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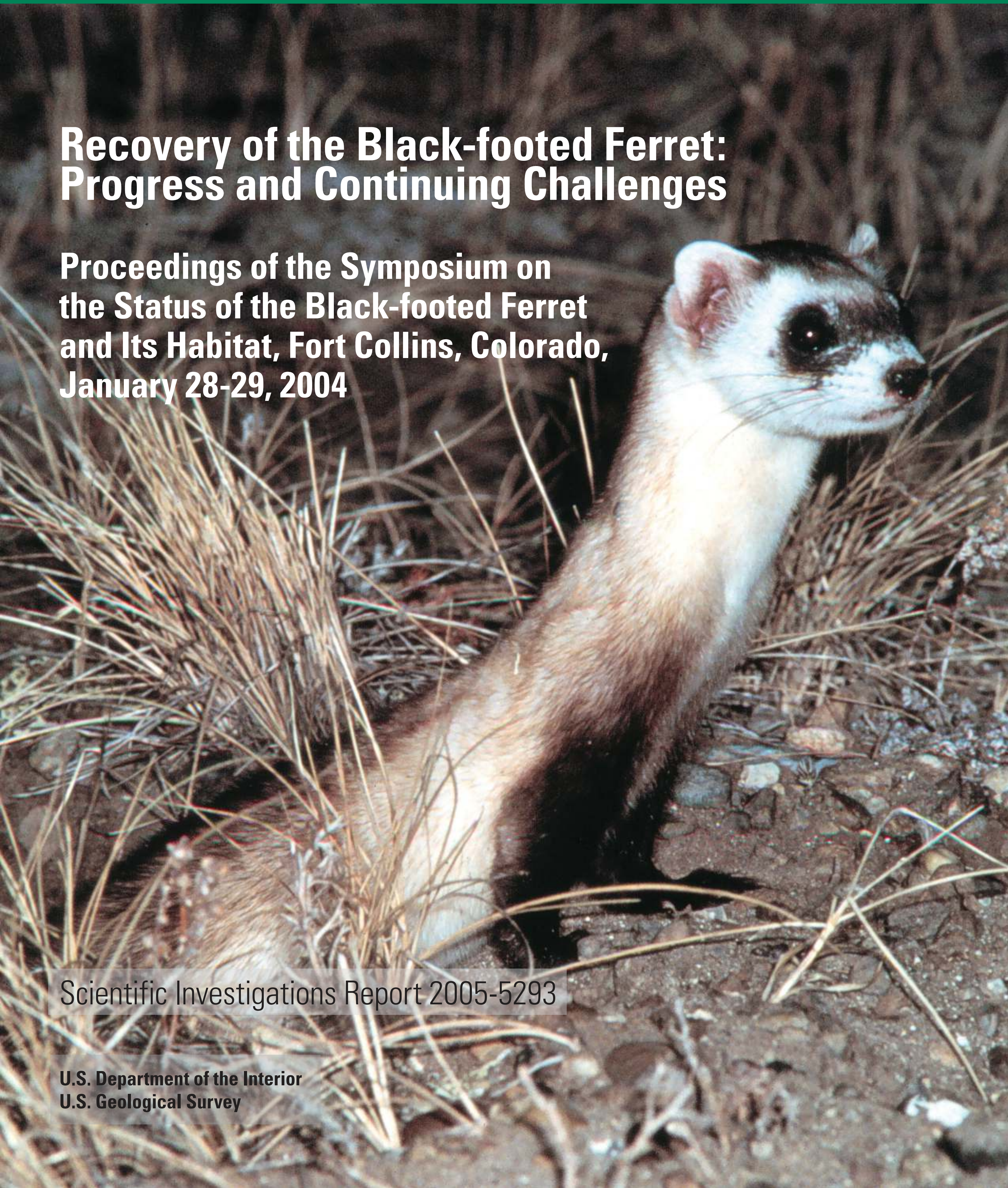
Proceedings of the Symposium on the Status of the Black-footed Ferret and Its Habitat, Fort Collins, Colorado, January 28-29, 2004



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Edited by James E. Roelle, Brian J. Miller, Jerry L. Godbey, and Dean E. Biggins

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Habitat Restoration and Management

By Joe C. Truett,[1] Kristy Bly-Honness,[2] Dustin H. Long,[3] and Michael K. Phillips[4]

Abstract

Black-footed ferrets (*Mustela nigripes*) historically occupied colonies of three prairie dog (*Cynomys*) species—Gunnison's (*C. gunnisoni*), white-tailed (*C. leucurus*), and black-tailed (*C. ludovicianus*)—more or less throughout their ranges. Historical declines in the abundance of ferret habitat (prairie dog colonies) resulted from poisoning of prairie dogs, sylvatic plague, conversion of habitat to agriculture, and changes in grazing practices to benefit mid-height and tall grasses. Prairie dog restoration often involves translocating prairie dogs into vacant habitat and managing vegetation to enhance colony growth. Sites for reestablishment should be selected with attention to ecological suitability, level of plague risk, return on economic investment in restoration and management, and social acceptability. Plague, conventional grazing and farming practices, and hostility of land managers toward prairie dogs can depress rates of restoration, but incentives may help overcome these obstacles. Two case histories illustrate restoration and management of black-tailed prairie dogs in two grassland types—mixed-grass and shortgrass. Options for expanding ferret habitat restoration and management opportunities include using small prairie dog complexes for ferret releases, introducing more intensive grazing to benefit black-tailed prairie dogs in taller grasslands, and reclaiming retired farmlands with shortgrass species beneficial to prairie dogs.

Keywords: black-footed ferret, *Cynomys* spp., habitat, management, *Mustela nigripes*, prairie dog, restoration

Introduction

Black-footed ferrets (*Mustela nigripes*) require populations of prairie dogs (*Cynomys* spp.) for sustained existence in the wild. Historical distribution records of ferrets coincide closely (though not exactly) with the presence of prairie dog colonies and the known historical ranges of three prairie dog species—black-tailed (*C. ludovicianus*), white-tailed (*C. leucurus*), and Gunnison's (*C. gunnisoni*). Ferrets collected outside prairie dog colonies or ranges could have come from ferret populations within colonies (Hubbard and Schmitt, 1984; Anderson and others, 1986). Efforts to recover ferrets proceed under the assumption that wild populations cannot long survive without prairie dogs (U.S. Fish and Wildlife Service, 1988).

Ferret habitat restoration thus implies restoration and management of prairie dogs, which of course requires suitable prairie dog habitat. Many landscapes historically occupied by black-tailed, white-tailed, or Gunnison's prairie dogs have been changed by conversion to agriculture, alterations in large herbivore abundance, or increases in woody vegetation. Singly or in combination, these changes have altered habitat suitability for prairie dogs (U.S. Fish and Wildlife Service, 2000; Knowles, 2002). Thus, habitat restoration for ferrets often must begin with habitat restoration and management for prairie dogs.

We focus herein on restoration and management of prairie dogs as a means of restoring ferret populations. First we discuss historical patterns of ferret and prairie dog abundance and, partly on that basis, regional priorities for restoration. Then we describe prairie dog restoration and management methods, challenges to both, and ways of expanding opportunities. Some issues, such as relative habitat quality among the prairie dog species, the influences of plague and predation, and the effects of livestock grazing, also are addressed elsewhere in this volume.

Ferret Habitat: A Historical Perspective

Historical information on ferret habitat is limited because of the fossorial and nocturnal habits of the species (Biggins and Schroeder, 1988) and its early demise. Even so, making the most of available data seems imperative; such data not only provide a rough template for restoration but also can inform the recovery process. The most reliable data primarily include past distributional abundance of ferrets based on verified records (usually collections) and the biogeographical patterns that can be inferred from these records. We recognize that collection records provide a poor surrogate for ferret abundance (numerous factors could influence collection density, as discussed later), but few other historical data sets are as relevant to restoration.

[1]Turner Endangered Species Fund, P.O. Box 211, Glenwood, NM 88039.

[2]Turner Endangered Species Fund, P.O. Box 1118, Fort Pierre, SD 57532.

[3]Turner Endangered Species Fund, P.O. Box 131, Cimarron, NM 87714.

[4]Turner Endangered Species Fund, 1123 Research Drive, Bozeman, MT 59718.

The general picture that emerges from verified records shows a ferret distributional range largely overlapping the ranges of the three prairie dog species (fig. 1). Black-tailed prairie dog range, being much more extensive than ranges of white-tailed and Gunnison's prairie dogs, encompasses most of the ferret range and accounts for most of the ferret records (Powell, 1982; Anderson and others, 1986). An important question for restoration is whether these records suggest any apparent preferences of ferrets for prairie dog species or biogeographic regions.

If one assumes that density (number per unit area) of ferrets collected or otherwise verified in prairie dog range correlates with habitat quality or preference, Anderson and others' (1986) distribution maps in most cases suggest no clear preference among species within the same regions. Other factors, however, such as proportion of prairie dog range occupied by colonies, could confound judgments of habitat quality based solely on ferret records. Biggins, Lockhart, and Godbey (this volume) and Ernst and others (this volume) note the likelihood that higher density populations of prairie dogs supported more ferrets per unit area, and, as Knowles (2002) indicated, black-tailed prairie dogs usually occur in higher densities than do the other two species. New Mexico presents a conundrum (see also below) in that about four times as many ferret records came from Gunnison's as from black-tailed prairie dog range in the State (Anderson and others, 1986) despite the probable greater density of black-tailed prairie dogs and the estimated similarity in area occupied by the two species (see Hubbard and Schmitt, 1984).

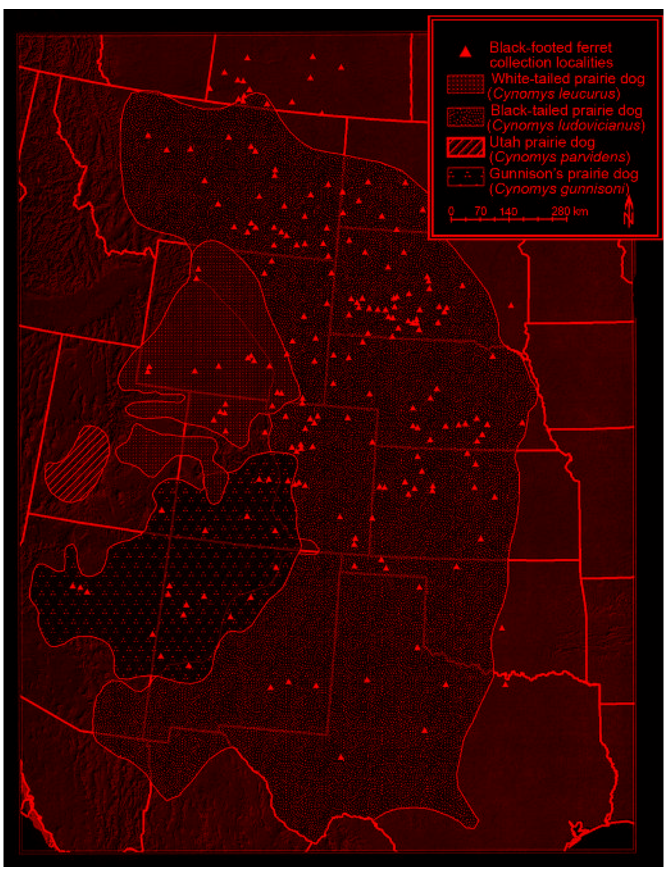

Figure 1. Collection locations for black-footed ferrets (*Mustela nigripes*) (Anderson and others, 1986) and historical ranges of prairie dogs (*Cynomys* spp.) across the Great Plains. Each collection location (dark triangle) represents ≥1 verified historical record(s).

The distribution of ferret records in black-tailed prairie dog range suggests that a greater density of ferrets occurred in northern parts than in southern parts. The northern half of the range produced about eight times as many ferret records as did the southern half (calculated from Anderson and others [1986]; fig. 1). Furthermore, numbers of ferret records from Montana, Texas, and the portion of New Mexico occupied by black-tailed prairie dogs (Anderson and others, 1986), viewed in light of estimated prairie dog colony area (table 1), show ferret records per habitat unit in Montana to be about 50 times those in New Mexico and well over 100 times those in Texas. Bailey (1905) described a single colony of black-tailed prairie dogs in Texas that occupied about 65,000 km^2; Anderson and others (1986) showed only two to five ferrets verified from the region occupied by that colony. In comparison, South Dakota's entire prairie dog range (including the unoccupied parts) covered only about twice that area but yielded 99 ferret records. Oklahoma, a southern State with roughly the same area of prairie dog range as that of South Dakota, yielded only four ferret records (Anderson and others, 1986).

Several factors other than habitat quality could have contributed to these north-south differences. Flath and Clark (1986) may have substantially underestimated the area of prairie dog colonies in Montana, and Bailey (1905) may have substantially overestimated it in Texas (D. Gober, oral commun., 2003). Trapping for furs, which accounted for some of the specimens collected (Anderson and others, 1986), may have been more intensive in areas producing better furs—that is, northern regions. The intrusion of agriculture into eastern portions of black-tailed prairie dog range may have occurred earlier in southern than in northern States, perhaps biasing

Table 1. Black-footed ferret (*Mustela nigripes*) collection records from black-tailed prairie dog (*Cynomys ludovicianus*) range in three states, and densities of records within ferret habitat based on reported habitat acreages (i.e., areas occupied by prairie dog colonies).

State	Number of ferret records[a]	Estimated area (km^2) of habitat available	Ferret records/ 100 km^2 of habitat
Montana	44	6,000[b]	0.733
Texas	13	230,000[c]	0.006
New Mexico	3	~21,000[d]	0.014

[a]Anderson and others (1986).
[b]Flath and Clark (1986).
[c]Bailey (1905).
[d]Hubbard and Schmitt (1984).

later collection efforts toward northern States (Anderson and others, 1986). Finally, far southwestern (Chihuahuan Desert) portions of black-tailed range, having historically lacked large wild grazers (Truett, 1996), may have supported low numbers of prairie dogs (and few or no ferrets) prior to the proliferation of cattle (*Bos taurus*) (Hubbard and Schmitt, 1984).

Definitive answers about latitudinal differences in habitat quality of black-tailed prairie dog colonies will come only with comparisons between ferret releases that span the historical range. To date, colony complexes near Janos, Chihuahua, Mexico, host the only ferret releases in southern parts of black-tailed prairie dog range. The youth of this release program precludes a reliable assessment of its success.

Regional Priorities for Restoration

The Black-footed Ferret Recovery Plan (U.S. Fish and Wildlife Service, 1988) calls for establishing the widest possible distribution of 10 or more self-sustaining ferret populations. Sites for release of ferrets are selected on the basis of several criteria of habitat suitability (Biggins and others, 1993), key among which are size and expected longevity of prairie dog colony complexes. To complement this strategy, those planning prairie dog restorations probably should set regional priorities. We believe that important criteria for setting such priorities include level of plague risk, species of prairie dog, and regional differences in habitat quality within prairie dog species. All of these criteria will affect relative costs of prairie dog restoration and management.

Plague Risk

The sensitivities of prairie dogs and ferrets to plague make it the most important long-term threat to ferret habitat restoration in regions susceptible to epizootics. The historical spread of sylvatic plague eastward from the west coast and the apparent termination of this advance at the so-called plague line are addressed elsewhere (Cully and Williams, 2001; Gage and Kosoy, this volume). At present, plague apparently occurs in the wild more or less throughout the ranges of white-tailed and Gunnison's prairie dogs and in black-tailed range to about the western borders of South Dakota, Nebraska, Kansas, and Oklahoma—the plague line (Cully and Williams, 2001). The chances of plague epizootics affecting prairie dogs and ferrets west of the plague line seem to vary considerably among localities and to diminish as one nears the line.

Prairie Dog Species

Available evidence suggests to us that, among prairie dog species, the Gunnison's ranks lowest in priority for ferret habitat restoration and that the black-tailed ranks highest. We rank the Gunnison's prairie dog lowest primarily because of the species' relatively high and persisting losses rangewide to plague (Cully and Williams, 2001; Knowles, 2002) and its relatively intact (unaltered) habitat (Knowles, 2002); these factors suggest that restoration and habitat management efforts may lead to little long-term improvement in population status of the species. The average low survival and reproduction of ferrets released into a large Gunnison's prairie dog complex in Arizona (Conservation Breeding Specialist Group, 2004) suggest that, for unclear reasons, ferret habitat quality may be poor (plague appears to be absent at release sites).

We rank the white-tailed prairie dog second in priority. Although also at high risk from plague rangewide, this species is believed to suffer lower losses to epizootics than do Gunnison's or black-tailed prairie dogs, perhaps because of its commonly low population densities (Menkens and Anderson, 1991; Cully and Williams, 2001). In support of this belief, releases of ferrets during 1991–94 into a white-tailed prairie dog complex in Wyoming's Shirley Basin (Luce and others, 1997) resulted in unexpectedly high numbers of ferrets present in 2003 (Grenier, 2003), despite plague epizootics in the interim (Luce and others, 1997; Cully and Williams, 2001). Like Gunnison's prairie dogs, however, white-tails probably offer low per capita returns on investment in restoration and habitat management because of their low density and relatively intact habitat (Knowles, 2002).

We rank the black-tailed prairie dog highest in priority. A substantial proportion of their relatively large range remains plague free, densities within colonies (especially in plague-free areas) tend to be relatively high, and restoration and management efforts can yield high per capita returns. Much of the habitat within their historical range has been degraded, but substantial proportions could be restored. The most successful releases of ferrets have been in plague-free parts of black-tailed prairie dog range (Conservation Breeding Specialist Group, 2004).

Regions Within Black-tailed Prairie Dog Range

Priority for restoration varies from place to place within black-tailed prairie dog range. Most obviously, priority increases with decreased risk of plague. Ferrets released east of the plague line in South Dakota have survived and reproduced much better than those released west of the plague line in Montana (Conservation Breeding Specialist Group, 2004). Also, as noted above, if distributional abundance of ferret records correlates with habitat quality, restoration priority increases with latitude.

Restoration Methods and Challenges

We discuss two aspects of prairie dog restoration: reestablishment of populations and habitat improvement. Hostile traditions toward prairie dogs among land managers represent an important socioeconomic challenge to prairie dog restoration; incentives may help address this challenge.

Translocation

Timely restoration will require reestablishing prairie dogs where they formerly existed. At least three factors will hinder natural recolonization: (1) large spatial vacancies within previously occupied ranges, (2) short dispersal distances of black-tailed prairie dogs (Knowles, 1985) and probably the other species as well, and (3) infrequency with which new colonies originate on their own (Knowles, 1982). Translocations to establish new colonies will greatly accelerate the rate of restoration (D. Long and K. Bly-Honness, unpub. data, 2004).

Unlike natural colonization, translocation can space colonies across landscapes to form complexes ideal for ferrets and compatible with other land uses (see Bevers and others, 1997; Hof and others, 2002). Because small, new colonies expand much faster than large, old ones (Knowles, 1982; D. Long and K. Bly-Honness, unpub. data, 2004), translocation accelerates the rate of population growth. Also, translocation can retard or control unwanted expansion in source colonies by removing substantial proportions of the populations.

Only Utah prairie dogs (*C. parvidens*) and black-tailed prairie dogs have been extensively translocated (Truett and others, 2001a). Translocations of Utah prairie dogs commenced in the early 1970s with concern for the imperiled status of that species. Large-scale translocations of black-tailed prairie dogs have taken place primarily since 1990 (Long and others, in press). Methodologies for both species have been published elsewhere; below we review and compare these methods and recommend approaches that seem to work best for ferret habitat restoration.

Black-tailed Prairie Dogs

Source populations for translocating black-tailed prairie dogs should be selected with attention to disease risks, potential legal restrictions, genetic makeup, and effect of removal on the source population (Truett and others, 2001a; Long and others, in press). To date, plague presents the greatest disease problem and may indicate the need to quarantine animals (Marinari and Williams, 1998) before release. Monkeypox is an emerging disease issue but so far is confined to captive prairie dogs and other rodents. State or Federal restrictions on trapping and transporting prairie dogs may exist; recent restrictions related to monkeypox (U.S. Department of Health and Human Services, 2003) are the most prohibitive to date in that they restrict trapping and transport of all prairie dogs without special exemption. With respect to maintenance of unique gene pools, some biologists have voiced concern about translocating prairie dogs long distances. In practice this concern has influenced few translocation programs, although in New Mexico we acquired prairie dogs from a specific locality to help preserve the gene pool. Using translocations to remove unwanted animals is an attractive idea but in fact is an inefficient and often ineffective control method, in part because most populations seem able to support sustained harvests of at least 25–30 percent annually (T. Livieri, unpub. data, 2002).

The best sites for releases often have evidence of previous occupancy, but risk of plague or encroachment of tall vegetation may have degraded the suitability of such sites (Long and others, in press). Sites without evidence of historical occupancy also can be suitable if soils are deep and relatively fine textured and slopes are less than about 6 percent (Reading and Matchett, 1997). Grass dominance by grazing-resistant species is an important indicator of release site suitability (Long and others, in press).

Operators capture prairie dogs for translocation usually with livetraps but sometimes by pulling them from burrows with a vacuum truck or flushing them out with water (Truett and others, 2001a; Long and others, in press). We advise immediately treating captured animals with a pesticide to kill fleas, which can transmit plague, and then transporting them in wire-mesh cages to quarantine facilities or release sites. Important protocols for handling captive prairie dogs include protection from extreme temperatures, provision of adequate food and water, euthanization if seriously injured, and necropsy of any dying from unknown causes (Marinari and Williams, 1998).

We and most other practitioners conduct translocations during July–September to reduce losses of the very young that would occur with translocations in spring and to give released animals time to excavate new burrows before winter (Long and others, in press). We (Truett and others, 2001a; Long and others, in press) mow tall vegetation at release sites to 10 cm or less and hold the prairie dogs there for several days in acclimation cages consisting of belowground nest boxes connected by an access tube to aboveground retention baskets. The acclimation cages contribute greatly to survival by reducing dispersal and providing shelter from predators during the first few months postrelease while the prairie dogs are excavating new burrows. Predation by coyotes (*Canis latrans*) and badgers (*Taxidea taxus*) during this period usually accounts for most of the postrelease losses; installation of nest boxes at least 1.2 m deep, monitoring for predators at release sites for 2–3 weeks, and selective control of predators during this time commonly result in 50 percent or more surviving onsite at the end of 2 months. By that time, loss rates decline substantially. We usually see recruitment of young at near normal rates the following May and June.

In our experience, most operators translocate prairie dogs in groups as trapped without trying to retain them in original family units or specific sex and age groups. We found no significant difference in postrelease survival or recruitment between groups of prairie dogs translocated as family units ($n = 4$) and those translocated as mixed-family groups ($n = 6$) (Bly-Honness and others, 2004), but Shier (2004) found that five groups she translocated as family units survived and reproduced at higher rates than did five groups trapped without attention to family unity. We found (insignificantly) greater average survival among mixed-family groups translocated after being quarantined together for 2 weeks than among those not quarantined (Bly-Honness and others, 2004). Preliminary data indicated lower survival in groups containing more than about 60 percent juveniles than in groups containing less than about 40 percent juveniles (K. Bly-Honness and D. Long, unpub. data, 2004).

After several months, released animals have usually excavated numerous new secure burrows, and control of depredating coyotes and badgers becomes less important. Occasionally, large losses of prairie dogs at a release site will necessitate supplemental releases during the first several months after the initial release. Supplements usually survive at higher rates than those originally released because they take advantage of the burrows excavated by the first contingent. After several months to a year, management of colonies established by translocation differs little from management of preexisting colonies.

Other Prairie Dog Species

The relatively extensive work on translocation of Utah prairie dogs may instruct efforts to translocate white-tailed and Gunnison's prairie dogs. Utah prairie dogs are more closely related to these two species than are black-tailed prairie dogs, and they occupy similar habitats (i.e., intermountain valleys, benches, and plateaus; Knowles, 2002). Utah prairie dogs were first translocated in 1972, and approximately 20,000 individuals have been moved to date (Long and others, in press). In this section we focus on aspects of these translocations that are different from those discussed above for black-tailed prairie dogs. These differences are rather minor; they include primarily release-site selection and preparation and postrelease protection and monitoring.

Coffeen and Pederson (1993), citing Crocker-Bedford and Spillett (1981), provided criteria for release-site selection for Utah prairie dogs. Sites should be well drained, with soils at least 1.2 m deep and not easily collapsible. Vegetation should be sufficiently short or sparse to allow good horizontal visibility but sufficiently lush to provide forage even in dry periods. Evidence of previous occupancy by prairie dogs increases a site's suitability rating.

Treatment of release sites for Utah prairie dogs has primarily involved removal of tall, dense vegetation and augering of artificial burrows. Player and Urness (1982) demonstrated the benefits of shrub removal to postrelease survival; removal of plants that obstruct horizontal visibility has become standard practice (McDonald, 1993). Augered holes 9–15 cm in diameter and 0.5–1.0 m deep at angles into the ground provide relief from temperature extremes and some level of protection from predators (Player and Urness, 1982; Jacquart and others, 1986; McDonald, 1993). Covering entrances of augered holes with wire-mesh retention baskets to temporarily restrain the prairie dogs and acclimate them to the site (Player and Urness, 1982; Jacquart and others, 1986) appears to improve postrelease survival (McDonald, 1993).

As with black-tailed prairie dogs, mammalian predators, particularly badgers, apparently have caused the greatest losses in translocated Utah prairie dogs (Jacquart and others, 1986; Coffeen and Pederson, 1993; McDonald, 1993). Badger damage has been greatest during the first year or two following release, before the prairie dogs have excavated many secure burrow systems (Jacquart and others, 1986). In comparison, black-tailed prairie dogs usually seem secure from extensive badger depredation after several months (see above). Postrelease monitoring for predators and selective control of badgers are commonly used to protect Utah prairie dogs at release sites (Jacquart and others, 1986; Coffeen and Pederson, 1993). Even so, loss of released animals to badger predation remains a major problem (McDonald, 1993; D. Biggins, written commun., 2003).

Vegetation Management

For several reasons we address primarily black-tailed prairie dogs in this section. This species has a larger historical range that has been proportionately more degraded by agriculture and vegetation change than is the case with white-tailed and Gunnison's prairie dogs (Knowles, 2002). Absence of plague in substantial portions of black-tailed range, coupled with greater average densities of the species, increases the unit-area benefits of habitat restoration. Further, more information exists about habitat restoration and management for black-tailed than for white-tailed or Gunnison's prairie dogs, although the scarcity of information on the latter can be partly offset by the relatively rich database for the Utah prairie dog.

Prairie dogs respond markedly to habitat structure—soil texture, slope, and particularly vegetation height and density (Slobodchikoff and others, 1988; Reading and Matchett, 1997; Truett and others, 2001a). Short vegetation benefits all three species (Longhurst, 1944; Knowles, 1982; Slobodchikoff and others, 1988), presumably because it facilitates visual detection of approaching predators. Black-tailed prairie dogs seem more adversely affected by tall, thick vegetation than do Gunnison's or white-tailed prairie dogs (Scheffer, 1947; Hoogland, 1981; Hubbard and Schmitt, 1984). This effect may be a consequence in part of interspecific differences in predator avoidance behavior (Hoogland, 1981). Detection of predators by visual cues and intraspecific warning calls seem more highly developed in black-tailed prairie dogs, as does clipping of vegetation to improve visibility (Tileston and Lechleitner, 1966; Hoogland, 1996). These characteristics of this species may be evolutionary adaptations to exploit heavily grazed landscapes (Truett, 2003).

Many have noted the positive response of black-tailed prairie dogs to intensive grazing by large herbivores. Osborn and Allan (1949), Snell and Hlavachick (1980), Knowles (1982, 1986), and Cable and Timm (1988) documented expansion of colonies with heavy grazing and their stabilization or shrinkage without grazing in areas supporting mid-height or tall grasses. Truett and others (2001b) and Truett (2003) discussed historical fluctuations in abundance of black-tailed prairie dogs in Great Plains grasslands as a function of changing abundance of large grazers. Other ways of keeping the vegetation short, such as burning or mowing, can substitute for grazing (Ford and others, in press).

Only in shortgrass steppe, which occupies a relatively small part of their historical range (compare fig. 1 with fig. 2), do black-tailed prairie dogs seem relatively free of the need for large grazers (D. Long, unpub. data, 2004). In mixed-grass and tallgrass prairie, sustained absence of grazing (Osborn and Allan, 1949; Knowles, 1982), or simply grazing deferment during the growing season (Snell and Hlavachick, 1980; Snell, 1985), can within a few years or decades exclude black-tailed prairie dogs. This may hold true as well in many historically occupied sites in Chihuahuan Desert grasslands (Truett and Savage, 1998; J. Truett, unpub. data, 2004).

White-tailed, Gunnison's, and Utah prairie dogs tolerate tall, dense vegetation better than do black-tailed prairie dogs. Hoogland (1981) noted the relatively large numbers of shrubs in white-tailed prairie dog colonies (compared with black-tailed colonies) and thought they might serve as protective cover. Taylor and Loftfield (1924) and Longhurst (1944) noted the tolerance of Gunnison's prairie dogs for tall grasses

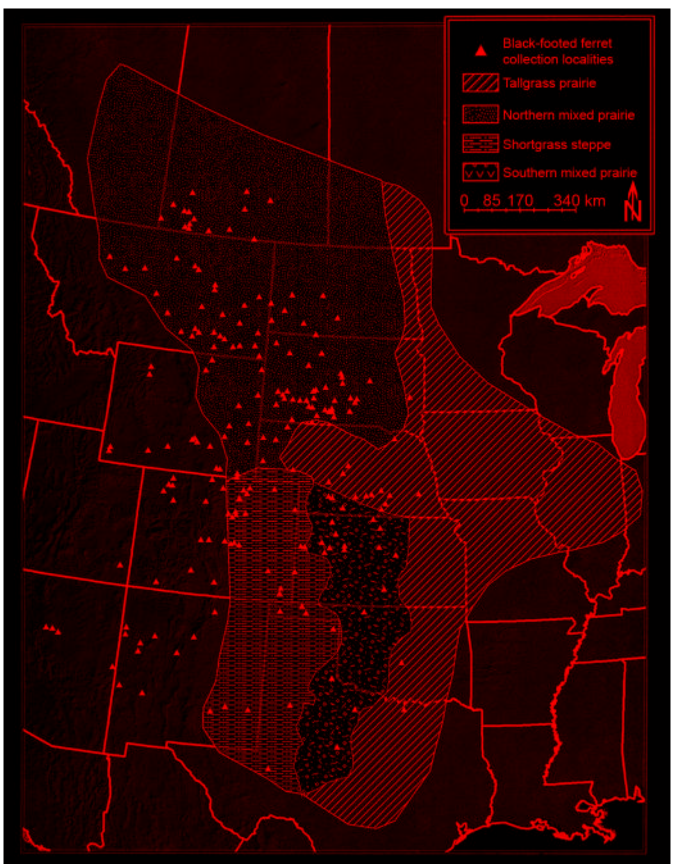

Figure 2. Collection locations for black-footed ferrets (*Mustela nigripes*) (Anderson and others, 1986) and distribution of Great Plains grassland types (Lauenroth and others, 1999). Each collection location (dark triangle) represents ≥1 verified historical record(s).

and shrubs in their colonies. Collier and Spillett (1975) and Coffeen and Pederson (1993) indicated that Utah prairie dogs often coexist with, and may benefit from, shrubs.

Still, habitat quality for these species often appears to decline with increasing shrub density beyond some point. Longhurst (1944) described increasing density of Gunnison's prairie dogs with decreasing shrub density and increasing visibility. Collier and Spillett (1975) and the U.S. Fish and Wildlife Service (1991) attributed declines of Utah prairie dogs partly to historical increases in shrub density. As with black-tailed prairie dogs, these species may continue to face declining habitat quality unless tall vegetation (shrubs in this case) can be controlled. The federally threatened status of the Utah prairie dog has prompted attempts at habitat rehabilitation by "chopping" (Coffeen and Pederson, 1993), "roto-beating," "railing," and burning (Player and Urness, 1982) shrubs. Similar efforts to improve habitat for white-tailed and Gunnison's prairie dogs have not been reported.

Socioeconomic Challenges

Aside from plague, the greatest impediment to prairie dog restoration may be hostile traditions among rangeland owners and managers. The historical demise of prairie dogs resulted in large part from control programs aimed at removing a presumed competitor with livestock (Merriam, 1902; Mulhern and Knowles, 1997). Perceptions molded by a century of institutionalized control of prairie dogs (Reading and others, 1999) will be difficult to reverse. To exacerbate the dilemma, livestock production on rangelands has long built on the tradition of moderate grazing uniformly distributed (Fuhlendorf and Engle, 2001), which, especially in mixed-grass and tallgrass prairie, militates against rapid restoration (Truett, 2003).

At a recent symposium on black-tailed prairie dogs, a Colorado rancher was asked why ranchers dislike prairie dogs. In response, he largely dismissed the risk of cattle breaking their legs in burrow entrances but pointed to the loss of forage that could reduce profits. Then, after some hesitation, he offered another important insight—prairie dog colonies simply look bad. Who wants to see his land blighted by the disturbed soil and rodent activity characteristic of prairie dog colonies? In word and gesture he portrayed prairie dogs as symbols of neglect, pariahs of the range, their presence a sign of lax stewardship comparable to an untidy house at Sunday dinner.

Independent of prairie dog control, grazing at light to moderate intensities has come to symbolize good land stewardship among range managers. To many, heavy grazing equates with "overgrazing" and unwise use. This perception took root in the early 1900s with Clements' (1916, 1936) model of "proper" grazing as that which maintained grasslands near climax condition (i.e., dominated by the tallest of the species at a given site). Historical evidence indicates that black-tailed prairie dogs thrived over the moister parts of their original range because of heavy grazing, first by bison (*Bison bison*) and then by cattle (Truett, 2003). Unfortunately for ferret restoration, the relatively moist and plague-free areas in the Great Plains that can support the greatest densities of prairie dogs need the heaviest grazing. Thus, black-tailed prairie dog restoration is squeezed between plague risks from the west and "good" range management from the east.

Managers' preferences for tall grass compromise another potentially fruitful avenue for prairie dog habitat restoration—reclamation of abandoned farmland (discussed later). The traditional maxim that tall grass is better grass leads most managers to recommend and use seed mixes containing largely tall or mid-height grass species for reclaiming lands such as those under the Conservation Reserve Program (CRP) of the 1985 Food Security Act.

In sum, those in the best position to restore prairie dogs on private and public lands usually lack the motivation to do so. They often come from rural backgrounds, which predisposes them to dislike prairie dogs (Reading and others, 1999). They subscribe to rural traditions that for generations have seen prairie dogs, and the range conditions associated with them, as economically and socially undesirable.

Given the entrenched nature of tradition, must changes in attitude await a new generation of managers with different cultural backgrounds? Perhaps not. For one thing, recent paradigm changes among professionals about what constitutes good conditions on rangelands (discussed later) may legitimize heavy grazing for conservation purposes (Task Group on Unity in Concepts and Terminology, 1995). A more immediate hope builds around incentives, particularly economic ones. Money has a history of reshaping tradition.

Incentives

Landowners, land managers, and agencies that set land management policy potentially can be motivated to restore prairie dogs through at least three kinds of incentives. The most direct and immediately effective incentive is probably economic—money offered to induce change. Regulation or the threat thereof can be brought to bear through the Endangered Species Act (ESA) or other legal means but may generate resentment and thus delay response. Self-motivated cultural change through education is slower still but usually longer lasting. Long-term success in prairie dog restoration may require a combination of all three strategies.

Economic incentives can come from private or public sources, and we can attest to the effectiveness of both. Turner Enterprises, Inc., and the Turner Endangered Species Fund (TESF) have supported prairie dog restoration on private ranches since 1995. Funding from TESF enabled restoration of prairie dog populations on six ranches and also promoted the concept of prairie dog restoration through educational efforts: technical publications, presentations at symposia and meetings, support of university graduate student programs, and field tours to educate people from grade schoolers through governors. Recently TESF funding has been supplemented by matching funds from nongovernment organizations (e.g., National Fish and Wildlife Foundation) and Federal agencies (e.g., U.S. Fish and Wildlife Service Private Stewardship Grants Program, or PSGP). The PSGP awarded grants for prairie dog restoration to other private landowners as well. In 2005, TESF received additional support through the new federally funded State Wildlife Grants Program as matching funds to assist with prairie dog restoration in South Dakota.

The U.S. Fish and Wildlife Service (2000) recently determined that the black-tailed prairie dog was warranted for listing as threatened under the ESA, listing being temporarily precluded by higher priority actions. This finding stimulated the States included in the species' historical range to collaborate on a conservation strategy (Luce and others, 2001). This strategy has involved a variety of actions including periodic meetings, interagency memoranda of understanding, and agreements on implementation schedules. Fear that management of the species would be assumed by the Federal government motivated this collaboration. The States organized working groups dedicated in part to planning and carrying out restoration actions, and many have completed population estimates and status assessments as a first step toward conservation (Luce and others, 2001). It is too early to assess the extent to which restoration on the ground will result from this action by the Federal government.

Over the longer term, the success of prairie dog and ferret restoration will rely on cultural acceptance of these species as valuable and appropriate components of grassland ecosystems. Private charities, Federal grants, and even government regulations that promote restoration all arose from cultural beliefs that more of nature should be preserved than just the parts generating income. All of these sources of support can disappear without consistent reinforcement of such beliefs. Maintenance of culture-based incentives will require a continuing effort to educate people about the intangible benefits of prairie dogs and other species that have little immediate economic worth. The most enduring incentives are likely to come through intergenerational transmission of values beyond money.

Case Histories

For several years the TESF has been restoring black-tailed prairie dogs on private ranches with the intent of eventually releasing ferrets into the habitat developed. Here we summarize restoration and management efforts on two of these ranches—Vermejo Park Ranch (Vermejo) in shortgrass prairie southwest of Raton, N. Mex., and the Bad River Ranches (Bad River) in mixed-grass prairie west of Pierre, S. Dak. Bison graze both ranches at generally moderate intensities.

Translocations to establish new colonies and protection of prairie dogs from poisoning and shooting have been key to restoration on both ranches. Most releases used source stock from within the respective ranches. Translocation methods followed Long and others (in press). Translocated animals were held for several days prior to release in acclimation cages at the release site; these cages had artificial underground nest chambers that prairie dogs continued to use after release while they excavated new burrows nearby. Predator control focused primarily on coyotes (both ranches) and badgers (Vermejo) during and for a few months following the translocation period. Major field efforts took place during May–October, involving one person on each ranch, with temporary help from another person for 2–3 months during June–August.

Vermejo

Annual monitoring of colony numbers and sizes commenced in 1997. Translocations began in 1999, and from then until 2003 we established 35 new colonies. Two colonies or fewer originated naturally during the 6-year period 1997–2003. Forty-six colonies currently exist, a few formed by the merging of two colonies that were originally separated.

Total area occupied by colonies increased from 202 ha in 1997 to 980 ha in 2003, expanding an average of 31 percent annually (mean of yearly values). Growth rate varied appreciably among colonies, mostly as a function of colony size. Colonies expanded an average of 12 percent per year during 1998–99 when a few large colonies predominated, but expansion increased to an average of 41 percent per year during 2000–03, during which time many small, new colonies were established by translocation.

The short-statured vegetation never seemed to offer much of an impediment to colony growth. Colony growth during 1999, when precipitation and vegetative growth substantially exceeded average, did not differ from that in 1998, when less rain fell. A major drought in 2001 and 2002 (21.8 cm and 23.9 cm, respectively, of precipitation compared with approximately 36.8 cm annual average) greatly reduced vegetative growth and recruitment of young into the prairie dog population but seemed not to influence areal expansion rate of colonies.

Bad River

Annual monitoring of colony numbers and sizes began in 1999, at which time 35 colonies existed. Translocations began in 2000, and from then until 2003 we established 35 new colonies. Eleven new colonies originated naturally during 1999–2003, mostly during a drought year (2002), and six disappeared during a wet year (2001). Seventy-eight colonies, a few having been formed by the merging of two original colonies, existed by late 2003.

Total colony area increased from 271 ha in 1999 to 584 ha in 2003; the average annual increase (mean of yearly values) was 25 percent. Smaller colonies grew faster than larger ones, but the greatest influence on colony growth resulted not from colony size but from grass height and density as a function of precipitation. In 2001, when rainfall and vegetative growth peaked, total colony area shrank 12 percent; in the drought year of 2002 colony area increased 72 percent.

Grazing by bison during years of average or above-average precipitation strongly influenced colony expansion. Heavily grazed colonies in these circumstances expanded at much greater rates than did colonies grazed lightly or not at all. Successful establishment of new colonies in wet years in the absence of grazing required us to mow release sites in summer, sometimes repeatedly, to enhance visibility and postrelease survival. Colonies in an area intensively managed—by establishment of new colonies, grazing at moderate intensities, and mowing as needed—grew 78 percent during the 2-year period that they were managed. Colonies outside this area grew by 29 percent during the same period.

Comparisons and Implications

Colony area in the shortgrass prairie at Vermejo expanded faster on average than that in the mixed-grass prairie at Bad River, and growth rate varied less among years at Vermejo. Our data suggest, however, that the potential average growth at Bad River with intensive grazing or drought may be substantially greater than that at Vermejo. This higher growth rate, coupled with the nearly threefold greater density of prairie dogs at Bad River (D. Long and K. Bly-Honness, unpub. data, 2004), illustrates the great potential that exists for ferret habitat restoration in taller grass regions of the Great Plains. Even so, it may be difficult to maximize this potential without changes in grazing management philosophy, which we discuss below.

Changing Paradigms, New Opportunities

Habitat scarcity seems a looming bottleneck in ferret restoration. The shortage of large prairie dog complexes suitable for ferret release coupled with the increase in ferrets annually available for release suggests a need to evaluate the use of smaller complexes. At the same time, changing philosophies and economics related to the major land uses in ferret range (i.e., grazing and farming) may open new avenues for habitat restoration and management. Below we assess some of the opportunities presented by these changes.

Minimum Size of Prairie Dog Complexes

Clearly, other factors being equal, larger complexes of prairie dog colonies offer better ferret habitat than do smaller ones. Although a high-density colony of black-tailed prairie dogs as small as 10 ha can in theory (Biggins and others, 1993) and in fact (Hillman and others, 1979) support a family of ferrets in the short term, Biggins and others (1993) recommended a minimum 400-ha colony area to sustain a ferret population. The Conservation Breeding Specialist Group

(2004) estimated that 2,440 ha of high-quality habitat (i.e., black-tailed prairie dog colonies in Conata Basin, S. Dak.) would be needed to support 120 breeding adult ferrets with more than 90 percent probability of persistence over 100 years. Moreover, they recommended development of 4,050-ha complexes to achieve ferret recovery objectives.

Given the current scarcity of large complexes secure from poisoning and plague, however, the Conservation Breeding Specialist Group (2004) also recommended investigating ways to enhance ferret recovery by using small (less than 2,000 ha) complexes. Use of smaller sites could attract collaborators (e.g., States and private landowners) excluded by large minimum-area requirements and quickly open up options spanning the entire historical ferret range. Literally and metaphorically, it could plant the seeds needed to ultimately establish larger complexes of prairie dog colonies and the widest possible distribution of ferrets.

Probabilities of extinction rise as ferret population size declines; thus, maintenance of ferrets in small colony complexes might necessitate periodic reintroductions from elsewhere. Still, this inconvenience might be trivial given the possible rewards—attracting wider public and private support, supplying wild-reared kits for release elsewhere, hosting research to better inform a variety of restoration schemes, and maintaining numerous wild populations as a hedge against regional catastrophe. Furthermore, finding ways to use small complexes could ultimately lead to shifts in grazing and farming philosophies to benefit ferret recovery.

New Directions in Grazing: Beyond Clements' Climax

Recently, members of the Task Group on Unity in Concepts and Terminology (1995) of the Society for Range Management laid to rest the conventional notion that grazing according to Clements (1916, 1936) (i.e., maintenance of grass communities near climax) is the sole gospel of good range management. They envisioned an array of potentially "good" grazing management options depending on management goals. In so doing, they legitimized such previously objectionable ideas as intensive grazing in areas of mixed-grass and tallgrass climax to benefit shortgrass species. In our view this change in perspective opened the door conceptually for extending prairie dog and ferret recovery efforts farther eastward into plague-free terrain.

Most ferret records for the Great Plains came from regions where prairie dog populations depended to some extent on grazing; that is, regions dominated by mixed or tall grasses (fig. 2) Historical accounts suggest that grazing by bison, before their demise in the 19th century, facilitated occupancy of these regions by prairie dogs and ferrets; the need for intensive and frequent grazing increased with distance eastward (reviewed by Truett, 2003). Bison had been eliminated in most Great Plains areas well before most ferret collections were made (cf. Anderson and others, 1986; Isenberg, 2000). Prior to bison extirpation, ferrets not only might have been more abundant in eastern portions of their range than numbers collected indicate, but also might have ranged farther east than ecologists have assumed.

Can intensive grazing (by livestock) be reinstated in these eastern, plague-free areas to pave the way for prairie dogs and ferrets? The historical rebound of prairie dogs in some of these areas following entry of cattle in very large numbers in the last decade or two of the 19th century (Merriam, 1902; Truett, 2003) suggests so. Several key management questions surround such a concept.

1. How far east can prairie dogs potentially thrive? Collection records (Hall, 1981) suggest that prairie dogs historically were common farther east than they generally occur now except under anomalous circumstances (e.g., predator-unfriendly sites such as remnant corners of pivot-irrigated fields or human settlements; Sidle and others, 2001; Truett, 2003). Some colonies established by people in high-rainfall areas east of historical range—for example, Nantucket Island off the coast of Massachusetts (Merriam, 1902) and a site east of Fort Worth, Tex. (Schmidly, 1983)—apparently have thrived. In the relatively cool and moist climate of the late Pleistocene, black-tailed prairie dog range extended substantially east of its historical limits (Goodwin, 1995), possibly because of heavy grazing by the numerous megaherbivores of the time (Truett, 2003). The key to prairie dog survival eastward to the limits of historical range and beyond may simply be short grass.

2. What vegetative changes come with the intensive grazing associated with prairie dog occupancy of mixed-grass and tallgrass sites? Mid-height and tallgrass species decline in dominance, often dramatically, and perennial shortgrasses and annuals increase (Detling, 1998; Truett and others, 2001b). Given availability of propagules, shortgrass species such as buffalograss (*Buchloe dactyloides*), blue grama (*Bouteloua gracilis*), and tumblegrass (*Schedonnardus paniculatus*) increase and often persist in dominance (Archer and others, 1987; Weltzin and others, 1997). Net primary productivity (indicative of forage quantity annually available) typically declines over time, but forage quality increases. Heavy grazing by livestock outside colonies causes similar but usually less dramatic changes (reviewed by Truett and others, 2001b).

3. Would these changes reduce profits from ranching operations? The many variables involved preclude a detailed response, but the short answer is sometimes yes and sometimes no (Detling, 1998; this volume). Prime among the important variables is the proportion

of the landscape occupied by prairie dog colonies. Livestock profits may decline if prairie dog occupancy level is high but may increase if occupancy level is low. For example, Vanderhye (1985) projected substantial benefits to bison at a site in South Dakota where prairie dog colonies occupied only 12 percent of the landscape. Moreover, heavy grazing by cattle to benefit prairie dogs may under some conditions yield greater sustainable profits than would more conventional grazing intensities (Manley and others, 1997; Sims and Gillen, 1999).

Reclaiming Retired Farmland

Large proportions of the plague-free part of the Great Plains have been converted to agriculture; these proportions generally increase with distance eastward and southeastward (Lauenroth and others, 1999). Retirement of farm acreages under programs such as the CRP may offer the potential for prairie dog restoration. Could prairie dogs reoccupy retired farmlands? If so, how should reclamation of such lands proceed?

Black-tailed prairie dogs readily colonize abandoned farmland, often in preference to undisturbed prairie. In Montana, Knowles (1982) found that colonies were disproportionately abundant on previously cultivated lands near abandoned homesteads. In Colorado, Koford (1958) observed that prairie dogs near Fort Collins readily invaded fields under cultivation, and D. Seery (oral commun., 2002) noted that many prairie dog colonies on Rocky Mountain Arsenal National Wildlife Refuge, Colo., occupied long-abandoned fields. In Badlands National Park, S. Dak., Langer (1998) found more and larger prairie dog colonies on long-abandoned farmland than on undisturbed prairie. We observed that prairie dogs near Pierre, S. Dak., quickly invaded land last plowed the previous year.

As expected, cultivated land with tall vegetation repels prairie dogs; land with short or very sparse vegetation attracts them (Koford, 1958). Retired farmland reclaimed with perennial shortgrasses should sustain prairie dogs and, in some circumstances, limit erosion better than if tallgrasses were used in reclamation (see Truett, 2003), the latter a prime goal of the CRP. Mid-height and tall species of grass usually dominate CRP seed mixes (Reynolds and others, 1994; Johnson and Igl, 1995; Patterson and Best, 1996), however, rendering fields reclaimed with such mixes unsuitable for prairie dogs and other shortgrass fauna (e.g., see Kamler and others, 2003). Retired farmlands seem lucrative targets for prairie dog restoration, but seed mixes dominated by shortgrass species would be needed, particularly under programs such as CRP that limit grazing on lands enrolled in the program.

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