Thomomys talpoides macrotis

Northern Pocket Gopher, subspecies macrotis

BY CERTIFIED MAIL

March 20, 2003

In the Office of Endangered Species
U.S. Fish and Wildlife Service
United States Department of Interior

Petitioners:	Petition for a Rule to List Thomomys talpoides macrotis (Northern Pocket Gopher, subspecies macrotis) as Threatened or Endangered under the Endangered Species Act, 16 U.S.C. § 1531 et seq. (1973 as amended) and for the Designation of Critical Habitat; Petition for an Emergency Listing Rule under the Endangered Species Act, 16 U.S.C. §§ 1533(b)(1)(c)(iii) and 1533(b)(7) and 50 C.F.R. § 424.20.
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I. Introduction

Center for Native Ecosystems, Forest Guardians, Michael C. McGowan, and Jacob Smith hereby petition the Secretary of the Interior and the U.S. Fish and Wildlife Service (FWS) for a rule to list the macrotis subspecies of the northern pocket gopher (Thomomys talpoides macrotis) as Threatened or Endangered within its known historic range under the Endangered Species Act (ESA) pursuant to the ESA, 16 U.S.C. § 1531, *et seq.* and regulations promulgated thereunder, and the Administrative Procedure Act, 5 U.S.C. § 553(e), and for the designation of Critical Habitat. Pursuant to 16 U.S.C. §§ 1533(b)(1)(c)(iii) and 1533(b)(7) and 50 C.F.R. § 424.20, Petitioners further petition the Secretary and FWS to promulgate a rule listing T. t. macrotis on an emergency basis due to significant risks to the well being of this species, as discussed below.

Thomomys talpoides macrotis is endemic to Colorado and thought to exist currently in only five locations in Douglas County. Historically, the subspecies was known from southwest Arapaho, northwest Douglas, and possibly extreme northwest Elbert counties. However, this subspecies has experienced extensive habitat loss and recent occurrences are limited to Douglas County (CNHP 2000, EOR 003-006).

The CDOW estimates the current global population for T. t. macrotis is only 501-1,000 individuals; or "unknown, but thought to be small" (CDOW 2001). Current populations occupy a range estimated at less than 3% of the state, while the size of the largest existing population is declining, subject to sub-optimal conditions (CDOW 2001). Thomomys talpoides macrotis exhibits limited distribution in an area degraded by widescale commercial and residential development (CDOW 2001). The few surviving populations of this subspecies are in imminent danger of being extirpated by future development disturbance. Immediate listing is essential for the continued existence of this subspecies.

A central purpose of the ESA is to "provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved…" (16 U.S.C. § 1531(b)). Pocket gophers are considered keystone species and keystone engineers. They have disproportionate effects on the species composition of ecosystems and must be preserved in order to maintain the integrity of the very ecosystems in which they exist. By listing T. t. macrotis under the ESA, FWS will provide needed protections to these ecosystems and the other species that inhabit them.

This petition provides sufficient information to demonstrate that the petitioned actions are warranted. Thomomys talpoides macrotis meets the definition of an Endangered species as defined by the Act.

II. Petitioners

Center for Native Ecosystems is a non-profit advocacy organization dedicated to conserving and recovering native and naturally functioning ecosystems in the Greater Southern Rockies and Plains. Center for Native Ecosystems values all of the ways that humans benefit from protecting native biological diversity, including clean water and fresh air, healthy human communities, sources of medicines and foods, and recreational opportunities. Center for Native Ecosystems also passionately believes that all species and their natural communities have the right to exist and thrive. Center for Native Ecosystems uses the best available science to forward its mission through participation in policy, administrative processes, legal action, public outreach and organizing, and education. Among other campaigns and projects, Center for Native Ecosystems is currently working to protect native biological diversity and open space impacted by growth and development in Colorado's Front Range.

Forest Guardians is a non-profit environmental organization committed to protecting flora, fauna, natural processes, and native habitats in Colorado, New Mexico, Arizona, and Utah. Forest Guardians has a grasslands protection campaign, with particular focus on short-grass prairie in the southern plains and southwestern desert grasslands. Forest Guardians is interested in the conservation of species that face high levels of imperilment, especially those who play important umbrella and keystone functions within their ranges. However, Forest Guardians strives for the restoration and preservation of all naturally occurring components and processes within native ecosystems.

Michael C. McGowan is an individual resident of Colorado. Mr. McGowan is a student of Geography at the University of Colorado, Boulder. Mr. McGowan has an interest in the conservation of native species in the state of Colorado in general, and T. t.

macrotis in particular. Mr. McGowan has visited and will continue to visit the habitat and home ranges of T. t. macrotis for recreational, photographic, and educational purposes.

Jacob Smith is an individual resident of Colorado and the Executive Director of Center for Native Ecosystems. He currently is a resident of Paonia but has lived on the Colorado Front Range for sixteen years. He has a substantial personal interest in the conservation of biological diversity and the protection of open space on the Front Range, and is particularly concerned about the decline and possible extinction of T. t. macrotis. He has visited and will continue to visit T. t. macrotis habitat.

As this petition will demonstrate, T. t. macrotis is a subspecies that faces extinction without an Endangered or Threatened designation under the ESA. All of the factors set forth in 424.11(c) have resulted in the present biological imperilment of T. t. macrotis.

III. ESA listing criteria

Under the ESA, imperiled species need to meet only one of the following listing criteria to merit formal listing (16 U.S.C. § 1533(a)(1)). Thomomys talpoides macrotis meets all five listing criteria and therefore clearly warrants designation as an Endangered or Threatened species under the ESA. Moreover, given the imminent risk of extinction of T. t. macrotis, it should be provided with emergency listing under the Act.

A. The present or threatened destruction, modification, or curtailment of the species' habitat or range

Development pressure and suburban sprawl have degraded and destroyed T. t. macrotis habitat. These threats are ongoing as many areas of remaining undeveloped land in Douglas County have been purchased and reserved for future development. In addition, one population of T. t. macrotis faces the imminent threat of inundation from a planned water project.

B. Overutilization for commercial, recreational, scientific, or educational purposes

Development, habitat conversion, recreational, and other activities may have resulted in the destruction of individual T. t. macrotis populations during the pursuit of commercial or recreational activities. Remaining individuals are similarly threatened. The preferred habitat of this subspecies occupies an area with high potential for alternate use. Destruction of property as a result of burrowing activity in residential areas may lead to increased poisoning and trapping of T. t. macrotis.

C. Disease or predation

Residential development and other human activities may increase rates of predation by domestic cats and dogs and by disturbance-tolerant predators such as raccoons and coyotes. Furthermore, additional and more varied raptor perches created by commercial and residential development increases predation risks from above ground.

D. Inadequacy of existing regulatory mechanisms

State and federal agencies have failed to conduct even basic monitoring for this subspecies, let alone protect it from development, recreational, and other pressures. Most remaining populations of T. t. macrotis are at least partly on private land, and no regulations pertaining to T. t. macrotis apply to these lands. While some populations appear to be partly on land owned by public entities including cities, recreational districts, and water districts, these lands are generally managed for either active recreation or municipal use rather than for maintenance of wildlife habitat.

E. Other natural or man-made factors affecting the species' continued existence

The small size of all remaining populations of T. t. macrotis makes them extremely vulnerable to extirpation due to factors such as environmental and demographic stochasticity and the loss of genetic variability. Increases in soil moisture and stochastic events such as flooding could potentially extirpate entire populations of this subspecies. Changes in climate such as warmer average temperatures and drought can create potentially drastic changes to T. t. macrotis habitat. Stress resulting from continuous habitat disturbance has been documented to affect biological processes, such as birth rates, in a wide variety of species. Thomomys talpoides macrotis is no exception.

IV. Classification and Nomenclature

Thomomys talpoides is known as the northern pocket gopher. The subspecies macrotis does not have a common name, but "macrotis" refers to large ears. Pocket gophers are part of the family Geomyidae. There are three genera of pocket gophers, or geomyids, in the U.S.: the western pocket gophers (Thomomys), eastern pocket gophers (Geomys), and yellow-faced pocket gophers (Cratogeomys). These genera include approximately thirty species of pocket gophers (Miller 1964; Chase et al. 1982; Armstrong 1987). In Colorado, there are four species of pocket gophers, representing all three genera: Thomomys talpoides, Botta's pocket gopher (T. bottae), the plains pocket gopher (Geomys bursarius), and the yellow-faced pocket gopher (Cratogeomys castanops) (Miller 1964; Hansen and Reid 1973; Armstrong 1987). There are approximately 60 subspecies of northern pocket gopher (Lechleitner 1969; Hansen and Reid 1973; Hall 1981), nine of which are found in Colorado (Armstrong 1972; CDOW 2000). Thomomys talpoides macrotis was described as a distinct subspecies of T. talpoides by F.W. Miller in 1930, and this nomenclature has not been revised (Armstrong 1972).

Although it is possible that additional research may suggest taxonomic revision, the best available science clearly identifies T. t. macrotis as a valid subspecies. However, even if FWS chooses not to treat T. t. macrotis in this manner, the taxon in question clearly meets the criteria for treatment as a Distinct Population Segment. Petitioners therefore expect FWS to treat T. t. macrotis as either a valid subspecies based on the best available science standard or as a Distinct Population Segment of T. talpoides. No additional research on northern pocket gopher systematics is expected in the immediate foreseeable future (David Hafner, New Mexico Museum of Natural History, pers. comm., 5 December 2001; David Armstrong, University of Colorado at Boulder, pers. comm., 11 October 2001).

V. Description

A. General description

Thomomys talpides macrotis is a fossorial (adapted to digging) rodent (Fig. 1). Thomomys talpoides is a small pocket gopher, weighing 120-150 grams. Thomomys talpoides macrotis measures 225-230 mm total. Its tail measures 53-60 mm and its hindfoot measures 27-32 mm (Armstrong 1972; 1987). Compared to other subspecies of T. talpoides, T. t. macrotis is described as large (Armstrong 1972). Among the subspecies of T. talpoides there is variation in color, from yellowish brown to pale grayish, but most

Fig. 1. Northern pocket gopher. Photo courtesy of Richard Reading.

are rich dark brown with pale brown chins and belly patches (Lechleitner 1969; Hall 1981). Armstrong (1972) describes T. t. macrotis as grayish buff in color. The incisors of Thomomys species lack longitudinal grooves, which differentiate them from other pocket gopher genera such as Geomys and Cratogeomys (Chase et al. 1982).

The morphology of the northern pocket gopher suits its burrowing nature (Miller 1964; Chase et al. 1982; Armstrong 1987). Its head is small and flattened, the neck is short, and shoulders and forearms are muscular and broad. The eyes are small and close together, and its eyesight is poor compared to other rodents. The small round ears are equipped with valves that can be closed when digging. The sparsely haired, short tail, in combination with the long hairs on its body, aids backward movements through tunnels. The mouth has furred lips that when closed extend behind the large incisors allowing the gopher to not ingest dirt while performing daily activities such as digging and root cutting. Pocket gophers have fur-lined cheek-pouches (pockets) in each cheek, which open externally and are used to transport food materials to and from caches. The vibrissae around the mouth and nose are sensitive and further aid the gopher in navigation. Hearing is inferior relative to other rodents (Lechleitner 1969; Chase et al. 1982; Armstrong 1987; Huntly and Inouye 1988).

The forefeet are larger than the hindfeet and are encircled with stiff hairs and large, sharp claws that are worn down with constant digging. The middle three nails grow at approximately twice the rate of the other nails. Its fur is fine and soft, with the nap of the coat lying close to the body and in one direction. Molt lines on Thomomys may be visible, sometimes showing three different coats simultaneously (Chase et al. 1982).

The incisors of the pocket gopher are rootless and grow throughout the life of the animal. The teeth are used for cutting roots, stems, and tubers, and are important for foraging and burrowing activities. They may also use the teeth to anchor themselves while digging and to loosen soil and rocks. The lower incisors grow significantly faster than the upper incisors (Chase et al. 1982).

B. Morphological differences between male and female *T. talpoides*

Adult pocket gophers exhibit secondary sexual dimorphism, with male T. talpoides weighing approximately 10% more than females and measuring 3-4% more in length (Hansen and Reid 1973; Chase et al. 1982).

C. Morphological differences between *T. t. macrotis* and other subspecies of *T. talpoides*

Thomomys talpoides macrotis is larger in size than T.t. retrorsus and larger and paler than T. t. rostralis, the nearest neighboring conspecific subspecies. In a 1972 publication, Armstrong stated that further research might demonstrate that T. t. macrotis and T. t. retrorsus are a single continuous population. According to the CDOW, evidence of this intergradation has not yet been established (CDOW 2000). Subspecies often are not completely reproductively isolated from one another, otherwise they would be classified as full species. Subspecies also may physically be reproductively compatible, but have no opportunity for interbreeding because they do not come in contact with one another. Referring to pocket gophers, Hart (1978, cited in Chase et al. 1982: 243) reported that, "reproductive compatibility between subspecies is doubtful." The best available information indicates that it T. t. macrotis is a distinct subspecies.

Even if T. t. macrotis's taxonomic status were to be called into question, the northern Douglas County T. talpoides population clearly meets the criteria for treatment by FWS as a Distinct Population Segment. Specimen records of T. talpoides from several museum collections indicate a distinct geographical separation between T. t. macrotis and other subspecies, and suggest that T. t. macrotis is the only subspecies found in northern Douglas County (DMNS 2003, KU 2003, USNM 2003, UMMZ 2003). Thomomys talpoides retrorsus is also found in Douglas County, but appears to be limited to the southeastern portion of the county along East and West Cherry Creeks (UCM 2001). Fitzgerald et al. (1994:206) describe the distribution of T. t. retrorsus as "eastward on the eastern plains along the Platte-Arkansas Divide", and most T. t. retrorsus specimens have been collected even further south, in El Paso County (UCM 2001; KU 2003; UMMZ 2003), and as far east as Kit Carson County (USNM 2003).

The great degree of genetic diversification in geomyids generally, and northern pocket gophers in particular, has been traced to their life history characteristics. Their discontinuous distribution derives from their fossorial nature. A fossorial existence dictates disjunct distributions effected by patchy soil conditions and strong territoriality. Because of this solitary, fossorial nature, gene flow is limited, resulting in increased genetic differentiation (Chase et al. 1982). Nine subspecies of T. talpoides are found in Colorado alone (CDOW 2001). Current populations of T. t. macrotis appear to be limited to locations in northern Douglas County (CDOW 2001), and T. t. macrotis is the only T. talpoides subspecies known to occupy northern Douglas County (UCM 2002). As a result, the remaining individuals of this subspecies represent a unique branch of the evolutionary diversification of T. talpoides.

Regardless of whether T. t. macrotis is perceived as an evolutionarily or biologically significant subspecies (or DPS), the statutory language of the ESA indicates quite clearly that, once imperiled, a broad array of native fauna and flora should be provided with statutory protection. The definition of "species" as including subspecies and distinct population segments testifies to this (16 U.S.C. § 1532(15)). In fact, the only biota explicitly precluded from potential protection under the ESA is "species of the Class Insecta determined by the Secretary to constitute a pest whose protection under the provisions of this Act would present an overwhelming and overriding risk to man" (16 U.S.C. § 1532(6)).

The rationale for such a narrow exemption from the Act's protections is that humans do not currently possess the scientific knowledge to accurately determine a species' worth, whether judged in terms of the "aesthetic, ecological, educational, historical, recreational, and scientific" values that the Act sets forward (16 U.S.C. § 1531(a)(3)). The ESA stands as a testament to the need to protect species, subspecies, and DPSs, regardless of whether humans can properly evaluate the values embodied in those life forms.

VI. Population dynamics

A. Reproduction

Breeding activity begins at about one year of age. Males are polygamous. Mating occurs from mid-March to mid-May, and females produce a single litter, averaging three to six young, each year (Hansen 1960; Miller 1964; Reid 1973; Chase et al. 1982; Armstrong 1987; CDOW 2000). The young are born in April or June after a gestational period of 28-30 days (Hansen 1960; Reid 1973), although captive members of the Thomomys genus have borne young after a gestation period of 18-19 days (Chase et al. 1982).

Thomomys talpoides young are born sightless and hairless, and weigh only 2.8-4 grams (Reid 1973; Chase et al. 1982). However, maturation is rapid; it takes 180 days for newborns to reach near-adult weights (Reid 1973). Weaning occurs at the age of 35-40 days (Chase et al. 1982). Young appear above ground as early as June (Armstrong 1987).

Males grow throughout their lifetimes but females grow very little after reaching sexual maturity. Young-of-the-year may be distinguished from adults by the size of their reproductive organs (Hansen 1960; Hansen and Reid 1973).

B. Mortality

Thomomys talpoides macrotis is short-lived, as are all T. talpoides subspecies. Approximately 75% of the breeding population of T. talpoides comprises yearlings, while only 25% consists of gophers two years or older (Lechleitner 1969). Individuals of T. talpoides have a maximum lifespan of approximately five years (Hansen and Reid 1973; Reid 1973; Chase et al. 1982). The average longevity for northern pocket gophers ranged from 1.7-2.6 years in one study (Reid 1973).

C. Effects of climate

Climate may be a factor in T. t. macrotis survival and recruitment. Vaughan (1967) noted that pocket gophers are generally more abundant in years of normal or above-normal moisture and lower in years of below-normal precipitation. Snowpack can also provide northern pocket gophers with access to vegetation and protective cover from predators (Reid 1973). On the other hand, when soils are too wet, due to excessive water levels in snowpack, early snowpack melting, or a rising groundwater table, northern pocket gophers may perish or be dislocated (Hansen and Reid 1973; Reid 1973; Chase et al. 1982). Particularly harsh winters lead to sub-optimal burrowing conditions, affecting survivorship. Freezing temperatures combined with moist soil make burrowing nearly impossible (Andersen and MacMahon 1981), and pocket gophers may avoid moist soils to prevent the heat loss associated with wet fur (Vaughan 1966). Researchers have not addressed whether the issues surrounding snowpack would directly relate to the subspecies T. t. macrotis, given its occupation of lower-altitude habitat. However, proximity to streambanks and flooding in urban areas with disrupted runoff patterns may pose a threat to the subspecies under certain conditions.

The threat posed by climate change on native biodiversity is not an esoteric concern (Tilman and El Haddi 1992; Hafner et al. 1998; Cameron and Scheel 2001; Hannah et al. 2002). For instance, climate change models for rodents in Texas indicated that two species were predicted to go extinct because of the loss of suitable habitat due to warming trends (Cameron and Scheel 2001). In addition, local extinctions of pikas (Ochotona princeps) in the Great Basin and the global extinction of the golden toad (Bufo periglenes) have been attributed to global warming trends (McCarty 2001; Beever et al. 2003).

VII. Ecology

A. Habitat requirements

Thomomys talpoides inhabits a variety of habitat types including deep, tractable soils, as well as shallow gravels and heavy compacted soil types (Miller 1964). This species occupies habitats from an altitude of 4,500 feet on the eastern plains to above timberline at 13,000 feet (Miller 1964; Reid 1973). Similarly, T. t. macrotis seems able to tolerate some variety in habitat types, albeit within a drastically restricted range. The five sites where T. t. macrotis is known to occur vary from streambanks to uplands in short- and mixed-grass prairie. The elevation for known occurrences ranges from 5720 to 6200 feet (CNHP 2000). These habitats are reviewed in more detail in the population status section below.

Despite some flexibility in toleration of habitat conditions, there are constraints on habitat suitable for T. talpoides. Soil porosity and moisture both factor in habitat suitability. Northern pocket gophers tend to avoid clay soils. This may be because clay soils hinder gas exchange. The closed burrow system of northern pocket gophers requires gas to diffuse to ensure proper gopher respiration (Hansen and Reid 1973; Chase et al. 1982). In addition, soil depths greater than four inches, and mean soil moisture of less than 10% to 50%, appear to be components of more favorable habitat (Hansen and Reid 1973). As described above, when soils become too mesic, pocket gopher recruitment may be hindered, and adult pocket gophers may perish or be dislocated. Harsh weather conditions in the winter and spring seasons can lead to frozen and moist soils, making burrowing difficult or impossible.

B. Social behavior

Adult pocket gophers are solitary, territorial, and have a very small home range. A burrow system generally contains only one pocket gopher, except during breeding (Chase et al. 1982). Juvenile pocket gophers disperse from their natal burrow at the age of two months or more, from July – September (Hansen and Reid 1973; Chase et al. 1982; Armstrong 1987). Males constitute the majority of dispersing sub-adult pocket gophers (Chase et al. 1982). Once a pocket gopher lives in a burrow system for one breeding season, it tends to remain there for life, with minor boundary alterations. A pocket gopher seldom moves to an entirely new area (Miller 1964).

Territory size is small, and borders do not fluctuate substantially. At one site, the surface area of a single burrow system was described as 2,000 square feet (0.5 acre), with several recaptures at distances of 120 feet or less from the original capture site (Hansen and Reid 1973). These findings indicate that an individual often lives out its life in the expanse of 1/20 of an acre.

Territory size varies between the sexes. Adult Thomomys males have been described as having territories approximately twice the size of adult females (Miller 1964; Chase et al. 1982). A relatively larger territory would facilitate their polygamous nature, as it would increase the chances of contact with more than one neighboring female. In addition, the male's larger body size corresponds to a larger territory (Miller 1964).

Thomomys talpoides inhabit extensive burrow systems, which may be over 150 meters long, and are generally 10-45 cm below the surface (Hansen and Reid 1973). It is difficult to determine with certainty where one burrow system ends and another begins, but there is minimal or no overlap of the burrow systems of neighboring pocket gophers (Armstrong 1987).

These burrow systems are generally shallow. On one T. talpoides site, 80% of the system was less than 12 inches below the surface. The diameter of the tunnels is approximately 2.5-3.5 inches. The main tunnel is longest, and lateral branches off the main tunnel are approximately 1-4 feet in length. They frequently terminate at the surface in earthen plugs or mounds (Hansen and Reid 1973) and provide increased access to the surface for disposing excavated soil, feeding, and storing food (Chase et al. 1982). The main tunnel system may be deeper, at 15-20 inches below ground, and a vertical tunnel may connect the shallower system with a deeper nesting chamber (Hansen and Reid 1973; Chase et al. 1982). The nesting chamber is spherical, approximately 25 cm in diameter, and contains dried grasses (Chase et al. 1982).

C. Population densities

The number of T. talpoides per hectare varies widely. In favorable habitat, northern pocket gopher populations may reach more than 50 individuals per hectare (Armstrong 1987). Population densities of members of the family Geomyidae are frequently 50-100 individuals per hectare, and sometimes more than 200 per hectare (Huntly and Inouye 1988). The density of T. talpoides at one site was 37 individuals per acre, (91 individuals per hectare) (Miller 1964), while Reid (1973) reported population densities of T. talpoides at 5-10 per acre, (12-25 per hectare).

D. Food habits

Northern pocket gophers consume a vegetarian diet, including a wide variety of species. They consume roots, leaves, and stems of forbs, grasses, and woody plants, but generally prefer forbs (Miller 1964; Vaughan 1967; Ward 1973; Chase et al. 1982; Huntly and Inouye 1988). They prefer foraging in areas of high soil nitrogen and high primary productivity (Huntly and Inouye 1988), and they change their diet seasonally (Vaughan 1967; Ward 1973; Chase et al. 1982). The water needs of T. talpoides are apparently met through consumption of succulent flora (Vaughan 1967; Chase et al. 1982).

The burrowing activities of pocket gophers result in high energy demands on these small rodents. These energy costs are 360 to 3400 times that of surface travel. Consequently, pocket gophers consume a much higher biomass than other mammals of similar mass (Huntly and Inouye 1988).

On shortgrass prairie, a strong dependence of T. talpoides on prickly pear cactus (Opuntia polycantha) has been documented (Vaughan 1967; Ward 1973). This plant provided 49.9% of the yearly diet, and 79% of the winter diet of northern pocket gophers, and likely provides both nutrition and water to northern pocket gophers (Vaughan 1967). There is shortgrass prairie habitat within the currently occupied range of T. t. macrotis, and there may be a similar association between this subspecies and prickly pear.

E. Pocket gopher roles within their ecosystems

Northern pocket gophers have been described as a "biological excavation service" (Armstrong 1987:107) and the actions of pocket gophers have been likened to those of "an animated bulldozer" (Hansen and Reid 1973). The reasons for such metaphors are becoming increasingly clear, as studies indicate the important relationships between pocket gophers and the ecosystems in which they are found. One study concluded "the activities of pocket gophers cascade through the trophic web" (Huntly and Inouye 1988:792). Pocket gophers play important roles in soil formation and movement (Armstrong 1987; Huntly and Inouye 1988; CDOW 2000) and consequent plant diversity (Huntly and Inouye 1988); as a prey base for avian, mammalian, and reptilian predators (CDOW 2000); and their burrows provide habitat for other species (Vaughan 1961; Chase et al. 1982; CDOW 2000).

The northern pocket gopher has been described as a keystone species (Sherrod 1999; Sherrod and Seastedt 2001), which is defined by Meffe and Carroll (1994:129) as "one that makes an unusually strong contribution to community structure or processes." Additionally, pocket gophers have been described as ecosystem engineers (Thorn 1978; Burns 1979, 1980; Sherrod 1999), which Byers et al. (2002:633) define as "capable of altering the normal functioning of ecosystems or the interactions of organisms even in relatively small numbers." Therefore, the northern pocket gopher may be considered to be a keystone engineer (Jones et al. 1994; Sherrod 1999).

1. **Soil impacts**

Pocket gophers alter their ecosystems by increasing soil aeration and fertility, and the ability of surface soils to absorb groundwater (Hafner et al. 1998). Pocket gophers move large amounts of soil, modify its qualities, and create mima mounds (described below), all of which significantly impact the ecosystems in which pocket gophers reside. Armstrong (1987) estimates that three tons of soil may be excavated for one pocket gopher burrow system measuring 150 meters in length, and 10-45 cm from the surface. As pocket gophers are solitary, Armstrong's estimate is a per capita measurement. Other approximations suggest similarly massive soil movement conducted by pocket gophers. Chase et al. (1982) report an annual per capita soil movement of 1,130 kg. Turner (1973) and Chase et al. (1982) cite an estimate of over 93 tons of soil being moved on one hectare with 74 pocket gophers. Turner (1973: 51) states that:

> Pocket gophers have markedly influenced the development of rangeland soils during the thousands of years they have inhabited North America. By continually burrowing and pushing soil to the surface, they promote vertical cycling and mixing of soil constituents.

Others estimate that the impact of pocket gophers on western rangelands dates back multiple millions of years, to the Pliocene Epoch (Chase et al. 1982). Whatever the timeline, researchers have described how pocket gophers have significantly shaped the ecosystems in which they are found.

Corroborating this characterization is an account from the volume Prairie Conservation, in which Benedict et al. (1996:153) state:

> Mammals also affect vegetative composition and structure by disturbing the soil. Wallowing by bison and digging by badgers, pocket gophers, prairie dogs, and other mammals provide unique microhabitats, affect soil conditions, and break the dominance of perennial grasses to provide habitat for annual forbs and grasses…
>
> The abundance of these disturbances on the prairies of the past undoubtedly led to a substantial increase in vegetative diversity and further enhanced the mosaic nature of grasslands. Unfortunately, of the three most important groups of mammals involved in soil disturbance (pocket gophers, prairie dogs, and bison), the latter two have been drastically reduced in number.

Chase et al. (1982) also comment on the fundamental role of pocket gophers and other fossorial rodents on the creation of prairie soils. Mutually beneficial relationships among the faunal shapers of the prairie have been observed. Prairie dogs (Cynomys spp.) and bison (Bison bison) benefit each other (Krueger 1986). Similarly, Chase et al. (1982: 250) write: "...the bison...grazed and trampled the dense prairie vegetation, accelerating forb growth, on which the gophers thrived. The gopher, in turn, worked the soil, thus increasing soil fertility and stimulating vegetative growth, increasing food for the bison." The impact of pocket gophers on soils goes beyond their movement of the soil to their fundamental effects on soil condition. These changes in soil condition result in important and ecologically significant alterations in plant growth and diversity.

Pocket gophers alter plant diversity by modifying soil nutrients. They create heterogeneous levels of soil nitrogen by bringing nitrogen-poor subsurface soils to the surface. In addition, backfilling activities may result in different soil densities and nutritional content than undisturbed soils. Uneaten food caches, located in sealed compartments only 3-4 inches below ground (Ward 1973; Chase et al. 1982), and excrement can also provide areas of high nutrient content (Turner 1973; Huntly and Inouye 1988). It is not uncommon for pocket gophers to leave food caches unutilized (Ward 1973), thus providing more opportunity for their transformation into soil nutrients.

A fascinating component of pocket gopher soil impacts is the mima mound. Mima mounds are circular soil formations up to two meters in height, 25-50 meters in diameter, found in densities of 50-100 per hectare. Mima mounds accumulate over long periods from the activities of burrowing mammals, particularly pocket gophers (Turner 1973; Huntly and Inouye 1988; Cox and Hunt 1990). Aggregates of mima mounds create mounded grasslands, which are widespread across a broad geographic range west of the Mississippi River from southern British Columbia, Canada, to northern Sonora, Mexico (Cox and Hunt 1990).

Cox and Hunt (1990: 90) provide the following description of mima mound formation:

> Investigations of Mima mounds in western North America support the hypothesis that mounds are formed by the gradual translocation of soil by pocket gophers (Rodentia: Geomyidae) toward deep, well-drained

> microsites…Pocket gophers center their activities and locate their nests in such microsites. Moundward translocation results from the backward displacement of soil that occurs during outward tunneling from activity centers.

In their grassland study area in northern Oregon, Cox and Hunt (1990) found that 0-6 individual northern pocket gophers inhabited each mima mound (n=18). Mounds with single pocket gopher inhabitants tended to feature centripetal soil translocation, with the mound growing upward and outward in a proportional relationship. Once the mound reached a large enough diameter, there was greater potential for occupancy by two animals and a consequent flattening of the shape of the mound.

Soils within these mounds are deeper and more fertile, primary productivity is higher, and they host a different species composition than surrounding areas. These mounds create an undulating topography, may serve as hotspots of activity for other small mammals and ungulates, and may lessen soil erosion (Turner 1973; Huntly and Inouye 1988).

Another soil impact involves winter casts. Pocket gophers dig tunnels through the snow to store the soil that they excavate during the winter. When the snow melts, ropes of excavated soil are left on the surface of the ground (Hansen and Reid 1973). All of these soil impacts reflect the important ecological services that T. talpoides provides in its role as a keystone species.

2. Plant diversity and succession

Pocket gopher impacts on soils result in lower than average nitrogen content as lower-nitrogen subsurface soils are brought to the surface. In addition to alteration of the level of nitrogen in the soil, pocket gophers cause a more heterogeneous distribution of nitrogen in their ecosystems (Huntly and Inouye 1988).

Pocket gophers also impact the availability of light in the microclimates they create. Their grazing and burying of vegetation results in increased light filtration to remaining plants. Moreover, their reduction of nitrogen levels results in decreased plant growth and biomass, and consequently higher light infiltration. The combination of more variability in nitrogen levels and distribution and light infiltration results in increased plant diversity. Huntly and Inouye (1988) concluded that plant diversity was significantly higher near or on pocket gopher mounds because of pocket gopher impacts on nitrogen and light availability. Vegetation around gopher mounds also shows signs of increased primary productivity (Grant et al. 1980; Spencer 1985; Huntly and Inouye 1988). High nitrogen environments are conducive to invading noxious weed populations, such as cheatgrass, and decreased yields of native flora such as bluebunch wheatgrass (Wilson et al. 1966).

Winter casts suppress the growth of some plants and thereby impact plant succession (Armstrong 1987). Indeed, in one experiment, pocket gopher activities were described as decreasing the rate of plant succession (Huntly and Inouye 1988). For example, Cantor and Whitham (1989) indicate that belowground herbivory by pocket gophers may keep aspen from becoming established in mountain meadows.

Pocket gopher activities often benefit their favorite forage species. For example, pocket gopher diggings bury vegetation, which some plant species cannot tolerate. Pocket gopher forage species are resistant to burial, and benefit from the decreased competition that results from gopher digging. This interdependent relationship where pocket gophers improve conditions for their own forage has often been likened to farming (Turner et al. 1973; Chase et al. 1982; Cortinas and Seastead 1996; Sherrod 1999).

3. Prey base

A variety of mammals, raptors, and reptiles utilize pocket gophers as prey (Huntly and Inouye 1988). Avian predators include the following: red-tailed hawk (Buteo jamaicensis), Swainson's hawk (Buteo swainsoni), ferruginous hawk (Buteo regalis), American kestrel (Falco sparverius), goshawk (Accipiter gentiles), great-horned owl (Bubo virginianus), long-eared owl (Asio otus), great gray owl (Strix nebulosa), burrowing owl (Athene cunicularia), and barn owl (Tyto alba) (Reid 1973; Chase et al. 1982). Mammalian predators include the badger (Taxidea taxus) and coyote (Canis latrans), who excavate pocket gopher burrows and prey on the residents (Armstrong 1987). Small mammals such as pocket gophers may be important for breeding and population dynamics of owls and coyotes (Huntly and Inouye 1988). Fox (Vulpes spp.), weasel (Mustela spp.), skunk (Mephitis spp. and Spilogale spp.), and bobcat (Lynx rufus) have also been identified as pocket gopher predators (Reid 1973; Chase et al. 1982;

Armstrong 1987). Reptilian predators include gopher and bull snakes (Pituophis spp.) and rattlesnakes (Crotalus spp.) (Reid 1973; Chase et al. 1982). Additionally, domesticated animals such as dogs and cats probably pose a predation threat in areas with residential development. Yensen et al. (1998) note that domestic cats in particular pose a threat to native rodent species.

4. **Burrows and other species**

The extensive burrow systems described above provide habitat for numerous other burrowing and opportunistic species. Armstrong (1987) notes that abandoned pocket gopher burrows provide habitat for salamanders, snakes, insects, and other rodents. Other researchers similarly describe the use of burrows by amphibians, reptiles, and other mammals (Huntly and Inouye 1988). Vaughan (1961, cited in Chase et al. 1982) provided the most complete list of species occupying both abandoned and active pocket gopher burrows: tiger salamander (Ambysoma tigrinum), spadefoot toad (Scaphiopus spp.), ornate box turtle (Terrapene ornate), six-lined racerunner (Cnemidophorus sexlineatus), earless lizard (Holbrook maculata), gopher snake (Pituophis catenifer), prairie rattlesnake (Crotalus viridus), eastern mole (Scalopus aquaticus), desert cottontail (Sylvilagus auduboni), ground squirrels (Spermophilus spp.), Ord's kangaroo rat (Dipodomys ordii), deer mouse (Peromyscus maniculatus), meadow voles (Microtus spp.), and long-tailed weasel (Mustela frenata). Less frequent inhabitants of these burrows include plains toad (Bufo cognatus), burrowing owl (Athene cunicularia), northern grasshopper mouse (Onychomys leucogaster), and striped skunk (Mephitis mephitis).

5. **Other associations**

Higher grasshopper (Melanoplus spp.) populations have been linked to pocket gopher mounds. Grasshoppers utilize gopher mounds for reproduction, as they oviposit in the open soil. Additionally, the mosaic of low- and high-density vegetation in pocket gopher-occupied areas creates conditions where grasshoppers can more efficiently forage (Huntly and Inouye 1988). Recent research also suggests that harvester ants (Pogonomyrmex occidentalis) select for old northern pocket gopher mounds as sites for new ant-mounds (Hopton 2001). In addition, pocket gopher activity tends to reduce litter, which makes habitat more suitable for deer mice (Peromyscus maniculatus), but less suitable for voles (Microtus spp.) The mutually beneficial relationship between bison and pocket gophers has been described above, and the petitioners note that other native ungulates who prefer forbs, such as pronghorn (Antilocapra americana), would likely benefit from pocket gopher impacts on vegetative composition and succession.

VIII. Geographic distribution

Thomomys talpoides has the widest distribution of all pocket gophers, extending from central Alberta through northern New Mexico and Arizona, from western North and South Dakota, to eastern Washington, Oregon, and northeastern California (Chase et al. 1982). In contrast, the historic distribution of T. t. macrotis is very narrow, with a range of only 100-1,000 square km (CDOW 2000). This range includes southwestern Arapaho, northern Douglas, and possibly extreme northwestern Elbert Counties (Armstrong 1972; CNHP 2000). The recent distribution of T.t. macrotis appears to be limited to five populations in Douglas County.

As a rule, different species of pocket gopher do not coexist in the same areas. Rather, they are allopatric (Hansen and Reid 1973). In the case of T. talpoides, Miller (1964) explained that the broad tolerance of this species for different habitat types resulted in its being out-competed for the richest habitats (e.g. deepest soils) by more habitat-restricted species such as T. bottae. Geomyids date from the Lower Miocene (the Miocene Epoch began 25 million years ago) to the Recent (Holocene) Epoch. The modern distribution in the western U.S. is explained by Miller (1964) as the result of pocket gopher species inhabitation of suitable areas in the post-Pleistocene Epoch (10,000-12,000 years ago). Miller suggests that T. talpoides occupied most of Colorado at one time, but that the other three geomyid species in Colorado subsequently invaded T. talpoides's range. Although shifts in their ranges have taken place, the four species of pocket gopher in Colorado have been established in the state for millennia (Hall and Kelson 1959; Miller 1964). In addition, as discussed above, pocket gopher shaping of western rangelands traces back several millions of years.

IX. Current population status throughout the range of *T. t. macrotis*

CDOW characterizes population trends of T. t. macrotis as unknown, but asserts that the subspecies is probably declining due to the effects of municipal development

(CDOW 2000). CDOW identified Douglas and Arapaho Counties as containing T. t. macrotis populations (Skiba 2000). As of November 2001, the Colorado Natural Heritage Program (CNHP) recognized four T. t. macrotis records, all of which were from Douglas County.

The global population size is characterized in CDOW's Colorado Vertebrate Ranking System (COVERS) as 501-1,000; or "unknown, but thought to be small", with 6-20, or an unknown number, of populations. The report also indicates that the population trend is thought to be declining (CDOW 2000). Site visits to four of the five[1] Douglas County populations identified in element occurrence records by the Colorado Natural Heritage Program (CNHP 2000) were conducted in January 2003. All five populations face multiple imminent threats (Echt and Tutchton 2003).

A. Arapahoe County

CDOW maintains that T. t. macrotis is known to occur in Arapahoe County within the abundance category of "common" (Gary Skiba, CDOW, pers. comm., 26 June 2000). While additional survey effort may reveal that T. t. macrotis does still inhabit Arapahoe County, there are no indications that it is common, and this assessment by CDOW appears to be erroneous. Specimen records from the University of Kansas indicate that one macrotis individual was collected in Arapahoe County in 1956, 4 miles north and 10 miles east of Parker (KU #72972 (Youngman #306)). This locale is near the county line, close to the Douglas County populations. CNHP's element occurrence records as of June 8, 2000 (CNHP 2000) do not identify any occurrence of the subspecies in Arapahoe County.

B. Douglas County

CNHP identified four element occurrences of T. t. macrotis in Douglas County, and field notes associated with these records suggest the presence of a fifth population (Fig. 2). Museum specimens indicate that T. t. macrotis historically occupied a sixth site.

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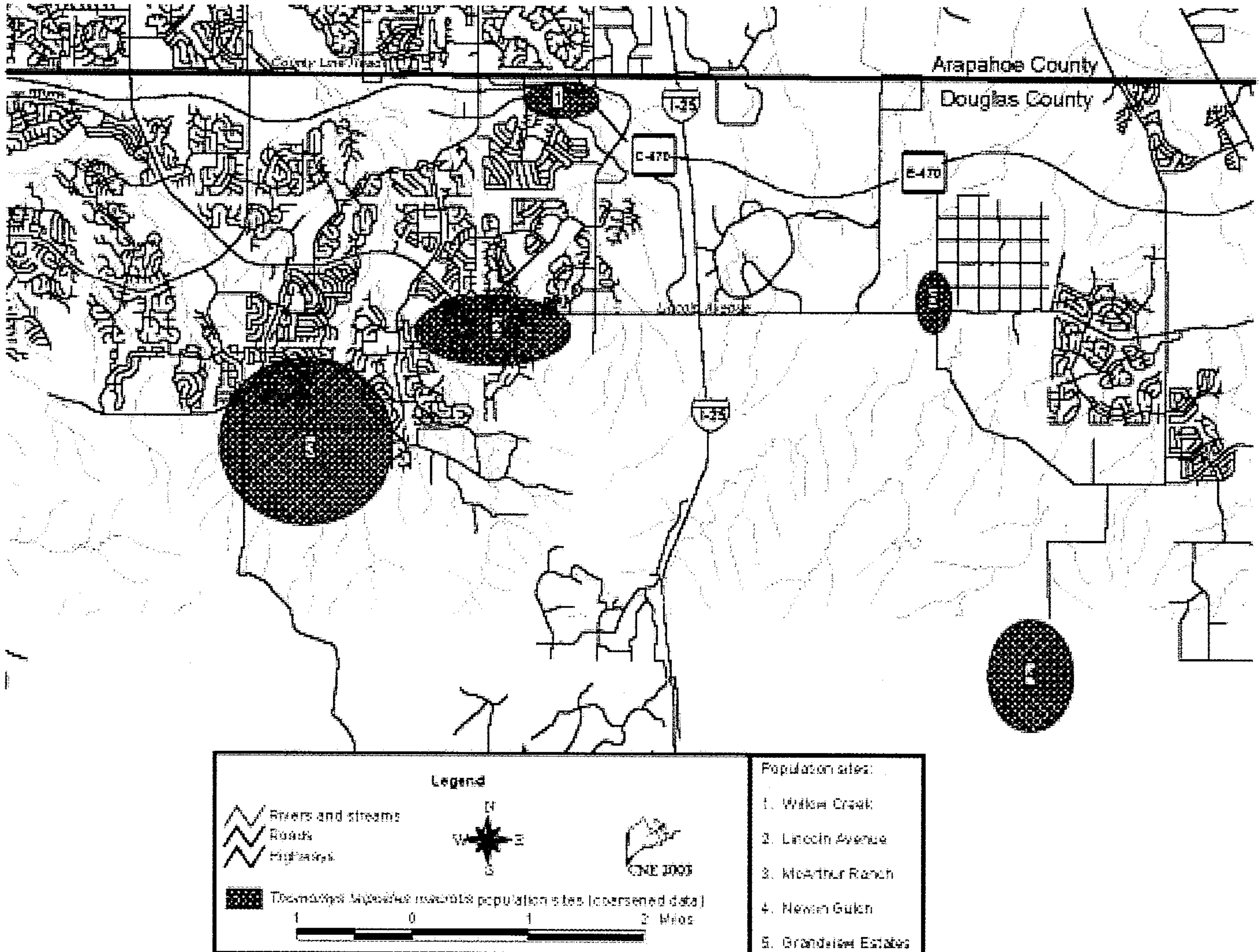
[1] The road to the Newlin Gulch population was gated and inaccessible.

Fig. 2. *Thomomys talpoides macrotis* populations.



1. Willow Creek[2]

The last T. t. macrotis observation at this site was on 10 December 1993. This site is described as "south side of County Line Rd., 1 mi. W of I-25, 0.2 mi. W of Willow Creek; and Willow Creek between County Line Rd. and [C]-470."

Aaron Ellingson, who surveyed the area for CNHP, noted three concentrations of gopher mounds west of Willow Creek on the map that accompanied his survey. Gopher mounds were described as "extensive" on the western bank of the creek. Ellingson captured one T. t. macrotis individual (UCM #17017 (Colorado Natural Heritage Program #ARE-93-137)) 0.2 miles west of the creek at 5,740 ft. Ellingson listed the dominant plant species in this area as seeded smooth brome (Bromus inermis), an exotic grass. He described the community as "former grassland, now seeded roadway". Ellingson summarized the site's condition as follows: "Area is heavily disturbed and fragmented by [C]-470 on S and 4-lane County Line Rd. on N. Former ephemeral streams and ravines have been cut off and area seeded with exotic grass."

Ellingson also captured two T. t. macrotis individuals within 20 meters of each other on the east bank of Willow Creek (UCM #17014 (Colorado Natural Heritage Program #ARE-93-138)[3]) on the same day and at the same elevation. Dominant plant species in this area were coyote willow (Salix exigua), Russian olive (Eleagnus angustifolia), smooth brome, and cottonwood (Populus deltoides). Ellingson described this community as "plains riparian- severely disturbed". Gopher activity was concentrated in "unfrozen sunny exposures" on the bank of the creek. He summarized this site's condition this way: "Area heavily disturbed – stream channelized through culverts under roads, bike path on W bank, many exotic plants (grasses, Russian olive), fragmented by major roads (County Line Rd. & [C]-470)."

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[2] All information in this section is from CNHP 2000, EOR #4 and field notes associated with this EOR unless otherwise noted.

[3] In several cases, the collection numbers recorded by Ellingson in his field notes and CNHP's EORs do not match those in UCM's records, based on locality. Ellingson recorded these collections as ARE-93-138A and B. UCM #17015 is also recorded as ARE-93-138 in UCM's database, but the location given is McArthur Ranch.

In his general description of the Willow Creep population, Ellingson wrote that the "uplands are near monoculture of smooth brome" and that "fragmentation should be primary concern".

According to information from the Douglas County GIS Division (2001, Zone District Map 2231 3B), this population is within the Lone Tree incorporated town boundary, and is considered part of the Centennial Airport Review Area. An unnamed park south of C-470 appears on this map, but Ellingson's captures were clearly north of C-470.

City of Lone Tree zoning maps (TST Inc. of Denver 2002) show small pockets of Open Space along Willow Creek north and south of C-470. According to Loretta Warner (personal communication, 2003) with the Douglas County Planning Division, this is not part of the Douglas County Open Space Program but rather the City of Lone Tree's Open Space program. John Johnson (personal communication, 2003), Community Development Director for the City of Lone Tree, explained that Lone Tree owns this land and it is currently managed by the South Suburban Parks and Recreation District. The area west of Willow Creek is zoned C1 commercial, which encompasses:

> Retail and personal service commercial, including auto sales and service; light industrial facilities including manufacture, fabrication, processing or assembling or products provided, however, that no effects from noise, smoke, glare, vibration, fumes, or other environmental factors shall be measurable at the property line; research and development facilities; warehousing and distribution facilities, "mini–warehouses" excluded; hotels, motels, conferences and meeting facilities; recreation facilities, public or private; educational and vocational training institutions; and Utility Service Facility, including offices, public and quasi-public facilities including police stations, libraries, schools, churches, and church schools, day care centers, etc." (City of Lone Tree 2002:12-9 - 12-10)

A site visit in January 2003 found most of this site heavily disturbed by development (Echt and Tutchton 2003) (Fig. 3). Areas in the vicinity of Willow Creek north of C-470 and south of County Line Road are now home to two car dealers and a strip mall extension of the Park Meadows Mall (Fig. 4). The grassland immediately south of C-470 appears to be in the early stages of being developed. Most of this open field has recently been graded and seeded. One small pocket of prairie dogs and potential gopher

Fig. 3. Aerial view of Willow Creek population vicinity. A: C-470. B: Thomomys talpoides macrotis individuals were collected along this strip of the creek north of C-470. Note bike path. C: Car dealerships now occupy the western sites where T. t. macrotis was collected. D: Much of the area south of C-470 was recently graded and seeded. Photo courtesy of Jacob Smith and Lighthawk.

Fig. 4. West end of Willow Creek population site. Car dealerships have replaced pocket gopher habitat. Photo courtesy of Kristin Echt.

habitat on the banks of Willow Creek remains, but this area is severely fragmented by C-470 and a bike path.

It appears that the two western concentrations of gopher habitat have likely been destroyed by commercial development. The easternmost concentration is maintained as undeveloped land but the primary use is active recreation by bikers. Threats to this population therefore are commercial development, altered hydrology, noxious weeds, habitat fragmentation, loss of native forage species, and recreational disturbance from the adjacent bikepath.

1. Lincoln Avenue

Ellingson's map of the Willow Creek population includes additional gopher signs approximately two miles to the south along Lincoln Avenue. There are two concentrations – one south of Lincoln Avenue between Lone Tree Parkway and Stoneglen Trail, and the other north of Lincoln in the vicinity of South Pinebrook Street and Lone Tree Parkway. These locations strongly suggest that this was T. t. macrotis but identification was not verified through capture, and CNHP does not include this site in its records.

According to information from the Douglas County GIS Division (2001, Zone District Map 2231 3B), the area south of Lincoln Avenue is zoned as planned development urban, and includes the Carriage Club development. City of Lone Tree zoning maps (TST Inc. of Denver 2002) show that a golf course is adjacent to this area. The Lone Tree Golf Club was built in 1985 (Lone Tree Golf Club & Hotel 2003), and it extends along both sides of Lincoln Avenue in this general area.

The area north of Lincoln Avenue is also zoned as planned development urban, and is part of the Highlands Ranch development (Douglas County GIS Division 2001, Zone District Map 2231 3B). The area where Ellingson detected gopher sign extends east into the Lone Tree incorporated boundary, which is zoned as suburban residential (TST 2002). The area is subzoned as SRM, where allowable uses include:

> Boarding House or Rooming House- licensed, which does not produce excess automobiles; single-family dwellings; open space, landscaping, trails; recreation areas, parks, recreation facilities, golf courses; guardhouse for ingress-egress security; accessory uses and buildings;

temporary offices and sales center; and public and quasi-public buildings and structures. (City of Lone Tree 2002:7-15)

The January 2003 site visit (Echt and Tutchton 2003) confirms the eastern area has been completely developed, with the former gopher habitat sodded with Kentucky bluegrass and unsuitable for pocket gophers (Fig. 5). No pocket gopher sign was visible and no pocket gophers are believed to remain here. The western area is close to an undeveloped area near Big Dry Creek. Pedestrian/bike paths are present and hydrology has been altered here. It is immediately bordered by residential neighborhoods to the south, east, and north, and by Quebec Street to the west (Fig. 6). The area is isolated from other greenways and is boxed-in by previous development.

The eastern concentration of gopher habitat south of Lincoln Avenue therefore appears to have been completely destroyed by residential development. The western concentration also appears to have been destroyed by residential development north of Lincoln Avenue, but undeveloped land south of Lincoln Avenue may still harbor pocket gophers, and soil disturbance that suggested pocket gopher activity was observed in this area in March 2003. This land appears to be maintained by a homeowners' association, and the main use is active recreation by walkers and bikers. Threats to this population (if it is still extant) therefore include development, fragmentation, pesticides, rodenticides, and herbicides associated with the golf course, loss of native forage, altered hydrology, and recreational disturbance.

2. McArthur Ranch[4]

The last observation of T. t. macrotis at this site took place on 10 December 1993. This area is described as "along road to McArthur Ranch"[5]. Ellingson noted that gopher sign was abundant along both sides of the road. He captured one individual on each side of the road.

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[4] All information this section from CNHP 2000, EOR #5 and associated field maps and notes unless otherwise noted

[5] Ellingson's map shows these gopher sites running through the center of T6S R67W SEC19, and signs of an old dirt road are present in the middle of this Section. The current McArthur Ranch Road is north of this.

Fig. 5. Eastern Lincoln Avenue site.

Fig. 6. Aerial view of Lincoln Avenue population vicinity. A: Lincoln Avenue. B: Lone Tree Golf Club. C: Eastern concentration. D: Potential pocket gopher habitat near Big Dry Creek. Photo courtesy of Jacob Smith and Lighthawk.

The macrotis individual collected to the south[6] was found "3/4 mi. E of Daniels Park Rd., near broken earthen dam" at 6,040 ft. The dominant plant species was described as "roadside seeded grasses (Bromus)" and the community was characterized as a "seeded roadside". Ellingson summarized the condition of this site as follows: "Soils are a fine sand and recently disturbed by road grading. Area fragmented only by road with large tracts of open land to N & S, mostly grazed grassland of moderate condition. Area to S known as Highlands Ranch 'Wildcat Mt. Preserve'."

The other individual was collected on the north side of the road[7] "2/10 mi. E of Daniels Park Rd." at 6,070 ft. The community and dominant plant descriptions were the same here. Ellingson gave this summary of the site's condition: "Soils are a fine sand, disturbed by road work. Area is relatively unfragmented with large open tracts to N & S of grazed grassland in moderate condition. Area to N likely zoned for development, to S known as Highlands Ranch 'Wildcat Mt. Preserve'."

In his overall description of the McArthur Ranch population record, Ellingson wrote, "Gopher mounds abundant on both sides of road but not in grasslands on either side as visible from road." He described Wildcat Mountain as "a homeowners' association open space. Protection status unknown."

According to information from the Douglas County GIS Division (2001, Zone District Map 2231 3B), the northern side of the old road is zoned planned development urban, and is part of the Highlands Ranch development.

The Wildcat Mountain Reserve is now referred to as the Highlands Ranch Open Space Conservation Area (Science Applications International Corp. and Hellmund Associates 2002), and its northern border runs along the old McArthur Ranch Road. The area that is closest to the old road is referred to as "The Gateway", and is slated for the "development of various community facilities, such as a Douglas County regional park" (Science Applications International Corp. and Hellmund Associates 2002:10). Planned developments include playing fields, the regional park, and "active

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[6] Ellingson recorded this collection as ARE-93-141. UCM #17012 (Colorado Natural Heritage Program s.n.) fits this locality.

[7] Ellingson recorded this specimen as ARE-93-142. UCM #17013 (Colorado Natural Heritage Program #ARE-93-144) and UCM #17015 (Colorado Natural Heritage Program #ARE-93-138) both match this locality.

recreation/education/cultural areas" (Science Applications International Corp. and Hellmund Associates 2002:28). The development company Shea Homes still owns this land, and the title is not scheduled to be turned over to the Highlands Ranch Community Association until the Highlands Ranch development is completely built out, which may be as long as nine years from now (Science Applications International Corp. and Hellmund Associates 2002).

A site visit January 2003 (Echt and Tutchton 2003) indicated that all areas described by CNHP as potential habitat sites here have been developed, are undergoing development, and/or have been reserved for the future development of housing, schools, and recreational facilities (Fig. 7). Many sections of remaining undeveloped land in the vicinity have been posted with signs indicating plans for future development (Fig. 8). Undeveloped areas along Monarch Boulevard (the extension of Quebec Road south of McArthur Ranch Road) appeared to be too high in elevation to serve as habitat for macrotis.

Therefore, it appears that the gopher habitat north of the old road is slated for full residential development, while recreational development is planned for the area south of the road. Threats to this population therefore include loss of native forage, fragmentation, road disturbance, and development.

3. Newlin Gulch [8]

The last observation of T. t. macrotis at this site took place on 29 June 1994. Aaron Ellingson was again the observer. He mapped four concentrations of pocket gopher mounds: three in T6S R66W SEC30, and one in SEC31. The habitat was described as follows:

> Area consists of rolling short to midgrass prairie dissected by steep, eroded dry gullies that cut through the deep sand substrates. Patches of Gambel's oak occur on the slopes of some gentle hills. Cheatgrass, knapweed, and Allyssum sp. are common in disturbed areas and ravine bottoms, but native grasses still dominate hill tops. Area has been used for cattle production for approx. 100 years….Gopher mounds observed in several locations: along roadside sandy banks, and open grasslands. 4 groups of mounds, each likely representing 1-2 individuals.

[8] All information in this section from CNHP 2000, EOR #6 and associated field map unless otherwise noted.

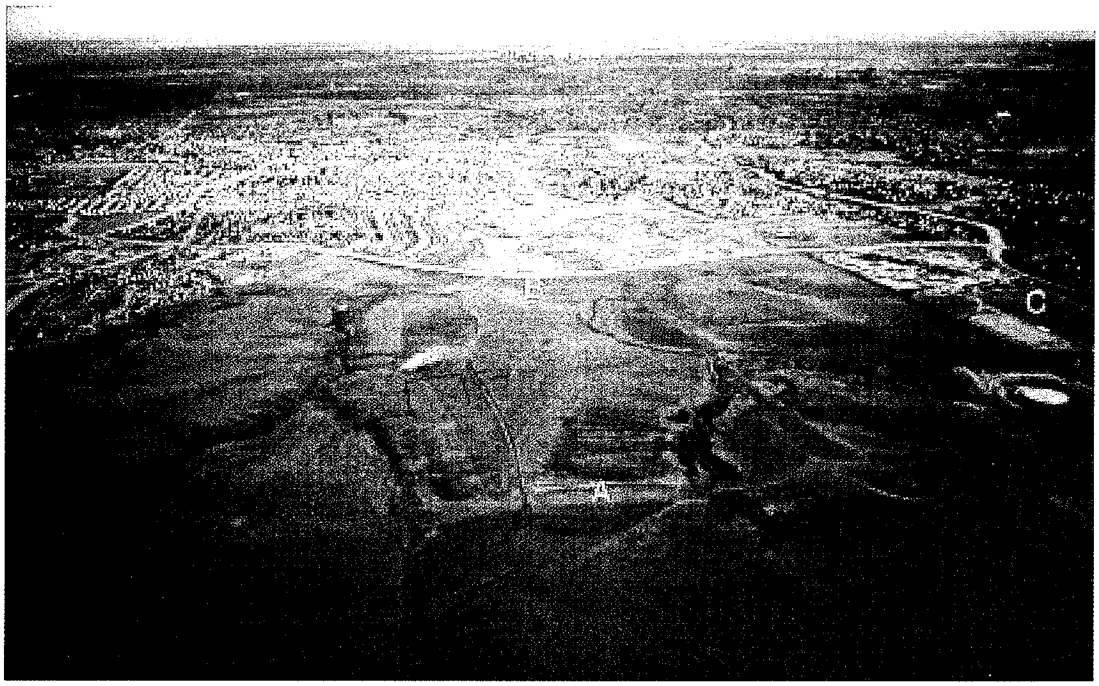

Fig. 7. Aerial view of McArthur Ranch population vicinity. A: Old road. B: New road. C: High school under construction. D: Housing developments under construction. Photo courtesy of Jacob Smith and Lighthawk.

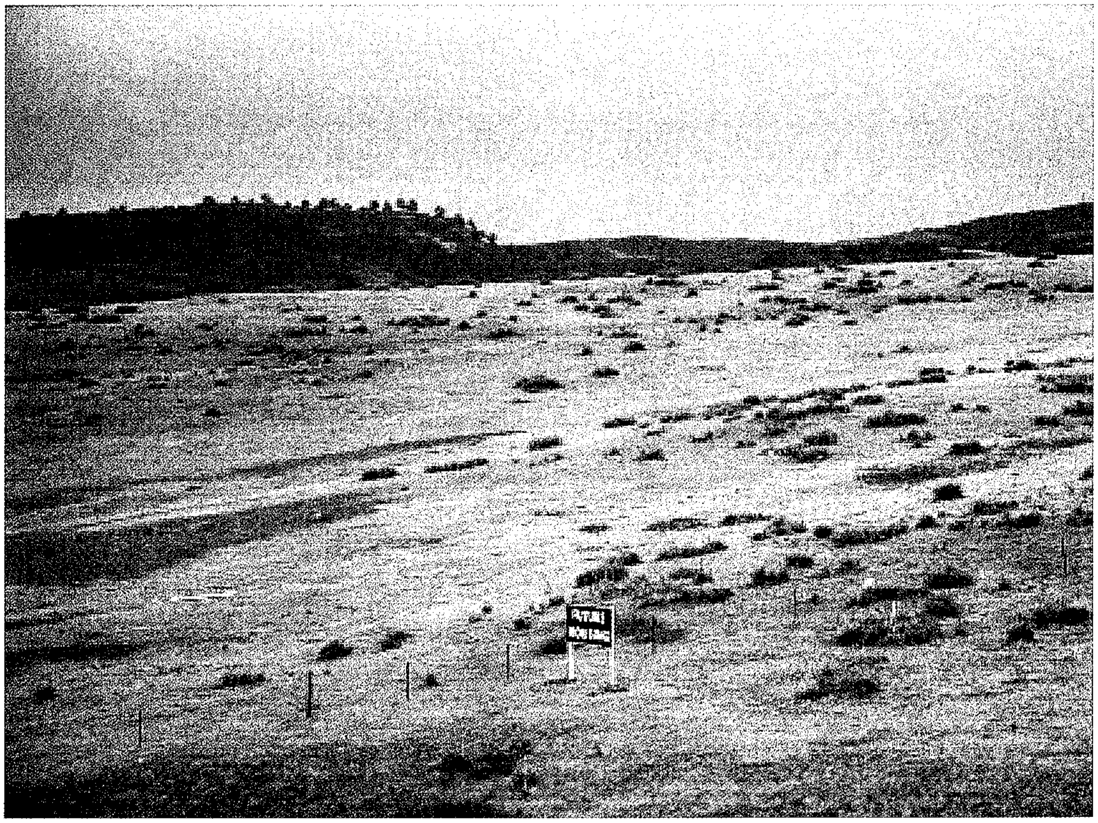

Fig. 8. Land for sale near the McArthur Ranch population site. Photo courtesy of Kristin Echt.

Although Ellingson did not attempt to trap any individuals here, he supported his identification of these mounds as belonging to macrotis by stating, "identification of mounds is possible since trapping in the area, as well as Armstrong 1972, indicate only one species of geomyind [sic] present in this area."

According to information from the Douglas County GIS Division (2001, Zone District Map 2233 2C), this site is zoned agricultural one and is part of the Centennial Airport Review Area. This is the only one of the five sites where T. t. macrotis was found recently that is not zoned for urban development. However, it faces the imminent threat of destruction from water development.

Ellingson included this statement about the ownership status: "Rosie Hess, owner is one of last to continue ranching in this area. Other cattle operations here are leasing the land from developers." Hess has since sold the land to the Parker Water and Sanitation District to be developed as a reservoir: "Parker Water and Sanitation District bought land from longtime Parker-area resident Rosie Rueter-Hess, whose family has lived in the area since the 1930s. The agreement called for the reservoir to be named after the Rueter-Hess family" (Parker Water and Sanitation District 2003).

Construction is slated to begin in 2004 and extend into 2005, and 470 acres will be inundated. Maps of the proposed reservoir as well as the legal description of the reservoir's location place it partly within the two sections where macrotis mounds were observed, and it is likely that at least the set of mounds that Ellingson observed on the boundary of these two sections will be destroyed (Parker Water and Sanitation District 1999; Woodward and Clyde Environmental Consultants 2000). They appear to be where the east end of the dam will be built. The sandy soils that Ellingson reported the macrotis individuals were using will have to be removed:

1. The proposed dam abutments contain some non-cemented sandstones and possibly some unconsolidated sand, as well as being underlain by hard to very hard, low-permeability claystone.
2. The porous materials on the abutments may require some engineering treatment.
3. The valley bottom contains significant quantities of porous sand and gravel, which likely will have to be removed from the dam footprint prior to construction. (Parker Water and Sanitation District 1999, online)

The project plan calls for retaining 2,000 acres as open space, but it is unclear which areas would be designated as open space.

One concentration of gopher habitat at this site is therefore threatened with imminent destruction because of this dam, and the others are at great risk of being destroyed as well either during construction or maintenance activities. Threats to this population therefore include the imminent construction of the Rueter-Hess Reservoir, changes in hydrology, disturbance associated with the construction and maintenance of the reservoir, disturbance associated with recreational opportunities around the reservoir, habitat fragmentation, noxious weeds, and removal of soils.

4. Grandview Estates[9]

One T. t. macrotis individual was collected just west of the Grandview Estates development, north of East Lincoln Avenue, west of North 1st Street, east of South Peoria Street, and south of East Cottonwood Avenue, on 11 November 1993 at 5,900 ft. by Aaron Ellingson[10]. He described the site as follows: "Flat, heavily disturbed grassland. Many exotic grasses and thistle dominant....Single individual captured. Most mounds in roadside ditch, only sporadic digging in field. Probably few individuals at this site....Development is primary threat."

According to information from the Douglas County GIS Division (2001, Zone District Map 2231 3A), this site is zoned planned development urban and is part of the Vista Pointe Technicenter development. The following minutes from the 1 May 2001 Douglas County special public meeting/special public hearing suggest that this area will be fully developed:

> Moving north toward Grandview, the land that sits between Peoria Street, or Meridian, and Grandview has been zoned for densities like Meridian since the early 1980s. The section of land immediately west of Grandview is Vista Pointe. North of that area extending across E-470 is Airport 320, which is urban level, non-residential development. Mr. Italiano said Time Warner has an option on land in Airport 320. So, any views from Grandview of the AT&T Broadband Building will no longer be visible, the

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[9] All information in this section from CNHP 2000, EOR #3 and associated field map unless otherwise noted.

[10] Ellingson recorded this as #ARE-93-128. UCM #17017 (Colorado Natural Heritage Program s.n.) matches this locality and collection date.

> mountain views will no longer be visible as the two planned developments between Grandview and Meridian build out. The zoning for those developments is already in place. (Douglas County Planning Commission 2001, online)

A site visit in January 2003 (Echt and Tutchton 2003) determined that for the moment this site remains as largely undeveloped open grassland (Fig. 9). This area occupies an approximately one-mile stretch between a residential development to the east and residential and business development to the west.

While this area appears to have experienced little change since Ellingson's 1993 survey, it is slated for full commercial development. Threats to this population therefore include development, loss of native forage, and habitat fragmentation

5. Historical record – D'Arcy Ranch

Specimen records from the Denver Museum of Nature and Science and the National Museum of Natural History show an additional Douglas County population at D'Arcy Ranch near Cherry Creek, two miles north of Parker. These collections were made between 1930 and 1932 (DMNS #4426-4438, 5950 (Landberg s.n.); USNM #249857-249858 (Miller, 2413/26573X, 26574X)). The USNM data indicate that these were topotype collections; in other words, the T. t. macrotis specimen used to first describe the subspecies was collected from this locality. However, the USNM specimens were collected by Miller in 1930, the same year he described macrotis, so it is conceivable that one of these is actually the very specimen he used to write the original description. This area is about two miles northeast of the Grandview Estates population. CNHP did not include this population in its list of element occurrences in 1993 and we have no additional information on this site.

The locality description suggests that this site was near E-470 and Parker Road, which suggests that development threatens this area as well.

C. Spurious records

1. Boulder County

One adult male T. t. macrotis is recorded as having been captured on City of Boulder Open Space land, on the Tracy-Collins property. The observation appears to have

Fig. 9. Commercial development threatens the Grandview Estates population site. Photo courtesy of Kristin Echt.

been from 1989 (Dawson 1989). The habitat at this site was described as mixed- and short-grass prairie (CNHP 2000).

This record has since been discredited. According to David Armstrong,

> There is no reason to expect [T. t. macrotis] to occur now or ever in Boulder County. Subspecies are not documented in a place by field observation of individuals; rather, delineation of subspecies is based on comparative study of samples of populations, almost always in the museum or laboratory. (David Armstrong, University of Colorado at Boulder, pers. comm., September 24, 2001).

Indeed, the location is entirely distant and disjunct from all other known locations of T. t. macrotis. Given that Boulder County is not part of the identified range of T. t. macrotis (Armstrong 1972), the individual live-trapped at the Boulder site therefore appears to have been misidentified. CNHP recently revised the Boulder record's designation and it is now considered to be that of a T. t. rostralis individual (Beth Hunter, CNHP, pers. comm., 4 December 2001).

2. Russelville Road

Thomomys talpoides macrotis specimen UCM #17010 (Colorado Natural Heritage Program s.n.) was collected 22 January 1994 from "Russelville Road, .5 miles, southeast of Red Hollow; T8S, R66W, sec. 12". However, the Colorado Natural Heritage Program has no record of this occurrence, and this site is around 9.5 miles southeast of the nearest recent occurrence (Newlin Gulch). A site visit in January 2003 (Echt and Tutchton 2003:1) also called the validity of this record into question: "the area marked is higher in elevation than all other macrotis sights surveyed. The presence of slightly rockier terrain and coniferous trees differentiate this area from all other observation sites in Douglas County."

X. ***Thomomys talpoides macrotis* meets all five criteria for listing**

A. Threats

The primary threat facing T. t. macrotis is habitat destruction and fragmentation effected by humans. Small population size also places this subspecies at high risk of extinction. In addition, changes in climate and soil moisture can pose hazards to northern pocket gopher recruitment and survival. Finally, while a variety of mammalian, avian, and reptilian predators prey on T. talpoides, the influx of domestic and generalist predators adapted to suburban life may threaten this subspecies as well.

1. Present and threatened destruction, modification, and curtailment of habitat and range.

Habitat destruction is the primary threat to T. t. macrotis (Figs. 10, 11). Hafner (1998: 17) notes that it is "axiomatic that species with small geographic distributions and low ecological tolerances are most vulnerable to habitat loss." CDOW's COVERS report indicates that this subspecies's range is very limited and is in an area undergoing rapid development "which will likely impact any resident pocket gophers" (CDOW 2000). Pocket gopher concentrations at three of the five sites where T. t. macrotis has been found in the past decade (Willow Creek, Lincoln Avenue, and McArthur Ranch) have evidently already been destroyed by commercial and residential development, and development of the Rueter-Hess dam and the Vista Pointe Technicenter threatens to destroy pocket gopher habitat at the remaining two sites.

Habitat fragmentation and isolation also threaten T. t. macrotis. Continued municipal development creates increasingly dense road networks, diminishes corridors suitable for macrotis dispersal, and separates T. t. macrotis populations. Roads act as barriers to finding mates, leading to inbreeding and loss of gene flow within individual populations. Habitat fragmentation results in shrinking islands of intact habitat with increased exposure to edge effects. The impacts of the disturbances associated with urbanization will only increase, given the tremendous municipal development pressures within the macrotis's geographic range.

Moreover, development is not just destroying and fragmenting habitat; it is also causing habitat degradation. Exotic plants were present within each extant population site when CNHP's (2000) records were collected. These exotics included Russian olive, cheatgrass, and knapweed (Centaurea spp.), which are all on Colorado's State Noxious Weed List (Colorado Department of Agriculture, Division of Plant Industry 2001). In fact, Russian knapweed (C. repens) and diffuse knapweed (C. diffusa) are both on the state's list of top ten prioritized weed species, and, along with spotted knapweed (C. maculosa), are also on the Douglas County noxious weed list (Douglas County Weed

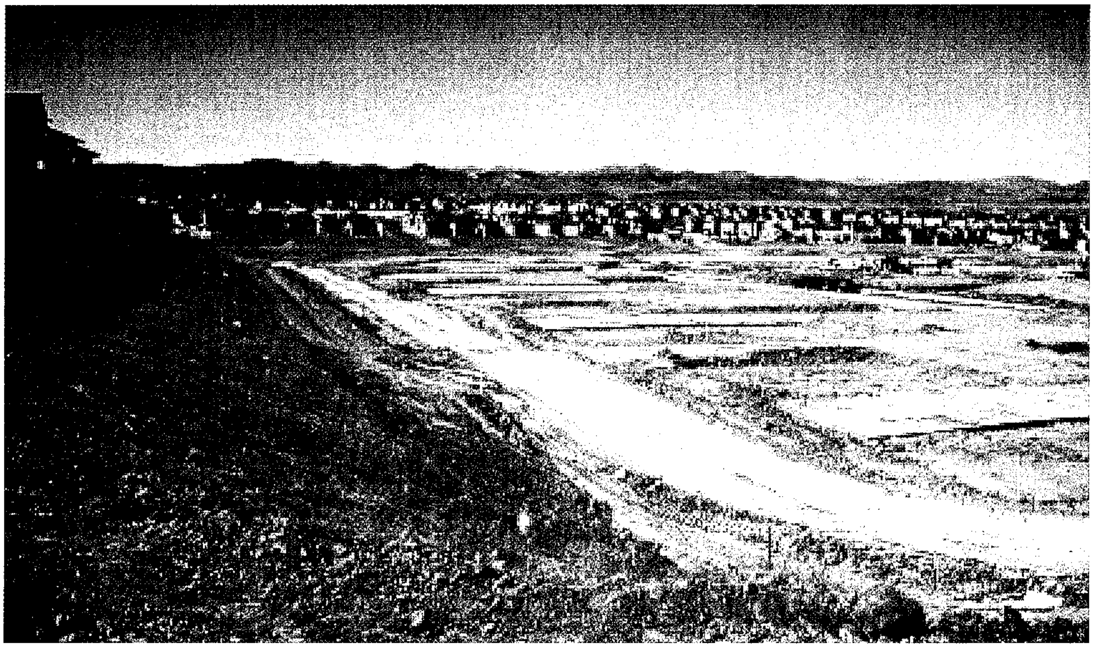

Fig. 10. New development underway in Douglas County. Disturbance to soils, vegetation, and hydrology are often severe when an area is developed. Photo courtesy of Jacob Smith.

Fig. 11. Excavating work in Douglas County. Note the height of the mound of soil that has been moved on the far right of the frame. Photo courtesy of Jacob Smith.

Division 1997). The Douglas County Weed Division (1997:online) characterizes the problem of noxious weeds as follows: "Approximately 97,000 acres within Douglas County are infested with undesirable weeds and this is a growing figure which constitutes a present threat to the continued economic and environmental value of the lands within Douglas County". Noxious weeds threaten half of the imperiled species in the U.S. (Wilcove et al. 1998), and T. t. macrotis is no exception.

Noxious weeds have been shown to limit population density in other fossorial mammals. Slobodchikoff et al. (1988) studied Gunnison's prairie dog (Cynomys gunnisoni) burrow densities at six sites and found that burrow density was significantly negatively correlated with the number of noxious weed species present. In fact, number of noxious weed species present accounted for 45.3% of burrow density variability. Groves and Steenhof (1988, as cited in Knapp 1996) and Yensen et al. (1992, as cited in Knapp 1996) both found that the number of active Townsend's ground squirrel (Spermophilus townsendii idahoensis) burrows significantly declined in areas where fire frequency and intensity increased because of cheatgrass presence.

Herbicide use also degrades pocket gopher habitat. Research has demonstrated that herbicides used for forb control have negatively impacted T. talpoides population levels in the past (Miller 1964; Hansen and Ward 1966; Tietjen et al. 1967; Tietjen 1973; Reid 1973; Chase et al. 1982). For example, an early study demonstrated that an application of the toxicant 2,4-D on a Colorado northern pocket gopher site caused an 87% decrease in the gopher population when the production of perennial forbs had decreased by 83% (Keith et al. 1959, cited in Miller 1964). T. talpoides prefer foods such as lupine (Lupinus sp.), western yarrow (Achillea lanulosa), penstemon (Penstemon redbergii), and agoseris (Agoseris sp.), but eat a wide variety of plants (Miller 1964). Where these plants exist on T.t.macrotis sites, herbicide application may be especially pernicious.

Habitat destruction in the range of T. t. macrotis has also disrupted natural water run-off patterns. This may pose a threat to T. t. macrotis by altering soil moisture and limiting habitat availability.

Habitat degradation, fragmentation, and loss threaten T. t. macrotis with imminent extinction. It appears that pocket gopher burrow systems have been destroyed at three of the five sites where T. t. macrotis was found in the past decade, and a dam and commercial development threaten the remaining two sites.

2. Overutilization for commercial and recreational purposes

Individual pocket gophers are killed in the pursuit of commercial and residential development. Individuals may also be killed for agricultural purposes. Finally, individuals may be destroyed to create recreational facilities.

a. Residential and commercial development kills individual pocket gophers

CDOW (2000) indicates that pocket gophers are killed as residential development occurs. The cultivation of gardens and other planned landscaping projects in residential areas may also result in poisoning or trapping of pocket gophers.

b. Pocket gophers are poisoned in an attempt to increase productivity on farmland and ranchland

Chemical toxicants continue to be available for T. t. macrotis control. CDOW cites poisoning as a threat to this subspecies (CDOW 2000). Pocket gophers are widely regarded as an agricultural pest (Tietjen 1973; Chase et al. 1982; Armstrong 1987; Huntly and Inouye 1988; Dillon 1999). Within the U.S. Department of Agriculture's Animal Plant Health Inspection Service, Wildlife Services (previously called Animal Damage Control) manufactures and disseminates toxicants to federal agencies, non-federal agencies, organizations, and private applicators (USDA/WS 1995; Wildlife Services 2001) to control pocket gopher populations for agricultural and silvicultural activities. Wildlife Services's researchers Engeman and Witmer (2000) describe an effective lethal control program as resulting in 90% annual mortality rates of targeted pocket gopher populations.

A wide range of toxicants and traps are available for lethal control of pocket gophers. The favored methods of controlling pocket gophers are kill-traps, fumigants, and poisoned baits. The tunnel of a pocket gopher is located, and the toxicant or trap is applied (Tietjen 1973; Chase et al. 1982). These methods are legal and fully available to landowners and managers of the five known remaining populations of this subspecies. More specifically, toxicants and traps available for use on pocket gophers include the oral toxicants strychnine alkaloid, zinc phosphide, warfarin, chlorophacinone, and diphacinone; the fumigants carbon monoxide/dioxide and aluminum phosphide; pincher traps, which crush pocket gophers with two spring-loaded jaws, or box chokers, which pin pocket gophers to the floor of the trap with a spring-loaded wire jaw (Engeman and Witmer 2000).

While pocket gophers may be considered a pest in rangelands, their actual impact on those lands is unclear. Tietjen (1973) describes two divergent perspectives, each possessing some degree of experimental evidence. According to the first viewpoint, pocket gophers are pests on rangeland and should be controlled, while the second view is that pocket gophers cause insignificant detrimental impact and therefore should not be controlled.

c. Constructing and maintaining recreational facilities may kill individual pocket gophers

At four of the five sites where T. t. macrotis has been found in the past decade, the development and maintenance of recreational facilities may destroy individual gophers. Bike paths cuts through the Willow Creek and Lincoln Avenue sites, and the eastern Lincoln Avenue gopher concentration was adjacent to a golf course. Parks and playing fields are slated for the McArthur Ranch site, and the Newlin Gulch site open space may be oriented toward recreation rather than habitat preservation. In highly developed areas like northern Douglas County, wildlife and recreationists are often forced to compete for the last remaining green spaces.

3. Disease and predation.

A variety of mammalian, avian, and reptilian species prey on northern pocket gophers. Chase et al. (1982: 249) assert that predation is generally not a limiting factor for pocket gopher abundance or distribution, remarking, "[p]ocket gophers are more important as a prey item to predators than predators are as a controlling factor of gophers." However, this may not be as true of avian predators, as studies have indicated raptors can significantly reduce pocket gopher populations" (Kimball et al. 1970, cited in

Chase et al. 1982). Predation has not historically been documented as limiting T. t. macrotis numbers or range but, given the extraordinarily small size of the remaining population, and new predation threats associated with municipal development, it may pose a limitation currently.

Three-dimensional structures like powerlines and buildings create raptor perches (U.S. Department of the Interior, Bureau of Land Management, Wyoming State Office, Buffalo Field Office 2003). Such development has transformed macrotis habitat from a largely flat plane to a three-dimensional world with increased opportunities for raptor predation. Residential development also raises the risk of predation from domesticated predators such as cats and dogs (Yensen et al. 1998). Control of coyotes in urban areas may result in the "mesopredator release", resulting in increased populations of smaller predators such as bobcats, badgers, foxes, and skunks, with potentially deleterious impacts on rodent abundance diversity (Henke and Bryant 1999; Gompper 2002).

Recreational paths run through the Willow Creek and Lincoln Avenue sites, so dogs and cats are probably common there. The Grandview Estates population is also likely frequented by the pets of homeowners who live across the street. A high school is being constructed near the McArthur Ranch site, and pets will become more common as The Gateway recreational area is developed. Finally, some of the Newlin Gulch area is slated to be preserved as open space, but the level of recreational use there cannot be projected yet. Therefore, it appears that increased predation should be of concern at all five sites where T. t. macrotis was found in the past decade.

Thomomys talpoides serves as a host for several endoparasites (internal parasites) and ectoparasites (external parasites). Internal parasites include roundworms and tapeworms, while external parasites include lice, fleas, ticks, and mites (Reid 1973; Chase et al. 1982).[11] Chase et al. (1982) note that studies of pocket gopher parasites have generally been incidental to research. Endoparasites and ectoparasites have not been

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[11]Chase et al. (1982) provide a list of endoparasites and ectoparasites as follows: Protozoa (Eimeria spp.), Cestoda (Cysticerci, Paranoplocephala spp.), Nematoda (Ransomus rodentorum, Longistriata vexillata, Protospirura ascaroidea, Trichuris fossor, Capillaria hepatica), Diptera (botfly: Cuterebra spp.), Acarina (mites and ticks: Haemogamasus ambulans, Hirstionyssus geomydis, Haemolaelaps geomys, Ixodes sculptus), Mallophaga (lice: Geomydoecus spp.), Siphonaptera (flea: Foxella ignota).

established as a significant limiting factor on the abundance or distribution of the T. t. macrotis.

While predation is a natural part of T. t. macrotis ecology, the influx of people and predators to its habitat may threaten this subspecies with population declines because of elevated predation rates.

4. The inadequacy of existing regulatory mechanisms

According to CDOW, there are no efforts specifically aimed at T. t. macrotis conservation, although the agency asserts that Douglas County's Open Space program "is undoubtedly protecting habitat for this subspecies" (Gary Skiba, CDOW, pers. comm., 26 June 2000). Again, this assertion by CDOW seems overly optimistic. It appears that the Willow Creek site is the only site where T. t. macrotis has been found in the past decade that is managed as open space by a public entity. However, it is not managed by the Douglas County Open Space program, but rather by the South Suburban Parks and Recreation District, which focuses on active recreational use. We are unaware of any evidence that either Douglas County of the municipalities of Lone Tree and Parker are actively working to conserve T. t. macrotis.

Thomomys talpoides was at one time considered a species of special concern in Colorado (CDOW 2000), but is no longer listed as such by the agency. The CDOW's COVERS report indicates that the agency does not believe there to be any sites where T. t. macrotis are protected (CDOW 2000). Given the imminent and high-magnitude threat of municipal development to remaining macrotis populations, the lack of regulatory mechanisms to protect individuals of this pocket gopher subspecies from development and related impacts must be considered a threat to T.t. macrotis.

5. Other natural or manmade factors affecting its continued existence

b. Vulnerability of small populations

This subspecies occupies an extremely narrow range. Only five populations have been documented recently, and substantial barriers have been created between these populations. Therefore, T. t. macrotis is extremely vulnerable to extinction.

Stochastic or random events pose a great threat to small populations because they often simply do not possess the resources to recover. Three main forms of stochasticity have been recognized as increasing extinction risk: demographic, environmental, and genetic (Brussard and Gilpin 1989; Miller et al. 1996; Vucetich and Waite 1998). These factors often work synergistically (Vucetich and Waite 1998). As Lacy (1997: 329) states, "Genetic instability and decline can cause demographic instability and decline, and greater susceptibility to environmental fluctuations and catastrophes. Demographic fluctuations and catastrophe-caused bottlenecks can in turn cause more genetic instability and depletion of genetic variation." Thomomys talpoides macrotis is vulnerable to each of these three forms of stochasticity.

i. Demographic stochasticity

Demographic stochasticity encompasses random events influencing individual birth and death rates (Brussard and Gilpin 1989; Lande 1995). Demographic factors that can vary randomly include "sex ratio, age of first reproduction, number of offspring, distribution of offspring over the lifetime of an individual, and age at death" (Brussard and Gilpin 1989). Larger populations are less influenced by demographic stochasticity because the greater number of individuals decreases the relative importance of the contribution of any one individual to the structure of the population as a whole. For example, if a female produces a litter of all females, the result will have much greater impacts on the sex ratio of the next generation if there are only a few litters produced that year.

The extremely short lifespan of T. t. macrotis, its vulnerability to mortality upon dispersal, and its relatively low rate of reproduction all exacerbate the susceptibility of T. t. macrotis to extinction, given its very small global population size. For instance, in reviewing a decline in northern pocket gophers on Grand Mesa, Colorado, Reid (1973: 37) writes: "A large loss of recruits in one breeding season, followed by an additional loss of older animals before the subsequent reproductive season, appears to have ultimately precipitated the declines." This indicates T. t. macrotis may be vulnerable to the Allee effect or similar dynamics regarding small populations, where decreasing population density results in a decreasing rate of reproduction (Allee et al. 1949;

Petersson 1985). Because all of the remaining populations are threatened by development, the potential for demographic bottlenecks and consequent extinction is great.

ii. Environmental stochasticity

Environmental stochasticity usually affects the death and birth rates of all the individuals in a given population in nearly the same way (Lande 1995). Environmental uncertainty can include major disturbances like fires or epidemics, or less catastrophic factors like year-to-year weather fluctuations (Brussard and Gilpin 1989). Changes in climate, competition, disease, resource availability, and predation all may be considered forms of environmental stochasticity (Brussard and Gilpin 1989). Here population size is not as important as the number of extant populations and the extent of their geographic distribution, since entire populations are usually affected.

For T. talpoides, issues such as drought, excessive level of water in snowpack, and mis-timing of snowpack melting can contribute to declines. As described above, all of these climatic conditions can thwart northern pocket gopher recruitment and result in the death or dislocation of adult pocket gophers. On Grand Mesa, late snowmelt in one year compromised recruitment. Subsequent adult mortality by the next breeding season, due to short average life spans, resulted in an abrupt decline in T. talpoides (Reid 1973). The case illustrates how the loss of one breeding season can result in longer-term decline. This would be a bleak scenario for T. t. macrotis, given its already low number of populations and small global population size. Climate change is likely to increase environmental variability.

iii. Genetic stochasticity

Small, fragmented, and isolated populations have fewer opportunities for genetic flow. Breeding partners are often limited to those found in the immediate area, and loss of fitness due to inbreeding depression can result. Lacy (1997:321) states:

> Inbreeding has been observed to cause higher mortality, lower fecundity, reduced mating ability, slower growth, developmental instability, more frequent developmental defects, greater susceptibility to disease, lowered ability to withstand stress, and reduced intra- and inter-specific competitive ability (Allendorf and Leary, 1986; Darwin, 1868, 1876;

> Falconer, 1989; Ledig, 1986; Lerner, 1954; Ralls et al., 1988; Wright, 1977).

For example, Stockley et al. (1993) found that more highly inbred wild common shrews (Sorex araneus) were smaller at time of weaning and had a decreased probability of reaching adulthood (Lacy 1997).

Inbreeding depression is often more severe when coupled with harsh or variable environmental conditions (Lerner 1954; Schmitt and Ehrhardt 1990; Keller et al. 1994; Miller 1994; Lacy 1997; Frankham 1998). As fitness is lost from inbreeding, population size continues to diminish, and further inbreeding becomes even more likely (Brussard and Gilpin 1989) while at the same time survivors become more vulnerable to extinction from demographic or environmental stochasticity (Goodman 1987; Lacy 1997).

There are several mechanisms that cause inbreeding depression. Without reliable sources of immigration, genetic diversity may quickly be lost through the random process of genetic drift, and deleterious mutations and alleles may spread throughout a population. These deleterious alleles can become fixed in small populations because allele frequencies in populations with fewer than a thousand breeding individuals are usually influenced more by random genetic drift than natural selection (Kimura 1983; Lacy 1987; Lacy 1997). As these maladaptive genes accumulate, populations decline and genetic drift may occur even more rapidly, creating the positive feedback termed "mutational meltdown" (Lacy 1997; Frankham 1998; Vucetich and Waite 1999). When only a few individuals establish a new population or survive a population bottleneck, their progeny are highly vulnerable to the effects of genetic drift and loss of genetic variability (Lande 1995; Lacy 1997). Many populations of mammalian species that have experienced bottlenecks have been shown to experience lower fitness compared to populations that did not experience bottlenecks (Lacy 1997). While inbreeding in some plants that reproduce by self-fertilization has been found to purge populations of maladaptive recessive alleles, there is little evidence that this occurs in mammals (Ralls et al. 1988; Barret and Charlesworth 1991; Barrett and Kohn 1991; Lacy 1997).

Inbreeding depression may also result from the loss of the competitive advantage conveyed by heterozygosity, or heterosis. Cothran et al. (1983) found that white-tailed deer (Odocoileus virginianus) with a greater number of heterozygous allozyme loci also had higher rates of twin births, more massive pregnant females, and faster fetal growth (Lacy 1997). Fitzsimmons et al. (1995) reported faster horn growth in bighorn sheep with higher levels of heterozygosity. Reed and Frankham (2003: 233) recently found that measures of population size, heterozygosity, and genetic variation were all "positively and significantly correlated with population fitness."

As heterozygosity is lost, populations are less able to adapt to change because there are simply fewer combinations of alleles available (Lande and Shannon 1996; Myers 1996). As Lacy (1997:321) summarizes:

> Bürger and Lynch (1995) found that fluctuations in genetic variance in small populations can reduce the rate of adaptation sufficiently to cause small populations to go extinct in the face of environmental change to which large populations would be able to adapt. We cannot know what adaptations will be required for persistence in future environments, but we do know that the rate of environmental change is much more rapid presently than perhaps at any time in past evolutionary history.

Effective population sizes of 5,000 individuals may be necessary to maintain potentially adaptive genetic variation, which means that actual population sizes should be even larger (Lande 1995). Effective breeding populations often only include one-quarter of the individuals in mammal populations because young and old individuals are not involved in breeding and certain mature individuals are more likely to pass on their genetic material (Groves and Clark 1986; Brussard and Gilpin 1989; Noss and Cooperrider 1994). It is highly likely that considerable loss of heterozygosity has already occurred given the small number of T. t. macrotis individuals that probably remain.

Since physical barriers separate the remaining T. t. macrotis sites, dispersal between them is unlikely. The total number of remaining individuals of this subspecies is likely to be very low. Therefore, the results of inbreeding depression may be irreversible. Lacy (1997:331) writes, "When a population is the only representative of its taxon, or exchange with other populations is not possible, then reversal of genetic depletion would come about only if the population can recover to large numbers and survive the 100s-1000s of generations needed for new mutations to restore variation." Clearly this will not be possible if T. t. macrotis habitat and population loss continues.

iv. **Summary: vulnerability of small populations**

In sum, small populations are *extremely* vulnerable to extinction by way of all these mechanisms. T.t. macrotis' extremely small aggregate population indicates that all of the above processes combine to create imminent, high-magnitude threats to this subspecies.

b. **Climate change**

Like many species, the survival of T. t. macrotis populations relies upon a certain degree of climatic stability. Hafner et al. (1998) note the important role of climate change in affecting the distribution and survival of species. Stochastic events due to unusual weather conditions can extirpate entire populations, which has even more dire consequences as macrotis population numbers and distribution diminish. Human-caused climate change may lead to the increased frequency and intensity of drought and flooding (Houghton et al. 1996). Hannah et al. (2002:264) summarized some of the effects of climate change as "changing rainfall patterns, declining water balances, increased extreme climate events, and changes in oscillations such as El Nino."

As Inouye et al. (2000:1633) state, "models of climate change predict increased winter/spring precipitation in Colorado (e.g., Giorgi et al. 1998), perhaps as much as 20-70% (U.S Environmental Protection Agency, Office of Policy, Planning and Evaluation 1997), as well as increases in temperature…." Such changes have direct implications for soil conditions. As precipitation and temperatures rise concurrently, soil can become inundated by moisture. As previously explained, high soil moisture prohibits proper gas exchange in burrow systems and makes burrowing more difficult.

The effects of climate change are not necessarily gradual. Sudden melting of winter snowpack due to unusually warm spring conditions could cause flooding, jeopardizing entire populations. Drought conditions may endanger the pocket gopher's food supply.

The ESA is clear about considering a broad array of threats in evaluating whether an imperiled species qualifies for the Act's protections, whether those threats can be addressed by federal agencies or not. The threat of climate change to T. t. macrotis should therefore not be dismissed. It is important to acknowledge that climate change will most likely have implications for species recovery. This makes it even more important that T. t. macrotis be expeditiously listed under the ESA so that recovery planning can commence, and climate change be considered in the development of a T. t. macrotis recovery plan. As McCarty (2001:327) advises:

> Conservation scientists need to look at climate change as a current, not just a future, threat to species. Although a causal link to climate cannot yet be rigorously demonstrated, the consistent patterns indicate that the prudent course for conservation is to take these changes seriously. Certainly, cases such as the extinction of the golden toad are of immediate concern, but changes in climate need to be taken into account as a possible factor contributing to declines in other species.

c. Stress

Many of the factors endangering T. t macrotis habitat could also contribute directly to increased pocket gopher stress levels. Development and the overall increase in human presence leads to increases in general surface disturbance. Additionally, noxious weed invasion and drought can lead to physical stressors such as malnutrition. Hoffman and Parsons (1991:226) state, "many stresses have a metabolic cost and this should tend to make the effects of different stresses cumulative…." Studies in other fossorial species, such as the white-tailed prairie dog, have shown reduced birth rates due to resorptions and abortions in pregnant females when exposed to environmental stressors (Foreman 1962). Stress may similarly impact T. t. macrotis reproduction and/or survival rates.

B. Continued human population growth within the range of *T. t. macrotis* translates to imminent, high magnitude threats

The subspecies T. t. macrotis faces high magnitude and imminent threats. CDOW's COVERS report indicated that 80% of the habitat of this subspecies could be reduced, and that this habitat destruction is "predictable", as the habitat for this species "readily lends itself to alternative use" (CDOW 2000).

Development pressures extend throughout the known range of T. t. macrotis because of the growth of Colorado's human population, which is most pronounced along the Front Range.

1. Colorado population growth and development

Between 1990 and 1995 Colorado's population growth rate exceed 2.5% (Hobbs and Theobald 1998). During this period only Arizona experienced greater population growth (Hobbs and Theobald 1998). According to the U.S. Census Bureau (2001A) Colorado's population growth rate between 2000 and 2001 was the third fastest of any state in the country. Colorado's population growth rate during this period was 2.7% as compared to a national average of 1.2% (U.S. Census Bureau 2001B.) From 1990 to 2000, Colorado's population increased 30.6%, as compared to a national change of 13.1% (U.S. Census Bureau 2001B).

This rapid surge in Colorado's human population will continue to drastically impact macrotis habitat in Colorado through associated municipal development. From 1960 to 2020 it is estimated that based upon projected population changes, urbanization will proceed at a rate of 60-70 square miles per year, totaling about 4000 square miles during this 60 year period (Hobbs and Theobald 1998).

According to the Colorado Department of Agriculture (CDA 2000), between 1987 and 1997, 1.4 million acres of agricultural land was converted in Colorado. This is the equivalent of an area 20 miles wide and 109 miles long (CDA 2000). Furthermore, this rate is accelerating. "From 1987 to 1997, the average annual rate of conversion was 141,000 acres per year. Between 1992 and 1997, the rate of conversion nearly doubled the 10 year average at 270,000 acres per year" (CDA 2002). The Front Range of Colorado is, and will continue to be, the center for much of Colorado's population growth, land conversion and habitat loss.

2. Front Range population growth and development

According to the Colorado Department of Local Affairs (CDOLA 2002A) the annual population growth rate of Colorado's Front Range was 2.6% between 1990 and 2000. The growth rate between 2000 and 2001 is estimated at 2.4% (CDOLA 2002A). The region's total population increase from 1990 (2,694,096) to 2001 (3,598,282) is estimated at 904,186 people (See CDOLA 2002A). This net growth of 904,186 people in the Front Range Region comprises approximately 80% of Colorado's total population growth during the same period (See CDOLA 2002A, Colorado's net population growth between 1990 and 2001 is estimated at 1,126,874).

According to the 2000 census, Colorado's Front Range population now nearly equals Colorado's entire population from 1990 (Greene 2001). Approximately 81% of all Coloradoans live in Front Range Counties (Greene 2001). More specifically, these regional population growth trends have been extremely pronounced in those counties with occurrences of T. t. macrotis: Arapahoe and Douglas.

3. Arapahoe County population growth and development

Between 1990 and 2000 Arapahoe County experienced an annual population growth rate of 2.2% (CDOLA 2002B). Its net population grew from 393,284 to 487,967 (CDOLA 2002B). According to the U.S. Census Bureau (2002C) Arapahoe County's population increased by 24.6% during this period. Arapahoe County's population continued to grow by 2.6% between 2000 and 2001, reaching 500,785 people (U.S. Census Bureau 2001C). 2001 population estimates rank Arapahoe County as the forth most populated county in Colorado (CDOLA 2002D). A significant surge in housing development and agricultural land conversion has accompanied this population growth. CDOLA (2002C) demonstrates that from 1985 to 2000 the total number of housing units in Arapahoe County increased from 153,726 to 196,385.

4. Douglas County population growth and development

Douglas County, home to all recent occurrences of T. t. macrotis, is experiencing the greatest population growth pressures of all of Colorado's counties. The northern portion of Douglas County, where the T. t. macrotis populations are found, is where Douglas County's land development and population growth are most concentrated.

In 1980 Douglas County had 25,000 residents (Rouse 2001). By 2001 it was the fastest growing county in the country (US Census Bureau 2002E). Douglas County's population grew by 13.6% between 2000 and 2001, and its total population reached 199,753 (U.S. Census Bureau 2002E). 2001 population estimates rank Douglas County as the eighth most populated county in Colorado (CDOLA 2002D). These 2001 numbers are the culmination of a decade of similarly intensive population growth.

Between 1990 and 2000 Douglas County had an annual population growth rate of 11.1% (as compared to a statewide rate of 2.7%) (CDOLA 2002B). Its population grew from 61,559 to 175,766 (CDOLA 2002B). According to the U.S. Census Bureau (2002E) Douglas County's population increased by 191% during this period.

CDOLA projections for population growth in Douglas County also show no indication of this growth trend terminating. State Demographer projections estimate that by 2025 Douglas County's population will exceed 389,000 (CDOLA 2002G). The Douglas County Planning Department projects even faster growth, and expects that the county's population will exceed 390,000 by 2020 (CDOLA 2002H). Significant housing development and agricultural land conversion have accompanied this population growth.

CDOLA (2002F) reports that from 1985 to 2000 the total number of housing units in Douglas County increased from 15,225 to 63,333. Between 1985 and 1999 the number of building permits in Douglas County grew from 2,160 to 7,166 (CDOLA 2002F). Estimates based on US Census data indicate that in 1960 Douglas County had a total of 405 developed acres out of a countywide total of 539,669 acres (Thesprawlsite 2000). By 1990, Douglas County's total developed acres had increased to 15,508 (Thesprawlsite 2000). Projections from this same data indicate that by 2025 Douglas County will have developed 82,858 acres (Thesprawlsite 2000). This rapid development in Douglas County as a whole is amplified in the area inhabited by T. t. macrotis.

All recent occurrences of T.t. macrotis are in the northern portion of Douglas County. According to the county's master plan, it is this portion of the county where development will be concentrated. In a 2001 interview with the Denver Post, then Douglas County Planning Director Peter Italiano indicated that "[t]he county's master plan calls for the southern region to remain more agrarian" (Rouse 2001). Italiano indicated that more than 85% percent of the county's population is in the northern portion of the county (Rouse 2001).

XI. Summary

Petitioners have demonstrated that the subspecies T. t. macrotis meets multiple criteria for protection under the ESA as either an Endangered or Threatened species. Thomomys talpoides macrotis meets the definition of an Endangered species as defined by the Act. "The term "endangered species" means any species which is in danger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta determined by the Secretary to constitute a pest whose protection under the provisions of this Act would present an overwhelming and overriding risk to man" (16 U.S.C. § 1532(6)). The extremely low number of remaining populations – five – and low estimated total population – under 1,000 individuals – considered alongside the multiple imminent and high-magnitude threats of habitat loss and degradation, potential eradication from chemical toxicants, impacts from human recreation and companion animals, climate change, and a variety of other threats, cause the macrotis subspecies to face extinction. If T. t. macrotis is not provided with ESA protections, it is extremely likely the subspecies will go extinct.

On this basis, petitioners request ESA listing for the macrotis subspecies of the northern pocket gopher. Thomomys talpoides macrotis is both a subspecies and is physically disjunct from populations of other T. talpoides subspecies and would therefore meet the Distinct Population Segment criteria if its taxonomic status were called into question. The northern pocket gopher is a keystone engineer species that actively shapes plant community structure and soil characteristics, and that serves as prey to a variety of predators. Pocket gophers have played foundational roles, alongside prairie dogs and bison, in shaping North American grasslands. It is therefore with humility and foresight that we must safeguard those life forms threatened by on-going anthropogenic threats such as habitat destruction.

XII. Requested designation

Petitioners hereby petition the USFWS to list the macrotis subspecies of the northern pocket gopher (Thomomys talpoides macrotis) as a Threatened or Endangered species throughout its range pursuant to the Endangered Species Act.

XIII. Request for an emergency listing rule

The ESA provides authority for the Secretary to issue temporary listing rules in the event of "any emergency posing a significant risk to the well being of any species of fish or wildlife or plants" (16 U.S.C. § 1533(b)(7)). Indeed, the Secretary is commanded to make "prompt use" of this authority "to prevent a significant risk to the well being of any such species" (16 U.S.C. § 1533(b)(3)(C)(iii)).

Thomomys talpoides macrotis is not protected by any state or federal regulations. Yet this subspecies is more imperiled than ever as continued human development and subsequent habitat degradation continue at a furious pace in Douglas County. The five remaining populations are dangerously close to being extirpated, if they have not been already. The extent of undeveloped grassland remaining in Douglas County is deceiving, as many areas have already been purchased and reserved for future development. The introduction of exotic grasses and noxious weeds further imperils T. t macrotis by jeopardizing the continued availability of food and suitable soil conditions. No regulatory mechanisms currently exist to protect this species from continued residential and commercial development. Current regulatory mechanisms are not adequate to protect this highly imperiled subspecies from extinction, and the magnitude and imminence of the threats involved require immediate attention; irrevocable harm will likely occur in the period of time (usually multiple years) expended during the standard listing process.

Therefore, in addition to requesting ESA listing, Petitioners further request that an emergency listing rule be promulgated immediately.

XIV. Benefits of ESA listing

The benefits of ESA listing for T. t. macrotis will be substantial, as we suggest in earlier sections of this petition.

- Listing will require that federal agencies, in conjunction with FWS, carefully consider the potential impacts to T. t macrotis of ongoing and proposed activities under their jurisdictions. The result will be significantly improved protection from commercial and residential development, noxious weeds, and other human disturbance.
- The designation of critical habitat, yet another exclusive benefit of ESA listing, will result in significant additional protection not only for occupied T. t. macrotis habitat but also for other habitat areas deemed essential to the recovery of the species but currently unoccupied.

- Listing will result in the development of a T. t. macrotis recovery plan aimed at biological recovery (and, if possible,[12] delisting).
- Listing will help spur research (and the required funding and scientific interest) necessary to fully understand how biological recovery of T. t. macrotis can be achieved. This research may further the recovery of similar imperiled species.
- Listing will help improve and standardize T. t. macrotis management.
- The State of Colorado and Douglas County have failed to adopt conservation measures to ensure T. t. macrotis recovery. Listing will significantly increase the likelihood that necessary measures are adopted.
- Listing will require protections that are not occurring now and will not occur otherwise through requirements for section 7 consultation for federal projects or projects with federal funding and section 9 prohibitions on take by government or private parties.
- Listing is necessary to ensure the persistence of T. t. macrotis given the ferocious rate of residential and commercial development throughout its range.
- Even the most ambitious scenario involving state and federal agencies adopting their own conservation measures would, at best, result in the reduction of threats to T. t. macrotis, not biological recovery.
- Listing T. t. macrotis may reduce the loss of other native wildlife species from development and secondary poisoning and trapping.
- Listing T. t. macrotis would be a step toward ecosystem protection, given the northern pocket gopher's status as a keystone species.

XV. Critical habitat

This petition requests that critical habitat be designated for T. t. macrotis concurrent with final ESA listing.

[12] Doremus and Pagel (2001) note that some species may be so imperiled, and their original habitat so depleted, that they should never be delisted – i.e., removed from ESA protected status.

XVI. Documents cited

Petitioners hereby incorporate by reference every document cited in this petition and/or cited in the References below. We are happy to provide copies of any of these documents upon request.

XVII. 90 day petition finding

This petition and accompanying material provide substantial scientific and commercial information indicating that ESA listing for T. t. macrotis may be warranted. Petitioners expect to receive a formal acknowledgment of this petition and a decision within 90 days of its receipt.

Respectfully submitted,

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