CONSERVATION AND MANAGEMENT PLAN FOR COLORADO BUTTERFLY PLANT AND PREBLE'S MEADOW JUMPING MOUSE ON F.E. WARREN AIR FORCE BASE

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June 30, 2004

Natural Heritage Program COLORADO

Colorado State University
Knowledge to Go Places

CONSERVATION AND MANAGEMENT PLAN

FOR COLORADO BUTTERFLY PLANT

AND PREBLE'S MEADOW JUMPING MOUSE

ON F.E. WARREN AIR FORCE BASE

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EXECUTIVE SUMMARY

This Conservation and Management Plan for Colorado butterfly plant (*Gaura neomexicana* ssp. *coloradensis*) and Preble's meadow jumping mouse (*Zapus hudsonius preblei*) provides guidance for F. E. Warren Air Force Base (Warren AFB) management decisions over the next five years (July 2004 – July 2009). It is based upon the most current scientific knowledge available. Research is ongoing, however, and this plan should be modified as new information becomes available.

Current Species Status

Colorado Butterfly Plant

In 2000, the Colorado butterfly plant was listed as Threatened under the Endangered Species Act by the U.S. Fish and Wildlife Service (USFWS). It was first documented on Warren AFB, on Crow and Diamond Creeks, in 1978 by Robert Dorn, and later on Unnamed Drainage in 1986. ***Available information indicates that Warren AFB supports the largest known* Gaura *population in the world, as well as the only population on federal lands. The viability of the Base population is critical to the long-term survival and recovery of this taxon.***

The U.S. Air Force began sponsoring research on the *Gaura* population at Warren AFB in 1984. Studies from 1984 – 1986 monitored tagged *Gaura* plants in a series of plots on Crow and Diamond Creeks, determining their reproduction levels, and characterizing soil moisture (Mountain West Environmental Services 1985; Marriott 1989). Researchers began a complete census of flowering *Gaura* plants on Warren AFB in 1986. This research has continued annually from 1988 – 2003 (Heidel 2004a). In addition, demographic monitoring was conducted over part of three growing seasons (Floyd 1995a; Floyd and Ranker 1998). Based on monitoring results, three studies have addressed *Gaura* response to one-time vegetation management treatments (Floyd 1995b; Munk 1999; Munk et al. 2002; Burgess 2003).

Preble's Meadow Jumping Mouse

In May of 1998, the Preble's meadow jumping mouse subspecies (*Zapus hudsonius preblei*) was listed as Threatened under the Endangered Species Act by the USFWS. PMJM was first documented on Warren AFB in 1888 by Bailey (Krutzsch 1954.) URS-Berger (1984) confirmed continued presence of PMJM on Warren AFB. Efforts to capture PMJM on Warren during the summers of 1993 and 1994 were unsuccessful (Compton and Hughie 1993), but the Wyoming Cooperative Research Unit captured two PMJM along Crow Creek within Warren AFB in 1995 (Garber 1995; Elliot 1996; USFWS 1998). In 1996, the Colorado Natural Heritage Program captured eight PMJM along Crow Creek (Schuerman and Pague 1997). Since 1996, the Wyoming Natural Diversity Database (WYNDD), from the University of Wyoming, has trapped drainages

within Warren annually, with captures documented in 1998, 1999, 2002, and 2003 along Crow Creek. Surveys in 1997, 2000, and 2001 failed to capture PMJM (see Beauvais 2004 for summary).

Habitat Requirements

Colorado Butterfly Plant

Gaura grows in the wet meadow zone associated with high plains riparian habitat, on mesic soils that occur on a gradient between the saturated soils along streams and the dry soils of surrounding mixed-grass or shortgrass prairie. This subspecies appears to have definite moisture requirements, and may require shallow subsurface water (MOU 1992). Most populations occur on level or gently sloping sites that are close to (but not directly adjacent to) streams, springs, and seeps. Colonies may be found on stream banks or in old, dry streambeds near the existing channel (Marriott 1987; Fertig 1994, 1998a, 2000). *Gaura* seedlings require an open habitat for establishment. The number and density of rosettes increase under favorable climate conditions (i.e., cool, moist spring weather) when competing forb, grass, and weed cover are eliminated (Munk 1999; Fertig 2000). Although *Gaura* may require an early seral setting, plants do not occur on recently disturbed soil (MOU 1992). Plants are typically not found in areas dominated by woody vegetation such as willow, or in areas of dense vegetation such as occur where noxious weeds invade, except in low numbers or at the margins of such habitat (Fertig 1994, 2000; Heidel 2004a).

Preble's Meadow Jumping Mouse

Preble's meadow jumping mice are typically found in dense riparian vegetation. Known PMJM locations sometimes have a tree overstory, but usually have a well-developed shrub layer and a thick herbaceous layer. Most often the shrub cover consists of willow species (*Salix*), but the species composition seems to be secondary to the overall presence of a mature shrub component. Armstrong et al. (1997) suggested that exotic, invasive plant species do not appear to conflict with PMJM habitat needs. Presence of non-native plants such as Canada thistle (*Cirsium arvense*), toadflax (*Linaria* spp.), and smooth brome (*Bromus inermis*), do not appear to prohibit PMJM from occupying an area; indeed, PMJM have been captured in the center of large Canada thistle stands on Warren AFB in the recent past (Beauvais 1998). However, the long-term impact of monocultures of these and other invasive weeds on PMJM population viability has not been investigated. What seems universally true for meadow jumping mouse habitat is that a dense, herbaceous ground cover immediately proximal to surface water need be present. Most often, PMJM are found in close association with these dense, riparian habitats. Numbers of PMJM captures appear to decrease the further one moves from this characteristic habitat (Corn et al. 1995; Meaney et al. 1996). Based on a study of kidney structure, it is believed that PMJM are dependent upon open water (Wunder 1998), which may explain their close association to these habitats.

Preliminary estimates of habitat use in Colorado indicate that PMJM spend 70% of their time in riparian shrub communities and 30% in upland grasslands, but specific activities in each habitat type are unknown (Schorr 2001). Upland use has occurred during the day as well as at night. Studies in Douglas County, Colorado, suggest that upland grasslands may serve as feeding "hotspots" (Shenk and Sivert 1998). It is clear that PMJM are regularly and consistently using upland grasslands adjacent to riparian habitat, so it seems logical to assume that this habitat type must be important for some life history component(s).

Conservation Issues on Warren AFB

The primary conservation issues for *Gaura* on Warren AFB are related to habitat degradation. Factors that are currently influencing *Gaura* habitat on Warren AFB include encroachment by weeds and willow, other habitat changes associated with idle condition, and changes to both stream flow and groundwater hydrology. ***The most significant long-term threat to Gaura on Warren AFB may be competition from noxious weeds***.

On Warren AFB, the primary issues that should be addressed in order to achieve long-term conservation of PMJM are small population size, isolation of populations, habitat degradation, and potential for catastrophic events.

Conservation Goals and Five-Year Management Objectives

Conservation Goals:

1. **Contribute to the recovery of *Gaura* and PMJM by enhancing the long-term persistence of Warren AFB populations.** This will be accomplished by increasing population size and distribution, which in turn will be accomplished by increasing the coverage, distribution, and connectivity of suitable habitat for each taxon.
2. **At a minimum maintain, and when possible enhance, the ecological integrity of riparian habitat along the Warren AFB portion of Crow Creek and its tributaries, and adjacent uplands.**

5-Year Management Objectives:

1. Ensure that *Gaura* subpopulations persist on all three drainages (Crow Creek, Diamond Creek, and the Unnamed Drainage). Subpopulations in each drainage should be stable or increasing in non-drought years.
2. Increase distribution of PMJM throughout the Warren portion of Crow Creek, primarily by evaluating and mitigating movement barriers and secondarily by enhancing streamside habitat along particular segments.
3. Create or restore habitat to provide PMJM with refugia against catastrophic events on the main stem of Crow Creek. Refugia should be available on at least one tributary

(Diamond Creek or the Unnamed Drainage) within five years. Long-term management objectives should provide for refugia on both tributaries.
4. Eliminate or minimize threats to *Gaura* and PMJM, and associated habitats, within Warren AFB boundaries.
5. Sponsor research and monitoring projects to answer high priority questions, to evaluate the effectiveness of management strategies, and to improve chances of conservation success.
6. Ensure that existing hydrologic function remains intact.

Research and Monitoring Needed

Further research is needed to better understand *Gaura* and PMJM habitat and life history requirements, and response to management. Specific research needs include, but are not limited to:

- Continue annual census of flowering *Gaura* plants.
- Conduct *Gaura* management response research.
- Complete intensive sampling of nonflowering plants and competing species.
- Promote research on *Gaura* life history, competition, and restoration.
- Generate a reliable estimate of PMJM abundance and distribution across Warren AFB, including a high-intensity sampling effort in all potential habitat and capture/re-capture analyses.
- Conduct telemetry research to evaluate PMJM movement and use of space.
- Investigate potential adverse impacts to PMJM from weeds and/or weed control measures.
- Determine habitat patch size parameters for managing *Gaura* and PMJM on the same stream segments (i.e., how small can an opening be and still sustain *Gaura*, and how large can an opening be and still be crossed by PMJM?).

This Plan is organized into five parts:

1. **Introduction** – a brief overview of the project, the planning process, and guiding principles.

2. **Conservation Assessment** – current knowledge on *Gaura* and PMJM ecology and habitat requirements, as well as rangewide reasons for decline and conservation issues on Warren AFB.

3. **Conservation Goals, 5-Year Management Objectives, and Strategies** for protection of *Gaura* and PMJM on Warren AFB.

4. **Conservation Zones** – specific geographic locations on Warren AFB where conservation strategies should be implemented.

5. **Management Areas** – details on status, issues, and recommendations for action on each drainage occupied by *Gaura* or PMJM.

PART 1: INTRODUCTION

This Conservation and Management Plan for the Colorado butterfly plant (*Gaura neomexicana* ssp. *coloradensis*) and Preble's meadow jumping mouse (*Zapus hudsonius preblei*) provides guidance for F. E. Warren Air Force Base (Warren AFB) management decisions over the next five years (July 2004 – July 2009). It is based upon the most current scientific knowledge available. Research is ongoing, however, and this plan should be modified as new information becomes available.

It is recognized that Colorado butterfly plant is a distinct and unique taxon; however, the taxonomic identity of Preble's meadow jumping mouse, and jumping mice on Warren AFB in general, is still somewhat in question (Beauvais 2001, 2003a; Ramey *in review*). For the purpose of this document, we assume that all jumping mice (*Zapus* sp.) in and near Warren AFB are *Z. h. preblei*. This agrees with the current assumptions of the U.S. Fish and Wildlife Service, and thus accurately informs management decisions on Warren AFB until further studies conclude otherwise.

Purpose of the Plan

Formal conservation agreements are required for all U.S. Air Force installations containing Threatened and Endangered species, in accordance with AFI 32-7064 under authority of the U.S. Endangered Species Act. This plan has been developed in support of the goals and objectives set forth in the Threatened and Endangered Species Management Plan, an operational component plan of the Integrated Natural Resources Management Plan for Warren AFB. The primary purpose of this document is to describe the specific objectives and strategies required to secure the long-term conservation of Colorado butterfly plant (*Gaura*) and Preble's meadow jumping mouse (PMJM) within Warren AFB.

Project Overview and the Planning Process

The Colorado butterfly plant was listed as Threatened under the Endangered Species Act in 2000. It was first documented on Warren AFB, on Crow and Diamond Creeks, in 1978 by Robert Dorn, and later on Unnamed Drainage in 1986. *Available information indicates that Warren AFB supports the largest known* Gaura *population in the world, as well as the only population on federal lands. The viability of the Base population is critical to the long-term survival and recovery of this taxon.*

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demographic monitoring was conducted over part of three growing seasons (Floyd 1995a; Floyd and Ranker 1998). Based on monitoring results, three studies have addressed *Gaura* response to one-time vegetation management treatments (Floyd 1995b; Munk 1999; Munk et al. 2002; Burgess 2003).

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In 2003, Warren AFB contracted with the Colorado Natural Heritage Program to prepare a conservation and management plan for the Base populations of *Gaura* and PMJM, in cooperation with WYNDD and the U.S. Fish and Wildlife Service. The planning process involved five steps of analysis, as follows:

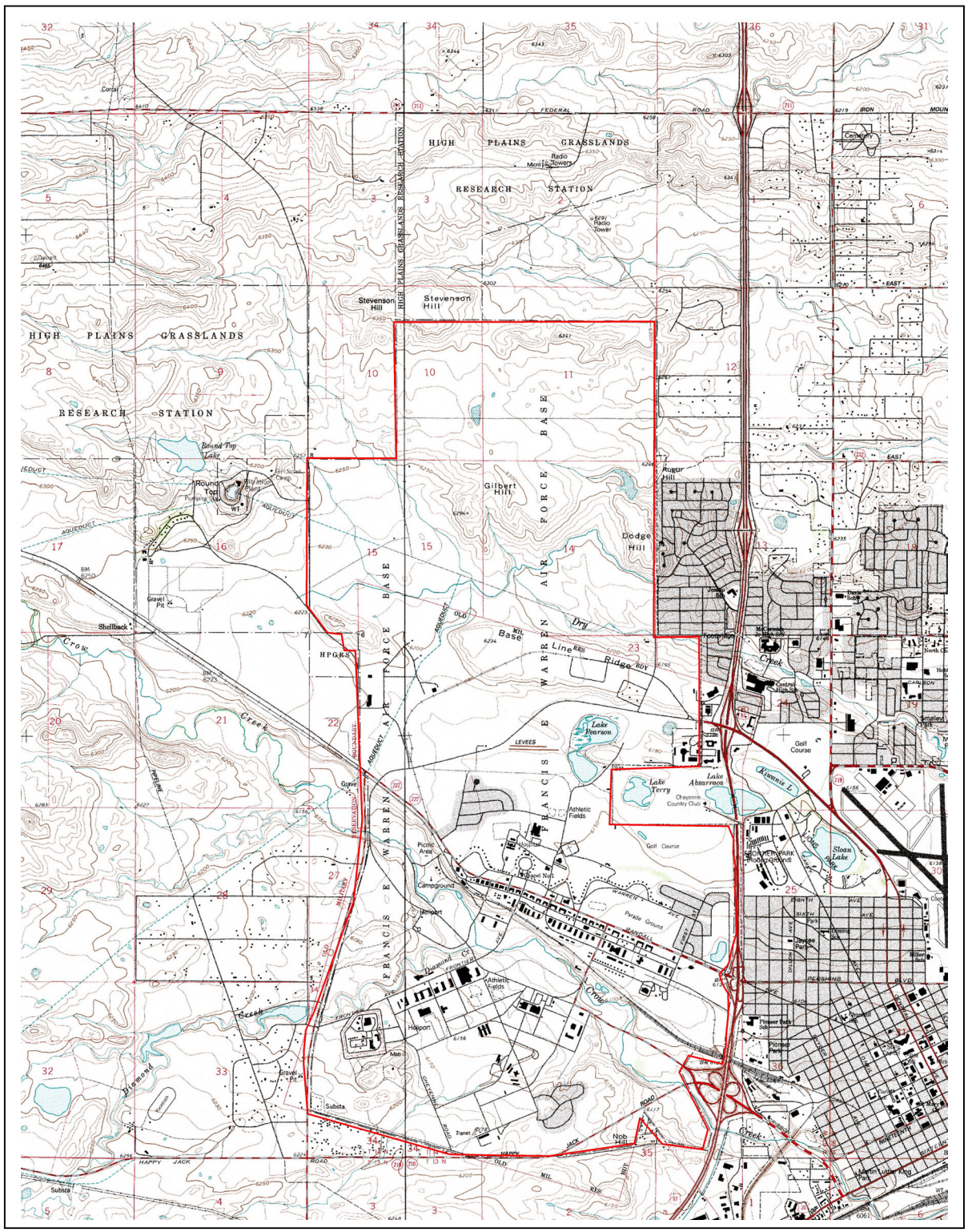
1. **Ecological systems** – Descriptions of the life history and habitat requirements for PMJM and *Gaura*, and the ecological systems that are necessary to sustain the species and their habitats.
2. **Threats assessment** – Identification of the existing threats to the species and their habitats, and planned or potential human activities that could affect management and achievement of conservation goals.
3. **Conservation goals** – Identification of goals to describe the desired condition of PMJM and *Gaura* populations on the Base over the next five years, and to set standards against which conservation success can be measured.
4. **Strategies** – Summary of actions that can be taken to achieve goals, and to eliminate or mitigate threats.
5. **Conservation Zones** – Delineation of specific geographic locations where strategies need to be implemented to achieve conservation goals.

Installation Profile

History and Mission

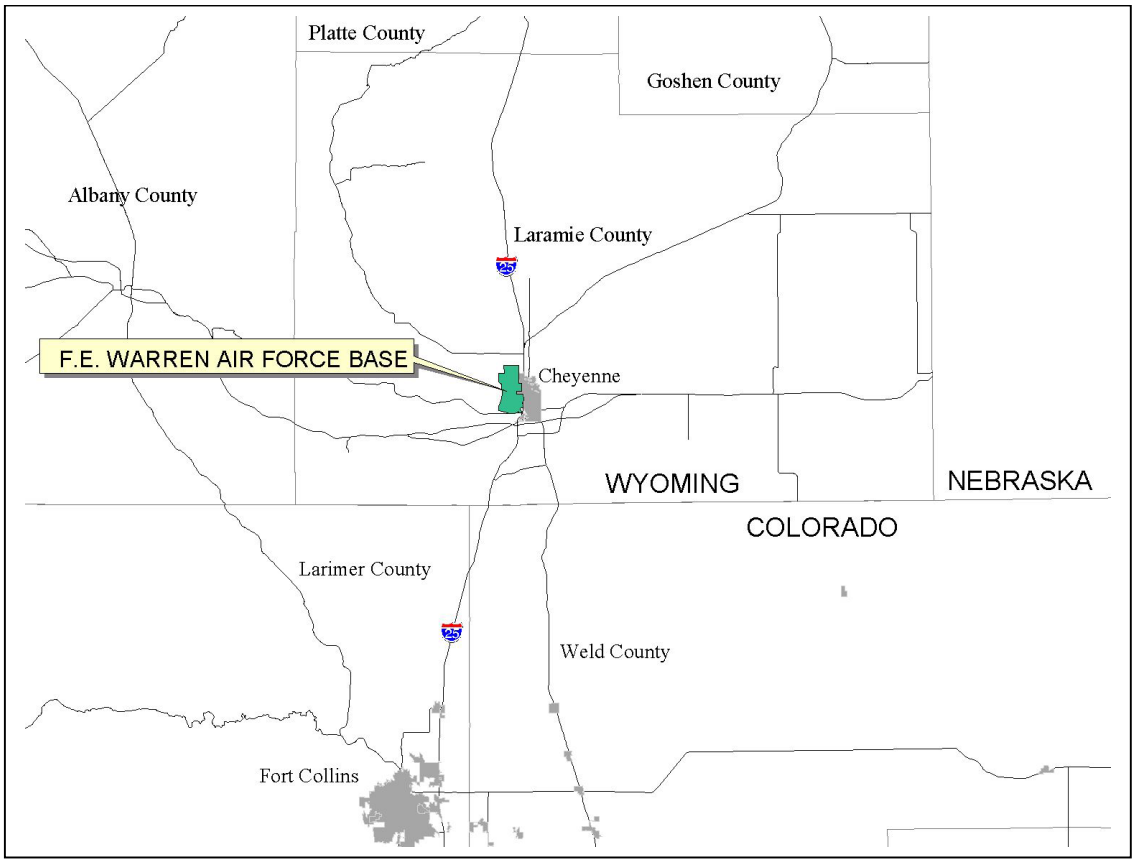
Warren AFB occupies 5,866 acres just west of Cheyenne, Wyoming (Figures 1 and 2). The installation was originally established as an Army post in 1867. Known as Fort D.A. Russell, it hosted artillery, cavalry, and infantry units over the years. During its peak

Figure 1. Warren Air Force Base and surrounding area. Warren AFB is bordered to the east by the City of Cheyenne. Most of the lands to the north, west, and south are open rangeland, but residential and commercial development in these areas is expected to increase.



cavalry occupation, the installation is reported to have housed from 8,000 up to 20,000 horses and mules (Barlow and Knight 1999; Western Ecosystems Technology, Inc. 2001). During World War II, the infantry and artillery units were replaced by the Quartermaster Replacement Training Center. The Air Force assumed control in 1947, and the installation became F.E. Warren Air Force Base in 1949. Warren AFB was used as a training base until 1958, when it was dedicated solely to Intercontinental Ballistic Missile operations. Since 1963, Warren AFB has been responsible for Missile Alert Facilities and Launch Facilities supporting Peacekeeper (currently being deactivated) and Minuteman III missiles deployed over 12,600 square miles in Colorado, Nebraska, and Wyoming (Warren AFB 2004a). The primary mission of Warren AFB is storage and maintenance of missiles for national security (Warren AFB 2001).

Figure 2. General location of Warren AFB.



Natural Setting

Warren AFB occupies generally flat terrain that is comprised primarily of mixed-grass prairie. Historically, dominant native species included blue grama (*Bouteloua gracilis*), western wheatgrass (*Pascopyrum smithii*), needle-and-thread grass (*Stipa comata*), and fringed sage (*Artemisia frigida*) (Samuel and Hart 1994; Barlow and Knight 1999). Crow Creek and its tributaries, including Diamond Creek and an unnamed drainage (hereafter referred to as Unnamed Drainage), flow eastward through the southern portion of the

Base, and constitute the extent of habitat for PMJM and *Gaura* on the Base. Early photographs of the area show shrubs (possibly skunkbush – *Rhus trilobata*, and chokecherry – *Prunus virginiana*) growing along Crow Creek, but no trees (Barlow and Knight 1999). Evidence from archeological excavations suggests that willow (*Salix* spp.) was also present along the creek (Connor 1993; Barlow and Knight 1999).

Vegetation on the Base currently consists of mixed-grass prairie, grasslands dominated by planted crested wheatgrass (*Agropyron cristatum*), riparian bottomlands with willow thickets, dry and wet meadows, and scattered cottonwood trees (Easter and Douglas 1996; Barlow and Knight 1999). The abundance of trees that exist in the riparian zones today probably originated as a result of former transplanting, landscaping, and natural establishment of seedlings from planted trees (Connor 1993; Barlow and Knight 1999). Riparian zones on Crow Creek are now dominated by tall shrubs of coyote willow (*Salix exigua*), with scattered cottonwood (*Populus deltoides*), in association with peachleaf willow (*Salix amygdaloides*), green ash (*Fraxinus pennsylvanica*), boxelder (*Acer negundo*), and the introduced Russian olive (*Elaeagnus angustifolia*) (Barlow and Knight 1999). Portions of Crow Creek also contain beaver ponds, and it is presumed that beaver presence here has varied over the long term with the amount of shrub and tree cover present. While beaver are usually characterized as agents of secondary succession, on a local scale they may elevate groundwater levels to favor vegetation encroachment and succession, and stabilize creek channel meandering. This is countered to some extent by their reduction of woody cover. Diamond Creek and the Unnamed Drainage support less woody vegetation, except in lower reaches of Diamond Creek, where there are patches of willow, wild currant (*Ribes* spp.), and cottonwood near the confluence with Crow Creek. The willow distribution on the Base has been mapped by Jones (2003). In addition, the noxious weeds Canada thistle (*Cirsium arvense*), leafy spurge (*Euphorbia esula*), Dalmatian toadflax (*Linaria dalmatica*), and common hound's tongue (*Cynoglossum officinale*) are prevalent throughout riparian zones and some upland areas. The noxious weed distribution on the Base has been mapped by Heidel and Laursen (2002).

Crow and Diamond Creeks and the Unnamed Drainage are naturally functioning high plains streams (Elliott 1996; Barlow and Knight 1999). However, the Crow Creek stream flow is modified by headwaters reservoirs and the stream course is locally modified by beaver activity. The Diamond Creek stream flow is modified by a drop-structure immediately upstream from the Base. The stream course of the Unnamed Drainage originates on the Base and has no upstream modifications, but may have been modified at the lower end of occupied *Gaura* habitat by a Base road with an elevated roadbed that parallels the stream course.

Cultural Setting and Past Land Use

The eastern boundary of Warren AFB is adjacent to the City of Cheyenne, Wyoming's state capitol and the seat of Laramie County. The most prominent land use east of the Base is urban and suburban residential. Areas north, west, and south of the Base are primarily low-density rural residential and rangeland (Laramie County 2001).

The installation now known as Warren AFB was among the first European-American settlements on the western Great Plains (Barlow and Knight 1999). The establishment of the military post resulted in significant changes in land use and management of the area. Permanent buildings were erected, and several thousand pine trees and cottonwoods were transplanted to the Base from the Pole Mountain area, approximately 36 km to the west. In addition, several thousand horses and mules were housed on the post. The horses and mules were mostly kept in corrals and fed imported hay, so grazing from domestic animals was probably not a significant impact overall. However, portions of the riparian zones were "crowded with horse and mule corrals" (Barlow and Knight 1999). In addition, the edges of riparian zones were used as garbage dumps from the 1870s until after World War II, and riparian vegetation was reduced by mowing and spraying for security reasons until 1989 (Barlow and Knight 1999; Western Ecosystems Technology, Inc. 2001). The location of most of these historic uses has not been documented, so it is unknown whether or not they overlapped with existing occupied riparian habitat for *Gaura* and PMJM. The absence of *Gaura* from the lower (eastern) half of Crow Creek may reflect historic uses, if not habitat unsuitability.

Current Land Use

There are 1,225 buildings and approximately 38 miles of roads on Warren AFB. Buildings and roads are primarily clustered in the southern half of the Base. The highest density of roads and buildings are north of Crow Creek, on the opposite side of the railroad tracks that roughly parallel the Crow Creek corridor. This area includes the Historic District with over 200 historic buildings, a golf course, cemetery, medical clinic, parade grounds, and mixed-use administrative, industrial, and community facilities. To the south of Crow Creek, there are large tracts of open space, an industrial/mission complex (including a helicopter operations complex and weapons storage area) along Diamond Creek, several landfills, a water treatment facility, and a housing complex with associated buildings along the southern boundary of the Base (Warren AFB 2001). There are a few buildings within the floodplain, including the central heating plant and its fuel stores, and the liquid propane tank farm (though the tank farm may be moved in the future). Also, Crow Creek is bordered by railroad tracks on one side and by Missile Drive on the other, and there are several road crossings. The railroad track that borders Crow Creek receives heavy daily use. The General Plan (Warren AFB 2004a) calls for an aggressive program to remove existing facilities from the floodplain, and to utilize the floodplain for open space and outdoor recreation.

The riparian zones along Crow Creek, Diamond Creek, and the Unnamed Drainage are now primarily managed for *Gaura*. In 1982, a Memorandum of Understanding and a management plan to protect *Gaura* on the Base were signed by the U.S. Air Force, the U.S. Fish and Wildlife Service, and The Nature Conservancy. Mowing and herbicide spraying were curtailed in 1989, with the exception of mowing to demarcate Crow Creek recreational zones and riparian habitat. Since 1990, the Crow and Diamond Creek segments occupied by *Gaura* have been managed as a research natural area.

The riparian areas inhabited by PMJM and *Gaura* on Crow Creek are mostly used for outdoor recreation. There is a picnic area, a campground, and a nature trail along the upper portion of Crow Creek, with access via a dirt road. Much of the area along upper Diamond Creek is high security, and access is restricted. The Unnamed Drainage is in a corner of the Base with surrounding developments, but there is limited riparian habitat use. Although human use of the riparian areas is comparatively low, some development activities still occur. Recent examples include flats plowed beside a portion of Crow Creek in 2003; road grading and widening beside occupied habitat along Unnamed Drainage in 2002; and repair of a drop structure upstream of Warren AFB on Diamond Creek in 2001 (Heidel 2004a).

Relationship of this Plan to Other Installation Documents

This Conservation and Management Plan for *Gaura* and PMJM has been prepared in accordance with management objectives set forth in the Threatened and Endangered Species Operational Component Plan (TES Plan) of July 2001. This Conservation Plan should be used in conjunction with the TES Plan, the Fish and Wildlife Management Operational Component Plan (Fish and Wildlife Plan), the Integrated Natural Resources Management Plan (INRMP), and other installation plans. The goals, objectives, and tasks outlined in this document were designed to contribute to the recovery of *Gaura* and PMJM, and to support the policies, goals and objectives of the TES, Fish and Wildlife, and INRMP plans. Those goals and objectives include:

Threatened and Endangered Species Operational Component Plan

Warren AFB policies in the management of federally listed species:

- Utilize an interdisciplinary scientific approach to management, conservation, and recovery of listed species;
- Encourage a healthy and diverse ecosystem including the management and promotion of listed species;
- Support the recovery of listed species through the use of professional wildlife managers with formal academic training in fisheries and wildlife biology and management.

Overall management goals:

1. Protect and conserve populations and habitat for listed species which are native and occur on the Base, specifically, Colorado butterfly plant and Preble's meadow jumping mouse (and other species which may be identified in the future);
2. Provide a framework for management actions for other species of concern and potentially future listed species;
3. Continue to participate in and encourage development of Cooperative Agreements and Memorandum of Understanding activities with Federal, State, and local government and support agencies;

4. Promote and support the scientific study and investigation of listed and potentially listed species management, conservation, and recovery by the academic community and qualified wildlife professionals; and
5. Increase public education and awareness of threatened and endangered species through management actions, a Base Watchable Wildlife Program, and a Prairie Ecosystem Education Center.

Management objectives:

- Contribute to the conservation and recovery of Colorado butterfly plant and Preble's meadow jumping mouse;
- Develop a Conservation Site Plan for Colorado butterfly plant and Preble's in cooperation with USFWS and the University of Wyoming, Wyoming Natural Diversity Database, and other entities with expertise and interest;
- Study the Colorado butterfly plant and Preble's meadow jumping mouse populations on F.E. Warren AFB;
- Support and provide opportunity for Federal and State Agencies and private entities to research and develop programs designed to enhance the understanding and conservation of Colorado butterfly plant and Preble's meadow jumping mouse.

Management actions:

- Continue to annually monitor for the Colorado butterfly plant and Preble's populations on Base through utilization of the latest survey methodology;
- Determine the need for and implement additional studies of Preble's on the Base (e.g., genetic tissue sampling and analysis, resource selection studies) as opportunity and developing science and technology present;
- Continue to implement wetland and riparian enhancement actions within the Crow Creek corridor;
- Develop and implement a Noxious Weed Control Plan for the Base;
- Establish buffer areas and education facilities to restrict public access in Colorado butterfly plant and Preble's meadow jumping mouse habitat;
- Support and cooperate with Federal and State Agencies and private entities in research and programs designed to enhance the understanding and conservation of Colorado butterfly plant and Preble's meadow jumping mouse throughout their ranges;
- Support and encourage study of Colorado butterfly plant and Preble's meadow jumping mouse in off-Base areas to enhance the general knowledge of the species.

Fish and Wildlife Management Operational Component Plan

Overall management goals:

1. Protect and conserve individuals and populations of native plants, fish, and wildlife on F.E. Warren AFB;
2. Preserve and enhance, to the extent practicable, native fish and wildlife habitats on F.E. Warren AFB;

3. Increase public education and awareness of fish and wildlife, and provide opportunities for consumptive and non-consumptive fish and wildlife-oriented recreation on F.E. Warren AFB.

Riparian habitat management objectives:

- Maintain or improve existing riparian conditions;
- Maintain and improve the ecological integrity of riparian areas.

Riparian management actions:

- Explore the possibility of allowing periodic flooding in riparian areas to create new channels and promote cottonwood seedling establishment;
- Limit any loss of riparian habitats;
- Attempt aggressive control of noxious weeds in riparian areas. Control methods should be discussed with the U.S. Fish and Wildlife Service to prevent violations of the Endangered Species Act;
- Prevent grazing in riparian areas except when used to control noxious weeds, and conducted in compliance with the Endangered Species Act;
- Continue to monitor and control beaver populations on Base as needed. Cooperate with Wyoming Game and Fish Department should beaver populations become troublesome and damage to mature cottonwoods becomes excessive.

Integrated Natural Resources Management Plan

The INRMP generally provides the same guidance as the Operational Component Plans. Additional recommendations noted in the INRMP include:

- Avoid unrestricted mowing within 200 feet of wetland, riparian, and floodplain areas;
- Restrict public access within existing and potential habitat for federally listed species;
- Coordinate with other Base programs, such as the Pest Management Program.
- Explore additional biological and non-chemical controls for the noxious weeds.

Overall, conservation of *Gaura* and PMJM will not only benefit the recovery of these listed taxa, but will also benefit the preservation of other native fish and wildlife species that use riparian and associated shrub and grassland habitats. In addition, conservation action targeting protection of *Gaura* and PMJM will help maintain the integrity of that portion of the Crow Creek watershed on Warren AFB lands.

Potential Conservation Issues from Future Projects

The following list of potential future projects was generated in coordination with the Warren AFB Civil Engineering Flight. These projects may involve issues relevant to the conservation of *Gaura* and PMJM if they are implemented in the future. Previously conducted consultations with the USFWS are noted where applicable. Future maintenance and operations of the Base may include any, all, or none of these projects. Furthermore, other projects not identified here may be identified as future Base needs.

Any projects that involve surface disturbance, or alteration of vegetation patterns or hydrological function, within *Gaura* or PMJM habitat should be coordinated with the Base Natural Resources Program Manager.

Storm Water Detention

There is inadequate storm water drainage north of the railroad tracks to effectively move offsite flows from storm events through the Base. The railroad embankment is a major obstacle, and the existing system is under-sized by modern standards. The existing system is not adequate to manage a 10-year storm, which is considered a minor event, and the local area has experienced five 500-year storms in the last century (Warren AFB 2004a). A storm water detention project has been planned for the Base, but has not been funded. The proposed system would include aboveground drainage channels, detention/retention areas, and two major underground systems. The component of the proposed plan that is most relevant to *Gaura* and PMJM habitat is a diversion channel planned for Central Avenue and Missile Drive that would divert 100-year storm flows into Crow Creek. Given that flood events are a significant factor in maintaining the riparian habitat of these species, the effects of this project on riparian habitat will depend strongly on design and implementation. If flood runoff is managed such that floodplain soils are enhanced, erosion is minimized, braided stream channels are maintained, and willow and cottonwood reproduction is encouraged, there could be short-term benefits to *Gaura* (which generally prefers early seral conditions) and long-term benefits to PMJM (which generally prefers late seral conditions). However, runoff that results in soil erosion and stream channelization will likely degrade habitat for both target taxa. Proper implementation of this storm water project is particularly important for Warren AFB because of the limited amount of existing PMJM habitat and its close proximity to the proposed storm water diversion channel in the upper portion of Crow Creek. This project is a high priority for funding via congressional insert, but the likelihood of securing funding is uncertain. Base engineers estimate that 2006 would be the earliest possible implementation date.

Demolition of Building 1260

The proposed plan calls for demolishing Building 1260, hydro-seeding the lot, and returning the area to a more natural state. There are no plans to re-build on this site, or to add additional roads or other access routes. This project site is roughly adjacent to Diamond Creek near a comparatively large patch of *Gaura*. The project site is outside of the 100-year floodplain, and is separated from the creek by an existing road. Therefore, this project is not expected to pose any direct threat to *Gaura* or PMJM. However, the noxious weeds that are prevalent throughout the riparian zones are considered a significant threat, to *Gaura* in particular. Canada thistle and common hound's tongue have been documented between the project site and the *Gaura* stand. Implementing this project in such a way as to avoid any introduction or spread of noxious weeds will be important.

Underground Electrical Cable Installation across Crow Creek

A series of projects is planned to replace overhead electrical lines with underground circuits to improve reliability of power delivery and aesthetics (Warren AFB 2004a). One of these projects traverses PMJM habitat along Crow Creek between South Frontier Road and Old Glory Road. However, project implementation is planned for the time of year when mice are in hibernation, and no disturbance to willow habitat is expected. Warren AFB has already consulted with USFWS on this project, and adverse impacts are not anticipated.

New Road Construction

An extension of Black Powder Road to the Carlin Heights housing complex is planned for fiscal year 2005. The proposed route crosses the Unnamed Drainage. Habitat at this site is not in good condition (the surroundings and lower reaches were bulldozed and recontoured to create artificial wetlands), and there are no documented occurrences of *Gaura* or PMJM. The nearest documented occurrences of PMJM are from 1995 near the confluence of Unnamed Drainage and Crow Creek, but relatively little survey effort has been directed toward this area. Warren AFB has already consulted with USFWS on this project, and adverse impacts to the listed species are not expected. Implementing this project in such a way as to avoid any introduction or spread of noxious weeds will be important.

Helicopter Operations Complex

A helicopter operations complex consisting of several buildings is planned for the area south of Commissary Road between Saber Road and Artillery Road. This project site is located well away from the riparian corridors, and access roads already exist. There are no adverse impacts to *Gaura* or PMJM anticipated.

Expansion of Carlin Heights Housing Complex

Additional housing units and a school are planned adjacent to the existing Carlin Heights housing complex between Unnamed Drainage and Happy Jack Road. Definitive plans should be completed within the year, with construction scheduled for fiscal year 2005. The current development scenario would place the new buildings well outside the riparian zones (at least 400 feet). There are no occurrences of *Gaura* or PMJM documented near this project area, and existing habitat is in poor condition. Existing roads and buildings separate the construction sites from known stands of *Gaura* further upstream. In general, adverse impacts to the listed species are not expected to occur. However, lower Crow Creek to the east of the project site is already infested with several noxious weeds. It will be very important to ensure that implementation of this project does not exacerbate this already troublesome problem.

Landfills 4A, 4B, and 7

Some remedial work is planned for Landfills 4A and 4B to the north of lower Crow Creek, and for Landfill 7 south of Crow Creek between South Frontier Road and Old Glory Road. The proposed remedial actions at Landfills 4A and 4B include excavation and off-Base disposal of unburned waste; removal of surface debris from the area adjacent to Crow Creek to the center of Landfill 4A; regrading of 4A and 4B to eliminate subsidence areas and improve drainage across the site; and reseeding with native vegetation (Warren AFB 2004b). Proposed remedial actions for Landfill 7 include regrading to remove areas of ponding and improve drainage across the site; placement of 12 inches of soil over the entire area to reduce contact with contaminated surface soil; reseeding with native vegetation; and removal of the access road across the site to limit access and use of the site (Warren AFB 2004b). Both of these projects are planned for fiscal year 2004. Warren AFB is currently consulting with USFWS on these projects. Approximately 30 acres of PMJM habitat will be impacted; *Gaura* has not been documented in either project area. Implementing this project in such a way as to avoid any introduction or spread of noxious weeds will be important.

Entry Gate Changes

The primary access to the Base to date has been via Randall Avenue directly into the center of the Base compound and historic district. The Base approved construction of a new Visitor Control Center that would shift most incoming traffic to the south gate at Missile Drive, directly above Crow Creek. Potential redevelopment of both entry gates is now being re-evaluated, with designs currently in the conceptual phase. If the Base entry point shifts to the south gate, the visibility of the riparian corridor will be raised, with a possible increase in recreation traffic and pressure. Also, there would be potential for further spread of noxious weeds.

Potential Transportation Improvement Projects

There are plans to pave the gravel road just northeast of South Frontier Road north of the railroad tracks. The introduction of an impervious surface will increase run-off through the storm water drain and into the Crow Creek drainage. The bridge over the upstream end of Crow Creek may be re-constructed at some point in the future, but there are no current plans. This project site would fall within the best PMJM habitat on the Base. Also, the full length of Missile Drive may be widened in the future to provide for the needs of missile transfer, and the bridge at the east end of Crow Creek replaced. Again, this is a potential future project that has not yet been planned. Winter maintenance on existing roads includes the use of de-icers and gravel. There is potential for deleterious impacts from all of these activities. A programmatic consultation with USFWS for on-going road maintenance along Crow Creek may be warranted.

Renovation of Buildings 660 and 654

The Base is interested in removing the smoke stacks and coal equipment from Buildings 660 and 654 just north of Crow Creek between South Frontier Road and Old Glory Road. Also, it is possible that there are pits underneath the pads. There are no plans currently in place, but if this project were to proceed, it would include a significant excavation component. These buildings are separated from Crow Creek by an existing road, but only a portion of the road is paved. Also, the floodplain along this stretch of creek is fairly narrow, and this project site is essentially wedged between the creek corridor to the south and the railroad grade to the north. There are no occurrences of *Gaura* documented along this stretch of Crow Creek. Occurrences of PMJM have been documented both upstream and downstream, in 1999 and 1998 respectively. There is no funding currently earmarked for this project, so any implementation would be at least two years out. A more realistic estimate of timeline for this project is five years.

Recreational Trail System

There is a conceptual plan to create a recreational trail system on the Base, but potential trails have not been designed. Preparation of an Environmental Analysis is currently underway. One component of the conceptual plan is an elevated trail along Crow Creek. There is no information on when this project might proceed, and it is assumed that the housing and 'downtown' areas would be higher priorities for implementation. Great care should be taken in design and construction of any additional trails along Crow Creek. This project could be accomplished with relatively few direct impacts to *Gaura* and PMJM, and could serve to increase public appreciation for these imperiled resources. On the other hand, numerous potential threats may be associated with trails, including the spread of noxious weeds.

TCE Plumes

There are seven areas between Crow Creek and the southern boundary of the Base where groundwater has been contaminated with trichloroethylene (TCE). These areas, known as TCE plumes, occur adjacent to Crow Creek and along Diamond Creek and the Unnamed Drainage. In 1999, an iron-filings wall was installed at the plume along Diamond Creek. Essentially, the wall works via a chemical reaction that results when TCE contacts the iron filings, causing the contaminants to degrade into non-toxic byproducts (Warren AFB 1999). The monitoring component of this project will determine the effectiveness of the wall, the impact of the wall on surface water chemistry of Diamond Creek, potential impacts to Diamond Creek from byproducts of the remediation process (e.g., pH, iron, chloride, etc.), and effects of the wall on groundwater flow paths (Warren AFB 2004c). Plans for additional remedial actions in FY04 include:

- Plume A1 (along Diamond Creek) – injection of potassium permanganate. The footprint for injection sites will be small (injection equipment will be in a pickup truck), and will be at least 200 feet away from the creek.

- Plume B (flows down gradient from the helicopter pads to Crow Creek) – mitigation will take place in Landfill 7, and will consist of the addition of one foot of cover soil over the landfills to create a barrier between people and hazardous materials.
- Plume C (flows from Buildings 831 – 833 toward Crow Creek) – a bark/mulch berm will be created at the creek. Otherwise, all TCE treatment will be outside the riparian habitat.
- The Zone A plume will receive injections of potassium permanganate at least 200 feet away from the creek. All TCE plume remediation in Zone B is complete. Any remediation for the Zone C plume will be outside the riparian habitat (John Wright, pers. comm.).

Upgrade of FamCamp Facilities

There has been discussion about paving the access road and parking areas at the FamCamp adjacent to Upper Crow Creek. The conceptual plan includes the creation of berms along Crow Creek to mitigate increased runoff from the addition of impervious surfaces. This is a somewhat controversial concept. Proponents of the plan suggest that paving would increase the capacity of the FamCamp, and would lengthen the season during which the facilities are reliably accessible. Opponents of the plan suggest that paving would detract from the natural feel of the place, and result in decreased user satisfaction. Given other priorities, funding will be difficult to secure for this project, and the earliest conceivable implementation date would be fiscal year 2007, if then.

Inadequate Consultation with Environmental Flight

Communication has been inconsistent between the Environmental Flight and other Base work centers relative to potential project impacts on the listed species and their habitats. Some projects have been undertaken in the riparian zones without consultation with the Base wildlife biologist. This situation increases the likelihood that unintended impacts to *Gaura* and PMJM will result. This is especially true for "direct scheduled work," which does not require consultation if the work can be accomplished with less than 50 hours of manpower, or if the work will cost less than $5,000. Development of a "consultation zone" map (i.e., delineating areas where listed species or their habitats occur) would assist Base work centers in determining when it would be advisable to consult with a biologist, whether or not consultation is strictly required. Distribution of this map to all Base work centers that have authority over weed control, new construction, road maintenance, excavation, grading, and trenching activities would be highly desirable.

Guiding Principles

The guiding principles listed below were developed in 1999 by Colorado's Science Advisory Team to guide development of conservation strategies for PMJM (Pague and Grunau 2000). They are synthesized from scientific data or theory pertinent to conservation planning, and are derived from consensus among the conservation biology

community. These guiding principles are equally relevant to the conservation of both PMJM and *Gaura* in Wyoming. Therefore, the strategies in this plan are based on these principles:

1. Larger reaches of habitat containing larger populations are better than the same or smaller reaches with smaller populations.
2. Populations are influenced by adjacent land uses and landscape context. Conservation activities that consider only riparian habitat are inadequate.
3. At a local scale, interconnected or adjacent reaches of habitat are preferable to isolated reaches.
4. Populations geographically well distributed across their native range are less susceptible to extinction than species confined to small portions of the range.
5. Populations representing the range of ecological variability (e.g., elevation, climate, stream order, soils, hydrology, etc.) at local, regional, and rangewide scales are less susceptible to extinction.
6. Populations that are stable or increasing over time are better than populations declining over time.
7. Conservative estimates of population sizes, habitat parameters, and conservation targets preserve options for adaptive management. Decisions based on fewer data warrant more conservative approaches.

PART 2: CONSERVATION ASSESSMENT

Colorado Butterfly Plant (*Gaura neomexicana* ssp. *coloradensis*)

Species Description

Colorado butterfly plant is a short-lived perennial in the evening primrose family (Onagraceae) that grows 2 – 3 feet tall. Plants have one or a few stems that are pubescent and reddish in color, with lance-shaped leaves that have smooth or wavy-toothed margins. Leaves are 2 – 4 inches long, and leaves higher on the stem are smaller and fewer in number than those lower on the stem. Flowers have four white petals, approximately one-half inch wide, that turn pink or reddish with age (Clark and Dorn 1979; Marriott 1987; Fertig 1994) (Figure 3). Only a few flowers are open at any one time (Fertig 1998a). There are eight stamens that curve downward, giving the flowers an asymmetrical appearance (Fertig 1998b) (Figure 4). Fruits are hard and nut-like, four-angled, and sessile (Clark and Dorn 1979; Marriott 1987; Fertig 1994). Non-flowering plants are prostrate rosettes with oblong leaves 1.5 – 8 inches long, mostly glabrous, with entire or toothed margins (Fertig 1998a, 2000).

Figure 3. Colorado butterfly plant
Photo by Walt Fertig

Figure 4. Colorado butterfly plant flower
Photo by S. Mills

Distribution

Gaura is restricted to 23 occurrences over approximately 1,700 acres of habitat (Jennings et al. 1997; Fertig 1998b) in Laramie and Platte counties, Wyoming; western Kimball County, Nebraska; and Weld and Boulder counties in Colorado (the Boulder County population is introduced). Historic native populations from Larimer, Douglas, and Boulder counties in Colorado have been extirpated (Marriott 1987; O'Kane 1988; Fertig 1994; Spackman et al.

1997). Extant occurrences are known only from the Bear, Crow, Horse, Lodgepole, and Spring Creek drainages of the North and South Platte River watersheds (Fertig 1998b). Most populations are on private land. The only populations on federal land, and the largest known, occur on Warren AFB. WYNDD currently defines the Crow and Diamond Creek subpopulations as one occurrence, and the subpopulation on Unnamed Drainage as a separate occurrence. However, genetics work to date suggests that these three occurrences may be more appropriately regarded as parts of one population. A few small populations occur on state or city owned land.

Habitat Requirements

Gaura grows in the wet meadow zone associated with high plains riparian habitat, on mesic soils that occur on a gradient between the saturated soils along streams and the dry soils of surrounding mixed-grass or shortgrass prairie. This subspecies appears to have definite moisture requirements, and may require shallow subsurface water (MOU 1992). Most populations occur on level or gently sloping sites that are close to (but not directly adjacent to) streams, springs, and seeps. Colonies may be found on stream banks or in old, dry streambeds near the existing channel (Marriott 1987; Fertig 1994, 1998a, 2000). *Gaura* seedlings require an open habitat for establishment. The number and density of rosettes increase under favorable conditions (i.e., cool, moist spring weather) when competing forb, grass, and weed cover are eliminated (Munk 1999; Fertig 2000). Although *Gaura* may require an early seral setting, plants do not occur on recently disturbed soil (MOU 1992). Plants are typically not found in areas dominated by woody vegetation such as willow, or in areas of dense vegetation such as occur where noxious weeds invade, except in low numbers or at the margins of such habitat (Fertig 1994, 2000; Heidel 2004a).

Species commonly associated with *Gaura* on the Base include redtop (*Agrostis stolonifera*), smooth scouring rush (*Equisetum laevigatum*), Kentucky bluegrass (*Poa pratensis*), goldenrod (*Solidago canadensis*), wild licorice (*Glycyrhhiza lepidota*), and white prairie aster (*Aster falcatus*) (Laursen and Heidel 2003).

This subspecies occurs on soils derived from sandstones, conglomerates, mudstones and siltstones of the Ogalalla, Tertiary White River, and Arikaree formations (Love and Christiansen 1985; Fertig 1998b). Precipitation in *Gaura* habitat averages 13 – 16 inches annually. Most precipitation is in the form of rain, which peaks in May at the western edge of the subspecies' range, and in July at the eastern edge (Martner 1986; Fertig 1998b). Elevation ranges from 5,000 – 6,400 feet (Fertig 1998a).

Life History

Phenology

Germination and establishment of seedlings can occur over the course of the growing season (Burgess 2003), but is probably concentrated in spring because recruitment is favored by cool temperatures during spring months (Laursen and Heidel 2003; Heidel

2004a). Flowering stems bolt in June. Flowering begins at the end of June or early July, and continues until the first hard frost (late September or early October), with inflorescenses elongating throughout the flowering season (Floyd 1995a). Fruiting occurs from late July through September (Fertig 1994; Fertig 1998b). Flowering is indeterminate and prolonged under favorable conditions, with flowering and fruiting overlapping during the later part of the summer.

Reproductive Biology

Gaura reproduces entirely by seed. Individual plants require at least two years as vegetative rosettes before flowering once, and then dying (Fertig 1998b). Rosettes may need to reach a minimum basal leaf diameter before flowering (Floyd 1995a; Fertig 1996). Data from Warren AFB indicate that approximately one third of all rosettes with a diameter greater than 18cm (7 inches) flower that year. In contrast, virtually no rosettes with diameters smaller than 18cm flower (Fertig 1998b). Flowering plants at Warren AFB accounted for 7 – 11% of the sampled population during the two years of monitoring high-density plots (Floyd 1995a).

This subspecies is pollinated by moths, but is also self-compatible (Floyd 1995a). It appears that the stamens mature prior to the pistil (protandry), which would favor outcrossing. Average fruit production can range from 143 – 483 fruits per plant (Mountain West Environmental Services 1985; Floyd 1995a). Species in the *Gaura* genus are known to produce one to four seeds per fruit (Munz 1938; Fertig 1994). According to data compiled by the Rocky Mountain Heritage Task Force, only one out of every 800 seeds produced on Warren AFB survives to flower.

Seed Germination and Dispersal

Germination and establishment occur from May through September. A period of after-ripening and adequate moisture seem to be required for seed germination. In cultivation, germination is over 50% when seeds have lain dormant for approximately nine months, but is very low when seeds are planted immediately after harvest (Floyd pers. comm. in Fertig 1994). Germination studies show that a two month cold-moist stratification enhances *Gaura* germination (Burgess 2003). Cold, moist springs are optimal for *Gaura* seedling germination, and summer rainfall is important for the recruitment of new plants (Floyd 1995a; Laursen and Heidel 2003; Heidel 2004a). Dry sites on Warren AFB have lower seedling establishment rates than more mesic areas (Fertig 1994; Floyd 1995a).

There is a strong possibility of a seedbank, as indicated by the fact that seeds retain full viability after five years on cold storage (Burgess 2003). Seedbanks may buffer short-lived species from climate extremes, and affect genetic makeup of a population if the plants that flower in any one year represent multi-year cohorts.

Seeds are dispersed within the nut-like fruits. Dispersal mechanisms for fruits are not entirely understood, but transport via floodwaters and muddy animals (including livestock and native ungulates) is possible, in addition to simple gravity dispersal (Fertig

Figure 5. *Gaura* habitat on upper Unnamed Drainage, 1995.
Photo by Walt Fertig

Figure 6. *Gaura* habitat on upper Diamond Creek, 1995.
Photo by Walt Fertig

1994). Fertig (2000) also suggested muddy waterfowl as a possible long-distance dispersal mechanism, based on preliminary findings by Brown (1999) of relatively homogenous genetics across widely spaced populations. However, since populations are often characterized by numerous seedlings and rosettes clustered underneath flowering plants, fruits may not normally be dispersed beyond the immediate vicinity of the parent plant (Fertig 1994; Floyd 1995a). This pattern of recruitment and gravity dispersal maintained relatively static *Gaura* distribution patterns in 2m x 2m plots over three years' time (Floyd 1995a).

Survival and Mortality

The most critical phases in the *Gaura* life cycle are the transition from rosettes to flowering plants, and recruitment (Floyd 1995a; Fertig 1998b, 2000). Summer precipitation, cold winter temperatures, herbivory, and competition with dense native and exotic vegetation may be important factors in seedling establishment and survival (Marriott 1987; Fertig 1994; Fertig 1996; Floyd and Ranker 1998). Floyd and Ranker (1998) reported 47% less seedling recruitment in sample plots on Warren AFB during the drought of 1994 compared to seedling recruitment in the wet summer of 1983. Additional studies suggest that cool, moist springs are optimal for successful germination, and adequate summer rainfall is required for seedling establishment (Floyd 1995a; Laursen and Heidel 2003; Heidel 2004a). Climate conditions, particularly those two years prior to flowering, are at least partially responsible for year-to-year variation in *Gaura* population numbers (Floyd 1995a; Heidel 2004a).

Survival rates from rosette to flowering plant were somewhat low, ranging from 26 – 44% during a 1984 – 1986 study on Warren AFB (Mountain West Environmental Services 1985; Fertig 1994). Intense demographic monitoring documented that it is recruitment into the small rosette stage (combination of early stages that include germination and establishment) that is the most critical phase in determining population trends, followed by the transition from nonflowering to flowering stage (Floyd 1995a). This is strongly supported by the long-term climate correlation analysis (Laursen and Heidel 2003; Heidel 2004a).

Periodic habitat disturbances that maintain short vegetative cover and early seral conditions are important for long-term population survival and establishment of new colonies (Marriott 1987; Fertig 1994; Fertig 1998b, 2001). Research conducted by Floyd (1995b) and by Munk (1999; Munk et al. 2002) at Warren AFB indicates that removal of associated herbaceous species favors increased *Gaura* rosette density, and that monocarpic herbaceous species of grassland riparian communities such as *Gaura* may require removal of above-ground herbaceous cover for reproductive success.

Demography and Population Ecology

Populations of *Gaura* usually occur in patchy colonies comprised of flowering plants (1 – 1,000+), first year seedlings, and 1+ year old vegetative rosettes (Fertig 1994; Fertig 1998a). The only intensive demographic monitoring study (Floyd 1995a) that spanned

the growing season did not tag plants smaller than 3cm, so there are no data to follow development from the smallest stages and evaluate relations between the stages and the ages. Sub-populations are often scattered along 2 – 10 miles of stream channels, with neighboring colonies as much as 1 – 4 miles apart (Fertig 1998b). Sub-populations that are interconnected by suitable habitat within the same drainage are presumed to be genetically linked (Fertig 1998b).

On the Base, *Gaura* is distributed along three confluent streams that span about 1.5 miles of occupied riparian habitat (Figure 9). The total occupied habitat varies from year to year, but cumulative mapping over three different growing seasons documents less than 10 acres total. The riparian corridor habitat on Crow and Diamond creeks is more or less continuous, but the habitat on Unnamed Drainage is isolated from Crow Creek by habitat conversion above its mouth on Crow Creek. Initial genetic studies conducted by Floyd (1995a) and by Tuthill and Brown (2003) indicate that the three sub-populations of *Gaura* on Warren AFB appear to have low levels of genetic variability. However, analysis of the results does indicate some small-scale genetic differentiation in terms of distribution and frequency of alleles. The Crow Creek sub-population in particular seemed to show the most genetic diversity (Floyd 1995a; Tuthill and Brown 2003).

Random sampling on Warren AFB in 1998 found the average ratio of rosettes to flowering stems to be 5:1 (Fertig 1998b), but sampling in particularly dense sub-populations has documented ratios as high as 13:1 (Fertig 1998c). Floyd (1995a) indicates that flowering plants at Warren AFB account for 7 – 11% of the population in her samples of *Gaura* in high-density conditions, which would indicate nonflowering to flowering ratios of 8:1 up to 13:1. However, Floyd (1995a) pointed out that the variability in recruitment from year to year is probably a major factor in trend, and also pointed out that it differs greatly from place to place. However, there were ratios of nonflowering to flowering plants ranging from 0 – 7.25 when rosette densities were sampled within a one meter radius of flowering plants on all three creeks. There may be no fixed demographic relations between nonflowering and flowering plant numbers over space or time.

The number of flowering stems, which can vary widely from year to year, is dependent upon the number of surviving rosettes and level of seedling establishment in previous years (Fertig 1994). The number of flowering and fruiting plants may also be influenced by habitat suitability and climatic factors (Fertig 1994; Floyd 1995a; Fertig 2001). Cool spring temperatures and adequate moisture are important to flowering of rosettes and seedling establishment (Laursen and Heidel 2003).

Populations are best developed in unshaded areas with sparse vegetation (Fertig 1994). Removal of other forbs, grass, and litter can enhance rosette establishment of *Gaura* (Munk 1999; Munk et al. 2002) under favorable climate conditions. Competition with invading species such as willow and Canada thistle may result in severely reduced *Gaura* populations if periodic disturbance does not maintain habitat in an early seral stage (Fertig 1994). One of the high-density *Gaura* study sites mowed by Floyd (1995b) on Crow Creek had 2m tall *Salix* and no persisting *Gaura* several years later (Fertig 2001).

Another of the high-density *Gaura* study sites mowed by Floyd (1995b) on Diamond Creek had 100% cover of Canada thistle and no persisting *Gaura* several years later (Heidel 2004b). The accumulation of dense vegetative cover, litter, and thatch associated with the absence of herbivory and fire may contribute to the decline of rare species such as *Gaura* in rich riparian habitats (Munk et al. 2002; Heidel 2004b).

Domestic livestock and native ungulates, including whitetail deer and pronghorn, graze on *Gaura* (Fertig 1994). Insect herbivory on foliage also occurs, but damage is usually well below 5% of the total leaf area (Fertig 1994). Insects observed on *Gaura* include aphids and the caterpillar of the *Schinia gaura* moth (Fertig 1994). The latter is not known in the state lepidopteran fauna (Shaw, pers. comm. to Bonnie Heidel 2003), and documentation is pending.

Abundance and Trends

Fertig (1998b) estimated the total rangewide number of flowering *Gaura* plants at 47,300 – 50,300 individuals. Including nonflowering plants, there could be 283,800 – 301,800 individuals (Fertig 1998b). Since *Gaura* only flowers once, it is probably more meaningful to focus on flowering plant numbers when estimating abundance. Compared to previous data from 1986 – 1997, Fertig's 1998 data documented increasing numbers in eight previously surveyed populations, including the Crow Creek, Diamond Creek, and Unnamed Drainage populations on Warren AFB. However, 1998 marked the third consecutive year of mild climatic conditions. Estimates from 1998 that are based on surveys of flowering plants in a favorable year may reflect high-end estimates and serve as a benchmark.

The overall long-term trends on Warren AFB show an increase (Laursen and Heidel 2003; Heidel 2004a). This bears out the population growth rate calculations by Floyd and Ranker (1998). However, the long-term trends on the three stream corridors differ. Crow Creek has experienced a long-term decline; its numbers in 2003 were only 10% of those present in 1986, and almost four times lower than any previous census. Crow Creek also provides the only stream corridor habitat associated with a perennial stream on the Base. Fertig hypothesized that perennial stream corridor habitat represents primary *Gaura* habitat compared to habitat along intermittent streams.

The relative contributions of the three stream corridors have changed over time, and highest numbers of flowering *Gaura* plants has shifted between the three streams over time. These shifts suggest that each stream has complementary roles in the support of *Gaura*. *Gaura* numbers on the Base had their peak in 1998. The only synchrony in trend between the three stream corridors was in the pattern of decline from 2000 – 2002 during drought conditions, as indicated by Palmer Drought Severity Index data (Heidel 2004a). It is not clear from the 2003 climate data whether or not the 2000–2002 drought conditions have ended, but the census numbers of 2003 compared to 2000–2002 were -0.06% overall, and -74.6% on Crow Creek, -51.2% on Diamond Creek, and a surprising 183.7% increase on Unnamed Drainage.

Over 55% of all *Gaura* numbers in the Warren AFB 2003 total were located within only two patches, both on the Unnamed Drainage in areas totaling less than 1% of occupied habitat. By contrast, in 2002 the largest concentration of numbers was located within three patches on Diamond Creek, representing 18.7% of all *Gaura* numbers on the Base that year. Over 50% of all patches in all three drainages declined between 2002 and 2003 (Heidel 2004a). This offers clear evidence that the population trends are spatially skewed. The spatial skewing of trend may indicate a need for a pool of high quality habitat to maintain the population. Since there are only two years of data at the patch scale, trend interpretations are preliminary. The nature, trend, and implications of this pattern are yet to be determined.

Research conducted by Floyd (1995b), Munk (1999), Munk et al. (2002), and Burgess (2003) at Warren AFB suggest that the accumulation of dense vegetative cover and litter associated with the absence of herbivory and fire may contribute to the decline of rare species, such as *Gaura*, in rich riparian habitats. Their results imply that a disturbance regime (mowing or fire in the absence of herbivory and major flood events) may be required to reduce native herbaceous cover and maintain the *Gaura*.

Reasons for Rangewide Decline

The primary anthropogenic threats to *Gaura* across its range are related to habitat degradation and destruction. These include indiscriminate spraying of herbicides; increased competition with noxious weeds (especially Canada thistle and leafy spurge); lack of natural disturbance in the habitat leading to denser stands of shrubs (especially willow), grasses, and forbs (particularly as the riparian and associated upland habitat is converted from agricultural uses and developed or fragmented); agricultural practices in areas that are mowed or hayed before *Gaura* plants can set fruit; livestock grazing when stocking rates are high, or livestock are present during the flowering/fruiting season; and habitat conversion to residential development, water diversion, cropland, and roads (Marriott 1987; Fertig 1994; Fertig 1998a; USFWS 2000). *Gaura* appears to have a seedbank, which would buffer it from climate extremes, but naturally occurring (stochastic) temperature and precipitation stress may compound the affects of any other threats. For example, livestock use of riparian habitat may have been magnified in recent drought years, resulting in reduced flowering in *Gaura*.

Gaura Conservation Issues on Warren AFB

The primary conservation issues for *Gaura* on Warren AFB are related to habitat degradation. Factors that are currently influencing *Gaura* habitat on Warren AFB include: encroachment by weeds and willow, other habitat changes associated with idle condition, and changes to both stream flow and groundwater hydrology.

Weed Encroachment

The most significant long-term threat to *Gaura* on Warren AFB may be competition from noxious weeds (Marriott 1989; Fertig 2001; Heidel and Laursen 2002; Heidel 2004b).

Heidel and Laursen (2002) estimate that noxious weeds occupy approximately 180 acres (35.5%) of the 508 acres of riparian habitat on Warren AFB. Distributions of Canada thistle (*Cirsium arvense*) and leafy spurge (*Euphorbia esula*) are the most extensive, followed by Dalmatian toadflax (*Linaria dalmatica*) and common hound's tongue (*Cynoglossum officinale*). There are only 7.4 cumulative acres of occupied *Gaura* habitat on the base (Laursen and Heidel 2003). Heidel and Laursen (2002) reported a negative correlation between distribution of *Gaura* on the Base and dense stands of Canada thistle at a coarse scale. This may be due to competition for light, nutrients, and space, or to allelopathic interactions (Wilson 1981; Heidel and Laursen 2002). Two years of intense sampling data suggest a negative distribution pattern between the number of nonflowering *Gaura* plants and the cover values of both Canada thistle and leafy spurge (Heidel 2004b). In almost all cases, the samples with high nonflowering *Gaura* plants were in settings with low weed cover. Conversely, almost all plots with high weed cover had low nonflowering *Gaura* plant numbers. The data also document the pervasiveness of the problem for *Gaura*. Of the 178 samples taken within a one meter radius around flowering *Gaura* plants on all three stream corridors, only seven were free of noxious weeds or willows. Heidel (2004b) reports noticeable increases in weed cover density, vigor, and extent over the past three years.

Canada thistle is not evenly distributed, but this weed is present throughout all five riparian segments over a total of 108 acres of riparian corridor. Infestations are most severe in Upper Crow Creek and Upper Unnamed Drainage. This species is the most extensive weed in four of the five riparian segments (Upper Crow Creek, Diamond Creek, Upper Unnamed Drainage, and Lower Unnamed Drainage) (Heidel and Laursen 2002). Canada thistle has been observed to be present with 100% cover in portions of the riparian habitat. Invasion of Canada thistle has skyrocketed with road reconstruction adjoining the locales on the Unnamed Drainage where two small areas comprised over 50% of flowering plant numbers in 2003. This incident, and this general pattern of change, may prevent *Gaura* from flourishing locally, and in a worst case scenario, reverse the long-term increasing trend on the Base.

Leafy spurge covers approximately 97 acres of riparian habitat, with the most severe infestations occurring in Upper and Lower Crow Creek. This species is very unevenly distributed, with occupation ranging from 30.6% of riparian habitat in Lower Crow Creek to 0.02% in Upper Unnamed Drainage (Heidel and Laursen 2002). This species is the most extensive weed present in Lower Crow Creek. Leafy spurge has been observed to be present with cover that approaches or reaches 100% in portions of the riparian habitat.

Note that areas that are infested with Canada thistle or leafy spurge, and areas where Canada thistle and leafy spurge overlap, are particularly challenging problems, and should be the highest priority for weed control programs. Consultation with the Cooperative Extension Service and interdisciplinary collaboration are warranted.

Dalmatian toadflax occurs over approximately 88 acres of riparian habitat, and is most extensive in Upper Crow Creek. This species is unevenly distributed, with coverage

ranging from 31.7% of riparian habitat in Upper Crow Creek to 1.2% in Lower Unnamed Drainage. Unlike the other noxious weeds, Dalmatian toadflax is widespread in adjacent uplands (Heidel and Laursen 2002). This is primarily an upland species, and does not occur at 100% cover in the riparian habitat.

Common hound's tongue is the least extensive of the noxious weeds, occupying a total of 51 acres of riparian habitat. Occupation ranges from 14.4% of riparian habitat in Upper Crow Creek to 3.8% in Diamond Creek. This species is the least extensive weed present in Upper Crow Creek, Diamond Creek, and Lower Crow Creek (Heidel and Laursen 2002). Common hound's tongue does not occur at 100% cover in the riparian habitat.

The Federal Noxious Weed Act of 1974, Executive Order 13112 signed in 1999, and the Wyoming Weed and Pest Control Act of 1973 all require that Warren AFB control the noxious weeds that are present throughout the riparian zones. However, weed control on the Base is complicated by several factors: the Air Force has mandated a 50% reduction in pesticide use; the herbicides that are most effective on the noxious weeds present cannot be used in riparian areas; the complete curtailment of weed control in *Gaura* habitat since 1990 has led to increasingly dense and widespread stands of the noxious weeds; and both weed control and failure to control weeds pose potential adverse impacts to PMJM and *Gaura*. Use of sheep and release of biological control agents have been tried with limited success at decreasing noxious weed cover, extent, and vigor. A sustained, long-term effort consisting of several complementary approaches to weed control will be necessary to abate this significant threat.

The treatment that had the highest success in different June clipping treatments was removal of herbaceous and litter cover without Canada thistle removal (Munk 1999; Munk et al. 2002). The treatment that had the highest success in different timing of mowing treatments was July mowing with or without fall application of clopyralid to reduce Canada thistle cover (Floyd 1995b).

Willow Encroachment

Compared to historic conditions, Crow Creek has experienced a noticeable increase in density of coyote willow (*Salix exigua*) (Barlow and Knight 1999; Fertig 2001; Heidel et al. 2002; Jones 2003; Heidel 2004b). Coyote willows over six feet tall are now dominant in many areas that were formerly open meadows (Fertig 2001; Heidel 2004b) (Figures 7 and 9). Jones (2003) documented approximately 28% cover of coyote willow in *Gaura* occupied segments of Crow Creek. In contrast, willow cover along Diamond Creek and the upper portion of the Unnamed Drainage occupied by *Gaura* is considerably less – estimated less than 1% above the mouth of Diamond Creek (Heidel 2004b). Census data show a long-term decline in *Gaura* numbers in upper Crow Creek, and long-term increases in Diamond Creek and the Unnamed Drainage. These trends may be influenced by a number of factors, including soil texture and water availability, but Heidel (2004b) hypothesizes that increased competition may play a role in the decline of the Crow Creek subpopulation. Research focusing on the effects of willow encroachment and control of willow in *Gaura* habitat is needed.

Figure 7. Willow encroachment in *Gaura* habitat along Crow Creek, October 2000. *Photo by Walt Fertig*

Figure 8. Mowed margin in *Gaura* habitat along Crow Creek, September 2000. *Photo by Walt Fertig*

Other Vegetation Competition and Habitat Changes Associated with Idle Condition

The increases in vegetation cover associated with idle management conditions over recent decades is not restricted to coyote willow and noxious weeds, but is to be expected in all parts of the plant community. The stream corridor habitat has a major component of native and non-native rhizomatous species that are untouched by cover removal treatments. The promising results demonstrated by one-time clipping (Munk 1999; Munk et al. 2002) and mowing treatments (Floyd 1995b) are a two-pronged promise, in that the vegetation will rebound with a vengeance favoring rhizomatous species if treatment is not repeated, but also that the competitive edge can be tilted in favor of short-lived taprooted species as *Gaura* with a systematic long-term treatment plan.

The existing interfaces between riparian habitat and recreational areas are mowed, and under 2002 – 2003 drought conditions, over 30% of *Gaura* numbers on Crow Creek were located at the mowed margin demarcating the recreational zone from riparian habitat (Figure 8). This represents a minute fraction of riparian habitat, and may indicate the importance of mowing at habitat ecotones to maintain *Gaura* numbers. Therefore, the capacity to maintain mowing practices at the riparian margins is identified as a key component in any recreational planning on Crow Creek.

The lack of *Gaura* response from applying mowing and fire treatments during a drought year (Burgess 2003) offers an important reminder that climate contingencies are to be incorporated in all long-term treatment plans.

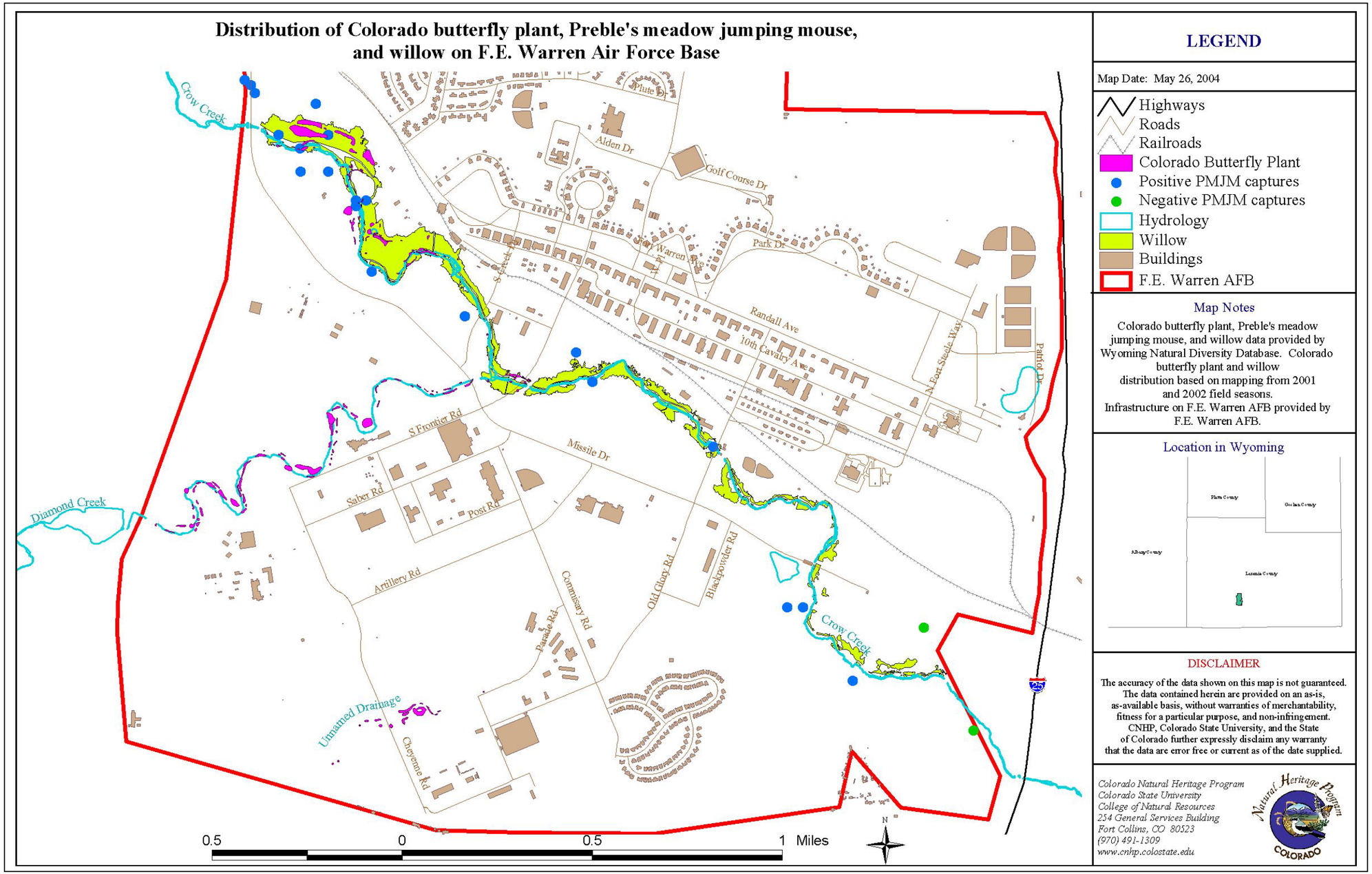
Stream Flow Changes

Stream flows are largely dictated outside the Base in the upstream watershed. The U.S. Geological Service (USGS) stream gauge data for 1994 – 1996 provide reference of stream flow patterns and volumes that are to be maintained to the extent that there is Base input. Late-summer water releases during drop structure repair on Diamond Creek in 2002 fostered a flush of new *Gaura* seedlings. However, because this repair was done in a drought year, the seedlings all perished (Burgess 2003), potentially diminishing the seedbank and resiliency of the Diamond Creek population (Heidel 2004a). Diversions, withdrawals, and impoundments all signify modifications to stream flow.

Groundwater Changes

Groundwater flows represent 100% of the hydrologic contribution to the Unnamed Drainage, and contribute at some level to the natural stream corridor hydrology of Crow and Diamond creeks as well. Practices and features that may, or could, affect groundwater flow include: ditching and tiling, particularly if flows to the creek are impeded; plowing the adjoining bottomland or uplands (this is possibly responsible for the decline or loss of *Gaura* plants at the lowest Crow Creek segment); and changes to runoff patterns that diminish percolation and accelerate water movement directly into the stream.

Figure 9. Distribution of *Gaura*, PMJM, and willow on Warren AFB.



Preble's Meadow Jumping Mouse (*Zapus hudsonius preblei*)

Species Description

The Preble's meadow jumping mouse is a small, brown rodent with a conspicuous dark dorsal band. For it's body size, it has large hind legs and hind feet and an extremely long tail (Figure 10). Adults average approximately 187 – 255 mm (7 – 10 inches) long and 17 – 22g in weight.

Figure 10. Preble's meadow jumping mouse
Photo by Rob Schorr

Taxonomy

Subspecific taxonomy of mice captured in Wyoming has been a subject of ongoing debate. Riggs et al. (1997) conducted mitochondrial DNA sequencing analysis on 92 specimens of *Zapus*, including both western (*Zapus princeps*) and meadow jumping mice (*Zapus hudsonius*). *Zapus* specimens from Albany County, Wyoming, south to Las Animas County, Colorado, were recognized as a coherent genetic group. Specimens from southeastern Wyoming and Weld County, Colorado, were more closely aligned with *Z. princeps*, but Hafner (1997) suggests this is likely due to the "leakage of mtDNA across species boundaries" since samples of *Z. princeps* are adjacent to populations of *Z. hudsonius*. He contends that the population identified as *Z. h. preblei* is a homogenous group based on Riggs et al. (1997) analysis. Morphometric work by Connor and Shenk (2003) confirmed presence of *Z. hudsonius* in southeastern Wyoming. They attribute southeastern Wyoming specimens to PMJM, based on discriminant function analyses using cranial characteristics. Ramey (*in review*) found that both mitochondrial DNA tests and skull measurements failed to distinguish between *Z. h. preblei* and *Z. h. campestris* (a more common subspecies of *Z. hudsonius* with a nearby range), and concluded that Preble's meadow jumping mouse is not a distinct subspecies (Denver Museum of Nature and Science 2004). The taxonomic status and distribution of *Zapus* forms in eastern Wyoming are still under study (e.g., Ramey *in review*), but based on the work Hafner (1997) and Connor and Shenk (2003), the geographic distribution of *Z. hudsonius*, and the proximity to confirmed PMJM populations, meadow jumping mice on Warren AFB are assumed to be PMJM. This

echoes the current assumption of the U.S. Fish and Wildlife Service, and therefore is appropriate to inform Base management decisions.

Distribution

Although the meadow jumping mouse (*Z. hudsonius*) is common and widespread across North America, the Preble's meadow jumping mouse subspecies (*Z. h. preblei*) currently occurs only in a few watersheds along Colorado's Front Range and in southeastern Wyoming. The historic abundance of PMJM is unclear. However, trapping surveys indicate that a number of historic PMJM sites are apparently no longer occupied. These sites have been disturbed and/or isolated as a result of changing land use (Ryon 1996). Evidence also suggests that the Denver metropolitan area has formed a barrier between the northern and southern extents of the PMJM range (Shenk 1998). In Colorado, PMJM is currently documented from seven counties (Weld, Larimer, Boulder, Jefferson, Douglas, Elbert, and El Paso). The largest and most stable populations documented across the range of the sub-species occur in East and West Plum Creeks in Douglas County, and in Monument Creek on the USAFA in El Paso County.

In Wyoming, understanding of the current distribution of *Z. h. preblei* is tentative due to confusing taxonomic information. It is possible that hybridization with *Z. princeps* is more prevalent here than along the Colorado Front Range (Beauvais 2003a), and there is possible connectivity between *Z. hudsonius* in eastern Wyoming and those in northeastern Wyoming (assumed to be *Z. h. campestris*) (Ramey *in review*). However, records for captures reported as PMJM suggest an historic distribution in Wyoming that included Albany, Laramie, Platte, Goshen, and Converse Counties (USFWS 1998). Recent records of PMJM in Wyoming are only from Crow Creek on the F.E. Warren AFB in Laramie County, and from the Lodgepole Creek drainage in the Medicine Bow National Forest in Albany County (USFWS 1998).

The current distribution of PMJM on Warren AFB (Figure 9) may be related to relatively recent changes in habitat. Based on descriptions of the historic condition of the area by Barlow and Knight (1999), it seems highly unlikely that the original cavalry post supported any significant PMJM habitat. It is possible that there was more suitable habitat in the surrounding stream network that held PMJM, which allowed for recolonization (or at least population enhancement via immigration) to the Base as habitat conditions improved.

Habitat Requirements

Preble's meadow jumping mice are typically found in dense, herbaceous riparian vegetation (Figures 11 and 12). Known PMJM locations sometimes have a woody overstory, but usually have a well-developed shrub layer and a thick herbaceous layer. Most often the shrub cover consists of willow species (*Salix*), but the species composition seems to be secondary to the overall presence of a mature shrub component. Armstrong et al. (1997) suggested that exotic, invasive plant species do not appear to conflict with PMJM habitat needs. Presence of non-native plants such as Canada thistle (*Cirsium*

arvense), toadflax (*Linaria* spp.), and smooth brome (*Bromus inermis*), do not appear to prohibit PMJM occupying an area; indeed, PMJM have been captured in the center of large Canada thistle stands on Warren AFB in the recent past (Beauvais 1998). However, the long-term impact of monocultures of these and other invasive weeds on PMJM population viability has not been investigated. What seems universally true for meadow jumping mouse habitat is that a dense, herbaceous ground cover immediately proximal to surface water need be present. Most often, PMJM are found in close association with these dense, riparian habitats. Numbers of PMJM captures appear to decrease the further one moves from this characteristic habitat (Corn et al. 1995; Meaney et al. 1996). Based on a study of kidney structure, it is believed that PMJM are dependent upon open water (Wunder 1998), which may explain their close association to these habitats.

Preliminary estimates of habitat use in Colorado indicate that PMJM spend 70% of their time in riparian shrub communities and 30% in upland grasslands, but specific activities in each habitat type are unknown (Schorr 2001). Upland use has occurred during the day as well as at night. Studies in Douglas County, Colorado, suggest that upland grasslands may serve as feeding "hotspots" (Shenk and Sivert 1998). It is clear, however, that PMJM are regularly and consistently using upland grasslands adjacent to riparian habitat, so it seems logical to assume that this habitat type must be important for some life history component(s).

Life History

Where specific data on the ecology of the PMJM subspecies is lacking, information has been extrapolated from studies of *Z. hudsonius* conducted in the eastern and mid-western U.S. Although some evidence indicates similarities in natural history and ecological requirements between PMJM and other *Z. hudsonius* subspecies, care should be taken in interpreting biological and ecological data extrapolated over the range of the species.

Reproduction and Mortality

Zapus hudsonius may produce up to three litters per season (Whitaker 1963), with an average of 4 – 6 young per litter (Quimby 1951; Fitzgerald et al. 1994). Peaks occur in early to mid-June, August, and possibly September (Whitaker 1963). Age at first reproduction is poorly known for PMJM, but *Z. hudsonius* females have been known to give birth at three months of age (Quimby 1951).

Little is known about PMJM longevity, but some recaptured individuals have survived at least three years. Estimates of survival rates based on mark-recapture studies in El Paso County, Colorado, indicate that 52 – 68% of PMJM survive over summer, while 21 – 52% of PMJM survive over winter (Schorr 2003). In areas of Douglas County, PMJM over summer survival was estimated at approximately 36% (T. Shenk, pers. comm.). Studies in Boulder County indicate mean over summer PMJM survival was 16%, while mean over winter survival was 54% (Meaney et al. 2003).

Figure 11. Preble's meadow jumping mouse habitat on Warren AFB, along Crow Creek . *Photo by Gary Beauvais*

Figure 12. PMJM habitat along Crow Creek.
Photo by Gary Beauvais

Observed sources of active season mortality of *Z. hudsonius* include cannibalism, roadkill, and depredation by house cats, garter snakes, rattlesnakes, and fox (Sheldon 1934; Schorr 1999; Shenk and Sivert 1998). Additional presumed causes of PMJM mortality include starvation, exposure, and disease (Whitaker 1972).

Hibernation

Meadow jumping mice spend at least seven months per year in hibernation, in underground burrows that they create themselves. One PMJM hibernaculum documented in Jefferson County, Colorado, was a leaf litter nest approximately 30cm below ground, 9m above a creek bed under thick shrub cover of chokecherry (*Prunus virginiana*), poison ivy (*Toxicodendron rydbergii*) and snowberry (*Symphoricarpos* spp.) (Wunder pers. comm.; Bakeman pers. comm.). This location is upland of the habitat used during the major active period (Armstrong et al. 1997).

Six possible hibernacula have been documented in El Paso County, Colorado. Distances from the creek ranged from 7m to 45m. One presumed hibernacula occurred on level ground; four of the five that occurred on slopes were north-facing. Four sites were within the riparian willow shrub zone, and two were outside, but all six sites were under some shrubby vegetation (snowberry, willow, or oak) (Schorr 2001). Only two were outside the 100-year floodplain.

Eight other possible hibernacula have been documented in Douglas County, Colorado. Detailed descriptions of these sites are not available, but distance data indicate that five of the eight mice using these possible hibernacula traveled greater than or equal to 90m from "the center of their typical September night time locations" (Shenk and Sivert 1998). One mouse moved 750m to a possible hibernaculum. The greatest distance from the center of a main drainage was 341m, or 78m if tributaries were considered.

Male *Zapus* emerge from hibernation prior to females (late April to early May, and early to late May, respectively). In Colorado, PMJM have been captured as early as May 5 for males and May 21 for females, and as late as November 7 (A. Ruggles, pers. comm.). Juveniles have been captured as late as October 26 (male) and 27 (female) (summarized in Shenk 1998). PMJM have been captured on Warren AFB as late as the second week of September. Based on these dates, the active period for PMJM is roughly May through October, but may be variable from year to year.

Behavior and Movement

PMJM are primarily nocturnal. However, they can also be observed during the day. Individuals have been seen sitting motionless during the day under shrub cover, in nests composed of grass, leaves, and woody material (Schorr 2001).

Radio telemetry studies in Jefferson County, Colorado, indicate movement both up and down stream channels, as well as perpendicular to the drainage. Mice stayed in

riparian/wetland areas, and did not travel over cobbles. Mice also moved along contours into adjacent drainages, again staying in riparian areas. Adult mice were observed to move 1.6k (approximately a mile) in a 24-hour period (Ryon 1999).

Current movement data can be summarized as follows:

- Maximum movement is greater than three miles.
- Greater use of upland habitats than was previously assumed has been observed.
- PMJM exhibit fidelity to day nest and nocturnal centers of activity (Shenk and Sivert 1998).
- There are seasonal shifts in movement patterns. These movement shifts may match dietary requirements, but a cause/effect relationship is unclear (Shenk and Sivert 1998).
- PMJM use both perennial and intermittent tributaries adjacent to capture drainages. Lateral movement from the stream is less on high order streams and increases on low order streams and meanders/floodplains.
- Long distance movement (>90 m) to new locations was observed prior to hibernation in September (Shenk and Sivert 1998).

Food Preferences

Armstrong et al. (1997) summarized available information on food preferences of meadow jumping mice as follows:

> "Studies of food habits in central and eastern United States indicate that they are governed by availability more than preference (Whitaker 1963). Grass seeds of several species are probably the most important component of the diet, and mice will shift to those species that have available seed. Invertebrates and fungi are also readily eaten. Mice feed on both adult and larval invertebrates, especially *Coleoptera* (beetles). Invertebrate feeding is very important in the spring as mice emerge from hibernation, and may consist of half of the diet at that time. Mice also feed on various species of fungi, which are often encountered during burrowing activity. As the growing season progresses, graminoid seeds dominate the diet."

Research in Douglas County, Colorado, indicates that PMJM are consuming more fungi and arthropods than researchers expected (Shenk and Sivert 1998). This study also indicates that shifts in diet content match movement shifts, but a cause/effect relationship is unclear. Shenk and Sivert (1998) observed that PMJM from different stretches of streams regularly congregate at the same feeding "hotspots." Additional research is needed to determine what mice are eating, as well as whether or not these nightly congregations have behavioral or social significance.

PMJM do not store food. Therefore, they must consume food prior to hibernation. Since sufficient energy to survive over winter must be provided by fat stores accumulated prior to hibernation, the availability of adequate food resources during this time of year is a critical factor for these mice. It seems reasonable to assume that graminoid seeds are

especially important during this period due to the proportionally high fat content of this food source.

Abundance and Density

Studies conducted over four years determined mean linear abundance estimates from South Boulder Creek in Boulder County, Colorado, is 37 mice per km (Meaney et al. 2003). At the U.S. Air Force Academy, PMJM linear abundance estimates ranged from 23 – 48 mice per km (Schorr 2003).

Populations of meadow jumping mice are known to fluctuate considerably from year to year (Blair 1940; Whitaker 1972; Adler et al. 1984; Boonstra and Hoyle 1986), and may vary by as much as 75% annually (Muchlinski 1988). Rate of PMJM capture from trapping efforts at U.S. Air Force Academy, Rocky Flats Environmental Technology Site (RFETS), and Boulder County all support the theory that PMJM populations, like other populations of meadow jumping mice, undergo fluctuations in abundance from year to year (T. Ryon, M. Bakeman, C. Meaney, pers. comm.).

Reasons for Rangewide PMJM Decline

The USFWS final rule to list the PMJM as a Threatened Species discussed threats to this subspecies based on the five listing factors set forth in section 4 of the Act (USFWS 1998). These factors are:

1. The present or threatened destruction, modification, or curtailment of its habitat or range;
2. Overutilization for commercial, recreational, scientific, or educational purposes;
3. Disease or predation;
4. The inadequacy of existing regulatory mechanisms;
5. Other natural or manmade factors affecting its continued existence.

The primary justifications for listing were Factor 1 (modification of habitat and range) and Factor 4 (inadequacy of existing regulatory mechanisms). The USFWS summarized its decision to list in the following statement:

> "…the Preble's meadow jumping mouse, historically a rare mammal, has declined…Riparian habitats required to support Preble's have been severely modified or destroyed by human activities in many areas…With current human population increases, the loss and modification of riparian habitat continues. Existing regulations have proven inadequate to protect Preble's, as witnessed by its apparent decline and the continued destruction and modification of its habitats."

Human activities that have contributed to the alteration, degradation, loss, and fragmentation of PMJM habitat across its range include:

- residential, commercial, and recreational development

- highway construction
- stream alteration in physical structure and hydrology
- excessive livestock grazing and conversion of grasslands to farms
- water development and flood control practices
- mining
- threats from hazardous material

Other issues noted as needing additional research into potential effects on PMJM were all related to human development and land use. These issues were: weeds, increased predation associated with human developments (both wildlife and domestic cats), pesticides and herbicides, and other effects of intensive human development such as noise, air pollution, and water pollution.

In Wyoming, excessive livestock grazing of riparian areas is thought to be a primary factor in the decline of PMJM (Western Ecosystems Technology, Inc. 2001). Some habitat has undoubtedly been lost to urban and suburban development as well (e.g., the town of Cheyenne is immediately downstream of Warren AFB), but to date the extent of such conversion has not been as intense or widespread in Wyoming as along the Colorado Front Range. On the other hand, certain agricultural practices (e.g., flood irrigation, created streams, permanent impoundments) within historically arid environments may occasionally lead to local increases in habitat extent and suitability.

PMJM Conservation Issues on Warren AFB

Rangewide declines of PMJM can be attributed to complex interactions among many human activities and landscape conditions, as described in Appendix A. On Warren AFB, the primary issues that should be addressed in order to achieve long-term conservation of PMJM are small population size, isolation of populations, habitat degradation, and potential for catastrophic events.

Small Population Size

Annual presence/absence surveys for PMJM on Warren AFB suggest that, although PMJM appears to be persistent on the Base, population size is probably quite small. Surveys for PMJM have been conducted on Warren AFB every year since 1993 with the following results:

1993: no *Zapus* captured (Compton and Hughie 1993);
1994: no *Zapus* captured (Elliot 1996);
1995: 2 *Zapus* captured, presumed to be PMJM (Elliot 1996);
1996: 8 *Zapus* captured, confirmed PMJM based on voucher specimen (Schuerman and Pague 1997);
1997: no *Zapus* captured (Travsky 1997);
1998: 8 (9 counting a re-capture) *Zapus* captured (Beauvais 1998);
1999: 1 *Zapus* captured (Young et al. 2000);
2000: no *Zapus* captured (Keinath 2001);

2001: no *Zapus* captured (Dark-Smiley and Keinath 2002);
2002: 4 *Zapus* captured (Beauvais 2003b);
2003: 1 *Zapus* captured (Beauvais 2004).

Total sampling effort on Warren AFB has not been consistent from year to year, and although relative abundance (captures/1000 trap-nights) is reported by Beauvais (2004) and presented here, the very small number of captures suggests that abundance estimates are tentative at best. Distribution of sampling effort on Warren AFB has also varied by year, although trapping has occurred on Crow Creek above the Family Campground every year since 1996 (Beauvais 2004). In Colorado, estimates range from 14 – 60 individuals per kilometer (Bakeman 2000; Meaney et al. 2003; Schorr 2003). Based on past experience trapping in habitat similar to that found on Warren AFB, we would have expected trapping success to be higher on Warren AFB. A comprehensive population study conducted annually would be necessary to accurately assess PMJM abundance and distribution on the Base.

Isolation of Populations

Population isolation results from the introduction of barriers into previously connected landscapes such that mice are not able to leave one population and join another. Common causes of PMJM population isolation include human developments, roads and other infrastructure, and hydrologic alteration that leads to drying up of streams. Isolation may result in loss of genetic variability or increased vulnerability to catastrophic events.

The nearest documented occurrence of PMJM to Warren AFB is approximately 64 km (approximately 40 miles) due west, in the upper Crow Creek basin on land managed by the U.S. Forest Service, Medicine Bow/Routt National Forest. Other *Zapus* captures, assumed but not confirmed as *Z. h. preblei*, near Warren AFB include a site approximately 32 km (approximately 20 miles) due north on Horse Creek, and a site approximately 21 km (approximately13 miles) south-southeast on Lone Tree Creek (data on file at WYNDD). These sites are only distantly connected via hydrology to Crow Creek on Warren AFB.

Private lands along Crow Creek immediately upstream of Warren AFB have not been surveyed for PMJM, and the amount and distribution of suitable habitat there is unknown. There are patches of willow along Crow Creek upstream of Warren AFB, but there is no information to indicate whether or not these patches are of sufficient size and distribution to allow immigration and emigration of mice between the upstream population managed by the Forest Service and the Warren AFB population. Although the intervening area is still rural with a high percentage of rangeland, there are some areas where roads and homes are concentrated, and there is a generally increasing trend of subdivision and development. As development increases, the likelihood that mice will be able to move between populations along Crow Creek will diminish.

Barriers may be problematic not only between Warren AFB and upstream populations, but also between segments of Crow Creek on the Base, and between Crow Creek, Diamond Creek, and the Unnamed Drainage. The crossing points of South Creek Drive, South Frontier Drive, and Old Glory Road over Crow Creek, and of Missile Drive over Diamond Creek, are all characterized by narrow culverts channeling the stream under the road bed, steep concrete embankments between the floodplain and road surface, and rather wide roads bordered by concrete and metal railings. These features, along with associated parking lots and buildings, likely present formidable barriers to individual PMJM attempting to move along the stream.

As noted previously, data do not support estimates of abundance for PMJM on Warren AFB. However, given the presumed small population size, likely minimal connectivity to off-base populations, and the potential for barriers to movement between habitat patches on the Base, this population may be vulnerable to inbreeding depression and other small population processes that reduce long-term viability. Connectivity between isolated patches of habitat along the main stem of Crow Creek, and restoration of potential habitat along Diamond Creek and the Unnamed Drainage will be required to ensure the long-term viability of the PMJM population on Warren AFB.

Habitat Degradation

Habitat degradation refers to changes in habitat composition, structure, or function that individually, or in combination, hamper the ability of PMJM to feed, reproduce, hibernate, or disperse. Hydrological alterations that lead to erosion, downcutting, and channelization could cause the band of riparian vegetation to narrow over time, reducing its capacity to support PMJM. On Warren AFB, the most common sources of habitat degradation are the creation of potential movement barriers, upland and riparian habitat impacts such as those caused by landfill construction, and potentially the invasion of noxious weeds.

The presence of some weedy species in PMJM habitat does not appear to preclude occupation by the mouse, but long-term impacts are not known. Armstrong et al. (1997) found PMJM occupying habitat patches that contained weeds, but they did not describe the degree of weed infestation. Researchers theorize that even monotypic stands of weeds may not be problematic for PMJM if the diversity and abundance of food resources are not adversely impacted. However, invasion by non-native species does alter the plant communities that make up PMJM habitat, both in the riparian zone and in the upland grasslands. From a general ecological systems standpoint, noxious weed infestation is an undesirable condition, and given the importance of graminoid seeds to the PMJM diet, it seems reasonable to assume that invasion of monotypic stands of noxious weeds would have a negative long-term effect on PMJM. Additional information is needed on potential long-term impacts of weeds, weed control, and plant species composition on PMJM populations.

Catastrophic Events

Catastrophic events are chance occurrences of sudden environmental change that may destroy a large percentage of a PMJM population. The most likely and widespread catastrophic event on Warren AFB is flooding of Crow Creek. Crow Creek has experienced five 500-year floods in the last century (Warren AFB 2004a). Other potential events include accidental spills of hazardous materials from roads or the railroad, and uncontrolled fires. The effects of hazardous spills and fires would likely be confined to smaller segments of Crow Creek than generalized flooding. Because catastrophes are unpredictable, PMJM conservation efforts on Warren AFB should provide for restoration of additional habitat on tributaries to Crow Creek (Diamond Creek and the Unnamed Drainage) to serve as refugia against such events.

Characteristics of Riparian Systems Occupied by *Gaura* and PMJM

Given that wildlife and plant management is typically achieved by managing habitat rather than target organisms themselves, most of the strategies presented in Part 3 of this plan are based on the need for maintenance or rehabilitation of riparian and associated upland habitat. In general, attributes necessary to sustain properly functioning riparian system are:

- Unconstricted floodplain to allow for stream channel movement;
- Natural succession of riparian communities through early and late seral stages;
- Occasional non-catastrophic hydrological disturbance during mid- and late-seral stages of riparian community development, including flooding at 3 – 75 year return intervals;
- Periodic fire, grazing of short duration (winter only, or short season with 3 – 5 year rest), or simulation of fire/grazing by mowing to reduce vegetation cover;
- Occasional catastrophic hydrological disturbance (100 – 500+ year flood events);
- Long time spans (approximately 10 – 20 years) between hydrological disturbance events with no disturbance other than normal stream flow events (Gwen Kittel, NatureServe riparian ecologist, pers. comm.).
- Presence of beaver are desirable for flood and sediment attenuation, and maintenance of high water table (Denise Culver, CNHP wetland/riparian ecologist, pers. comm.).

The relationship between stream flow and maintenance of riparian vegetation has not been quantified for the systems occupied by *Gaura* and PMJM. Clearly, however, some threshold for in-stream flow and/or groundwater is necessary in order to prevent loss of function and to maintain the current extent of riparian vegetation. Fortunately, although some human modification of the local hydrology has taken place, Crow Creek and its tributaries have retained natural function, and still support a relatively wide band of healthy riparian vegetation. One question that remains unanswered is the degree of future change this system can sustain without negative impacts to riparian habitat. It should be noted that the severe drought currently affecting southeastern Wyoming has apparently

not impacted riparian habitat along Crow Creek on Warren AFB in any noticeable way to date.

Characteristics of Upland Habitats Used by PMJM

Upland habitat on Warren AFB is primarily mixed-grass and shortgrass prairie typical of eastern Wyoming. Dominant species include blue grama, western wheatgrass, and needle-and-thread grass (Barlow and Knight 1999). The distribution of vegetation may be influenced by local climatic conditions, grazing by native ungulates or livestock, burrowing of small mammals, and periodic fires (Knight 1994; Barlow and Knight 1999). The patchy nature of these influences results in a shifting mosaic of vegetation types on the ground over time. Because of the absence of trees in the landscape, fire return intervals are difficult to estimate. According to Wright and Bailey (1980), shortgrass to mixed-grass prairie on level topography burned approximately every 5 – 10 years, and approximately 20 – 30 years on dissected topography.

Offsite Considerations

The West Cheyenne Land Use and Infrastructure Improvement Plan (City of Cheyenne 2002) proposes mixed-use/urban reserve (e.g., residential, office/commercial, light industrial, open space, recreational, and/or public) immediately south of Warren AFB. Medium density residential development, commercial/industrial development, and other urban uses are planned for the area to the west of the Base south of Diamond Creek. The area west of the Base north of Diamond Creek is slated for lower density (i.e., one dwelling unit per five acres) residential development. It is impossible to know whether or not the lands adjacent to Warren AFB will develop in the manner suggested by the plan. However, if current trends continue, it is likely that residential and other forms of urban/suburban development will increase along the west and south boundaries of the Base. Much of the private land to the west of Warren AFB is owned by only three families, and some of these lands have been offered for sale several times (Dorothy Wilson, City of Cheyenne Development and Zoning Director, pers. comm.).

There is local community interest in extending the Greater Cheyenne Greenway trail system onto the Base along Crow Creek. The feasibility of this project is uncertain in today's climate of increased security. However, if residential development increases on the west side of the Base, community interest in completing this trail will likely increase.

According to the City of Cheyenne Board of Public Utilities, the reservoirs along Crow Creek upstream of the Base were recently upgraded. There are no plans for additional water development projects that would affect the quantity, quality, or timing of in-stream flows in Crow Creek. Water conservation measures to address local drought issues may require a 15% reduction in water use within the City of Cheyenne, but since their water is piped through the Base and does not flow in the creek, implementation of these or similar measures is not expected to impact stream dynamics or riparian habitat on the Base.

However, managers on Warren AFB should bear in mind that any significant alteration of the hydrologic regime of Crow Creek upstream of the Base could have implications for management of the riparian habitats on the Base. Periodic communication with the decision makers who have authority over upstream water usage is warranted.

PART 3: GOALS, OBJECTIVES, AND STRATEGIES

Warren AFB is well positioned to make significant contributions toward the recovery and future viability of *Gaura* and PMJM. Warren supports the largest known occurrence of *Gaura* in the world, and the only population known to occur on federal land. The Warren population of PMJM is of management significance because it is one of the few populations known from federally managed lands. The future stability of these populations will require increased population size, increased spatial distribution, and resiliency in the riparian ecosystem. The conservation goals, five year management objectives, and strategies outlined in this plan are designed as initial steps toward improving the security of these populations.

In order to fully demonstrate maximum protection of *Gaura* and PMJM on Warren AFB, specific numeric goals for populations should ultimately be set. However, based on the data currently available, the setting of population goals is premature. Wide annual fluctuations in *Gaura* numbers across the three drainages are not well understood, and additional research will be necessary to determine which biological and environmental factors are driving these trends. The distribution of PMJM on the Base has not been thoroughly studied, but mice are not well distributed, and appear to be absent from seemingly high quality habitat. Research on distribution, population size and demographics, habitat use, and other issues needs to be much more robust before population goals can be set. The possibility of setting measurable population goals with some degree of confidence should be re-visited during the next iteration of this plan.

In lieu of setting actual population goals, we have considered measures of habitat quantity and quality to inform this plan, under the rather straightforward assumption that more and better habitat will lead to larger and more stable populations.

Overall, conservation of PMJM and *Gaura* will benefit not only the recovery of these listed species, but also the preservation of other native fish and wildlife species that use riparian and associated shrub and grassland habitats. In addition, conservation action targeting protection of PMJM and *Gaura* will help maintain the integrity of the portion of the Crow Creek watershed on Warren AFB lands.

Conservation Goals:

1. **Contribute to the recovery of *Gaura* and PMJM by enhancing the long-term persistence of Warren AFB populations**. This will be accomplished by increasing population size and distribution, which in turn will be accomplished by increasing the coverage, distribution, and connectivity of suitable habitat for each taxon.
2. **At a minimum maintain, and when possible enhance, the ecological integrity of riparian habitat along the Warren AFB portion of Crow Creek and its tributaries, and adjacent uplands**.

5-Year Management Objectives:

1. Ensure that *Gaura* subpopulations persist on all three drainages (Crow Creek, Diamond Creek, and the Unnamed Drainage). Subpopulations in each drainage should be stable or increasing in non-drought years.
2. Increase distribution of PMJM throughout the Warren portion of Crow Creek, primarily by evaluating and mitigating movement barriers and secondarily by enhancing streamside habitat along particular segments.
3. Create or restore habitat to provide PMJM with refugia against catastrophic events on the main stem of Crow Creek. Refugia should be available on at least one tributary (Diamond Creek or the Unnamed Drainage) within five years. Long-term management objectives should provide for refugia on both tributaries.
4. Eliminate or minimize threats to *Gaura* and PMJM, and associated habitats, within Warren AFB boundaries.
5. Sponsor research and monitoring projects to answer high priority questions, to evaluate the effectiveness of management strategies, and to improve chances of conservation success.
6. Ensure that existing hydrologic function remains intact.

Objective 1. Ensure that *Gaura* subpopulations persist on all three drainages (Crow Creek, Diamond Creek, and the Unnamed Drainage). Subpopulations in each drainage should be stable or increasing in non-drought years. *Gaura* distribution along Crow Creek is currently limited to the area immediately adjacent to South Frontier Road and upstream. Expanding distribution of *Gaura* into downstream segments of Crow Creek is not among the management priorities for the next five years, and the lower reaches may not provide suitable habitat under current conditions. Any future experimental transplant studies or habitat creation should be restricted to the areas downstream of South Frontier Road.

Task 1.1: Program requirements for this objective in the Automated Civil Engineer System database and submit for funding.

Strategy 1A. Control noxious weeds.

Warren AFB will begin preparation of a weed management plan in 2004, with completion scheduled for 2005. Decisions regarding weed control measures will be complicated by the presence of *Gaura* and PMJM within infested areas. This situation presents an opportunity to test potential methods for weed control in threatened and endangered species' habitat for effectiveness, likelihood of adverse impact to sensitive species, and manageability. Ultimate control of noxious weeds will require a combination of management tools implemented over many years. The tasks listed below are suggested first steps toward identifying the most appropriate tools for Warren AFB. (Refer to Appendix B for species abstracts that describe the four noxious weeds that

occur in *Gaura* habitat, including brief summaries of life history and potential management tools.)

Task 1.2: Implement a systematic plan with a combination of methods for weed control in threatened species' habitat. Focus weed control efforts to reduce competition in habitat occupied by *Gaura* when weather conditions favor higher *Gaura* seedling establishment (i.e., cool/wet years). Focus (but do not restrict) weed control efforts in unoccupied habitat during hot/dry years, when seedling establishment will be reduced.

General areas of focus for weed management strategies are displayed on Figure 13. Because distribution of *Gaura* and the noxious weeds may change from year to year, these focus areas should be considered guidelines only. Weed management strategies should be re-evaluated annually.

Task 1.3: In high priority patches (Figure 13), use a combination of mowing and herbicide application for weed control. The highest priorities include:

- Those colonies of *Gaura* on Crow Creek with over 20 plants in recent years with inferred Canada thistle competition;
- Those dense expanses of Canada thistle along Crow Creek that are seedbanks for the entire riparian corridor;
- Those recreation margin areas where both *Gaura* and weeds are present;
- The biggest, densest Canada thistle infestations in proximity to those places that have supported large *Gaura* colonies on Diamond Creek and the Unnamed Drainage in recent years.

Timing of mowing should consider the phenology of *Gaura* and the target weed species. Mowing in occupied *Gaura* habitat should be done prior to *Gaura* bolting in spring or early June. The July mowing documented as effective by Floyd (1995b) can be incorporated in moist summers. In unoccupied *Gaura* habitat, mowing and herbicide application should be done at appropriate times of year for the target weed species. Ideal timing for both mowing and herbicide application will be somewhat variable from year to year, depending on climatic conditions. In general, mowing should be done around late June (i.e., before seed formation), and herbicides should be applied around mid-September (when uptake by the plants will be increased during pre-winter root growth). The mow/herbicide approach will require at least one mow per year. If resources allow, two mowing cycles, one in spring and one in early summer, will be more effective. Mowing within *Gaura* habitat should be done selectively with a hand-held device such as a weed eater. Herbicides should also be applied selectively using non-broadcast methods (e.g., wet-blade, wick, or backpack or hand-held sprayer). Carefully consider potential for adverse impacts to *Gaura* and other native vegetation when selecting herbicides. In areas occupied by PMJM, herbicides should be carefully evaluated for potential impacts to food resources. Reduction of seed availability August through October (the fattening up period prior to PMJM entering hibernation) could pose a significant threat. If herbicides are selectively applied only to the

noxious weeds in all riparian areas, not just occupied *Gaura* habitat, this should not be a problem.

Task 1.4: In areas not occupied by *Gaura*, use a combination of annual goat grazing and reseeding with native species to reduce competitive advantage of weeds (Figure 13). Release goats in early May and late August/early September. Reseed with native grass at the same time. It will be very important to work with experienced goat handlers, to provide very explicit instructions relative to goat grazing in threatened species habitat, and to coordinate carefully regarding the location of *Gaura* plants.

Task 1.5: A biocontrol release program is scheduled to begin in 2004 to address eight noxious weeds on Warren AFB, including Canada thistle, leafy spurge, common hound's tongue, and Dalmatian toadflax. Coordinate the biocontrol release program with other weed control approaches, and with conservation and management of *Gaura* and PMJM.

Task 1.6: If common hound's tongue patches are identified outside the areas delineated for implementation of other weed control methods, develop a volunteer program to test the effectiveness of hand pulling. Recruit volunteers from the local community (e.g., local Boy Scout troops, etc). Focus effort on small patches that could be eliminated before they spread, especially in areas occupied by *Gaura*. Common hound's tongue is a state-listed noxious weed in Wyoming, and therefore must be controlled. However, for the purposes of this Plan, it must be noted that common hound's tongue is not a serious competitor with *Gaura*, so control of this weed should be lower priority than control of Canada thistle, leafy spurge, and Dalmatian toadflax.

Task 1.7: Areas of leafy spurge infestation, and areas where leafy spurge and Canada thistle overlap, are particularly challenging problems, and are high priorities for weed control efforts. Schedule additional consultation with the Cooperative Extension Service and interdisciplinary collaboration to focus on this problem.

Task 1.8: Monitor results of each weed control method for effectiveness, manageability, and adverse impacts on *Gaura* and PMJM. Monitoring should be conducted annually. Consult with the USFWS as well as state and local weed experts when evaluating each method to determine whether early results are indicative of long-term effectiveness, and to identify necessary changes in management.

Strategy 1B. Enhance habitat to improve Gaura's competitive advantage.

Task 1.9: Reduce willow encroachment in occupied *Gaura* habitat. Willow removal should focus on areas of recent willow invasion, as identified by willow stem diameter and breaks between willow size classes. A qualified botanist and a qualified zoologist should work together to flag areas proposed for willow

removal. *Gaura* can persist in relatively small habitat patches, so it should be possible to remove willow in patches that are large enough to sustain *Gaura* but small enough that PMJM should not be affected.

The best available guidelines for PMJM habitat removal come from the Colorado PMJM Science Team's *Maximum Allowable Disturbance Area for Preble's Meadow Jumping Mouse in Ditch-side Habitat* (Pague 1999). A riparian shrub patch approximately 540 ft^2 (33.3 m^2), and no longer than 23 feet along the associated creek or stream, was the recommended maximum willow riparian patch that should be altered within PMJM habitat. These guidelines are presented only as a starting point for evaluating optimum patch size of willow removal on Warren AFB. There are some important caveats to consider: First, this guideline was developed by assuming a patch size equal to 5% of a PMJM home range would not jeopardize the survival of an individual animal (an untested assumption). Second, these recommendations were made for consolidated impacts to ditch systems where habitat is contiguous. The extent and quality of habitat, and the size of PMJM populations, present in Colorado are much greater than those present on Warren AFB. Therefore, even if the assumption that loss of 5% of an individual home range would not jeopardize the survival of that animal were true in Colorado, it may not be true on Warren AFB. Research will be required to answer this question.

There are no guidelines for creating riparian habitat patches for *Gaura* regeneration. However, using the above outlined PMJM guidelines, adapted for the specific conditions on Warren AFB, may allow willow removal for the generation of *Gaura* without jeopardizing PMJM viability. Additionally, creating multiple, geographically disparate patches that, in total, equal no more than the maximum allowable patch (540 ft^2) should reduce the impacts to PMJM persistence, while increasing the opportunity for *Gaura* regeneration.

Task 1.10: Increase mowing in high priority grassy areas (Figure 13) to increase the amount of open habitat and reduce competition with *Gaura* seedlings for light. If other installation plans include mowing restrictions, these should be modified to include an exception for occupied *Gaura* habitat. Mowing is an important task throughout occupied *Gaura* habitat, and also has a direct bearing on the effectiveness of weed control.

Objective 2. Increase distribution of PMJM throughout the Warren AFB portion of Crow Creek, primarily by evaluating and mitigating movement barriers and secondarily by enhancing streamside habitat along particular segments**.**

Task 2.1: Program requirements for this objective in the Automated Civil Engineer System database and submit for funding.

Strategy 2A. Investigate current presence or absence, habitat suitability, and potential threats in middle and lower stream segments of Crow Creek.

Task 2.2: Conduct a comprehensive survey of all potential PMJM habitat on the Base to verify current distribution. PMJM have not been documented downstream of South Frontier Road since 1999, and downstream of Old Glory Road since 1995.

Task 2.3: If surveys fail to document PMJM downstream of South Frontier Road, formulate and test hypotheses to explain the absence of mice in apparently high quality habitat, with special attention to road-crossings as potential movement barriers.

Strategy 2B. Remove existing barriers and restore habitat, as necessary, to facilitate movement of PMJM between upper and lower stream segments of Crow Creek.

Task 2.4: Evaluate road crossings at South Creek Drive, South Frontier Road, and Old Glory Road as potential barriers to PMJM movement. Reduce the length of separation between habitat patches.

Task 2.5: Increase willow cover in areas where distance between existing willow patches may discourage dispersal of PMJM.

Objective 3. Create or restore habitat to provide PMJM with refugia against catastrophic events on the main stem of Crow Creek. Refugia should be available on at least one tributary (Diamond Creek or the Unnamed Drainage) within five years. Long-term management objectives should provide for refugia on both tributaries.

Task 3.1: Program requirements for this objective in the Automated Civil Engineer System database and submit for funding.

Strategy 3A. Create a connection between habitat patches on lower Unnamed Drainage and Crow Creek.

Task 3.2: Work with Base engineers to develop and implement a method for altering the retention pond dam and/or culvert at Landfill 2 to enhance connectivity between Crow Creek and the Unnamed Drainage.

Task 3.3: Plant additional willow along lower Unnamed Drainage to increase the amount of suitable habitat and enhance connectivity between drainages.

Strategy 3B. Create a connection between habitat patches on Diamond Creek and Crow Creek.

Task 3.4: Increase PMJM habitat suitability (i.e., by increasing vegetation cover in general, and willow cover in particular) along lower Diamond Creek. Focus habitat enhancement activities primarily from the junction with Crow Creek to the upstream limit of existing tree coverage, where habitat is less suitable for *Gaura*. This task must be undertaken with great care to avoid adverse impacts to *Gaura*. Monitoring will be necessary to ensure that habitat along Diamond Creek is sufficient to function as refugia for PMJM, but does not restrict the ability of *Gaura* to thrive along Diamond Creek.

Task 3.5: Evaluate whether or not the crossing of Missile Drive and Diamond Creek poses a barrier to PMJM movement. If so, work with Base engineers to develop and implement a crossing design that will offer mice access to habitat along Diamond Creek. Widening of Missile Drive has been identified as a potential future project. If this project is implemented, there may be an opportunity to address habitat connectivity issues at the same time.

Objective 4. Eliminate or minimize threats to *Gaura* and PMJM, and associated habitats, within Warren AFB boundaries.

Task 4.1: Program requirements for this objective in the Automated Civil Engineer System database and submit for funding.

Strategy 4A. Restore degraded habitat.

Task 4.2: Implement habitat improvement tasks outlined under the previous Objectives and Strategies relative to weed control, willow management, and riparian system connectivity.

Task 4.3: Coordinate with weed control experts and USFWS to design the most appropriate weed control strategy for *Gaura* and PMJM habitat.

Task 4.4: Work with the Environmental Leadership Council to: establish habitat improvement and threatened species conservation as a management priority; ensure that necessary resources and personnel are available to implement conservation and management strategies; and commit to annual implementation of a comprehensive weed control program along Crow Creek and its tributaries.

Strategy 4B. Avoid, minimize, and mitigate adverse impacts from mission operations, installation improvement projects, etc.

Task 4.5: Work with knowledgeable biologists to develop general Best Management Practices (BMPs) for use in offsetting impacts to *Gaura* and PMJM from mission, operational, and installation improvement activities. Guidelines developed by Colorado's PMJM Science Advisory Team for conservation

measures to be implemented in emergency situations are included in Appendix C.

Task 4.6: Institutionalize a channel of communication between the wildlife biologist and other Base work centers to ensure that appropriate project review is conducted, and BMPs are implemented as necessary.

Task 4.7: Distribute a "consultation zone" map to all Base program managers who have jurisdiction over projects that could impact *Gaura*, PMJM, or their habitats, including community planning, customer service, engineering, maintenance, grounds maintenance, entomology, environmental, readiness, and SABER, to further facilitate appropriate project review and implementation.

Task 4.8: Develop an educational program package for laypeople that synthesizes the most important information on *Gaura*, PMJM, and their habitats. This program should be designed so that it can be readily used and easily understood by current and future Base personnel. Possible tools include: slide or powerpoint presentation, fact sheets, brochures, maps, and a website.

Task 4.9: Maintain appropriate channel and floodplain features. Carefully monitor and mitigate any unavoidable hydrological alteration. Control sedimentation and altered runoff.

Objective 5. Sponsor research and monitoring projects to answer high priority questions, to evaluate effectiveness of management strategies, and to improve chances of conservation success.

Task 5.1: Program requirements for this objective in the Automated Civil Engineer System database and submit for funding.

Strategy 5A. Continue* Gaura *research and monitoring.

Task 5.2: Continue annual census of flowering *Gaura* plants.

Task 5.3: Conduct management response research. Treatment areas should be clearly mapped on aerial photos, or identified by GPS points for cross-reference between *Gaura* and PMJM research.

Task 5.4: Complete intensive sampling of nonflowering plants and competing species.

Task 5.5: Promote research on life history, competition, and restoration.

Strategy 5B. Increase research effort on PMJM population.

Task 5.6: Generate a reliable estimate of PMJM abundance and distribution across Warren AFB, including a high-intensity sampling effort in all potential habitat and capture/re-capture analyses.

Task 5.7: Conduct telemetry research to evaluate PMJM movement and use of space.

Task 5.8: Investigate potential adverse impacts to PMJM from weeds and/or weed control measures.

Task 5.9: Determine habitat patch size parameters for managing *Gaura* and PMJM on the same stream segments (i.e., how small can an opening be and still sustain *Gaura*, and how large can an opening be and still be crossed by PMJM).

Objective 6. Ensure that existing hydrologic function (i.e., flow quantity, timing, and duration) remains intact.

Task 6.1: Program requirements for this objective in the Automated Civil Engineer System database and submit for funding.

Strategy 6A. Coordinate with Installation neighbors to minimize adverse impacts to Warren AFB populations of* Gaura *and PMJM, and their habitats, from offsite activities. Both *Gaura* and PMJM rely upon riparian habitat for survival. The quality of this riparian habitat is inseparable from the hydrological system of the Crow Creek basin. Warren AFB does not have jurisdiction over lands outside installation boundaries, but its conservation and management efforts could be greatly enhanced or constrained by future offsite activities. On-going coordination with neighbors will help in early identification of potential offsite threats and retain management options.

Task 6.2: Identify local government representatives from City of Cheyenne and Laramie County (e.g., planning and development departments, board(s) of public utilities, weed coordinators, etc.), the U.S. Forest Service, a state lands representative, and any others, who should be included in outreach efforts. Inform these representatives of Warren AFB conservation and management activities. Solicit input on relevant offsite activities and other entities that should be contacted.

Task 6.3: Stay informed about significant changes in adjacent and upstream land and water use. Participate in local planning efforts related to *Gaura* and PMJM conservation objectives, and promote strategies that offer opportunities for collaborative conservation.

Task 6.4: Monitor groundwater levels to detect any potential changes to the water table from off-site activities. The Base's Installation Restoration Program has

thousands of existing monitoring wells (installed for monitoring TCE plumes) that could be used for this purpose. Consult with a hydrologist to identify appropriate monitoring intervals.

Strategy 6B. Allow persistence of a healthy beaver population in Crow Creek.
The activities of beaver assist in groundwater recharge and maintain the high water table necessary for the support of healthy riparian vegetation.

Task 6.5: Limit active beaver management to areas where beaver activity is in direct conflict with safety issues (i.e., roads, drainage culverts, bridges, etc.).

Task 6.6: If beaver damage to cottonwoods becomes problematic, attempt to mitigate damage (e.g., wrap trunks with chicken wire or some other material) prior to beaver removal.

Task 6.7: Monitor impacts of beaver activity on *Gaura*. If beaver cause a net reduction in occupied *Gaura* habitat, the approach to beaver management will need to be re-evaluated.

Figure 13. High priority areas for weed control, and for grass mowing in *Gaura* habitat. Boundaries are guidelines only, and should be re-evaluated annually.

PART 4: CONSERVATION ZONES

In order to achieve the goals and objectives of this plan, management strategies will need to be implemented in specific locations on the landscape. Conservation zones as used herein depict geographic areas where habitat maintenance, habitat restoration, and research activities should be focused. Management strategies are related to each conservation zone, or to specific areas within a zone, as appropriate. The conservation zones appearing on Warren AFB lands are listed below, and are displayed on Figure 14. Note that Zone 4 should ultimately become Zone 3 when management objectives are achieved.

Zone 1: *Gaura* Management
Zone 2: *Gaura* Experimentation
Zone 3: PMJM Management
Zone 4: PMJM Restoration

These subspecies are directly dependent upon maintenance of a healthy and functioning riparian system and associated uplands. Alterations to the hydrologic regime of the Crow Creek watershed that take place outside these boundaries have the potential to impact the quality and condition of habitat within the boundaries. Thus, even though much of the habitats outside the riparian zone are not included within conservation boundaries, management of these areas should be conducted in a manner consistent with maintenance of existing flows, hydroperiod, and geomorphology within the watershed.

Zone 1: *Gaura* Management

Zone 1 represents areas in which *Gaura* is known to occur, as well as adjacent habitat patches that are likely to be occupied. Management for *Gaura* in this zone should be as inclusive as possible.

Conservation Focus: Manage for open habitats adjacent to the riparian zone to maximize the number of *Gaura* plants and the quality of their habitat.

General Guidelines for Management:

1. Limit activities to existing use only. Additional permanent structures should not be erected within this zone.
2. Plan and execute maintenance of existing buildings and infrastructure, weed control, and other management activities to minimize damage or destruction of riparian and upland vegetation.
3. Avoid additional changes to local hydrology. Consult with the USFWS if hydrological alteration is unavoidable. Any unavoidable hydrological alteration should be minimized and carefully monitored, and adverse impacts mitigated. Control erosion and altered run-off.
4. Restore local pockets of poor quality habitat, and monitor plants annually to ensure their presence.

Zone 2: *Gaura* Experimentation

Zone 2 identifies areas that are not currently suitable for occupation by *Gaura*, but may be experimentally manipulated using transplantation and creation of new habitat to test restoration techniques.

Conservation Focus: This area is ancillary to the core objective of maintaining and enhancing *Gaura* numbers. This area has the most severe infestation of leafy spurge in riparian corridor habitat. Control of leafy spurge is the main conservation focus. This area has the potential to be used for *Gaura* transplantation and artificial habitat creation in the future.

General Guidelines for Management:
1. Control leafy spurge.
2. Consider the area for *Gaura* transplantation and habitat construction that restores or creates wet meadow zones or wet meadow swales with native vegetation.
3. Monitor to evaluate success.

Zone 3: PMJM Management

Zone 3 represents areas in which PMJM is known to occur, as well as adjacent habitat patches that are likely to be occupied. Management for PMJM in this zone should be as inclusive as possible. In most cases, the boundaries of this zone should be measured approximately 100m from the best estimation of the 100-year floodplain. Based on the most current information available on mouse movement and habitat use, this area should provide enough undisturbed habitat to accommodate PMJM life history requirements. However, this estimate may change if future research indicates greater use of upland habitats or different movement patterns than is currently documented.

Conservation Focus: Manage riparian and upland systems to maximize the number of mice and the quality of their habitat.

General Guidelines for Management:
1. Limit activities to existing use only. Additional permanent structures should not be erected within this zone.
2. Plan and execute maintenance of existing buildings and infrastructure, weed control, and other management activities to minimize damage or destruction of riparian and upland vegetation.
3. Avoid additional changes to local hydrology. Consult with the USFWS if hydrological alteration is unavoidable. Any unavoidable hydrological alteration should be minimized and carefully monitored, and adverse impacts mitigated. Control erosion and altered run-off. Recognize that beaver presence and activity maintain high quality PMJM habitat over the long term. Local alterations in

hydrology and riparian vegetation from beaver activity is not a negative impact to PMJM as long as the disturbed site has potential for natural seral progression.
4. Restore local pockets of poor quality habitat, and monitor mice annually to ensure their presence.

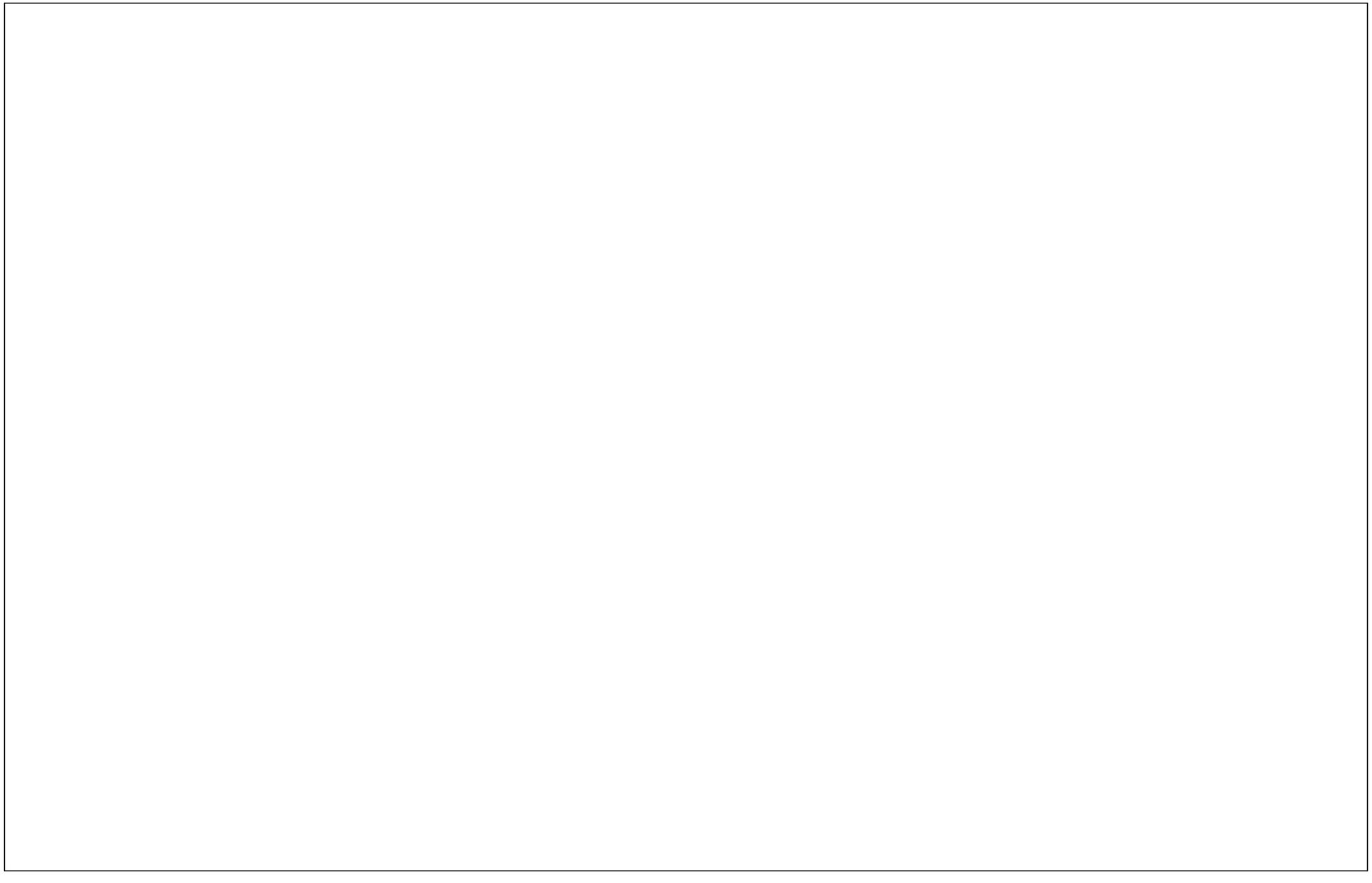
Zone 4: PMJM Restoration

Zone 4 identifies areas that are either not currently suitable for occupation by PMJM (but that may be restorable to high quality PMJM habitat), or areas that may be inhabited by PMJM, but to a greatly reduced extent. Zone 4 also contains areas that could, if restored, provide refugia against catastrophic events on the mainstem of Crow Creek. Restoration of Zone 4 areas could significantly increase the potential number of mice in the Warren AFB population.

Conservation Focus: Restore altered habitat to riparian vegetation with density and structural diversity sufficient to support PMJM at levels believed to be within the range of natural variability.

General Guidelines for Management:
1. Investigate feasibility of restoring late seral riparian vegetation patches, including a woody component (i.e., willow overstory) in altered areas.
2. If possible, restore patches in suitable size, density, and configuration to increase the Warren AFB habitat area, and to facilitate movement between upstream and downstream PMJM populations. Consult on the construction or modification of road crossings and similar structures to ensure permeability to PMJM.
3. Monitor annually to evaluate success.

Figure 14. Conservation Zones for *Gaura* and Preble's meadow jumping mouse.



PART 5: GEOGRAPHIC MANAGEMENT AREAS

The Conservation Zones for *Gaura* and PMJM presented in the previous section overlap in several places. Because *Gaura* and PMJM have different habitat requirements within these overlapping areas, there is potential for conflicting management needs. The management areas presented in this section are included as a means of synthesizing the management needs of both species in specific geographic locations, and to highlight those areas where management for one species needs to be coordinated with management for the other.

Upper Crow Creek

The Upper Crow Creek management area extends from the western boundary of Warren AFB to South Frontier Road.

Unit description:
Crow Creek is a perennial creek with abandoned channels in its upper reach (Heidel and Laursen 2002). USGS stream flow data for Crow Creek from 1994 – 1996 document a major peak in flow volume during June (Laursen and Heidel 2003), indicating that Crow Creek is fed by montane headwaters. Crow Creek has a more stable water table because of the perennial flow, but the soils are coarser in texture at the surface of Crow Creek than Diamond Creek and the Unnamed Drainage. Thus, the surface soils of Crow Creek do not hold water as well as those of Diamond Creek and the Unnamed Drainage (Laursen and Heidel 2003). Part of this area contains a nature trail, and is used intensively for recreation (Munk et al. 2002).

The riparian areas within the floodplain are a mosaic of some woodlands, extensive willow thickets, occasional cattail marshes, swales, abandoned oxbows, and dry and moist meadows. Coyote willow (*Salix exigua*) is pervasive and dominant through much of the area. Other species present include green ash (*Fraxinus pennsylvanica*), lanceleaf cottonwood (*Populus* x *acuminata*), strapleaf willow (*S. eriocephala* var. *ligulifolia*), cattail (*Typha latifolia*), Nebraska sedge (*Carex nebrascensis*), woolly sedge (*C. lanuginosa*), redtop (*Agrostis stolonifera*), Baltic rush (*Juncus balticus*), Kentucky bluegrass (*Poa pratensis*), little bluestem (*Schizachyrium scoparium*), and licorice-root (*Glycyrrhiza lepidota*). Adjacent dry uplands consist of grasslands with scattered patches of ash and cottonwood (Marriott and Jones 1988; Heidel and Laursen 2002; Laursen and Heidel 2003).

The noxious weeds Canada thistle, leafy spurge, common hound's tongue, and Dalmatian toadflax are extensive throughout. Among riparian areas, Upper Crow Creek has the most extensive infestations of Canada thistle, common hound's tongue, and Dalmatian

toadflax on the Base (Heidel and Laursen 2002). It also has the only extensive willow thickets, which have spread extensively in recent years (Jones 2003).

Since Crow Creek is a perennial stream, and is the closest of the three Warren AFB drainages to the historic Fort complex, it is presumed that the historic uses described by Barlow and Knight (1999) in riparian habitat were concentrated on Crow Creek. The placement of these uses, including corrals, gardens, local water supply infrastructure, and garbage dumps, is not known, but the gentler terrain and broader bottomlands at the lower (eastern) end of Crow Creek would seem to be more conducive than those in the upper end.

Management of the upper end of Crow Creek and Diamond Creek are addressed in a 1982 MOU, have had mowing and spraying of weeds curtailed since 1988, and are part of a Research Natural Area designated for *Gaura* in 1990.

Gaura Status:
Monitoring data from 1986 – 2003 show long-term major declines in *Gaura* numbers along Crow Creek (Laursen and Heidel 2003; Heidel 2004a) as compared to the other two creeks. *Gaura* numbers along Crow Creek in 2003 were over four times lower than all previous low values (Heidel 2004a). At two previous times over the monitoring period, Crow Creek supported the highest numbers of *Gaura* plants of all three creeks.

PMJM Status:
The majority of past capture locations on Warren AFB, as well as the most recent capture locations, are documented from this management area. Four PMJM were captured in 2002, all in the extreme western (upstream) area; one PMJM was captured here in 2003 (Beauvais 2004). Prior captures were in 1998 (seven locations scattered throughout the management area upstream of South Creek Drive), and in 1996 (four locations, all in the upstream half of the management area).

Conservation Issues: Habitat degradation; Isolation of PMJM population.
Noxious weeds are present throughout. The distribution of coyote willow is ubiquitous in Upper Crow Creek. The extent and height of willow thickets in this area have increased such that many formerly open meadows are now dominated by coyote willow over 4 feet tall (Laursen and Heidel 2003). While this condition represents an improvement in habitat for PMJM, willow encroachment is not compatible with sustaining *Gaura* populations.

Conservation Zones: Zone 1 – *Gaura* Management; Zone 3 – PMJM Management.

Primary Management Focus:
1. Control noxious weeds.
2. Reduce willow cover to decrease competition with *Gaura* and increase seedling establishment. **Must be coordinated with management for PMJM**. Reduction in willow should be done on an appropriate spatial scale to facilitate *Gaura*

establishment without adversely affecting PMJM. Research is needed to define appropriate size of willow removal patches.

3. Continue *Gaura* research and monitoring.
4. Conduct additional research to increase understanding of PMJM status.
5. Identify and eliminate barrier(s) to downstream movement of PMJM.
6. Minimize site-specific impacts to *Gaura* and PMJM, and their habitat, from installation facilities and activities, including (but not limited to) FamCamp, the nature trail, and roads and bridges.
7. Maintain the hydrological integrity of Crow Creek as it passes through Warren AFB, and allow the natural processes associated with the presence of beaver to operate.

Diamond Creek

Unit description:
Diamond Creek is a highly meandered, intermittent tributary to Crow Creek. Standing water remains during most years, but flow ceases in late summer. Steep, north-facing slopes border the valley on the south. There is a notable absence of willow species except at the mouth. Woodland and shrubland habitat is confined to the lowest reach, and the bottomlands are a mosaic of wet and dry meadows that follow the meanders. The sheltered, north-facing valley slope has wet meadow habitat extending short distances upslope. The upper end of Diamond Creek is located in a high-security area, and access by humans is limited.

The wet meadow species associated with *Gaura* include *Agrostis stolonifera*, *Aster falcatus*, *Panicum virgatum*, *Equisetum laevigatum*, and *Solidago canadensis*. Large flats along the meandered creek are dominated by Canada thistle, and the north-facing valley slope directly above the creek could see tremendous increases in leafy spurge above and beyond the current levels of infestation.

Recent disturbance on the Base includes a pipeline crossing in the 1980s at the upper (western) end of the Creek. An unimproved road crossing has been added in the high—security area for patrol units. Immediately west of the Base, there was temporary stream flow alteration when the drop structure was repaired in 2002, and large areas of the Diamond Creek watershed west of the Base are under subdivision development.

Management for Diamond Creek and the upper end of Crow Creek are addressed in a 1982 MOU, have had mowing and spraying of weeds curtailed since 1988, and are part of a Research Natural Area established for *Gaura* in 1990.

Gaura status:
Monitoring data from 1986 – 2003 show that Diamond Creek had the highest *Gaura* numbers for 14 years, compared to the other two creeks (Heidel 2004a). *Gaura* along Diamond Creek show an overall long-term pattern of increase, despite four consecutive years of decline that are at least partially due to drought.

PMJM status:
Not known to occur. The only PMJM sampling known to occur along Diamond Creek was in 1998, when 3 trapping transects were active along the stream (Beauvais 1998). Two transects covered an approximately 150m segment immediately upstream of the confluence with Crow Creek, and one transect covered an approximately 50m segment due north of the junction of Cheyenne Road and South Frontier Road. No *Zapus* were captured.

Conservation Issues: Habitat degradation; Isolation of PMJM population.
Noxious weeds are present throughout. Willow thickets are expanding outside of *Gaura* polygons at the lower end of Diamond Creek (Laursen and Heidel 2003), which could result in reduced habitat quality for *Gaura*. Potential barrier at Missile Drive and poor habitat quality (low willow density) for PMJM presumed to prevent dispersal of mice from along Crow Creek.

Conservation Zones: Zone 1 – *Gaura* Management; Zone 4 – PMJM Restoration.

Primary Management Focus:
1. Control noxious weeds.
2. Increase willow cover from confluence with Crow Creek to Nebraska Avenue to provide refugia for PMJM. **Must be coordinated with management for *Gaura*.**
3. Eliminate or mitigate potential barrier to PMJM movement at Missile Drive.

Upper Unnamed Drainage

Unit description:
The Unnamed Drainage is an intermittent tributary to Crow Creek that originates in the gentle uplands on the Base. It consists of a single meandered watercourse in a broad, open setting (Laursen and Heidel 2003). It has a much shorter segment of *Gaura* occupied habitat and a much smaller area of habitat compared to the other two creeks.

The wet meadow habitat is quite similar to that on Diamond Creek. This is the only riparian habitat on the Base that does not have leafy spurge.

A road that runs parallel to Unnamed Drainage was recently graded, broadened, and re-opened for general access. It is not known if the ditching or entry of the embankment in wetland habitat has altered groundwater movement, but the shoulders that border *Gaura* have experienced an explosion in Canada thistle cover.

Upper Unnamed Drainage was included in the 1982 MOU, and mowing was curtailed in 1988, but this area is not included in the Research Natural Area designated for *Gaura* in 1990.

Gaura status:
Monitoring data from 1986 – 2003 on the Unnamed Drainage show a long-term increase in *Gaura* (Heidel 2004a), despite a short-term decline from 2000 – 2002 associated with drought (Laursen and Heidel 2003). In 2003, the *Gaura* numbers on the Unnamed Drainage increased greatly compared to previous years, and made up the highest *Gaura* numbers on the Base for the first time, compared to the other two creeks (Heidel 2004a).

PMJM status:
Not known to occur, and habitat is not suitable. This management area is not currently relevant to PMJM. A cursory survey, consisting of a single trapping transect, was conducted in 1998 with no *Zapus* captured (Beauvais 2004).

Conservation Issues: Habitat degradation.
Noxious weeds are present throughout.

Conservation Zones: Zone 1 – *Gaura* Management.

Primary Management Focus:
1. Control noxious weeds.

Lower Unnamed Drainage

The Lower Unnamed Drainage management area extends from Commissary Road downstream to the confluence with Crow Creek.

Unit description:
The Unnamed Drainage is an intermittent tributary to Crow Creek. It consists of a single meandered watercourse in a small valley setting at its lower end, part of which has been substantially bulldozed and recontoured in the creation of artificial wetlands.

The lower reach of Unnamed Drainage above the mouth on Crow Creek has been entirely re-contoured, plowed, and seeded for the creation of artificial wetlands. The creation of open water destroyed what wet meadow habitat there may have been. The short segment of un-impounded riparian habitat between the housing development and the re-contoured area is a narrow band of trees with weeds present throughout, but no wet meadow zone. However, survey information was gathered during the same year as earth-moving, which was a drought year. Lower Unnamed Drainage was determined to be unsuitable in its current condition for inclusion in proposed *Gaura* transplantation studies by University of Wyoming professor Dr. Ann Hild.

Gaura status:
Not known to occur. This area would be suitable for adding to the *Gaura* experimentation zone.

PMJM status:
Documented here in 1995. The only PMJM sampling known to occur along lower Unnamed Drainage was in 1995, when two *Zapus* were captured as part of a general small mammal survey (Elliot 1996). In 1998 and again in 2002, trapping transects targeting *Zapus* were active along Crow Creek near the confluence with Unnamed Drainage, with no *Zapus* captured.

Conservation Issues: Habitat degradation; Isolation of PMJM population.
Noxious weeds are present throughout.

Conservation Zones: Zone 4 – PMJM Restoration.

Primary Management Focus:
1. Control noxious weeds.
2. Increase willow cover from confluence with Crow Creek to Commissary Road to provide refugia for PMJM.
3. Eliminate or mitigate potential barrier to PMJM movement at Landfill 2 detention pond.

Lower Crow Creek

The Lower Crow Creek management area extends from South Frontier Road downstream to the eastern boundary of Warren AFB.

Unit description:
The lower reaches of Crow Creek consist of a single channel (incised in places), with a broad, well-drained floodplain. There are large patches of willow and cattail that decrease in width and density downstream. Noxious weeds (Canada thistle, leafy spurge, common hound's tongue, and Dalmatian toadflax) are extensive throughout, and this area has the heaviest infestation of leafy spurge of any riparian corridor on the Base (Heidel and Laursen 2002).

In many places, shrub cover approaches or exceeds 100%. There is some wet meadow habitat that is not dominated by shrubs, but is rather dominated by tall, non-native grasses such as smooth brome (*Bromus inermis*) and quackgrass (*Elymus repens*). These are rhizomatous grasses that form monocultures with 100% cover. These grasses are scarce or absent in occupied *Gaura* habitat.

This is the area that is most likely to have been the center of historic riparian habitat disturbance. Historic impacts cited by Barlow and Knight (1999) in riparian habitat include horse corrals, gardens, drinking water sources, and garbage dumps. There was a 500-year flood on Crow Creek in 1985.

Gaura status:
There is no evidence that *Gaura* occupied this area in recent history. Periodic surveys have been conducted for new *Gaura* subpopulations across all riparian habitat on the Base, including this area, though the habitat is not considered suitable.

PMJM status:
Trapping in 2002 at the downstream edge of the management area, near the eastern boundary of Warren AFB, failed to capture any *Zapus*. The most recent capture was in 1999, at one location downstream of South Frontier Road. Previous captures were in 1998 (1 capture at Old Glory Road); in 1995 (2 captures near the confluence with Unnamed Drainage); and in 1987 (1 location downstream of South Frontier Road).

Conservation Issues: Isolation of PMJM population; Habitat degradation.
Noxious weeds are present throughout. Potential barriers to PMJM movement may exist at South Frontier Road and Old Glory Road.

Conservation Zones: Zone 2 – *Gaura* Restoration; Zone 4 – PMJM Restoration.

Primary Management Focus:
1. Control noxious weeds.

2. Conduct additional research to increase understanding of PMJM status.
3. Identify and eliminate barrier(s) to movement of PMJM.
4. Minimize site-specific impacts to PMJM and its habitat from installation facilities and activities.
5. Maintain the hydrological integrity of Crow Creek as it passes through Warren AFB.

Table 1: Implementation Table – Objectives, Tasks, and Timeline.

Task	Description	Timeline
Objective 1. Ensure that *Gaura* subpopulations persist on all three drainages (Crow Creek, Diamond Creek, and the Unnamed Drainage). Subpopulations in each drainage should be stable or increasing in non-drought years.		
Task 1.1	Program requirements for this objective in the Automated Civil Engineer System database and submit for funding.	June 2004
Task 1.2	Implement a systematic plan with a combination of methods for weed control in threatened species' habitat.	2005; ongoing.
Task 1.3	In high priority patches, use a combination of mowing and herbicide application for weed control.	Generally spring and fall, starting 2005; repeat annually.
Task 1.4	In areas not occupied by *Gaura*, use combination of goat grazing and re-seeding with native species to reduce the competitive advantage of weeds.	Early May and late August/early September, starting 2005; repeat annually
Task 1.5	Coordinate scheduled biocontrol release program with other weed control approaches, and with conservation and management of *Gaura* and PMJM.	Summer 2005; repeat annually.
Task 1.6	Develop volunteer program to test effectiveness of hand-pulling common hound's tongue.	May – July 2004; repeat annually.
Task 1.7	Schedule consultation with Cooperative Extension to collaborate on leafy spurge and Canada thistle control.	2004
Task 1.8	Monitor results of each weed control method for effectiveness, manageability, and adverse impacts on *Gaura* or PMJM.	Annually
Task 1.9	Reduce willow encroachment in occupied *Gaura* habitat.	Summer 2004
Task 1.10	Increase mowing in high priority grassy areas to increase the amount of open habitat and reduce competition with *Gaura* seedlings for light.	In spring prior to *Gaura* bolting in June; repeat annually.
Objective 2. Increase distribution of PMJM throughout the Warren AFB portion of Crow Creek.		
Task 2.1	Program requirements for this objective in the Automated Civil Engineer System database and submit for funding.	June 2004
Task 2.2	Conduct a comprehensive survey of all potential PMJM habitat on the Base to verify current distribution.	2005 – 2006; repeat as necessary.

Task	Description	Timeline
Task 2.3	If surveys fail to document PMJM downstream of South Frontier Road, formulate and test hypotheses to explain absence.	2007; ongoing as necessary.
Task 2.4	Evaluate road crossings at S. Creek Drive, S. Frontier Road, and Old Glory Road as potential barriers to PMJM movement. Reduce length of separation between habitat patches.	2005 – 2006; repeat as necessary.
Task 2.5	Increase willow cover in areas where distance between existing patches may discourage dispersal of PMJM.	2005
Objective 3. Create or restore PMJM habitat to provide PMJM with refugia against catastrophic events on the main stem of Crow Creek.		
Task 3.1	Program requirements for this objective in the Automated Civil Engineer System database and submit for funding.	June 2004
Task 3.2	Work with Base engineers to develop and implement a method for altering the retention pond dam and/or culvert at Landfill 2 to enhance connectivity between Crow Creek and the Unnamed Drainage.	2004 – 2005
Task 3.3	Plant additional willow along lower Unnamed Drainage to increase suitable habitat and connectivity.	2006
Task 3.4	Increase willow cover along lower Diamond Creek.	2006
Task 3.5	Evaluate the crossing of Missile Drive and Diamond Creek as barrier to PMJM movement. Work with Base engineers to develop and implement crossing design that will offer mice access to habitat along Diamond Creek.	2006
Objective 4. Eliminate or minimize threats to *Gaura* and PMJM, and associated habitats.		
Task 4.1	Program requirements for this objective in the Automated Civil Engineer System database and submit for funding.	June 2004
Task 4.2	Implement habitat improvement tasks relative to weed control, willow management, and riparian system connectivity.	2004; ongoing.
Task 4.3	Coordinate with weed control experts and USFWS to design the most appropriate weed control strategy for *Gaura* and PMJM habitat.	2004 – 2005
Task 4.4	Work with the Environmental Leadership Council to establish habitat improvement and conservation as a priority; ensure that necessary resources and personnel are available to implement strategies; commit to annual implementation of weed control program.	2004; ongoing.
Task 4.5	Develop Best Management Practices for offsetting impacts to *Gaura* and PMJM.	2004 – 2005

Task	Description	Timeline
Task 4.6	Institutionalize chain of communication between Base wildlife biologist and other Base work centers.	2004
Task 4.7	Distribute "consultation zone" map to Base program managers who have jurisdiction over projects that could impact *Gaura* and PMJM habitats	2004
Task 4.8	Develop educational program package for the Base that synthesizes the most important information on *Gaura*, PMJM, and their habitats.	2005
Task 4.9	Maintain appropriate channel and floodplain features. Carefully monitor and mitigate unavoidable hydrological alteration. Control sedimentation and altered runoff.	Ongoing
Objective 5. Sponsor research and monitoring projects to answer high priority questions, to evaluate effectiveness of management strategies, and to improve chances of conservation success.		
Task 5.1	Program requirements for this objective in the Automated Civil Engineer System database and submit for funding.	June 2004
Task 5.2	Continue annual census of flowering *Gaura* plants.	Ongoing
Task 5.3	Conduct management response research.	2005; ongoing.
Task 5.4	Complete intensive sampling of nonflowering *Gaura* plants and competing species.	2005
Task 5.5	Promote research on *Gaura* life history, competition and restoration.	2005; repeat annually as necessary.
Task 5.6	Generate reliable estimate of PMJM abundance and distribution across Warren AFB.	2005 – 2006; repeat annually as necessary.
Task 5.7	Conduct telemetry research to evaluate PMJM movement and use of space.	2006; repeat annually as necessary.
Task 5.8	Investigate potential adverse impacts to PMJM from weeds and/or weed control.	2006; repeat annually as necessary.
Task 5.9	Determine ideal patch size parameters for managing *Gaura* and PMJM on the same stream segments.	2005 – 2006
Objective 6. Ensure that existing hydrologic function remains intact.		
Task 6.1	Program requirements for this objective in the Automated Civil Engineer System database and submit for funding.	June 2004
Task 6.2	Identify and approach federal, state, and local government representatives, and others who should be included in coordination of riparian system management.	2005; ongoing.

Task	Description	Timeline
Task 6.3	Stay informed about significant changes to adjacent and upstream land and water use.	Ongoing
Task 6.4	Monitor groundwater levels to detect potential changes to the water table from off-site activities.	2005; ongoing. Consult with hydrologist to identify appropriate monitoring intervals.
Task 6.5	Limit active beaver management to areas where beaver activity is in direct conflict with safety issues.	Ongoing
Task 6.6	Mitigate beaver damage prior to beaver removal.	Ongoing
Task 6.7	Monitor impacts of beaver activity on *Gaura*. Re-evaluate approach to beaver management if beaver cause net reduction in occupied *Gaura* habitat.	2005; repeat annually.

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APPENDIX A: RANGEWIDE THREATS TO PREBLE'S MEADOW JUMPING MOUSE

The information presented in this Appendix is based in part on discussions held by Colorado's PMJM Science Advisory Team, in a series of meetings conducted during 1998 and 1999, and funded by the Colorado Department of Natural Resources. It was originally compiled by Chris Pague (The Nature Conservancy) and Lee Grunau, Rob Schorr, and John Armstrong (CNHP) in August, 1999. The following discussion was based on an analysis of the complex interactions of land use and other human-related factors operating in PMJM habitat within Colorado. It is not meant to specifically address either *Gaura* or PMJM in Wyoming. However, as a summary of how these issues are generally related to PMJM viability or decline, it may prove useful to Warren AFB in their efforts to conserve this threatened species.

Situation Analysis Based on Issues Related to Conservation of Preble's Meadow Jumping Mouse in Colorado

General consensus exists among researchers and experts that the historic range and distribution of PMJM have declined in recent decades. In order to preserve remaining self-sustaining populations, the natural and human-related factors influencing PMJM decline must be identified and managed. Then persistence can be attained through reserve design principles and management. To assist wildlife agencies and local stakeholders in devising appropriate protection strategies, the Science Team conducted an evaluation of all potential conservation issues brought forth in three forums: 1) the USFWS documentation on the listing decision, 2) input from local stakeholders in each sub-area, and 3) the science team's analysis of PMJM ecology and field observations of habitat integrity/land use.

Given the complexity of the wildland/urban interface that exists along Colorado's Front Range, and the rapid pace at which land use patterns are changing, it is not surprising that the conservation issues for this species involve numerous, highly interrelated factors and conditions. The following discussion presents a synopsis of the most significant issues that are widespread and influencing PMJM populations across their Colorado Range.

Each of these issues is operating to a greater or lesser degree in each sub-area; likewise, different issues emerge as primary factors in different PMJM drainages. From a rangewide perspective, however, implementation of conservation strategies that address the following issues should largely serve to protect this species in Colorado.

In order to present this complex information as clearly and concisely as possible, it is presented in three steps. Step one identifies those processes or events that have direct deleterious ecological or physiological impacts on PMJM. These processes and events are referred to as "stresses." Step two identifies general landscape conditions, often related to the quality and viability of PMJM habitat, which are considered to be direct

causes of one or more stresses. These conditions are termed "proximate sources." Step three identifies the primary human activities that ultimately give rise to the proximate sources, and therefore the stresses. These activities are referred to as "ultimate sources." It should be reiterated that these stresses and sources are not evenly distributed across the landscape, and that each may act alone or in concert to limit individual PMJM populations.

Stresses to PMJM Populations and Habitat

The PMJM Science Advisory Team thoroughly reviewed all available information on the biology, ecology, and habitat use of PMJM in Colorado. Interpretation of these data in light of commonly accepted conservation biology principles indicates that Colorado's PMJM populations may be stressed by any one, or a combination, of the following conditions:

- Small population loss
- Decreased genetic variability
- Altered population structure (sex/age ratios)
- Decreased reproductive success
- Increased mortality rate
- Increased immigration or decreased emigration

Rangewide (in Colorado), each of these conditions play some role in limiting PMJM populations. These stresses are interrelated, and for each population, different stresses may be acting in concert to affect viability of that particular population, and thus persistence of the subspecies as a whole.

The complexity of PMJM population stability is not limited to the interrelationships of stresses on populations and habitat. Colorado's Front Range is a patchwork of human-dominated and natural landscapes, and that patchwork continues to undergo rapid land use change and ecological alteration. Because of this, any one stress may be caused or exacerbated by a variety of direct (proximate) and indirect (ultimate) sources. Also, most sources actually result in more than one stress.

Proximate Sources of Stress

Six immediate sources currently are, or have potential to be, causing the previously listed stresses to PMJM populations or habitat. These sources are:

- habitat destruction
- habitat degradation
- succession of riparian vegetation
- direct mortality to PMJM
- isolation of populations
- catastrophic events

Habitat destruction refers to the conversion of natural riparian and upland vegetation to other uses. Conversion may be permanent and essentially irreversible (as in the case of residential, commercial, and industrial development, parking lots associated with recreation facilities, flood control structures, and roads), or it may be at least partially reversible (as in the case of agricultural development, construction of utility lines, mining operations, trails, etc.). The greatest cause for concern in PMJM protection is permanent, irreversible land conversion.

Habitat degradation refers to changes in habitat composition, structure, or function that individually, or in combination, hamper the ability of PMJM to feed, reproduce, hibernate, or disperse. Habitat degradation may result from effects to vegetation, stream bank structure, or both. Changes to vegetation are sometimes caused by introduction and spread of weeds (especially stand-replacing invasives), or reduced density of cover from incompatible grazing. Long-term incompatible grazing can also lead to destabilization of stream banks.

Succession of riparian vegetation is closely related to hydrologic regime, including the amount of surface and ground water, as well as the timing and magnitude of flood events. Landscape changes that greatly increase or decrease any aspect of the hydrologic regime may hamper the regeneration of riparian systems, or cause them to convert to dryland systems. Conditions that commonly result in severe changes to hydrology include increased stormwater runoff from expansion of hard surfaces (such as buildings, parking lots, and roads), and flood control and water retention measures (such as impoundments and stream channelization). Changes to water quality have not been shown to adversely impact PMJM or its habitat at this time. Note that upland shrub systems may also succeed to unsuitable forested environments in the absence of periodic fire. Succession of either riparian or upland vegetation could negatively impact PMJM through reduced availability of food resources and cover habitat.

Direct mortality to PMJM refers to the death of individual mice. Direct mortality can result from construction (of building, roads, or infrastructure), increased rates of predation (from changes in predator numbers associated with human development, or reduced cover), or starvation (including overwinter mortality) from reduction in food resources. Of the other potential causes of mortality, disease is not known to impact PMJM, there is no economic value to stimulate over-collection, and trap mortality from scientific research has been minimal.

Population isolation results from the introduction of barriers into previously connected landscapes such that mice are not able to leave one population and join another. Common causes of PMJM population isolation include human developments, roads and other infrastructure, in-stream mining, and hydrologic alteration that leads to drying up of streams. Isolation may result in loss of genetic variability or increased vulnerability to catastrophic events.

Catastrophic events are chance occurrences of sudden environmental change that result in destruction of a large percentage of a PMJM population. Possible events include

catastrophic fire, accidental spills of hazardous materials, and floods. Because these catastrophes are unpredictable, and therefore impossible to manage for, PMJM conservation efforts must provide for protection of multiple populations, as well as for additional habitat to serve as refugia against such events.

Ultimate Sources of Stress

While the proximate sources have been identified as those factors leading directly to stresses on PMJM and it's habitat, the proximate sources are ultimately responses to, or effects of, direct or indirect actions from some ultimate source. The ultimate sources of the stresses on PMJM as they currently exist along the Front Range of Colorado can be traced to four primary human activities:

- residential or commercial development
- transportation corridors (construction and maintenance)
- recreational development
- agricultural land use (especially the maintenance of livestock on parcels of 40 acres or less)

Each of these ultimate sources may interact with the others, but should respond to different strategies for resolution. Also, each source can occur independently of the others. Identifying the relationships between these sources is important in prioritizing conservation strategies that can make the greatest difference in ameliorating the stress(es).

Residential and Commercial Development

Riparian habitat and adjacent lands important for PMJM may be lost or altered through housing and commercial/industrial development. This typically occurs either as direct loss from replacement of natural vegetation with buildings and hard surface landscapes, or from habitat degradation from secondary causes. The growth of Colorado's Front Range communities suggests that housing construction and commercial/industrial development will increase throughout the Colorado portion of the mouse's range for the foreseeable future. Although specific causes of mouse losses are poorly documented, there is a strong negative association between presence of PMJM and dense human housing. Possible causes of mouse extirpation from such areas include the presence of the Norway rat, house mouse, and non-native predators such as house cats. In addition, the urban landscape often compromises the habitat of PMJM, especially upland areas. In addition to direct and indirect effects on habitat, there is some evidence that the decline of small mammal faunas in urbanizing landscapes does not occur in a linear fashion. Instead, the faunal response may show a threshold effect where essentially no impact could be detected until the threshold level is surpassed.

Residential/commercial development is considered to have by far the most potential to degrade or destroy PMJM habitat. These types of developments often have significant impacts in terms of magnitude, geographic scope, and irreversibility. Direct impacts include mortality of PMJM individuals from construction activities or destruction of

PMJM habitat. Residential and commercial developments are also associated with more indirect impacts than the other three ultimate sources (roads, recreation, and agriculture). Indirect impacts are most likely to affect PMJM by altering the quality, amount, or connectivity of its habitat through degradation, fragmentation, destruction, or succession of the riparian vegetation upon which PMJM depends. Indirect impacts can include:

- Alteration of the amount of surface or ground water, or the timing of hydrologic flows. These impacts may be caused by:
    - flood control measures (impoundments and channel manipulation),
    - efforts to meet water demand (impoundments, wells),
    - increased hard surface leading to increased flows from storm water runoff
- Alteration of the quality of surface or ground water caused by:
    - pollution from leachfields, sewage plants, or weed control measures,
    - erosion or sedimentation (another common result of increased flow amounts from flood control and water development or increased hard surface)
- Alteration of natural composition of flora/fauna communities
    - introduction of noxious or invasive weeds that can alter the composition, structure, or density of riparian vegetation.
    - introduction or supplementation of domestic animals that may either compete with PMJM for food resources (e.g., house mice, rats) or prey upon PMJM (e.g., domestic cats and possibly Norway rats).
- Where new construction increases the transportation infrastructure, there are other indirect impacts:
    - introduction of barriers that isolate populations
    - rock/sand extraction leading to destruction of habitat or direct PMJM mortality
    - on-going habitat disturbance associated with maintenance of utility corridors
    - increased potential for catastrophic fire because of fire suppression typically associated with human development

Transportation Corridors

Roads, highways, and interstate superhighways all constitute a critical component of human communities. Direct and indirect impacts to PMJM or its habitat can result from new construction as well as the improvement or maintenance of current infrastructure (e.g., adding lanes, rebuilding bridges). Construction can have short-term and long-term impacts on riparian ecosystems. Short-term issues include direct impacts such as loss of habitat, temporary barriers to dispersal, degradation of riparian habitat from sedimentation, changes in stream morphology that alters the spatial arrangement and species composition of riparian vegetation, and pollution of waterways from chemical run-off associated with vehicles and road maintenance. Indirect impacts include:

- in-stream mining of rock, sand, or gravel to provide construction materials
- introduction or spread of weeds, and unintentional destruction of native vegetation from weed control measures

- increased hard surface area which increases run-off, and can further lead to accelerated erosion and increased sedimentation of streams
- potential for catastrophic accidents such as hazardous spills from road or railroad stream crossings

It should be noted that evidence from the USAFA I-25 interchanges suggests that PMJM adapts well to restored riparian habitats where sufficient ecosystem integrity exists to support a mouse population and both habitat and mice are present on both sides of the disturbance. However, alteration of dispersal patterns and increasing rates of habitat alteration (e.g., encouraging additional housing and commercial/industrial development) which result from roadway construction are long-term issues, and are ultimately of equal or greater concern.

Recreational Development

Recreational development is closely associated with residential development, but is typically smaller in scope and overall impacts to natural systems may not be as severe. The effects of trails and bike paths can be quite different from those of more intensively developed facilities such as ball parks and golf courses. Trails may provide corridors of easy access to predators of PMJM, fragment habitat, cause direct loss of habitat, and, with some infrastructure, degrade habitat. There is little evidence to date suggesting that they inhibit PMJM movement or dispersal. In fact, PMJM is known to cross trails, roads, and railroad tracks. However, trails in City of Boulder Open Space along South Boulder Creek are associated with slight (although statistically insignificant) reductions in the number of PMJM trapped (Meaney et al. 1999).

Poorly planned trails in riparian zones may impact habitat through soil compaction, bank erosion, and vegetation damage. Of greater concern may be the resulting increase in human disturbance from pedestrians, cyclists, and equestrians. Such habitat degradation may be the cause of reduced numbers, especially in areas of narrow riparian areas or already compromised habitat.

Impacts from large-scale recreational developments such as ball parks and golf courses are more problematic. While floodplains and riparian zones are often considered hazardous for buildings, these areas are often sought for recreational development. Facilities such as golf courses and ball parks built in or adjacent to riparian areas contribute directly to habitat destruction, habitat degradation, and isolation of populations. Other effects include chemical runoff from fertilizers and herbicides, introduction and spread of weeds, and alteration of local hydrological patterns from increased hard surface area (parking lots, maintenance structures, and other associated buildings). While PMJM uses grasslands, it is unlikely that groomed playing fields and fairways would provide satisfactory habitat.

Agricultural Development

Agricultural development includes both crop farming and livestock management. In most areas along the Front Range, crop farming and hay production have already reached the maximum expected extent. While land conversions of this sort may have contributed to the historic decline of PMJM, farming and hay production are not expected to contribute much to future threats. Crops other than hay are probably not used extensively, if at all, by PMJM. There are conflicting effects of hay farming. PMJM is known to occupy alfalfa fields, at least during feeding or travel. However, haying temporarily removes or seriously degrades habitat. Nonetheless, the PMJM science team generally agreed that farming that leaves a riparian buffer strip is unlikely to have major impacts on PMJM.

Commercial and private livestock management occurs at many sites occupied by PMJM. In addition, there are many localities where 40 acre or smaller parcels support livestock, usually horses. There is well documented potential for range management to degrade PMJM habitat. However, grazing is a natural ecological process throughout the range of PMJM. There are examples where livestock management co-occurs with what are apparently high quality occurrences of PMJM. However, incompatible range or pasture management has been observed in Colorado. Poor range condition is commonly observed in small properties where overstocking occurs. In short, the issue of concern here is not livestock, but herbivory that heavily impacts riparian shrublands and to a lesser extent, grasses and forbs. Secondary impacts can cause lowered water tables, stream down-cutting (gullying), and severe changes in geomorphology.

APPENDIX B: SPECIES ABSTRACTS FOR NOXIOUS WEEDS

Canada Thistle (*Cirsium arvense*)

Canada thistle. *Photo by Peggy Lyon*

Identifying characteristics:
Flowers pink-purple or occasionally white, borne in clusters of 1 – 5 per branch; leaves are spiny, alternate, oblong or lance-shaped, with the base leaves stalkless and clasping, or extended down along the spiny stem, plants 1 – 5 feet tall, single stemmed, rhizomatous; perennial (Handwerk 2002).

Phenology:
Flower: June – August. Fruit: August – October.

Dispersal mechanism:
Canada thistle invades natural communities mainly through vegetative expansion, but can be dispersed long distances by wind blown seed. It quickly spreads vegetatively via deep rhizomes, and it readily resprouts when cut (Beck 2003).

Other Relevant Life History:
Canada thistle is dioecious, having male and female flowers on separate individual plants, with only female flowers producing seeds (Nuzzo 1998). Seeds can remain viable in soil for up to 21 years, and up to four months in water (USGS 2003). The species is shade intolerant. Roots grow both horizontally and vertically. Horizontal roots can grow out 60-90cm, then bend down and grow vertically, with new horizontal roots initiated at the bend. Vertical roots can grow as deep as 6.8m (Nuzzo 1998). Root bud elongation is greatest in summer; root bud development is highest in autumn. The root carbohydrate reserves are lowest in June, just before flowering, and begin to increase in early fall as shoot growth declines (Butterfield et al. 1996; Nuzzo 1998).

Management Options:
The key to control of *Cirsium arvense* is twofold – the growth of native herbaceous species must be enhanced while stressing the Canada thistle plants, and forcing them to use stored root nutrients (Nuzzo 1998; Beck 2003). Management programs should focus on killing established clones since Canada thistle spreads mainly from its from roots; preventing seed production should be secondary. Areas treated with burning, spot-applied herbicides, biocontrols, and infrequent mowing will retain or enhance most of the native community. However, areas treated with repeated discing or mowing, or broadcast herbicides will leave little native vegetation, and therefore are not recommended for natural areas where it is important to maintain the growth of native herbaceous species (Nuzzo 1998). A single control method is rarely sufficient, and it will

take at least two growing seasons to determine whether or not a particular method is effective (Nuzzo 1998). Also, strategies should be adjusted to weather conditions (e.g., drought stress reduces effectiveness of herbicides, but increases effectiveness of mechanical controls) (Nuzzo 1998).

The most effective herbicide is picloram (Tordon), which is often used in combination with dicamba (Banvel) or 2,4D as a spring application prior to flowering, or in the fall when rosettes are growing (Butterfield et al. 1996). However, picloram is not recommended in natural areas, and is restricted from use amongst trees. It may persist in soil for up to three years, is relatively soluble, and may percolate into the water table (Beck 2003). Dicamba is effective in dry western states, including Wyoming, where it does not leach or break down as rapidly, but is restricted from use among trees (Biesboer 1998). Clopyralid plus 2,4-D (Curtail) and chlorsulfuron (Telar) are also effective against Canada thistle, especially when combined with cultural or mechanical control (Beck 2003). An alternative treatment is glyphosate (Roundup) in the bud stage or in the fall during the rosettes' growth period.

The Nature Conservancy's Phantom Canyon Preserve (in northern Colorado) has had success with multiple cuttings or grazing before flower buds show any purple, then fall selective herbicide application before the first hard frost. They use the herbicide Telar, which does not bind to the soil, breaks down within 48 hours, and is cleared for use near water. Curtail can also be used, and is less expensive, but it affects a broader range of species (H. Knight, pers. comm.).

Sandy Floyd, who conducted a Canada thistle control experiment on F.E. Warren AFB, reports that the most effective control methods were a July mow and fall spray. This resulted in significantly reduced cover and density of thistle, and an increase in cover of other desirable native plants (Floyd 1995).

Canada thistle response to burning varies, depending on the season of burn, soil moisture and location. In general, dormant season burns have been shown to stimulate native species growth and reduce the abundance of thistle, whereas growing season fires may reduce thistle density but harm native species (Nuzzo 1998).

The effectiveness of biological controls alone is not clear. Their suitability for use can vary depending on local conditions (such as moisture), timing of application can be critical, and effectiveness may vary between sites and years. *Ceutorhynchus litura* (a weevil) is currently used as a biocontrol agent in Colorado, and has also been released and become established in other areas (Butterfield et al. 1996). However, *Ceutorhynchus* alone will not effectively control Canada thistle. A combination of control measures must be used for effective control (Beck 2003).

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Leafy Spurge (*Euphorbia esula*)

Identifying characteristics:
Flowers yellowish-green, small, arranged in numerous small clusters with a pair of heart-shaped yellow-green bracts below each flower; leaves are alternate, narrow with smooth margins, 1 – 4 inches long; stems are unbranched and typically clustered together; plants up to 3 feet tall, the entire plant contains a milky latex; perennial (Handwerk 2002).

Leafy spurge. *Photo by Dave Anderson*

Phenology:
Flower: May – June. Fruit: July – August.

Dispersal mechanism:
Leafy spurge invades natural communities primarily through seed dispersal from mid to late July, into early August. The seed capsules explode, forcibly ejecting seeds up to 5m. The seed can be transported by water and wildlife. Leafy spurge also spreads vegetatively via deep rhizomes and roots (Beck 2003).

Other Relevant Life History:
Leafy spurge emerges earlier in spring that most other species, giving it a competitive advantage. It can produce over 100,000 seeds per plant; the seeds have a high germination rate (60 – 80%), and may remain viable in the soil for approximately 5 – 8 years (Butterfield et al. 1996). Peak germination occurs in May, and after 10 – 12 days seedlings are able to reproduce vegetatively by developing buds on roots (Beck 2003). Leafy spurge's extensive root system can give rise to shoot buds almost anywhere along its length. Both crown buds and root buds can remain viable in the soil for a number of years (Rutledge and McLendon nd). Butterfield et al. (1996) report roots of nearly 5m laterally and 9m deep, with up to 300 buds. Due to the extensive root system, cultivation or shallow removal of plants can actually increase the number of stems (Biesboer 1998). Rapid re-establishment of dense stands can occur after apparently successful management because of the long-lived root system (Biesboer 1998). Leafy spurge has been reported to cause severe irritation to the mouth and digestive tract of cattle (Rutledge and McLendon nd).

Management Options:
The most effective control of leafy spurge will require a number of different management techniques aimed at reducing root reserves and stressing the plants (Rutledge and McLendon nd). Monitoring and repeated control measures are generally considered necessary for at least 10 years following initiation of active management (Biesboer 1998).

Reduction of infestation to manageable levels is possible with herbicides. Picloram (Tordon) is most effective, and is sometimes used in conjunction with 2,4D. However, picloram is not recommended in natural areas, and is restricted from use amongst trees. It may persist in soil for up to three years, is relatively soluble and may percolate into the water table (Beck 2003). Dicamba (Banvel) is effective in dry western states (including Wyoming) where it does not leach or break down as rapidly, but is restricted from use among trees (Biesboer 1998). Imazapic (Plateau) has been recently registered for use in noncrop areas. It is safe to use around trees, but may injure cool season perennial grasses (Beck 2003). Leafy spurge is sensitive to the timing of herbicide application; the most effective times are in spring at flowering and late September during fall regrowth (Beck 2003).

Grazing sheep or goats can help deplete root reserves, and could be used in conjunction with fall herbicide application. Sheep eat leafy spurge in early spring; goats eat it at most times in growing season (Beck 2003). If livestock are grazed after seed formation, they should be held in a corral for at least seven days before moving them to a different location to prevent seed transport (Beck 2003). Research at CSU indicates that six to eight sheep/acre grazing 10 days in July for five years decreased spurge by 90%. When sheep and flea beetles were grazed simultaneously, leafy spurge density was reduced 100% (Beck 2003).

Biocontrol agents such as insects can play an important role in leafy spurge control, especially in areas where herbicide use is difficult or risky (Beck 2003). Several species of flea beetles are available for use as biocontrol agents; the two most promising are *Apthona nigriscustis* (the black-dot flea beetle) and *A. flava* (the copper spurge flea beetle) (Butterfield 1996; Beck 2003).

Burning in conjunction with herbicides is effective in open areas, but must be repeated over years. Burning alone is not likely to be effective because of resprouting from roots. Many of The Nature Conservancy preserves use a combination of burning and/or mowing, with herbicide application. Mowing can reduce above ground stands, and stress the plants in a manner similar to grazing, but must be used in conjunction with herbicides to be effective (Biesboer 1998). Mechanical cultivation is not recommended for leafy spurge control due to the species ability to resprout from root buds (Rutledge and McLendon nd; Butterfield 1996).

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Dalmatian Toadflax (*Linaria dalmatica* ssp. *dalmatica*)

Identifying characteristics:
Flowers yellow, resembling snapdragons, occurring in terminal, elongated racemes; leaves are waxy, alternate, broad and rounded, crowded with upper leaves clasping the stem; stems 1 – 25 per plant, somewhat woody, clumps of stems can be up to 3 feet tall; perennial (Handwerk 2003). Dalmatian toadflax closely resembles a related invasive weed – yellow toadflax (*L. vulgaris*). The leaves of the species *dalmatica* distinguish it from *vulgaris*, which has narrow, linear, and pointed leaves that do not clasp the stem.

Linaria vulgaris. *Photo by Dave Anderson*

Phenology:
Flower: May – August. Fruit: July – October.

Dispersal mechanism:
Dalmatian toadflax invades natural communities via seed and vegetative propagation (Carpenter and Murray 1998). Seed is dispersed primarily by wind, but also via livestock. The species can also spread rapidly by rhizomes (Rutledge and McLendon nd).

Other Relevant Life History:
In one season, an individual plant of Dalmatian toadflax can produce 1 – 25 floral stems, resulting in as many as 500,000 seeds per year (Carpenter and Murray 1998; CNAP 2000). Seeds mature in late summer, generally germinating the following spring, but can remain dormant up to 10 years. Seedlings are ineffective competitors for soil moisture, and initial root development is slow, making seedlings an ideal growth stage for control. However, once established, reproduction from root buds begins as early as 2 – 3 weeks after germination. Roots as short as 1cm can produce stems (Beck 2001). The taproot of established plants can penetrate the soil as deep as 1m, and extend horizontally for several meters (Carpenter and Murray 1998). The extensive, deep root system and waxy leaves make control very difficult (Rutledge and McLendon nd).

Management Options:
Dalmatian toadflax is difficult to control and management plans should incorporate as many strategies as possible to achieve success (Beck 2001). The main key to control is to eliminate or greatly reduce seed production, and to destroy seedlings from the seed bank before they can become established. Plants can be successfully controlled by pulling or

applying herbicides before seed production begins, but control efforts must continue for at least 10 years, since seeds remain viable that long and plants can reproduce vegetatively. Desirable native species such as competitive grasses and/or forbs should be planted to replace the controlled Dalmatian toadflax (Carpenter and Murray 1998). Management should be conducted in June, when buds are formed and beginning to flower, and root reserves are lowest, with a follow-up treatment in late June/early July to catch late-flowering plants (Carpenter and Murray 1998).

Several herbicides are considered effective for Dalmatian toadflax management. Glyphosate (Roundup) will kill non-target plants but can be applied directly; it biodegrades in soil, but may persist in active form for as long as 79 days. Dicamba (Banvel) does not bind to soil, but may leach into groundwater, and has the potential to persist in natural areas for long periods of time (Carpenter and Murray 1998), and is restricted from use among trees (Biesboer 1998). Picloram (Tordon) may leach into water, and damage to non-target vegetative is major problem. Picloram is not recommended in natural areas, and is restricted from use amongst trees (Beck 2003). Research also indicates that chlorsulfuron (Telar) is effective in controlling Dalmatian toadflax in non-crop areas (Beck 2001).

Burning is not recommended as a management option due to the large, deep root systems of Dalmatian toadflax, and the susceptibility of burned areas to increased infestations of weedy species (Carpenter and Murray 1998). Also, grazing and shallow cultivation will not destroy plants because of the deep root system. Removal of above ground growth by cutting at the soil surface or hand pulling can eliminate reproduction by seed if it is done in spring or early summer (Carpenter and Murray 1998).

There are several biological control agents available to control toadflax, but their effectiveness remains largely unknown (Beck 2001). Several insects have been approved for release by in the United States. *Brachypterolus pulicarius,* the toadflax flower beetle feeds on the reproductive parts of the plant (Beck 2001). *Calophasia lunula,* the toadflax moth, can defoliated up to 20% of stems where established, but it is not well adapted to cold, high elevation areas (Carpenter and Murray 1998; Integrated Weed Control 2003). *Gymnaetron antirrhini,* the seed-eating weevil, usually attacks yellow toadflax but one strain has adapted to feed on Dalmatian toadflax, and has the potential to reduce seed production (Carpenter and Murray 1998).

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Common Hound's Tongue (*Cynoglossum officinale*)

Identifying characteristics:
Flowers reddish-purple, with five petals, and occur in long, sometimes branched, terminal clusters; leaves are alternate, 1 – 12 inches long, 1 – 3 inches wide, rough, hairy, and lacking teeth or lobes; stems are erect, stout, heavy, 1.5 – 3 feet tall; the entire plant is covered with soft white hairs; biennial or short-lived perennial (Handwerk 2002).

Common hound's tongue. *Photo by Dave Anderson*

Phenology:
Flower: May – July. Fruit: July – August.

Dispersal mechanism:
Hound's tongue invades natural communities primarily through seed dispersal. Seeds drop to the ground, are transported on clothing or in animal fur, or may remain on plants over winter for subsequent dispersal (Butterfield et al. 1996).

Other Relevant Life History:
A single hound's tongue plant may produce as many as 2,000 seeds. The seeds are readily dispersed, and can remain viable 2 – 3 years if they remain on the parent plant. However, seed does not remain viable underground for much more than one year (Butterfield et al. 1996). Hound's tongue foliage contains toxic alkaloids that kill cattle and horses. Sheep are more resistant than cattle or horses, but only some eat it readily (CNAP 2000; Harris and DeClerck-Floate 2003). The prostrate rosette produced the first year resists mowing and grazing, and its taproot stores enough nutrients the first year for normal seed production the next year, even if the plant is completely defoliated early in spring. However, mowing second year plants during flowering can cause a significant reduction in seed production (Butterfield et al. 1996). Timing of mowing is important; if the stems are cut when seeds are green but fully formed, the seeds left on the ground will ripen and germinate the following spring (Harris and DeClerck-Floate 2003).

Management Options:
Effectiveness of control relies on there being enough desirable native plant species to replace the hound's tongue (Butterfield et al. 1996). Mechanical controls such as mowing second year plants during flowering can dramatically reduce seed production (Butterfield et al. 1996).

The herbicide 2,4D applied to first year rosettes in May provides effective control. It is also fairly effective when applied at flowering to second year plants. Picloram (Tordon),

chlorsulfuron (Telar) and dicamba (Banvel) applied in either spring or fall can provide excellent control of this species (Butterfield et al. 1996). However, picloram is not recommended in natural areas, and is restricted from use amongst trees. It may persist in soil for up to three years, is relatively soluble and may percolate into the water table (Beck 2003). Dicamba is effective in dry western states (including Wyoming) where it does not leach or break down as rapidly, but is restricted from use among trees (Biesboer 1998).

There are no well-established biological controls in the United States, but Canada has had some success with the root weevil *Mogulones cruciger* and the root-feeding flea-beetle *Longitarsus quadriguttatus*. The indigenous diseases *Erysiphe cynoglossi* (a mildew) and *Phoma pomorum* found in Canada, have been observed to reduce seed production and reduce roots, respectively (Harris and DeClerck-Floate 2003).

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APPENDIX C. CONSERVATION MEASURES TO BE IMPLEMENTED IN EMERGENCY SITUATIONS

The following guidelines were developed by Colorado's Science Advisory Team in 1998. These guidelines were originally intended as recommendations for minimizing disturbance in PMJM habitat during emergency situations. The following measures would not constitute complete Best Management Practices (BMPs) for *Gaura* and PMJM habitat, but they do provide a starting point for identifying the types of responses that should be incorporated into a comprehensive BMP program. They may serve as general direction while BMPs for Warren AFB are being developed.

1. Access the site via an alternate route or designate a single route through the habitat. The route should be of minimal width (i.e., one narrow lane).
2. Stage heavy equipment outside of the habitat (preferably >150 feet), whenever possible.
3. Excavate, fill, or clear only those areas absolutely necessary.
4. Avoid burying additional habitat with excavation spoils. Remove excess fill from site or to an area at least 150 feet from PMJM habitat.
5. Direct dewatering activities away from habitat and into an area that will not drain directly into PMJM habitat. Minimize dewatering activity to that which is absolutely necessary for safe and efficient emergency response.
6. Minimize local and downstream siltation by placing erosion barrier fences around excavated materials, if they are to remain for more than one day.
7. Revegetate disturbed areas as soon as equipment is moved and the response action is completed. Whenever possible, seed mixtures or planting stock should match the vegetation existing at the site prior to disturbance. Additionally, as a temporary measure, stems from removed shrubby vegetation can be used to cover freshly reseeded ground, and to provide cover for PMJM and for protecting seedlings. Finally, where willows are removed, willow stems should be planted for efficient revegetation.
8. Any residue of chemicals should be cleaned and/or removed from site to a safe disposal area.
9. To the extent possible, leave no structures, residues, trash, tracks, holes, or other fill materials that will impair the natural hydrological flow of the streams, wetlands, or ground water.