2.1.1.2: Identify appropriate conservation strategies (as outlined in the *Colorado Conservation Strategy* document) to be applied on a more intensive basis in identified management emphasis areas (see Strategy 2.1.1.1) in order to protect entire GUPD and WTPD ecosystems (e.g., plague dusting, reintroduction of prairie dogs, habitat enhancement, and land-use restrictions).

STRATEGY 2.1.1.3: Apply identified strategies (see Strategy 2.1.1.2) in the management emphasis areas (see Strategy 2.1.1.1). Evaluation of results will help determine if the conservation strategies used are appropriate and effective, and whether these can and should be implemented in other occupied habitats within the GUPD and WTPD ranges.

ISSUE 2.2: Monitor the success of GUPD and WTPD management and effects on associated species.

OBJECTIVE 2.2.1: Continue established and develop new monitoring protocols to evaluate the population status of species associated with GUPDs and WTPDs.

STRATEGY 2.2.1.1: Continue to intensively monitor BFF populations and their habitat (i.e., prairie dog densities) as per accepted protocols.

STRATEGY 2.2.1.2: Develop and implement monitoring strategies for burrowing owls, ferruginous hawks, mountain plovers and kit fox in identified management units (see Strategy 2.1.1.1).

ISSUE 2.3: WYGSs appear to incur a competitive advantage over GUPDs or WTPDs, following a plague epizootic.

OBJECTIVE 2.3.1: Reduce the frequency of plague in areas that contain both WYGSs and prairie dogs.

STRATEGY 2.3.1.1: Develop and implement a plague management/reduction program in areas that contain both WYGSs and prairie dogs (e.g., dust colonies, oral vaccine; see "Disease" issue section).

OBJECTIVE 2.3.2: Use population augmentation to help reestablish prairie dog populations after die-offs in areas with WYGSs.

STRATEGY 2.3.2.1: Translocate GUPDs and WTPDs from nearby locations to augment populations (see "Population Reestablishment" strategy section).

STRATEGY 2.3.2.2: In areas that are identified to receive translocated prairie dogs, use dusting to reduce flea abundance and thus the incidence of plague.

STRATEGY 2.3.2.3: Intensively monitor the success of GUPD and WTPD translocations, as well as interactions between WYGSs and prairie dogs.

OBJECTIVE 2.3.3: Increase understanding about potential competitive interactions between WYGSs, GUPDs, and WTPDs.

STRATEGY 2.3.3.1: Investigate the competitive interaction between WYGSs, GUPDs, and WTPDs.

C. Disease

The primary factor limiting GUPD and WTPD populations and distribution in Colorado is plague, an introduced, flea-transmitted disease caused by the bacterium *Yersinia pestis* (Heller 1991, Cully and Williams 2001). Plague is thought to be the most critical threat to sustained conservation of prairie dog species (Cully and Williams 2001, Pauli et al. 2006b), and is currently an issue over which managers have relatively little control (Cully and Williams 2001). Tularemia, caused by a native pathogen (the bacterium *Francisella tularensis*), is another disease found in prairie dogs. Its impact on prairie dog populations is unknown.

Background

Plague

Plague is a non-native pathogen that originated in Asia, arriving in North America around 1899. Plague was first recorded in native North American mammals in California in 1908 (Barnes 1982). Since then the disease has spread from the Pacific Coast, east to about the 100th meridian, infecting 76 species in 6 mammalian orders (Barnes 1993). The earliest confirmations of plague in GUPDs were in northwestern Arizona in 1932, in eastern Arizona in 1937, and in New Mexico in 1938 (Eskey and Haas 1940). Confirmation of plague in WTPDs occurred in Wyoming in 1936 (Eskey and Haas 1940). The first plague-positive finding in Colorado was made in San Miguel County in 1941 (Ecke and Johnson 1952) when both marmots and ground squirrels were found to be infected. Between 1941 and 1947, plague was isolated from GUPDs when an epizootic occurred in South Park (Ecke and Johnson 1952). Today, plague-free GUPD and WTPD populations are unlikely to exist within their range (Biggins and Kosoy 2001b).

Plague is primarily transmitted via flea vectors, though carnivores can also be exposed through consumption of infected prey. Studies have demonstrated that many species of flea can transmit the disease and some species can survive for years in abandoned prairie dog burrows (Fagerlund et al. 2001, Padovan 2006). It is unclear if there are mammal species that function as reservoir hosts in the wild, maintaining the bacteria in an enzootic phase (presence of the disease that results in relatively lower mortality than an epizootic event) between epizootics. Antolin et al. (2002) suggested that some species (e.g., deer mouse, Ord's kangaroo rat) act as resistant hosts, maintaining the bacteria in an enzootic phase. Laboratory trials have shown evidence that the northern grasshopper mouse may become resistant to plague, allowing it to serve as a reservoir host (Thomas et al. 1988). Carnivores may also serve to spread infected fleas among prairie dog colonies, but currently there are no data to support this hypothesis (Ubico et al. 1988, Cully and Williams 2001, McGee at al. 2006).

GUPDs experience nearly 100% mortality during plague epizootics and eradication of populations can occur within 1 active season (Lechleitner et al. 1962, 1968; Rayor 1985; Cully 1989; Cully and Williams 2001). WTPDs have been found to experience slower rates of plague transmission and less consistent population declines (85%-96%) than other prairie dog species (Clark 1977, Anderson and Williams 1997). WTPD populations, which generally occur in low-density colonies with dispersed aggregations of animals, may experience lower transmission rates due to their spatial pattern and distribution. Possible long-term consequences of continued plague infection in GUPD and WTPD populations include (1) local extirpation of colonies; (2) reduced colony size and densities; (3) increased variance in population sizes, and (4) increased inter-colony distances.

The susceptibility of prairie dog populations to epizootics is thought to correspond with high population densities, abundant flea vectors, and uniformly low resistance (Biggins and Kosoy 2001a). Stapp et al. (2004) suggested that plague outbreaks tend to occur after El Niño events, which may facilitate increased flea and prairie dog populations, and thus transmission of the disease. Rayor (1985) described an epizootic in GUPDs following an unusually warm winter with little snowfall.

Biggins et al. (2010) suggest the occurrence of plague at enzootic levels is responsible for significantly reduced survival in prairie dogs. Matchett et al. (2010) found decreased BFF survival without experiencing a noticeable prairie dog die-off (indicative of a plague epizootic), further suggesting that plague occurring at enzootic levels can have serious implications for prairie dogs and BFF.

Current research has documented that individual prairie dogs have survived plague infection and seroconversion (development of antibodies against plague) has occurred (Williams et al. 1979, Thomas et al. 1988 *in* Cully 1993; Pauli et al. 2006b). Resistance to plague may differ among populations of the same species, and it may change depending on amount of exposure (Biggins and Kosoy 2001b). Antibody titers have been found in GUPDs and WTPDs, indicating individual exposure to plague and subsequent recovery (Cully and Williams 2001, Biggins 2003a). A recent study in Arizona focused on a complex of GUPDs that has not been infected by plague since 1974 (Wagner and VanAndel 2007). GUPDs at this site had significantly higher levels of antigens associated with killing intracellular pathogens such as plague (Wagner and VanAndel 2007). The authors noted that this would be the same immune response expected if the prairie dogs had been vaccinated against plague.

The impacts of plague outbreaks, which lead to the loss of prairie dog colonies of all sizes (Roach et al. 2001), are likely magnified by isolation of colonies. Colony growth after an epizootic might be the result of re-colonization by inter-colony dispersers (Antolin et al. 2002). Increased isolation decreases the likelihood the colony can be re-colonized following a plague outbreak if the distance between the infected colony and the next nearest colony are beyond the dispersal capabilities of the species. For example, Lechleitner et al. (1962) documented a 1959 plague outbreak in a Colorado GUPD colony that killed all members of the colony. Prior to the outbreak, this colony had been continuously occupied for 20 years, despite several poisoning attempts. Two years after the plague outbreak, the colony still had not been re-colonized, being isolated from other colonies by more than 7 miles. Recovery rates of GUPD colonies studied 2 years post-epizootic found that GUPDs experienced 100% mortality and remained depopulated throughout the study due to the lack of available immigrants (Turner 2001).

In addition to immigration being important to colony recovery after a plague epizootic, survivors of epizootics may be crucial in repopulating plague-decimated colonies (Pauli et al. 2006b). Turner (2001) found that a UTPD colony had 12 animals surviving a plague epizootic, which enabled the population to rebound to 37% of the pre-plague population of adults within 2 years following the epizootic event.

Human actions may compound the impacts of plague, at least in the short-term, and should be addressed where possible to lessen the impacts or duration of the disease. The effects of plague may be amplified and recovery rates slowed when additional impacts such as shooting, poisoning, and habitat loss/conversion occur. All of these pressures acting together may exacerbate isolation and extirpation of prairie dog populations. If plague infiltrates isolated areas and local populations are eradicated, source animals may not be present to re-colonize the area.

Currently, there are few methods for managing plague in prairie dog colonies at a landscape-scale. For smaller areas, it may be feasible to dust prairie dog burrows with an insecticide to kill fleas and curtail an epizootic (e.g., Hoogland et al. 2004). Historically-used insecticides, such as 2% carbaryl, did not effectively reduce flea populations for long periods of time or halt epizootics. The application of an insecticide (deltamethrin) currently appears to be the most effective mechanism to control plague. However, dusting is costly and labor intensive. Griebel (2008) details the extensive resources and procedures that are required to curtail plague in a large BFF reintroduction site containing over 30,000 acres of prairie dog colonies. A review of Griebel (2008) can help shape a plague contingency plan.

Another problem associated with dusting is that the insecticide is not species-specific and therefore kills not only fleas, but all arthropods inhabiting prairie dog burrows where dust is applied. The local reduction of insects could impact birds, mammals, and other occupants of treated burrows by reducing food sources.

Poche et al. (2008) have demonstrated the effectiveness of a systemic insecticide (imidacloprid) for controlling fleas on WYGSs and BTPDs in a laboratory setting. The effectiveness and duration of effect are expected to be investigated on wild prairie dogs in 2009 (David Jachowski, US Fish and Wildlife Service, personal communication 2009).

An oral vaccine has shown considerable promise for immunization of prairie dogs exposed to high levels of plague in the laboratory (Rocke et al. 2008). Registration of this vaccine is expected to occur in 2009 or 2010. A bait preference and acceptance study of oral delivery of the vaccine was tested in BTPDs (Creekmore et al. 2002). Additional field trials of bait uptake began in Colorado in 2009 to provide data specific to applications in GUPD and WTPD populations. Field trials during the next few years may provide new tools that managers in Colorado and elsewhere could use to stabilize fluctuating populations of prairie dogs and subsequently benefit BFF populations where they occur. These method(s), or a combination thereof, may offer wildlife managers a feasible tool for plague management that is a longer-lasting alternative to burrow dusting with fewer potential collateral impacts.

Tularemia

Tularemia, a disease native to North America, also can cause disease-related declines in prairie dog populations (Davis 1935); however, the long-term impact of this disease is unknown (Barnes 1982). Because tularemia is caused by a native pathogen, it is thought that prairie dog species have developed evolutionary defenses that guard against large-scale die-offs. Most observations suggest that when tularemia is found within a colony, die-offs occur at small localized sites and do not spread throughout a colony or area (D. Biggins, USGS, personal communication 2007). In addition, tularemia is transmitted by ticks. Researchers that work with prairie dogs report finding few ticks on individuals, suggesting that ticks may not be an adequate vector to transmit the disease across large areas (D. Biggins, USGS, personal communication, 2007).

History of Disease in Colorado

Gunnison's Prairie Dog

The impact of plague on GUPD populations in Colorado has been well-documented. In 1941, GUPDs occupied an estimated 914,000 acres in South Park (Ecke and Johnson 1952). From 1947 to 1949, plague reduced the occupied habitat of this area to less than 5% of its former extent (Ecke and Johnson 1952). Lechleitner et al. (1962) observed a colony of 275 GUPDs that was eliminated near South Park in 1959 and from 1964-1966, he observed 5 of 7 colonies die out during a plague epizootic in Saguache County, Colorado (Lechleitner et al. 1968). Fitzgerald and Lechleitner (1974) studied the biology of the GUPD in South Park. During their research project, a plague epizootic caused the main study colony to die off. From 2002-2005, CDOW identified approximately 3,000 acres of colonies in South Park, 0.3% of the original area occupied in the 1940s.

Rayor (1985) described an outbreak of plague that spread through a 148-acre colony in the CURE, west of Gunnison, in 1981. In less than 2 months, Rayor reported the loss of 1,000-1,500 prairie dogs. A few animals survived the disease and Cully (1989), who visited the area in 1986, noted that GUPDs were again abundant. As of 2007, the CURE staff estimated that 28 acres of occupied GUPD habitat existed within the National Recreation Area. Six documented plague epizootic events (1971, 1981, 1992, 1996, 2005 and 2007) have occurred in the CURE (T. Childers, National Park Service, personal communication 2009).

In 2003, the southern half of Montezuma County was surveyed to evaluate GUPD occupancy (Coyler 2003). From these surveys, 23 colonies on 608 acres were located in Mancos Valley and 28 colonies on 539 acres were in Montezuma Valley. During the surveys, evidence of plague was noted. As described by Coyler (2003) while in the area, "It appears populations build up, numbers get high per colony, and new colonies are formed up to 5 or more miles from core colonies. Then plague hits and colonies nearly die off with some completely dying out. Plague travels along drainages, with neighboring drainages somewhat protected from epizootics. A few prairie dogs are usually able to survive the epizootic and within 2-3 years the population begins to rebuild". Plague appeared to impact Montezuma County in 1985, 1993, and 1999 (Coyler 2003).

In 2008, the CDOW collected fleas from GUPDs trapped as part of a genetics study to evaluate flea loads and flea species composition. Seven colonies were sampled during this effort. Preliminary analysis of PCR data from pooled flea samples has revealed evidence of *Y. pestis* DNA in one colony east of Gunnison and at 2 colonies in San Miguel County. Colonies in San Miguel County recorded positive flea PCR samples in 1 of 33 prairie dogs sampled. These 2 colonies remained active throughout the season and colonies were again reported active in the spring of 2009. However, the sampled colony east of Gunnison also had positive PCRs on flea samples collected throughout the colony. This colony appeared to die off immediately following sampling.

White-tailed Prairie Dog

The LSMA was the first area to be selected as a BFF reintroduction site in Colorado; however, a dramatic die-off of WTPDs in 1994 precluded the area from further consideration as a BFF reintroduction site. Twelve years after a plague epizootic was first documented, WTPD numbers and occupied habitat within the LSMA have not recovered to pre-plague densities and distribution. It is unknown why WTPDs in this area have been unable to recover.

The significant fluctuations in WTPD numbers recorded for the WCMA and the CBMA (Tables 5, 6, and 7) may be due to plague. However, small mammal disease sampling at both the WCMA and LSMA in 2006 yielded 542 samples that all were seronegative for evidence of plague exposure.

Some prairie dog population fluctuations at the WCMA and the CBMA also could be due to tularemia. Tularemia was documented in WTPDs at the Dinosaur National Monument, Colorado headquarters area in June/July of 2007. Utah Division of Wildlife Resources also reported a simultaneous die-off of prairie dogs in the Bonanza area, near Colorado. However, none of the 542 small mammal samples in either the LSMA or WCMA tested positive for tularemia. BFF mapping and transecting crews did not detect dead prairie dogs during the summer of 2006 in either the WCMA or areas mapped in the LSMA.

In cooperation with the BLM and U.S. Geological Survey - Biological Research Division (D. Biggins, personnel communication 2008), paired-plot monitoring and treatment of prairie dog colonies with deltamethrin was conducted in the summer of 2005 in the WCMA. Deltamethrin was applied to 900 acres in 2 WTPD colonies. Prairie dog density increased in both colonies between 2005 and 2006, although this was true for all but 1 colony within the WCMA.

As part of ongoing obligations to support BFF reintroduction in northwestern Colorado, the CDOW developed in-house capacity for conducting large-scale plague surveillance in WTPD complexes during 2007–2009. These approaches were developed to provide tools for identifying endemic plague foci and emerging plague epizootics in prairie dog populations to facilitate preventive management where warranted. For surveillance, fleas were collected by systematically swabbing WTPD burrows at four sites: the WCMA, LSMA, CBMA, and Snake John Reef. Fleas were identified to species, pooled by burrow and species, and tested for presence of *Y. pestis* DNA using PCR. In addition to burrow sampling, carcasses of prairie dogs and other mammals were collected or sampled opportunistically in the field and subsequently tested for evidence of plague.

Analysis of flea PCR data revealed evidence of *Y. pestis* DNA in flea pools from several colonies in the WCMA beginning in August 2007 (Griffin et al. 2010). Plague also was confirmed independently in carcasses of a desert cottontail rabbit and a WTPD found in different parts of the WCMA. Based on these findings and the proximity of plague activity to the core BFF release area, prairie dog burrows over about 860 acres, including parts of two prairie dog colonies on the eastern side of the WCMA, were dusted with deltamethrin in September–October 2008 in an effort to reduce flea populations and the potential impact of plague on populations of both WTPDs and BFFs.

Multiple plague positive WTPD carcasses and flea pools were recovered from the study area in 2009 and the non-dusted control colonies have experience severe reductions in the WTPD populations due to plague. The areas dusted in 2008 and 2009 appear to be free of plague (post dust application) and the WTPD populations in these areas appear to be stable (D. Tripp, CDOW, personal communication 2010). The CDOW is continuing to monitor the WTPD and flea populations in these areas for the presence of plague

Public Health

Five to 15 people are infected with plague annually in the U.S. and mortality rate is 14% (1 in 7 cases) (Centers for Disease Control and Prevention 2009). Antibiotics are available to treat plague infection and mortality from the disease is usually caused by delays in getting treatment. Since its establishment in Colorado in 1941, plague has been a public health concern. In the 43-year period between 1957 and 1999, there were 45 confirmed human plague cases originating in Colorado, of which 9 resulted in death (Cranshaw and Wilson 2007). From 1970-1997, the CDC reported human cases of plague in 19 counties in Colorado (Fig. 18; Centers for Disease Control and Prevention 2007).

According to the CDC web site (2009):

"Rock squirrels and their fleas are the most frequent sources of human infection in the southwestern states. For the Pacific states, the California ground squirrel and its fleas are the most common source. Many other rodent species, for instance, prairie dogs, wood rats, chipmunks, and other ground squirrels and their fleas, suffer plague outbreaks and some of these occasionally serve as sources of human infection. Deer mice and voles are thought to maintain the disease in animal populations but are less important as sources of human infection. Other less frequent sources of infection include wild rabbits, and wild carnivores that pick up their infections from wild rodent outbreaks. Domestic cats (and sometimes dogs) are readily infected by fleas or from eating infected wild rodents. Cats may serve as a source of infection to persons exposed to them. Pets may also bring plague-infected fleas into the home."

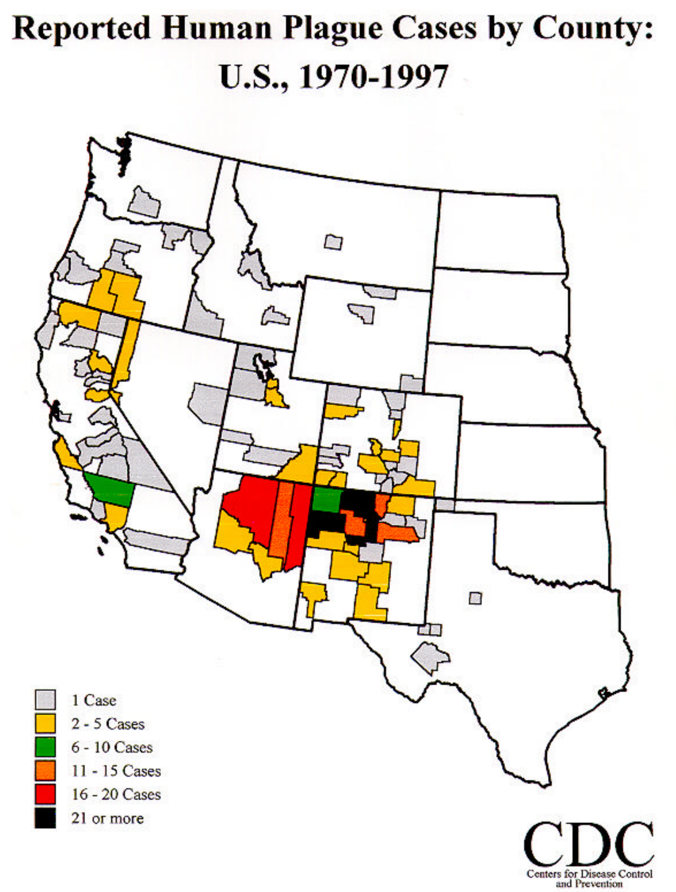


Fig. 18. Human plague cases in the western U.S., 1970–1997 (Centers for Disease Control and Prevention 2007).

Population Viability Analysis Results

The predicted impacts of plague on GUPD and WTPD populations in Colorado were explored using a PVA (see "Population Viability Analysis" section under ANALYSIS, and APPENDIX G). Plague effects on prairie dog dynamics were examined under 3 different scenarios within the PVA model: (1) where plague acted as an enzootic; (2) where plague acted as an epizootic, with varying frequency and intensity; and (3) where dusting was assumed to lessen plague impacts on prairie dogs.

First, an enzootic scenario was simulated with plague operating at a relatively low level each year. This was modeled by increasing average annual rates of mortality above a more benign non-enzootic scenario where disease did not play a major role in determining long-term rates. These alternative mortality schedules grew out of lengthy discussions among species experts with differing views of the causes of significantly different survivorship rates between GUPDs and UTPDs reported in Hoogland (2001). Results showed, as expected, that scenarios including higher mortality from enzootic plague showed lower population growth rates than those where plague mortality is absent, although extinction rate was not affected.

Second, periodic plague epizootics were incorporated as "catastrophes," which could have potentially severe demographic impacts. Catastrophes were assumed to be singular environmental events outside the bounds of normal environmental variation affecting reproduction and/or survival. Plague epizootics were modeled to occur at intervals of 5, 10, or 15 years. In addition, 2 different levels of severity for a given epizootic were simulated, with an average of 92% or 99% of the total population being killed by the epizootic.

Sensitivity analysis results indicated that the baseline simulation models were relatively more sensitive to changes in the frequency of plague epizootics than to a similar proportional change in the severity of the same type of event. An increase in the frequency of plague epizootics led to reduced ability of the population to demographically rebound following the event. In contrast, if the epizootics were relatively infrequent but more severe, the population (if not rendered extinct outright from the epizootic itself) retained the capacity to rebound from the event. But even this advantage appeared easily overcome: when plague epizootics occurred repeatedly and with relatively higher frequency, plague produced dramatic declines in population size.

Results for a small set of models for WTPDs (results for GUPDs were similar) showed that when the severity of epizootic plague was relatively mild (in this model 92% mortality), the frequency of the epizootics was a major factor in determining the overall risk of prairie dog population extinction (see Fig. 15). More frequent plague epizootics led to a much higher extinction risk.

Very severe plague epizootics (99% mortality) led to very high extinction risks even when epizootics were infrequent (e.g., 15-year interval). The presence of enzootic plague (see Fig. 15) affecting the underlying annual mortality rates did not appear to play a significant role in determining the fate of a population exposed to plague epizootics.

Third, an additional set of models was developed in which a specific level of plague management was assumed in a given prairie dog colony. This simulated management scenario took the form of dusting the colonies with chemicals that reduced the numbers of fleas in the colony and hence, the rate of transmission of the infectious agent among prairie dogs. The efficacy of this dusting was simulated through a reduction of the severity of a given epizootic down to 80% (range: 77%-83%) in the year that an epizootic was deemed to occur. This level of reduction in epizootic intensity led to dramatic declines in the extinction risk of affected prairie dog populations.

Stakeholder Workshop

The group assigned to developing conservation strategies to address disease issues in GUPD and WTPD conservation identified the following primary concerns:

- "There is a lack of understanding of the epidemiology and dynamics of plague and its relationship to environmental changes."
- "There are currently no effective techniques for large-scale management of plague."
- "Our ability to predict and manage plague is hindered by a lack of surveillance and monitoring."
- "Population recovery (abundance and local distribution) after epizootics is inconsistent and poorly understood."
- "Plague is perceived as having a potentially significant effect on public health and thus affects the public perception of prairie dogs."

Conclusion

Plague is the greatest single threat to prairie dog populations in Colorado, particularly when compounded by other factors present on the landscape, and will likely remain a threat throughout the range of both the GUPD and WTPD in the foreseeable future. The PVA model indicated that the frequency of plague epizootics was the dominant factor in determining the long-term impacts to populations. Many unknowns still surround this disease and current management options are limited, costly, and extremely labor intensive. However, the PVA demonstrated that a relatively modest reduction in the severity of plague epizootics can lead to a dramatic reduction in the long-term impacts of epizootics.

Work is being conducted on the ecology of plague and possible oral vaccine development, but managing for the effects of plague epizootics will be an immense challenge for resource managers and scientists. Without answers to basic questions such as how plague maintains itself in natural foci and under what conditions epizootics will occur, managers are limited in their ability to predict the movement, impact, and/or timing of plague epizootics. In addition, investigations are needed to understand the effects of changes in population demographics and recovery rates of colonies following a plague epizootic.

The CDOW recognizes that understanding and controlling plague has emerged as a critical need for stabilizing native wildlife species and ecosystems imperiled by recurrent epizootics throughout Colorado. Consequently, the CDOW's research and adaptive management efforts directed toward plague will be expanding through a series of interconnected studies to develop and evaluate tools and strategies for adaptively monitoring and preventively managing or controlling plague on a landscape level.

The effects of tularemia on prairie dog populations are unknown. The disease also could have detrimental long-term localized effects, and additional research is needed.

Disease - Conservation Strategies

ISSUE 3.1: Plague is the greatest single threat to maintaining viable GUPD and WTPD populations in Colorado. There is a lack of understanding about the epidemiology and dynamics of the disease in GUPD and WTPD populations, as well as the disease's relationship to environmental variation.

OBJECTIVE 3.1.1: Improve the understanding of the epidemiology and dynamics of plague in GUPD and WTPD populations.

STRATEGY 3.1.1.1: Continue research to determine whether plague is enzootic in GUPDs and WTPDs (e.g., sampling of host and vectors) and what the effect of enzootic plague is on the species.

STRATEGY 3.1.1.2: Determine what happens to plague between epizootics (i.e., maintenance mechanisms).

STRATEGY 3.1.1.3: Determine the role of other mammals associated with prairie dogs in the maintenance and transmission of plague.

STRATEGY 3.1.1.4: Further examine under what conditions plague events are likely to occur (e.g., temperature, precipitation).

STRATEGY 3.1.1.5: Examine flea biology, including the fleas' ability to reproduce during plague epizootics, depression of flea numbers after an epizootic, and time-to-recovery for flea populations.

STRATEGY 3.1.1.6: Explore the use of climate modeling to help predict when epizootic events may occur.

STRATEGY 3.1.1.7: Intensively monitor (long-term) a sample of GUPD and WTPD colonies throughout their range for evidence of exposure to plague, to develop a model that predicts where plague is likely to occur in prairie dogs in the future.

STRATEGY 3.1.1.8: Develop a GIS database that tracks the frequency and geographic distribution of plague across the landscape in GUPD and WTPD range, and populate with historic and future data.

STRATEGY 3.1.1.9: Share GUPD and WTPD plague information with research and management agencies.

ISSUE 3.2: The ability to predict and manage plague in GUPDs and WTPDs is hindered by a lack of plague surveillance and monitoring.

OBJECTIVE 3.2.1: Develop and implement appropriate plague surveillance and monitoring strategies in GUPD and WTPD areas to: (1) facilitate further research and analysis of plague dynamics; and (2) facilitate immediate management of plague outbreaks.

STRATEGY 3.2.1.1: Review and analyze existing datasets for efficacy of past plague monitoring and surveillance efforts in GUPD and WTPD range (e.g., Curecanti, CDC, County and City health departments).

STRATEGY 3.2.1.2: Determine the spatial and temporal structure of plague surveillance and monitoring sites needed in GUPD and WTPD range to provide appropriate data.

STRATEGY 3.2.1.3: Implement plague monitoring and surveillance efforts for GUPD and WTPD management needs.

STRATEGY 3.2.1.4: Develop a mechanism for dissemination of plague monitoring data in GUPD and WTPD range to research and management agencies.

ISSUE 3.3: There are currently no effective techniques for large-scale management of plague in GUPD and WTPD populations.

OBJECTIVE 3.3.1: Develop effective management techniques to promote large-scale GUPD and WTPD population resilience in the presence of plague.

STRATEGY 3.3.1.1: Complete development and laboratory testing of an oral vaccine for plague in prairie dogs.

STRATEGY 3.3.1.2: Test the oral plague vaccine efficacy in different field situations for both GUPDs and WTPDs.

STRATEGY 3.3.1.3: If an effective oral plague vaccine for GUPDs and WTPDs is developed, prepare a vaccine application protocol.

STRATEGY 3.3.1.4: If an effective oral plague vaccine for GUPDs and WTPDs is developed, determine priority areas for distribution.

STRATEGY 3.3.1.5: Work with land management agencies to gain approval for application of oral plague vaccine in priority GUPD and WTPD areas.

STRATEGY 3.3.1.6: Apply oral plague vaccine in GUPD and WTPD priority areas, as per developed protocol.

STRATEGY 3.3.1.7: Determine the minimum amount of dusting (pesticide) or other appropriate flea control methods necessary to maintain GUPD and WTPD populations during plague epizootic events and to prevent future epizootic events (optimal dusting protocol).

STRATEGY 3.3.1.8: When optimal dusting protocol or another appropriate flea control method is developed, determine priority GUPD and WTPD areas for dusting application.

STRATEGY 3.3.1.9: Work with land management agencies to gain approval for application of dust or other appropriate flea control methods in priority GUPD and WTPD areas.

STRATEGY 3.3.1.10: Apply dust or other appropriate flea control methods in priority GUPD and WTPD areas, as per developed protocol.

STRATEGY 3.3.1.11: Use the Plague Contingency Plan being compiled by the BFF Conservation Committee that is currently in draft form to assist in the management of plague within GUPD and WTPD habitats.

STRATEGY3.3.1.12: Work with private landowners to identify colonies to manage for plague using available techniques (e.g., dusting, oral baits) and develop voluntary partnerships to implement techniques on private lands.

ISSUE 3.4: The ability of GUPD and WTPD populations to recover after plague epizootic events is variable and poorly understood.

OBJECTIVE 3.4.1: Develop an understanding of GUPD and WTPD population recovery following plague epizootic events.

STRATEGY 3.4.1.1: Monitor GUPD and WTPD dynamics and demography to understand population recovery following plague outbreaks (see also "Population Monitoring" strategies).

STRATEGY 3.4.1.2: Sample GUPD and WTPD individuals that survive an epizootic to determine if there is a genetic component to plague resistance.

STRATEGY 3.4.1.3: Determine if population reduction caused by plague results in a decrease in genetic heterozygosity in GUPDs and WTPDs.

STRATEGY 3.4.1.4: Using intensive population monitoring (e.g., ongoing monitoring at BFF reintroduction sites), determine if plague leads to a long-term reduction in GUPD and WTPD population size following population recovery from plague epizootic events (see also "Population Monitoring" strategies).

OBJECTIVE 3.4.2: Identify and implement feasible and effective techniques to assist in GUPD and WTPD population recovery following plague epizootic events.

STRATEGY 3.4.2.1: Determine if augmentation of GUPDs and WTPDs is an effective technique for improving recovery of post-plague populations.

STRATEGY 3.4.2.2: Investigate techniques (other than relocation) for improving recovery of post-plague GUPD and WTPD populations.

STRATEGY 3.4.2.3: Implement techniques that are determined to be effective to enhance GUPD and WTPD population recovery following plague events.

ISSUE 3.5: Because plague is associated with prairie dogs and has potentially negative effects on human health, there is also a negative public perception of prairie dogs.

OBJECTIVE 3.5.1: Improve awareness of the value of prairie dogs and the role of prairie dogs in plague dynamics.

STRATEGY 3.5.1.1: Improve public understanding of the role of prairie dogs in ecosystems (e.g., website, pamphlets, radio and TV shows).

STRATEGY 3.5.1.2: Improve public understanding of the role of prairie dogs in plague epidemiology (e.g., website, pamphlets, radio and TV shows).

ISSUE 3.6: The effects of tularemia on GUPD and WTPD populations are poorly understood.

OBJECTIVE 3.6.1: Improve the understanding of the effects of tularemia on GUPD and WTPD populations.

STRATEGY 3.6.1.1: Implement tularemia monitoring and surveillance efforts for GUPD and WTPD management needs.

STRATEGY 3.6.1.2: If monitoring indicates that tularemia is present in declining GUPD and WTPD populations, expand monitoring to additional sites and begin evaluation of the disease's impact on prairie dog populations.

D. Energy & Mineral Development

Current understanding of how energy (primarily oil and natural gas), solar, and mining development in Colorado affects prairie dog populations and their spatial distribution is insufficient. Prior to the recent economic slowdown and lowering of oil and gas prices, energy development was occurring at a record pace. Although oil and gas activities have slowed significantly, concerns about the impacts of this activity are still warranted and need to be evaluated, as it is feasible that the markets will rebound and we will return to high demands for energy development in Colorado. In addition, alternative energy sources such as solar have started being developed at a rapid pace as part of Colorado' New Energy Economy (http://www.colorado.gov/governor/newenergyeconomy). The impacts of these new developments are unknown but they also may have impacts on prairie dog populations.

Background

Prior to the recent economic slowdown and lowering of oil and gas prices, there was a dramatic increase in oil and gas development over the past 6 years on federal lands. The majority of oil and gas activity was concentrated in Colorado, Montana, New Mexico, Utah, and Wyoming (U.S. Government Accountability Office 2005). Thirty-five percent of the total WTPD range has authorized (935,755 acres) or pending (145,463 acres) federal oil and gas leases (Table 15; see "GIS Analyses"). Six percent of the GUPD range is under authorized or pending federal lease (492,491 acres; Table 15).

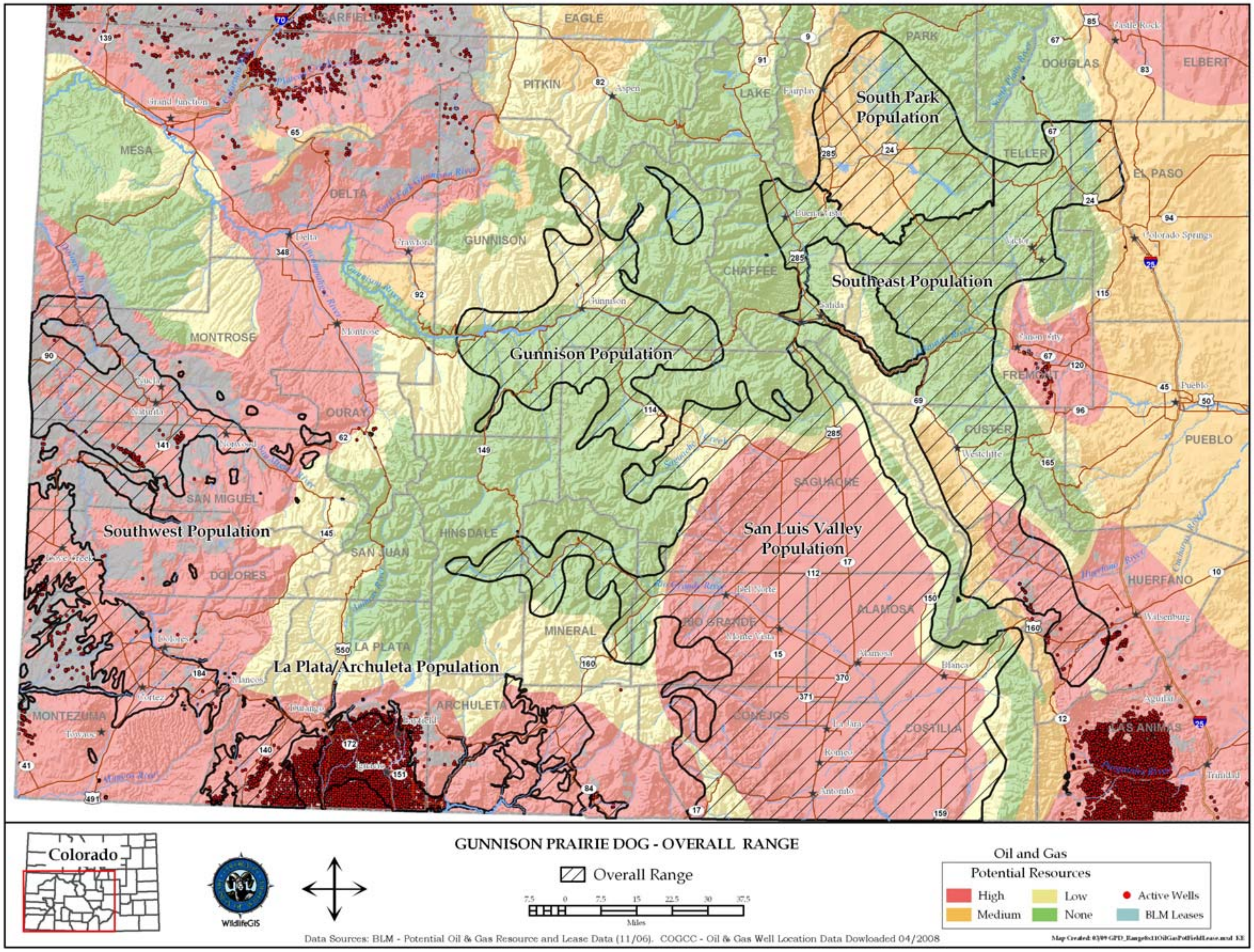


Fig. 19. Current and potential oil and natural gas development in the Gunnison's prairie dog (GUPD) overall range in Colorado.

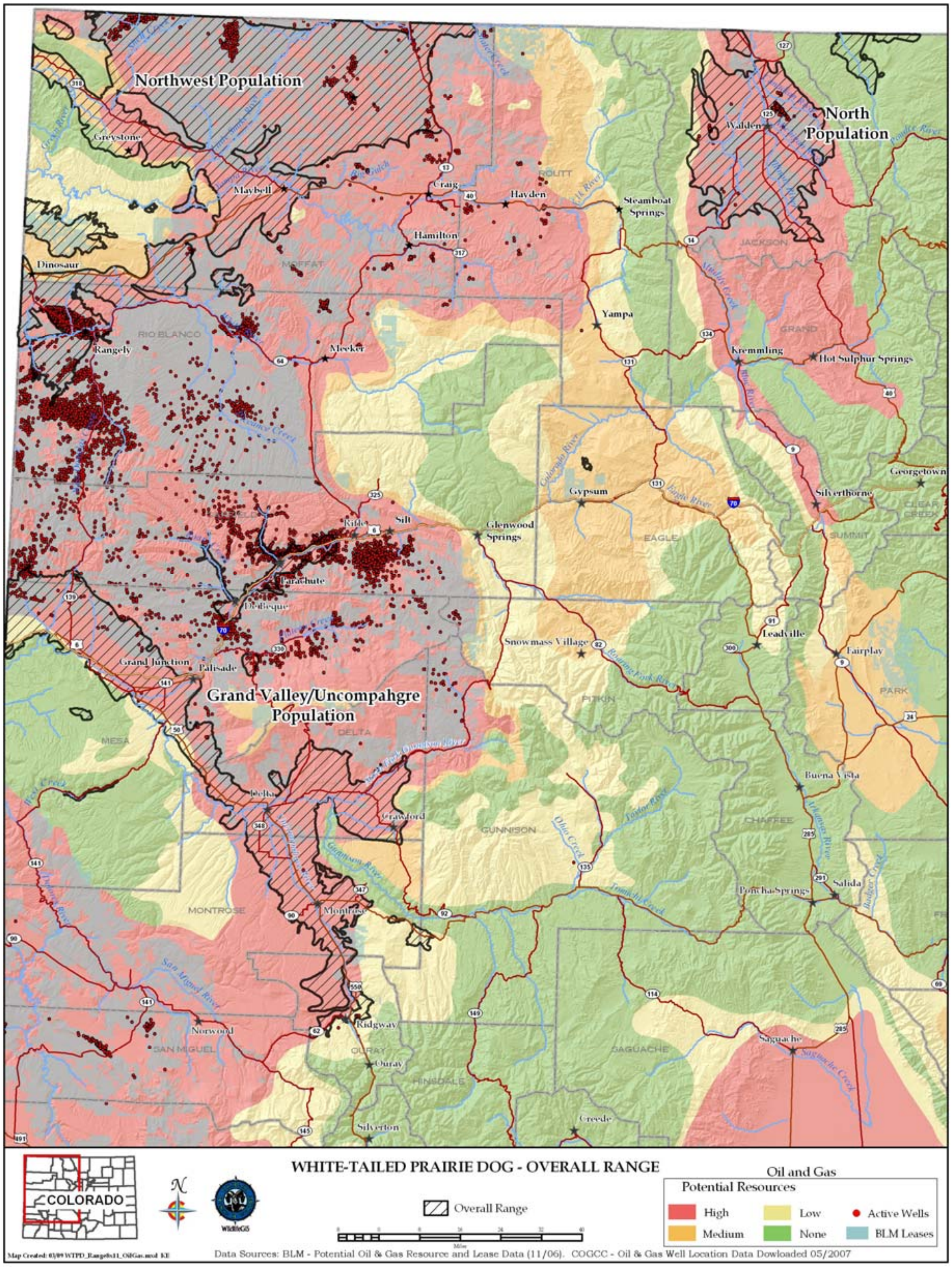


Fig. 20. Current and potential oil and natural gas development in the white-tailed prairie dog (WTPD) overall range in Colorado.

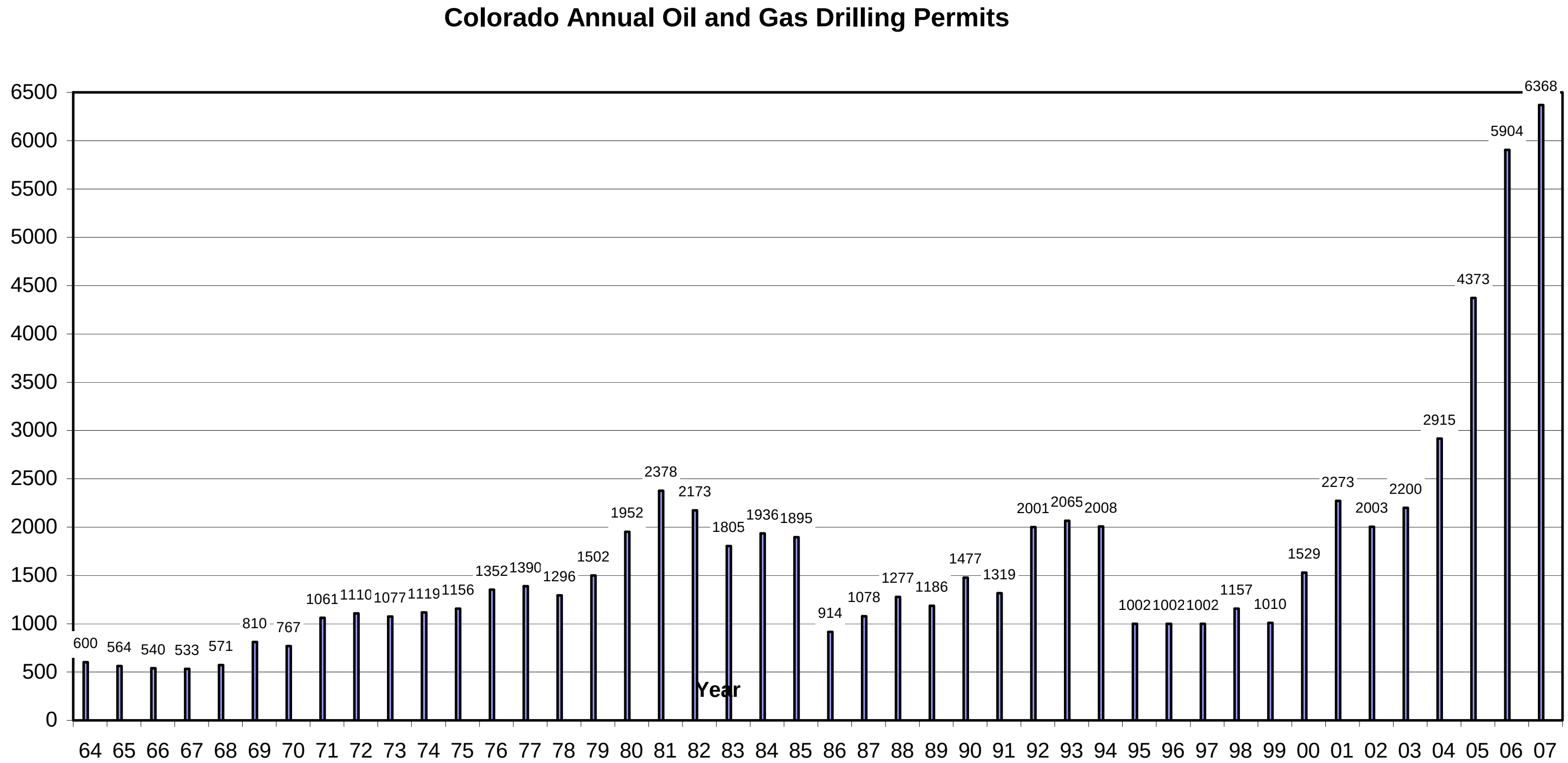


Fig. 21. Annual Colorado oil and gas drilling permits, 1964 – 2007 (COGCC 2002, 2003, 2004, 2005, 2006, 2007, and 2008). Data are actual numbers of statewide permits.

The 2005 Energy Act (Energy Policy Act of 2005, H.R.6, Section 369) included an emphasis on the development of domestic energy sources, and in particular, oil shale. The largest US deposits of oil shale are in the Green River formation, which includes the Piceance Basin and part of the Washakie Basin in extreme northwestern Colorado, affecting only a small portion of the WTPD overall range, and none of the GUPD overall range (Fig. 22). Seventy-two percent of these deposits are owned by federal entities (Bartis et al. 2005). The new legislation removed earlier provisions that restricted large-scale development of oil shale, and required that public lands be made available for research, development, and demonstration (RD&D) leases for oil shale within 6 months. This legislation, along with higher oil prices and the advent of new oil shale *in situ* extraction techniques, has encouraged companies to pursue the development of oil shale resources; however, authorized oil shale leasing and potential development in Colorado is limited to the Piceance Basin and is located outside WTPD and GUPD habitat. Leasing and potential development of oil shale resources in the Washakie Basin, which underlie WTPD habitat, was not authorized by the Oil Shale Programmatic Environmental Impact Statement completed by the BLM in 2008. Five RD&D leases were issued by BLM in the Piceance Basin. Each of these 160-acre tracts, along with preference lease rights resulting from successful development of the RD&D tracts, are located outside occupied WTPD range.

Coal is also increasing in demand and use as an energy source. Coal production in the United States reached record levels in 2005 (Freme 2005). The wide-ranging economic expansion experienced in China in 2004 drove world markets for many commodities into overdrive and helped to reestablish the United States into Asian coal markets (Energy Information Administration 2005). Colorado ranked 6th in U.S. coal production, which has increased dramatically since 1958, and reached 40 million tons produced in 2004 (Colorado Geological Survey 2004). Demand for coal is expected to remain high due to continued economic expansion and elevated natural gas prices (Freme 2005). The largest coal reserves in Colorado also overlap prairie dog habitat and include portions of the WTPD NO IPA (Fig. 24).

Uranium mining impacts to GUPDs and WTPDs from prospecting, claim location, and exploration may occur without the BLM's or other land managers' knowledge or oversight in several basins and areas that have metal potential and are not withdrawn from entry to mining. Only upon large-scale exploration or production mining will thresholds be triggered to allow for full National Environmental Policy Act (NEPA) analysis and for mitigation of impacts to occur. Impacts due to claiming efforts are probably not significant because most involve no real mining operations or activities. The preferred location for larger scale operations tends to be on hillsides and rims, rather than on flatter ground where prairie dogs are located, so there may be little direct impact to prairie dogs. Nevertheless, these sites would bring in additional infrastructure and traffic, resulting in highly fragmented habitats.

Sand, gravel and other mineral mining activities may occur adjacent to existing river and stream channels, or in upland habitat areas. This type of mining may also be located close to towns or areas of impending development, potentially affecting prairie dog colonies. When these operations are located in prairie dog habitat, they could directly remove existing habitat. In addition, they require close proximity to a well-developed haul road to facilitate material transport, which may mean roads need to be constructed.

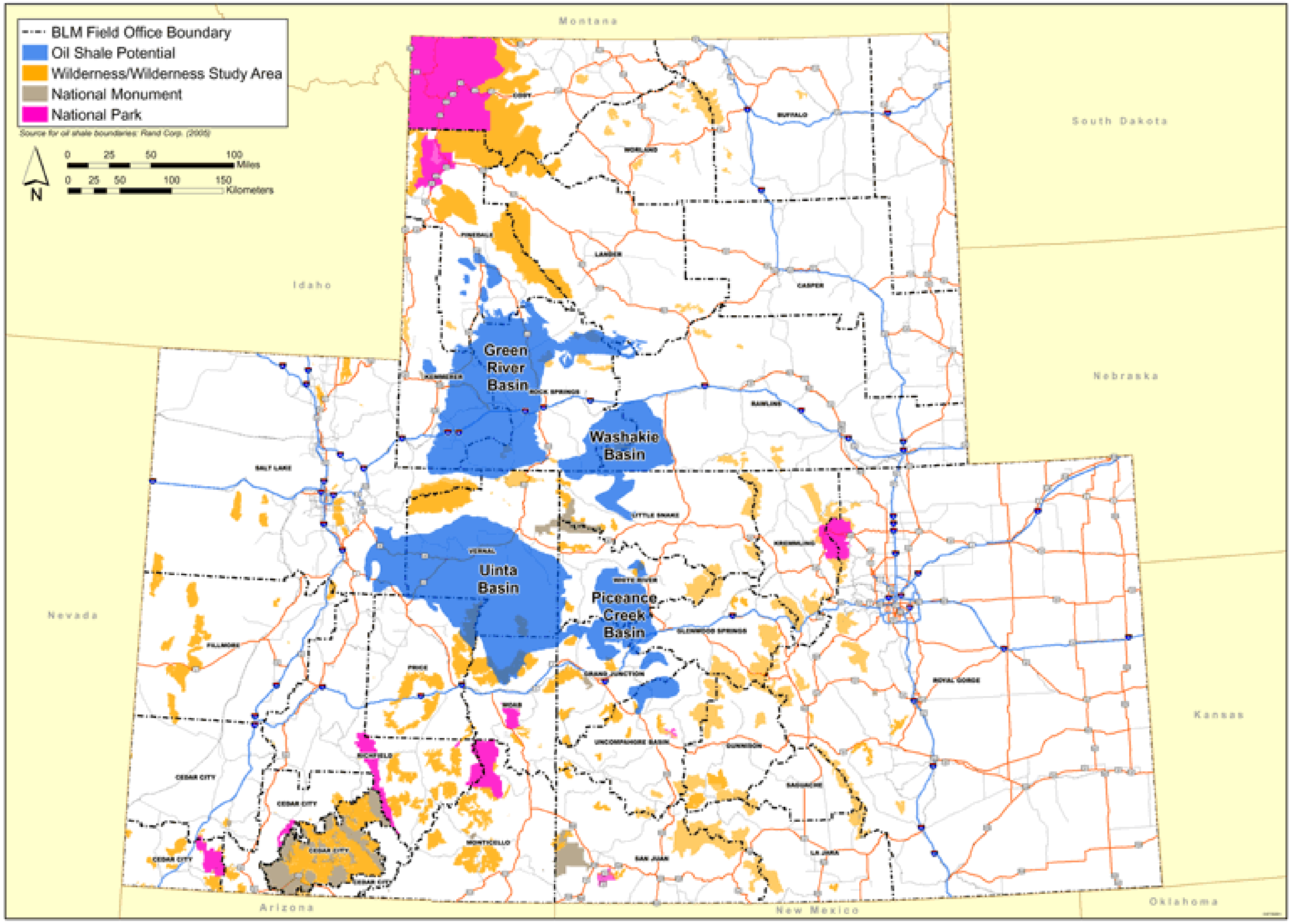


Fig. 22. Potential oil shale resources in Colorado and neighboring states (Bureau of Land Management 2006a).

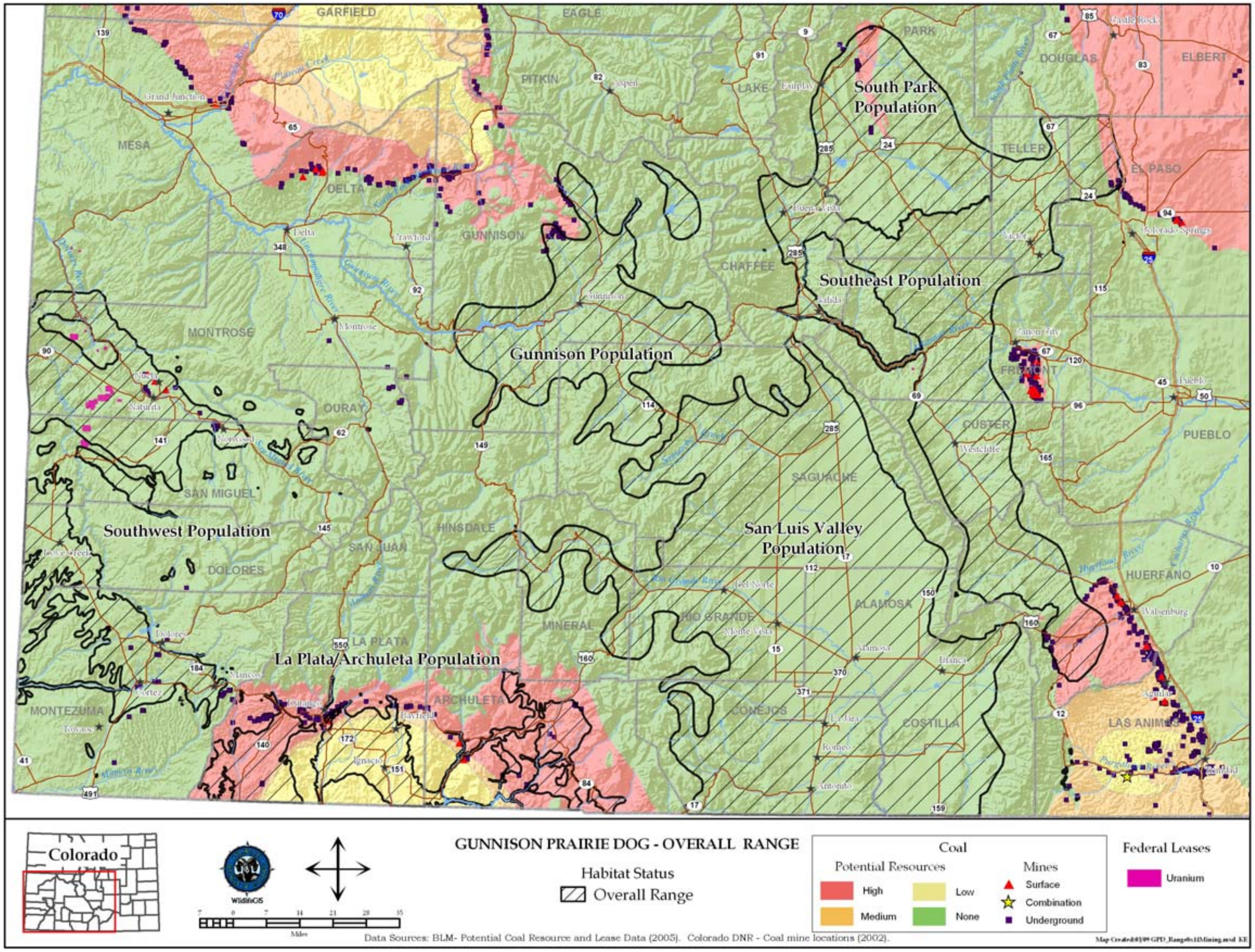


Fig. 23. Current and potential coal and other mining development in Colorado Gunnison's prairie dog (GUPD) individual population areas.

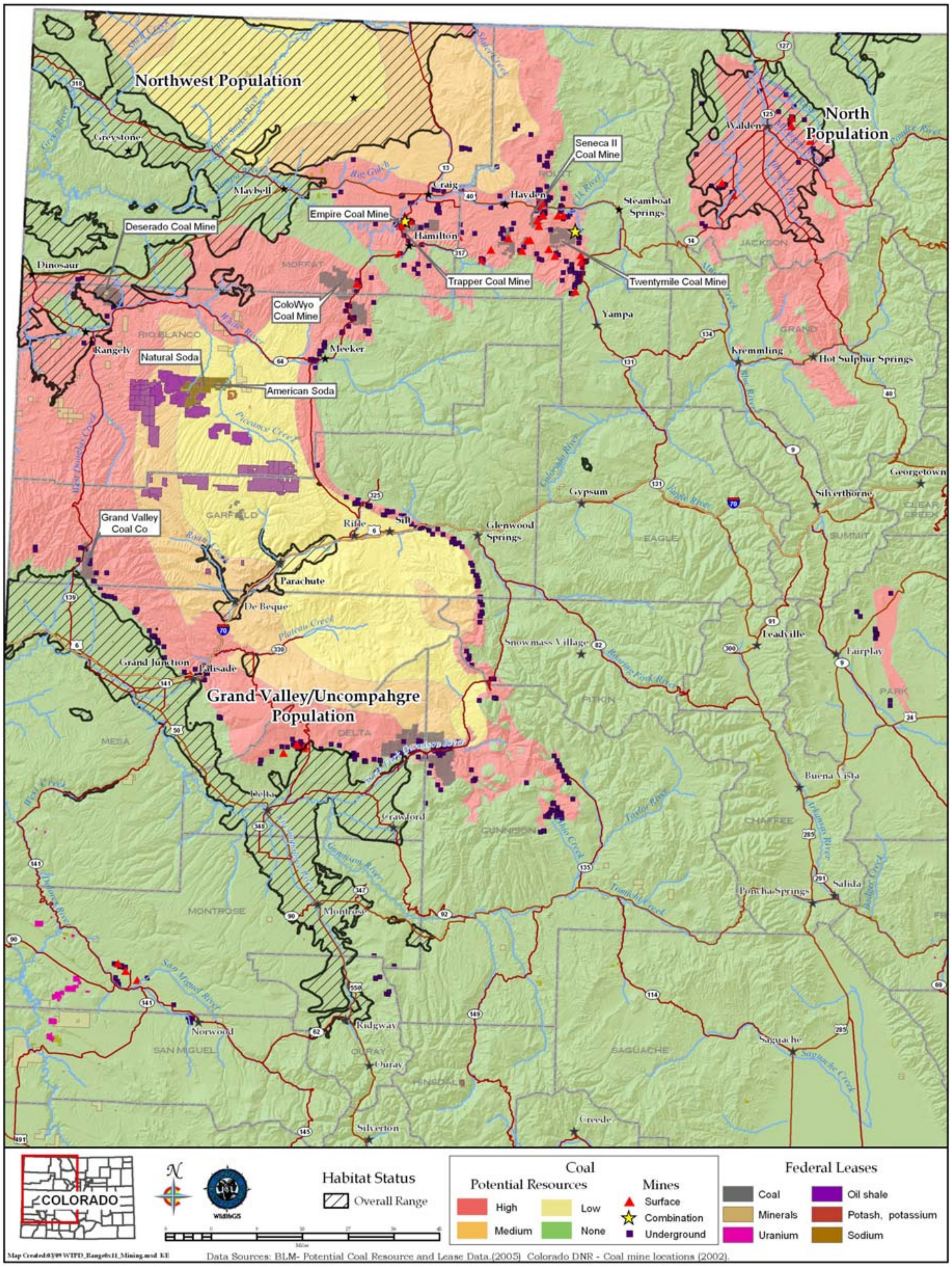


Fig. 24. Current and potential coal and other mining development in Colorado white-tailed prairie dog (WTPD) individual population areas.

Possible Impacts of Energy & Mineral Development

Possible direct adverse impacts to prairie dogs associated with oil and gas development include (1) clearing and crushing of vegetation; (2) reduction in available habitat due to pad construction, road development, pipeline development and well operation; (3) fragmentation of available habitat; (4) displacement and mortality of prairie dogs; (5) alteration of surface water drainage; and (6) increased compaction of soils (U.S. Fish and Wildlife Service 1990). There are presently no empirical studies that quantify the occurrence, severity, or persistence of these or other effects of oil and gas development on WTPDs and GUPDs. Studies are needed to evaluate these potential impacts.

The final footprint of individual oil and gas well pads often affects less than 2 acres, but initial well pad construction and the development of new road and pipeline corridors can add substantial disturbed acreage for each well pad constructed. Multi-well pads are larger and often result in a 5 acre footprint. Multiple-well pads are increasing in application, but are still rare outside the Piceance Basin in northwestern Colorado and in the southwestern corner of Colorado. For instance, relatively dense oil and gas development occurring in the Hiawatha Field, located in northwestern Moffat County, is primarily conducted from single well pads. With the potential for close spacing of well pads, and significantly more well pads proposed within both GUPD and WTPD range, oil and gas development has the potential to significantly decrease the amount of available prairie dog habitat. Colorado has reclamation rules that require impacted lands to be restored to their original condition after a well is abandoned, but during the life of a well, habitats will remain lost. Seismic exploration may also affect prairie dogs by collapsing tunnel systems, causing auditory impairment, and disrupting social systems (Clark 1986).

Indirect effects of energy development on prairie dogs and their ecosystem may include (1) increased exposure to shooters and OHV users because of improved road access into remote areas – Gordon et al. (2003) found that shooting pressure was greatest at colonies with easy road access, as compared to more remote colonies – and (2) invasion of habitats by invasive and noxious weeds.

A potential positive impact of oil and gas development on prairie dogs is reduction in shrub cover through blading and grading for well pads, roads, and pipelines (Buys and Associate Inc. 2005). Creating these open sites increases the potential for colonization because removal of shrub and other thick, tall cover improves the site for prairie dog occupation. In addition, many initial surveys of WTPD colonies in Colorado, conducted in response to oil and gas companies evaluating potential BFF habitat within project areas as required by the USFWS (U.S. Fish and Wildlife Service 1986), provided valuable WTPD data. Although these clearances were conducted using the 1986 USFWS procedures for BFF clearances, they also yielded temporal data on the geographic extent and activity of prairie dog colonies. In some instances, intensive prairie dog colony mapping efforts were the direct result of terms and conditions and conservation measures required by ESA Section 7 consultations with the USFWS. Thus, this information has provided historical data on prairie dog colony location and occupation rates that would not have been available without the completion of these clearances.

Coalbed methane wells are a relatively new technology that relies on the extraction of methane gas from coal 200 to 5,500 feet below the surface. The Rocky Mountain region has extensive coal deposits with untapped resources of coalbed methane. Potential problems for prairie dogs associated with coalbed methane development are (1) reduction in available habitat due to well development and associated pipeline, road, and compressor site development, and well operation; (2) fragmentation of available habitat; (3) increased human disturbance at development sites; (4) increased potential for shooting due to additional road development; (5) increased risk of non-native/noxious weeds; and (6) direct project-induced mortality (e.g., increased roadkills).

Colorado

There is extensive overlap of both (1) oil and gas (Figs. 19 and 20); and (2) mineral leases (Figs. 23 and 24) within the GUPD and WTPD overall range in Colorado. Specifically, those IPAs most at risk of potential impact due to these disturbances include the SW and LPA GUPD populations and the GVUN, NO, and NW WTPD populations. These areas are identified by the BLM as having high oil and gas potential resources, but field development is not yet occurring at a level to cause concern for prairie dog populations.

Development of energy and mineral resources on BLM lands in Colorado has been occurring at an unprecedented rate and will continue as part of the BLM multiple use plan (Colorado Bureau of Land Management Website 2004). Currently, the federal government manages 36% of Colorado's 66 million surface acres and 41% of the mineral estate (Buys and Associate Inc. 2005). Clearly, federal land management agency participation is very important in the conservation of the prairie dog ecosystem.

Gunnison's Prairie Dog

The BLM manages 21% of GUPD range in Colorado (Table 2), and management is within the jurisdiction of 5 BLM Field Offices, none of which currently has stipulations specifically to protect GUPD habitat from oil and gas development impacts.

Oil and gas development have increased within the SW IPA. Currently, 351,558 acres (32%; Table 15) of the GUPD overall range within the SW IPA have been authorized for federal oil and gas leases.

Much of the LPA IPA lies within the boundary of the Fruitland outcrop. This coal formation has been the focus of extensive coalbed methane energy development in recent years. The 2006 Record of Decision (Bureau of Land Management and U.S. Forest Service 2007) for the Northern San Juan Basin coal bed methane project Final Environmental Impact Statement (FEIS) provides for an additional 185 new wells.

Uranium leasing and mining is widespread across the western edge of the state and is occurring in occupied GUPD habitat in the SW IPA. The majority of current activity is staking new claims at old uranium sites. There are a few large-scale active mining operations in and around Gateway, Naturita, Big Gypsum Valley, Dry Creek Basin, and Paradox Valley. There is intent to open a mill site in Colorado (Paradox Valley), which would open the door for more mining operations than currently exist. Uranium activity has slowed since the fall of 2008 with a decrease in prices, but is expected to accelerate as the current economic recession fades and as the search for alternative energy sources intensifies.

In the San Luis Valley, the potential for solar energy development has increased rapidly in 2009. With the current technology available, solar energy projects require large expanses of area for solar panels. For example, the planned Alamosa Photovoltaic Solar Plant is an 8.2-megawatt facility that would cover roughly 82 acres of land in the San Luis Valley with solar panels (http://www.nrel.gov/data/pix/collections_alamosa_pv_plant.html). The potential impacts to wildlife of this new renewable energy development are uncertain but could be significant.

White-tailed Prairie Dog

The BLM manages 49% of WTPD overall range in Colorado (Table 2) and management falls within the jurisdiction of 6 BLM Field Offices; 4 of these Field Offices having no stipulations for oil and gas development in WTPD habitat. The Little Snake and White River BLM Field Offices include BFF reintroduction areas and have stipulations related to BFF habitat (i.e., WTPD colonies) which helps address WTPD conservation in the context of maintaining healthy populations for BFFs.

Oil and gas development in the DeBeque to Rifle portion of the GVUN IPA could be a substantial threat to the WTPDs that remain in this corridor (Fig. 20). In addition, the area north of Grand Junction in the Grand Valley has recently been leased and overlaps WTPD range (Fig. 20).

Recently, oil and gas development activity has increased in the NW IPA. Both the White River and Little Snake BLM Field Offices (in the NW IPA) experienced growth in oil and gas development over the past several years. The pace of oil and gas development slowed in portions of Moffat County in 2008 and slowed considerably across the range beginning in the late fall as a result of the economic recession. Oil and gas development is expected to accelerate with improving economic conditions, though perhaps not to the level experienced through 2007. The 20-year forecast for oil and gas development in the NW IPA calls for significant growth. Oil and gas development of federal mineral estate in the BLM Little Snake Field Office is projected to reach 3,031 wells drilled in the 20 years from 2007 to 2027. Drilling activity in the Little Snake planning area resulted in 594 wells drilled over the previous 20-year period (BLM 2007). Drilling activity on federal mineral estate in the BLM White River Field Office is currently projected to reach 17,000-20,000 wells drilled within the next 20 years. The previous 20-year estimate of drilling activity in the White River planning area projected that 1100 oil and gas wells would be drilled between 1997 and 2017 (Bureau of Land Management 2006b); however, the vast majority of the wells anticipated in the White River Field Office will occur outside the WTPD overall range.

The vast majority of the NW IPA area has either high or medium potential for oil and gas development (Fig. 25), and a large portion has already been leased for energy development (Table 15). Oil and gas development in the NW IPA is occurring primarily in areas of high oil and gas potential, as shown in Figure 20. The Reasonable Foreseeable Development scenario for the Little Snake Field Office RMP revision suggests that approximately 96% of new wells will be drilled in areas with high oil and gas potential (BLM 2007). Due in part to the recent growth in this industry, both of the BLM Field offices within this IPA are undergoing either a Resource Management Plan revision (Little Snake) or an oil and gas amendment (White River) to address the increase in this industry and associated impacts.

A recent major find of crude oil by EOG Resources in North Park was announced in March, 2008. EOG Resources has accumulated 100,000 net acres in North Park. The company plans to drill additional wells during 2008 and 2009. Crude oil was produced historically in North Park, but this recent find is large enough that it is expected to create an energy boom in North Park. Much of the BLM mineral estate in North Park has been leased and overlays the WTPD range.

Much of the preceding description addresses oil and gas development on federal mineral estate. Leasing and development of state and private minerals is occurring at what appears to be an equivalent pace, but data for these lease and development rates are more difficult to acquire. The Colorado Oil and Gas Conservation Commission information presented in Fig. 21 includes all well permits approved in Colorado. Federal permits make up 35-40% of the total number of well permits issued.

Uranium exploration and mining have been dormant in the NW IPA for a lengthy period, but there has been a recent increase in lease filings and exploration activities. As in the GUPD range, uranium activity in WTPD habitat has slowed since the fall of 2008 with a decrease in prices, but is expected to accelerate as the current economic recession fades and as the search for alternative energy sources intensifies.

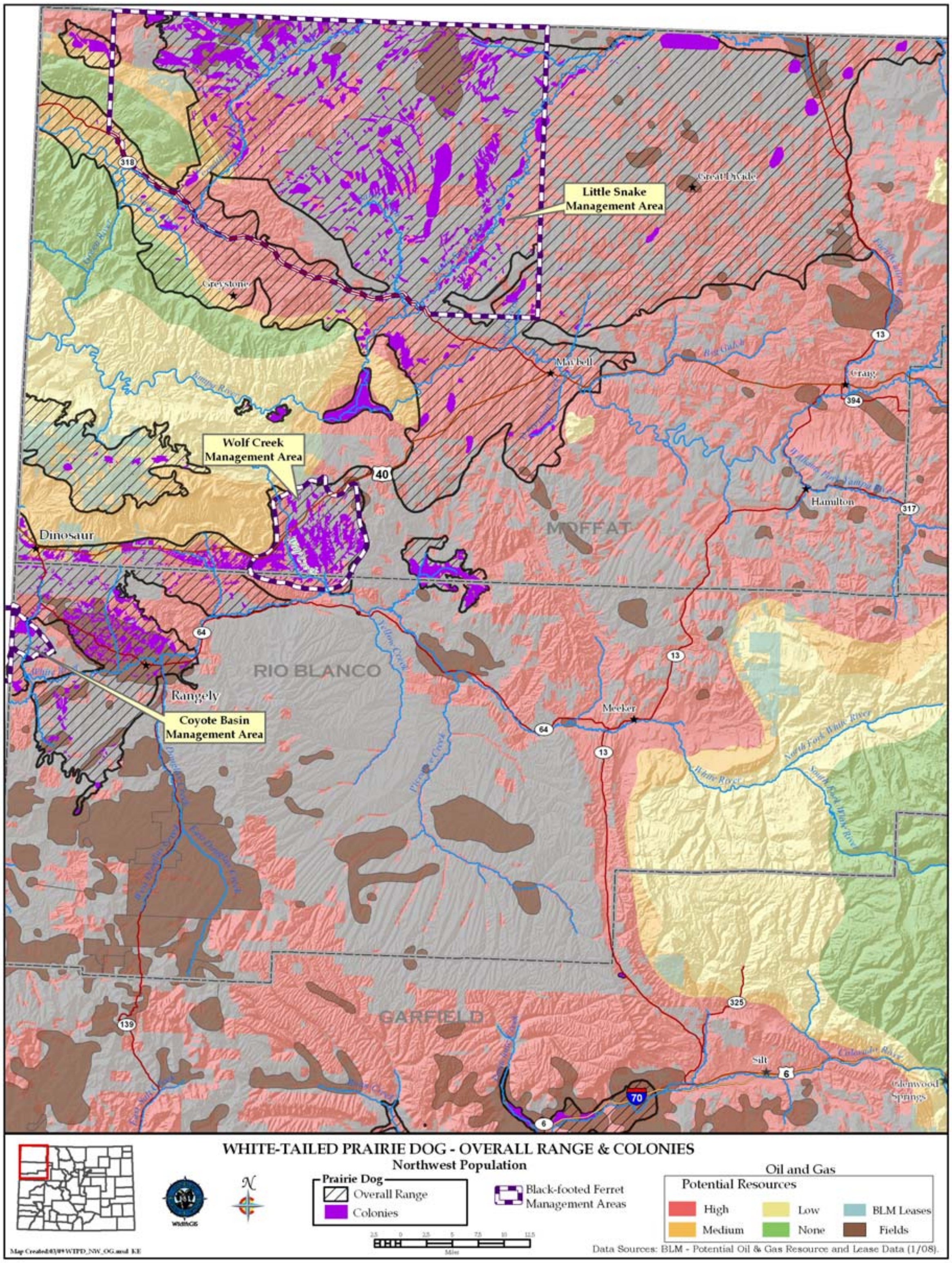


Fig. 25. Current and potential energy development in the white-tailed prairie dog Northwest Individual Population Area.

Geographic Information System Analysis Results

WTPDs in Colorado have a greater potential to be impacted by oil and gas development than GUPDs; 35% of the total WTPD overall range has authorized (935,755 acres) or pending (145,463 acres) federal oil and gas leases (Table 15; see "GIS Analyses" section). In contrast, only 6% of the GUPD overall range has authorized or pending federal leases (492,491 acres; Table 15).

Table 15. Acres of federal oil and gas leased-lands within Gunnison's prairie dog (GUPD) and white-tailed prairie dog (WTPD) population areas in Colorado based on Colorado Oil and Gas Conservation Commission and Bureau of Land Management data from 2007.

Population Area	Federal Oil and Gas Leases Authorized (acres)	Federal Oil and Gas Leases Pending (acres)	Total Area (acres)	Range that is Leased or Pending (%)
GUPD				
Gunnison	0	0	905,081	0
La Plata/Archuleta	10,650	738	549,041	2.1
San Luis Valley	15,680	0	3,488,005	0.4
South Park	52,477	0	700,811	7.5
Southeast	31,167	0	1,713,607	1.8
Southwest	357,171	27,649	1,102,086	34.9
GUPD Total	**467,145**	**28,387**	**8,458,631**	**5.9**
WTPD				
Grand Valley / Uncompahgre	145,789	2,043	957,702	15.4
North Park	110,778	5,942	447,917	26.1
Northwest Colorado	822,733	10,212	1,657,653	50.2
WTPD Total	**1,079,300**	**18,197**	**3,063,272**	**35.8**

Stakeholder Workshop

The group assigned to developing conservation strategies to address energy and mining development issues in GUPD and WTPD conservation identified the following primary concerns:

- "The understanding of oil and gas activities is insufficient to determine the affects [*sic*] on prairie dog populations and their spatial distributions. Data related to oil and gas impacts on prairie dogs and their ecosystems are insufficient to make robust management decisions. Drilling is occurring at a pace where it will be difficult to wait for research results and effectively conserve the prairie dog ecosystem."
- "Oil & gas development may result in habitat loss, degradation, and loss of connectivity between colonies, partially due to the rate at which it is occurring."
- "Other associated components of the prairie dog ecosystem may not tolerate certain aspects of oil and gas development activities. Preserving only the prairie dog populations in the ecosystem may not be enough to preserve the functional integrity of the system."

- "There may be both direct and indirect impacts to prairie dog populations of increased road density and accessibility within prairie dog habitat resulting from oil and gas development."
- "The federal/private/tribal interface is often complex, leading to difficulties in data sharing and effective communication from the state and federal to tribal interests."
- "There is a concern with imposing regulatory mechanisms on oil and gas development prior to the collection and presentation of defensible data on its impact to local wildlife."
- "There may be a significant economic cost of conservation-based mitigation of oil and gas development, thereby increasing the financial burden to those companies involved in development of the resource."

The workshop group also developed a prioritized list of objectives (this prioritization step was not undertaken by other groups):

- "Maintain connectivity between colonies to the maximum extent possible."
- "Minimize habitat loss and degradation through temporal and spatial planning."
- "Develop adaptive prairie dog Best Management Practices (BMPs) that utilize the best available information."
- "Conserve the functional integrity of the system in order to sustain all the dependent components."
- "Collect data related to oil and gas impacts on prairie dogs and their ecosystems.
- "Complete more field surveys to map occupied and potential habitat."
- "Mitigate impacts in a timely fashion."
- "Increase awareness of land manager to prairie dog needs."
- "Increase the number of areas where conserving PD ecosystems is the primary objective."

Conclusion

Energy development, particularly for oil and gas, was occurring at an unprecedented rate in Colorado until the recent economic slowdown. Both the GUPD and WTPD overall ranges overlap with energy development; however, the WTPD overall range has a greater potential for oil and gas development than the GUPD overall range. Impacts to the species from these activities are not fully known because scientific studies have not been conducted. It is thought, however, that there can be both indirect and direct impacts to the 2 species from energy development activities, and that entire localized prairie dog systems may be affected. Due to the pace of energy development and the potential risk to the species, management actions need to be developed and implemented in the short-term in federal Land Use Plan (LUP) revisions to protect these species and their habitats. Adaptive management will need to be employed to determine if management actions are effective or if modifications need to be made to ensure maintenance of the species and ecosystem health.

Energy & Mineral Development - Conservation Strategies

ISSUE 4.1: There is a lack of understanding regarding energy and mineral development impacts on GUPD and WTPD population dynamics and distribution.

OBJECTIVE 4.1.1: Design and initiate research to examine the impacts of energy and mineral development on GUPDs, WTPDs, and their ecosystems.

STRATEGY 4.1.1.1: Promote GUPD and WTPD research topics within academic and research institutions.

STRATEGY 4.1.1.2: Conduct research on the Rangely oil field (an example of a high development situation) to determine long-term impacts on the prairie dog ecosystem.

STRATEGY 4.1.1.3: Conduct research in newly developing oil and natural gas fields in GUPD and WTPD range, to determine impacts on prairie dog population dynamics.

STRATEGY 4.1.1.4: Examine the physiological and social responses of GUPDs and WTPDs to anthropogenic activities associated with energy and mining development.

STRATEGY 4.1.1.5: Evaluate GUPD and WTPD distribution, population densities, and colonization rates at sites prior to, during, and after oil and gas development.

STRATEGY 4.1.1.6: Evaluate "on-the-ground" effectiveness of oil and natural gas BMPs on GUPDs, WTPDs, and their ecosystems (research; see strategies under Objective 4.2.2).

STRATEGY 4.1.1.7: Determine the effects of energy and/or mineral development on species associated with GUPDs and WTPDs.

STRATEGY 4.1.1.8: Evaluate the effects of seismic exploration on GUPDs and WTPDs

ISSUE 4.2: Adequate information regarding impacts of energy development on GUPDs and WTPDs is not available.

OBJECTIVE 4.2.1: Evaluate GUPD and WTPD populations and habitat in occupied habitat areas being impacted by energy and/or mineral development.

STRATEGY 4.2.1.1: Map occupied GUPD and WTPD habitat prior to, during, and after energy and/or mineral development.

STRATEGY 4.2.1.2: Evaluate GUPD and WTPD distribution and persistence at sites prior to, during, and after energy and/or mineral development (see also "Population Monitoring" strategies).

STRATEGY 4.2.1.3: Monitor vegetation changes in GUPD and WTPD habitat after wells are constructed and when they are removed.

STRATEGY 4.2.1.4: Provide data to COGCC in order to put GUPD and WTPD colony information on the COGCC website and to allow sharing of data with industry.

OBJECTIVE 4.2.2: Minimize impacts of energy and/or mineral development on GUPDs and WTPDs.

STRATEGY 4.2.2.1: Develop adaptive prairie dog BMPs for energy and mineral development that use the best available information. Review existing industry, agency, and other state oil and gas BMPs.

STRATEGY 4.2.2.2: Complete on-the-ground compliance monitoring to insure implementation of oil and gas BMPs for GUPDs and WTPDs.

STRATEGY 4.2.2.3: Annually review oil and gas BMPs for GUPD and WTPD conservation concerns.

STRATEGY 4.2.2.4: Investigate opportunities and provide incentives for phased energy development, where appropriate, in GUPD and WTPD habitat.

ISSUE 4.3: Oil and gas development within GUPD and WTPD range may result in habitat loss, degradation, and loss of connectivity between colonies.

OBJECTIVE 4.3.1: Identify and manage areas where conserving GUPD and WTPD ecosystems is the primary objective.

STRATEGY 4.3.1.1: Identify high quality GUPD and WTPD habitat with conservation potential, and work toward protective management of these areas.

STRATEGY 4.3.1.2: Develop collaborative agreements between private, public, and state land interfaces for GUPD and WTPD conservation areas identified in strategy 4.3.1.1.

STRATEGY 4.3.1.3: Develop and fund voluntary economic incentives for private landowners to conserve GUPDs and WTPDs on their land (see "Urban Development" strategy section for additional strategies for private landowners).

STRATEGY 4.3.1.4: Designate large complexes as special management areas for GUPDs and WTPDs.

OBJECTIVE 4.3.2: Minimize current and future GUPD and WTPD habitat loss and degradation using temporal and spatial planning; include components related to connectivity.

STRATEGY 4.3.2.1: Develop potential mitigation measures (e.g. speed limits, seasonal road closures) to improve habitat connectivity within GUPD and WTPD range.

STRATEGY 4.3.2.2: Minimize impacts to GUPDs & WTPDs from energy and/or mineral development by implementing BMPs that modify pad size, location, pad construction, and road construction based on topographic features and prairie dog colony location (e.g., co-location, directional drilling, collector roads to access multiple well sites).

STRATEGY 4.3.2.3: Develop reclamation requirements to allow for GUPD and WTPD movement and re-colonization.

STRATEGY 4.3.2.4: Ensure rapid interim reclamation; if possible, revegetation efforts should be with native weed-free seed suitable for sites in GUPD and WTPD habitat.

STRATEGY 4.3.2.5: Maintain reclaimed areas as weed-free sites within GUPD and WTPD habitat.

STRATEGY 4.3.2.6: During revision of LUPs to manage leasing and development in GUPD and WTPD complexes, address prairie dog management needs and maximize habitat potential to prevent prairie dog habitat loss.

STRATEGY 4.3.2.7: Use larger-scale planning (i.e., geographic area plans) to adequately address cumulative impacts of oil and gas development in GUPD and WTPD habitat.

OBJECTIVE 4.3.3: Private and public land managers should be educated in GUPD and WTPD issues and concerns for implementation of project mitigation for prairie dog management for short-term and long-term management.

STRATEGY 4.3.3.1: Develop a long-term GUPD and WTPD management team of multiple disciplines to aid in development of appropriate project mitigation for prairie dog conservation.

ISSUE 4.4: Associated components of the prairie dog ecosystem may not tolerate certain aspects of oil and gas development activities. Conserving only GUPD and WTPD populations in the ecosystem may not be enough to preserve the functional integrity of the system (see also "Associated Species" strategy section).

OBJECTIVE 4.4.1: Management of oil and gas field developments should focus on GUPD and WTPD habitat components (e.g., vegetation, soils, perches, burrows) that maintain the functional integrity of the system.

STRATEGY 4.4.1.1: Design energy development to maintain large blocks of undisturbed GUPD and WTPD habitat to ensure long term functionality of the ecosystem for prairie dogs and associated species.

E. Genetics

The initial steps in managing an at-risk species are to resolve taxonomic uncertainties (identify potential subspecies) and to delineate the fundamental unit of management (e.g., colony, complexes, metapopulation; T. King, U.S. Geological Survey, personal communication 2008). In addition, because inbreeding depression can affect the persistence of populations and undermine conservation efforts, an evaluation of this potential risk is needed to develop and implement appropriate conservation strategies to maintain viable populations. Currently data do not exist to adequately evaluate levels of genetic diversity, effective population size, and inter-colony gene flow for either WTPDs or GUPDs (Seglund et al. 2006).

Background

On 1 February 2008, the GUPD became a candidate species for listing under the ESA within the "montane" portion of its range as defined by the USFWS (U.S. Fish and Wildlife Service 2008). The "montane" range identified in the USFWS 12-month finding of the GUPD replicated the subspecies boundary used by taxonomists that divide the GUPD into 2 subspecies: *C. g. gunnisoni* and *C. g. zuniensis* (Hollister 1916). *C. g. gunnisoni* is thought to be confined to the Rocky Mountain region of central and south-central Colorado and northern New Mexico, and *C. g. zuniensis* ranges from extreme southeastern Utah, northwestern and west-central New Mexico, and southwestern Colorado to the San Francisco Mountain Region and the Hualapai Indian Reservation in Arizona (Hollister 1916). The existence of 2 subspecies, however, has not been adequately resolved. Analyses of morphology, chromosomes, and serum proteins did not show significant differentiation between the two described subspecies (Pizzimenti 1975). Conversely, analysis of mtDNA provided evidence of past geographic isolation and subsequent genetic differentiation of *C. g. gunnisoni* apart from *C. g. zuniensis* (Hafner et al. 2005). Currently, the CDOW recognizes a single species of GUPD in the state based on the Integrated Taxonomic Information System. For effective implementation of the ESA and management of the species, additional genetic information is necessary for a robust assessment of the status of the 2 putative subspecies (Metcalf et al. 2007).

Reasons for designating the GUPD as a candidate species in the "montane" portion of the range included a suspected higher incidence of plague and a lack of a metapopulation structure to allow persistence of populations after plague epizootics occurred. Conversely, the USFWS found that the "prairie" portion of the GUPD range did not warrant listing because, although plague is present, this portion of the range was thought to maintain the colony structure and connectivity required to provide source animals to plague-affected sites to ensure long-term population viability. More research is needed to determine the level of genetic variation measured within the 2 ranges defined by the USFWS 12-month finding to evaluate effects of colony isolation on inbreeding and migration rates in order to manage and conserve the GUPD

Long-term impacts of frequent plague outbreaks on colonies can be population declines and extirpation. This results in geographic isolation of colonies as immigration opportunities become limited when distances between colonies are beyond the dispersal capabilities of the species and fluctuations in population densities affect migration rates. Concerns about isolated colonies are eventual inbreeding and random drifts in gene frequencies (Charlesworth and Charlesworth 1987). Individual and population consequences of these issues are an increase in the phenotypic expression of recessive, deleterious alleles (Charlesworth and Charlesworth 1987), and a reduction in the overall fitness of individuals in the population, making them more susceptible to diseases, parasites, and environmental changes (Williams 1975; Shields 1982, 1993; Ralls et al. 1986; Stearns 1987).

Colorado

Concern over the long-term viability of GUPD and WTPD populations in Colorado stems from their apparent declines in population numbers and distribution, due predominantly to plague, and to a lesser extent to poisoning campaigns, conversion of lands to agriculture, urban development, rangeland condition, and recreational shooting. The result of population declines and habitat loss has been fragmentation and isolation of populations. A concern for geographically isolated populations is inbreeding (occurrence of breeding among closely related individuals) and inability to re-colonize after a plague epizootic. The genetic consequence of inbreeding is increased homozygosity (Falconer 1981). This increase in homozygosity can have individual and population consequences (Fig. 26), either by increasing the phenotypic expression of recessive, deleterious alleles (Charlesworth and Charlesworth 1987), or by reducing the overall fitness of individuals in the population ("inbreeding depression"), assuming there is increased fitness in being heterozygous (i.e., the heterozygote advantage; Wright 1977), or both (Kimura and Ohta 1971).

INBREEDING →	GENETIC CONSEQUENCES →	INDIVIDUAL CONSEQUENCES →	POPULATION CONSEQUENCES
	Increased homozygosity; increased potential for expression of recessive deleterious alleles, or loss of heterozygosity	Increased susceptibility to disease; physical deformity; reduced reproduction, increased mortality	Decreased recruitment; declining population growth rate; greater probability of extirpation or extinction

Fig. 26. Diagram of the consequences of inbreeding.

Currently, there are no data to evaluate genetic variation present within GUPD or WTPD colonies in Colorado. In North Park, Cooke (1993) found that WTPDs had lower genetic variation than either BTPDs or ground squirrels, and she postulated that reduced gene flow between populations could be a concern. Restricted gene flow can be the result of habitat and colony destruction by anthropogenic influences coupled with the already sedentary nature of prairie dogs, and physiographic barriers (Pizzimenti 1976). Microsatellite-based studies of BTPDs revealed reasonably high levels of genetic variation within colonies and migration rates that show a negative logarithmic decline with geographic distance (i.e. isolation by distance; L. Sackett, University of Colorado Boulder, personal communication 2008). Because inbreeding depression can negatively affect the persistence of populations and undermine conservation (Hedrick and Kalinowski 2000, Van Buskirk and Willi 2006, Rodrigues and Diniz 2007), not only from increased probability of exposing deleterious recessive alleles, but also from lower resistance to diseases, parasites, and environmental changes (Williams 1975; Shields 1982, 1993; Ralls et al. 1986; Stearns 1987), evaluation of this potential issue is needed to develop and implement conservation strategies that maintain viable population structures throughout the GUPD and WTPD overall range in the state.

At one time the two ranges of the GUPD and the WTPD were thought to overlap in the Uncompahgre Valley between Ridgway and Olathe, and in the Cimarron River drainage (Lechleitner 1969, Armstrong 1972, Renner 2003). To clarify this zone of overlap, the CDOW visited colonies within the Uncompahgre Valley to evaluate the status of each species and to map distributions. Since the pelage of the GUPD and the WTPD become similar and the species unidentifiable by visual characteristics in the overlap area, GUPDs and WTPDs were identified based on calls, particularly alarm calls, which are unique to each species (Renner 2003). From these surveys, GUPDs were found only in the Uncompahgre Valley southeast of Ridgway; otherwise they appeared extinct in the remaining area of historic sympatry with the WTPD. The USFWS defines the "montane" portion of the GUPD to include Montrose County and the Uncompahgre Valley, but provided no information on differentiating WTPDs from GUPDs within this zone of overlap. Therefore, genetic information is needed to resolve and define the extent of each species' range, and investigate possible hybridization in the zone of contact.

<u>Conclusion</u>

Genetic research is needed to aid biologists in identifying fine-scale population structure, determining the degree of reproductive isolation among populations, and identifying the presence of and delineating the extent of metapopulation structure (T. King, U.S. Geological Survey, personal communication, 2008). In addition, information is needed to resolve taxonomic uncertainties with regard to subspecies status of the GUPD as well as defining the range extent of the GUPD and the WTPD in the zone of sympatry. Information gained from this research is needed to develop and prioritize appropriate conservation strategies for both the WTPD and GUPD.

Genetics - Conservation Strategies

ISSUE 5.1: Within the last century, GUPD and WTPD populations have been impacted by a number of issues which have resulted in smaller, more isolated colonies than occurred historically. How these changes have affected the genetic structure of both species is not understood.

OBJECTIVE 5.1.1: Conduct baseline genetic analysis (e.g., DNA-microsatellite analysis) from samples collected at GUPD and WTPD colonies.

STRATEGY 5.1.1.1: Evaluate the levels and patterns of genetic variation and diversity.

STRATEGY 5.1.1.2: Using results from the genetic analysis identify GUPD and WTPD colonies and complexes that are especially important for conservation due to their genetic identity.

STRATEGY 5.1.1.3: Determine the existence and extent of metapopulation structure by examining patterns of effective gene exchange among populations/colonies. For GUPDs compare this information between the range referred to as 'montane" and "prairie" by the USFWS (U.S. Fish and Wildlife Service 2008).

OBJECTIVE 5.1:2: Prairie dog colonies lost to plague may not be close enough to the nearest neighbor colony to be repopulated, and augmentation by translocation may be necessary for re-colonization. Investigate movement between colonies and potential impacts of translocations.

STRATEGY 5.1.2.1: Evaluate patterns of genetic diversity and variation among populations of GUPDs and WTPDs to evaluate metapopulation and/or source/sink dynamics.

STRATEGY 5.1.2.2: Using genetic research, investigate gene flow among colonies in various locations and habitats, and with differing colony juxtaposition.

STRATEGY 5.1.2.3: Determine if population reduction caused by plague results in a decrease in heterozygosity in GUPDs and WTPDs.

ISSUE 5.2: Resolve taxonomic uncertainties of the GUPD

OBJECTIVE 5.2.1: Based on genetic analyses and morphometrics, investigate the possible existence of GUPD subspecies.

STRATEGY 5.2.1.1: Collect DNA and morphometric samples from the GU, SLV, SP, SE, SW and LPA IPAs to be used in determining subspecies designation.

ISSUE 5.3: The ranges of the GUPDs and WTPDs are thought to overlap in the Uncompahgre Valley. Currently, CDOW uses vocalizations to differentiate the 2 species and for defining the current range boundaries. Information is needed to better understand and define this range boundary.

OBJECTIVE 5.3.1: Based on genetic analysis, determine the southern and eastern boundary of WTPD range in Colorado.

STRATEGY 5.3.1.1: Collect genetic samples from prairie dogs occupying sites from Montrose south to Dallas Creek, a few miles west of Ridgeway, east of Montrose to the summit of Cerro Ridge, between Cedar Creek and Cimarron, east along the North Fork of the Gunnison to Hotchkiss and Paonia, and along the west base of the West Elk Mountains, between Hotchkiss and Crawford.

F. Poisoning

As early settlement of the Intermountain West occurred, control of mammalian species considered "pests" became common practice. Prairie dog species became the focus of widespread eradication efforts, largely as a result of their reputation as range and agricultural pests (Clark 1989). Although poisoning has declined in recent decades, its impact on today's smaller, more fragmented prairie dog populations remains an issue. There are no data that track the amount and location of current poisoning efforts on private or public lands, making it difficult to adequately assess the issue.

Background

Private initiatives to poison prairie dogs had significant effects on prairie dogs between 1870 and 1915, and may have reduced populations prior to government programs being instituted (Oakes 2000). The U.S. Department of Agriculture Biological Survey implemented a "Westside Plan" that envisioned elimination of prairie dogs, along with predators, across western rangelands (Oakes 2000). The Agriculture Appropriations Act of 1915 gave statutory authorization for the Biological Survey to conduct this large-scale eradication program on national forests and all other public lands (Oakes 2000), and by 1919, cooperative poisoning campaigns had begun in all states where GUPDs and WTPDs occur.

Assessing the extent of past poisoning efforts on GUPDs and WTPDs is difficult because accounts of poisoning are not usually site- or species-specific. BTPDs were the main focus of eradication campaigns, but GUPDs and WTPDs also were targeted directly and indirectly. Poisoning became less common after the 1970s due to federal regulation of poisons. Poisoning on private lands still continues today. Only toxicants registered by the EPA may be legally used to control prairie dogs.

Knowles (1982) and Apa et al. (1990) found that BTPD colonies were able to recover from poisoning within a relatively short time frame, due to an increase in the intrinsic rate of growth. For example, colonies reduced by 45% were able to rebound within 10 months, while those completely controlled required 5 years or more to return to pre-control densities. These data provide evidence that if BTPDs are protected from eradication efforts they can rebound, implying similar potential for GUPDs and WTPDs if colonies are distributed sufficiently across the landscape to allow migration among colonies. However, long-term impacts to GUPDs and WTPDs from poisoning are unknown, and may or may not mimic the BTPDs.

Colorado

Between 1903 and 1912, efforts to exterminate prairie dogs in Colorado were initiated primarily by individual cattlemen (Clark 1989). Organized statewide efforts began with the Pest Inspection Acts of 1911 and 1915. In 1912, the first systematic eradication efforts began, with nearly every part of the state being treated at one time and most areas being poisoned annually (Clark 1989). Between 1923 and 1958, rodent control records reported that from 160 to 101,450 acres of WYGSs were treated annually which would have impacted both WTPDs and GUPDs since their ranges overlap with WYGSs (Wolf Creek Work Group 2001). Colorado poisoned 23,178,959 acres of the 3 species of prairie dogs from 1915-1964 (Forrest 2002). The peak year was 1947, when 1,278,415 acres were poisoned (Forrest 2002). Unlike many states, Colorado was still poisoning on the order of 130,966 acres per year, into the 1960s (Forrest 2002).

Today the only approved toxicant that can be used to control GUPDs and WTPDs is zinc phosphide. Fumigants that can be used legally are gas cartridges and aluminum phosphide. In 2006, the CWC approved the use of handheld devices designed to ignite a mixture of gases to control animals through concussive force and collapsing of burrows. This change was made to help agricultural producers suffering economic losses due to an increase in burrowing animals in and around sprinkler-irrigated fields and some rangeland areas.

In 2006, the Colorado Department of Agriculture (CDA) approved Special Local Needs (SLN) applications (24c) for both chlorophacinone (Rozol) and diphacinone (Kaput) for control of BTPDs in counties in eastern Colorado. On 13 May 2009, the EPA issued a final registration approval and label for Rozol Prairie Dog Bait, containing the active ingredient chlorophacinone. The label approved the product for use against BTPDs in eleven states: Arizona, Colorado, Kansas, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, and Wyoming. The CDOW does not support Rozol or Kaput being used on any prairie dog species, but authorization for use of these compounds falls under the jurisdiction of the CDA.

Population Viability Analysis Results

The application of poison can be an effective means of prairie dog population control. Information presented by experts in the field indicates that baited poisons are 75-85% effective and fumigants could be as effective as 95% (B. Andelt, Colorado State University (CSU), personal communication 2007). In the PVA (see "Population Viability Analysis" section under ANALYSIS), the use of these poisons was simulated by eliminating a total of 85% of a given prairie dog population in the year of poison application. These poisons were used at 2 different frequencies in the model: either every 3 or 5 years. In the intervening years between poison applications, demographic rates were assumed to be normal (baseline levels).

As expected, the periodic application of poison to prairie dog populations, assuming 85% efficacy of the agent, had dramatic effects on their long-term size trajectories. Due to the underlying robust growth potential inherent in the baseline models, less frequent poison application (in our model, every 5 years) offered a better opportunity for the population to rebound than more frequent poisoning, if the population is still extant (see Fig. 17). However, even the lower frequency poison application (5-year interval) led to high risks of population extinction over the 50-year time period of the simulation. It should be noted that re-colonization of a poisoned colony by immigrants from nearby colonies was not included in this modeling exercise. Clearly, isolated colonies with no opportunity for re-colonization would be at risk when frequent poisoning occurs, regardless of their size.

Stakeholder Workshop

The group assigned to developing conservation strategies to address poisoning issues in GUPD and WTPD conservation identified the following primary concerns:

- "Proper use and effectiveness, efficiency, unsanctioned methods, extent of use."
- "At what geographic locations and situations should/should not poisons be utilized."
- "Public perception and reduced management control options."
- "Effects of poison on associated species (fox, coyote, hawks) prey, burrows."
- "Poisoning of non-target and residual effects."
- "Modeling and information translation."

Conclusion

The PVA model demonstrated that poisoning practices can reduce the long-term survival of even the largest prairie dog colonies, especially if poisoning is implemented on a frequent basis and immigration among colonies cannot occur. Landowners, however, need to have tools to protect their lands and crops from potential damage caused by prairie dogs. Alternative non-lethal methods (e.g., unpalatable grasses, visual barriers) to protect landowners should actively be developed to reduce the impacts to agriculture and rangelands incurred by prairie dogs (see Agricultural Conversion strategy 1.1.1.1). If poisoning is used by landowners, the amount of acres poisoned and location of these efforts should be tracked to help land managers better evaluate poisoning impacts to prairie dogs. In addition, better education on proper use of poisons (e.g., when, where, and how to use), should be developed to avoid impacts to associated species and reduce the number of poisoning efforts needed to control prairie dog populations. Finally, the CDOW needs to remain diligent in providing input to the EPA and CDA on approval of poisons for prairie dog control to better manage prairie dogs and associated species.

Poisoning - Conservation Strategies

ISSUE 6.1: Currently, data are not collected on the extent of use of poisons for controlling GUPDs and WTPDs, complicating management of prairie dog populations.

OBJECTIVE 6.1.1: Develop a means of tracking the use of poison for controlling GUPDs and WTPDs.

STRATEGY 6.1.1.1: Develop a reporting system that tracks how much poison is purchased for GUPD and WTPD control, and where it is used (e.g., acres/county) on an annual basis.

STRATEGY 6.1.1.2: Cooperatively work with the Colorado Department of Agriculture to provide poisoning information data to the CDOW on an annual basis.

ISSUE 6.2: Some poisoning efforts have limited effectiveness in controlling GUPDs and WTPDs, but this may be due in part to improper use of poisons. Improper use of poisoning can impact associated species and result in continued use of poisons on the landscape.

OBJECTIVE 6.2.1: Provide better education on the proper use of poisons for use in controlling GUPDs and WTPDs (i.e., where, when, how) to decrease frequency of application and minimize effects on non-targets.

STRATEGY 6.2.1.1: Educate poison applicators on the importance of following label restrictions.

STRATEGY 6.2.1.2: Recommend maintaining the current limited/restricted use of poisons for prairie dogs on public and state rangelands.

ISSUE 6.3: Use of poisons to control GUPDs and WTPDs may negatively impact associated wildlife species.

OBJECTIVE 6.3.1: Minimize impacts of poisoning to non-target species.

STRATEGY 6.3.1.1: Recommend the use of poisons that result in the least impact to non-target species (i.e., zinc phosphide instead of anticoagulants).

STRATEGY 6.3.1.2: Assemble information and disseminate to those using poisons to minimize impacts to non-target species.

STRATEGY 6.3.1.3: Develop non-lethal control for prairie dogs on public lands to protect populations and associated species.

STRATEGY 6.3.1.4: Continue to comment and promote consideration of impacts on species by the EPA for approval of anticoagulants such as Rozal and Kaput in GUPD and WTPD range.

G. Population Monitoring

Accurately assessing the status of GUPD and WTPD populations at the state and range-wide levels has been difficult due to the lack of complete and consistent surveys, variable time periods between estimates at specific sites, and a lack of a standardized, objective monitoring technique to evaluate long-term population trends. Thus, there is a need to develop techniques to adequately monitor GUPD and WTPD populations on a large, landscape scale. There also is a need for site-specific monitoring/inventorying of colonies to assess implementation of conservation strategies for an adaptive management approach to local action plans, surveillance for plague, and to provide baseline occupation for land-use planning.

Background

Primary techniques used for estimating distribution, occupied habitat, and abundance of prairie dogs have included mail surveys, mapping of colony boundaries, interpretation of satellite imagery, occupancy modeling, transecting of burrows, mark/recapture, visual counts and line intercept aerial surveys. Selection of the appropriate inventory method is dependent on the question being asked and the geographic scale of interest. Recognizing definition of objectives and limitations of each method must be completed prior to implementation. Some of the methods described below will be appropriate at a site-specific scale and others will be appropriate for range-wide and/or statewide implementation.

State & Range-wide Monitoring Techniques

Mail Surveys

Mail surveys require individuals to estimate prairie dog acreage on their lands. This technique can be biased if a significant proportion of the sample does not respond and if the respondents cannot adequately identify prairie dogs or accurately estimate extent of acreage occupied. In a probable scenario, mail surveys are likely to over-estimate prairie dog abundance if landowners with prairie dogs return survey forms, whereas landowners without prairie dogs do not.

Mapping Surveys

Mapping of colony boundaries based on burrow distribution has been the predominant technique used to evaluate prairie dog populations. However, GUPD and WTPD colony boundaries in some areas are difficult to map due to variability in distribution and activity levels within these boundaries. Mapping efforts can become subjective exercises with investigators using their best estimates to map colony extent based on site topography or breaks in vegetative communities. In addition, individual burrow activity is not always assessed, resulting in both active and inactive areas being included in estimates of occupied habitat. The consequence of mapping both active and inactive areas is an inaccurate estimation of occupied habitat.

Mapping acreages of GUPDs and WTPDs on a state and range-wide basis to determine population trends is both time-consuming and expensive. Obtaining permission to gain access to private and tribal lands where prairie dogs occur is sometimes difficult. In addition, because prairie dog occupancy is not static on the landscape, it is difficult for ground crews to provide a minimum estimate of acreage by only visiting areas where prairie dogs have been reported to occur in past surveys. Thus, new areas need to be searched and mapped to adequately assess changes in occupied acreage.

Because of the problems stated above, the estimation of occupied habitat of GUPDs and WTPDs is not accurate enough to allow direct comparisons and to determine trends, except at a gross level. Until a systematic measure of variation between mapping efforts can be developed, colony mapping can only provide a gross approximation of occupied habitat on a range-wide scale. Gross approximations are meaningful in areas that have experienced dramatic declines in prairie dogs (e.g., South Park; see "South Park IPA" under CONSERVATION ASSESSMENT), or significant increases, but in areas where changes have been less extreme, mapping cannot produce comparative results.

Satellite Imagery

High-resolution (3-feet) satellite imagery has been used for estimating distribution of BTPDs (Sidle et al. 2002). In 2004, the New Mexico Department of Game and Fish and the BLM requested that a feasibility study be completed using Digital Orthophoto Quarter Quadrangles (DOQs) to evaluate the potential of remote sensing to inventory occupied habitat within the range of GUPDs in New Mexico (Johnson et al. 2004). The 2004 survey indicated that accuracy of DOQ photo interpretation as a survey method for GUPDs was lower than for BTPDs. The discrepancy was due to GUPD burrows being less clumped and their colonies smaller, on average, than those of BTPDs. GUPD habitat also is much more varied, with colonies occurring in various grassland habitats, including grasslands interspersed with woodland (e.g., piñon, juniper, ponderosa pine) or scrubland (e.g., sagebrush) habitat. Because of the problems encountered, DOQ surveys for GUPDs were determined to be unfeasible at the present time (Johnson et al. 2004).

Aerial Surveys

Aerial surveys, using line-intercept methodology, were developed for estimating occupied acreage of BTPDs (Sidle et al. 2001), and have been successfully used in Colorado (Odell et al. 2008). Because of the success of this survey design, a pilot study using aerial line-intercept surveys for estimating distribution and acreage of GUPDs and WTPDs was attempted in Colorado and Utah to evaluate its applicability to these 2 species (Andelt et al. 2003b; see APPENDIX H, "Results of Aerial Surveys"). Unfortunately, the pilot study showed that aerial line-intercept sampling was not a viable technique for estimating acreage of GUPDs and WTPDs. The reasons for failure were 3-fold: (1) GUPD and WTPD colonies are not as coalesced as BTPD colonies, making delineation of the edge of the colony difficult. Because determining the exact point at which a flight line intersects the colony is subjective, the line-intercept method therefore becomes invalid; (2) GUPD and WTPD colonies occur in habitats with diverse topography and vegetative communities resulting in irregularly-shaped colonies. To effectively survey such irregular shapes with line-intercept sampling would require that observers be able to record these intersections, many of which would occur in a fraction of a second at routine flight speeds; and (3) aerial crews found that the 2 prairie dog species are difficult to detect from the air.

Occupancy Estimation

Occupancy modeling, which entails determining the proportion of sites occupied by a species (MacKenzie et al. 2002), can provide measures of statistical precision and confidence intervals (unlike acreage estimates). Occupancy surveys have the potential to be a successful tool for establishing baseline occupancy rates for GUPDs and WTPDs in order to monitor changes in occupancy through time (Andelt et al. 2009a). Because of these attributes and after determining the difficulties in using acreage estimates to evaluate GUPD and WTPD populations, CDOW biologists investigated the use of occupancy modeling for monitoring state and range-wide prairie dog trends.

Occupancy modeling for prairie dogs requires surveying sites of 0.096 miles^2 (quadrats) to determine prairie dog presence. The population of sites (sampling frame) was defined based on UTM coordinates, so that the total number of sites (N) divided into the number of occupied sites was the proportion of sites occupied (O), or occupancy rate. Of particular importance in this approach, the model of MacKenzie et al. (2002) was used to correct observations of quadrats for false negatives, where occupied quadrats were sampled, but no prairie dogs were detected. To provide this correction to detection probabilities that are <1, multiple visits to plots were required to estimate the probability (p) that prairie dogs are observed, given that the plot is occupied.

In the WAFWA Conservation Plan (Western Association of Fish and Wildlife Agencies 2007) it was suggested that GUPD and WTPD populations be monitored range-wide, using occupancy modeling. The first year of occupancy sampling would establish a baseline, against which all future changes in occupancy would be measured. From this baseline, specific conservation actions would be triggered when a 40% range-wide decline (95% CI) is detected from the baseline. All states within the GUPD range have agreed to this coordinated effort, but only Colorado and Utah have agreed to conduct surveys for WTPDs. In addition to this range-wide occupancy sampling, Colorado will continue to sample sufficiently to evaluate statewide trends for both GUPDs and WTPDs.

Site-specific Monitoring

Transecting

With the discovery of BFFs in 1981 at Meeteetse, Wyoming, states within the historic range of this species initiated programs to identify complexes of prairie dog colonies as potential reintroduction sites for BFFs. Because BFF are obligate predators of prairie dogs, evaluation of suitable habitat for BFFs was dependent on describing prairie dog factors such as size and spatial arrangement of colonies and densities of prairie dogs within these areas (Forrest et al. 1985; Biggins et al. 1989, 1993). To aid in evaluation of prairie dog habitat, Biggins et al. (1989, 1993) developed a technique that involved counting active burrows within 0.6 miles x 3 feet transects distributed across colonies. Transects were designed to sample the mean burrow density for an entire complex within 10%, at the 95% confidence level. The number of active burrows was then converted from burrows to prairie dog counts, and finally to an estimate of prairie dog density. This method (Biggins et al. 1989, 1993) also attempted to define and standardize mapping of colonies and complexes.

No relationship between burrow density and above-ground counts has been found for either BTPDs or WTPDs (Menkens 1987, Powell et al. 1994, Severson and Plumb 1998). Similarly, Van Horne et al. (1997) did not detect a consistent relationship between burrow entrance counts and Townsend's ground squirrel population estimates. These authors recommended that burrow counts not be used to index population density unless first thoroughly verified. However, other studies involving ground squirrels did find a correlation between counts of burrows and abundance estimates (Owings and Borchert 1975, Nydegger and Smith 1986, Weddell 1989 *in* Van Horne et al. 1997).

The reason for the above discrepancies among studies may result from several factors. The first is an observer's ability to reliably differentiate between active and inactive burrows (activity status has not always been clearly defined). Biggins et al. (1989, 1993) developed a standard definition of active prairie dog burrows as those that have fresh fecal material detected within 1.5 feet of a burrow entrance, thus not leaving the determination of activity status up to subjective judgment. The second problem that may occur when correlating burrow density with above-ground counts is timing of surveys. Ground squirrels, GUPDs, and WTPDs limit above-ground activity in winter, and conducting surveys too early in the year may provide an inaccurate measurement of activity. Surveys at BFF reintroduction sites using methods of Biggins et al. (1989, 1993) are conducted at the same time each year to provide a consistent estimate of activity. Finally, the scale at which the surveys are conducted may affect correlation between active burrow density and population estimates. Burrow indices appear to be better suited for indexing trend over relatively broader geographic scales and over longer time periods (Biggins 2004).

Within Colorado, 2 sites were selected to be used for BFF reintroduction. Transecting results for both sites have shown that WTPD populations can fluctuate dramatically from year-to-year. For example, transecting in CBMA (NW IPA) yielded population estimates ranging from 308 to 6,666 prairie dogs, resulting in an overall coefficient of variation (a relative measure of variation defined as the ratio of the standard deviation to the mean) of 72% (see Table 6). With such a high coefficient of variation, it is impossible to obtain estimates with precision adequate to detect changes in population estimates.

Mapping

Due to the problems identified above, estimation of occupied habitat of GUPDs and WTPDs through mapping surveys is often not accurate enough to allow direct comparisons and to determine trends, except at a gross level. In addition, unlike other monitoring techniques, there has been no attempt to develop specific protocols to direct colony mapping. This has been less important for BTPDs, but for GUPDs and WTPDs a standardized set of guidelines would be useful. For example, active areas within GUPD and WTPD colonies can often be separated by distances greater than 100 meters, and determining whether such areas represent a single colony or separate discrete colonies is subjective and left to the observer. Therefore, until a systematic measure of variation between mapping efforts or standardized guidelines can be developed, colony mapping can only provide a gross approximation of occupied habitat.

In spite of its difficulties, mapping does have several advantages as a means for surveying prairie dogs. Prairie dog colony acreage is still commonly used when describing large scale patterns of abundance. In addition, knowing the extent of occupied acreage is necessary for successful management of associated species, notably the BFF. Furthermore, knowing the size and location of occupied areas is useful in conservation planning and in developing mitigation and avoidance measures for important habitat areas where development or other land alterations may be planned.

Visual Counts

Visual count methods to determine prairie dog abundance have been used for BTPDs (Severson and Plum 1998, Powell et al. 1994), UTPD (Bonzo and Day 2001) and WTPDs (Menkens et al. 1990, Fagerstone and Biggins 1986).

Visual counts involve making repeated aboveground counts of prairie dogs within a defined area of known size during peak prairie dog activity periods. Because not all prairie dogs are active (i.e. aboveground) at the same time, total counts of prairie dogs must be adjusted to account for detection probabilities of <1.0 at any given time. Visual counts can serve as an index to prairie dog abundance, but will underestimate true prairie dog densities. To evaluate how well visual counts correlate to actual number of animals, several authors have used robust population estimation methods (primarily mark-recapture) to compare with visual counts (Severson and Plumb 1998, Menkens et al. 1990, Fagerstone and Giggins 1986). These authors concluded that maximum aboveground visual counts of prairie dogs were strongly correlated with estimates derived from mark-recapture, and that visual counts can serve as a useful and rapid indicator of prairie dog abundance.

To make a meaningful assessment of prairie dog abundance, the visual count method requires that two assumptions be met. First, the probability of detecting individual prairie dogs must be constant across all plots. For WTPDs and GUPDs this assumption may not be met because of the diverse habitat types these species occupy which can include shrub cover and varied topography. If detection probabilities vary between plots, final estimates of abundance across the area of interest will be biased. Second, this method makes the assumption of demographic closure. That is, the number of prairie dogs present within each sample unit is assumed to remain constant during the survey period. Because the visual count methodology employs both repeated counts within a day, as well as counts over multiple days, the assumption of closure may be violated if repeated days of counts are spread out over a long period of time. For that reason, most surveys have included counts over 3 to 5 consecutive days to account for weather conditions that may affect aboveground activity levels but still satisfy the assumption of demographic closure. Additional recommendations for designing effective visual count surveys are provided by Severson and Plumb (1998).

Mark-Recapture & Mark-Resight

For many wildlife species, mark-recapture methods (or some variation on mark-recapture) are the most rigorous means of obtaining reliable estimates of densities. Much has been written on mark-recapture and related techniques (e.g. Otis et al. 1978, Seber 1982, Pollock et al. 1990). Two recent studies have applied these types of population estimation techniques to prairie dogs (Magle et al. 2006, Facka et al. 2008). Both studies employed a combination of techniques, including both traditional mark-recapture as well as mark-resight, to estimate prairie dog densities. The purpose was to test the efficacy of mark-resight methods, which are less time consuming and less costly than traditional mark-recapture, for making robust population estimates for prairie dogs. Both studies concluded that mark-resight methods are reliable and recommend their use as a way to make accurate estimates of prairie dog densities when cost prohibits mark-recapture programs. These methods would be most useful for monitoring prairie dog response to management actions at local scales. However, both methods are still more labor intensive and costly than other means of monitoring prairie dogs described above and implementation at range-wide or even statewide scales would be impractical.

Conclusion

Current results suggest that occupancy sampling is the most promising method for evaluating long-term population trends for both GUPDs and WTPDs state and range-wide (see "Recent Survey Efforts" section, Table 1). This sampling approach will allow managers to detect declines that can provide triggers to initiate management action, taking into account the natural biological variation of the species. With the occupancy sampling method, unlike acreage estimates, measures of statistical precision and guidance for sampling design can be developed, and confidence intervals can be calculated. All other methods that have been proposed and used to monitor and assess the 2 species of prairie dogs statewide have significant limitations, and none provides an objective, repeatable sampling scheme that would be defensible in court or in the scientific community.

Site-specific sampling can employ various techniques depending on the need to evaluate population abundance, distribution, or densities: transecting is commonly used to evaluate complexes of colonies for potential BFF habitat; mapping of individual colonies on a site-specific basis can provide information on distribution and extent needed for land-use planning; mark-recapture and mark-resight techniques are promising for evaluating the response of prairie dogs to management and conservation strategy implementation; and visual counts can provide an index to abundance for long-term monitoring of populations.

Population Monitoring - Conservation Strategies

ISSUE 7.1: Appropriate monitoring techniques must be used to monitor GUPD and WTPD populations at the state and range-wide, as well as at a site-specific, scale.

OBJECTIVE 7.1.1: Develop and implement an objective, repeatable estimation technique to monitor GUPD and WTPD populations state and range-wide.

STRATEGY 7.1.1.1: Implement occupancy sampling every 3 years (start year for GUPDs was 2005; start year for WTPDs is 2004) as per current protocol. If the range-wide trigger (Western Association of Fish and Wildlife Agencies 2007) is reached, increase sampling frequency to annual sampling.

OBJECTIVE 7.1.2: Conduct appropriate site-specific monitoring

STRATEGY 7.1.2.1: Continue intensive sampling at WTPD BFF areas to evaluate areas for ferrets and provide long-term site specific data.

STRATEGY 7.1.2.2: Intensively monitor a GUPD site for long-term, site-specific data to compare with variation in population estimate.

STRATEGY 7.1.2.3: Develop monitoring schemes in areas identified for implementation of GUPD and WTPD conservation strategies to identify responses of populations to management.

STRATEGY 7.1.2.4: Refine and standardize GUPD and WTPD mapping to facilitate data collection for land-use planning.

STRATEGY 7.1.2.5: Develop and maintain a central repository for GUPD and WTPD monitoring and inventory data.

H. Population Reestablishment

Throughout the overall ranges of both GUPDs and WTPDs in Colorado, there are areas where populations that were previously established have been extirpated due to plague or other impacts. The reason these colonies have not reestablished may be because they are not located close enough to other occupied areas for natural recolonization to occur. Reintroduction of prairie dogs into these areas may be the only means for population reestablishment.

There are isolated populations of GUPDs and WTPDs that experience no genetic interchange outside of their occupied areas. Although genetic analysis is currently limited, ongoing research could show that translocation of prairie dogs amongst populations may be warranted to improve genetic variation. In addition, it is important to maintain the integrity of species and subspecies, so relocations should be planned appropriately to allow interchange only among similar taxonomic groups.

Background

Past efforts to conserve prairie dogs involved translocation of animals to supplement small populations or to restore extirpated ones, and have usually targeted UTPDs and BTPDs (Robinette et al. 1995, Truett et al. 2001, Dullum et al. 2005). Translocation of prairie dogs has occurred primarily by removing them from agricultural/urban areas where they are deemed pests, into receiving areas, usually on public lands (Overturf 2004). Active translocation efforts for BTPDs in urban areas occur in Colorado, primarily in the Denver/Boulder area. These efforts are usually led by private non-profit groups. A small group in the Grand Valley began WTPD relocation efforts in 2004 from areas targeted for development to BLM lands identified as "receiving areas."

Survival of translocated GUPDs and WTPDs depends on the techniques used and on timing. BTPDs translocated within their family groups may be five times as likely to survive and have higher reproductive success as compared to those translocated without their family groups (Shier 2006). Trapping and releasing prairie dogs within their family units is even more essential to the survival of translocated GUPDs and WTPDs, because they exhibit greater territorial behavior as compared to BTPDs (Paula Martin, Prairie Ecosystem Conservation Alliance, personal communication 2009). Social behavior of WTPDs seems to be most similar to UTPDs, both species being highly unsocial and therefore requiring a larger area for reintroduction (P. Martin, Prairie Ecosystem Conservation Alliance, personal communication 2009).

The number of animals released also influences the success of prairie dog translocations. With BTPDs, Robinette et al. (1995) found that only 60-animal groups had more survivors and progeny than the number of animals originally released; group sizes compared were 10, 30, and 60. This study recommended a minimum release of 60 animals in areas where immigration is possible. Larger group size was recommended in isolated areas that do not have the possibility of immigration ("larger" was not defined).

Dullum et al. (2005) recommended releasing a minimum of 120 BTPDs into a new colony area. Little work has been done to determine the numbers of GUPDs and WTPDs needed for successful relocation. GUPDs have a very short time period for acclimation after they are released and are more apt to disperse if not released within their social units. Relocation of GUPDs in New Mexico has shown that a minimum of 300 GUPDs are needed to successfully establish a population in an area. Even with 300 individuals released, it takes 2 or more years for the animals to start successfully reproducing (P. Martin, Prairie Ecosystem Conservation Alliance, personal communication 2009). Relocation work with WTPDs has indicated that approximately 200 animals are needed to successfully establish a new population (P. Martin, Prairie Ecosystem Conservation Alliance, personal communication 2009).

Timing of relocation also plays a significant role in the survival of relocated prairie dogs. Ideally, GUPDs and WTPDs should be captured 2 to 4 weeks after juveniles have emerged above ground and 6 to 8 weeks before adults enter into aestivation. This allows time for adults to find and occupy artificial burrows and begin to excavate their own burrows before they curtail above-ground activity. Timing of juvenile emergence and adult aestivation varies by site (P. Martin, Prairie Ecosystem Conservation Alliance, personal communication 2009).

The period immediately following the release seems to be the most critical to translocation success (Truett et al. 2001). Short-term losses are caused by predation, dispersal, and weather, with predation being the primary cause of mortality for translocated animals (McDonald 1993, Overturf 2004). Survival rates have been shown to increase with more active site management such as placement of artificial burrows constructed with plastic pipes (Overturf 2004), soft releases, releasing prairie dogs into sites with similar habitat to that from which they were removed, and predator control (Truett et al. 2001). For inactive or small colonies, initial survival rate may be improved and dispersal rates limited by releasing prairie dogs over a few weeks.

Consideration must be given to the location of donor populations in relationship to the location of a receiving area. Until genetic information is available, it is recommended that source populations be as close as possible to the transplant area. For instance, if it is determined that there are 2 subspecies of GUPDs, as some currently suspect, it would be inappropriate to move animals between the suspected subspecies' range. As an example, vacant habitat in the SP IPA, SLV IPA, or GU IPA should not be repopulated with individuals from the lower-lying areas of GUPD range in the SW IPA. Future genetic work may shed more light on genetic differences between population areas and may provide additional guidance regarding geographic redistribution of some individuals for genetic enhancement. Until that time, however, it is prudent to carefully evaluate options prior to selecting source populations. In addition to genetic concerns, consideration must also be given to potential impacts that translocations may have on private landowners. Direct consultation with landowners within and adjacent to receiving areas will be necessary for education purposes and to avoid possible conflicts.

Unintentional introduction of disease (i.e., plague) into a transplant location is a possibility if translocated prairie dogs harbor infected fleas. Most relocation efforts suggest or require that captured prairie dogs be treated with a pesticide, such as carbaryl or permethrin, to kill fleas on captured animals. Truett et al. (2001) recommend that prior to prairie dog capture, source areas be surveyed for evidence of plague, through carnivore or small-mammal seroprevalence assessments, flea sampling, or prairie dog activity surveys. In addition, in plague-prone source areas, they recommend a 14-day quarantine period of the prairie dogs prior to release.

For moving prairie dogs in Colorado, a relocation permit must be secured from the CDOW. The permit lists specific conditions that must be adhered to during capture and relocation activities. Special conditions are fairly detailed and require compliance with and consideration of a number of human health and wildlife handling guidelines. Violation of any of the conditions can result in suspension of the permit. In addition to the CDOW permit, state law (SB-99111) requires approval by the Board of County Commissioners of the receiving county for any relocation crossing county lines. Since the inception of SB-99111 in 1999, relocation of prairie dogs across county lines has become a complicated process due to the political nature of the law. Strong involvement and positive communication between state agency and county personnel must occur. Relocation of prairie dogs from within the same county may also be a viable option if the situation allows. Starting in 2003, the Food and Drug Administration (FDA) began requiring that activities related to prairie dogs be evaluated for potential health concerns related to monkey pox; a letter of non-objection is required from the FDA for prairie dog handling/relocation activities.

Conclusion

Translocations to reestablish GUPD and WTPD populations require significant resource investment and are not always successful. Without adequate precautions, risk of disease transfer can be high. Efforts should primarily be directed toward sites where translocation is necessary to reestablish prairie dogs in formerly occupied population areas, or to increase genetic variation within isolated populations. Sociological factors such as state law and potential impacts to private landowners must be taken into account when planning for translocations of prairie dogs.

Population Reestablishment - Conservation Strategies

ISSUE 8.1: There are areas of suitable habitat for GUPDs and/or WTPDs that were formerly occupied, are no longer occupied, and are too far from existing colonies to naturally reestablish.

OBJECTIVE 8.1.1: Reestablish GUPDs and/or WTPDs in high priority areas in suitable habitat that was formerly occupied.

STRATEGY 8.1.1.1: Identify and prioritize for possible reestablishment areas of formerly occupied GUPD and/or WTPD habitat. Emphasis should be placed on areas that: (1) are too far from current colonies to reestablish naturally; (2) are necessary for increasing and/or expanding current range into formerly occupied range; (3) are on lands where stakeholders are willing to participate in management; and (4) have little to no impact on private landowners.

STRATEGY 8.1.1.2: Determine cause(s) of previous extirpation of sites identified in 8.1.1.1, and discern whether those risks have been sufficiently eliminated or reduced.

STRATEGY 8.1.1.3: Work with public land agencies, local governments, private landowners, and other stakeholders to gain support and approval for reestablishment sites; refine selected areas through this process.

STRATEGY 8.1.1.4: Secure appropriate permits with the CDOW, the USFWS, and the FDA for GUPD and/or WTPD reestablishment. Acquire county government support.

STRATEGY 8.1.1.5: Identify the most appropriate GUPD and WTPD source populations, and consider potential genetic similarities (subspecies) and habitat issues.

STRATEGY 8.1.1.6: Conduct GUPD and WTPD trap and transplant activities; follow protocols to minimize potential for disease transfer and use transplant techniques that offer highest likely survival rates.

STRATEGY 8.1.1.7: Annually monitor sites post-transplant for a minimum of 5 years, and evaluate success of transplant.

Note: For translocation activities relating to loss of habitat from urbanization, see "Urban Development" strategy section.

I. Rangeland Condition

Lasting changes in rangeland condition have occurred across the west, including Colorado. These changes were precipitated by the introduction of large numbers of cattle and sheep, by spraying of herbicides and use of mechanical methods to kill and thin sagebrush stands, by invasion of non-native plant species, and by changes in fire frequency. These predominantly human-induced alterations resulted in contemporary rangelands comprised of different species composition and community structure than prior to settlement. How these changes have affected prairie dog populations is unknown because benchmarks do not exist to allow examination of populations prior to changes.

Background

Drought

GUPDs and WTPDs have evolved to live in arid areas that experience periodic droughts. However, human-facilitated changes to ecosystems in the west, including altered plant species composition, ecosystem function, and ecosystem structure (Fleischner 1984), may cause prairie dogs to be more susceptible to drought conditions. For example, historic overgrazing by livestock in arid areas caused the formation of deep, erosive gullies (Cottam 1961), increased soil compaction and decreased water infiltration (Kauffman and Krueger 1984, Abdel-Magid et al. 1987, Ordoho et al. 1990). One of the most important impacts of this alteration is the lowering of water tables leading to desertification of habitats (Fleischner 1984). There are estimates that over 4,000,000 acres of western rangeland have undergone desertification (Dregne 1983 *in* Fleischner 1994). This desertification could impact GUPDs and WTPDs by decreasing the availability of forage resulting from a reduction in the vigor of cool season grasses. In addition, climate change may be increasing the number and duration of drought events, making it more difficult for prairie dogs to survive. Thus, drought may be a significant factor limiting distribution and affecting population trends.

Fire Frequency

Beginning in the 1890s, fires decreased in frequency and intensity in the southwestern U.S. (Bahre 1991, Swetnam et al. 1999 *in* Oakes 2000). Settlement resulted in active suppression of wildfires, and grazing reduced biomass on the range, resulting in less intense fires (McPherson 1995 *in* Oakes 2000). Alteration in fire regimes within the ranges of the GUPD and WTPD has produced changes in structure and function of plant communities. Habitat associations of GUPDs and WTPDs have not been examined over a large number of colonies or across a large geographic area, but in general fire is thought to be beneficial for prairie dogs because it can: (1) reduce the shrub component of shrub-steppe communities leading to more open tracts of habitat and increased visibility; (2) release plant nutrients, temporarily increasing the nutrient content of forage; (3) stimulate fruit and seed production and increase the yield and quality of herbaceous vegetation; and (4) remove unwanted vegetative litter, which can increase the suitability of an area for prairie dogs (CNHP 2000, NRCS 2001, BLM 2001b, 2002d *in* Buys and Associates Inc. 2005). Research examining experimentally induced colony expansion in BTPDs found that controlled burning at the margins of existing BTPD colonies allowed for greater colony expansion and occupation (Milne-Laux and Sweitzer 2006).

Introduced Species

Rangeland condition has been altered by the introduction of non-native plant species including but not limited to cheatgrass, crested wheatgrass, halogeton, Dalmatian toadflax, leafy spurge, and camelthorn which are primarily spread by livestock grazing and wind. Little is known about the impact of these non-native weedy species on populations of GUPDs and WTPDs; some non-native plants may be more beneficial and others more harmful. However, Slobodchikoff et al. (1988) found that GUPDs did better at sites that contain predominantly native species of plants and tended to avoid sites with a high proportion of introduced weedy species.

In Colorado, non-native plants have infiltrated the ranges of both GUPDs and WTPDs. Information is needed to adequately assess the impact of these plant community changes to prairie dog population dynamics. For example, cheatgrass is an aggressive species that can become a monoculture due to its ability to change soil structure, deplete soil moisture, and out-compete native perennials. The proliferation of cheatgrass over native perennial grasses and forbs may impact the ability of prairie dogs to meet their dietary needs resulting in increased mortality rates and decreased productivity (Ritchie 1999). Cheatgrass may not provide sufficient above- or below-ground forage or water stores that GUPDs and WTPDs need to subsist. In addition, the early green-up of cheatgrass may be beneficial to prairie dogs in spring, but as it goes to seed and dries out prairie dogs may have few options to supplement their diets. During drought conditions, vast monocultures of cheatgrass may be detrimental to prairie dog populations. This is because cheatgrass seeds will remain dormant during dry years, and thus prairie dog colonies located in cheatgrass-dominated sites will have their forage severely depleted, resulting in an inability to develop fat stores to survive over the winter or to produce litters.

Questions have arisen about the role of GUPD and WTPD populations in the spread of invasive weeds across the landscape. GUPDs and WTPDs are a disturbance related species, and have the ability to activate dormant seed banks through their burrowing activities and through consuming non-native weed seeds that can be dispersed in the fur and feces of the animals. Prairie dogs can also indirectly affect hydrology and nutrient cycling through their burrowing and grazing activities (Whicker and Detling 1988 *in* Fahnestock and Detling 2002). However, the limited amount of research conducted on GUPDs and WTPDs found few vegetative differences between prairie dog colonies and non-colonies in relation to vegetation cover, canopy height, species diversity, and nitrogen concentration (Grant-Hoffman and Detling 2006).

Research on BTPDs has shown that their effects on rangeland condition are not uniform (Johnson-Nistler et al. 2004). Activities associated with BTPD colonies can cause a reduction in grass biomass, an increase in bare ground, and an increase in forb biomass (Fahnestock and Detling 2002, Johnson-Nistler et al. 2004). Some studies have found that exotic plant species become more common at on-colony sites than at off-colony sites (Fahnestock in press *in* Fahnestock and Detling 2002). This may indicate that BTPD colonies can be important sites for the establishment of exotic species or as a reservoir for their seeds (Fahnestock in press *in* Fahnestock and Detling 2002). However, other studies have shown a decreased contribution of exotic plants to total plant cover on BTPD colonies relative to off-colony sites. These differences suggest that impacts of prairie dogs on the landscape are highly dependent on habitat, climate, and age of the colony (Fahnestock and Detling 2002).

Making clear comparisons between the impacts of BTPDs on mid- and short grass prairie and those of WTPDs and GUPDs on their habitats is difficult for the reasons mentioned above, as well as the relatively limited above-ground activity of WTPD and GUPD. In addition, because GUPD and WTPD do not actively "clip "vegetation to alter their surroundings, they have less impact on their local environment. However, continued research is needed to adequately assess the impact of GUPD and WTPD colonies on the landscape.

Livestock Grazing

Historic livestock grazing played an important role in altering the range condition of the West (Seglund et al. 2005, 2006). The numbers of sheep and cattle on western rangelands peaked in the early 1900s with livestock grazing centered on season-long use and stocking rates routinely exceeding carrying capacity of habitats (Cottam and Stewart 1940 *in* Collier and Spillett 1975; Young and Sparks 1985 *in* Crawford 2004). Within the last 40 years, stocking rates have been reduced by more than 25% (USDI-BLM 1990) and concurrent with these reductions, public rangelands have seen improvements (Box 1990, Laycock et al. 1996 *in* Crawford 2004).

Since the early 1930s grazing in WTPD and GUPD habitats has centered on winter/spring/fall sheep grazing, but due to a declining sheep market within the last 10–20 years, spring cattle grazing was instituted in some areas. The BLM has attempted to manage grazing with the objective of providing adequate rest during the critical growing season to allow for reproduction and replenishment of plant reserves (E. Hollowed, BLM, personal communication 2005).

Much attention has been focused on competition between livestock grazing and prairie dog use. Cattle and BTPDs exhibit a high dietary overlap in the mid- and short grass prairie (60–64%; Uresk 1984, 1986 *in* Miller et al. 2007). Though dietary overlap does not prove that either species is adversely affected, livestock producers have actively worked to eradicate prairie dogs. In contrast to such widely-held perceptions, induced alterations caused by BTPDs seem to attract bison and other large herbivores who tend to utilize BTPD colonies for grazing far more than predicted (Koford 1958, McHugh 1958, Coppock et al. 1983, Krueger 1986 *in* Fahnestock and Detling 2002).

Recent research on the MEPD found that controlled livestock grazing can be compatible with prairie dog conservation (Mellado et al. 2005). Prairie dogs prefer forbs and the proportion of grasses and forbs in their diet changes seasonally, while cattle forage predominantly on grasses throughout the year. Additional work on the UTPD examining different intensity (none, moderate, and heavy) of simulated livestock grazing showed an increase in average forage nitrogen and digestibility in "grazed" plots, but a decrease in forage biomass (Cheng and Ritchie 2006). For prairie dogs, this reduction in biomass resulted in a reduction in overall growth rates, increased juvenile foraging time, and a subsequent reduction in vigilance; however, with grazing of moderate intensity, which is common on most rangelands today, prairie dogs demonstrated a preference for grazed areas over "ungrazed" areas. The reason for this preference was attributed to the benefits of ungrazed plots (higher biomass) declining over time, while biomass in grazed (higher quality) plots remained relatively constant.

GUPD and WTPD colonies are commonly found occurring in early successional areas (Fitzgerald et. al 1994), such as recently disturbed, sparsely vegetated areas that are dominated by low-lying, new-growth vegetation (Buys and Associates Inc. 2005). Both species of prairie dogs have been found to prefer relatively open plant communities with short-stature vegetation (Tileston and Lechleitner 1966, Clark 1977, Collins and Lichvar 1986, Menkens 1987, Orabona-Cerovski 1991), most likely due to their dependence on visual surveillance for predators, dietary needs, and intraspecific interactions (Fitzgerald and Lechleitner 1974). Livestock grazing generally promotes sites with the above-mentioned characteristics and can be a beneficial management tool for prairie dogs (Buys and Associates Inc. 2005).

Piñon -Juniper Encroachment

Loss of habitat within the range of GUPDs and WTPDs in Colorado can be attributed in some areas to piñon-juniper (a vegetation type dominated by piñon pine and juniper trees) and/or shrub expansion and encroachment into formerly occupied habitats. Although the amount of prairie dog habitat lost to piñon-juniper encroachment or shrub expansion in Colorado is unknown, there is local knowledge of areas where range restriction or fragmentation of GUPD and WTPD habitat has occurred. Unlike BTPDs, both GUPDs and WTPDs can be found in areas of sparse shrublands; however, as density of overstory increases, the habitat becomes more unsuitable. GUPDs and WTPDs rely primarily on line of sight for predator avoidance, which becomes more difficult when vegetation gets too tall and/or thick.

Stakeholder Workshop

The group assigned to developing conservation strategies to address rangeland condition in GUPD and WTPD conservation identified the following primary concerns:

- "Uncertainty exists in relation to the following areas: the size of a healthy prairie dog population, the relationship between grazing and prairie dogs, distribution of prairie dogs across different land ownership (i.e. private vs. public land), different habitat types (soil, weather, etc.) and different management styles, the relationship between prairie dogs and fire, predators, plague, and invasive species."

- "The potential for listing of white-tailed and Gunnison's [*sic*] prairie dog and related regulations could lead to losses within much of the livestock business. Succeeding land-uses could be detrimental to prairie dogs and the related ecosystem function."
- "Polarization between CDOW, agricultural producers, and other environmental groups leads to a gap in current research, and to doubts about conclusions being drawn regarding prairie dog population conditions and the interaction between producers and prairie dogs."
- "The scale of analysis is critical in the assessment of ecosystem condition. Different conclusions about the health and function of range ecosystems will be drawn, depending on the extent of the area surveyed. Analyses that focus on a habitat mosaic are more relevant to conservation than analysis of individual pasture areas."
- "Competition for forage between prairie dogs and ungulates."
- "Relationship between predators and prairie dogs (including importance of prairie dogs as prey)."

Conclusion

Healthy landscapes should be the ultimate goal of all natural resource management actions. Species-specific management should only be implemented when specific threats have been identified and strategies exist to bolster population viability of species of concern.

There is a lack of information on the impacts of rangeland changes on prairie dogs; additional research is needed. Currently, many land-use agencies have improved and continue to improve rangeland conditions by managing intensity and duration or timing of grazing, working to control invasive weed infestations, and seeding areas to promote grass, forb, and sagebrush growth. Through these efforts, GUPD and WTPD habitat will likely be improved.

Management of rangelands needs to consider the relative influence of climate change. While there are many uncertainties about how climate change will affect certain habitats, an overall management strategy that maintains a larger landscape and thereby increases the ability of the given species to adjust their range should be incorporated in the overall conservation of these 2 species.

Rangeland Condition - Conservation Strategies

ISSUE 9.1: There is a lack of information on the relationship between GUPD and WTPD populations and rangeland condition.

OBJECTIVE 9.1.1: Develop and implement an integrative and applied research program to address data gaps in the relationships between GUPD and WTPD demographic parameters and population trends, and rangeland condition (e.g., invasive weeds, grazing, fire).

STRATEGY 9.1.1.1: Determine how to define high quality GUPD and WTPD habitat; share definitions with partners.

STRATEGY 9.1.1.2: Compare how habitats that contain non-native weeds and those that do not impact GUPD and WTPD mortality rates, reproductive output, and population viability over the long-term.

STRATEGY 9.1.1.3: Determine the effects of timing and intensity of grazing regimes on the use of habitats by prairie dogs.

STRATEGY 9.1.1.4: Evaluate the response of prairie dogs' use of areas to fire events.

STRATEGY 9.1.1.5: Determine the effect habitat enhancement projects (designed to reduce sagebrush cover and improve forb and grass cover) have on prairie dog reproductive output and survival.

STRATEGY 9.1.1.6: Determine GUPD and WTPD dietary needs and habitat requirements in order to develop appropriate seed mixes and seed application techniques for reclamation activities and habitat enhancement projects with respect to prairie dogs.

STRATEGY 9.1.1.7: Apply research findings to develop appropriate mitigation standards focused on achieving rangeland conditions that will support prairie dogs.

ISSUE 9.2: There is a perception that current grazing practices may not be compatible with healthy GUPD and WTPD populations.

OBJECTIVE 9.2.1: Develop demonstration projects showing the relationship between current grazing management and GUPD and WTPD habitat.

STRATEGY 9.2.1.1: Develop and implement demonstration projects in appropriate locations in GUPD and WTPD range (include public and private lands, various habitat types, various ungulate species [e.g., sheep, cattle, wild ungulates], integration of prairie dog management practices and a working ranch). Lead tours of multi-stakeholder groups.

ISSUE 9.3: There is a lack of communication among agencies, private landowners, agricultural producers, non-governmental organizations (NGOs), and other stakeholders that results in polarization regarding GUPD and WTPD conservation issues, especially range condition.

OBJECTIVE 9.3.1: Coordinate meetings among agencies, private landowners, agricultural producers, NGOs, and other stakeholders to discuss GUPD, WTPD management and range condition.

STRATEGY 9.3.1.1: Provide an annual report on progress made in implementation of GUPD and WTPD conservation strategies and the impact of these strategies on populations (see also "Population Monitoring" strategies).

STRATEGY 9.3.1.2: Explore the use of local work groups for GUPD and WTPD conservation in Colorado.

STRATEGY 9.3.1.3: Encourage and continue constructive organized dialogue among stakeholders (including agencies, private landowners, agricultural producers, NGOs) regarding rangeland condition BMPs for GUPDs and WTPDs.

STRATEGY 9.3.1.4: Design and implement an effective method to disseminate GUPD, WTPD, and rangeland condition research results to stakeholders.

ISSUE 9.4: There is a lack of understanding of the competition for forage between prairie dogs and livestock.

OBJECTIVE 9.4.1: Identify and implement grazing management practices that are neutral or beneficial to GUPDs and WTPDs.

STRATEGY 9.4.1.1: In important GUPD and WTPD habitat areas, identify grazing management practices that consider type of ungulate, season, duration, distribution, frequency, and intensity of grazing use to maintain sufficient vegetation for prairie dog habitat.

STRATEGY 9.4.1.2: Develop a rangeland management BMP handbook for GUPDs and WTPDs based on valid research results (under Objective 9.1.1), to include a scale-appropriate assessment tool for rangeland condition.

OBJECTIVE 9.4.2: Develop incentives for private landowners to maintain appropriate GUPD and WTPD populations in priority areas as a part of a functioning agricultural/range business operation.

STRATEGY 9.4.2.1: Develop an incentive plan (e.g., CCAAs) for private landowners, state lands and BLM lessees and permittees to maintain GUPD and WTPD habitat.

STRATEGY 9.4.2.2: Implement an incentives program (e.g.,CCAAs) for GUPD and WTPD habitat areas deemed to be important for species/ecosystem maintenance.

STRATEGY 9.4.2.3: Consider implementation of an assurance program (e.g., CCAA) on private lands for habitat areas deemed to be important for GUPD and WTPD ecosystem maintenance.

ISSUE 9.5: Shrub and piñon-juniper encroachment can result in loss and fragmentation of GUPD and WTPD habitat.

OBJECTIVE 9.5.1: Minimize loss and fragmentation of GUPD and WTPD habitat due to shrub and piñon-juniper encroachment.

STRATEGY 9.5.1.1: Identify and map significant areas of current or former GUPD and WTPD habitat that have experienced encroachment by shrubs and/or piñon-juniper.

STRATEGY 9.5.1.2: Prioritize areas in GUPD and WTPD range to treat for shrub and/or piñon-juniper encroachment.

STRATEGY 9.5.1.3: Conduct pre-project planning (e.g., project design, necessary archeological clearances, EAs) for identified shrub and piñon-juniper treatment areas in GUPD and WTPD range.

STRATEGY 9.5.1.4: Conduct pre-restoration monitoring using a recognized technique appropriate to measure the treatment objective in GUPD and WTPD habitat.

STRATEGY 9.5.1.5: Implement planned treatments in GUPD and WTPD habitat.

STRATEGY 9.5.1.6: When reseeding a treatment area in GUPD and WTPD habitat, use certified weed-free seed stock.

STRATEGY 9.5.1.7: Monitor vegetation response to treatments in GUPD and WTPD habitat using appropriate monitoring technique.

STRATEGY 9.5.1.8: Evaluate effectiveness of treatment on GUPD and WTPD populations.

ISSUE 9.6: Noxious and invasive weeds may have adverse impacts on GUPD and WTPD habitat and populations.

OBJECTIVE 9.6.1: Minimize the impacts of noxious and invasive weeds on GUPD and WTPD habitat and populations.

STRATEGY 9.6.1.1: Identify and map significant areas of current or former GUPD and WTPD habitat that have experienced undesirable noxious weed invasions.

STRATEGY 9.6.1.2: Work to prevent new invasions of noxious and invasive weeds in GUPD and WTPD habitat. This refers to both new infestations of known weedy species and future infestations of as-yet-unidentified weed species. Coordinate efforts across property boundary lines.

STRATEGY 9.6.1.3: Prioritize areas of GUPD and WTPD habitat to treat for weed infestations.

STRATEGY 9.6.1.4: Conduct pre-project planning (e.g., project design, Environmental Assessments [EAs]) for identified weed treatment areas in GUPD and WTPD habitat.

STRATEGY 9.6.1.5: Implement planned weed treatments in GUPD and WTPD habitat.

STRATEGY 9.6.1.6: When reseeding a treatment area in GUPD and WTPD habitat, use certified weed-free seeds.

STRATEGY 9.6.1.7: Monitor the effectiveness of treatments of noxious and invasive weeds in GUPD and WTPD habitat.

STRATEGY 9.6.1.8: Evaluate how the spread of noxious weeds is occurring and if GUPD and WTPD populations play a role in spreading noxious weeds.

ISSUE 9.7: There is a need to address drought impacts on prairie dog habitat.

OBJECTIVE 9.7.1: Manage GUPD and WTPD habitat in anticipation of drought conditions.

STRATEGY 9.7.1.1: In areas experiencing drought, adjust grazing practices, prescriptive fire, and/or vegetation management to minimize additive impacts to GUPD and WTPD habitat.

STRATEGY 9.7.1.2: Develop grass banks for livestock producers to graze in GUPD and WTPD habitat during extreme drought conditions or develop drought fund to offset feed costs.

STRATEGY 9.7.1.3: Review agency policies and practices to explore adjusting agency policy (if deemed necessary) for the benefit of selected GUPD and WTPD habitats during drought conditions.

ISSUE 9.8: There is a need to manage fire in prairie dog habitat.

OBJECTIVE 9.8.1: Manage fire in GUPD and WTPD habitat to benefit prairie dog populations while protecting associated species' needs.

STRATEGY 9.8.1.1: Identify areas in which fire might allow and encourage GUPD and WTPD colonization and expansion.

STRATEGY 9.8.1.2: Use prescribed burning at identified areas (Strategy 9.8.1.1) to improve quality and quantity of GUPD and WTPD habitat.

STRATEGY 9.8.1.3: Provide comments on federal Land-use Plans with regard to fire management and prairie dog ecosystem health.

STRATEGY 9.8.1.4: To encourage GUPD and WTPD colony expansion by providing new habitat, conduct controlled burns adjacent to colonies.

STRATEGY 9.8.1.5: Where appropriate for GUPD and WTPD conservation, allow naturally started fires to burn.

STRATEGY 9.8.1.6: In GUPD and WTPD habitat, use native seed if possible to reseed after fires.

STRATEGY 9.8.1.7: Balance prescribed burns for prairie dog conservation with needs of other species.

STRATEGY 9.8.1.8: Monitor prescribed burn treatments in GUPD and WTPD habitat, to evaluate effectiveness.

J. Recreational Shooting

Recreational Shooting results in direct mortality of targeted prairie dogs. Although the effects of recreational shooting on GUPDs and WTPDs have not been extensively studied, by its nature recreational shooting operates at the individual animal level rather than at a population level like some of the other issues evaluated in this document. Effects within individual colonies can be significant, but recreational shooting activity is irregularly dispersed across the range of GUPDs and WTPDs. As a result, it is not expected that shooting alone can have a sufficient population level effect to move GUPDs or WTPDs towards extinction. Nevertheless, where recreational shooting activity occurs regularly or at high intensity, shooting has the potential to locally reduce prairie dog densities and slow recovery rates of colonies impacted by plague or other disturbances, especially in the case of isolated colonies. Application of public land seasonal shooting closures may be an effective technique for maintaining recreational shooting mortality within acceptable limits for conservation of GUPD and WTPD populations.

Background

Limited research on the effects of shooting on prairie dog populations exists, and the information available comes predominantly from BTPD research efforts. Applicability of these data to GUPDs and WTPDs can only be inferred. Research examining the effects of shooting on BTPDs has found it can result in removal of pregnant females and young of the year, increase vigilance, decrease foraging rates, and increase emigration. Impacts associated with decreased foraging rates and increased vigilance included a reduction in body condition and lower reproductive output (Knowles 1988, Stockrahm and Seabloom 1988, Vosburgh and Irby 1998, Buskirk and Pauli 2003).

Shooting in GUPD and WTPD habitats has traditionally consisted mainly of local shooters, and not the large number of nonresidents known to participate in recreational shooting of BTPDs (Knowles 2002). The primary reasons for out-of-state shooters preferring to shoot BTPDs is because their colony boundaries are easy to identify, colonies have high densities of animals, mounds are very conspicuous, and colonies are open and devoid of plants that might obscure a shooter's vision. The reason it is important to identify the type of shooter, is that out-of-state shooters usually spend more time shooting prairie dogs and use customized guns, rests, and other equipment to improve their accuracy (Gordon et al. 2003). Many recreational shooters use weapons that enable them to be consistently accurate at distances of greater than 400 yards, and to take large numbers of prairie dogs per day.

Secondary lead poisoning has been suggested as an indirect consequence of shooting and a source of mortality for species associated with prairie dog colonies. Pauli and Buskirk (2007) found that many prairie dog shooters used expanding bullets, and after shooting prairie dogs, rarely removed carcasses. The amount of lead found in prairie dogs shot with expanding bullets was sufficient to acutely poison scavengers and predators that may feed on prairie dog remains. Thus, prairie dog shooting may provide a portal for lead entering the food chain. However, Stephens et al. (2003) examined lead concentration in ferruginous hawk and golden eagle nestlings, and feather samples of burrowing owls for clinical signs of lead poisoning in Thunder Basin National Grasslands, Wyoming. They failed to detect lead poisoning in any of the raptors and concluded that low-intensity shooting did not contribute to lead poisoning; however, the effects of high-intensity shooting remained unclear.

Colorado

Peak shooting pressure on GUPD and WTPD colonies tends to occur from April to June when the weather is cool and juveniles are emerging. This timing in shooting pressure makes lactating females and young of the year vulnerable, and causes loss of dependent young when females are killed. Significant take of these individuals can reduce the yearly reproductive output of a colony and may become additive to natural mortality.
To address this effect, a shooting closure was instituted in Colorado between 1 March and 14 June on public lands, to protect breeding animals and their young.

Both GUPDs and WTPDs are classified as small game species under the CWC Regulation #300 A.2. Regulation #302.B sets method of take, which includes rifles, handguns, shotguns, handheld bows, crossbows, pellet guns, slingshots, hawking, and toxicants. A small game license is required to take GUPDs and WTPDs, with the exception of private landowners, their immediate family members, and designees, who may take prairie dogs causing damage on their lands. No bag or possession limits (#308) exist during the open season. Participants in shooting contests can take no more than 5 prairie dogs during an event (Regulation #302-1.a.1). No take is permitted on National Wildlife Refuges.

Population Viability Analysis Results

PVA results are described more fully in the Analysis Section of this document and the complete PVA report is presented in Appendix G. The specific results for recreational shooting are repeated here to assist the reader. The PVA simulated 4 different levels of shooting-based mortality across all age classes of GUPDs, under current conditions of seasonal closure rules in effect 1 March – 14 June (see "Population Viability Analysis" section). Specifically, 5%, 10%, 15% or 20% additional shooting related mortality was imposed across all age-sex classes, in addition to the baseline mortality rates.

To investigate the effectiveness of removing the current seasonal closure, the same simulated additions to mortality were used while also decreasing the percentage of adult females that successfully weaned a litter. This was done because shooting during the current closure season will lead to removal of pregnant females and dependant young. In particular, it was assumed that 80% of the shooting mortality occurs during the time period of 1 March to 14 June; therefore, the reduction in the percentage of successful females is 80% of the specified increase in shooting mortality. For example, if shooting imposes an additional 10% increase in mortality, then there would be an 8% reduction in the percentage of adult females weaning a litter.

As described in the introductory paragraph, shooting mortality operates against individual animals and all scenarios demonstrated an increase in individual animal mortality. The PVA accumulated these individual effects to assess colony level impacts. Simulation of the current seasonal shooting closure in the PVA showed low to negligible risk of extinction for colonies. If the current seasonal shooting closure was retracted, all scenarios showed an increase in the overall population extinction risk, although for most models this risk was still relatively low (<10 %). The exception was models in which enzootic plague was included, and especially when the initial population size was less than 250 individuals (resulting extinction risk was > 50%). Therefore, the impact of shooting on prairie dog population persistence may be tied to the presence of low-level enzootic plague in these populations, particularly when populations are small in size (i.e., < 250 individuals).

The addition of plague epizootics would dramatically reduce the viability of all modeled populations that included recreation shooting effects, essentially eliminating any variation in population performance that may result from the underlying demographic profile. As a result, particular scenarios combining the processes of plague and shooting were not developed for this analysis.

Stakeholder Workshop

The group assigned to developing conservation strategies to address recreational shooting in GUPD and WTPD conservation identified the following primary concerns:

- "The issue of prairie dog shooting is highly polarized across the general public."
- "Shooting may have potential detrimental impacts on prairie dog population dynamics, perhaps leading to longer-term population decline."
- "There are socio-economic benefits, as well as potential gains or losses to shooting prairie dogs, thereby strengthening the debate over the topic."
- "There is a general lack of reliable information on the current levels of harvest, the specific types of impact to prairie dog populations, and the impacts on non-target species."
- "Prairie dogs have detrimental impacts on property, making shooting a desirable method of population control under some circumstances."

Conclusion

Shooting, unlike plague, is a manageable threat to prairie dogs. Shooting has the potential to locally reduce population densities and could slow or preclude recovery rates of colonies reduced by plague or other disturbances by being an additive factor to other mortality. However, the PVA suggested that the potential for colony extirpation solely from recreational shooting was quite low. Lower rates of shooting-based mortality appear to be sustainable in otherwise demographically robust (i.e., plague-free) prairie dog populations. Populations appear to become less stable when shooting is practiced during the primary reproductive period when pup production would be compromised. Thus, maintaining the newly instituted shooting closure during the reproductive period appears to be important in conserving both prairie dog species.

Recreational Shooting Conservation Strategies

ISSUE 10.1: The issue of prairie dog shooting is highly polarized across the general public.

OBJECTIVE 10.1.1.: Improve public understanding of the (1) effects of shooting on prairie dog populations; (2) status and trends of GUPD and WTPD populations (numbers and distribution); and (3) current regulatory and management actions.

STRATEGY 10.1.1.1: Create an internet educational site (aimed primarily at more urban audiences, non-hunters) that addresses all 3 objective points.

STRATEGY 10.1.1.2: Approach other organizations and stakeholders (e.g., shooting and environmental groups) regarding their interest in education efforts on prairie dog populations and shooting; encourage a unified message.

STRATEGY 10.1.1.3: Launch education efforts via multiple venues (e.g., newspapers, brochures).

STRATEGY 10.1.1.4: Continue to inform hunters about prairie dog regulations in small game brochures.

ISSUE 10.2: Recreational shooting may have detrimental impacts on GUPD and WTPD population dynamics, as well as on associated species. There are, however, socio-economic benefits to shooting prairie dogs by the public and local communities that may conflict with prairie dog conservation management.

OBJECTIVE 10.2.1: Maintain sustainable GUPD and WTPD populations while continuing to allow for recreational shooting opportunities.

STRATEGY 10.2.1.1: Provide for local management flexibility on a site-specific basis. If necessary, due to population declines or die-offs, institute temporary closure of prairie dog shooting in GUPD and WTPD populations (see also "Disease" strategies).

STRATEGY 10.2.1.2: Develop a monitoring technique that would allow managers to adjust GUPD and WTPD harvest levels to make shooting sustainable, and to avoid causing significant declines and/or extirpation of populations.

STRATEGY 10.2.1.3: If information indicates that GUPD and/or WTPD populations are being significantly impacted by shooting, evaluate shooting management.

STRATEGY 10.2.1.4: Identify ways to encourage recreational shooters to concentrate on GUPD and WTPD colonies on private lands where populations are high (see also "Agricultural Conversion" strategies).

STRATEGY 10.2.1.5: Encourage recreational shooters (e.g., through CDOW small game brochure) not to shoot prairie dogs on small, isolated colony sites, or in BFF release areas.

OBJECTIVE 10.2.2: Preserve and enhance prairie dog recreational shooting opportunities and the resulting economic benefits from this activity when supported by sustainable prairie dog population.

STRATEGY 10.2.2.1: Maintain the existing regulatory framework that allows GUPD and WTPD shooting as a control method on private lands when supported by data and management objectives.

STRATEGY 10.2.2.2: Evaluate the potential for a walk-in-access program for prairie dogs on private lands (access to different areas from year-to-year) to assist in achieving population management objectives, as well as other site specific objectives such as control.

STRATEGY 10.2.2.3: Investigate opportunities to assist landowners with promoting shooting on their properties (with access fees), as a way to encourage landowners to be more accepting of GUPDs and WTPDs on their land (see also "Agricultural Conversion" strategies).

OBJECTIVE 10.2.3: Protect non-target species from impacts associated with recreational shooting.

STRATEGY 10.2.3.1: Monitor (and promote research on) the impacts of secondary lead ammunition poisoning on associated species. If data indicate environmental lead is a problem, encourage the use of non-expanding or lead-free ammunition for prairie dog shooting.

ISSUE 10.3: There is a lack of reliable information on prairie dog harvest, including (1) the current levels of harvest; and (2) the specific types of impact to prairie dog populations.

OBJECTIVE 10.3.1: Collect information regarding GUPD and WTPD harvest.

STRATEGY 10.3.1.1: Conduct a spatial analysis of the characteristics of shooting of GUPDs and WTPDs (e.g., locations of hunters relative to roads, locations of GUPD and WTPD colonies, areas experiencing high harvest, field interviews with hunters).

STRATEGY 10.3.1.2: Collect additional information on prairie dog harvest (e.g., number of prairie dogs harvested, public versus private land hunting, hunting days, location by Game Management Unit).

STRATEGY 10.3.1.3: Consider a harvest permit for GUPDs and WTPDs. Follow-up with phone surveys to collect harvest information.

STRATEGY 10.3.1.4: Encourage prairie dog shooters to keep logbooks.

OBJECTIVE 10.3.2: Collect information regarding recreational shooting impacts on GUPDs and WTPDs.

STRATEGY 10.3.2.1: Investigate potential behavior changes of GUPDs and WTPDs due to shooting pressure.

STRATEGY 10.3.2.2: Develop and conduct a study comparing exploited and non-exploited WTPD and GUPD populations. Analysis should include effects on social interactions, foraging, distribution, emigration, population trends, and reproductive output. Studies should be conducted on a large scale over an extended time period, to accurately evaluate effects of this disturbance.

STRATEGY 10.3.2.3: Studies should be conducted that evaluate different levels of harvest on GUPD and WTPD populations. This would provide information to help manage harvest levels and timing to protect populations.

STRATEGY 10.3.2.4: Evaluate population impacts of shooting closures on GUPDs and WTPDs (using existing data sources if available) to improve available information.

K. Urban Development

Urbanization causes direct eradication and permanent loss of prairie dogs and their colonies, resulting in fragmentation and isolation of populations. Indirect effects of urbanization are poisoning or other control efforts deemed appropriate for human health and safety, predation from domestic pets, and increased vigilance and concealment behavior by prairie dogs in response to recurring disturbance in and around colonies (Magle et al. 2005).

Background

The impact of urbanization on GUPD and WTPD habitat has not been studied. Evaluating the impacts of urbanization on BTPDs, Collinge (2003) found that burrow and prairie dog densities were initially higher in BTPD colonies that were surrounded by urbanization and roads. The higher densities were due to (1) highly nutritious irrigated vegetation that accompanied urbanization; and (2) barriers that prevented dispersal of individuals. These higher densities of prairie dogs created greater competition for resources and reduced habitat quality, leading to eventual population declines. In addition, because dispersal was reduced or eliminated in urbanized landscapes, re-colonization after a plague epizootic or other population decline was improbable, leading to eventual loss of individual colonies over time.

Geographic Information System Analysis Results

Urban development on the west slope of Colorado is occurring rapidly. Between 2000 and 2020, 38% of GUPD range in Colorado is predicted to be impacted by high urban development (<40 acres/unit), 6% of the predicted range by moderate development (40-80 acres/unit), and 5% by low development (>80 acres/unit; Table 16, Fig. 27; see "Geographic Information System Analyses" section under ANALYSIS). For WTPDs, 28% of the range is predicted to be impacted by high urban development, 5% by moderate development, and 8% by low development (Table 17, Fig. 28).

Table 16. Predicted future housing density in Gunnison's prairie dog (GUPD) individual population areas (IPA) in Colorado. Housing density is never predicted to decline, and land in the "public" category is never expected to increase in housing density. Total acreages for each area are not identical to those in other tables, due to minor rounding and data conversion errors.

Population Area	2000 Housing Density [a]	# Acres in Different 2020 Predicted Housing Density Categories [a] Public	Low	Moderate	High	Total Area (acres)
Gunnison IPA	Public	682,529				682,529
	Low	13,486	170,339	1,177	670	185,672
	Moderate	1,318		12,387	478	14,183
	High	2,025			20,674	22,699
Gunnison IPA Total (acres)		**699,358**	**170,339**	**13,564**	**21,822**	**905,083**
	% of total area	**77.4**	**18.9**	**1.5**	**2.4**	**100.0**
La Plata-Archuleta IPA	Public	166,715				166,715
	Low	9,729	177,320	30,137	536	217,722
	Moderate	1,934		56,480	17,813	76,227
	High	2,366			86,009	88,375
La Plata-Archuleta IPA Total (acres)		**180,744**	**177,320**	**86,617**	**104,358**	**549,039**
	% of total area	**32.9**	**32.3**	**15.8**	**19.0**	**100.0**
San Luis Valley IPA	Public	1,723,801				1,723,801
	Low	34,581	1,560,079	3,034	2,501	1,600,195
	Moderate	3,135		87,371	1,633	92,139
	High	2,383			69,486	71,690
San Luis Valley IPA Total (acres)		**1,763,900**	**1,560,079**	**90,405**	**73,620**	**3,488,004**
	% of total area	**50.6**	**44.7**	**2.6**	**2.1**	**100.0**
South Park IPA	Public	368,021				368,021
	Low	14,646	189,830	67,271	46	271,793
	Moderate	1,840		8,942	17,886	28,668
	High	2,847			29,481	32,328
South Park IPA Total (acres)		**387,354**	**189,830**	**76,213**	**47,413**	**700,810**
	% of total area	**55.3**	**27.1**	**10.9**	**6.8**	**100.0**
Southeast IPA	Public	680,300				680,300
	Low	28,420	687,339	72,803	2,871	791,433
	Moderate	2,910		79,664	22,799	105,374
	High	5,206			131,294	136,500
Southeast IPA Total (acres)		**716,837**	**687,339**	**152,467**	**156,965**	**1,713,608**
	% of total area	**41.8**	**40.1**	**8.9**	**9.2**	**100.0**
Southwest IPA	Public	530,126				530,126
	Low	14,577	399,455	21,285	918	436,235
	Moderate	1,346		56,840	7,955	66,141
	High	827			68,756	69,583
Southwest IPA Total (acres)		**546,876**	**399,455**	**78,125**	**77,629**	**1,102,085**
	% of total area	**49.6**	**36.2**	**7.1**	**7.0**	**100.0**
All GUPD IPAs, Total (acres)		**4,497,358**	**3,233,124**	**505,486**	**487,283**	**8,725,251**
	% of total area	**51.2**	**37.7**	**5.8**	**5.3**	**100.0**

[a] Housing density information is based on Theobald (2005). High= <40 acres/housing unit; Moderate = 40-80 acres/housing unit; Low = >80 acres/housing unit.

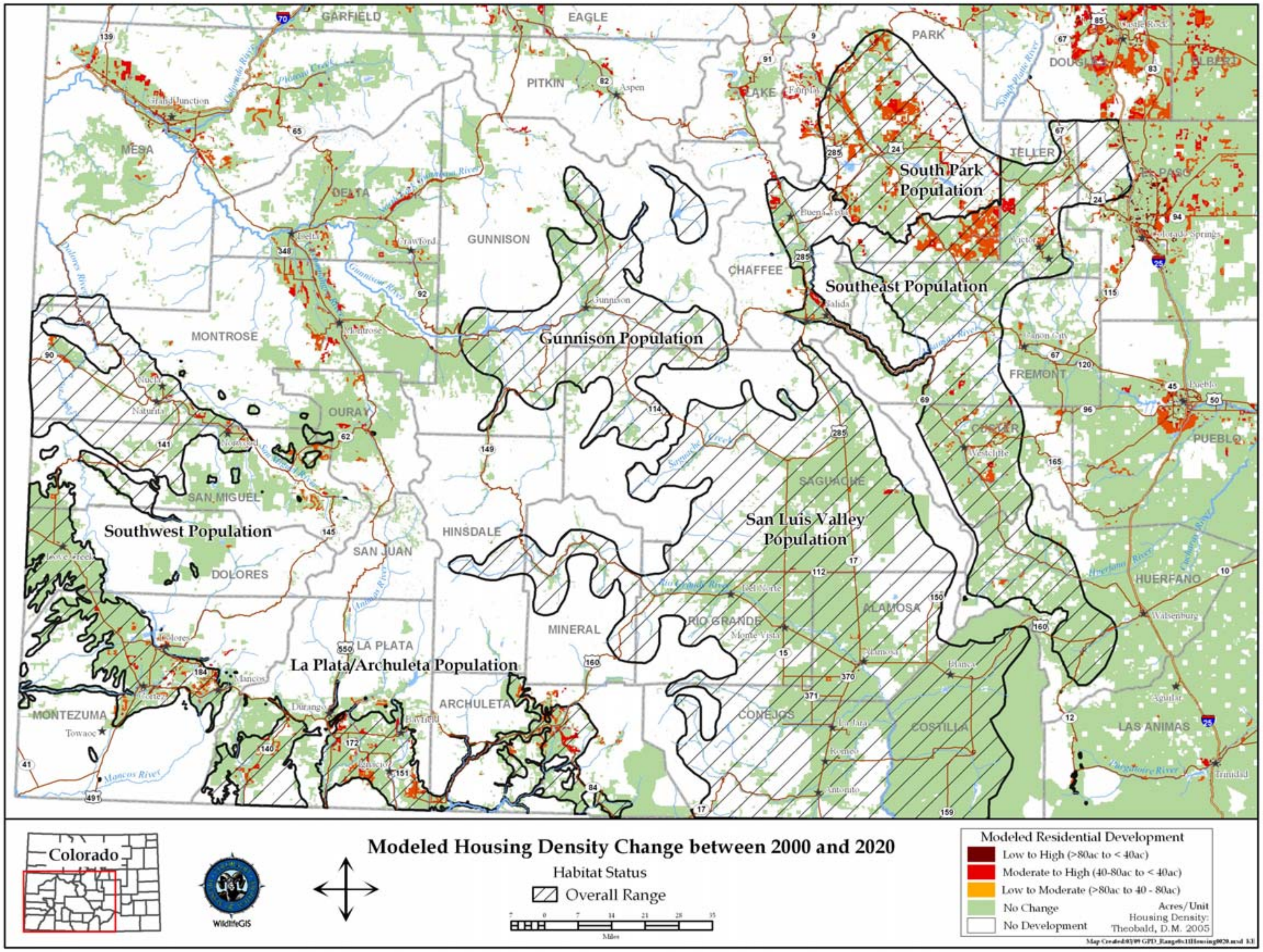


Fig. 27. Predicted change in housing density from 2000 to 2020 in the Gunnison's prairie dog (GUPD) overall range in Colorado.

Table 17. Predicted future housing density in white-tailed prairie dog (WTPD) individual population areas (IPA) in Colorado. Housing density is never predicted to decline, and land in the "public" category is never expected to increase in housing density. Total acreages for each area may not be identical to those in other tables, due to minor rounding and data conversion errors.

Population Area	**2000 Housing Density [a]**	**# Acres in Different 2020 Predicted Housing Density Categories [a]**				**Total Area (acres)**
		Public	**Low**	**Moderate**	**High**	
Grand Valley-Uncompahgre IPA	Public	333,443				333,343
	Low		232,662	35,231	5,843	273,757
	Moderate			102,024	28,356	130,379
	High				220,123	220,123
Grand Valley-Uncompahgre IPA Total (acres)		**333,443**	**232,662**	**137,275**	**254,322**	**957,702**
	% of total area	**34.8**	**24.3**	**14.3**	**26.6**	**100.0**
North Park IPA	Public	224,038				224,038
	Low		219,940	0	106	220,046
	Moderate			1,856	15	1,871
	High				1,963	1,963
North Park IPA Total (acres)		**224,038**	**219,940**	**1,856**	**2,084**	**447,917**
	% of total area	**50.0**	**49.1**	**0.4**	**0.5**	**100.0**
Northwest Colorado IPA	Public	1,250,537				1,250,537
	Low		400,019		173	400,192
	Moderate			3,699	499	4,199
	High				2,726	2,726
Northwest Colorado IPA Total (acres)		**1,250,537**	**400,019**	**3,699**	**3,398**	**1,657,653**
	% of total area	**75.4**	**24.1**	**0.2**	**0.2**	**100.0**
All WTPD IPAs, Total (acres)		**1,808,018**	**852,621**	**142,830**	**259,804**	**3,063,272**
	% of total area	**59.0**	**27.8**	**4.7**	**8.5**	**100.0**

[a] Housing density information is based on Theobald (2005). High = <40 acres/housing unit; Moderate = 40-80 acres/housing unit; Low = >80 acres/housing unit.

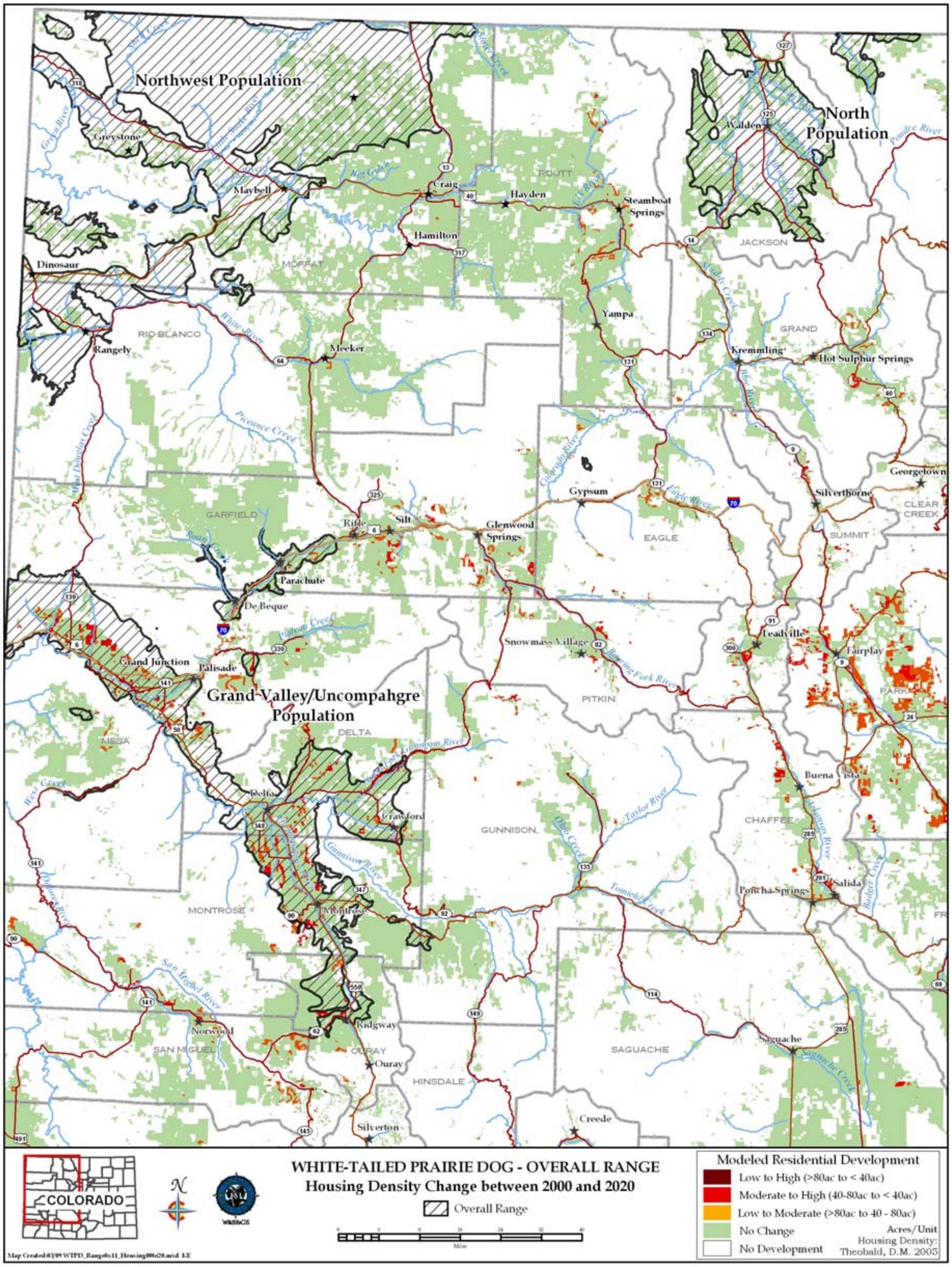


Fig. 28. Predicted change in housing density from 2000 to 2020 in the white-tailed prairie dog (WTPD) overall range in Colorado.

Stakeholder Workshop

The group assigned to developing conservation strategies to address urban development in GUPD and WTPD conservation identified the following primary concerns:

- "Housing development and urbanization causes habitat fragmentation and permanent loss of prairie dog habitat."
- "There is a lack of knowledge and understanding in sub/urban areas relating to prairie dogs. "
- "Sub/urban development results in increased predation and disturbance on prairie dogs by domestic pets."
- "Sub/urban development increases disturbance on prairie dog from recreational activities, potentially affecting survival and reproduction of prairie dog colonies."
- "Prairie dog habitat is not typically recognized by land-use planning practices related to development and mitigation of impacts."

Conclusion

Urbanization in the overall ranges of the GUPD and WTPD in Colorado is a concern at localized scales in areas that are growing at a rapid pace (e.g., Durango, Grand Junction, and Montrose; Figs. 2 and 4). Management options to alleviate negative impacts related to urbanization are limited. Participation from city and county planners and education of the urban populace will be crucial in developing and implementing strategies for GUPD and WTPD conservation in areas near and within urban locales.

Urban Development - Conservation Strategies

ISSUE 11.1: Urbanization results in the fragmentation of prairie dog habitat and permanent loss of colonies.

OBJECTIVE 11.1.1: Within existing GUPD and WTPD habitat, minimize habitat loss and fragmentation in *existing developments*.

STRATEGY 11.1.1.1: Identify and map movement corridors between and among existing GUPD and WTPD colonies.

STRATEGY 11.1.1.2: Identify and map sustainable GUPD and WTPD colonies within sub/urban areas.

STRATEGY 11.1.1.3: Identify funding sources for land protection of GUPD and WTPD habitat.

STRATEGY 11.1.1.4: Work with willing landowners to maintain identified sustainable GUPD and WTPD colonies using conservation easements, land trade, and other land conservation tools.

OBJECTIVE 11.1.2: Within existing GUPD and WTPD range, minimize habitat loss and fragmentation from *future sub/urban development*.

STRATEGY 11.1.2.1: Identify and map movement corridors between and among existing GUPD and WTPD colonies.

STRATEGY 11.1.2.2: Develop BMPs for sub/urban site development in GUPD and WTPD habitat.

STRATEGY 11.1.2.3: Work with willing landowners to maintain GUPDs and WTPDs through conservation easements, land trades, and other land conservation tools.

STRATEGY 11.1.2.4: Work with local governments to amend local plans (i.e., Comprehensive Plans) to address prairie dog issues.

OBJECTIVE 11.1.3: Evaluate GUPD and WTPD relocation options within sub/urban areas.

STRATEGY 11.1.3.1: Identify GUPD and WTPD colonies for which relocation might be considered, due to risks from sub/urban development.

STRATEGY 11.1.3.2: Identify and regulate groups to conduct GUPD and WTPD relocation efforts.

STRATEGY 11.1.3.3: Identify sending and receiving areas for GUPD and WTPD relocation efforts.

STRATEGY 11.1.3.4: Conduct relocation activities for GUPDs and WTPDs.

STRATEGY 11.1.3.5: Evaluate current and future GUPD and WTPD relocation efforts and study techniques to improve relocation success.

ISSUE 11.2: There is a lack of knowledge and understanding of GUPD and WTPD natural history, disease issues, and the importance of the species on the landscape by the public in sub/urban areas.

OBJECTIVE 11.2.1: Create public outreach materials to increase knowledge and understanding of GUPDs and WTPDs.

STRATEGY 11.2.1.1: Initiate a systematic survey of urban community perceptions of prairie dogs.

STRATEGY 11.2.1.2: Develop informational materials regarding GUPDs and WTPDs in sub/urban landscapes.

STRATEGY 11.2.1.3: Develop and implement an outreach program for homeowners regarding (1) GUPD and WTPD biology; (2) disease issues; and (3) importance of prairie dogs to the ecosystem.

STRATEGY 11.2.1.4: Prepare, distribute and present informational materials about GUPDs and WTPDs to land-use planners, developers, landowners, realtors, utility companies, relevant agencies, and housing residents.

ISSUE 11.3: Sub/urban development results in increased predation and disturbance on GUPDs and WTPDs by domestic pets.

OBJECTIVE 11.3.1: Reduce predation pressure on GUPDs and WTPDs that is associated with sub/urban development.

STRATEGY 11.3.1.1: Encourage enforcement and existence of animal control regulations (leash law) in GUPD and WTPD areas.

STRATEGY 11.3.1.2: Educate landowners on the effects of domestic pets on GUPD and WTPD behavior and survival.

ISSUE 11.4: Sub/urban development increases disturbance on GUPDs and WTPDs from recreational activities, potentially affecting survival and reproduction in prairie dog colonies.

OBJECTIVE 11.4.1: Reduce disturbance to GUPDs and WTPDs from recreational activities.

STRATEGY 11.4.1.1: Plan recreational activity areas that minimize disturbance to GUPD and WTPD colonies.

STRATEGY 11.4.1.2: When appropriate, recommend recreational activity closures on public property areas (e.g., town, county) that have GUPD or WTPD activity.

ISSUE 11.5: Prairie dog habitat is not typically recognized or considered in land-use planning practices related to urban development and in the mitigation of impacts.

OBJECTIVE 11.5.1: Work with local governments to amend county and local comprehensive plans to address prairie dog issues.

STRATEGY 11.5.1.1: Make information about prairie dog conservation available to planners and policy makers in developing areas.

STRATEGY 11.5.1.2: Provide maps of GUPD and WTPD potential habitat and known colonies to planners and policy makers.

STRATEGY 11.5.1.3: Encourage biologists and land managers to work with planners to address GUPDs, WTPDs, and development issues.

VI. IMPLEMENTATION PROCESS

A core challenge in any conservation plan is ensuring that broad strategies are translated into effective on-the-ground actions. A plan full of good ideas will never achieve its goals if those ideas are not ultimately implemented. With that in mind, this section describes how the CDOW recommends that conservation strategies identified in this document should be translated into appropriate and effective on-the-ground actions to maintain the long-term viability of GUPD and WTPD populations. In brief, implementation will be managed through *3- to 5-year action plans* in each of the 9 IPAs. These action plans will be developed through *collaborative rapid assessment workshops* that review issues and previously identified strategies and set priorities for immediate implementation. All 9 action plans will be completed by May 2010.

Context: Local Variability & Strong Stakeholder Interest

GUPDs and WTPDs are found in colonies scattered throughout their respective ranges on public, tribal, and private lands. While many issues span the entire range of the 2 species, there are also some significant differences across the 9 IPAs in the relative scope, severity and importance of these issues. In addition, there is great variety in the social and economic interests of the people, communities, and government agencies that have a stake in prairie dog management. Some stakeholders are very concerned about the long-term survival of these animals and the ecosystems they inhabit. At the same time, other stakeholders are concerned about the adverse impact that prairie dogs can have on the working lands important to local economies.

As a general principle, the CDOW believes that public involvement is essential to the implementation of effective, practical conservation actions. Given the issues at stake, strong stakeholder involvement will be crucial to the success of any conservation efforts aimed at the GUPD and WTPD. We believe that the prompt implementation of effective actions to protect these species will benefit local communities; we also believe that maintaining sustainable local communities will contribute to the long-term conservation of prairie dogs and their habitat.

This plan outlines numerous issues that can and may impact GUPD and WTPD populations in Colorado. These issues and their possible impacts were discussed at a stakeholder workshop, among agencies, with experts, and internally within the CDOW. These discussions led to the development of a menu of strategies that could be implemented to alleviate threats to prairie dogs, maintain viable populations statewide, and avoid the need to list the species under the federal ESA. The full set of strategies identified in this plan encompasses hundreds of different action items across the 11 issues identified. Collectively, these conservation strategies are unrealistic to implement range-wide. Time, funding, and workforce limitations would prevent the implementation of all but a very few strategies. In addition, many issues and strategies are population specific, and a range-wide effort would gloss over the management needs unique to the 9 IPAs.

Working Together to Take Action: IPA Action Plans

In order to ensure that the strategies identified in this document are effectively implemented at the local level as appropriate to meet local conservation and management goals, CDOW will develop individual action plans for each of the 9 IPAs. These action plans will provide for the on-the-ground implementation of conservation actions in a 3–5 year time frame.

Process

Each IPA action plan will be developed through a "rapid assessment" workshop using a collaborative, facilitated discussion and ranking process. Participation in the planning workshop will be open to anyone with an interest in the management of prairie dogs in the defined project area: local communities, landowners, conservationists, state, federal and local agencies, and any other interested individuals or organizations. By using a rapid assessment workshop we aim to avoid "meeting fatigue" and ensure that the full range of interests are represented in the process. Because the workshops will draw on the strategies identified in this document, it should be possible to complete the process in one day.

Each workshop will use a facilitated process to ensure that participants' views are heard and to promote consent around short-term action needs. Using a consistent approach, participants will collectively rank the scope and severity of each of the issues within their IPA. Participants will then use the high ranking issues to prioritize strategies for implementation within that individual population area. Individual strategies will be prioritized according to (1) contribution to species/ecosystem conservation, (2) feasibility, (3) cost, and (4) social & political importance/acceptance.

Deliverables & Accountability

The deliverable from each rapid assessment workshop will be a tailored action plan for prairie dog conservation that contains the IPA's top ranked issue(s) and prioritized actions for immediate implementation with timelines, costs, and responsible parties. Action plans will serve as an addendum to the *Colorado Conservation Strategy* and will be available on the CDOW website.

The appropriate CDOW area conservation biologist will be responsible for coordinating the implementation of actions defined in the action plan. The CDOW will provide annual reports on action implementation, including (1) strategies implemented (including the success of strategy implementation, cooperating partners, and research or management results); (2) results and updates for all population monitoring and surveys conducted (including occupancy monitoring, BFF family rating surveys, colony mapping, or other surveys completed during the year); and (3) an evaluation of species status.

VII. GLOSSARY

Additive mortality – Occurs when an increase in a single mortality factor causes an immediate reduction in overall survival within a population (i.e., mortality in excess of natural or expected mortality rates).

Aestivation – A condition in which an organism greatly curtails or temporarily suspends normal activities.

Agonistic – An aggressive or defensive social interaction, usually between individuals of the same species.

Allele – Any one of the natural alternative forms of a given gene (Everything Bio 2007).

Allele frequency – Also called "gene frequency"; a measure of how common a given allele is in a population.

Antibody – A protein (immunoglobulin) molecule, produced by the immune system, that recognizes a particular foreign antigen and binds to it; if the antigen is on the surface of a cell, this binding leads to cell aggregation and subsequent destruction (Science Dictionary 2007).

Antibody titer – A measure of the circulating antibody an organism has produced.

Antigen – A molecule whose shape triggers the production of antibodies that will bind to the antigen.

Arthropod – An invertebrate animal (insect, arachnid, crustacean) of the phylum Arthropoda.

Associated species – Here, a species that benefits from prairie dogs, either directly or indirectly, but is not dependent on them for survival.

Augmentation – Adding individuals of a species to a given population, usually to increase population viability, from either or both a demographic or genetic perspective.

Best management practice – Method that has been determined to be the most effective, practical means of maintaining or reaching a habitat or species management goal.

Candidate species – Plants and animals that the USFWS, through review of available information, has determined should be proposed for addition to the federal threatened or endangered species list but are precluded from listing due to the need to list higher priority (i.e., more imperiled) species.

Chaining – A mechanical method of removing vegetation (especially piñon-juniper overstory) from a landscape where a heavy chain is dragged across the landscape between 2 bulldozers.

Chromosome – A piece of DNA that contain genes.

Clan – A group of related individuals.

Coefficient of variation – A normalized measure of dispersion of a probability. It is the ratio of the standard deviation to the sample mean.

Colony – A concentration of prairie dogs with a minimum of 20 burrow openings per ha on 5 ha or larger parcels.

Compensatory mortality – Occurs when the increase in a particular mortality factor (e.g., predators, disease, starvation) does not change the overall survival rate within a population, at least up to some threshold (i.e., one mortality factor is a replacement for another within the range of the natural or expected overall mortality rate caused by all factors combined).

Complex – A group of prairie dog colonies distributed so that individual black-footed ferrets can migrate between them commonly and frequently. Colonies within a complex are not separated from the nearest adjacent colony by more than 7 km and no impassable barriers exist between colonies that would hinder black-footed ferret movement.

Compound 1080 – A highly toxic "restricted use" pesticide (no longer legally available for use in the U.S.) used to control mammalian "pest" species.

Confidence interval – An estimate of precision around a sample mean.

Conservation – (a) From section 3(3) of the federal Endangered Species Act: "… the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided under {the} Act are no longer necessary;" (b) The retention of natural balance, diversity, and evolutionary change in the environment.

Conservation easement – A legal agreement which places restrictions on the use of private property to advance conservation goals.

Conservation Reserve Program – A program within the Farm Bill that retires environmentally-sensitive farmlands from production. Subject land is typically enrolled under 10 year contracts and the landowner receives annual rental payments

Conservation strategy – An approach for protecting a particular species, habitat, or ecosystem.

Control measure – Action taken to reduce the numbers and/or occupied habitat of prairie dogs, primarily through lethal means.

Corrected acres – The occupied habitat of the white-tailed prairie dog colony where there are $\geq$ 8 burrows per survey transect.

Coterie – A territorial, harem-polygynous family group of prairie dogs, typically consisting of a breeding adult male, two or three adult females and several yearlings or juveniles.

Deleterious allele – An alternate form of a gene (one member of a pair) which confers a harmful effect on the organism.

Demographic (parameter, rate) – The specific properties of a population regarding birth and death rates, age distribution, sex ratio, and population size (Wilson 1992).

Demographic stochasticity – The natural variation in the characteristics of a population (e.g. birth rates, death rates, sex ratios)

Density – Number of animals per unit of area.

Directional drilling – A technique used in drilling for oil and/or natural gas in which some of the bore path is oriented at least partially horizontally; this allows for multiple wells to be drilled from a single surface site.

Dispersal – Movement away from an existing population or from the parent organism.

Diurnal – An animal that is predominantly active during daylight hours.

Divergence – The accumulation of differences between groups which can lead to the formation of new species.

Dixie harrow – A particular piece of equipment used to thin sagebrush stands.

Ecosystem – Dynamic and interrelating complex of plant and animal communities and their associated nonliving (e.g., physical and chemical) environment.

Ectoparasite – An organism that lives on the exterior of its host and contributes nothing to the host's survival.

Emigration – Permanent movement out of an area or from a population.

Endangered species – A species which is in danger of extinction throughout all or a significant portion of its range [ESA§3(8)].

Enzootic plague – The constant presence of low-level plague in a wildlife population.

Eolian – Deposited by wind.

Epidemic – A disease outbreak afflicting a large number of individuals within a population (usually of humans).

Epidemiology – Study of the distribution of disease.

Epizootic – A disease outbreak afflicting a large number of individuals within an animal population (i.e., an epidemic in an animal population).

Epizootic plague – An outbreak of plague in a wildlife (especially prairie dog, in this context) population.

Eradication – The removal of an organism from a given region or location.

Exotic – A species that is not native to a region. See also "nonnative."

Extant – Still existing; not extinct.

Extinction – The state or process of ceasing or causing something to cease to exist (a species, in this context).

Extirpated species – A species no longer occurring in a region that was once part of its range.

Fee-title acquisition – The acquiring of land in fee title through donation, bargain sale, or outright purchase.

Fire suppression – When natural or prescribed burning is not allowed.

Forb – An herbaceous plant which is not a grass (Science Dictionary 2007).

Fruitland outcrop – An underground geologic formation occurring in southern Colorado & northern New Mexico containing coal from which methane gas is extracted.

Functional integrity – The intactness of ecosystem components and processes that maintain ecosystem health.

Gene flow – The movement of genes from one population to another by way of interbreeding (Science Dictionary 2007).

Genetic – Of or relating to genes or heredity.

Genetic differentiation – The accumulation of differences in allelic frequencies between completely or partially isolated populations.

Genetic drift – Change in the gene pool as a result of chance and not as a result of selection, mutation, or migration (Keeton and Gould 1986).

Genetic isolation – Occurs when the genetic makeup of two or more groups becomes different enough to serve as a barrier to successful breeding between the groups.

Genetic stochasticity – The natural variation in the genetic makeup of a group, unrelated to outside forces.

Genetic variation – The variation that exists in a given set of genes, whether in an organism or a population. The ability of a population to provide the hereditary mechanisms needed for adaptive change and dynamic evolution to future breeding individuals of the species (Emmel 1976).

Genotype – The specific allelic composition of a cell, either of the entire cell or more commonly for a certain gene or a set of genes (i.e., the genes that an organism possesses).

Geographic Information System (GIS) – A system of spatially referenced information, including computer programs that acquire, store, manipulate, analyze, and display spatial data in a geographic context (Science Dictionary 2007).

Geographic isolation – When a group of individuals within a population becomes separated by man-made or natural barriers and can no longer mate with individuals outside of the population. No individual is able to enter or exit the population without being born or dying there.

Grass bank – A conservation management tool whereby a value is assigned to healthy grasslands and that value can be used, traded, and saved.

Good black-footed ferret habitat – Habitat capable of supporting black-footed ferret reproduction by carrying at least ~3.6 prairie dogs per hectare (= ~1.4 prairie dogs per acre), as formally estimated from transect data (Biggins et al. 1993).

Habitat – The local environment occupied by an organism and those components required to complete its life cycles, including air, food, cover, water, and spatial requirements.

Habitat fragmentation – The breaking up of habitat into unconnected patches interspersed with other habitat that may or may not be inhabitable by the species occupying the habitat that was broken up. The breaking up usually results from human actions (e.g., the clearing of shrubland or grassland for agriculture or residential development; Science Dictionary 2007).

Habitat treatment – An action that alters a given habitat, usually to improve its quality.

Herbaceous – Having characteristics of an herb; a plant with no persistent woody stem above ground (Science Dictionary 2007).

Herbicide – A chemical pesticide designed to control or destroy plants, weeds, or grasses.

Herbivory – The consumption of non-woody vegetation.

Heterogeneity – Not uniform; being composed of differing components.

Heterozygosity – Having two different alleles of the same gene (Campbell et al. 1999).

Hibernacula – Particular locations or structures where hibernation occurs. (Singular: hibernaculum.)

Historic range – Those geographic areas a species was known or believed to occupy in the past.

Homozygous – Having two copies of the same allele at the same gene site.

Hydrophyllic – Water loving or water attracting.

Hyper-productive – Exhibiting extremely high productivity.

Hyperthermia – A state in which an organism overheats.

Incentive – Assistance, financial payment, or other action that encourages individuals or organizations to participate in an effort or activity, or that offsets any sacrifices an individual or organization may make to participate in an effort or activity.

Immigration – Permanent movement into an area.

Inbreeding – Breeding between close relatives.

Inbreeding coefficient – The probability of homozygosity by descent (having common ancestors). The probability that a zygote obtains copies of the same ancestral gene from both its parents because they are related (Science Dictionary 2007).

Inbreeding depression – A decline in reproductive fitness due to repeated mating between related individuals.

Index – A relative measure used as an indicator of the true state of nature (Thompson et al. 1998).

Infanticide – The killing of an individual's young offspring.

Inference – A conclusion derived from reasoning.

Insecticide – A pesticide compound specifically used to kill or prevent the growth of insects (Science Dictionary 2007).

Intercolony disperser – Individual (prairie dogs) that travels to a different colony to live.

Intermittent – Not continuous; occurring at intervals.

Intermontane – Located between mountain ranges.

Invasive (plant, species) – A species capable of asserting itself in communities where it did not naturally occur (EverythingBio 2007).

Keystone species – A species that has a disproportionate effect on its environment relative to its abundance.

Kin cluster – Spatial groupings of related territory owners.

Lawson aerator – A particular piece of equipment used to thin sagebrush and fracture the top upper layers of soil.

Life history – The significant features of the life cycle through which an organism passes, with particular reference to strategies influencing survival and reproduction (Science Dictionary 2007).

Mapping – In this context, estimating the amount of area occupied by prairie dogs by locating colonies and plotting a line around the outermost burrows within a colony. Most mapping includes both active and inactive burrows.

Metapopulation – A set of local populations within some larger area, where typically migration from one local population to at least some other patches is possible (Hanski and Simberloff 1997).

Microsatellite – Any of numerous short segments of DNA that are distributed throughout the genome, that consist of repeated sequences of usually 2 to 5 nucleotides, and that are often useful markers in studies of genetic linkage because they tend to vary from one individual to another.

Mitigation – Actions taken to avoid, reduce, or compensate for the effects of human-induced environmental damage (Science Dictionary 2007).

Mitochondrial DNA – The genetic material found in mitochondria, the organelles that generate energy for the cell. Not inherited in the same fashion as nucleic DNA, but rather of maternal origin (EverythingBio 2007).

Model – A simplified representation of a real system.

Morphology – The physical form or structure of an organism.

Nonnative (plant, species) – A species that is not indigenous to a region (Science Dictionary 2007). Also called "alien" or "exotic."

Nutrient cycling – The processes by which nutrients move through biological systems.

Obligate species – Here, a species that depends on prairie dogs for survival, either directly (e.g., black-footed ferrets prey exclusively on prairie dogs) or indirectly (e.g., species that survive only in habitats modified by prairie dogs).

Occupied habitat – Land (measured in acres) that has prairie dogs in residence.

Ontogeny – Origin and development of an organism from the fertilized egg to its mature form.

Pathogen – A causative agent of disease.

Petition (for federal listing) – A formal request, with the support of adequate biological data, suggesting that a species be listed, reclassified, or delisted, or that critical habitat be revised for a listed species under section 4(b)(3)(A) of the ESA.

Phenology – Periodic biological phenomena that are correlated with climatic conditions.

Phenotypic – The observable properties of an organism that are produced by the interaction of the genotype and the environment.

Phylogeography – The study of the geographic distribution of genealogical lineages.

Physiography – Landform; physical geography (Science Dictionary 2007).

Piñon-juniper – A vegetation community dominated by both piñon pines (*Pinus edulis*) and juniper (*Juniperus* spp.) trees and bushes.

Plague – An acute, infectious disease – caused by the bacterium *Yersinia pestis* – that primarily affects prairie dogs and other rodent species, as well as lagomorphs (e.g., rabbits, hares) and some associated carnivore and scavenger species. The agent is transmitted via the bite of an infected flea or direct contact with an infected carcass. Plague is an introduced disease in North America that can cause dramatic, disease-related declines in prairie dog (and other rodent and lagomorph) populations. Outbreaks in wildland settings are sometimes referred to as "sylvatic plague".

Pleistocene – The epoch or period of time from 1.8 million to 10,000 years before present.

Pliocene – The epoch or period of time from 5.3 million to 1.8 million years before present.

Polygamous – Having a mating system in which one male mates with more than one female (polygyny) or one female mates with more than one male (polyandry).

(Demographic) Population – A biological unit at the level of ecological integration where it is meaningful to speak of a birth rate, a death rate, a sex ratio and an age structure in describing the properties of the unit (Emmel 1976).

(Genetic) Population – A group of sexually interbreeding individuals (Strickberger 1985).

Population augmentation – Adding individuals of a species to a given population, usually to increase its viability, from either or both a demographic or genetic perspective.

Population trend – An important average change in magnitude and direction of some population parameter within a specified area across multiple time intervals (Thompson et al. 1998).

Prescribed burn (or fire) – A fire set intentionally, with specific vegetation and weather prescriptions, in order to achieve a specific resource objective.

Pre-settlement (habitat) – Habitat that existed prior to European settlement in North America.

Rangeland – A habitat in which the native vegetation is predominantly grasses, grass-like plants, forbs, or shrubs. This includes lands revegetated naturally or artificially when routine management of the vegetation is through manipulation of grazing. Rangelands include natural grasslands, savannas, shrublands, most deserts, tundra, alpine communities, coastal marshes, and wet meadows.

Range-wide – In this context, the area that includes all of the populations of GUPD and WTPD found throughout North America.

Recessive – An allele that is not expressed in the heterozygous condition (Science Dictionary 2007).

Recolonize (or recolonization) – To reoccupy an area previously inhabited.

Reestablish – To restore (reintroduce) a species to an area that it historically inhabited.

Reintroduction – To release a species in an area previously inhabited to restore the population in that area.

Reservoir host – A host that harbors a pathogen (sometimes with few or no ill effects).

Resilience – The ability to adjust or recover from a perturbation.

Semi-fossorial – Adapted to living a portion of life underground.

Seroconversion – The development of antibodies (here, against plague).

Seronegative – Referring to the absence of specific antibodies (here, against plague).

Sexual dimorphism – Differences in form or appearance between males and females of the same species.

Species – A group of individuals that can actually or potentially breed with each other and produce fertile offspring under natural conditions, but cannot breed with other such groups.

Stakeholder – An individual who has an interest in a particular issue or topic.

State Trust lands – Lands entrusted to the state by the Federal government and managed by the State Land Department for revenue for Trust beneficiaries (e.g., public schools, colleges, hospitals, charitable institutions). These are not public lands except in Arizona, Montana and Wyoming (access permit required) and South Dakota (no access permit required).

Statistical precision – A measure of how close an estimator is expected to be to the true value of a parameter.

Stipulation – In BLM management of energy development, a measure added to the terms of a lease designed to mitigate impacts of energy development on other on-site resources.

Stochasticity – The quality of lacking any predictable order or plan.

Subcomplex – An aggregation of prairie dog colonies not separated from the nearest adjacent group by more than 7 km, but due to various factors (e.g., state boundaries, land ownership) the whole complex is not surveyed and management occurs on only a portion of the entire complex.

Subspecies – A group of interbreeding natural populations differing morphologically and genetically, and often isolated geographically from other such groups within a species but interbreeding successfully with them where their ranges overlap.

Taxonomic status – The assigned classification of a species or group of organisms.

Taxonomy – Classification, especially of animals and plants into phyla, species, etc. (McKechnie 1983).

Temporal – Relating to time or the sequence of time.

Threatened species – A species that is likely to become endangered throughout all or a significant portion of its range.

Topographic – Relating to the natural structural features of a landscape.

Transect – Linear measurements in sampling.

Translocate – To move an individual from one location to another.

Tularemia – A disease native to North America – caused by the bacterium *Francisella tularensis* – that can cause disease-related declines in prairie dog (and other rodent and lagomorph) populations.

Uncorrected hectares – Includes the total area (in the metric measure of hectares; about 2.5 acres equals 1 hectare) of a prairie dog colony regardless of activity levels.

Upland – A general term for nonwetland; elevated land above low areas along streams or between hills; any elevated region from which rivers gather drainage.

Urbanization – Refers to the process where rural or natural lands are developed to support a higher density of human population.

Variance – In statistics, a measure of the variation shown by a set of observations, calculated as the average of the squared deviations of the individual observations from their mean value.

Vector – An organism that transmits a pathogen from one host to another.

Viable – Self-sustaining over the long term.

Wean – To cease nursing.

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APPENDIX A

Memorandum of Understanding
For
Conservation and Management of Species of Conservation Concern
Associated with Prairie Ecosystems

APPENDIX A. Final Prairie Memorandum of Understanding

MEMORANDUM OF UNDERSTANDING
FOR
CONSERVATION AND MANAGEMENT OF SPECIES OF CONSERVATION CONCERN
ASSOCIATED WITH PRAIRIE ECOSYSTEMS

I. Purpose

The purpose of this Memorandum of Understanding (MOU) is to provide, under auspices of the Western Association of Fish and Wildlife Agencies (WAFWA), for interagency cooperation in conservation and management of species associated with prairie ecosystems of the Western Great Plains (i.e. parts of Arizona, Colorado, Kansas, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, Wyoming, and Utah). The primary focus is on federally-listed species, state-listed species, and species of conservation concern. The participating agencies agree that cooperation is necessary to collect and analyze data on these species and their habitats, and to plan and implement actions necessary to establish and/or maintain viable populations of each species that are sufficient to preclude present or future endangerment, within the constraints of approved budgets.

Parties to this MOU are collectively referred to herein as Signatories.

II. Background

The Signatories have been involved in a variety of long-standing and recently initiated efforts to conserve and manage wildlife and habitats in the Western Great Plains. Many of these efforts have been conducted with a single species approach. Despite significant successes to date, the Signatories believe it is in their best long-term interest to move toward a landscape level approach that enables better planning and coordination, efficiency in time and scale of accomplishment, and greater cost effectiveness. The Signatories recognize that such a transition will take time, require adaptive management to respond to emerging needs and priorities, and present unique challenges in terms of process management, shared decision-making, and increased emphasis on community based conservation. They also recognize that as they move toward a landscape level or ecosystem focused, they must ensure that their commitment to conservation and management of individual species cannot be diminished such that imperilment occurs. Given these considerations, in 2004 WAFWA directed its Habitat and Nongame and Endangered Species committees to use renewal of an MOU for black-tailed prairie dog conservation as a vehicle for beginning the transition toward an ecosystem approach (i.e. prairie) in the Western Great Plains. WAFWA also directed the two committees to ensure that the prairie effort is fully coordinated with, and complementary to, a companion effort to conserve sagebrush and sage-steppe communities (and associated species of wildlife) in the Great Basin, because the two biomes share many important species.

III. Objectives

The Signatories agree to accomplish the following conservation objectives:

1. Recognize that because the white-tailed prairie dog (WTPD) and Gunnison's prairie dog (GUPD) inhabit sage-steppe and prairie scrub ecosystems rather than grasslands, they will fall under the purview of the WAFWA Sagebrush MOU when a new one is developed in 2007.
2. Develop a WTPD and GUPD conservation strategy by January 31, 2006 to complement WAFWA's existing black-tailed prairie dog conservation strategy.
3. Develop state-specific prairie dog management plans, or integrate prairie dog management components into other state-specific and/or regional management plans, as appropriate, by December 31, 2007.
4. Develop a cohesive, comprehensive, WAFWA prairie conservation strategy by June 30, 2010 that integrates pertinent components of companion efforts for the WTPD, GUPD, BTPD, black-footed ferret, swift and kit foxes, lesser prairie chicken, mountain plover, burrowing owl, ferruginous hawk, Swainson's hawk, loggerhead shrike, and, as appropriate and feasible, other shrub and grassland species in the Western Great Plains.
5. Coordinate with, establish, or otherwise convene various conservation teams, work groups, etc. as necessary to implement this MOU.
6. Cooperate to maintain and enhance, to the extent practicable, the populations and habitats of the species addressed pursuant to this MOU.
7. Coordinate with, as necessary and appropriate, companion conservation efforts in the United States, Canada, and Mexico.
8. Enhance awareness of the Signatories and local communities, industries, nongovernmental organizations, and private individuals regarding this conservation effort, and encourage and enhance their participation in partnerships to accomplish mutually agreeable conservation objectives.
9. Remain aware of, and inform WAFWA on, any legal, regulatory, or policy action associated with the species addressed pursuant to this MOU.

IV. Actions

1. WAFWA will identify a State Director to serve as Sponsor for this MOU.
2. The State Sponsor or their designee will:
   a. Approve additional Signatories and modifications to this MOU;
   b. Collaborate with IAFWA in contracting an Interstate Coordinator for this MOU; and
   c. Provide appropriate guidance to the Interstate Coordinator for managing this MOU, including (i) ensuring timely, effective coordination with the companion WAFWA conservation effort for sagebrush and sage-steppe habitats and the species therein; and (ii) integrating this conservation effort into WAFWA's support for development of a Western Shrubland Science and Management Information Consortium.

3. The Interstate Coordinator will serve as Chair for WAFWA's Prairie Dog Conservation Team and liaison to WAFWA's sagebrush and sage-steppe conservation program.
4. The Interstate Coordinator will facilitate the Signatories' efforts to identify and implement the most appropriate way(s) to collect data (e.g. rangewide survey and monitoring recommendations) for the species addressed pursuant to this MOU.
5. The Interstate Coordinator will assist WAFWA in integrating WTPD and GUPD strategies into its sagebrush and sage-steppe conservation effort.
6. The Interstate Coordinator will facilitate Signatory cooperation in developing major media releases and media projects, as well as website support and other public outreach efforts, pursuant to this MOU.
7. The Interstate Coordinator will provide quarterly reports to WAFWA and IAFWA in April, July, and October, an Annual Report to WAFWA and IAFWA in February of each year, progress reports to WAFWA's Habitat Committee at annual WAFWA Summer Conferences and Mid-Winter Business Meetings, and an annual report to the Prairie Dog Conservation Team.
8. The Interstate Coordinator will provide appropriate grant progress reports to the National Fish and Wildlife Foundation in May 2006 (Phase 2 Report).
9. The Signatories will assist the Interstate Coordinator as necessary to ensure timely, effective, and well coordinated activities and completion of products and services pursuant to this MOU.
10. The Signatories will cooperate to maintain, and enhance to the extent practicable, viable populations and habitats of the species addressed pursuant to this MOU.
11. The Signatories will assist the Interstate Coordinator in ensuring local governments, communities, private citizens, and other interested and affected parties are informed on the status of this conservation effort, including ways that might provide local economic benefits.
12. The Signatories will recognize and respect the separate authorities of each signatory agency and the interests of other affected or interested parties.
13. The Signatories will cooperate in providing financial support for the Interstate Coordinator for this MOU, with a total annual budget of: YR1 $112,000; YR2 $112,000; YR3 $116,000; YR4 $118,000; and YR5 $123,000 (the intent is for 50% of the stated annual amounts to be contributed by State Wildlife Agencies and 50% by Federal Agencies).
14. The Signatories will provide facilities, equipment, logistical support, authorizations, and permits as necessary and available to implement this MOU.

V. Authorities

This MOU is among various WAFWA States and the Bureau of Indian Affairs, Bureau of Land Management, Department of Defense, National Park Service, Natural Resources Conservation Service, U.S.D.A. APHIS Wildlife Service, U.S.D.A Forest Service, U.S. Fish and Wildlife Service, and U.S. Geological Survey, under provisions of the following Federal laws:

Federal Land and Policy Management Act of 1976 (43 U.S.C. 1701 et seq.)
Fish and Wildlife Act of 1956 (16 U.S.C. 742 et seq.)

Fish and Wildlife Coordination Act (16 U.S.C. 661-667)
Multiple-Use Sustained-Yield Act [of 1960] (16 U.S.C. 528-531)
Forest and Rangeland Renewable Resources Research Act of 1978 (16 U.S.C. 1641-48)
National Forest Management Act of 1976 (16 U.S.C. 1600 et seq.)
Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.)
National Wildlife Refuge Administration Act of 1966, as amended by the National Wildlife Refuge System Improvement Act of 1997 (16 U.S.C 668dd et seq.)

VI. Terms and Conditions

It is mutually agreed and understood by and between the Signatories that:

1. This MOU is neither a fiscal nor a funds obligation document. Nothing in this agreement may be construed to obligate Federal Agencies or the United States to any current or future expenditure of resources in advance of the availability of appropriations from Congress. Any endeavor involving reimbursement or contribution of funds between the Signatories to this MOU will be handled in accordance with applicable regulations, and procedures, including those for federal government procurement and printing. Such endeavors will be outlined in separate agreements that shall be made in writing by representatives of the Signatories and shall be independently authorized in accordance with appropriate statutory authority. This MOU does not provide such authority.
2. This MOU in no way restricts the Signatories from participating in similar activities with other public or private agencies, organizations, and individuals.
3. This MOU is executed as of the last date shown below and expires five years from the execution date, at which time it will be subject to review, renewal, or expiration.
4. Modifications within the scope of this MOU shall be made by issuance of a mutually executed modification prior to any changes being performed.
5. Any party to this MOU may withdraw with a 60-day written notice to the State Sponsor.
6. Any press releases with reference to this MOU, the Signatories, or the relationship established between the Signatories of this MOU, shall be reviewed by the Interstate Coordinator and State Sponsor prior to release.
7. In any advertising done by any of the Signatories, this MOU shall not be referred to in a manner that states or implies that any Signatory approves of or endorses unrelated activities of any other.
8. During the performance of this MOU, the Signatories agree to abide by the terms of Executive Order 11246 on nondiscrimination and will not discriminate against any person because of race, age, color, religion, gender, national origin, or disability.
9. No member of or delegate to Congress, or resident Commissioner, shall be admitted to any share or part of this agreement, or to any benefit that may arise from, but these provisions shall not be construed to extend to this agreement if made with a corporation for its general benefits.
10. The Signatories agree to implement the provisions of this MOU to the extent personnel and budgets allow. In addition, nothing in the MOU is intended to supersede any laws, regulations, or directives by which the Signatories must legally abide.

VII. Approval

In witness thereof, the Signatories hereto have executed this Memorandum of Understanding as of the last written date below.

Approved ______________________ Date 2-14-06
Arizona Game and Fish Department

Approved ______________________ Date 1/8/06
Colorado Division of Wildlife

Approved ______________________ Date 01/31/06
Kansas Department of Wildlife and Parks

Approved ______________________ Date 1/18/06
Montana Fish, Wildlife, and Parks

Approved Rex Amack Date January 30, 2006
Nebraska Game and Parks Commission

Approved ______________________ Date 1-8-06
New Mexico Department of Game and Fish

Approved ______________________ Date 1/31/06
North Dakota Game and Fish Department

Approved ______________________ Date 1-8-06
Oklahoma Department of Wildlife Conservation

Approved ______________________ Date 1/8/06
South Dakota Game, Fish, and Parks

Approved ______________________ Date 2/17/06
Texas Parks and Wildlife Department

Approved ______ Date 1/8/06
Utah Division of Wildlife Resources

Approved ______ Date 1/8/06
Wyoming Game and Fish Department

Approved ______ Date ______
Bureau of Indian Affairs

Approved ______ Date ______
Bureau of Land Management

Approved ______ Date ______
Department of Defense

Approved ______ Date 4/12/06
USDA APHIS Wildlife Services

Approved ______ Date 6/14/06
US Fish and Wildlife Service

Approved ______ Date 6/6/2006
U.S. Fish and Wildlife Service

Approved ______ Date ______
Natural Resources Conservation Service

Approved ______ Date ______
USDA Forest Service

Approved ______ Date 12/20/07
National Park Service, Intermountain Regional Director

Approved ______ Date 1-2-2008
National Park Service, Midwest Regional Director

APPENDIX B

Western Association of Fish & Wildlife Agencies Conservation Strategy:

Objectives & Guidance

Actions under the Conservation Strategy and Conservation Plan (Western Association of Fish and Wildlife Agencies 2006, 2007) were designed to: (1) promote conservation of the species and their habitats; (2) reduce the risk of overutilization of populations due to commercial, recreational, scientific, and/or educational purposes; (3) identify specific research needs; (4) manage existing regulatory mechanisms to maintain species viability; (5) reduce the risk of factors, such as plague, that negatively impact prairie dog populations; and (6) increase landowner participation in prairie dog conservation efforts. The Conservation Strategy and Conservation Plan recognize that prairie dog population control is appropriate in certain circumstances.

<u>Conservation Strategy Objectives</u>

The Conservation Strategy has 9 objectives for conserving GUPD and WTPD range-wide. These objectives allow cooperators to manage prairie dog populations in a manner that ensures long-term viability while also maintaining management flexibility. The 9 objectives are:

1. Implement the Conservation Strategy.
2. Continue participation on the Prairie Dog Conservation Team, White-tailed and Gunnison's Prairie Dog Working Group, and state work groups if formed.
3. Identify and monitor the distribution and status of both species.
4. Promote public education.
5. Identify, prioritize, and implement research needs.
6. Address the 5 listing factors in individual state management plans.
7. Integrate WTPD and GPD conservation strategy objectives with management and habitat objectives of other sage-steppe and prairie species such as greater sage-grouse (*Centrocercus urophasianus*), Gunnison sage-grouse (*Centrocercus minimus*), ferruginous hawk (*Buteo regalis*), black-footed ferret (*Mustela nigripes*), burrowing owl (*Athene cunicularia*), kit fox (*Vulpes macrotis*), and pygmy rabbit (*Brachylagus idahoensis*).
8. Develop a detailed addendum to this Conservation Strategy.
9. Evaluate progress and accomplishments.

Conservation Plan Prioritized Issues

The Conservation Plan identified and prioritized issues, which are listed below in order of their future, potential negative impacts on GUPD. Conservation activities were developed to address these impacts.

Priority issues and associated conservation activities

A. Plague. Develop management actions to mitigate plague outbreaks. These actions may include dusting, translocation, closures, land protection, predator control, and increased monitoring.

B. Range condition (i.e. non-native species, altered fire regimes, drought, juniper encroachment). Management actions may include habitat manipulation (i.e., chaining, initiating fire regimes, reseeding native grasses, and cheat grass eradication).

C. Chemical control. Management actions may include developing conservation easements or non-lethal control options (translocation, public education, green barriers)

D. Shooting. Management actions may include reviewing regulations, implementing closures, monitoring take, and educating the public.

E. Oil/gas development. Management actions are currently underway and will be ongoing. These include tracking impacts to colonies when development is on or near them. State agencies will continue commenting on development plans.

APPENDIX C

Scientific Names of Organisms Mentioned in the *Colorado Conservation Strategy* Text

Table C-1. Common and scientific names of birds and mammals referred to in the *Colorado Conservation Strategy*.

Birds	
Common Name	**Scientific Name**
Burrowing owl	*Athene cunicularia*
Ferruginous hawk	*Buteo regalis*
Greater sage-grouse	*Centrocercus urophasianus*
Gunnison sage-grouse	*Centrocercus minimus*
Lesser prairie-chicken	*Tympanuchus pallidicinctus*
Loggerhead shrike	*Lanius ludovicianus*
Mountain plovers	*Charadrius montanus*
Swainson's hawk	*Buteo swainsoni*
Mammals	
Common Name	**Scientific Name**
Badger	*Taxidea taxus*
Black-footed ferret	*Mustela nigripes*
Black-tailed prairie dog	*Cynomys ludovicianus*
Coyote	*Canis latrans*
Deer mouse	*Peromyscus maniculatus*
Ground squirrel	*Spermophilus* spp.
Gunnison's prairie dog	*Cynomys gunnisoni*
Marmot	*Marmota flaviventris*
Mexican prairie dog	*Cynomys mexicanus*
Northern grasshopper mouse	*Onychomys leucogaster*
Ord's Kangaroo rat	*Dipodomys ordii*
Pygmy rabbit	*Brachylagus idahoensis*
Kit fox	*Vulpes macrotis*
Swift fox	*Vulpes velox*
Utah prairie dog	*Cynomys parvidens*
White-tailed prairie dog	*Cynomys leucurus*
Wyoming ground squirrel	*Spermophilus elegans*

Table C-2. Common and scientific names of herbaceous and woody plants referred to in the *Colorado Conservation Strategy*.

Herbaceous Plants	
Common Name	**Scientific Name**
Alfalfa	*Medicago spp.*
Alkali sacaton	*Sporobolus airoides*
Annual wheatgrass	*Eremopyrum triticeum*
Baltic rush	*Juncus balticus*
Basin wildrye	*Leymus cinereus*
Blue grama	*Bouteloua gracilis*
Cheatgrass	*Bromus tecorum*
Colorado Wildrye	*Leymus ambiguous*
Crested Wheatgrass	*Agropyron cristatum*
Elk sedge	*Carex garberi*
Field bindweed	*Convolvulus arvensis*
Foxtail	*Alopecurus spp.*
Fescue	*Festuca spp.*
Galleta grass	*Pleuraphis jamesii*
Halogeton	*Halogeton* spp.
Indian Paintbrush	*Castilleja* spp.
Indian Ricegrass	*Achnatherum hymenoides*
Jointed goatgrass	*Aegilops cylindrical*
Junegrass	*Koeleria macrantha*
Knapweed	*Centaurea spp.*
Kochia	*Bassia prostrate*
Lobeleaf Groundsel (Senecio)	*Packera multilobata*
Mountain muhly	*Muhlenbergia Montana*
Mutton Grass	*Poa fendleriana*
Needlegrass	*Stipa comata*
Needle and thread grass	*Hesperostipa comata*
Oxeye Daisy (Whiteweed)	*Leucanthemum vulgare*
Russian knapweed	*Centaurea repens*
Saline wildrye (Salina)	*Leymus salinus*
Salt Grass	*Distichlis spicata*
Sedge	*carix spp*
Sweet clover	*Melilotus* spp.
Sandberg bluegrass	*Poa secunda*
Toad Flax	*Nuttallanthus spp.*
Western Wheatgrass	*Pascopyrum smithii*
Woody Plants	
Antelope Bitterbrush	*Purshia tridentate*
Basin big sagebrush	*Artemisia tridentata tridentata*
Big sagebrush	*Artemisia tridentata*

Table C-2. Common and scientific names of herbaceous and woody plants referred to in the *Colorado Conservation Strategy*.

Bitterbrush	*Purshia* spp.
Black sagebrush	*Artemisia nova*
Currant (Currant rose)	*Ribes spicatum*
Douglas fir	*Pseudotsuga menziesii*
Engelmann spruce	*Picea engelmannii*
Fourwing Saltbush	*Atriplex canescens*
Fringed sagebrush	*Artemesia frigida*
Oak	*Quercus spp.*
Gardner's saltbush	*Atriplex gardneri*
Greasewood (Black)	*Sarcobatus* spp.
Juniper	*Juniperus* spp.
Utah juniper	*Juniperus osteosperma*
Mountain big sagebrush	*Artemisia tridentata vaseyana*
Mountain mahogany	*Cercocarpus* spp.
Piñon pine	*Pinus edulis*
Piñon- juniper	*Pinus edulis- Juniperus communis*
Ponderosa pine	*Pinus ponderosa*
Rabbitbrush	*Chrysothamnus* spp. and/or *Ericameria* spp.
Sagebrush	*Artemisia* spp.
Serviceberry	*Amelanchier* spp.
Shadscale (saltbrush)	*Artiplex confertifolia*
Skunkbush	*Navarretia squarrosa*
Rabbitbrush	*Chrysothamnus spp.*
snakeweed and broom snakeweed	*Gutierrezia sarothrae*
Winterfat	*Krascheninnikovia lanata (Ceratoides)*
Wyoming big sagebrush	*Artemisia tridentata wyomingensis*

APPENDIX D

Acronyms & Abbreviations Used in the *Colorado Conservation Strategy* Text

Acronym, Term, or Responsible Group	Definition
APHIS	Animal and Plant Health Inspection Service (part of USDA)
AWR	Arapaho National Wildlife Refuge
BFF	Black-footed ferret
BLM	Bureau of Land Management
BMPs	Best management practices
BOR	Bureau of Reclamation
BTPD	Black-tailed prairie dog
BTPDCT	Black-tailed prairie dog conservation team
CBMA	Coyote Basin Management Area
CBSG	Conservation Breeding Specialist Group
CCAA	Candidate Conservation Agreement with Assurances
CDA	Colorado Department of Agriculture
CDC	Centers for Disease Control and Prevention
CDOW	Colorado Division of Wildlife
CI	Confidence Interval
CNHP	Colorado Natural Heritage Program
COGCC	Colorado Oil and Gas Conservation Commission
CoMAP	Colorado Ownership, Management, and Protection dataset
Colorado Conservation Strategy	Colorado Gunnison's and White-tailed Prairie Dog Conservation Strategy (this document)
County Governments	Includes several aspects of county governments, such as land use planning, pest control agents, weed control, and county commissioners.
CRP	Conservation Reserve Program
CSU Extension	Colorado State University Extension Service
CURE	Curecanti National Recreation Area
CWC	Colorado Wildlife Commission
DNA	Deoxyribonucleic acid; molecule that carries the genetic information in a cell
DOQ	Digital Orthophoto Quarter Quadrangles
DWM	District Wildlife Manager
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FDA	Food and Drug Administration
FEIS	Final Environmental Impact Statement
FFR	Ferret Family Rating
FTE	Full-time equivalent (one person working full-time)
GIS	Geographic Information System

Acronym, Term, or Responsible Group	Definition
GU IPA	Gunnison IPA
GUPD	Gunnison's prairie dog
GUSG	Gunnison's sage-grouse
GUWTWG	Gunnison's and white-tailed prairie dog working group
GVUN IPA	Grand Valley – Uncompahgre IPA
Industry	Oil, gas, mining, or utility industries, depending on context
IPA	Individual Population Area
Local Governments	City and municipality governments (not county)
LPA IPA	La Plata – Archuleta IPA
LSMA	Little Snake Management Area
LUP	Land use plans
MEA	Management Emphasis Area
MEPD	Mexican prairie dog
MOU	Memorandum of Understanding
mtDNA	Mitochondrial DNA
NEPA	National Environmental Policy Act
NGOs	Non-governmental organizations, including local land trusts, The Nature Conservancy, and other non-profit groups
NO IPA	North IPA
NPS	National Park Service
NRA	National Recreation Area
NRCS	Natural Resources Conservation Service
NW IPA	Northwest IPA
O&G	Oil and Gas
OHV	Off highway vehicle
PCR	Polymerase chain reaction
Private Landowners	Non-public landowners/managers
PVA	Population viability analysis
RD&D	Research, Development, and Demonstration (a type of BLM lease)
RMP	Resource Management Plan
SB	Senate Bill
SD	Standard deviation
SE	Standard Error
SE IPA	Southeast IPA
SERGoM	Spatially Explicit Regional Growth Model
SLB	Colorado State Land Board
SLN	Special local needs
SLV IPA	San Luis Valley IPA
SP IPA	South Park IPA
SW IPA	Southwest IPA

Acronym, Term, or Responsible Group	**Definition**
SWReGAP	Southwest Regional GAP Land Cover Classification
Universities	Specifically, researchers and research programs at universities
USDA	United States Department of Agriculture
USDI	United States Department of the Interior
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USU	Utah State University
UTM	Universal Transverse Meridian
UTPD	Utah prairie dog
WAFWA	Western Association of Fish and Wildlife Agencies
WCMA	Wolf Creek Management Area
WRRA	White River Resource Area (a BLM management area)
WTPD	White-tailed prairie dog
WYGS	Wyoming ground squirrel

APPENDIX E

Protocol for Conducting Prairie Dog Occupancy Surveys

PROTOCOL FOR CONDUCTING PRAIRIE DOG OCCUPANCY SURVEYS

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February 2007

Introduction

The White-tailed (*Cynomys leucurus*; WTPD) and Gunnison's Prairie Dog (*C. gunnisoni*; GUPD) Conservation Plan (WAFWA 2007) required the development and use of an objective, repeatable estimation technique to measure the response of WTPD and GUPD populations to factors affecting their viability. Techniques used to evaluate prairie dog populations have relied on delineating colony boundaries based on burrow distribution. However, WTPD and GUPD colony boundaries can be difficult to map with distribution and activity levels within boundaries extremely variable. The end result of mapping is therefore a subjective effort by investigators who rely on their best estimate by using topographic features or breaks in habitats to delineate boundaries. In addition, individual burrow activity is not assessed, resulting in both active and inactive areas included in estimates of occupied habitat. The consequence of mapping both active and inactive areas is an inaccurate estimation of occupied habitat.

In 2002, Colorado embarked on an effort to develop an objective technique to monitor WTPD and GUPD populations. Aerial surveys using the line intercept methodology had been developed for estimating occupied area by black-tailed prairie dogs (*C. ludovicianus*). Thus this was the first method investigated to determine if it could be successfully used for WTPD and GUPD. After conducting a pilot study, it was determined that the line intercept methodology significantly overestimated the lengths of GUPD and WTPD colonies compared to lengths measured on the ground. In addition, the proportions of lengths of prairie dog colonies detected by aerial crews were only weakly correlated; the crews did not consistently report finding prairie dogs in the same areas along transects. Due to the lack of correlation between aerial and ground crews, the line intercept methodology was abandoned as a viable technique to monitor WTPD and GUPD populations.

After abandoning the use of the line intercept methodology, Colorado investigated using Occupancy Modeling (MacKenzie et al. 2002) as an objective technique to monitor WTPD and GUPD. Unlike acreage estimates, measures of statistical precision and confidence intervals could be calculated for occupancy estimates. Currently Colorado is implementing Occupancy Modeling for both WTPD and GUPD within in the state. Colorado has completed one year of surveys in 2004 for WTPD and in 2005 for GUPD. Results from the surveys found WTPD occupying 24.1% (SE = 12.8) of 47,710 0.25-km^2 plots and GUPD occupying 7.5% (SE = 1.3) of 158,225 0.25-km^2 plots (Andelt et al. 2005).

Occupancy surveys have the potential to be a successful tool for establishing baseline occupancy rates for WTPD and GUPD in order to monitor changes in occupancy through time (Andelt et al. 2005, 2006a, 2006b). This manuscript was prepared to standardize occupancy surveys throughout the range of both the GUPD and WTPD. All states within the range of these species have agreed, in the Multi-state Conservation Plans, to implement an occupancy approach to monitor range-wide WTPD and GUPD population trends.

Range-wide Methodology for Occupancy Sampling for WTPD and GUPD

Defining Sampling Areas: Occupancy will be estimated by sampling 0.25 km^2 (0.5 km per side) quadrats. Quadrats will be randomly selected within each state boundary in areas designated as suitable WTPD and GUPD habitat. This defined area of inference within states will remain constant throughout the duration of the monitoring effort. In addition, the quadrats randomly selected to be sampled will not change unless all quadrats are disposed of and a new set of quadrats are randomly selected from the area of inference.

Suitable habitat does not necessarily mean that the habitat is occupied, rather it is defined as suitable or potentially suitable based on variables designated by a state as necessary for prairie dog colonization. States need not define their areas of inference in the same manner in order to conduct a range-wide occupancy survey. It is only necessary that the states develop the most accurate area of inference from the best available data. The area of inference may include tribal lands if the state is given permission to sample these lands, however they should be placed in a different strata since the permission to sample these lands may be removed at any time.

States may wish to include the use of stratification. Stratification is useful for:

- Interest in occupancy at subdivisions smaller than the whole state or range
- Logistical convenience (ability to sample an entire stratum quickly and with similar methods)
- Need for different methods in different areas (some strata may be more easily sampled from the ground versus the air, some strata may have very good information on prairie dog locations)
- Variance reduction (individual strata with uniform occupancy rates will increase precision)

States however do not need to stratify and in addition, stratification does not need to be the same within each state boundary in order to conduct a range-wide occupancy approach.

Below is a description of how Colorado developed their area of inference and selected quadrats to sample for both WTPD and GUPD.

Colorado - Protocol for Developing Base Maps to Overlay Quadrats

Methods

WTPD: Development of Maps and Sampling Areas: Field personnel from the Colorado Division of Wildlife, Forest Service, and the Bureau of Land Management mapped colonies of active (prairie dogs present during the last ± 3 years), inactive (prairie dogs occurred in the area in the past but were not recently present) and unknown (prairie dogs had been active but current status was unknown) WTPD colonies on 1:50,000 US Geological Survey County maps in the summer of 2002 (Colorado Division of Wildlife 2002). These data, in addition to data on the overall range of WTPD areas were input into a GIS database by Colorado Division of Wildlife personnel. The final product included active, inactive, and unknown colonies, and the overall range of white-tailed prairie dogs in each county on 11 x 17-inch (28 x 43-cm) colored topographic maps which contained an overlay of township, range, and sections. County extension agents, weed and pest supervisors, and Natural Resources Conservation Service, USDA Forest Service, Bureau of Land Management, and CDOW personnel reviewed and updated the sampling frame (Figure 1).

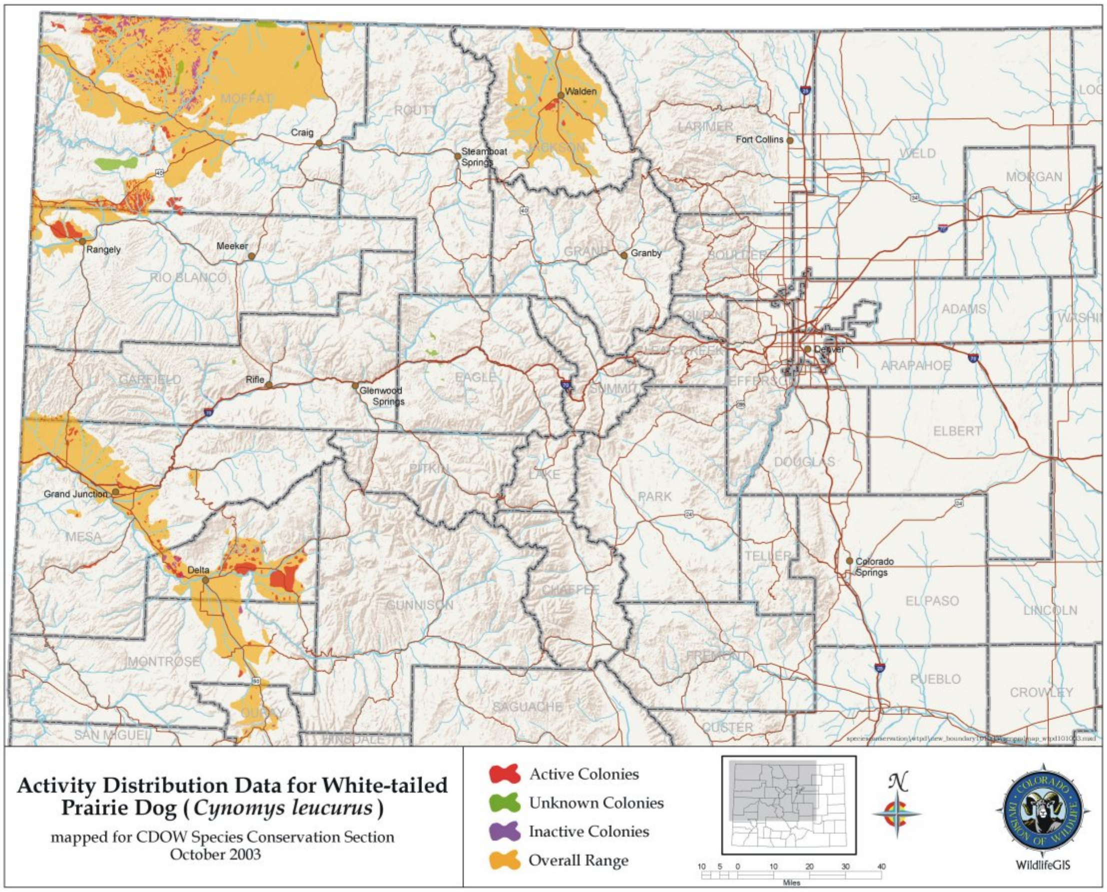

Figure 1. Range of white-tailed prairie dogs in Colorado. Three primary sampling strata consisted of Moffat and Rio Blanco counties, Eagle, Grand, Jackson, Larimer, and Routt counties, and Delta, Garfield, Mesa, Montrose, and Ouray counties.

WTPD: Selection of Quadrats: The range of WTPD in Colorado was overlaid with 1,640 x 1,640 feet (500 x 500 m) quadrats in ArcInfo using the NAD27 datum and the Zone 13 projection. Quadrats were eliminated if they occurred above 10,000 feet (3,048 m) elevation (using the 30 m digital elevation model), were on slopes >30^{o}, or were in vegetation where WTPD do not occur. A sampling frame of 47,710 quadrats was established from which a stratified random sample of 318 quadrats was selected from 10 strata (Table 1). Three general areas were sampled: Grand Junction (GJ), North Park (NP), and Northwest (NW). Quadrats in GJ and NW were classified a priori based on Colorado Division of Wildlife GIS layers as active, inactive, unknown, or other. Quadrats in NP were classified as either unknown (active, inactive, unknown) or other. The number of quadrats in each stratum was optimized based upon our a priori estimates of the probability (active = 0.9, unknown = 0.5, inactive = 0.1, and other = 0.05) of WTPDs being present within quadrats.

Table 1. Stratification for the sample of 318 quadrats from 10 strata of the WTPD occupancy survey in northwestern Colorado.

Strata	Stratum Population	Stratum Sample
GJ Active	1,963	20
GJ Inactive	170	12
GJ Other	11,654	55
GJ Unknown	523	9
NP Other	7,442	35
NP Unknown	462	7
NW Active	4,237	53
NW Inactive	1,278	23
NW Other	19,289	96
NW Unknown	692	8
Total	47,710	318

GUPD: Sampling Areas and Selection of Quadrats: A sampling area for GUPD was established preliminary from range maps in Armstrong (1972) and Fitzgerald et al. (1994). However, the sampling area was expanded by including areas in north-central Archuleta County, north-west El Paso County, and extreme north-east San Miguel County where colonies of GUPD were reported or where they were believed to possibly occur (Colorado Division of Wildlife 2002). Delta County, the northeastern portion of Montrose County, and the northern half of Ouray County were eliminated from the sampling area because prairie dogs in these areas are WTPD (P. M. Schnurr, Colorado Division of Wildlife, personal communication). This modified range was input in a GIS database by personnel from the Colorado Division of Wildlife. Seven strata (Figure 1) were developed based upon the overall ranges (Armstrong 1972, Fitzgerald et al. 1994) of the *zuniensis* subspecies (Ute Mountain Ute Indian Reservation, Southern Ute Indian Reservation, and remaining areas [South-West]), and the *gunnisoni* subspecies (Gunnison Valley, San Luis Valley, South Park, and South-East), and geography of Colorado. The Continental divide and other mountain ridges usually separated strata.

Longhurst (1944) reported that GUPD are probably limited to 10,000 feet (3,048 m) in elevation however, in areas with warm air currents they may be found at slightly higher elevations. Pizzimenti and Hoffman (1973) and Fitzgerald et al. (1994) reported that GUPD range in elevation from 6,000–12,000 feet (1,830 to 3,660 m) across their range. Several professionals (J. Ferguson, Bureau of Land Management; M. Threlkeld, Colorado Department of Agriculture; J. A. Capodice, Bureau of Land Management [retired]; and J. F. Cully, Kansas State University; personal communications), familiar with Gunnison's prairie dogs in Colorado, indicated that they generally are not found above 10,000 feet (3,048 m) elevation.

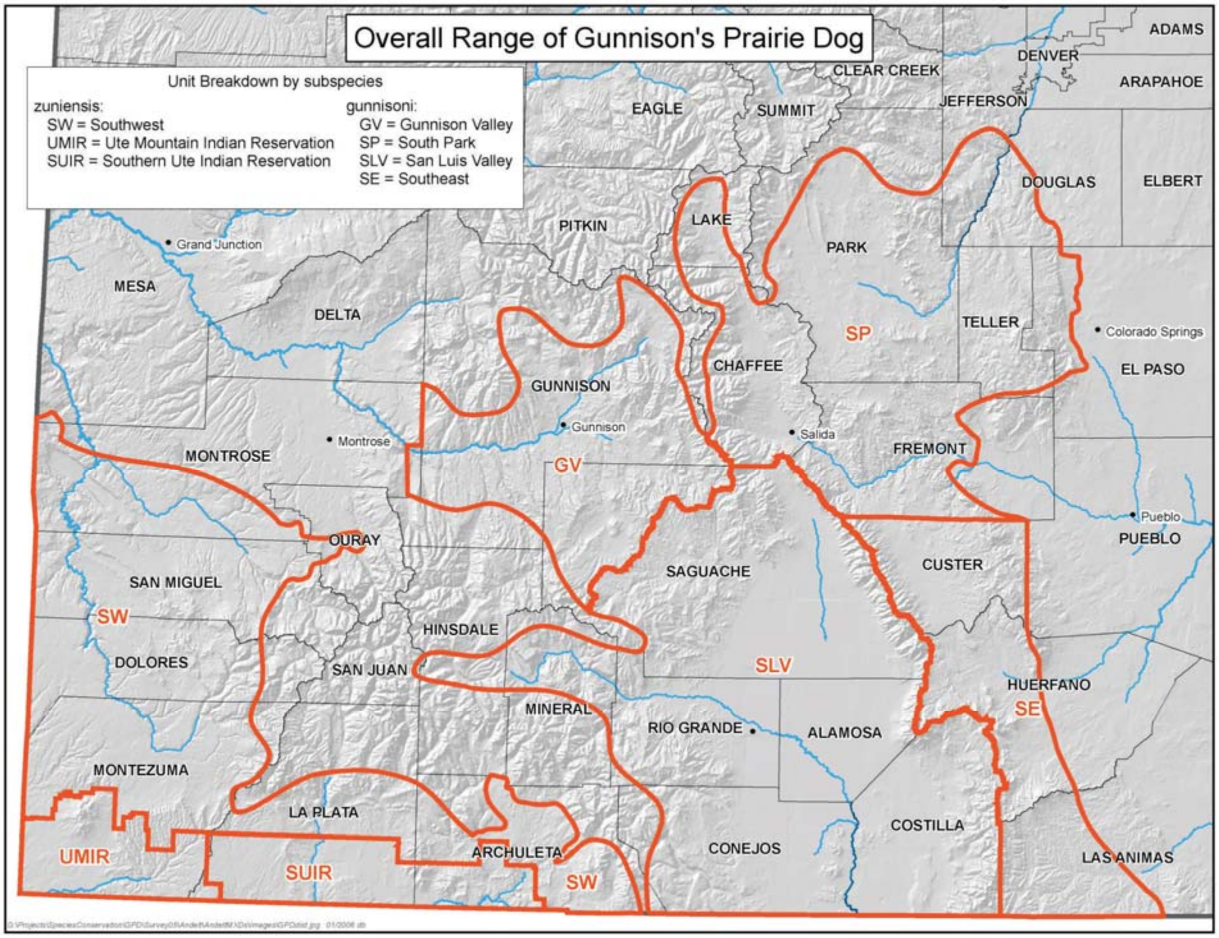

Figure 1. Strata used for sampling Gunnison's prairie dogs in Colorado during 2005.

GUPD have been described as inhabiting grasslands (Travis and Slobodchikoff 1993, Travis et al. 1997, Bangert and Slobodchikoff 2000, Perla and Slobodchikoff 2002, Girard et al. 2004), grasslands and shrub-grasslands (Cully 1997), grasslands to montane meadows (Findley et al. 1975), mountain grasslands (Lechleitner et al. 1962), valley floors to higher meadows (Longhurst 1944), and alpine meadows (Perla and Slobodchikoff 2002). The above articles and the expertise of 3 professionals (J. Ferguson, Bureau of Land Management; J. A. Capodice, Bureau of Land Management [retired]; and A. E. Seglund, Utah Division of Wildlife Resources; personal communications), familiar with GUPD, was used to further refine vegetation cover types contained in the Basin Wide Geographic Information System (GIS) as potentially occupied or unoccupied by GUPD in Colorado (Appendix 1). In addition, since GUPD are generally not found on slopes >15% (Fitzgerald and Lechleitner 1974; Lorance et al. 2002 [cited by Seglund et al. 2005]; Yazzie and Sanders 2003 [cited by Seglund et al. 2005]; J. Ferguson, Bureau of Land Management; M. Threlkeld, Colorado Department of Agriculture; J. A. Capodice, Bureau of Land Management [retired]; and J. F. Cully, Kansas State University; personal communications) a slope layer was added to better depict the suitable habitat. The overall range of GUPD in Colorado (Figure 1) was overlaid with 1,640 x 1,640 feet (500 x 500 m) square quadrats and the Basin Wide vegetation cover types in ArcInfo (ESRI, Redlands, California) using the NAD27 datum and the Zone 13 projection. Quadrats were eliminated if all areas within quadrats were above 10,000 feet (3,048 m) elevation (30 m digital elevation model), were on slopes <15%, or were in vegetation types where GUPD are not known to occur.

Three hundred and eighty-one quadrats were randomly selected from within 7 strata where occurrence of GUPD likely varied. The number of quadrats in each stratum were optimized (Table 2) based upon a priori estimates of the probability of GUPD occurrence within quadrats (W. F. Andelt, unpublished data) using the methods described in Thompson et al. (1998). Permission to visit quadrats on the Ute Mountain Ute Indian Reservation early in the sampling process was denied. Thus, this stratum was dropped from the survey, and the original sample size was reduced to 361 quadrats.

Table 2. A priori estimates of probability of occurrence of GUPD in quadrats, number of quadrats available for sampling, optimal allocation of the sampling effort, and actual numbers of quadrats sampled for each of 7 strata in Colorado during 2005.

Strata (h)	Estimated Probability of occurrence	Quadrats Available (U_h)	Optimal Allocation of Quadrats to Sample	Quadrats Sampled (u_h)
Gunnison Valley	0.03	14,178	20	20
South-East	0.03	15,543	21	21
San Luis Valley	0.05	47,143	83	83
South Park	0.05	27,297	48	47
Southern Ute Indian Reservation	0.25	9,823	34	34
Ute Mountain Ute Indian Reservation	0.10	7,600	20	0
South-West	0.25	44,241	155	153
Totals		165,826	381	358

Sampling of Quadrats

To locate quadrats on the ground, UTM locations of the 4-corners of a quadrat will be downloaded from ArcInfo shape files into GPS units. In addition, topographic maps (11 x 17 inch (28 x 43-cm) and land management maps (1:100,000) showing the location of quadrats will be provided to observers to assist in locating quadrats.

Quadrats will be visited 2 times during periods when prairie dogs are most active. For Colorado, these activity periods run from late March through mid-July for WTPD and late March through mid to late August for GUPD. Other states seasonal duration of sampling may differ due to elevation and latitudinal differences. Two visits to quadrats will be attempted to determine the detection probability however, limitations due to personnel, funding, and weather may result in areas being surveyed a single time. States will prioritize non-detection sites for revisit and those sites with a positive detection on the first visit as a lower priority for a second visit.

Two visits to a quadrat must be completed within 7 days so as to minimize violating the assumption of a closed population. To avoid observer bias and minimize possible independence violations (more likely to redetect a species once it has been detected due to prior knowledge), different observers should visit the quadrat on each of the two occasions. However, if only one technician is hired to conduct surveys, it is recommended that a supervisor or second observer visit a subset of the plots. Quadrats should be sampled unless winds are greater than 23 mi/hour or there is moderate to heavy rainfall.

Visual observations of a prairie dog are the only acceptable method that counts as a positive detection. Because auditory detections are hard to pinpoint with regards to exact location of the calling animal, this type of detection cannot be used since detections need to be confirmed within a quadrat. Scat samples are also not acceptable as the age of the scat is too difficult to pinpoint without an in depth analysis.

After arriving at a quadrat corner, if an observer detects a prairie dog they do not need to visit all four corners of the plot. If the observer arrives and no prairie dogs are detected in the quadrat, they must conduct 5 minute observations at each of the four corners of the plot until they detect a prairie dog or until all four corners have been visited. If as walking between corners a prairie dog is detected you can discontinue the survey of that plot.

Data recorded for each study quadrat will include the name of the individual conducting the sampling, date, quadrat number, time spent at quadrat, and UTM coordinates of the southwest corner of the quadrat (Appendix 2). At each plot, the observer will record air temperature and wind speed averaged over 10 seconds.

During sampling of quadrats, observations of other important species such as ferruginous hawks (*Buteo regalis*), burrowing owls (*Athene cunicularia*), Mountain plovers (*Charadrius montanus*) and kit fox (*Vulpes macrotis*) can be recorded. Note that private landowners in Colorado were not informed that information on the occurrence of these species were to be collected beforehand. Some landowners later expressed concern about this oversight. We recommend that data collection be limited only to those species that landowners have specifically approved.

Estimating Occupancy of WTPD or GUPD Quadrats from Aircraft

To locate quadrats from the air, a GPS unit will be attached to a laptop computer that contains an appropriate mapping program. The coordinates for the 4 corners of each grid quadrat are entered in the program and overlaid on a topographic map. The track function can be used to show the position of the airplane relative to each quadrat and saved for later reference. The airplane is flown at an elevation of about 100 m above ground and 3 passes spaced across each quadrat are completed. The pilot and observer both watch for prairie dogs.

Statistical Analyses

Data will be input into an access database and the analysis will be conducted by Colorado. Occupancy models (MacKenzie et al. 2002) will be fit to the observed encounter histories for WTPD and GUPD with program MARK (White and Burnham 1999) with model selection by information-theoretic methods (Burnham and Anderson 2002). MacKenzie et al.'s model estimates the probability of detection (p) during a single visit and the probability of occupancy (Ψ) based on multiple visits to quadrats. Thus, this model corrects for "false negatives", i.e., quadrats where no prairie dogs are observed, but where prairie dogs actually exist. The logit link will be used in all models to relate covariates to detection and occupancy probabilities.

Quadrat-specific covariates that will be collected to improve the estimate of occupancy probability for each quadrat include: average temperature, wind speed, starting time, and Julian date. Elevation of the quadrat and elevation squared have been incorporated as covariates to improve prediction of occupancy rates for WTPD and GUPD in Colorado and will be included in the range-wide sampling effort. If states wish to include additional covariates that they think may improve the estimate of occupancy probability they can include it in their data collection efforts.

Occupancy estimation for entire sampling frame in Colorado: Model selection results placed almost all weight on one model for both WTPD and GUPD, so model averaging was not required. However, quadrat-specific covariates greatly improved prediction of occupancy rates for both species, so a complex procedure was required to estimate occupancy rates for all quadrats in the sampling frame. For the minimum AICc model with *r* quadrat-specific covariates, the fitted model was

$$\hat{\psi}_i = \frac{\exp\left(\sum_{k=0}^{r} \hat{\beta}_k x_{ki}\right)}{1+\exp\left(\sum_{k=0}^{r} \hat{\beta}_k x_{ki}\right)} \quad ,$$

where the *r* covariate values for observation i are x_{1i}, x_{2i}, …, x_{ri}, and $x_{0i} = 1$. The estimates from Program MARK are the intercept ($\hat{\beta}_0$) and *r* slope parameters ($\hat{\beta}_1$, $\hat{\beta}_2$, …, $\hat{\beta}_r$). The number of quadrats estimated to be occupied in stratum $h = 1,\ldots,H$ (H = 6 for GUPD, 10 for WTPD) with the minimum AICc model that included *r* covariates was computed as the sum of the estimated probability of occupancy of each quadrat, $\hat{N}_h = \sum_{i=1}^{U_h} \hat{\psi}_i$, where U_h is the number of quadrats in the population of stratum *h*. The total number of occupied quadrats for all strata was estimated as $\hat{N} = \sum_{h=1}^{H} \hat{N}_h$. The variance of $\hat{N}_h$ was estimated as the sum of the estimated variance-covariance matrix of the $\hat{\psi}_i$, $i = 1,\ldots,U_h$, where

$$\hat{\mathrm{Var}}(\hat{\psi}_i) = \left[\hat{\psi}_i(1-\hat{\psi}_i)\right]^2 \left[\sum_{k=0}^{r} x_{ki}^{\ 2}\hat{\mathrm{Var}}(\hat{\beta}_k) + \sum_{k'=0,k'<k}^{k-1} 2x_{ki}x_{k'i}\hat{\mathrm{Cov}}(\hat{\beta}_k,\hat{\beta}_{k'}) \right] \quad ,$$

and

$$\hat{\mathrm{Cov}}(\hat{\psi}_i,\hat{\psi}_j) = \hat{\psi}_i(1-\hat{\psi}_i)\hat{\psi}_j(1-\hat{\psi}_j) \left[\sum_{k=0}^{r} x_{ki}x_{kj}\hat{\mathrm{Var}}(\hat{\beta}_k) + \sum_{k'=0,k'<k}^{k-1} (x_{ki}x_{k'j} + x_{kj}x_{k'i})\hat{\mathrm{Cov}}(\hat{\beta}_k,\hat{\beta}_{k'}) \right]$$

where Var(.) indicates the variance of the enclosed estimator, and Cov(.,.) indicates the covariance of the 2 enclosed estimators. Thus,

$$\hat{\mathrm{Var}}(\hat{N}_h) = \sum_{i=1}^{U_h} \hat{\mathrm{Var}}(\hat{\psi}_i) + 2\sum_{j=1,j<i}^{i-1} \hat{\mathrm{Cov}}(\hat{\psi}_i,\hat{\psi}_j) \quad .$$

The covariance of pairs of $\hat{\psi}_i$ estimates, when they occur in strata h and h' ($h \neq h'$), was also computed with the above covariance estimator formula, but indicator variables were used to adjust for different intercepts between the 2 strata. The covariance between pairs of $\hat{\psi}_i$ estimates, when they occur in strata h and h' ($h \neq h'$), was needed to compute the covariance of the $\hat{N}_h = \sum_{i=1}^{U_h} \hat{\psi}_i$ between the 6 or 10 strata. For GUPD strata where the Division of Wildlife Range covariate was not available, the x_{1i} or x_{1j} covariate value was taken as zero, and the formula reduces properly to the correct covariance. These formulae are different than those presented in Bowden et al. (2003) because they used a covariate to predict an estimated population size using a ratio estimator with correlated estimates, whereas our covariates are used to estimate directly the correlated estimates of occupancy rate.

Miscellaneous

Equipment: Equipment needed to conduct surveys may include all of the following: clipboards, waterproof pens, topographic maps, compasses, GPS units, battery chargers and rechargeable batteries, 10-power binoculars, backpacks, high lift jacks, tow chains, shovels, jumper cables, quadrat corner stakes, fluorescent red paint for corner stakes, hammers, thermometers, appropriate windspeed and temperature meters (i.e., Speedtech Instruments, Great Falls, Virginia), phone cards, and first aid kits.

Establishing Ownership of Quadrats: Plot ownership can be established by contacting County Assessor web sites and offices, reviewing plat books, and by contacting adjacent landowners. Contact information for lessees of State Land Board lands can be obtained from the State Land Board. Data sheets need to contain the plot number, owners name, address, and telephone number. The observer should record each phone call made to the landowner and special instructions such as need to notify a lessee shortly before visiting the land, access thru locked gates, and if the owner desires a copy of the final report. If information on species other than prairie dogs is desired, landowners should be asked for permission to collect that data.

Informing Cooperators: Inform anyone who may be affected by surveys including Extension Agents, County Sheriffs, Bureau of Land Management, U.S. Forest Service, Division of Wildlife, Division of Parks and Outdoor Recreation, National Park Service, National Wildlife Refuges, State Land Board, The Nature Conservancy, Native American tribes, Natural Resources Conservation Service, and USDA/APHIS Wildlife Services.

Liability Issues: Some private landowners may be concerned about their liability for observers while they are on the landowner's property. In Colorado, our legal advisors believe that a landowner's liability to persons on their land would be covered under provisions of Section 13-21-115 of the Colorado Revised Statutes. Observers should be considered a "licensee" on private property. A landowner can only be found liable to a licensee if he/she fails in his/her duty owed to that other person as that duty is described in the statute. The statute limits the landowner's risk of liability, and should provide adequate protection to a landowner under normal circumstances.

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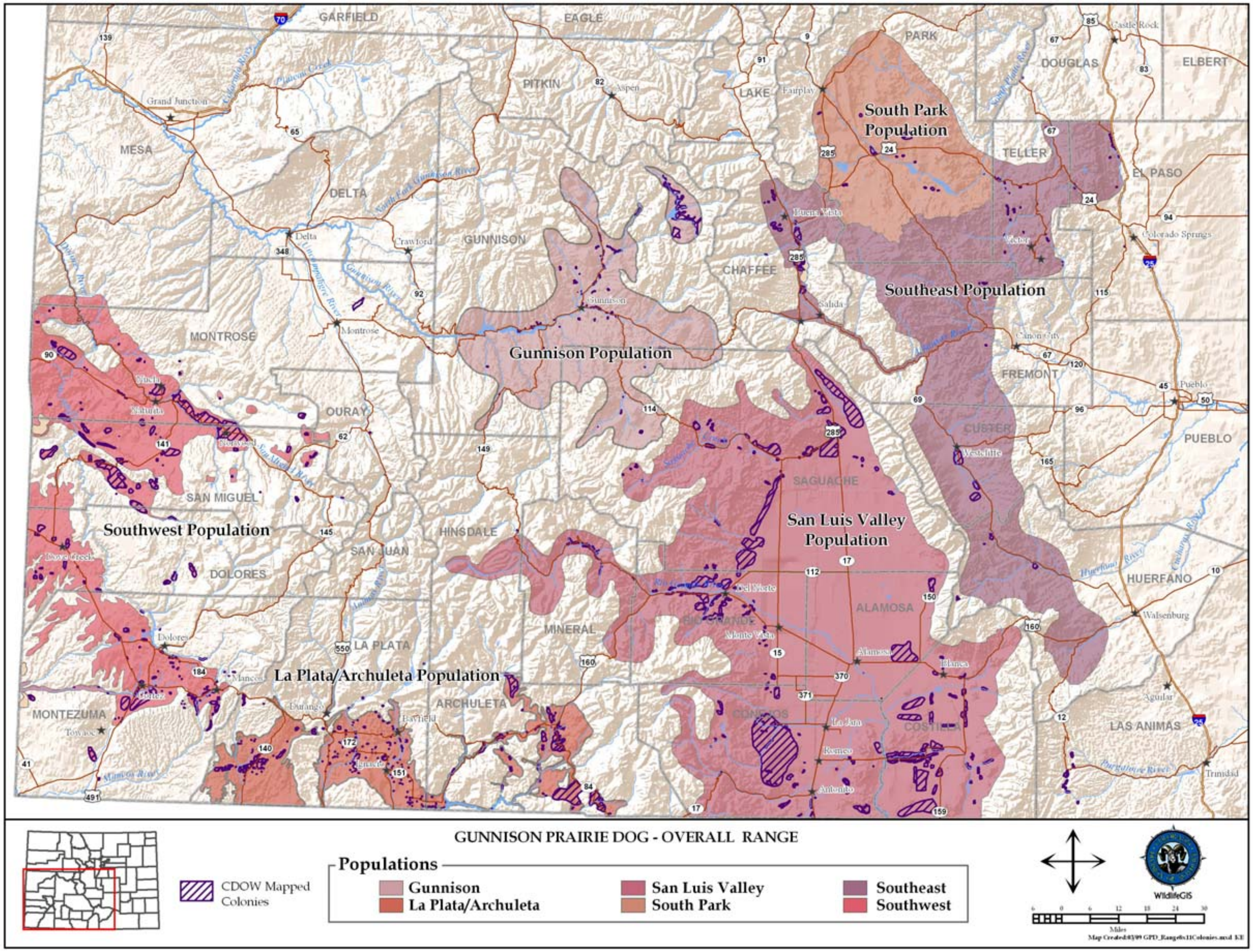
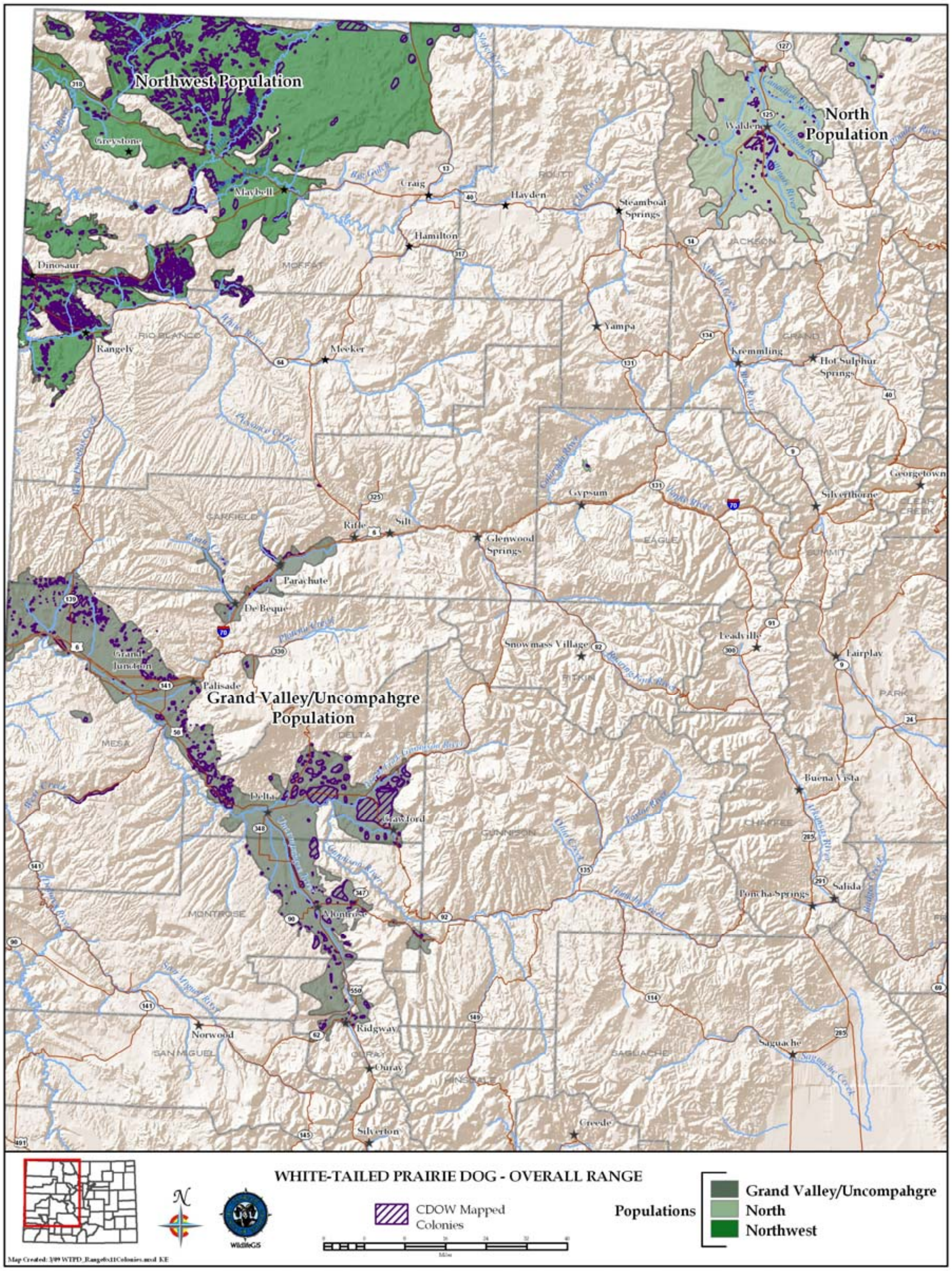
APPENDIX F

Gunnison's Prairie Dog & White-tailed Prairie Dog Overall Range

With Colony Locations Identified During the

Colorado Division of Wildlife Species Activity Mapping (2002–2008)


GUNNISON PRAIRIE DOG - OVERALL RANGE
South Park Population
Southeast Population
Gunnison Population
San Luis Valley Population
Southwest Population
La Plata/Archuleta Population
GARFIELD
EAGLE
PARK
DOUGLAS
ELBERT
PITKIN
LAKE
MESA
DELTA
GUNNISON
CHAFFEE
TELLER
EL PASO
MONTROSE
FREMONT
OURAY
CUSTER
PUEBLO
SAGUACHE
SAN MIGUEL
HINSDALE
SAN JUAN
DOLORES
HUERFANO
ALAMOSA
MINERAL
RIO GRANDE
LA PLATA
ARCHULETA
MONTEZUMA
CONEJOS
COSTILLA
LAS ANIMAS
CDOW Mapped Colonies
Populations
Gunnison
La Plata/Archuleta
San Luis Valley
South Park
Southeast
Southwest
WildlifeGIS
Miles


Northwest Population
North Population
Grand Valley/Uncompahgre Population
Greystone
Maybell
Craig
Hayden
Steamboat Springs
Hamilton
Walden
Dinosaur
Rangely
Meeker
Yampa
Kremmling
Hot Sulphur Springs
Georgetown
Silverthorne
Gypsum
Rifle
Silt
Glenwood Springs
Parachute
De Beque
Grand Junction
Palisade
Snowmass Village
Leadville
Fairplay
Delta
Crawford
Buena Vista
Montrose
Poncha Springs
Salida
Ridgway
Norwood
Ouray
Saguache
Silverton
Creede
WHITE-TAILED PRAIRIE DOG - OVERALL RANGE
CDOW Mapped Colonies
Populations
Grand Valley/Uncompahgre
North
Northwest

APPENDIX G

Population Viability Analysis Report

Population Viability Analysis for the Gunnison's Prairie Dog (*Cynomys gunnisoni*) and the White-tailed Prairie Dog (*Cynomys leucurus*) of Colorado

Report prepared by:
Philip S. Miller
IUCN / SSC Conservation Breeding Specialist Group

In collaboration with

Members of the
Gunnison's and White-tailed Prairie Dog
Conservation Plan Steering Committee

Population Viability Analysis for Gunnison's Prairie Dog (*Cynomys gunnisoni*) and the White-tailed Prairie Dog (*Cynomys leucurus*) of Colorado

Philip Miller, Conservation Breeding Specialist Group
and
Gunnison's and White-tailed Prairie Dog Conservation Plan Steering Committee Members

TABLE OF CONTENTS

Population Viability Analysis for Gunnison's Prairie Dog (*Cynomys gunnisoni*) and the White-tailed Prairie Dog (*Cynomys leucurus*) of Colorado

Philip Miller, Conservation Breeding Specialist Group
and
Gunnison's and White-tailed Prairie Dog Conservation Plan Steering Committee Members

Introduction

Concern over the long-term viability of Gunnison's and white-tailed and prairie dogs across the state of Colorado stem from their apparent declines in population numbers and distribution due predominantly to plague and to a lesser extent to historic overgrazing by livestock, poisoning campaigns, conversion of lands to agriculture, urban development, and recreational shooting. The development of a State Conservation Plan for Colorado is part of a range-wide effort identified in the Western Association of Fish and Wildlife Agencies Final Prairie Grasslands Memorandum of Understanding. The purpose of the State Conservation Plan will be to: 1) promote conservation of both species and their habitats; 2) identify specific research needs; 3) examine existing regulatory mechanisms and their ability to maintain viable populations; 4) reduce the risk of factors negatively impacting populations; and 5) increase stakeholder participation in prairie dog conservation efforts. Given these goals for the State Plan, a quantitative analysis of prairie dog population dynamics, particularly in the context of those processes seen as potentially threatening to the species' long-term persistence, is an important component of the larger natural resource management decision-making process.

Population viability analysis, or PVA, can be an extremely useful tool for investigating current and future risk of Gunnison's and white-tailed prairie dog population decline or extinction. The need for and consequences of alternative management strategies can be modeled to suggest which practices may be the most effective in managing prairie dog populations in its wild habitat. *VORTEX*, a simulation software package written for population viability analysis, was used here as a vehicle to study the interaction of a number of prairie dog life history and population parameters, to explore which demographic parameters may be the most sensitive to alternative management practices, and to test the effects of selected management scenarios.

The *VORTEX* package is a simulation of the effects of a number of different natural and human-mediated forces – some, by definition, acting unpredictably from year to year – on the health and integrity of wildlife populations. *VORTEX* models population dynamics as discrete sequential events (e.g., births, deaths, sex ratios among offspring, catastrophes, etc.) that occur according to defined probabilities. The probabilities of events are modeled as constants or random variables that follow specified distributions. The package simulates a population by recreating the essential series of events that describe the typical life cycles of sexually reproducing organisms.

PVA methodologies such as the *VORTEX* system are not intended to give absolute and accurate "answers" for what the future will bring for a given wildlife species or population. This limitation arises simply from two fundamental facts about the natural world: it is inherently unpredictable in its detailed behavior; and we will never fully understand its precise mechanics. Consequently, many researchers have cautioned against the exclusive use of absolute results from a PVA in order to promote specific management actions for threatened populations (e.g., Ludwig 1999; Beissinger and McCullough 2002; Reed et al. 2002; Ellner et al. 2002; Lotts et al. 2004). Instead, the true value of an analysis of this type lies in the assembly and critical analysis of the available information on the species and its ecology, and in the ability to compare the quantitative metrics of population performance that emerge from a suite of simulations, with each simulation representing a specific scenario and its inherent assumptions about the available data and a proposed method of population and/or landscape management. Interpretation of this type of output depends strongly upon our knowledge of prairie dog biology in its habitat, the environmental conditions affecting the species, and possible future changes in these conditions.

The *VORTEX* system for conducting population viability analysis is a flexible and accessible tool that can be adapted to a wide variety of species types and life histories as the situation warrants. The program has been used around the world in both teaching and research applications and is a trusted method for assisting in the definition of practical wildlife management methodologies. For a more detailed explanation of *VORTEX* and its use in population viability analysis, refer to Appendix I, Lacy (2000) and Miller and Lacy (2003).

Specifically, we were interested in using this preliminary analysis to address the following questions:

- Can we build a series of simulation models with sufficient detail and precision that describe the dynamics of Gunnison's and white-tailed prairie dog populations across Colorado with reasonable accuracy?
- What are the primary demographic factors that drive growth of Gunnison's and white-tailed prairie dog populations?
- How vulnerable are small, fragmented populations of Gunnison's and white-tailed prairie dog in Colorado to extinction under current management conditions? How small must a population become to increase its risk of extinction to an unacceptable level?
- What are the predicted impacts of plague on Gunnison's and white-tailed prairie dog populations in Colorado?
- What are the predicted impacts of current shooting practices on Gunnison's and white-tailed prairie dog populations in Colorado?
- What are the predicted long-term impacts of poisoning practices on Gunnison's and white-tailed prairie dog populations in Colorado?
- Can we devise reasonable management practices to reduce predicted impacts of these activities on Gunnison's and white-tailed prairie dog populations in Colorado?

Baseline Input Parameters for Stochastic Population Viability Simulations

In developing appropriate input datasets for our stochastic simulation models, we referred primarily to the fieldwork reported in Hoogland (2001, 2007), Cully (1997) and Biggins (U.S. Geological Survey, personal communication, 2007), with additional data coming from CDOW data on prairie dog biology and human activities around the state. Other specific studies used as justification for input are given below.

Breeding System: prairie dog mating strategy varies with regard to resource availability and population density. For example, when population densities are low and resources uniform, Gunnison's prairie dogs employ a monogamous mating system. As plant patchiness and population densities increase, monogamy gives way to polygyny, with females mating with multiple males throughout the colony. Hoogland (1998) reported a 92% probability of pregnancy and parturition in Gunnison's prairie dogs for females that copulated with 1 or 2 males, as compared to 100% for females that copulated with at least 3 males.

We are unable to modify the breeding system as a function of population density. Consequently, we employed a polygynous mating system in all our models. We predict that this will not have significant demographic impacts on the population compared to a more complex model of density-dependent breeding strategies.

Age of First Reproduction: *VORTEX* considers the age of first reproduction as the age at which the first clutch of eggs is laid, not simply the onset of sexual maturity. Females of both species of prairie dogs will begin breeding as yearlings (i.e., one year of age). Age of first reproduction for male Gunnison's prairie dogs is variable, and appears to depend on the number of older, breeding males in the population (Rayor 1985, 1988; Hoogland 1996). About 50% of white-tailed males breed at one year of age, but the other 50% do not breed until they are two years old (Hoogland 2007 and references therein). We used one year of age as the first age or reproduction for both males and females.

Age of Reproductive Senescence: In its simplest form, *VORTEX* assumes that animals can reproduce (at the normal rate) throughout their adult life. Both prairie dog species have been documented to live to 5 – 6 years of age, although very few individuals actually survive that long. We have set the maximum breeding age at five years of age, with no discernible reduction in breeding tendency (i.e., no reproductive senescence).

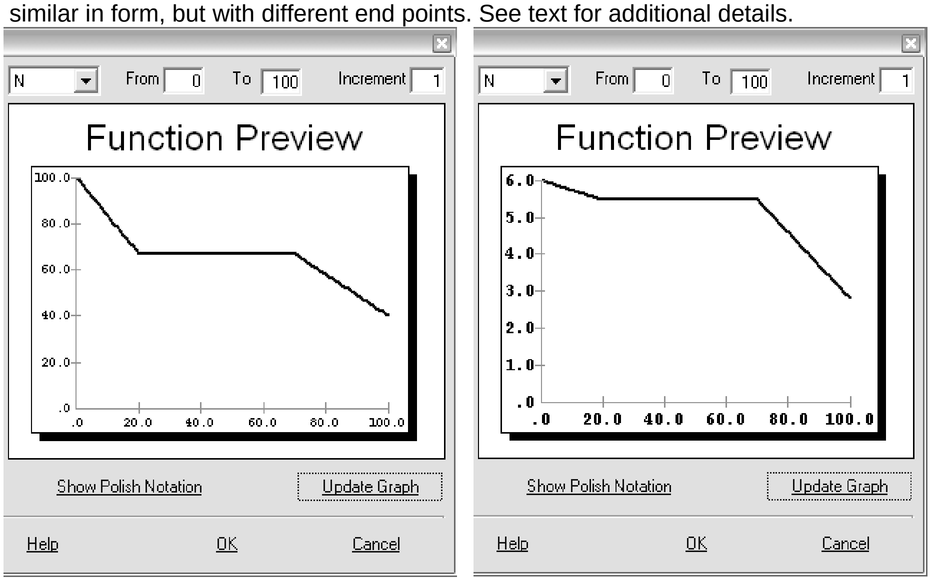
Offspring Production: Because of the difficulty in directly observing litters immediately after birth, we defined "reproduction" for our purposes here as the production of weaned litters. With this definition, we modified data from Hoogland (2001, 2007) and Cully (1997) to account for observations of higher reproductive output at low prairie dog densities. Specifically, we used species-specific parameters to define the percentage of adult female prairie dogs that successfully wean litters in the average year, as a function of density (defined here as the ration of population size *N* to carrying capacity *K*):

Table 1. Density-dependent reproductive parameters used in prairie dog simulation models. See text for additional information.

	Population Density		
Species	Low (N/K = 0.0)	Medium (0.2 < N/K < 0.7)	High (N/K = 1.0)
	Adult females weaning a litter (%)		
Gunnison's	100	82	40
White-tailed	100	67	40
	Mean litter size at weaning		
Gunnison's	4.6	3.8	1.8
White-tailed	6.0	5.47	2.8

Furthermore, we assumed that as population density increases, the percentage of adult females that wean a litter in a given year will decrease linearly as in Figure 1 below.

Figure 1. Graphical representations for percentage of adult females weaning a litter (left) and mean litter size at weaning (right) for simulated Gunnison's prairie dog populations. Functions for white-tailed reproductive performance are qualitatively similar in form, but with different end points. See text for additional details.



Based on these data, we observe that female Gunnison's prairie dogs are expected to produce smaller litters at weaning more frequently, while white-tailed females produce larger litters at weaning less frequently. The comparative impact of these differences is not immediately apparent and will have to await explicit analysis.

Annual environmental variation in female reproductive success is modeled in *VORTEX* by specifying a standard deviation (SD) for the proportion of adult females that successfully wean a litter within a given year. Data from Hoogland (1998, 2001, 2007) indicate a significant level of variability in this parameter. We specified that the standard deviation in the percentage of adult females weaning a litter is 15%, while the standard deviation around the mean litter size at weaning was set at 2.0.

<u>Male Breeding Pool</u>: In many species, some adult males may be socially restricted from breeding despite being physiologically capable. This can be modeled in *VORTEX* by specifying a portion of the total pool of adult males that may be considered "available" for breeding each year. While specific data from the field on this parameter are lacking, we assume that all males of reproductive age are equally capable of breeding with an adult female.

<u>Mortality</u>: *VORTEX* defines mortality as the annual rate of age-specific death from year x to $x + 1$; in the language of life-table analysis, this is equivalent to $q(x)$.

For both species, data from Hoogland (2001) indicate that survivorship of juveniles is consistently <50%. In order to develop mortality rates for sub-adult and adult age classes, we assumed two alternative mortality schedules indicative of sylvatic plague (and perhaps other diseases) acting as either enzootic or non-enzootic in the system (Table 2). In an enzootic scenario, plague operates at a relatively low level each year, thereby increasing average annual rates of mortality above a more benign non-enzootic scenario where disease does not play a major role in determining these long-term rates. These alternative mortality schedules grew out of lengthy discussions among species experts with differing views of the causes of significantly different survivorship rates between Gunnison's and Utah prairie dogs reported in Hoogland (2001).

Table 2. Age-specific prairie dog annual mortality rates under alternative conditions of enzootic or non-enzootic sylvatic plague. See text for additional details.

Age Class	% Mortality (SD)			
	Gunnison's		White-tailed	
	Females	Males	Females	Males
Non-Enzootic				
0 – 1	52.0 (10.0)	55.0 (10.0)	52.0 (10.0)	55.0 (10.0)
1 – 2	33.0 (5.0)	35.5 (5.0)	33.0 (5.0)	35.5 (5.0)
2 – 3	31.0 (5.0)	48.0 (5.0)	31.0 (5.0)	48.0 (5.0)
3 – 4	13.5 (5.0)	60.0 (5.0)	13.5 (5.0)	60.0 (5.0)
4 – 5	100.0	100.0	100.0	100.0
Enzootic				
0 – 1	52.0 (10.0)	55.0 (10.0)	52.0 (10.0)	55.0 (10.0)
1 – 2	66.0 (5.0)	74.0 (5.0)	66.0 (5.0)	74.0 (5.0)
2 – 3	66.0 (5.0)	60.0 (5.0)	66.0 (5.0)	60.0 (5.0)
3 – 4	60.0 (5.0)	50.0 (5.0)	60.0 (5.0)	50.0 (5.0)
4 – 5	100.0	100.0	100.0	100.0

Inbreeding Depression: *VORTEX* includes the ability to model the detrimental effects of inbreeding, most directly through reduced survival of offspring through their first year. There are no direct data on rates of inbreeding in wild populations of Gunnison's or white-tailed prairie dogs, nor the impacts on demographic rates if it were to occur. Hoogland (1982) postulates that inbreeding is actively avoided among black-tailed prairie dogs. Consequently, we did not include inbreeding effects in this analysis.

Catastrophic Plague Epidemics: In addition to our assumptions about the enzootic nature of sylvatic plague in Colorado prairie dog populations, we included periodic plague epidemics that could have potentially very severe demographic impacts. Catastrophes are singular environmental events that are outside the bounds of normal environmental variation affecting reproduction and/or survival. Natural catastrophes can be tornadoes, floods, droughts, disease, or similar events. These events are modeled in *VORTEX* by assigning an annual probability of occurrence and a pair of severity factors describing their impact on mortality (across all age-sex classes) and the proportion of females successfully breeding in a given year. These factors range from 0.0 (maximum or absolute effect) to 1.0 (no effect), and in the most basic implementation, are imposed during the single year of the catastrophe, after which time the demographic rates rebound to their baseline values.

We assumed that plague epidemics would occur at intervals of 5, 10, or 15 years (equivalent to annual probabilities of occurrence of 0.20, 0.10, or 0.0667). Moreover, we simulated two different levels of severity for a given epidemic, with either 92% (range: 89% – 95%) or 99% (range: 98.5% – 99.5%) of the total population killed by the epidemic. The variability in plague severity was accomplished by writing simple functions in *VORTEX* that included normal distributions around the specified mean severity.

Finally, an additional set of models was developed in which we assumed a specific level of plague management in a given prairie dog colony. This management takes the form of dusting the colonies with chemicals that reduce the numbers of fleas in the colony and, hence, the rate of transmission of the infectious agent among prairie dogs. The efficacy of this dusting was simulated through a reduction of the severity of a given epidemic down to 80% (range: 77% – 83%) in the year that an epidemic was deemed to occur.

Initial Population Size: Our initial baseline simulation models were initialized with a total of 10,000 individuals. As *VORTEX* is constructed assuming an immediate pre-breeding census, all individuals comprising the initial population are at least one year of age. Subsequent models, designed explicitly to investigate the effects of small population size on extinction risk, were initialized with between 25 and 3000 individuals. *VORTEX* distributes the specified initial population among age-sex classes according to a stable age distribution that is characteristic of the mortality and reproductive schedules described previously.

It is important to recognize that the populations simulated here do not correspond to specific known colonies or complexes of Gunnison's or white-tailed prairie dogs in Colorado. In addition, we are focusing our analyses on individual populations (colonies or demographically well-connected complexes) and not on the species as entire entities across the state.

Carrying Capacity: The carrying capacity, K, for a given habitat patch defines an upper limit for the population size, above which additional mortality is imposed randomly across all age classes in order to return the population to the value set for K.

The estimation of a carrying capacity is a very difficult process. The approach taken in this analysis was to assume that most prairie dog populations are not at their long-term ecological carrying capacity and therefore have the opportunity for growth (or decline) from one year to the next. Therefore, we assumed for all models in this analysis that carrying capacity was equivalent to twice the initial population size for a given scenario.

Iterations and Years of Projection: All population projections (scenarios) were simulated 500 times. Each projection extends to 50 years, with demographic information obtained at annual intervals. All simulations were conducted using *VORTEX* version 9.70 (March 2007).

Simulating the Impacts of Human Activity on Gunnison's and White-tailed Prairie Dog Population Dynamics

Once the baseline demographic parameters were established, additional work was directed to determining the mechanisms through which specific human activities within prairie dog habitat may influence the two species' population dynamics into the future. The two primary activities investigated here were shooting and poisoning. Each individual activity is discussed in detail below.

Shooting

We simulated four different levels of shooting-based mortality across all age classes of white-tailed and Gunnison's prairie dog, under current conditions of seasonal closure rules in effect 1 March – 14 June. Specifically, we assumed that 5%, 10%, 15% or 20% mortality is imposed across all age-sex classes in addition to the baseline mortality rates discussed above.

Then, to investigate the impact of removing the current seasonal closure rules, we impose the same simulated additions to mortality while also decreasing the percentage of adult females that successfully wean a litter. This is because shooting during the current closure season will lead to removal of pregnant females and those dependant young that lose their mother during this time if she is removed from the population. In particular, we assume that 80% of the shooting mortality occurs during the time period of 1 March to 14 June; therefore, the reduction in the percentage of successful females is 80% of the specified increase in shooting mortality. For example, if shooting imposes an additional 10% increase in mortality, then there would be an 8% reduction in the percentage of adult females weaning a litter.

In deriving these values for additional shooting-based mortality, we are not making explicit statements about the extent to which this mortality is additive or compensatory. Our only concern is the total increase in mortality above that which would be expected in the absence of such activity.

Poisoning
The application of various poisons throughout the state can be an effective means of prairie dog population control. Information presented by experts in the field indicate that baited poisons were 75-85% effective while fumigants could be as high as 95%. We simulated the use of these poisons by eliminating a total of 85% of a given simulated prairie dog population in the year of poison application. We also assumed that these poisons were used at two different frequencies: either every three years or every five years. In the intervening years between poison application, demographic rates were assumed to be normal (baseline levels).

Definitions of Simulation Modeling Results

Results reported for selected modeling scenarios include:

$\underline{r_s}$ (SD) – The mean rate of stochastic population growth or decline (standard deviation) demonstrated by the simulated populations, averaged across years and iterations, for all simulated populations that are not extinct. This population growth rate is calculated each year of the simulation, prior to any truncation of the population size due to the population exceeding the carrying capacity.

$\underline{P(E)_{50}}$ – Probability of population extinction after 50 years, determined by the proportion of 500 iterations within that given scenario that have gone extinct within the given time frame. "Extinction" is specifically defined here in our *VORTEX* model as the absence of either sex.

$\underline{N_{50}}$ (SD) – Mean (standard deviation) population size at the end of the simulation, averaged across all simulated populations, including those that are extinct.

$\underline{GD_{50}}$ – The gene diversity or expected heterozygosity of the extant populations, expressed as a percent of the initial gene diversity of the population. Fitness of individuals usually declines proportionately with gene diversity.

Baseline Model Projections

Table 3 gives the summary results from the four baseline models representing the different demographic profiles (combinations of differential reproductive output and mortality rates) discussed in the preceding section. Note that all four scenarios – from the "most optimistic" non-enzootic white-tailed model to the "least optimistic" enzootic Gunnison's model – show rather robust population growth dynamics. More specifically, the white-tailed reproductive profile leads to higher growth rates – suggesting that the higher frequency of weaning litters, even if those litters are smaller on average than those of Gunnison's prairie dogs, leads to more vigorous population growth. Moreover, as expected, scenarios including higher mortality from enzootic plague show lower growth rates than those where plague mortality is absent.

A representative trajectory for a single iteration of the enzootic white-tailed model is shown in Figure 2. Variability in growth rate over the timeframe of the simulation, producing short-term fluctuations in population size of as much as 50%, seems to be realistic when compared to field census data for actual prairie dog colonies or complexes. As a result, we feel comfortable that these four baseline models are good starting points for realistic examinations of future risks among Gunnison's and white-tailed prairie dog populations in the face of human activities that may impact species persistence.

Table 3. Colorado prairie dog PVA. Mean demographic performance across 500 iterations for fifty-year baseline model projections for each demographic profile. "Non-Enzootic" and "Enzootic" refer to alternative mortality schedules in the absence or presence of enzootic sylvatic plague, respectively, while "White-Tailed" and "Gunnison's" denote alternative descriptions of reproductive performance. Initial size of each population is 10,000 and carrying capacity is 20,000. See text for additional information on model construction and definitions of result metrics.

Scenario	r_s (SD)	PE_{50}	N_{50} (SD)	GD_{50}
Non-Enzootic White-Tailed	0.084 (0.199)	0.000	19,001 (1519)	0.999
Non-Enzootic Gunnison's	0.039 (0.203)	0.000	18,096 (1871)	0.999
Enzootic White-Tailed	0.055 (0.272)	0.000	17,666 (2537)	0.998
Enzootic Gunnison's	0.026 (0.274)	0.000	16,679 (2766)	0.998

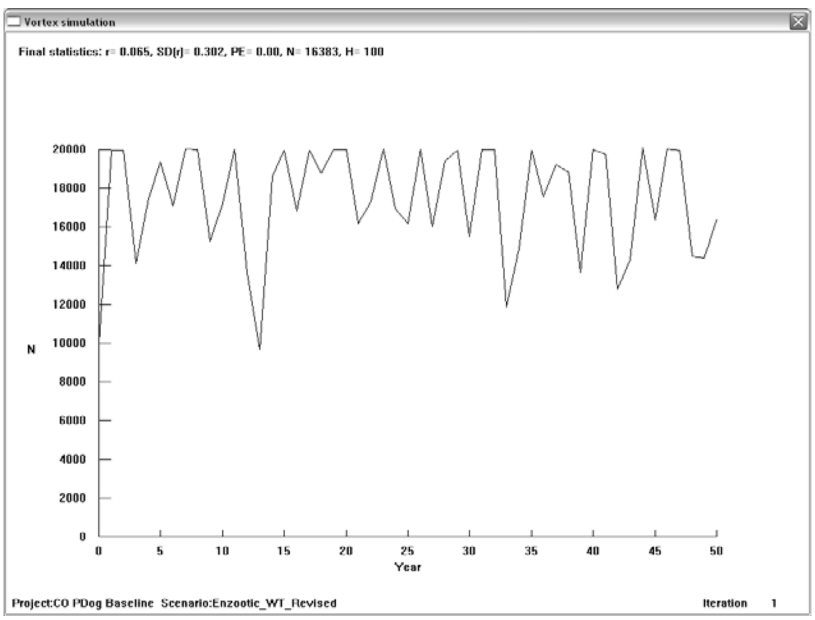


Figure 2. Representative 50-year trajectory for a simulated white-tailed prairie dog population under conditions of enzootic disease (plague) mortality. Variation in population size through time in any single iteration, and average growth rate over many iterations of this dataset, are considered to be realistic in their portrayal of prairie dog population dynamics.

Demographic Sensitivity Analysis

During the development of the baseline input dataset, it quickly became apparent that a number of demographic characteristics of Gunnison's and white-tailed prairie dog populations were being estimated with varying levels of uncertainty. This type of measurement uncertainty, which is distinctly different from the annual variability in demographic rates due to extrinsic environmental stochasticity and other factors, impairs our ability to generate precise predictions of population dynamics with any degree of confidence. Nevertheless, an analysis of the sensitivity of our models to this measurement uncertainty can be an invaluable aid in identifying priorities for detailed research and/or management projects targeting specific elements of the species' population biology and ecology.

To conduct this demographic sensitivity analysis, we identify a selected set of input parameters whose estimates we see as considerably uncertain. We then develop proportional minimum and maximum values for these parameters (see Table 4).

For each of these parameters we construct two simulations, with a given parameter set at its prescribed minimum or maximum value, with all other parameters remaining at their baseline value. With the six parameters identified above, and recognizing that the aggregate set of baseline values constitute our single baseline model, the table above allows us to construct a total of twelve additional, alternative models whose performance (defined, for example, in terms of average population growth rate) can be compared to that of our starting baseline model.

For the entire suite of sensitivity analysis models, we will consider a generic population of 5,000 individuals and a carrying capacity of 10,000 individuals. This population is large enough to be relatively immune from excessive demographic uncertainty that is characteristic of small populations. Furthermore, carrying capacity is large enough to allow for significant population growth and to observe proper demographic dynamics.

The proportional sensitivity of a given simulation model, S, is given by

$$S = [(\lambda_{Min} - \lambda_{Max}) / (0.2 * \lambda_{Base})]$$

Where $\lambda = e^r$ is the annual rate of population growth calculated from the simulation and subscripts *Min*, *Max* and *Base* refer to simulations that include the minimum, maximum, and baseline values of the appropriate parameter, respectively. Using this formulation, model parameters with large S values show strong differences in λ when values are manipulated (modified from Heppell et al., 2000).

Table 4. Uncertain input parameters and their stated ranges for use in demographic sensitivity analysis for a simulated white-tailed prairie dog population under baseline conditions of enzootic disease (plague) mortality. Parameter estimates for mean litter size and % adult females weaning a litter are designated for high / medium / low density conditions, while adult mortality estimates are given for specific age classes, specifically 1-2 year olds / 2-3 year olds / 3-4 year olds. Highlighted rows indicate those demographic parameters that show the highest sensitivity, *S*, as listed in the far right-hand column of the table (absolute values are used in parameter ranking). Stochastic population growth rates for each simulation are not reported here for brevity but are available from the author. See accompanying text for more information.

	Parameter Estimate			
Model Parameter	Minimum	Baseline	Maximum	*S*
% Female Juvenile Mortality	46.8	52.0	57.2	0.155084
Mean Litter Size	5.4 / 4.92 / 2.5	6 / 5.47 / 2.8	6.6 / 6.02 / 3.1	-0.09505
% Adult Females Weaning a Litter	100 / 60.3 / 36	100 / 67 / 40	11 / 73.7 / 44	-0.08008
% Adult Female Mortality	59.4 / 59.4 / 54	66 / 66 / 60	72.6 / 72.6 / 66	0.06006
% Adult Male Mortality	49.5	55.0	60.5	0.025013
% Juvenile Male Mortality	66.6 / 54 / 45	74 / 60 / 50	81.4 / 66 / 55	0.00000

The results of the sensitivity analysis are shown in tabular form in Table 4 and graphically in Figure 3. Those lines with the steepest slope – specifically, juvenile female mortality, mean litter size, and adult female breeding (weaning) frequency – show the greatest degree of response in terms of population growth rate to changes in those parameters and, hence, the greatest sensitivity. These parameters can then be targeted in subsequent field activities for more detailed research and / or demographic management.

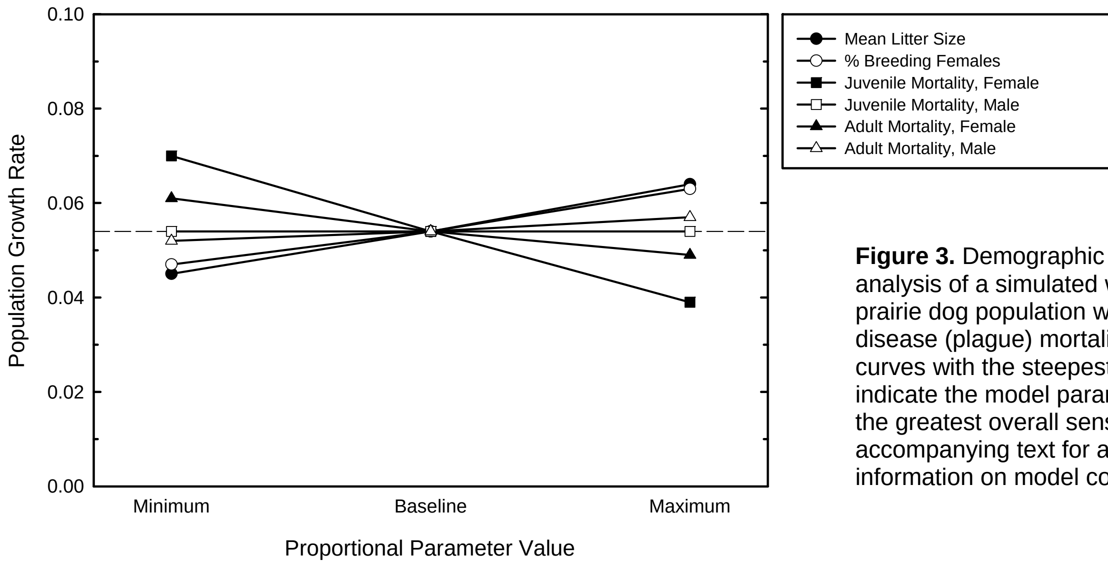


Figure 3. Demographic sensitivity analysis of a simulated white-tailed prairie dog population with enzootic disease (plague) mortality. Those curves with the steepest slope indicate the model parameters with the greatest overall sensitivity. See accompanying text for additional information on model construction.

Risk Analysis I: Impacts of Population Size on Gunnison's and White-Tailed Prairie Dog Population Dynamics

Our results of this analysis, in which population size was varied across a range of 25 to 3000 individuals for each of the four baseline demographic profiles, indicate that Gunnison's and white-tailed prairie dog populations have the capacity for robust population growth in the absence of significant demographic disturbance from either natural or anthropogenic events. For brevity, Table 6 shows results from only one of the four demographic profile model sets: enzootic Gunnison's demographics, the "least optimistic" of the four profiles in terms of population growth potential. Even here, all population growth rates are strong and, with the exception of the smallest population that shows only a very small risk, there is no risk of population extinction among the scenarios.

Table 6. Colorado prairie dog PVA. Output from risk analysis models with different initial population sizes under the enzootic Gunnison's demographic profile. Results for the three additional demographic profile model sets are not shown here, largely because the growth dynamics are even more robust than those presented here. See text for additional information on model construction and output metrics.

Initial Population Size	r_s (SD)	PE_{50}	N_{50} (SD)	GD_{50}
25	0.034 (0.324)	0.006	40 (9)	0.4748
50	0.031 (0.302)	0.000	80 (16)	0.6981
75	0.029 (0.291)	0.000	123 (24)	0.7918
100	0.028 (0.285)	0.000	163 (29)	0.8408
250	0.026 (0.275)	0.000	410 (72)	0.9324
500	0.026 (0.274)	0.000	818 (144)	0.9658
750	0.026 (0.274)	0.000	1229 (204)	0.9770
1000	0.025 (0.273)	0.000	1626 (285)	0.9827
2000	0.026 (0.273)	0.000	3305 (554)	0.9914
3000	0.025 (0.271)	0.000	4970 (824)	0.9942

Despite this negligible risk, it is perhaps worthwhile to note that the smaller populations – in particular, those of no more than approximately 100 individuals – show rather high rates of loss of genetic diversity during the course of the 50-year simulation. While inbreeding and its potential deleterious effects have not been included in this model, there remains the possibility that such low levels of genetic variability in these small populations may lead to longer-term problems for populations that may otherwise show little or no demographic shortcomings in the short-term.

With this set of models as a background, our remaining analyses focus on various natural and anthropogenic processes – specifically, sylvatic plague epidemic, shooting and poisoning – that may compromise the long-term growth potential of Gunnison's and white-tailed prairie dog populations in Colorado.

Risk Analysis II: Impacts of Plague Epidemics on Gunnison's and White-Tailed Prairie Dog Population Dynamics

Our investigation of plague epidemics begins with a method of sensitivity analysis very similar to that discussed in more detail previously. In particular, we constructed a comparative analysis of the sensitivity of our models to variation in either the frequency of the epidemic or the severity of the event. The parameter estimates are given in Table 5, and the graphical results of this analysis are presented in Figure 4.

Table 5. Uncertain plague epidemic input parameters and their stated ranges for use in demographic sensitivity analysis for a simulated white-tailed prairie dog population under baseline conditions of enzootic disease (plague) mortality. Highlighted rows indicate those demographic parameters that show the highest sensitivity, *S*, as listed in the far right-hand column of the table (absolute values are used in parameter ranking). Stochastic population growth rates for each simulation are not reported here for brevity but are available from the author. See accompanying text for more information.

	Parameter Estimate			
Model Parameter	Minimum	Baseline	Maximum	*S*
Epidemic frequency (annual probability)	0.055	0.067	0.080	0.050
Epidemic severity (multiplicative factor)	0.120	0.100	0.080	-0.020

These results indicate that our baseline simulation models are relatively more sensitive to changes in the frequency of plague epidemics in comparison to a similar proportional change in the severity of the same type of event. An increase in the frequency of plague epidemic leads to a reduced ability of the population to demographically rebound following the event. In contrast, if the epidemic is relatively infrequent but more severe the population – if not rendered extinct outright from the epidemic itself – will retain the capacity to rebound rather strongly from the event. This is even more probable given the fact that our models include an increased reproductive output at lower population densities. This feature of the model likely leads to a comparatively more robust prairie dog population at lower densities. But even this advantage can not easily be overcome when catastrophic plague epidemics repeatedly produce dramatic declines in population size with relatively higher frequency.

The management consequences of such a finding require additional discussion. In particular, it will be of value to determine the relative efficacy of management actions designed to reduce the frequency of plague epidemics in comparison to those that may decrease their severity. Economic considerations of the relative costs of alternative management options to achieve a particular outcome are also important.

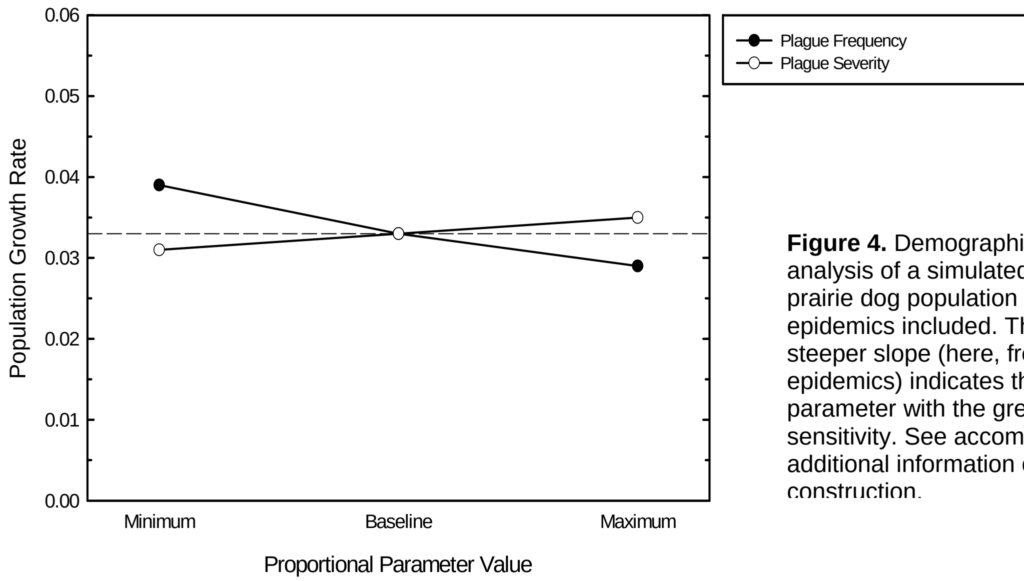


Figure 4. Demographic sensitivity analysis of a simulated white-tailed prairie dog population with plague epidemics included. The curve with the steeper slope (here, frequency of epidemics) indicates the model parameter with the greatest overall sensitivity. See accompanying text for additional information on model construction.

The implications of this plague epidemic sensitivity analysis are plainly evident in Figure 5. The population shows a robust ability to recover from a single epidemic event that eliminates more than 90% of the population, but is unable to withstand repeated epidemics over a short period of time and rapidly declines to extinction in the face of frequent disease events. It is important to remember that the ability of our simulated prairie dog populations to recover from relatively isolated epidemic events is facilitated by the higher levels of reproductive ability at lower population densities. This feature is supported by field observations that document occasional recovery of colonies or complexes following catastrophic declines in numbers of individuals, presumably due to a disease event like plague.

As discussed in the previous section on simulation model input parameters, plague can act as an enzootic mortality factor in addition to creating dramatic population declines through epidemic events. An investigation of the interactions between underlying plague-based mortality and the frequency and

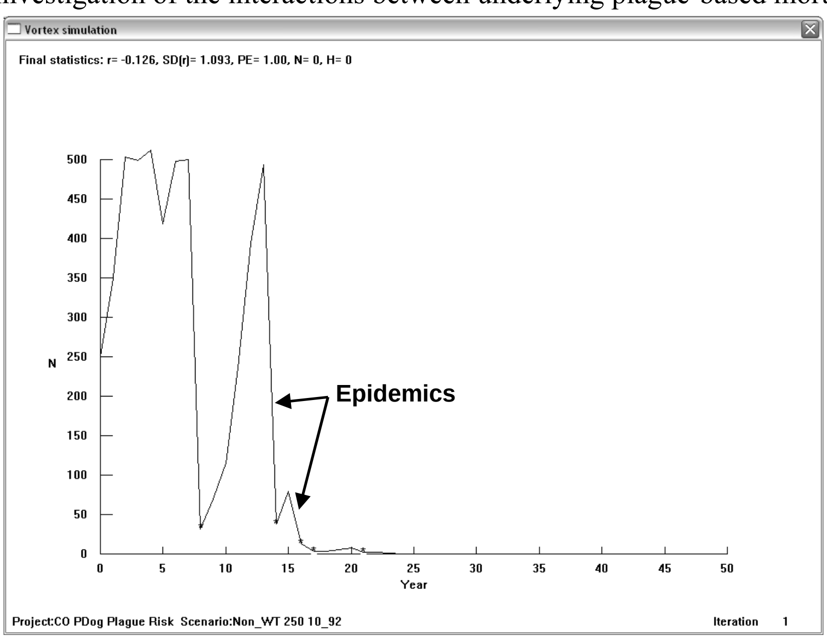


Figure 5. Representative fifty-year trajectory of a simulated white-tailed prairie dog population with the inclusion of plague epidemics (frequency of once every ten years, 92% severity). See text for additional information on model construction.

severity of plague epidemics (Figure 6) leads us to conclude the following:

- When the severity of epidemic plague is relatively mild, the frequency of the epidemics is a major factor in determining the overall risk of prairie dog population extinction. More frequent plague epidemics lead to a much higher extinction risk.
- Very severe plague epidemics – those the eliminate approximately 99% of the population – lead to very high extinction risks even when the frequency of those epidemics is relatively low.
- The presence of enzootic plague affecting the underlying annual mortality rates does not appear to play a significant role in determining the fate of a population exposed to plague epidemics.

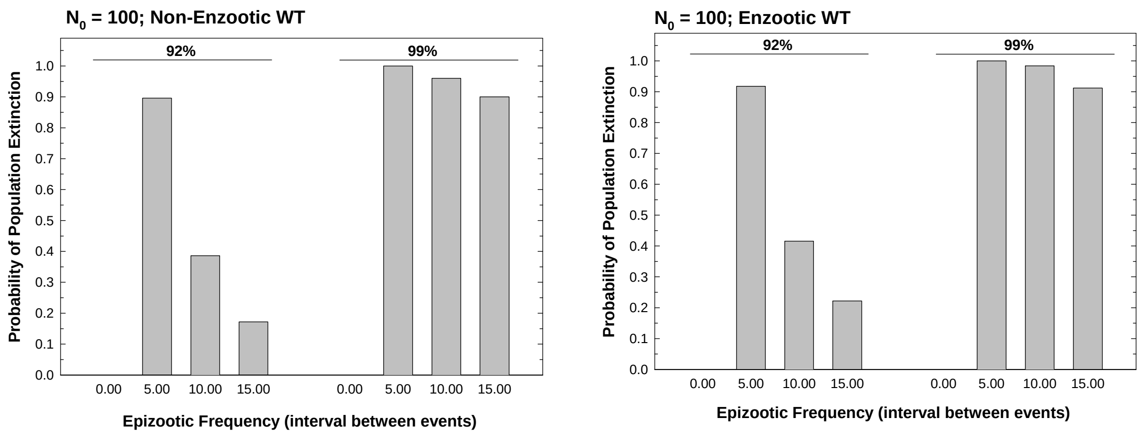


Figure 6. Fifty-year extinction probabilities for a simulated population of white-tailed prairie dogs in the presence of plague epidemics. Initial population size is 100 individuals. Epidemic frequency intervals are in years, and bars are grouped according to alternative assumptions regarding the severity of a given epidemic (92% or 99% of the population eliminated). Gunnison's prairie dog models give very similar results and are therefore not reported here for clarity. See text for additional information on model construction.

Figure 6 shows only those results for a small set of models for white-tailed prairie dogs; models with similar starting parameters and assuming a Gunnison's – type demographic profile show nearly identical results and, therefore, have not been included in the figure for general clarity of presentation. Given the full range of output data reported here, the results are clear: epidemic plague as described here, based on our best estimates of its demographic character, can be a critical factor in determining the long-term persistence of Gunnison's and white-tailed prairie dog populations.

The full body of simulation models constructed to study plague in Gunnison's and white-tailed prairie dogs in Colorado – a total of 360 unique input datasets, each simulated with 500 iterations – can be summarized graphically to give us a more broad picture of the risks posed by this natural process. Each of the four demographic profiles was simulated under alternative assumptions regarding initial population size, plague frequency (defined here as the number of years on average separating each event) and plague severity. The fundamental unit of presentation of the results from these models is a 2 x 5 matrix with the individual cells corresponding to the 10 different initial population sizes making up the analysis (see Figure 7).

25	75	250	750	2000
50	100	500	1000	3000

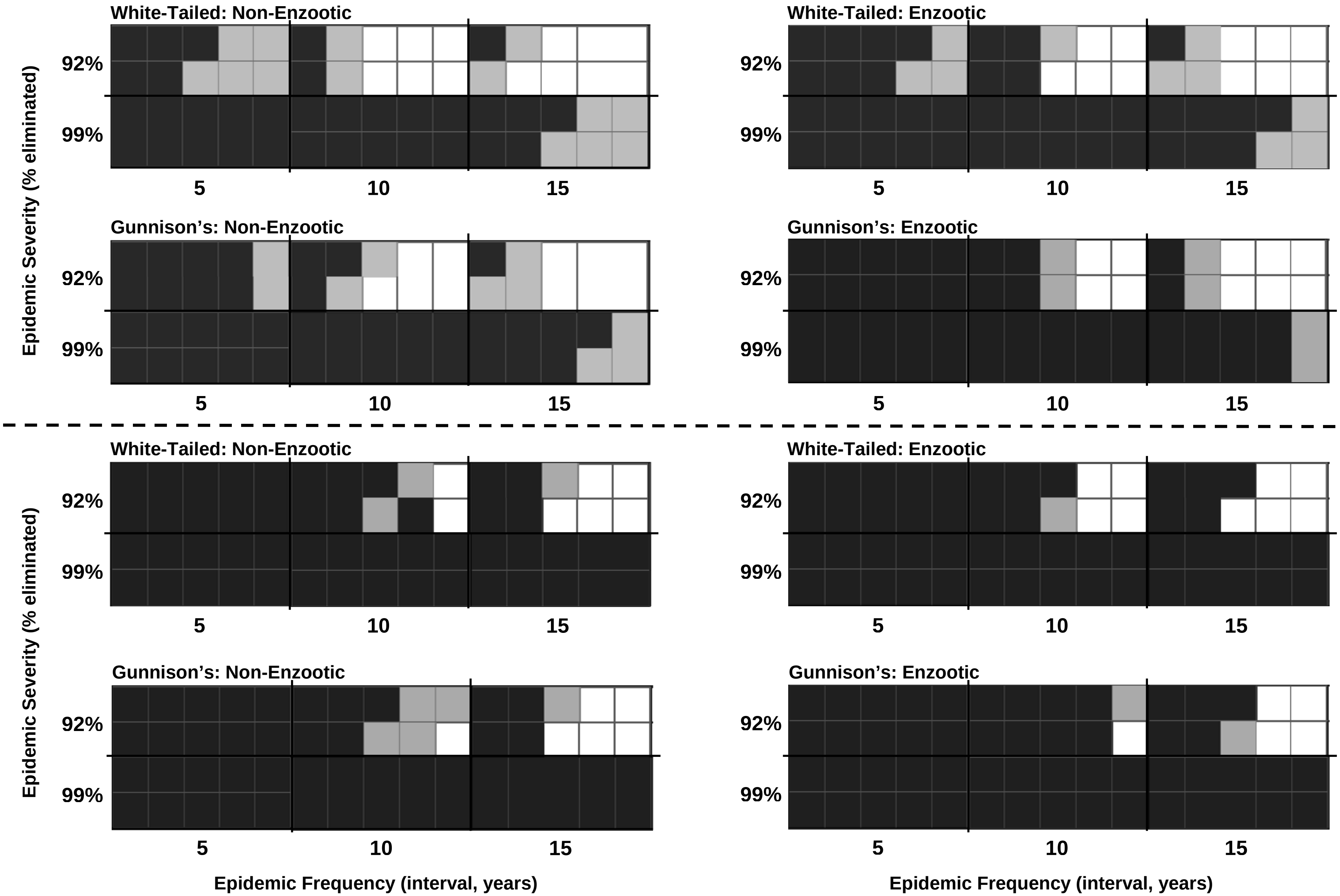
Figure 7. Fundamental unit of presentation of plague models, with each element of the 2 x 5 matrix corresponding to a unique model scenario with a different initial population size ranging from 25 to 3000 individuals. The cells are arranged so that the progression of increasing population size can be read broadly from the upper left to the lower right of the matrix.

These 10-block matrices are then combined within each of the four demographic profiles to produce a composite of the 60 models corresponding to all the combinations of initial population size, plague frequency, and plague severity. These composite matrices are shown in Figure 8.

The color-coded output metric displayed in the top half of figure 8 is a general estimate of extinction risk for a given scenario, with the darkest gray color indicating a "high" risk of extinction (P(E) > 0.50), the light gray a "moderate" risk (P(E) < 0.50), and the white a "low" risk (P(E) < 0.20). With these definitions, we are able to see that both the frequency and the severity of plague epidemics are major factors in determining the risk of prairie dog population extinction. In particular, we are able to see that the underlying demographic profiles are also important factors in governing this risk. Specifically, we see in the non-enzootic white-tailed profile matrix that 33 of the 60 scenarios show a "high" risk of population extinction, while 44 of the 60 scenarios show that same category of risk in the enzootic Gunnison's demographic profile. These two profiles represent the best and worst cases, respectively, for underlying demographic performance in the absence of plague epidemics. Therefore, we can conclude (not surprisingly) that those populations with poorer demographic performance are more vulnerable to extinction from plague epidemics than their more demographically vigorous counterparts.

The mode of presentation of these results in Figure 8 allows us to address an interesting aspect of endangered species management policy in the context of risk assessment. The top half of Figure 8 is constructed using a specific set of thresholds for high, moderate and low levels of risk. In fact, most people would consider these thresholds – including a 20% risk of extinction defined as "low" – to be unacceptably high. Stated another way, these thresholds would typify a highly *risk tolerant* approach, where relatively high risks of extinction are considered acceptable for the purposes of developing management strategies. On the other hand, others involved in risk analysis and interpretation may adopt an approach where only very low levels of risk are considered acceptable. This *risk averse* approach is demonstrated in the bottom half of Figure 8, where the previous thresholds for risk have now been modified so that P(E) > 0.10 is now considered "high", P(E) < 0.10 is "moderate", and P(E) < 0.05 is considered "low". Under these more strict definitions, many more individual modeling scenarios will come out as displaying a high risk of extinction. This is borne out when inspecting the bottom half of Figure 8 for a given demographic profile and comparing it to the top half.

Adopting a relatively more risk-tolerant or risk-averse approach in this situation may have significant consequences for the intensity of management required to achieve a specific goal, often linked to reducing population extinction risk to an acceptable level. A risk-averse approach implies a more intensive management effort, while a greater tolerance for risk allows greater flexibility in developing management options – but at a potentially much higher cost if those options fail. Careful consideration of one's approach to risk, and the willingness to develop management options appropriate to that approach, should be an important component of developing a comprehensive endangered species conservation strategy.


White-Tailed: Non-Enzootic
White-Tailed: Enzootic
Gunnison's: Non-Enzootic
Gunnison's: Enzootic
Epidemic Severity (% eliminated)
92%
99%
5
10
15
White-Tailed: Non-Enzootic
White-Tailed: Enzootic
Gunnison's: Non-Enzootic
Gunnison's: Enzootic
Epidemic Severity (% eliminated)
92%
99%
5
10
15
Epidemic Frequency (interval, years)
Epidemic Frequency (interval, years)

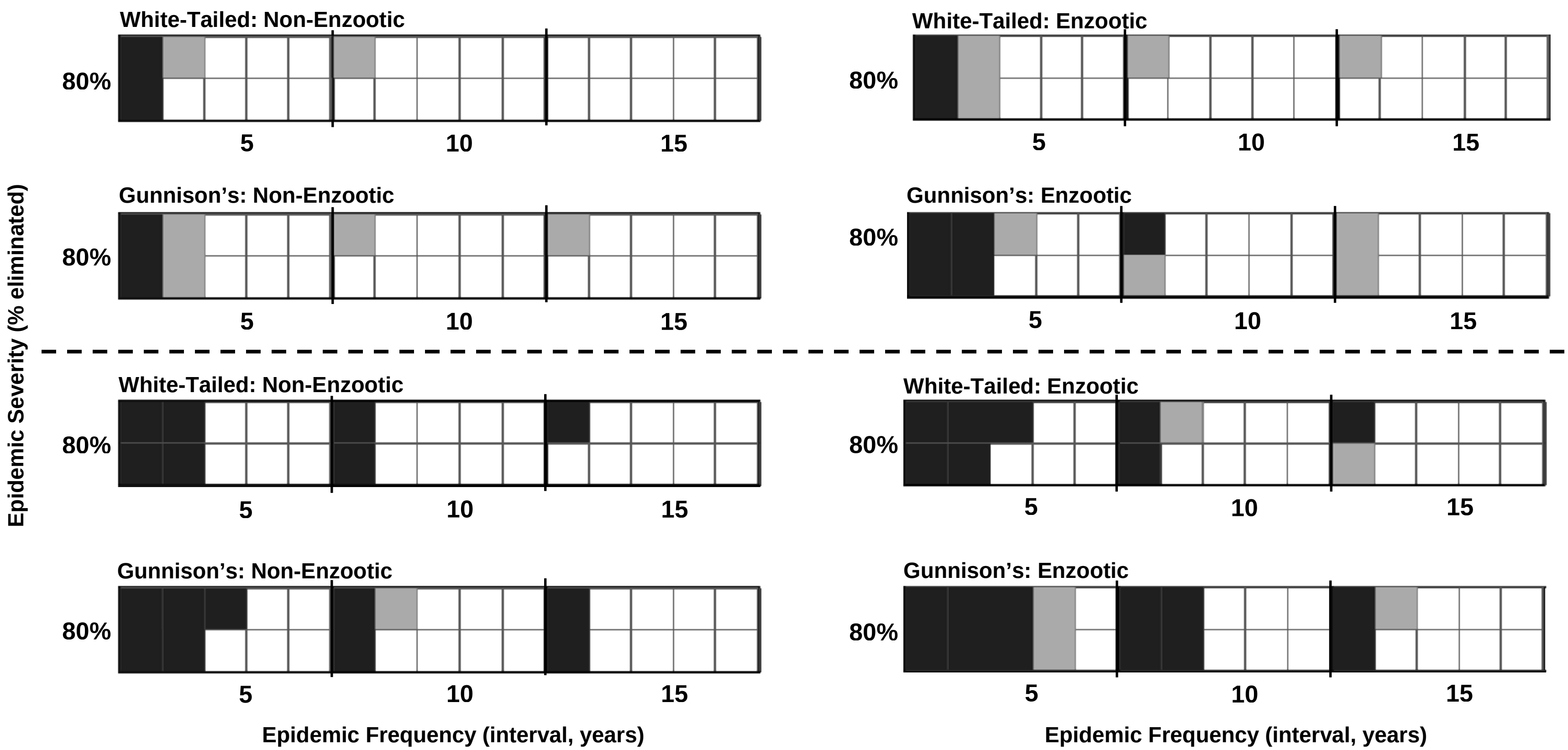


Figure 8 (*preceding page*). Extinction probabilities for models investigating the impact of plague epidemics on simulated prairie dog populations under the four alternative baseline demographic profiles. Each larger matrix is composed of smaller 2 x 5 blocks with each cell corresponding to a model with a specific initial population size (see Figure 7 for more information). The top half of the Figure (separated by the dashed line) assumes a risk-tolerant approach, while the bottom half assumes a more risk-averse approach, both defined by the thresholds for high, moderate and low risk corresponding to the shading in each cell. Top half of the figure (risk tolerant): dark gray, probability of population extinction (P(E) > 0.50; light gray, P(E) < 0.50; white, P(E) < 0.20. Bottom half of the figure (risk averse): dark gray, probability of population extinction (P(E) > 0.10; light gray, P(E) < 0.10; white, P(E) < 0.05.

Figure 9. Extinction probabilities for models investigating the impact of plague epidemics on simulated prairie dog populations under the four alternative baseline demographic profiles and the addition of burrow dusting as a potential means of flea control and, subsequently, mitigation of impacts of plague. Dusting is assumed to reduce the severity of a given epidemic from 92%-99% to 80%, while maintaining the same frequency of events. The top half of the Figure (separated by the dashed line) assumes a risk-tolerant approach, while the bottom half assumes a more risk-averse approach, both defined by the thresholds for high, moderate and low risk corresponding to the shading in each cell. See Figure 8 legend and text for additional information on model construction and interpretation of results.

Next, we investigated the effects that could result from a given level of burrow dusting with chemical agents that could reduce the intensity of plague epidemics down to 80% from the original estimates of 92% - 99%. This particular level of reduction follows from preliminary field observations by Biggins and others of the efficacy of more limited dusting efforts among subsets of individual prairie dog complexes. Figure 9 gives the results from this second set of analyses. As is plainly evident from the Figure, this level of reduction in intensity of epidemics leads to a dramatic decline in the extinction risk of affected prairie dog populations. Although we still see the same general trends as before in the absence of dusting – lower baseline demographic performance and higher epidemic frequency leading to increased relative risk – the overall picture is considerably improved with the addition of dusting as a method for flea control.

It is very important to note here that there is no explicit definition in this analysis of the amount of dusting effort (manpower, financial resources, time, etc.) required on the ground to achieve a given level of mitigation of plague epidemic severity. A separate analysis, outside the purview of this or any PVA, must be undertaken to consider this critical relationship and its implications for prairie dog disease management.

Risk Analysis III: Impacts of Shooting on Gunnison's and White-Tailed Prairie Dog Population Dynamics

Demographic analyses of the impacts of shooting were conducted under the assumptions of (i) continuation of the current seasonal shooting closure or (ii) future retraction of the current seasonal closure.

When the current seasonal shooting closure remains in place (Figure 10), nearly all scenarios except those with the highest levels of shooting-based mortality show positive population growth and low to negligible risk of extinction. The smallest populations – specifically, those of less than about 100 individuals – show some rather aberrant demographic behavior resulting from the relatively large random fluctuations in birth and death rates from one year to the next. In addition, and as seen in previous sections of this analysis, more robust demographic profiles such as the non-enzootic white-tailed models show comparatively higher rates of population growth across all levels of added shooting-based mortality.

When the current seasonal shooting closure is retracted (Figure 11), all scenarios show a decrease in mean stochastic growth rate and, if it were present in the presence of the closure, an increase in the overall population extinction risk. However, the precise extent of this reduced demographic performance is clearly dependent on the underlying demographic profile. A more robust profile like that of the non-enzootic white-tailed scenario set show less impact of closure removal than does the set of scenarios defined by the enzootic Gunnison's demographic profile. The bulk of this difference appears to be due to the inclusion of enzootic plague-based mortality in deference to the alternative reproductive output values that define white-tailed vs. Gunnison's scenario sets. Therefore, the impact of shooting on prairie dog population persistence may be tied rather closely to the presence of low-level enzootic plague in these populations – particularly when they are small in size (i.e., < 250 individuals).

Of course, the addition of plague epidemics would dramatically reduce the viability of all scenario sets presented in Figure 10, effectively wiping out any variation in population performance that may result from the underlying demographic profile. As a result, particular scenarios combining the processes of plague and shooting were not developed for this analysis.

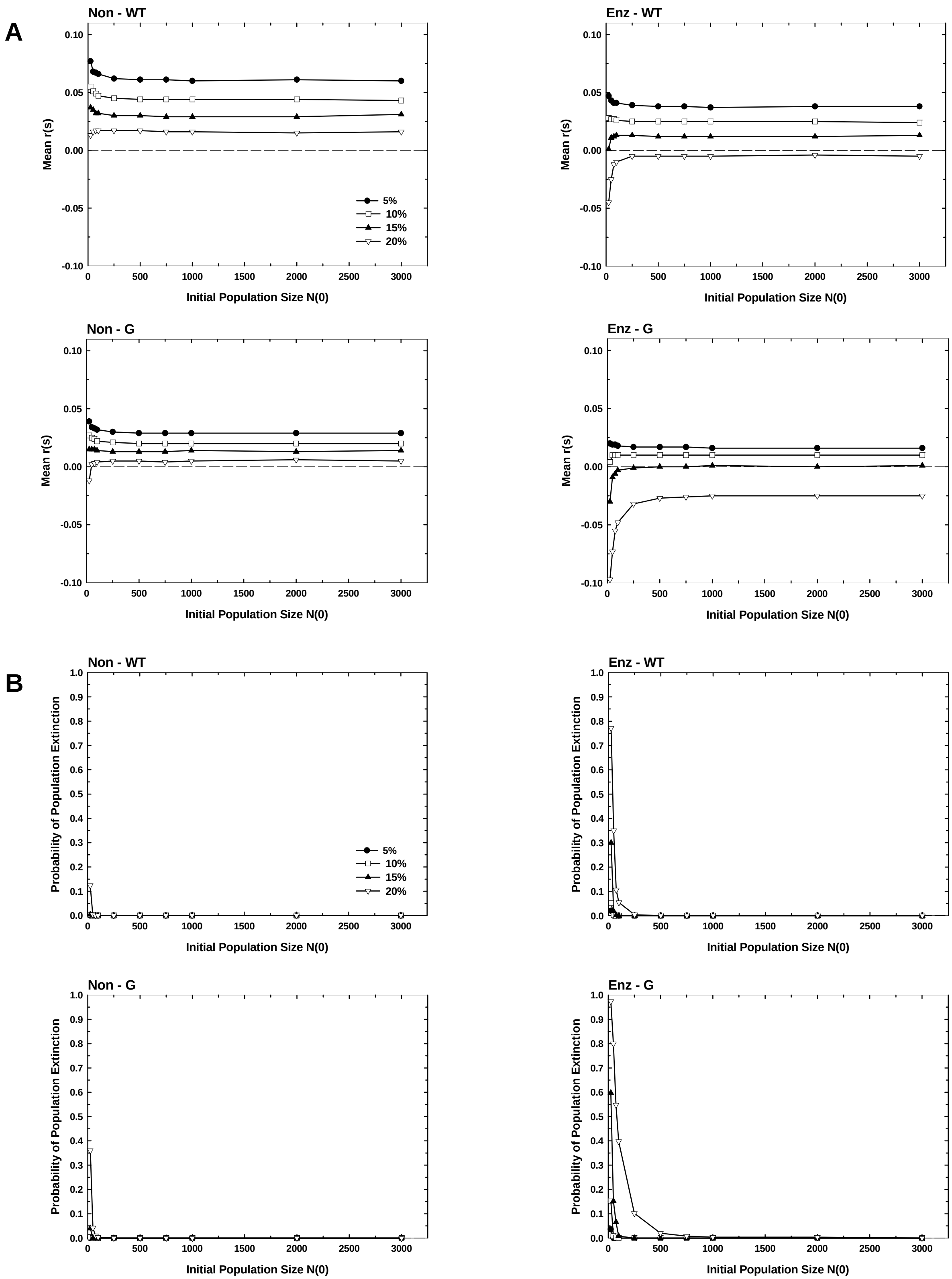


Figure 10. Mean stochastic population growth rate (A) and risk of extinction (B) for simulated populations of prairie dogs in Colorado under increasing rates of shooting-based mortality, and in the presence of the current seasonal closure. See text for additional details of model construction.

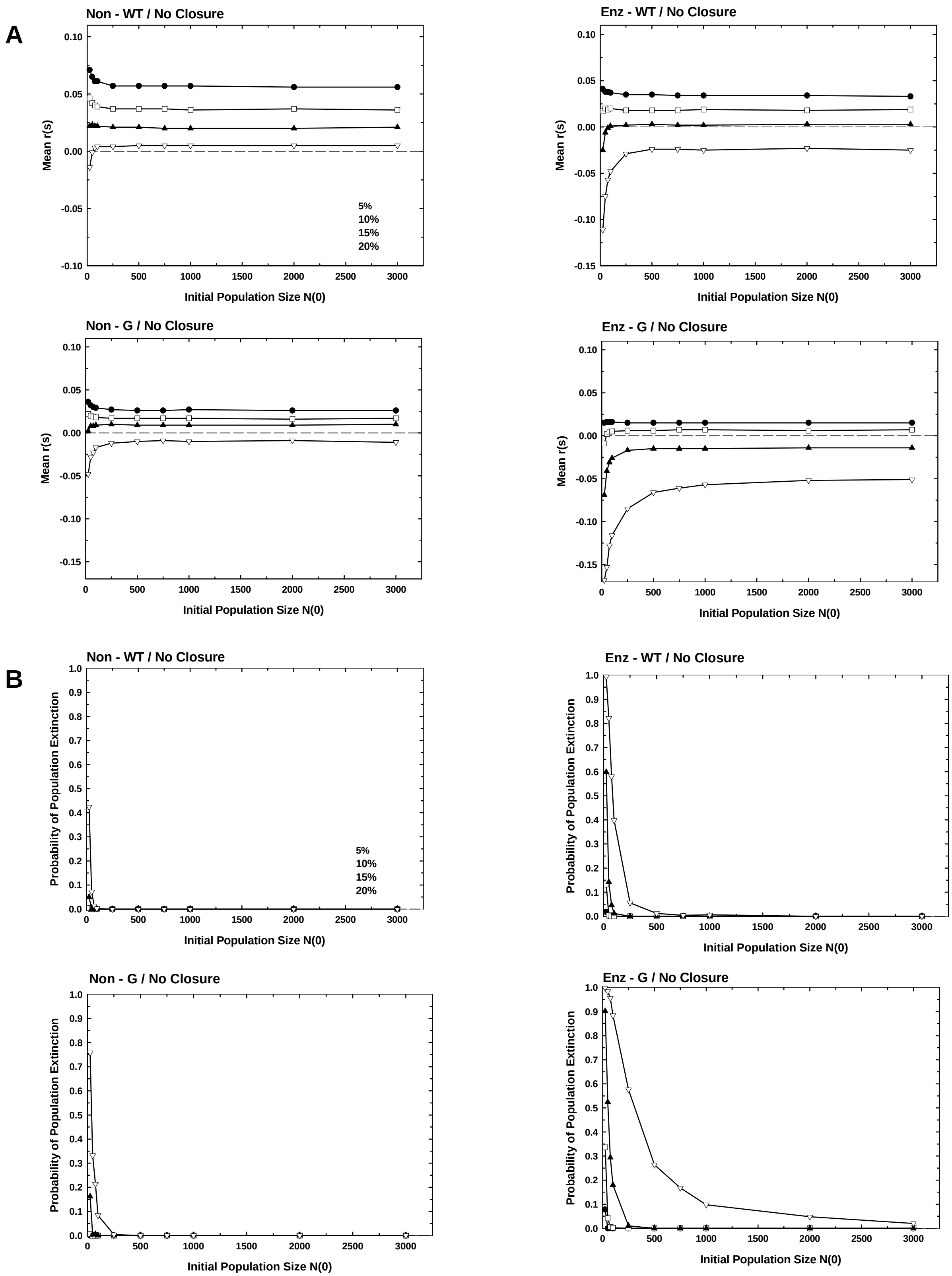


Figure 11. Mean stochastic population growth rate (A) and risk of extinction (B) for simulated populations of prairie dogs in Colorado under increasing rates of shooting-based mortality, and in the presence of the current seasonal closure. See text for additional details of model construction.

Risk Analysis IV: Impacts of Poisoning on Gunnison's and White-Tailed Prairie Dog Population Dynamics

As expected, the periodic application of poison to prairie dog populations, assuming 85% efficacy of the agent, has dramatic effects on their long-term size trajectory (e.g., Figure 12). Due to the underlying robust growth potential inherent in each of the four demographic profiles, less frequent poison application (in our case, every five years) leads to an enhanced opportunity for the population to rebound if still extant. However, Figure 13 shows that even lower frequency poison application leads to very high risks of population extinction over the 50-year time period of the simulation.

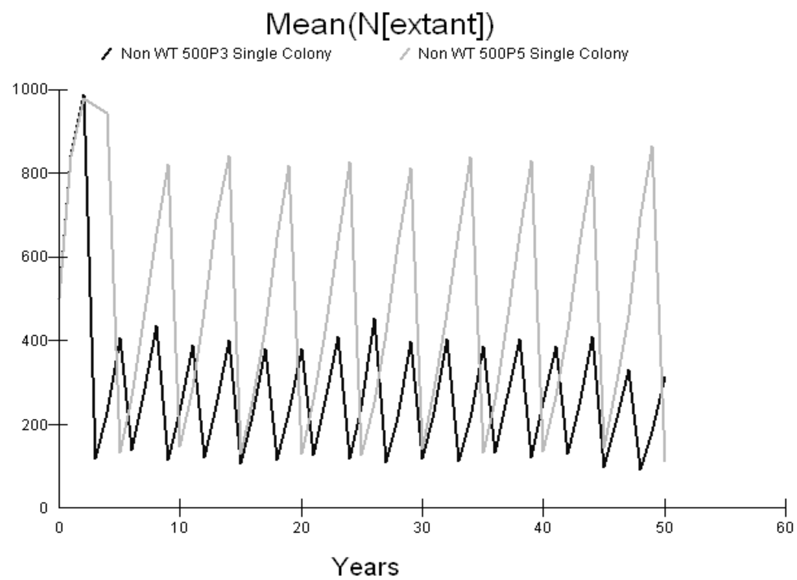
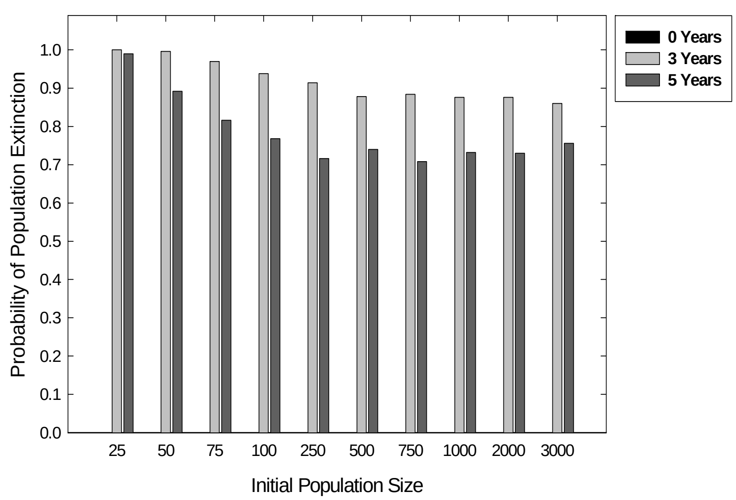


Figure 12. Average extant size of a simulated prairie dog population with a non-enzootic white-tailed demographic profile in the presence of periodic poisoning. The dark line indicates poison application every three years, while the light line indicates application every five years. Poisoning is assumed to 85% effective, resulting in the elimination of 85% of the population during the year of application. Initial population size is 500 individuals. See text for additional information.

Figure 13. Probability of extinction over 50 years for simulated prairie dog populations of different initial size, and exhibiting a non-enzootic white-tailed demographic profile in the presence of periodic poisoning. Light gray bars indicate poison application every three years, while the dark gray bars indicate application every five years. Black bars, indicating no poison application (control), appear absent but merely represent a zero extinction risk in the absence of poison application. See text for additional information.



Additionally, Figure 13 shows that even the largest populations have quite similar extinction risks compared to much smaller populations. This reinforces the field observations of the effectiveness of such agents when applied frequently.

As with other sets of scenarios described here, the results shown in Figures 12 and 13 are for only one of the four demographic profiled constructed at the beginning of this PVA. However, because the non-enzootic white-tailed profile shown here is the most robust demographic performer among the profiles, the remaining profiles will show an even greater level of decline in the presence of periodic poisoning.

Conclusions

We may conclude our analysis of Colorado prairie dog population viability by returning to the original set of questions that provided the foundation for our study.

- *Can we build a series of simulation models with sufficient detail and precision that describe the dynamics of Gunnison's and white-tailed prairie dog populations across Colorado with reasonable accuracy*?

  Our overall demographic analysis, combined with observations from the field, indicates that we are indeed capable of building such models. It is extremely important to remember, however, that reliance on the absolute outcome predicted by any one modeling scenario must always be interpreted with extreme caution due to the inherent uncertainty in model input parameterization. A comparative analysis between models, in which a single factor (or at most two factors) is studied while all other input parameters are held constant, provides a much more robust environment in which alternative management scenarios can be evaluated for their effectiveness in increasing the viability of the target species.

- *What are the primary demographic factors that drive growth of Gunnison's and white-tailed prairie dog populations?*

  Our demographic sensitivity analysis indicates that models of prairie dog population dynamics are most sensitive to rates of juvenile female survival and adult female reproductive success (probability of weaning a litter and mean litter size). If appropriate and/or feasible, research and management efforts could be focused on these aspects of prairie dog biology in order to improve the persistence of selected populations in a conservation management context.

- *How vulnerable are small, fragmented populations of Gunnison's and white-tailed prairie dog in Colorado to extinction under current management conditions? How small must a population become to increase its risk of extinction to an unacceptable level?*

  Current simulations (and field observations) indicate that prairie dog populations, if free from natural or anthropogenic stressors, can show strong demographic dynamics. This greatly reduces the risk of extinction for even the smallest populations on the landscape.

- *What are the predicted impacts of plague on Gunnison's and white-tailed prairie dog populations in Colorado?*

  Plague epidemic events are a major threat to the future survival of prairie dog populations in Colorado, particularly in combination with other stressors present on the landscape. Our models indicate that the frequency of such events is a critical factor in determining the long-term impacts. However, what seems like a relatively modest reduction in the severity of plague epidemics, effected through flea dusting practices, can lead to a dramatic reduction in the long-term impacts of epidemics.

- *What are the predicted impacts of current shooting practices on Gunnison's and white-tailed prairie dog populations in Colorado?*

  Lower rates of shooting-based mortality appear to be sustainable in otherwise demographically robust (i.e., plague-free) prairie dog populations. However, populations appear to become less stable when shooting is practiced during the primary reproductive period when pup production would be compromised.

- *What are the predicted long-term impacts of poisoning practices on Gunnison's and white-tailed prairie dog populations in Colorado?*

  Current poisoning practices greatly reduce the long-term survival of even the largest prairie dog towns. This reduction in viability is, as expected, more acute when poisoning is implemented more frequently.

- *Can we devise reasonable management practices to reduce predicted impacts of these activities on Gunnison's and white-tailed prairie dog populations in Colorado?*

  Overall, results from this analysis suggest that management practices currently proposed for prairie dogs – activities such as flea dusting among prairie dog burrows, seasonal shooting closures, and restrictions in the geographic extent of poison use – can have measurable positive impacts on the long-term viability of prairie dog populations. Careful consideration of extent and scope of selected management options must occur so that conservation of an important prairie resource in Colorado can be achieved within an atmosphere of social, political and cultural acceptance.

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Appendix I:
Population Viability Analysis and Simulation Modeling

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Introduction

Thousands of species and populations of animals and plants around the world are threatened with extinction within the coming decades. For the vast majority of these groups of organisms, this threat is the direct result of human activity. The particular types of activity, and the ways in which they impact wildlife populations, are often complex in both cause and consequence; as a result, the techniques we must use to analyze their effects often seem to be complex as well. But scientists in the field of conservation biology have developed extremely useful tools for this purpose that have dramatically improved our ability to conserve the planet's biodiversity.

Conservation biologists involved in recovery planning for a given threatened species usually try to develop a detailed understanding of the processes that put the species at risk, and will then identify the most effective methods to reduce that risk through active management of the species itself and/or the habitat in which it lives. In order to design such a program, we must engage in some sort of predictive process: we must gather information on the detailed characteristics of proposed alternative management strategies and somehow predict how the threatened species will respond in the future. A strategy that is predicted to reduce the risk by the greatest amount – and typically does so with the least amount of financial and/or sociological burden – is chosen as a central feature of the recovery plan.

But how does one predict the future? Is it realistically possible to perform such a feat in our fast-paced world of incredibly rapid and often unpredictable technological, cultural, and biological growth? How are such predictions best used in wildlife conservation? The answers to these questions emerge from an understanding of what has been called "the flagship industry" of conservation biology: Population Viability Analysis, or PVA. And most methods for conducting PVA are merely extensions of tools we all use in our everyday lives.

The Basics of PVA

To appreciate the science and application of PVA to wildlife conservation, we first must learn a little bit about population biology. Biologists will usually describe the performance of a population by describing its demography, or simply the numerical depiction of the rates of birth and death in a group of animals or plants from one year to the next. Simply speaking, if the birth rate exceeds the death rate, a population is expected to increase in size over time. If the reverse is true, our population will decline. The overall rate of population growth is therefore a rather good descriptor of its relative security: positive population growth suggests some level of demographic health, while negative growth indicates that some external process is interfering with the normal population function and pushing it into an unstable state.

This relatively simple picture is, however, made a lot more complicated by an inescapable fact: wildlife population demographic rates fluctuate unpredictably over time. So if we observe that 50% of our total population of adult females produces offspring in a given year, it is almost certain that more or less than 50% of our adult females will reproduce in the following year. And the same can be said for most all other demographic rates: survival of offspring and adults, the numbers of offspring born, and the offspring sex ratio will almost always change from one year to the next in a way that usually defies precise prediction. These variable rates then conspire to make a population's growth rate also change unpredictably from year to year. When wildlife populations are very large – if we consider seemingly endless herds of wildebeest on the savannahs of Africa, for example – this random annual fluctuation in population growth is of little to no consequence for the future health and stability of the population. However, theoretical and practical study of population biology has taught us that populations that are already small in size, often defined in terms of tens to a few hundred individuals, are affected by these fluctuations to a much greater extent – and the long-term impact of these fluctuations is always negative. Therefore, a wildlife population that has been reduced in numbers will become even smaller through this fundamental principle of wildlife biology. Furthermore, our understanding of this process provides an important backdrop to considerations of the impact of human activities that may, on the surface, appear relatively benign to larger and more stable wildlife populations. This self-reinforcing feedback loop, first coined the "extinction vortex" in the mid-1980's, is the cornerstone principle underlying our understanding of the dynamics of wildlife population extinction.

Once wildlife biologists have gone out into the field and collected data on a population's demography and used these data to calculate its current rate of growth (and how this rate may change over time), we now have at our disposal an extremely valuable source of information that can be used to predict the *future* rates of population growth or decline under conditions that may not be so favorable to the wildlife population of interest. For example, consider a population of primates living in a section of largely undisturbed Amazon rain forest that is now opened up to development by logging interests. If this development is to go ahead as planned, what will be the impact of this activity on the animals themselves, and the trees on which they depend for food and shelter? And what kinds of alternative development strategies might reduce the risk of primate population decline and extinction? To try to answer this question, we need two additional sets of information: 1) a comprehensive description of the proposed forest development plan (how will it occur, where will it be most intense, for what period of time, etc.) and 2) a detailed understanding of how the proposed activity will impact the primate population's demography (which animals will be most affected, how strongly will they be affected, will animals die outright more frequently or simply fail to reproduce as often, etc.). With this information in hand, we have a vital component in place to begin our PVA.

Next, we need a predictive tool – a sort of crystal ball, if you will, that helps us look into the future. After intensive study over nearly three decades, conservation biologists have settled on the use of computer simulation models as their preferred PVA tool. In general, models are simply any simplified representation of a real system. We use models in all aspects of our lives; for example, road maps are in fact relatively simple (and hopefully very accurate!) 2-dimensional representations of complex 3-dimensional landscapes we use almost every day to get us where we need to go. In addition to making predictions about the future, models are very helpful for us to: (1) extract important trends from complex processes, (2) allow comparisons among different types of systems, and (3) facilitate analysis of processes acting on a system.

Recent advances in computer technology have allowed us to create very complex models of the demographic processes that define wildlife population growth. But at their core, these models attempt to replicate simple biological functions shared by most all wildlife species: individuals are born, some grow to adulthood, most of those that survive mate with individuals of the opposite sex and then give birth to one or more offspring, and they die from any of a wide variety of causes. Each species may have its own special set of circumstances – sea turtles may live to be 150 years old and lay 600 eggs in a single event, while a chimpanzee may give birth to just a single offspring every 4-5 years until the age of 45 – but the fundamental biology is the same. These essential elements of a species' biology can be incorporated into a computer program, and when combined with the basic rules for living and the general characteristics of the population's surrounding habitat, a model is created that can project the demographic behavior of our real observed population for a specified period of time into the future. What's more, these models can explicitly incorporate random fluctuations in rates of birth and death discussed earlier. As a result, the models can be much more realistic in their treatment of the forces that influence population dynamics, and in particular how human activities can interact with these intrinsic forces to put otherwise relatively stable wildlife populations at risk.

Many different software packages exist for the purposes of conducting a PVA. Perhaps the most widely-used of these packages is *VORTEX*, developed by the IUCN Conservation Breeding Specialist Group (CBSG) for use in both applied and educational environments. *VORTEX* has been used by CBSG and other conservation biologists for more than 15 years and has proved to be a very useful tool for helping make more informed decisions in the field of wildlife population management.

Strengths and Limitations of the PVA Approach

When considering the applicability of PVA to a specific issue, it is vitally important to understand those tasks to which PVA is well-suited as well as to understand what the technique is not well-designed to deliver. With this enhanced understanding will also come a more informed public that is better prepared to critically evaluate the results of a PVA and how they are applied to the practical conservation measures proposed for a given species or population.

The dynamics of population extinction are often quite complicated, with numerous processes impact the dynamics in complex and interacting ways. Moreover, we have already come to appreciate the ways in which demographic rates fluctuate unpredictably in wildlife populations, and the data needed to provide estimates of these rates and their annual variability are themselves often uncertain, i.e., subject to observational bias or simple lack of detailed study over relatively longer periods of time. As a result, the elegant mental models or the detailed mathematical equations of even the most gifted conservation biologist are inadequate for capturing the detailed nuances of interacting factors that determine the fate of a wildlife population threatened by human activity. In contrast, simulation models can include as many factors that influence population dynamics as the modeler and the end-user of the model wish to assess. Detailed interactions between processes can also be modeled, if the nature of those interactions can be specified. Probabilistic events can be easily simulated by computer programs, providing output that gives both the mean expected result and the range or distribution of possible outcomes.

PVA models have also been shown to stimulate meaningful discussion among field biologists in the subjects of species biology, methods of data collection and analysis, and the assumptions that underlie the analysis of these data in preparation for their use in model construction. By making the models and their underlying data, algorithms and assumptions explicit to all who learn from them, these discussions become a critical component in the social process of achieving a shared understanding of a threatened species' current status and the biological justification for identifying a particular management strategy as the most effective for species conservation. This additional benefit is most easily recognized when PVA is used in an interactive workshop-type setting, such as the Population and Habitat Viability Assessment (PHVA) workshop designed and implemented by CBSG.

Perhaps the greatest strength of the PVA approach to conservation decision-making is related to what many of its detractors see as its greatest weakness. Because of the inherent uncertainty now known to exist in the long-term demography of wildlife populations (particularly those that are small in size), and because of the difficulties in obtaining precise estimates of demographic rates through extended periods of time collecting data in the field, accurate predictions of the future performance of a threatened wildlife population are effectively impossible to make. Even the most respected PVA practitioner must honestly admit that an accurate prediction of the number of mountain gorillas that will roam the forests on the slopes of the eastern Africa's Virunga Volcanoes in the year 2075, or the number of polar bears that will swim the warming waters above the Arctic Circle when our great-grandchildren grow old, is beyond their reach. But this type of difficulty, recognized across diverse fields of study from climatology to gambling, is nothing new: in fact, the Nobel Prize-winning physicist Niels Bohr once said "Prediction is very difficult, especially when it's about the future." Instead of lamenting this inevitable quirk of the physical world as a fatal flaw in the practice of PVA, we must embrace it and instead use our very cloudy crystal ball for another purpose: to make **relative**, rather than **absolute**, predictions of wildlife population viability in the face of human pressure.

The process of generating relative predictions using the PVA approach is often referred to as sensitivity analysis. In this manner, we can make much more robust predictions about the relative response of a simulated wildlife population to alternate perturbations to its demography. For example, a PVA practitioner may not be able to make accurate predictions about how many individuals of a given species may persist in 50 years in the presence of intense human hunting pressure, but that practitioner can speak with considerably greater confidence about the relative merits of a male-biased hunting strategy compared to the much more severe demographic impact typically imposed by a hunting strategy that prefers females. This type of comparative approach was used very effectively in a PVA for highly threatened populations of tree kangaroos (*Dendrolagus* sp.) living in Papua New Guinea, where adult females are hunted preferentially over their male counterparts. Comparative models showing the strong impacts of such a hunting strategy were part of an important process of conservation planning that led, within a few short weeks after a participatory workshop including a number of local hunters (Bonnaccorso et al., 1998), to the signing of a long-term hunting moratorium for the most critically endangered species in the country, the tenkile or Scott's tree kangaroo (*Dendrolagus scottae*).

PVA models are necessarily incomplete. We can model only those factors which we understand and for which we can specify the parameters. Therefore, it is important to realize that the models often underestimate the threats facing the population, or the total risk these threats collectively impose on the population of interest. To address this limitation, conservation biologists must try to engage a diverse body of experts with knowledge spanning many different fields in an attempt to broaden our understanding of the consequences of interaction between humans and wildlife.

Additionally, models are used to predict the long-term effects of the processes presently acting on the population. Many aspects of the situation could change radically within the time span that is modeled. Therefore, it is important to reassess the data and model results periodically, with changes made to the conservation programs as needed (see Lacy and Miller (2002), Nyhus et al. (2002) and Westley and Miller (2003) for more details).

Finally, it is also important to understand that a PVA model by itself does not define the goals of conservation planning of a given species. Goals, in terms of population growth, probability of persistence, number of extant populations, genetic diversity, or other measures of population performance must be defined by the management authorities before the results of population modeling can be used.

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APPENDIX H

Results of Aerial Surveys for Gunnison's & White-tailed Prairie Dogs

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EVALUATION OF AERIAL SURVEYS FOR ESTIMATING ACREAGE OF GUNNISON'S AND WHITE-TAILED PRAIRIE DOGS IN COLORADO AND UTAH

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During November 2002, we (Andelt and Schnurr 2002) reported our assessment of 3 survey techniques, including ground surveys, interpretation of satellite imagery (Sidle et al. 2002), and aerial surveys (Sidle et al. 2001), for obtaining a valid estimate of the distribution and acreage of Gunnison′s prairie dogs (*Cynomys gunnisoni*) in Colorado. We concluded that ground surveys likely would be very difficult, if not impossible to implement for obtaining a valid scientific estimate of acreage of Gunnison′s prairie dogs in Colorado. However, we recognized that ground surveys could be used to provide an estimate of the minimum acreage of Gunnison′s prairie dogs in Colorado. We concluded that satellite imagery is very expensive ($2,000 per 36 mi^2 or $2,880 per 100 mi^2 of digital imagery [John Norman, Natural Resources Ecology Lab, CSU; personal communication]), the imagery would need to be interpreted and verified, activity of prairie dog towns would need to be ascertained on the ground, and it is unknown if the technology would be suitable in rolling terrain. Aerial surveys, using line intercept methodology, have been used to estimate area occupied by black-tailed prairie dogs (*Cynomys ludovicianus*) (Sidle et al. 2001, J. Dennis and F. Pusaterie, Colorado Division of Wildlife; personal communication). We concluded that the technique held promise for estimating acreage of Gunnison′s prairie dogs in Colorado. In this paper, we report on our current progress in evaluating aerial surveys for estimating acreage of Gunnison′s and white-tailed prairie dogs (*Cynomys leucurus*) in Colorado and Utah.

Initially, on 13 June 2002, William Andelt accompanied Jim Dennis and Dave Younkin on an aerial survey of black-tailed prairie dogs to gain additional familiarity with the technique. On 24 June 2002, William Andelt and Larry Gepfert, CDOW, flew over the 32 active Gunnison′s prairie dog colonies reported by Joe Cappodice. With the aid of a GPS unit, all colonies were located, although some of the smaller colonies were somewhat difficult to observe. We ascertained that aerial surveys appear to have potential for establishing distribution of Gunnison′s prairie dogs and that further investigation of the technique was merited. However, because of some difficulty in observing some colonies, we, in collaboration with Gary White, decided that future test flights should also obtain photos of prairie dog colonies; classify colonies as being located in grassland, short shrubs, tall shrubs, or agriculture; rank the colonies as barely detectable, detectable, or highly detectible; and classify colonies as active, inactive, or unknown. Our plans were to use these data to estimate detection probabilities for the various categories of colonies. We then planned to use the detection probabilities to correct acreages of prairie dog colonies observed from the air (White 2002).

Subsequently, during summer 2002, Pam Schnurr and Gary White met with Amy Seglund and Bill Bates, biologists with the Utah Division of Wildlife Resources (UDWR). Both states agreed to coordinate and cooperate to further ascertain the feasibility of aerial surveys to estimate acreage of Gunnison's and white-tailed prairie dogs, and to develop detection probabilities for both species.

Methods

We entered the boundaries of known Gunnison's and white-tailed prairie dog colonies in both Colorado and Utah into GIS Arc/Info. We established 31, 17, 19, and 11 transects across these Gunnison's and white-tailed prairie dog colonies in Colorado and Utah, respectively. These transects were established across known colonies in both states along with a number of control transects (i.e. transects over areas without colonies). Beginning and ending UTM coordinates were ascertained for each transect and placed in a spreadsheet. We hired and trained a ground crew that verified the distribution of all white-tailed prairie dog colonies on the transects in Colorado.

Jim Dennis and Dave Younkin, CDOW, and _____ and _____, from the Utah Division of Wildlife Resources flew all 4 sets of transects and obtained GPS coordinates for the beginning and end of prairie dog colonies on the transects. The crew from Colorado had extensive experience surveying black-tailed prairie dogs, whereas the crew from Utah had extensive experience with aerial surveys of wildlife, other than prairie dogs. The Utah and Colorado survey teams flew the transects in opposite directions.

We plotted the endpoints of the prairie dog colonies that were ascertained by both aerial crews on all transects in GIS Arc/Info. We used Arc/Info to determine the lengths of each colony on each transect and then entered these data in a spreadsheet. We summed the lengths of colonies ascertained on the ground and from the air on each transect. We analyzed these data in SAS using Proc GLM to determine the effect of aerial team, rating of colony visibility, and rating of habitat type on the proportion of colonies observed on aerial versus ground surveys. We censored transects without prairie dogs known on ground surveys, and then used Spearman Correlation (Proc CORR) analyses to ascertain correlations for proportion of colonies observed, ratings of visibility, and ratings of habitat types between the 2 aerial crews. We also used Spearman Correlation analyses to ascertain correlations between ratings of visibility of colonies and proportion of colonies detected, and ratings of habitat types and proportion of colonies detected.

Results

The Colorado and Utah teams overestimated lengths of Gunnison's prairie dog colonies on transects in Colorado and Utah (Table 1). Both teams also overestimated lengths of white-tailed prairie dog colonies on the white-tailed site in Utah. In contrast, the Colorado team underestimated lengths of colonies on the white-tailed site in Colorado. Although the Utah team closely estimated the overall average lengths of colonies on this site, we found considerable variation between total lengths of colonies on transects observed by this team versus those known on the ground. The Utah aerial team ($\bar{x}$ = 5.3; S.E. = 1.11), compared to the Colorado team ($\bar{x}$ = 2.3; S.E. = 0.36), observed a greater proportion of lengths of colonies on transects (Tables 1, 2), however both teams significantly overestimated the lengths of colonies compared to the lengths ascertained on the ground. The proportion of length of prairie dog colonies observed from the air compared to the lengths ascertained from the ground were not related to ratings of visibility nor to ratings of habitat types observed from the air (Table 2).

Proportion of lengths of prairie dog colonies detected by aerial crews from Colorado and Utah were weakly correlated (Table 3). However, ratings of visibility of colonies and ratings of type of habitat found on transects of colonies were not correlated between the Colorado and Utah aerial crews. The 2 crews did not consistently report finding prairie dogs in the same areas along the same transect. This may partially explain the differences between the 2 crews in their ratings of visibility of colonies and rating of habitat types on transects.

Proportions of lengths of colonies detected by aerial crews were not correlated with rating of visibility of colonies on transects (Table 4). The greatest proportions of lengths of colonies were detected by aerial crews on transects described as grasslands followed by transects described as short shrubs and then followed by transects described as tall shrubs (Table 4).

The Colorado team rated prairie dogs on 76% of 51 transects as active, 12% as unknown, and 12% as a combination of active and unknown. The Utah team rated prairie dogs on 28% of 63 transects as active, 2% as inactive, 57% as unknown, and 25% as a combination of active, inactive, and unknown.

Discussion and Recommendations

We recognize a number of goals when inventorying prairie dogs. We believe the most important goal is to obtain accurate and repeatable estimates (i.e. low variation within and among survey crews) of the acreage of Gunnison's and white-tailed prairie dogs. Low variation among survey crews is necessary so that differences between estimates of acreage are actually related to increases or decreases in acreage of prairie dogs rather than differences between crews. Another goal for inventorying prairie dogs is to establish minimum acreages of prairie dogs which we can relate to their status and decisions about listing them as threatened or endangered.

Our goal has been to ascertain the feasibility of aerial surveys for estimating acreage of Gunnison's and white-tailed prairie dogs in Colorado and Utah. We envisioned this as a multistep process. We first flew over known Gunnison's prairie dog colonies and noted that many of the colonies were visible from the air. Next, we arranged aerial surveys by crews from Colorado and Utah to estimate the length of colonies on transects where the distribution of prairie dogs were known to us, but unknown to the crews. Accuracy of aerial surveys was not sufficient to estimate detection probabilities.

We found significant variation between the 2 aerial teams in estimates of lengths of prairie dog colonies on transects, however these estimates were weakly correlated between the 2 teams. Shortly after completing the aerial flights and before data were compiled, Jim Dennis noted that his team likely could have more accurately estimated lengths of prairie dog colonies by conducting some flights followed by ground reconnaissance of the same transects to verify what they were observing from the air (see Appendix 1). We anticipate this training would enhance accuracy of estimates. We recommend that training, or other methods to improve estimates between teams, are needed before broad scale surveys are conducted. The large variation between teams in our study indicate that, without improving accuracy and consistency between teams, it would be difficult to ascertain even moderate changes in acreages of prairie dogs.

The Colorado and Utah teams surveyed the Colorado white-tailed prairie dog site on 20 September and 28 August 2002, respectively. The Colorado team rated 10 of the transects as active and 2 as unknown. The Utah team rated 4 transects as active, 1 as inactive, 5 as unknown, and 4 as active-inactive or active-unknown. We surveyed part of the Colorado white-tailed site from the ground on 23 September 2002 and found very little sign of activity by prairie dogs. Thus, we recommend that ground crews verify ratings of activity on a random sample of future transects. If aerial crews are unable to accurately determine activity, a ground crew will need to verify activity on a random portion of transects on future surveys.

We reviewed potential causes for why estimates of lengths of prairie dog colonies varied between ground surveys and aerial surveys, and between the 2 aerial crews. We closely surveyed the distribution of prairie dogs on the white-tailed sites in Colorado and Utah, but additional verification on the ground is needed for the 2 Gunnison's prairie dog sites to insure that accuracy of ground surveys is not a cause of error.

Coordinates of prairie dog colonies were recorded on the ground and by the Utah team in the NAD27 datum. The Colorado team used the WGS84 datum when they flew the transects. The use of the WGS84 resulted in the Colorado team being 38 to 219 m off the actual transect, depending on the study area and direction of flight (east-west versus north-south). Although we initially suspected that the 38 to 219 m away from transects resulted in some errors, our review of the data suggested that accuracy appeared similar when the airplane was on the transect versus away from the transect. The Utah team strayed over 1,000 m from portions of 4 transects which likely attributed to some errors.

We recognize 2 general approaches (ground vs. aerial surveys) for continuing surveys of Gunnison's and white-tailed prairie dogs. To continue aerial surveys, we recommend that the distribution of prairie dogs is more accurately verified on the ground on the 2 Gunnison's prairie dog sites. If distributions are different than what is currently known, the distribution of prairie dogs on aerial and ground surveys should be compared again. Then, we recommend training aerial crews by conducting flights over short transects over some colonies and then surveying the colonies from the ground so that they can better ascertain what they are observing from the air. After this training, we recommend re-flying the previous transects to ascertain if accuracy can be improved. If accuracy cannot be improved, we recommend discontinuing aerial surveys.

An alternative to surveying prairie dogs from the air would be to continue Pam Schnurr's earlier work of meeting with biologists to plot known distribution of Gunnison's and white-tailed prairie dogs on maps. A ground crew should then verify a random portion of these distributions. Although this alternative likely would cost less than aerial surveys, it likely would underestimate acreage of prairie dogs and would not provide an adequate and repeatable sample for future comparisons. However, this methodology might be sufficient for considerations of listing prairie dogs as threatened or endangered.

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Table 1. Average length (m) of Gunnison's and white-tailed prairie dog colonies, observed from the ground and reported by aerial survey crews from the Colorado Division of Wildlife and the Utah Division of Wildlife Resources, on transects surveyed in Colorado and Utah during August, September, and November 2002.

				Transects		Avg. length of colonies/transect[a]		Proportion of colony length observed[b]		
Area	Species	Team	Date of survey	N	Avg. length	Ground	Aerial	N	$\bar{X}$	S.E.
Colorado	Gunnison's	Colo	9/19-20	31	8,671	264	723	18	2.6	0.65
Colorado	Gunnison's	Utah	10/1	31	8,671	246	1,511	18	8.4	2.57
Colorado	White-tailed	Colo	9/20	17	5,446	1,955	1,202	14	0.7	0.16
Colorado	White-tailed	Utah	8/28	17	5,446	1,955	1,984	14	1.8	0.80
Utah	Gunnison's	Colo	9/23	19	10,660	424	1,770	11	3.5	0.97
Utah	Gunnison's	Utah	8/28	19	10,660	424	3,406	11	7.5	2.09
Utah	White-tailed	Colo	9/24	11	40,403	2,912	9,714	8	2.7	0.85
Utah	White-tailed	Utah	8/26	11	40,403	2,912	5,418	8	1.7	0.44
			TOTAL:							
		Colo		78	12,928	1,045	2,350	51	2.3	0.36
		Utah		78	12,928	1,045	2,626	51	5.3	1.11

[a]Represents average length of colonies known primarily from ground reconnaissance, and estimated from aerial surveys on transects with and without prairie dog colonies.

[b]Represents proportion of length of prairie dog colonies observed from aerial surveys divided by lengths ascertained from ground reconnaissance on transects with prairie dog colonies.

Table 2. Effects of aerial teams[a], ratings of visibility of colonies[b], and ratings of habitat types[c] on proportions of length of Gunnison's and white-tailed prairie dog colonies observed on aerial transects during August, September, and November 2002.

Independent variable	df	F	P
Aerial teams	1	6.79	0.011
Rating of visibility	4	0.57	0.684
Rating of habitat type	5	0.48	0.793

[a]Aerial team from Colorado Division of Wildlife and from Utah Division of Wildlife Resources.

[b]Barely detectible, barely detectible-detectible, detectible, detectible-highly detectible, highly detectible.

[c]Grassland, grassland-short shrub, short shrub, short shrub-tall shrub, tall shrub, agricultural.

Table 3. Correlations between aerial crews from the Colorado Division of Wildlife and the Utah Division of Wildlife Resources for proportions of lengths of prairie dog colonies detected, ratings of visibility[a], and ratings of habitat types[b] on aerial transects of Gunnison's and white-tailed prairie dogs observed during August, September, and November 2002.

	Colorado team			Utah team				
Variable	N	$\bar{X}$	S.E.	N	$\bar{X}$	S.E.	r_s	P
Proportion of colony length detected	51	2.3	0.36	51	5.3	1.11	0.301	0.032
Rating of visibility of colony	30	2.4	0.11	30	2.5	0.10	-0.020	0.916
Rating of habitat type on colony	22	2.2	0.12	22	1.4	0.08	-0.066	0.769

[a]1 = barely detectible, 1.5 = barely detectible-detectible, 2 = detectible, 2.5 = detectible-highly detectible, 3 = highly detectible.

[b]1 = grassland, 1.5 = grassland-short shrub, 2 = short shrub, 2.5 = short shrub-tall shrub, 3 = tall shrub.

Table 4. Correlations between ratings of visibility[a] and proportions of prairie dog colony lengths detected, and ratings of habitat types[b] and proportions of prairie dog colony lengths detected on transects of Gunnison's and white-tailed prairie dogs combined by aerial crews from the Colorado Division of Wildlife and the Utah Division of Wildlife Resources combined during August, September, and November 2002.

	Visibility/Habitat			Proportion of colony detected				
Variable	N	$\bar{X}$	S.E.	N	$\bar{X}$	S.E.	r_s	P
Visibility versus proportion of colony length detected	77	2.4	0.07	77	4.5	0.76	0.038	0.742
Habitat versus proportion of colony length detected	65	1.7	0.07	65	4.3	0.88	-0.246	0.048

[a]1 = barely detectible, 1.5 = barely detectible-detectible, 2 = detectible, 2.5 = detectible-highly detectible, 3 = highly detectible.

[b]1 = grassland, 1.5 = grassland-short shrub, 2 = short shrub, 2.5 = short shrub-tall shrub, 3 = tall shrub.

Appendix 1. Suggestions for Aerial Surveys (from Andelt and Schnurr 2002).

Based upon our flight with Larry Gepfert and suggestions from Jim Dennis and Dave Younkin we have developed a number of suggestions for aerial surveys of Gunnison's prairie dogs and white-tailed prairie dogs:

- Elevation and overall range distributions (Armstrong 1972, Fitzgerald et al. 1994) should be ascertained before aerial surveys are conducted to minimize the area that needs to be surveyed.
- Flight crews should spend at least 1 day on the ground in Gunnison's prairie dog and white-tailed prairie dog towns to become more familiar with the towns before they fly transects. The crews should also gain experience by flying over known colonies. After flying over known colonies, the crew should spend some time on the ground in a colony to better ascertain what they have seen from the air.
- Transects should be constructed along drainages, instead of across drainages, to minimize changes in elevation while conducting surveys. Further, transects should be flown down the drainage, instead of up drainages, to maximize aircraft maneuverability while minimizing danger.

Recommended Plans for Future:

- Complete ground surveys to establish the remaining "known" boundaries for white-tailed prairie dog colony transects already flown in Colorado. Compare known and aerial estimates of the locations of prairie dog colonies to ascertain accuracy of aerial surveys.
- Ascertain if a correction for detection probabilities will need to be employed. This will be primarily needed if the aerial crews were unable to observe a significant proportion of the "known" colonies.
- Determine strata boundaries utilizing recent WRIS mapped activity areas and elevation limits for prairie dogs to minimize the extent of surveys.

- Establish transect lines along drainages and within strata.
- Determine who will conduct aerial surveys in Colorado. We suspect that we will need to contract with a commercial company.
- Ascertain if prairie dog colony activity can be determine from the air. If colony activity cannot be determined from the air, a subset ground sampling technique will need to be established to determine activity. During September field trips to the white-tailed colony in Colorado, we were unable to ascertain activity of many colonies because many prairie dogs apparently entered hibernation early this year due to the drought (Dean Biggins, personal communication).