

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 its 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.