Mountain Plover Studies

Pawnee National Grassland

1985 - 2007

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Introduction

When I originated my early studies of the Mountain Plover on the Pawnee National Grassland (PNG), Weld County, Colorado, I would have benefited greatly if I had access to an overview and field notes from previous research efforts. The intent of this effort is to assure that such a record was available from my research for future efforts. I felt an obligation to the plover resource to provide such documentation, and appreciate funding assistance from my partners (Audubon Societies of Greater Denver, Colorado Division of Wildlife (CDOW), US Forest Service's (USFS) Arapaho/Roosevelt National Forest) in compiling this document. This summary is the product of that four-party, collaborative effort.

Background to the 1986-2007 Studies

Over the period of my studies of Mountain Plovers on the PNG, I have had numerous office and field conversations with Dr. Walt Graul regarding his 1969 – 1972, 1974, studies of plovers on the area. I recall him saying that he chose the Mountain Plover for his doctoral research at the University of Minnesota with some hesitation expressed by his major professor, Dr. Frank Bellrose, that he would not be able to find an adequate population for the study. He contacted Dr. Ron Ryder of Colorado State Univresity (CSU) and Dr. Ryder pointed him towards the PNG as a likely location. One visit assured both he and Dr. Bellrose that the PNG population would be adequate to pursue his ethological studies of the breeding system of the plover. Dr. Graul concentrated his studies in the Keota area, specifically on the Keota and South grazing allotments.

At the same time Dr. Graul was working on the PNG, the US International Biological Program was funding Dr. Ryder and his student, Mr. Brent Giezentanner, to study avian assemblages of the PNG. They reported banding 179 Mountain Plover chicks in 1969

alone. Dr. Paul Baldwin of CSU was also funded to conduct a food habits investigation of the plover. He collected 8 adult and 5 immature plover for stomach analyses during the 1970 and 1971 breeding seasons. Birds were collected on the Central Plains Experimental Range and on the PNG proper, although specific collection sites were not cited in his report (Baldwin, P.H. Diet of the Mountain Plover at the Pawnee National Grassland, 1970-1971. U.S. International Biological Program Grassland Biome Technical Report No. 134, 1971).

At the request of Dr. Peter Stettenheim, Editor of *The Condor*, Dr. Graul (personal communication) subsequently worked with Ms. Lois Webster to provide an estimate of the number of Mountain Plover in the U.S. They estimated 214,200 - 319,220 birds continentally, mostly breeding in Colorado, Montana, and Wyoming. Dr. Graul subsequently informed me that the estimate was done by simplistic extrapolation of PNG information, not precise, and may have been off by a magnitude. Thus, he concluded a true population possibly being as few as 24,000 – 32,000 birds or as many as 2,140,000 – 3,192,200 birds.

During the early 1980s, while employed as the Nongame Bird Biologist with CDOW, Dr. Graul participated in an experimental transplant of plover chicks to Kansas. Dr. James Sedgwick had just completed his graduate studies at CSU and was hired as a temporary employee of CDOW to capture the chicks. Fifty PNG chicks were relocated to Wallace County, Kansas, in 1982, and another 18 were transported there in 1983 (Ptacek, J. and M. Schwilling. Mountain Plover reintroduction in Kansas. *Kansas. Ornithological Soiety. Buletin.* 34: 21–22. 1983). The transplants were evidently unsuccessful (Schulenbert, J. H. Status of the Mountain Plover reintroduction in Kansas. *Kansas Department of Parks and Wildlife,* Pratt, KS, 1983).

In 1983, Mr. Brian McCaffery of Luther College (Iowa) started a Master's of Science degree working under the guidance of Dr. Tex Sordahl. Mr. McCaffery conducted a brief study as follow-up to Dr. Graul's work in Weld County, working on the U.S. Department of Agriculture's Central Plains Experimental Range, and in the Coal (called "Wildhorse"

in his publication) and Elliot grazing allotments. He subsequently went on to visit South Park (Park County) briefly to confirm the presence of breeding plover at that location and then spent some time observing plover on their wintering grounds in California. Only the Weld County observations were published from his few months of work.

Also in 1983, Dr. Sedgwick subsequently began working with me on my FWS studies of riparian bird assemblages at the South Platte Management Area of CDOW and Arapaho National Wildlife Refuge of FWS. Having always been interested in wetland birds, and shorebirds specifically, in 1985, I asked Dr. Sedgwick to give me a one-day lesson on Mountain Plover on the PNG. In June 1985, he showed me plovers and talked about their ecology as we visited the site (Coal Allotment just north of County Road 96) where he had easily captured the chicks for the Kansas transplant. This was 13 years after Dr. Graul completed his studies of plover breeding on the PNG.

The Annual Population Survey

The 1986 Survey

Additional trips to PNG and casual observations of plover during the summer of 1985 did not seem to support the decade-earlier estimate of >20,000 birds in Weld County. That same year FWS (*Federal Register* 50:37958-37967, 1985) published a review of vertebrate wildlife species of special concern that included the Mountain Plover. As a consequence of these two, independent events, I attempted to derive a statistically valid estimate of the breeding population of plover on the PNG during the 1986 breeding season using a new statistical software at that time called TRANSECT (Burnham et al. 1980. Estimation of density from line-transect sampling of biological populations. *Wildlife Monograph* No. 72). I enlisted Dr. Sedgwick to assist in a 6-day survey for breeding plover in 47 randomly selected sections of the PNG. Those surveys were conducted 2-5, 9, and 13 June. With the permission of Grant Godbolt, PNG District Ranger, we drove two, parallel diagonal transects approximately 400km apart on each of

the 47 sections. The locations of the 1986 survey sections and the transect orientation within each section are attached as Appendix I. The total transect length was 128.6 km. Transects were driven at #8kph and we recorded the perpendicular distance from the transect line to each plover detected.

To obtain a valid estimate of population density, program TRANSECT required about 40 detections of birds. Our surveys, however, were only able to detect a total of 9 birds. Three sightings were of individuals, 2 of birds on nests with eggs, and 4 of birds with chicks. Further, 2 of the sightings were actually of birds detected in flight, which precluded a distance measure for use in a density estimate. The 7 other sightings were of birds 0-45m from the transect line, but only one was >9m. We felt confident that we did not miss birds within 10m of the truck, resulting in 22m (10m to the left + 10m to the right + 2m for the truck width) as effective strip width of the transect. Thus, the effective area actually *censused* was 4.53km^2 and the density of birds was 1.32/ km^2. This value was well below Dr. Graul's earlier density estimate ranging between 4-32 birds/km^2.

I summarized this finding in a memorandum to the FWS Endangered Species Regional Recovery Coordinators, at that time being Mr. Dave Fleming and Ms. Jane Roybal, both located in the Salt Lake City office. That memorandum was dated 14 July 1986, and therein I concluded that the density of plover in Weld County appeared lower than the range of values reported for the early 1970s. I also noted that the birds seemed clumped in their dispersion among PNG allotments as all plover sightings were within only 5 of the 47 sections surveyed. I closed by suggesting that a more intensive survey of the status of the species on PNG seemed timely.

The summary of the 1986 survey was circulated within FWS and aroused some interest that resulted in a 2-year effort to prepare a status review of the species. That review, co-authored by Barbara Osmundson and Robert Leachman of the FWS Ecological Services Office in Grand Junction, Colorado, was published and circulated in 1990 (Status of the Mountain Plover: a literature review. *U.S. Fish and Wildlife Service, Golden, Colorado,* 1990). Barbara Osmundson subsequently accepted a position as a Contaminants

Biologist within the Grand Junction Field Office and Robert Leachman became the lead Mountain Plover biologist within FWS who subsequently wrote the Draft Listing Package for public comment. That document proposed listing the Mountain Plover as Threatened under the auspices of the Endangered Species Act (*U. S. Fish and Wildlife Service.*1999. Endangered and threatened wildlife and plants: proposed threatened status for the Mountain Plover. *Federal Register* 64(30):7587-7601).

Design of the Annual Survey

Prior to the 1990 breeding season, I designed an annual survey for plovers to monitor populations through time and, hopefully, derive a more precise population estimate. I examined all grazing allotments and narrowed the survey to include only those allotments that had at least 6.4km of internal (i.e., excluding boundary) roads or 2-tracks. From that pool, I selected 8 allotments at random. Those selected included the Center, Keota, Keota Steer, Reno, South, Vivian, Wildhorse and East Willow allotments. The East Willow Allotment subsequently did have two stakes located along the east edge of the allotment, but in otherwise contiguous habitat. Within each allotment I installed 14 permanent survey points at a minimum of 0.32km apart. The points were adjusted as necessary to enhance visibility of the surrounding landscape; i.e., I avoided locating stakes in deep washes or within roadside cuts. Each point was marked by cutting a 21.4dm 'T' post in half and driving it into the ground 8-9dm. A hole was burned through the top of each post and a stainless steel plate with the plot number was riveted to the post:

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Many of these posts remain intact, but some have been destroyed. All posts were removed by vandals in the East Willow Allotment on two occasions and had to be replaced. A handful of posts had the stainless-steel plot marker removed, which was replaced with a different stainless tag or a painted number to assure its identity. Since 1990, one 2-track within the South Allotment has fallen into disuse with construction of oil-field roads in the allotment, but the stakes remain in their original positions. All other 2-tracks and roads used in the survey are intact in 2008.

In 2007 the locations of all 112 stakes for the plover survey were recorded by Stephen Kittrell of the PNG using a Global Positioning System to assure future relocation of precise survey locations in the advent of stake disappearance with time. These locations are provided in Appendix II.

The timing of the annual survey is critical to maintain consistency for comparison among years. Whereas displaying birds may often move elsewhere rather than breed at a site, and whereas nesting birds sit tightly on nests unless flushed, a survey of the

breeding population of plovers is nearly impossible using a point-survey technique. Thus, the survey was timed to be conducted during the last 10 days of June annually. At that time, adults are much more visible due to their tending of mobile chicks. The chicks of the early breeders cannot yet fly and the chicks of later breeders have just left the nest. The few chicks hatching after 20 June over the years of the study were never known to survive to fly from the PNG. Thus, the annual survey of Mountain Plovers on the PNG is a survey of the *successful-breeder* population, rather than the breeding population as is more typical of most avian monitoring programs.

Surveys were conducted from one half hour after sunrise until no later than 10:00 hours. I drove to each sample point, stepped from the vehicle and slowly surveyed 360 degrees around the stake with 7x35mm binoculars until I was convinced that I had not missed any birds. The location of each bird detected was noted and its distance from the stake was paced in meters.

Having standardized the (1) location of the survey plots, (2) survey timing across years, and (3) weather by only surveying on calm, dry mornings, the remaining source of potential variability in the survey was investigator ability. This was standardized in that I personally conducted the survey each year, 1990 through 2007.

The 1990 Test of the Population Survey Design

I tested the new point-transect survey for plovers on the PNG by first repeating the 1986 line-transect survey from 14 to 18 May 1990. Dr. Jim Sedgwick, who assisted me in the 1986 surveys, also assisted in 1990. During the survey, plovers were in the early phase of the nesting cycle with most birds on completed clutches and incubating. Thus, the driven line-transects constituted a “flushing” approach—investigators relying on disturbing birds to enhance bird detections.

The 1990 driving surveys were conducted on the same randomly selected sections as the 1986 surveys with two exceptions. Two sections in the 1986 survey were on the

Central Plains Experimental Range administered by USDA's Agricultural Research Service. Those sections (T 10 N, R 65 W Section 31 and T 10 N, R 66 W Section 25) were replaced by two additional PNG sections (T 9 N, R 63 W Section 30 and T 9 N, R 63 W, Section 31) to assure that all information was pertinent to the primary manager of plover habitats: the USFS.

Diagonal transects were driven in the same direction on the random sections in 1990, as in 1986. Transects were driven at <8kph with one of the two observers standing in the bed of a pickup truck. The driver generally surveyed the terrain forward and to the left of the vehicle and the standing observer surveyed forward and to the right of the vehicle. As in 1986, the transect was a corner-to-corner diagonal followed by a 3-km movement along one of the far edges of the section and then a parallel diagonal back to the starting point. The distance driven using this technique was generally between 4.56 and 4.80 km/section. Where topographical features precluded the prototype transect, we adapted the route to approximate the same linear coverage within a section. Upon detection, the perpendicular distance from the transect line to the location of first sighting of each plover was paced in meters.

The line-transect survey totaled 136km on the 47 sections. In all, 40 plovers were observed at paced distances of 0-99 m from the transect line in 1990. Fifteen plovers were seen <10 m from the transect, while 5 were 10-29, 10 were 20-39, 5 were 40-59, and 4 were >60m off the transect line. As in 1986, (1) we felt that we had detected all birds within 10 m on each side of the vehicle, (2) we were confident that we didn't miss plovers on the line, and (3) we noted that detection of plovers dropped quickly beyond 10m.

I then subsequently, and independently, conducted the new point-transect survey described above on 22, 25, 27-29 June and 2-3, 5 July, the survey taking longer than expected due to the number of birds encountered. Each survey began at sunrise, with one allotment (14 stakes) being surveyed each morning. A total of 77 plovers were observed at 23 (20.5%) of the 112 stakes. Sighting distances ranged from 16-401 m.

Sighting distance for both the line and point transects were analyzed as raw data (i.e., not 'grouped' or 'internalized'). The respective data sets were not truncated to smooth detection curves and increase precision of estimates. Data were analyzed using the Fourier Series model of program TRANSECT.

Unlike the 1986 survey, we detected sufficient plovers on the driven/line transect to calculate a population density using program TRANSECT. (The greater number of detections relative to the 1986 survey may be attributed to running the survey about 3 weeks earlier in 1990.) The calculated density of plovers in 1990 was 3.8 ± 1.1 (SE) birds/km^2 or 9.87 birds/mi^2. That estimate corresponded to a PNG population of approximately 2,941 plovers on the PNG in 1990.

The point-transect density estimate of the plover population on the PNG for 1990 was 4.7 ± 1.2/km^2, within the confidence limits of the 3.81/km^2 from the line transect survey. The point-survey estimate is equivalent to 6.3 plover/km^2 or 3,447 plovers on the PNG in 1990. Whereas the two estimates were comparable, I decided to continue with the point-transect approach for two logistical reasons: (1) it had the distinct advantage that annual surveys can be repeated more precisely than line transects, and (2) it did not require driving on the grassland proper.

Results of the Annual Survey, 1990-2007

The annual breeding population survey was conducted 20-30 June each year with the exception of the first year (see above) and the unusually wet spring of 1995 (due to many days of fog). That 1995 survey was completed on 3 July. The detection distances of the total of 182 adult plovers observed from 1990-1992, were pooled and I worked with Dr. David Anderson of the Colorado Cooperative Fish and Wildlife Research Unit to generate a tighter detection curve for me as the observer. The original detections for each of the three years, and each subsequent year, were then fitted with the multi-year detection curve to calculate the annual plover density on the

PNG using the Hazard model within program DISTANCE (Buckland et al. 2001. *Introduction to distance sampling: estimating abundance of biological populations.* Oxford Univ. Press, New York). The calculated density of successfully breeding plover on the PNG from 1990-2007 is given in Appendix IV. The actual numbers of plovers observed by year and allotment are provided in Appendix V.

Whereas the annual survey detected 33-77 plovers/year, 1990-1994, the 1995 survey resulted in only 2 plovers being detected. Virtually all plover habitat was overgrown with forbs by late June that year. Even the non-leaking stock tanks predictably used by plovers for brood rearing were waist-high vegetation. The two birds seen were both single birds on Weld County Road 105, and neither had a brood. I believe that the nearly total reproductive failure of plovers on the Grassland in 1995 was due to the high rainfall in May that (1) destroyed many nests due to flooding, (2) increased predation on eggs and chicks, and (3) resulted in the loss of brood-rearing habitat for any chicks that may have hatched due to the extensive flush of knee-high vegetation (especially three-awn (*Aristida stricta*) and the exotic mustard (*Lepidium densiflorum*), plus other forbs around water tanks) across the PNG. As a result, virtually all birds had left the grassland before the annual survey in late June.

In 1996, much of the residual 1995 vegetation was still standing. Portions of some allotments looked more like mixed-grass than short grass prairie (e.g., the South Allotment) and I only recorded 9 plovers on the 112 plots. Many additional birds were seen in the vicinity, but all on private land, especially cultivated fields. Interestingly, I failed to record a bird on Keota allotment (one of the most predictable allotments over the past 25 years), which had a relatively dense stand of residual blue grama (*Bouteloua gracilis*) seed heads from 1995 that gave the whole allotment a “fuzzy” appearance. Whereas the plover population bounced back somewhat in 1996, another rainy period increased soil moisture during June to the point that most prickly-pear cactus (*Opuntia polyacantha*) did not bloom. The taller residual vegetation in spring of 1997 again resulted in a minimal plover presence on PNG. The following 1997 photo is of a ‘flat’ in the northeastern corner of the East Willow allotment (looking north from survey stake #154) regularly used for nesting by plovers in the early 1990s:

(© f. l. knopf)

Note the nearly concealed calf lying down just above and to the rear of the ear of the foreground cow).

More normal precipitation in 1997 resulted in a higher population of successful breeders in 1998, the first real “recovery” since the spring of 1995. However, another very rainy week in April 1999 resulted in 7.5 – 17cm of precipitation across the District. That rainfall resulted in a major flush of cool season and exotic vegetation beginning in late May. The early precipitation did not appear to affect breeding plovers, although breeding birds seemed fewer and more localized than in the early 1990s. The rainfall and subsequent flush in tall vegetation produced another 1995-year-like total reproductive failure of plovers on the Grassland and I failed to detect a single bird on the 112 survey points.

I invited Walt Graul to tour the PNG with me on 26 July 1999 to compare observations from his work in the 1969-1970 seasons with what I was seeing in the late 1990s. Basically, the vegetation had become so rank in many places that it no longer constituted plover habitat. His prime study area in the South Allotment had not had birds nest in it for almost 10 years. He described it as much more rank in 1999. The bare ground component was completely absent. We agreed that the best looking nesting habitat was on the private lands south of Grover. Those rangelands seemed to be grazed harder and did not have nearly the extent of mixed grasses and invader forbs.

Continuation of the surveys in the early 2000s revealed a minimal plover population, and one that did not seem reproductively viable. The PNG continued to have a lot of residual vegetation which gave the appearance of a shag carpet. Three-awn and some other species seem to me to stand longer than one year as residual vegetation, which may or may not be true. This is in contrast to the way it looked in the early 1990s. As an example, following is a photo of the Coal Allotment approximately one mile N of CO14 on CR61 from late April 1990, when plovers were selecting nest sites. Note the still dormant vegetation not even covering the soles of the shoes and the prominence of cactus pads:

(© f. l. knopf)

Following the drought of 2002, the entire Pawnee still looked more like an interface of mixed-grass prairie and hay fields with many flowering forbs by mid June in 2003. Casual observations lead me to think that wheat grass (*Agropyron smythii*) and needle-and-thread grass (*Stipa comata*) especially spread following spring rains. The South allotment where Walt Graul had 80 nests/quarter section in 1970, illustrates this point:

(© f. l. knopf)

The white object in the foreground of this 2003 photograph is my straw cowboy hat. The photo was taken at plover survey stake no. 185, which is immediately behind and to the west of the vehicle.

Based upon these changes in vegetation from the early 1990s, I suggested that a historical photo-point comparison of the prairie across the Grassland would be very interesting. Bob Peterson (PNG Range Ecologist) assured me one existed, but I had not heard back from him regarding access to the photo record before he retired.

Surprisingly, a total of 12 plovers were detected on the 2005 survey. Four birds were seen locally in each of Center, Wildhorse, and East Willow allotments. This increase in the number of birds in 2005 was not sustained in the 2006 or 2007 surveys.

After the 1995 population crash, I never again regularly saw birds flush from county roads as was common in the early 1990s. Back then, a drive along CR 103 heading 2km south from Keota regularly flushed more than a dozen birds from the road surface. As a check on the trend in the population survey data, each year from 1995 on I spent the week following the annul survey driving to sites used predictably by plovers for brood rearing 1990-1994. These sites especially included windmill/water tank sites characterized by extensive cattle use and no increased soil moisture due to the tank leaking. The survey efforts only rarely located a plover with chicks.

In 2002, I aggressively searched many areas that contained good breeding populations of plover in the early 1990s. Those included Willow, Reno, Allenbaugh, Jackpot, Yearling, South, Halter, Sand, and Keota Steer, plus areas not burned in Vivian, Wildhorse, Raven, Keota, and East Keota. Few birds were located. Most notable, 2002 was the first year since 1990 not to have at least one nest in ▪plover alley• in the Center allotment. The 3 nests found off the burn in Keota included 2 on a prairie dog town and one in a buffalo (*Bison bison*) wallow; no nests were in undisturbed prairie.

Besides nest searches, I surveyed for broods at stock tanks and other historical brood-rearing areas in each of these allotments and was unable to locate any plover broods.

The Breeding Biology Studies, 1992-1994

Background

Concurrent with the development of the population survey protocol for the Mountain Plover on the PNG, I had discussions with many folks within the USFS regarding the need to revisit the breeding biology of the species relative to the findings of Dr. Graul and the apparent subsequent population decline. Mr. Larry Mullen of Region 2 was highly receptive and agreed to send $40,000 to the Arapaho-Roosevelt Forest (ARNF) for the studies. Those funds were redirected at ARNF to the PNG district to begin their own grassland-wide survey. Mr. Mullen then sent a second allotment of $40,000 to the ARNF for transfer to the FWS (my sponsoring agency at that time) for the breeding biology studies in 1992. This administrative process repeated the following two breeding seasons, 1993 and 1994.

Field Efforts

I focused the 1992 breeding season on learning plover behavior, refining nest location skills, perfecting plover capture techniques, photographing microhabitats of nest locations, and acquiring preliminary data on nesting success of plover on the PNG. Dr. Brian Miller assisted in these studies and we employed radio-telemetry to track growth and survivial rates of juvenile plovers. The results of those studies have been presented in two publications (Miller, B.J. and F.L. Knopf. Growth and survival of Mountain Plovers. *Journal of Field Ornithology* 64:500-506, 65:193, 1993; and Knopf, F.L. and B.J. Miller. *Charadrius montanus*—montane, grassland or bare-ground plover? *Auk* 111:504-506, 1994), and being peer-reviewed and published those data are attached as PDF copies. The significant findings reported therein were:

1/ Plovers tended to put nests in half-meter patches that had a minimum of 30% bare ground and a dried pile of cow manure; they tended to avoid the

immediate proximity of a prickly pear cactus relative to the surrounding vegetative cover.

2/ Nest success rates of plovers in 1992 appeared comparable to those reported earlier by Dr. Graul.

3/ Juvenile plovers weights increased logarithmically with age. Chicks that were generally born at 10g fledged at approximately 70g in about 36 days. Thus, chicks fledged at approximately 70% or less of adult weights.

4/ Egg and chick mortalities were due primarily to mammalian predation, with swift foxes (*Vulpes velox*) having the major impact on both. Additional egg predators likely were badgers (*Taxidea taxus*) and stripped skunks (*Mephitis mephitis*).

5/ Of the eggs hatching, daily survival rates of chicks was 0.979 across the 36 days resulting in an average 1.2 chicks surviving to fledging.

6/ Post-fledging monitoring revealed a 0.974 daily survival rate that ultimately resulted in 0.7 chicks/nesting attempt leaving the study area, or 1.4 chicks/pair of breeding birds.

With the assistance of Mr. Jeffery Rupert, I continued the telemetry studies in 1993 and 1994. In 1993, I focused efforts on the Crow Valley Unit of the PNG. In 1994, I chose to spend a majority of the season in the Keota and Owens allotments of the Pawnee Unit. The primary objective of those studies was to determine the minimum area of habitat required for a plover to raise a brood of chicks. Results were peer-reviewed and published (Knopf, F.L. and J.R. Rupert. Reproduction and movements of Mountain Plovers breeding in Colorado. *Wilson Bulletin* 108:28-35, 1996) and a PDF of that paper is also attached. Significant findings of that study included:

1/ Predation rates of eggs during 1993 and 1994, were higher than previously reported with only 26% and 37% of nests being successful, respectively.

2/ Survival rates of chicks (0.957 and 0.951, respectively) were lower during 1993 and 1994, due to higher predation rates.

3/ Brood-rearing area ranged from 28 to 91 ha, averaging 56.6 ha, or approximately 140 acres.

4/ Plovers tended to move chicks to areas of heavy cattle activity:

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Where chicks foraged on the higher densities of invertebrates:

(© f. l. knopf)

5/ Most of the breeding birds left the PNG in late July, with subsequent sightings on the PNG apparently being post-breeding birds from other areas.

A satellite effort during the 1994 studies included the monitoring of plover activities on one boundary of the PNG that bordered an agricultural field that was planted to Conservation Reserve Grasses in May of that year. This site was a private field on the north of, and surrounded by, the Owens Allotment. Those results were peer-reviewed/published also (Knopf, F.L. and J.R. Rupert. The use of crop fields by breeding Mountain Plovers. *Studies in Avian Biology* 19:81-86, 1999; attached as PDF) and revealed that:

1/ Plovers used the PNG and contiguous field similarly during courtship and nest initiation.
2/ Cultivation of the field in early May resulted in intensive new courtship activity on the field, likely due to destruction of existing nests combined with enhanced attractiveness of the newly cultivated site to additional plovers.
3/ Cultivated fields may represent an ecological 'trap' for breeding plovers, stated as a speculation.

Incidental monitoring in following years revealed that plovers in the PNG area do successfully hatch eggs in the warm-season crop plantings even though those crops often reach knee-high by hatch date. A subsequent study by Dr. Victoria Dreitz (Dreitz, V.D. and F.L. Knopf. 2007. Mountain Plovers and the politics of research on private lands. *BioScience* 57:681-687, 2007) went on to test the speculation from the earlier study. The later study identified cultivated fields as preferred over native prairies by breeding Mountain Plovers in eastern Colorado, and with comparable nesting success. Preliminary findings of Dr. Dreitz' studies were one critical input to the decision by the FWS to

withdraw their proposal to list the plover as Threatened under the Endangered Species Act (U.S. Fish and Wildlife Service. *Federal Register* 68[174]:53083-53101. 2003.)

The PNG Burn Program for Mountain Plover

(Photo courtesy of *The Coloradoan*)

Origin of the Burn Program

During studies of Mountain Plovers in the vicinity of the Pixley National Wildlife Refuge (Tulare County) California during the winter of 1992-1993, we were fortunate to find a recently burned patch of grassland where plovers returned each evening to roost. That burn was either accidental or arson, but certainly not a planned management activity. Based upon our success in locating plovers there, we were able to capture birds to attach radio transmitters. The following year I requested the assistance of US Bureau of Land Management biologist, Sam Fitton, in conducting two early autumn burns in the Carrizo Plain (San Luis Obispo County) just prior to our arrival to initiate telemetry studies of habitat use on the Carrizo. Those burning efforts were highly successful in attracting plovers and became critical to our ability to find and capture individual birds.

Seeing the plover response to burns in California, in 1993, I inquired of the PNG Rangeland Ecologist, Robert Anderson, if the PNG had ever conducted any burning programs in the past. He grinned and responded that nobody "had ever given PNG a reason to burn". I mentioned the plover response in California and Bob became genuinely intrigued by the idea of burning (which is a management mainstay in prairie conservation) on the PNG. The PNG conducted its first experimental burning the following year, 1994, when the bottoms of 3 small drainages in the north pasture of the Wildhorse Allotment, T 9 N, R 63 W, Section 32, were burned. One of those drainages had plovers in it each year, 1990-1993, another had an occasional bird, and the third had not had a plover seen in it. These 3 burns were respectfully east-to-west in alignment totaled 90 acres. Plovers were seen in all three burns that year. This result instilled enthusiasm for implementing a burn program to create/enhance plover breeding habitat beginning in 1995. To my knowledge, this was the first burn program implemented in short grass prairie landscapes in Colorado (and possibly within the entire ecosystem).

Biological Rationale for a Burn Program

Our 1991-1994 studies of Mountain Plovers on the PNG had demonstrated some consistency in nesting locations of birds across years. I speculated that plovers tended to return to the same site to breed in subsequent years (which we confirmed with banding studies from many locales in subsequent years). Such "site fidelity" is commonly noted across ornithology. When birds return and the habitat is not available, they will move to alternate locales. Spring burning thus came to be considered a valid tool to reduce standing vegetation just prior to the arrival of the breeding plover population in hopes of attracting more birds to assure a continued plover presence on the PNG until that time when the habitat 'recovered' from the wet spring of 1995.

Summary of PNG burns from 1994 through 2006

Following the experimental burns of 1994, PNG burned almost a full section (250ha) in 1995 and again in 1996 on the Wildhorse Allotment (R63W, T8N, Section 7). The SE corner of the section just across CR 94 from the Range Rider's house was not burned. I recorded a minimum of 50 and possibly up to 100 plovers on that section during a May visit in 1996. Funding constraints did not permit the actual monitoring of plover breeding efforts on that burn in either year. My records reveal that the PNG burned the following acreages (English, not metric, measure as provided by PNG) for plovers from 1995-2006:

Year	**Grazing Allotment(s)**	**Total Acres Burned**
1995	Wildhorse	620
1996	Wildhorse	620
1997	Coal	640
1998	Vivian	640
1999	Coal, E. Keota, Jackpot, Owl, Wildhorse	1310
2000	Halter, Keota	1300
2001	Coal, Halter	1280
2002	E. Keota, Geary, Keota, Vivian, Wildhorse, Yearling	2800
2003	Halter	40
2004	Buttes, Center, Murphy, Simmons, South, W. Stoneham Wharton-Fuss	5540
2005	E. Stoneham, Geary, Gunn, Halter, Klingensmith, Nicklas, Vivan	3640
2006	Center, E. Stoneham, Elliot, Horsetail, Howard, Jackpot, Keota, South, W. Willow, Yearling	5871

The collective burns over the 12-year period totaled 9,486ha. The burn of only 16ha in 2003 was due to severe drought in the summer of 2002 that left little residual vegetation in the spring of 2003. That small 2003 burn was to assure continuation of the rangeland response study being conducted at that time by Dr. Daniel Milchunas of CSU. Burning was conducted for the 2007 breeding season but funds were not available for the monitoring effort.

Mountain Plover Responses to the Burn Program

Whereas the burn program was originated to attract Mountain Plover to the PNG, in later years the selection of burn sites was based also on broader objectives of ecosystem health. Thus, some burn sites had no recent history of plover use and did not have the wide-vista topography generally favored by plovers, and plovers did not respond well to those burns.

I lacked funding to track the 1995 through 1997 burn efficacy for plovers in other than a casual manner. Each year thereafter, I surveyed each experimental burn for breeding plovers during the latter part of April to familiarize myself with the burn and record use by migrating/incoming plovers. I then conducted a thorough survey of each burn between 4-11 May to identify burns with breeding plovers. Those burns with plovers present were subsequently visited 3-6 additional times during mid May and early June to follow nest success and search for additional nests. All burns were then again surveyed 13-17 June to search for nests and for plover broods (when birds are more visible). This second round of searches was especially undertaken to confirm lack of plover breeding on those burns where no plover activity was seen in the early May surveys.

> **The 1998 Burn.--** The burn of the Vivan Allotment was very successful in attracting plover with a minimum of 29 nest attempts. A few of those nests were on the east side of the allotment, but 22 were on the NW quarter, which is a high, flat, and open landscape. One nest was

abandoned, and 27 of the remaining 28 were predated after two swift fox families moved on to the burn. This was the only year that I saw excessive nest predation on a burn vs. native grassland or prairie-dog habitats.

The 1999 Burn.-- The 1999 burn effort included one section in E. Keota, and 4 burns of 160 acres each. A total of 16 nests were located on burns, 13 of which were on the East Keota, 2 on the Allenbaugh, and 1 on the Owl allotments. An additional 20 nests were located in rangeland and 10 on prairie dog towns in Keota and Owl allotments. Because of the small area of prairie dog towns, and large area of grasslands, the actual densities of breeding plovers per habitat would show plovers most dense on prairie dog towns, less dense on burns, and least dense on grasslands.

Of the nests on each habitat-type, 8 of 16 survived until at least one egg hatched on the burns, 1 of 20 on the grassland, and 6 of 10 on the prairie-dog towns. Five of the 9 nests on the Owl prairie dog town were successful. Whereas only one of the 29 nests on the Vivian burn in 1998 was successful, the burns actually had good nest success in 1999. As each site was picked in hopes of avoiding swift foxes, the success on burns increased measurably this year.

Among burns, only 3 nests were located on the four quarter-section burns compared to 13 on the full-section East Keota burn. Whereas each of the smaller burns attracted plovers during migration, the larger burn was more effective in attracting plovers to breed.

The 2000 Burns.-- I requested sites for the 2000 burns that had no history of plovers nesting (Keota Steer Allotment) or looked too rolling as far as the landscape (Halter Allotment) even though I had seen breeding plovers there in past surveys. Like 1999, each burn was used by plovers during

migration. Plovers did not nest on the Keota Steer burn, which surprised me as the high plateau area burned is a very predictable site where post-breeding birds congregate. A total of 6 nests were found in the rolling landscape of the Halter burn; 4 of the 6 nests were successful. The conclusions I drew from the 2000 management burns was that burns need to be located in allotments with a previous history of use by plovers for nesting.

Besides the planned burns, two additional burns were monitored in 2000: one of about 13 acres started by a lightning strike in the north end of the Coal Allotment and the other of about 80 acres (ignited by a discarded cigarette along Colorado Highway 14) in the Jones Allotment. The relatively small, short grass Coal burn ultimately had 8 nests, and may have had at least one more as I saw an un-banded adult with a freshly hatched chick on it in early June. Only 3 of the 8 nests were successful on this burn, which does not surprise me due to the annual high use of this area by foxes.

The pre-burn vegetation on the Jones Allotment was mostly cool-season bunch grasses more than knee tall that left a very blackened surface with a lot of bare ground. Six of 12 nests on the Jones Burn were successful. Two of the 6 unsuccessful nests were abandoned and subsequently destroyed by hail. The successful nests were mostly on the southern half of this burn, closer to Charlie Jones' buildings than to Colorado Highway 14. The vegetation was quite tall as chicks were growing on this burn, the site being mostly bunch grasses rather than short grasses. The contiguous areas were taller grasses also but with rank previous season litter (actually supporting Grasshopper Sparrows [*Ammodramus savannarum*]) and plovers were thus forced to stay on the burn site until chicks fledged. The nest density on these two burn sites was markedly the highest I ever saw on the PNG. The Jones burn provided additional insight into what

constitutes attractive habitat for plovers: burning of taller, non-matted vegetation results in a much cleaner, blacker burn with lots of exposed bare ground that is more attractive to plovers than a blue grama or buffalograss site that tends toward matted vegetation and has trouble carrying a fire due to lack of fuel.

The 2001 Burns.-- I was only able to locate 19 nests on the PNG in 2001. That number compared to ~50 in any given year in the early 1990s. The 19 nests were very widely scattered with 8 in Owens, 3 in Coal, 2 in Keota, 2 in East Keota, 2 in Center, and one each in Allenbaugh and Owl allotments. Of these, 7 nests (37%) were successful and 12 (63%) were predated, this being lower than the usual ~50% success rate, but typical of grassland nesting birds in general. Dr. Susan Skagen of the US Geological Survey reported a similar rate of 35% success for Lark Buntings (*Calamospiza melanocorys*) on the PNG in 2001.

During the surveys, I was able to locate many nests more easily on tilled fields. I easily spotted 16 nests near roads. That information was provided to the Colorado Farm Bureau/FWS/CDOW cooperative effort documenting success on tilled ground vs. rangelands. Of comparative interest for the Pawnee Grasslands, however, 10 (62%) of the 16 agricultural-field nests were successful. Of the others, one was destroyed by farm machinery and 3 would have been destroyed by machinery if they hadn't been flagged. Only 2 (13%) were predated.

Compared to rangeland and agricultural nesting areas, plover response to the 2001 burns was very poor. Three migrating plovers were spotted on the Halter Burn, but no birds nested there. Migrating plovers peaked with 25 birds on the Coal Burn on 10 April. Three courting pairs and 2 singles were on that burn on 25 April, one pair on 28 April. Eventually, 2 nests were found on the burn, both were predated just before hatching in June.

Basically, both burns were in areas where I did not have a recent history of plover use.

The 2002 Burns.-- Going into the 2002 season Mark Ball (PNG District Wildlife Biologist) and I treated den sites of Swift Fox on burns in attempt to encourage foxes to relocate dens away from burns. Treatment included dropping moth balls into fox dens that appeared on burns. My impression is that the effort was not successful in reducing fox predation on plover eggs or chicks. At least two fox litters were subsequently seen in ♣treated♠ dens. One treated den on the Geary that had active pups was within just a few meters of a plover nest. That nest was eventually lost to predation.

I noted a general lack of plover response to the Vivian burn and only a mild plover response to the Wildhorse burn. Such is disconcerting in that we had an excellent response to the initial burn of the Wildhorse section in 1996 (which I lacked funding to quantify at that time), and the Vivan burn in 1998 (29 nests on the section in 1998 vs. only 2 this year.) Of the other Crow Valley burns, I found one nest on the Raven, 3 on the Geary, and none on the Yearling allotments.

In contrast to the Crow Valley numbers, the excellent response to the East Keota burn in 1999 (13 nests) and again in 2000 with 15 nests plus the phenomenal response to the Keota burn (24 nests) where I had not found plover nests since 1990 attest to (1) the apparent decline in plover use of the Crow Valley side of the Grassland and (2) the Keota area continuing to be the primary area attractive to plover on the Grassland. This conclusion follows Walt Graul♣s statement that the Keota area provided the best plover habitat in the late 1960s and early 1970s.

Of the 50 nests that I found on burns, 27 (54%) were successful. I attribute this more 'normal' success to the drought creating less favorable conditions for mammalian predators to find nests by olfactory cues. The rate of nest abandonment, however, was more than twice (12%) the normal (5%).

In comparison, I was able to locate 13 nests on native prairie sites. These included 6 nests in the Owens, 3 in the Keota, 2 in the Coal, and 1 nest each in the Owl and Raven allotments. The Owl and two of the Keota nests were in prairie-dog towns. Of these nests, 9 (69%) were successful. Two were predated and 2 were abandoned. There was also at least one additional nest (in Allenbaugh) that I did not find, but I did see the young brood near the large buffalo wallow just SW of CR 45 and 122. This latter bird may have nested on bare ground within the wallow as this was the first year that I found nests (one each in Raven and Keota) actually located within (dry) wallows.

The 2003 Burn.-- The early spring burn program was cut back drastically in 2003 due to the 2002 drought. As mentioned earlier, the primary PNG purpose (per Steve Curry, PNG District Supervisor) was to continue the vegetation-response monitoring being done by Dr. Dan Milchunas of CSU and to assure that the burn program continued as an active management activity on the Grassland. The 16ha burned were not in good potential habitat for plovers due to the rolling nature of the terrain. Periodic surveys of the burn failed to reveal any plover use (migrants or nesters) on the site.

With a nest-searching effort consistent with previous seasons, I was able to locate 14 nests on native prairie sites. These nests included 8 in the East Keota, 2 each in Wildhorse and Owens, and 1 each in Coal (near the Wildhorse windmill) and Keota allotments. Ten (71%) were successful; the other 4 were predated. Surprisingly, all nests that were predated were

in E. Keota. I had no predations in other allotments. The nest success rate was the highest ever seen, indicating a possible decline in predator populations or in predation efficacy during the 2002 drought. Besides these nests, I had 3 additional birds show up with newly hatched chicks. I knew 2 of these birds had nests in Wildhorse but I never could find them. The other brood appeared in E. Keota.

I searched many additional areas that contained many birds in the early 1990s. These included Willow, Reno, Allenbaugh, Jackpot, Yearling, South, Halter, Sand, and Keota Steer allotments, plus areas not burned in Vivian, Wildhorse, Raven, Keota, and East Keota allotments. For the second straight year since 1990, I did not have a single nest (or plover) in Mark Ball's old "plover alley" of the Center allotment.

No nests were located on the Crow Valley Unit prairie-dog towns in 2003, but 12 nests were found on prairie-dog towns in the Pawnee Unit. These included 1 in each of the Simmons and Box allotments, and 10 in West Stoneham Allotment. Of these nests, 7 (58%) were successful, 2 (17%) were predated, and 3 (25%) failed from unknown reasons. The 2 nests that were predated were located in the West Stoneham prairie-dog town. Coyotes, badgers, and foxes, were potential predators observed in the area during plover surveys. Besides these numbers, 1 additional brood was observed on the prairie-dog town in Simmons and 5 additional broods in West Stoneham.

In addition to the 14 nests found on native grasses and 12 found on prairie-dog towns of the Grassland, an additional 26 nests were located on private lands (22 on agricultural fields, 4 on prairie) bordering the PNG. The private land work was coordinated with Dr. Dreitz, then a Postdoctoral Fellow at CSU. Of the 22 nests on agricultural fields, 9 (41%) were successful, 5 (23%) failed, and final outcomes of the remaining 8 (37%)

were unknown. The high number of unknown outcomes was a result of the weather as wet conditions hindered access to private lands in order to check the status of nests. In most of the areas of the unknown-outcome nests, some adults with chicks were observed at a later date.

The 2004 Burns.-- The number of nests on the 2004 burns included minimums of 8 nests on Murphy, 5 on Center, 3 on South, 1 on Simmons, and none on Buttes or Wharton Fuss allotments. On the two most successful burns, most nests were on the north section of the Murphy burn and west side of the Center burn (especially in the long, broad draw that ends at the stock tank). Of the nests on burns, 11 (69%) were successful, 5 were predated, and 1 nest outcome was unknown.

The large number and collective coverage of burns compromised my time available to survey extensively for plover nests off burns. However, during the course of the summer I was able to confirm 2 nests on the Owl (prairie-dog town), 3 in Wildhorse, and 1 in Elliot allotments. Four (66%) of those nests were successful. Working independently, Dr. Dreitz, now of CDOW, found 15 additional nests in the West Stoneham prairie-dog town.

The mid-April date of the 2004 burns led to fast green-up and a very short window of blackened landscape to attract birds. Thus, I believe the plover response was probably less than in previous years when burns have been traditionally conducted in February.

The 2005 Burns.-- In 2005, I was only able to locate 4 plover nests on the experimental burns vs. 21 in native prairie and 15 on prairie-dog towns. Plover nests on burns included 2 in the Halter and 1 each in the Geary and Nicholas allotments. Of the 40 nests, eggs hatched in 27 (68%), 8 were predated, 4 were abandoned, and one was flooded during

the Memorial Day weekend rains, being in the bottom of a buffalo wallow in West Stoneham Allotment. Breaking down the nesting success information, 12 of 21 (57%) nests were successful in native rangelands, 12 of 15 (81%) were successful in prairie-dog sites, and 3 of 4 (75%) were successful on the burns.

Despite the greatest plover nest success being on prairie-dog towns, most dog towns did not host plovers. In fact, plovers preferred just 3 towns of any size: the West Stoneham, Sand, and Keota allotments in that order. I did not survey the Sand Allotment towns for nests given that prairie-dog researchers from CSU were present almost daily when I needed to run nest searches. The south side of East Keota, west end of Owens, and southwestern-most section of Wildhorse allotments (previously burned in two years) continued to be the most predictable rangeland plover habitats on PNG.

The 2006 Burns.-- Migrating plovers were seen on all burns except Yearling Allotment during April visits. I noted in April that grasshopper numbers seemed especially high on Horsetail and West Willow allotments during those visits.

A total of 17 nests were located on burns during the 2006 season: 6 on West Willow, 4 on Horsetail, 3 each on Keota, and 1 on each of East Stoneham, Howard, South and Yearling allotments. No nesting was documented on Center, Elliot, or Jackpot allotments. Of the 17 nests on burns, 5 (29%) were successful, 11 (65%) were predated and 1 was abandoned.

Due to the extensive coerage of burns across 10 distant parcels, little time was available to search for plovers in rangeland or prairie-dog landscapes. Opportunistic searches of a few sites were done midday after completion

of searching burns. Two additional nests were located on rangeland in East Keota Allotment and 3 each on prairie-dog towns in Keota and West Stoneham allotments. Both of the East Keota nests were predated and only 1 of the Keota nests was successful, the other two being predated during CSU prairie-dog trapping activities on the site. All 3 nests on West Stoneham Allotment (prairie-dog site) were successful.

The Mountain Plover Population on Pawnee National Grassland

Besides the intent of providing a detailed record of my years of Mountain Plover research on PNG, my three cooperators were especially interested in my thoughts as to why the plover population 'crashed' on the PNG since 1990. No single question has plagued me more than this one while researching what a Mountain Plover is ecologically, and how the PNG environment has changed to (1) become unattractive to plovers looking for breeding habitats, (2) become unable to support that population through a breeding season, or (3) lead to reduced reproductive success or non-breeding season survival of the population to levels unsustainable across recent (54 years of USFS management) time. The following statements summarize my thoughts at present, and surely will be subject to revision given future research by my active coworkers and other ploverologists.

I note in beginning that whereas many of my speculations herein are based upon over 20 years of thinking about plovers on the PNG, major insights influencing my thoughts come from other regions of the plover range. Whereas local studies often look at where a species *is* versus *is not* in a landscape, seeing a species in all of its haunts at a range-wide scale drastically facilitates the process of looking for what is common, or at least similar, among sites. I have made every attempt over the last 15 years to pursue plovers at all possible sites of known, current presence. These include spring studies in Nuevo Leon, San Luis Potosi, and Zacatecas, Mexico, New Mexico, Colorado, Utah, Wyoming, and Montana. Whereas many of my observations have been made somewhat autonomously, many more were shared with, and the product of research efforts by, my coworkers. I would be uncomfortable if I failed to specifically acknowledge Mr. Jeff Rupert for his two years of assistance on the PNG and another two full wintering seasons in San Luis Obispo and Tulare counties, California. Jeff also was logistically instrumental to my Mexican studies. Steve Dinsmore has researched the population ecology of plovers in Montana since 1991, and those state-of-the-art studies have continued through 2008. Mike Wunder's insights from his work in Park County, Colorado, and both initiated-and-

supervised studies in Imperial County, California, Texas and Mexico, have been very enlightening as have the insights gained from his work across all projects using stable isotope technology to provide regional- and continent-level perspectives on plover ecology. Both Steve and Mike used aspects of our collaborative work to fulfill requirements for the doctoral degree at CSU. Dr. Victoria Dreitz was equally exemplary in conducting studies of agricultural land issues relative to plovers, initially through a post-doctoral fellowship at CSU and in her current position as Grassland Bird Researcher for CDOW. Her studies have been critical to securing the future of the plover on the eastern plains. In addition, Regan Plumb applied two years of extensive plover surveys in Wyoming towards her MS Degree at the University of Wyoming. Regan's surveys were fundamental to defining and quantifying the Wyoming population for the first time. Finally, almost countless field technicians joined our collaborative research with three: Aaron Brees, Martin Margulies, and Chris Mettenbrink deserving special praise for their multiple years of dedicated contribution to both the plover and the research program. Citations to those additional studies (as of 2006) are available in the Mountain Plover account within the *Birds of North America* available on-line as (Knopf, F.L. and M.B. Wunder. *The Birds of North America Online*. [A. Poole, Ed.] Ithaca: Cornell Laboratory of Ornithology. 2006. http://bna.birds.cornell.edu/BNA/account/Mountain Plover/.) Paying tribute to these great peers, I must acknowledge that whereas the following thoughts benefited from our mutual research program the speculations and interpretations are mine alone and may not necessarily infer their individual or collective concurrence.

What was the Historical Plover Population in Weld County?

The Mountain Plover was first collected by John Kirk Townsend, zoologist on the Wyeth Expedition of 1834, in the arid uplands along the Sweetwater River of central Wyoming. Townsend noted that the plover was collected near the continental divide (South Pass vicinity) and the specimen and notes were sent (via ship) from Astoria, Oregon, back to the Philadelphia Academy of Sciences. This and other specimens collected by Townsend resulted in a delay of the final volume of John James Audubon's *Birds of North America* as Audubon labored to classify, name, and paint the new material coming in from

landscapes he had never seen. Thus, Audubon named the plover the Rocky Mountain Plover and painted it in an alpine landscape based upon Townsend's description of it being near the Divide.

As a product of our collective studies of the species range-wide, I am of the opinion that this species--unlike previous accounts (e.g., R.M. Mengel. The North American central plains as an isolating agent in bird speciation. Pp. 280–340 *in Pleistocene and recent environments of the central Great Plains* (W. Dort and J. K. Jones, eds.). Univ. of Kansas Press, Lawrence. 1970) identifying the Mountain Plover as a grassland species--is an ecological associate of xeric uplands typical of central and western Wyoming, South Park, northern New Mexico, and Mexico during the breeding season. Some plovers breed eastward onto the prairies where either poor soils fail to support sod development of the grasses or intensive disturbance of that sod results in areas of bare ground and some shrub incursion. The historical, intensive grazing of prairies from northern Texas to Montana provided much habitat for the species with accounts of one buffalo hunter killing 200 in an hour near Dodge City (M. Sandoz. *The Buffalo Hunters.* Hasting House. New York, 1954).

Records of the Mountain Plover in the Weld County vicinity are unfortunately lacking for this early exploration period. John Charles Fremont's expeditions (Fremont, J.D. *Report of the Exploring Expedition to the Rocky Mountains in the year 1842, and to Oregon and North California in the Years 1843-1844.* US Army Topograpical Engineers [1845], reprinted by Smithsonian Institution Press, Washington, D.C. [1988]) along the South Platte during the early 1840's provided insights into the potential plover landscape in some passing notes in his journals. First, Fremont mentioned the problems with prickly pear giving problems to the horses' feet along the main Platte and South Platte rivers of Nebraska and Colorado. Prickly pear is not a species of sod prairie, but of bare soils or a broken turf. Also, Fremont mentions a buffalo herd to every horizon once the expedition left the Forks of the Platte almost to the site of modern daily Greeley as he ascended the South Platte. At Fremont's Orchard (now Orchard) he mentions buffalo so thick that they strolled into camp at night and spooked the expedition's horses. Each of these

passing statements describes an ecosystem intensively grazed by large herds of bison, at least seasonally.

Although bison moved across the landscape at some debatable scale, they may not have been strictly summer residents in Weld County. During the winter of 1811-1812, the Astorians journeyed overland from the mouth of the Columbia River (where they had arrived by boat financed by John Astor of Boston) to Independence, Missouri, charting what was ultimately to become the Oregon Trail. Upon entering western, modern-day Nebraska, they were forced to retreat back upstream along the North Fork of the Platte to the vicinity of modern-day Torrington, Wyoming, to winter. The wintering site was selected based upon that locale being the eastern edge of the wintering bison herds, upon which they were dependent for food (P.A. Rollins. *The discovery of the Oregon Trail.* University of Nebraska Press. 1995). This observation implies that bison were in the Platte Headwaters throughout the year, and coupled with the high numbers of very large 'wallows' still visible in the Keota area especially, argues for a historically heavily grazed short grass prairie in Weld County. An account summarizing Luke Voorhees' (Wyoming Territorial Treasurer) writings is telling:

> "During the spring and summer of 1859 he made a trip across the country from the South Platte to Pawnee Buttes near where the town of Kimball, Nebraska, now stands, and as far north as he traveled, his way was through one vast herd. To estimate or comprehend the number of animals would have been entirely futile; he had traveled more than two hundred miles with buffalo on all sides as far as the eye could see, and to say there were millions of them would not adequately express the sight. He pursued his journey from Pawnee Buttes to some pine-covered bluffs, now called Pine Bluffs, and from that eminence he observed that the entire country east, west, and north from where he stood on the bright, clear day in August, 1859, was one brown-colored carpet of buffalo cows and calves, the bulls evidently being farther north. The very old bulls of the herds were usually found in the rear." (from Voorhees, L. *Personal recollections of pioneer life on mountains and plains of the Great West.* Cheyenne, 1920; as cited

in: Garretson, M.S. *The American Bison.* New York Zoological Society. New York. 1938.)

The intensive historical grazing is further supported in knowing that black-tailed prairie dogs were also a part of this landscape. Extensive prairie-dog towns existed between Cheyenne and Greeley (I.L. Bird. *A lady's Life in the Rocky Mountains*. University Oklahoma Press. 1960), and likey across eastern Colorado as the species was recorded as abundant from western Oklahoma by Washington Irving (*A Tour on the Prairies*, University of Oklahoma Press, 1956) and S. W. Woodhouse (Tomer, J.S. and M. J. Brodhead [eds.]. *A Naturalist in Indian Territory, The Journals of S.W. Woodhouse, 1849-1859.* University Oklahoma Press. 1992) to the Upper Missouri River as reported by F.V. Hayden (as cited to G.K. Warren [1858] in R.D. Dorn. *The Wyoming Landscape, 1805-1878.* Mountain West Publishing, Cheyenne. 1986) and as far east as Omaha (where Lewis and Clark collected the first specimen in and shipped it back to Thomas Jefferson) and Wichita, Kansas, vicinity as mentioned by Thomas Say in 1820 (H.E. Evans. *The Natural History of the Long Expedition to the Rocky Mountains, 1819-1820.* Oxford University Press. 1997). Thus, the prairie-dog was surely a significant component of the Weld County grazing assemblage prior to the arrival of immigrants from eastern states. An historic black-footed ferret (*Mustela nigripes*) skull was recovered in a prairie-dog digging on the PNG in the middle 1980s (Dean Biggins, personal communication).

Given the historical reference to large herds of bison in the Platte Headwaters and a prairie-dog herbivore as an additional grazing driver in the short grass landscape, I speculate that Mountain Plovers were rather ubiquitous across the uplands of Weld County at the time of Euro-American Settlement of the region.

What Was the Consequence of Euro-American Settlement, 1850-1930?

As difficult it is to speculate on the pre Euro-American population levels of plover in Weld County, I find it a somewhat easier task to speculate on how the plover responded

to the changes in land use that came with fencing of grazers and plowing of the sod. With the progressive, rapid expansion of the railroad westward across Kansas, entrepreneurial hide hunters had a means for shipping the heavy hides east. The resulting slaughter of bison for profit surely foreshadowed a rapid decline in the continental plover population. As the bison were extirpated from the landscape from the "Black Prairie" of Texas to the Powder River County of Montana, taller grasses flourished and shaded out the short grasses to the point of being able to harvest hay (D.J. Blakesley. Persistence and change in the natural and cultural landscapes of the Central Plains. *Transactions of the Kansas Academy of Science* 99:86-94, 1996; R.H. Hart. Where the buffalo roamed—or did they? *Great Plains Research* 11:83-102, 2001.). Such was a perfect progression for domesticating the wild lands of the central parts of the country with cattle.

Watching bison graze I have often been fascinated with the long tongue that sweeps up grass stems and rhizomes and rips them into the mouth, much in contrast to cattle which use the tongue less extensively and actually tend to "bite" more. I hypothesize that bison grazing results in taller, shallower-rooted grasses being ripped from the ground roots and all whereas buffalo grass and blue grama have a deep root system that results in only the above ground portions of the plant being taken, thus allowing the plant to follow grazing with rapid vegetative re-growth. Dr. Milchunas (personal communication) describes the difference as 90% of the biomass above vs. below ground for the two groups of grass.

Specific historical data on changes in the grass species assemblage with the removal of bison in Weld County are obviously lacking. The large ranching operation of John Wesley Illiff beginning in 1861, resulted in an obvious transition of the county from a short grass prairie towards one with increasing percentages of taller grass species. The last bison was recorded in the area in 1864, the year of the Sand Creek Massacre. The enactment of the Homestead Act of 1862, did not have an immediate impact on Weld County, which was still remote to the Euro-American population push. Illiff immediately had his hired hands 'homestead' parcels including all water sources in the multi-county area. Iliff secured these 'homesteads' from public access with the invention of barb wire in the mid 1870s.

Cattle don't forage as far from water as bison. Thus, not only did the taller grasses surely continue to flourish in the absence of the bison after 1864, but also in locales distant from water experiencing no grazing at all. Such transition from the native-ungulate grazer to the domesticated grazer would have precipitated a slow decline from historical plover numbers. The status of the prairie dog at this time is unknown, but plague had not yet arrived on the landscape and it is possible that a resident population of plovers became more and more limited to areas of prairie dog activities from 1861-1885.

In 1885, all fences were ordered removed from federal lands by Presidential order and, coupled two years later with the arrival of the railroad from Sterling to Cheyenne in 1887, homesteaders moved into Weld County rapidly. It was at this time that the towns of Stoneham, Raymer, Buckingham, Keota, and Grover sprung up along the tracks, primarily to ship cattle and grains. By 1918, the human population in the Keota area alone comprised ~1250 homesteads with the town itself being home to 140 people (http://www.fs.fed.us/r2/arnf/about/history/pawnee/index.shtml).

Armistice Day Parade, Keota, Colorado, 1921 (University of Northern Colorado Library)

Despite the likely decline in plover population with ranching after 1861, the conversion of rangelands to row crops beginning in the mid 1880s certainly reversed the trend. The 160-acre parcels on homesteads were entirely too small to be economically viable, and the intensive heavy grazing of pastures mixed with small fields tilled with historical farm equipment would have provided extensive breeding habitat for plover. I am of the opinion that homesteading through the 1920s most likely resulted in a substantial, growing plover population. The presence of plover in the county is only verifiable, however, through a search of egg collections in major museums of the United States (e.g., the Denver Museum of Nature and Science), such collections having specimens and egg sets (clutches) from Weld County from the late 1880s through the 1950s.

How Did the Dust Bowl Affect the Plover Population?

Plovers as a taxonomic group are species of bare ground and little vegetative cover. Snowy Plovers (*Charadrius alexandrinus*) breed on saline flats in Oklahoma and Utah, and Mountain Plovers prefer such flats in the Central Valley of California (F.L. Knopf and J.R. Rupert. Habits and habitats of Mountain Plovers in California. *Condor* 97:743-751, 1995). Other inland plovers like the Piping (*C. melodus*) and Semipalmated (*C. semipalmatus*), and the coastal Wilson's (*C. wilsonia*) are found on sandy beaches and mudflats (reference the individual species accounts in *The Birds of North America* at http://bna.birds.cornell.edu/bna). Given the importance of bare ground to breeding Mountain Plovers as identified by our continent-wide studies, the Dust Bowl provided extensive habitat for the species. In addition to the vast coverage of bare ground available to plovers, the lack of vegetation and seeds for small mammal foods likely decimated those populations in the area resulting in swift fox (as the primary plover egg and chick predator in Weld County) also occurring in very low numbers due to the lack of prey during the fall and winter. Thus, I am of the opinion that the plover in Weld County reached a population-numbers peak in the late 1930s, perhaps even exceeding historical population numbers.

What Has Been the Plover Response to 'Recovery' of the Prairie?

With the passing of the Bankhead-Jones Farm Tenant Act of 1937, the U.S. Soil Conservation Service (SCS) began purchasing marginal farmlands across the drought-striken West, including in Weld County. The Resettlement Administration began relocating families to better farming parcels outside the high plains and, following joint housing of the purchasing and resettlement programs within SCS, the human population of Weld County declined as the federal government became a major land owner in Weld County. The SCS aggressively seeded the broken land, primarily with the exotic crested wheatgrass (*Agropyron cristatum*). Surviving ranch families in the Keota and Briggsdale areas collaborated to form two grazing associations (the Pawnee and the Crow Valley) to oversee grazing of this created grassland and, with completion of the recovery period, the 'stabilized' SCS properties were administratively transferred to be managed by the USFS (working with the grazing associations) in 1954. That transfer was formalized with the formation of the National Grasslands within USFS in 1960.

Plovers select local patches of bare ground within a grass landscape for nest locations (F.L. Knopf and B. Miller. *Charadrius montanus*--montane, grassland, or bare-ground plover? Auk 111:504-506, 1994), and then move the precocial hatchlings to grass-forb (W.D. Graul. 1975. Breeding biology of the Mountain Plover. *Wilson Bulletin* 87: 6–31, 1975) or grass-shrub (S.C. Schneider et al. The relationship of shrubs and forage availability to Mountain Plovers in South Park, Colorado, USA. *Southwestern Naturalist* 51:197-202, 2005) ecotones where chicks are raised. AS seedings on the SCS properties began to die out, blue grama and buffalograss started to re-establish on the PNG. Over the period of 40-50 years, the short grasses slowly became sod-forming locally and the number of acres/hectares available to plovers for nesting and brood-rearing declined a bit more with each year's increase in the sod coverage. When local sodding of patches began blocking up portions of the landscape larger than the minimum brood-rearing

home range of approximately 26 ha, plover populations likely began to decline, the decline reflecting the more uniform, less destructive grazing by cattle vs. the larger, mobile bison herds and omnipresent prairie-dogs of the native ecosystem.

A photo-point comparison of the historical PNG landscape and contemporary landscape would be very enlightening. As previously noted, conversations with Steve Currey (District Supervisor) and Robert Anderson in 2004, revealed that historic photo-points are available. Although I do not have a series of photos to serve such a purpose between 1986 and 2008, I do have one site that I photographed in June 1986:

(© f. l. knopf)

That I was able to relocate in July 2008:

(© f. l. knopf)

The photographed site is in Section 6 of the Wildhorse Allotment (Latitude 40.69152 / Longitude 104.47606, looking northeast towards the windmill and lone cottonwood (*Populus sargentii)* in the south end of the Sand Allotment). Comparison of the two photos reveals that the windmill fell down in the interim and the grassy flat that contained a plover nest (just behind Dr. Sedgwick, which is why the truck had been backed up) transitioned into a woody community dominated by *Atriplex*. The vegetative changes make this site unattractive for nesting by plovers, being much more typical of brood-rearing habitats as those seen both on the PNG and elsewhere in the breeding range such as on Chapman Bench (Park County), Wyoming:

(© f. l. knopf)

Predator control was another human activity in Weld County that also influenced the Mountain Plover population through the middle part of the 20th century. I have been unable to locate a review of this subject that is specific to Weld County, or eastern Colorado in general. I'm unclear if specific records even exist on predator kills or the intensity of poisoning efforts, or if the consequences of either has been evaluated. Shooting of coyotes (*Canis latrans*) is a tradition within historical ranching communities. Biologists and ranchers would agree, however, that it is nearly impossible to eliminate coyote populations by shooting.

The baiting of predators with the chemicals strychnine and 1080 likely had a profound impact on predator populations: coyotes as the target, and swift foxes, badgers, and skunks as non-targets. With the banning of these chemicals in 1972, composition of the predator assemblage on the PNG changed. Whereas chemical baits reduced coyote populations, they surely reduced swift fox populations also. With the chemical bans,

only coyotes continued to be shot as swift foxes have never been considered a threat to the ranching industry. The combined result of no longer poisoning (as a non-target) foxes and continued shooting of the coyote (the major predator limiting fox populations) surely resulted in a rapidly increasing population of swift foxes on the PNG after 1972. Swift foxes are the major predator on plover eggs and the primary predator on plover chicks. Thus, the plover population incurred increased predation pressure by foxes (and badgers and skunks?) at the same time habitat quality was slowly declining on the PNG.

I am of the opinion (as that was what was requested herein) that the Mountain Plover population on the PNG began declining in the late 1940s or early 1950s due to ecological succession within the grass landscape and that the rate of decline increased with changes in the predator assemblage (and increases in Swift Fox numbers specifically) beginning in the 1970s. I believe that the population was already in decline during Dr. Graul's studies, 1969 through 1971. As evidence, I note that he reported nesting success of plovers very similar to that I was seeing in the early 1990s--the significance being that the nest success of ~50% that we were seeing is well below the annual nest success of 90% being recorded by Drs. Steve Dinsmore in Phillips County, Montana, and Michael Wunder in Park County, Colorado.

Why Did the Mountain Plover Population 'Crash' in 1995, and Why Hasn't It Recovered?

The first serious research of the Mountain Plover population on the PNG was conducted by Dr. Walt Graul beginning in 1969. Coauthoring with Lois Webster, he estimated a Weld County population of approximately 20,820 plovers as of 1976 (W.D. Graul and L.E. Webster. Breeding status of the Mountain Plover. *Condor* 78:265-267, 1976). With my first survey of the plover population on PNG in 1990, I detected 4.7 ± 1.2 birds/km^2, or a PNG population of approximately 3,502 plovers on the PNG specifically. The population fluctuated between 2 and 4 plover/km^2 through the early 1990s.

The very wet spring of 1995 resulted in hail destruction of eggs and extensive flooding of many nests, followed by a rapid flush of tall vegetation that left the PNG undesirable as plover nesting habitat. The nearly continuous moist soil conditions also surely increased egg and chick losses to olfactory-driven predators (primarily mammals) as predation events on eggs generally occur within 24 hours of a rainfall (Dinsmore, S.J. et al. Advanced techniques for modeling avian nest survival. *Ecology* 83:3476-3488, 2002.) The survey of the plover population in 1995 detected only 3 birds, down from 3.6 ± 0.4 birds/km^2 in 1994. Two of the birds were seen standing on County Road 103 in the Keota Allotment and one in Center Allotment. None of the birds had chicks.

The only chick I found in 1995 was an adult with a single chick about 7 days old in Reno Allotment on 6 June. I searched that allotment intensively that day and only found that one adult. Given the almost non-existence of plovers on PNG in late June, I spent 3-5 July visiting many locations where plovers predictably raised broods in previous years. Those sites were in the Reno, Wildhorse, Keota, and Owens allotments. I was unable to locate any plovers on the Grassland. On those same July searches, I was able to locate 16 adult plovers in 15 minutes on fallow fields along County Roads 95, 97, and 100 just west of Keota.

The residual vegetation from the very wet spring of 1995 was still standing when plovers arrived to breed in the subsequent years of 1996 and 1997. As a result, there was very little breeding habitat available for the arriving birds. With drying of the grassland those two years, the population started to recover in 1998, but then declined again with a very wet spring in 1999. The population has not recovered since that 1999 decline.

Following each population survey from 1999 on, I spent 3-5 days searching former locales where I predictably found plovers with chicks, 1990-1994. Most of these were around stock watering tanks that did not leak. I was unable to locate any plovers at these historically predictable brood-rearing sites, confirming the population crash in 1995. Also, during the 2002 breeding season, I hired Mr. Joe Fontaine, a graduate student at CSU with strong 'plover awareness', to independently search allotments where I routinely had plovers in the early 1990s. His hire was a test of my own abilities to find plovers. Joe was unable to locate any additional nests after my searches.

In addition to the above two "checks" on the annual survey that detected the 1995 population crash, I had the opportunity for an additional check by repeating the 'expanded' 1990 survey. The 1990 survey was the first intensive point survey of plover, but during that year I also recorded all other bird species seen at each point. The original intent was to try to identify other species on PNG that indicated either an increasing or decreasing likelihood of seeing a plover. That survey recorded 3 species on the PNG that occurred in large numbers and that might provide some insight into the likelihood of seeing a plover: the Horned Lark (*Erimophila alpestris*), Lark Bunting and McCown's Longspur (*Rhynchophanes mcconii*). As a result of that survey, I concluded that I had an increasing probability of finding a Mountain Plover if I was seeing Horned Larks (a bare-ground habitat species), and a decreasing probability of finding a breeding Mountain Plover if I was seeing Lark Buntings (a species of open shrub landscapes). McCown's Longspurs occurred across all habitats of the PNG, providing no information on the likelihood of seeing a plover. I subsequently used that set of observations (among others) in agency seminars over the following 15 years to assist biologists in evaluating potential plover habitat.

In early 2003, it occurred to me that the number of Horned Larks and Lark Buntings on the PNG may also have changed if, in fact, habitats did change following the wet spring of 1995, and then again in 1998. If the grassland had evolved towards more shrub and taller-herbaceous vegetation, I predicted that the Horned Lark population would have declined like the plover population and that the Lark Bunting population may have even increased. Thus, I repeated the 1990 counts of Horned Larks, Lark Buntings, and McCown's Longspurs during the 2003 plover survey. The major change in the avian assemblage across that 14-year period was the documented crash in the plover population (77 birds detected on 112 points in 1990 vs. 1 in 2003) and an explosion in the Lark Bunting population (219 birds in 1990 vs. 623 in 2003). The apparent increase in Lark Buntings supported conclusions that the PNG was continuing to be invaded by shrubs. In contrast, the number of Horned Larks remained comparable between years (315 in 1990 vs. 328 in 2003), indicating that Mountain Plover habitat was still present *at some scale* on the PNG despite the population decline in plover—at least following a severe drought year as seen in 2002. Obviously, the home-range spatial requirements of Horned Larks is much smaller than that of the plover, enabling the lark to occupy habitat patches too small to support a plover.

After the very wet spring and reproductive failure of 1995, those plovers returning to breed on the PNG in 1996 and 1997 did not find suitable habitat for nesting due to the taller, residual vegetation those springs. Given that our current estimate of the annual adult survival rate averages about 90% based on studies in Montana (Dr. Steve Dinsmore, personal communication), only about 70% of the breeding population of 1995 was alive to return to breed on the PNG when the physical habitat became attractive again in the spring of 1998. That year was also a wet spring resulting in another flush of taller vegetation that dominated most plover nesting areas in the following years and the surviving adult population continued to decline to the point that when drought conditions led to more favorable habitats in the early 2000s, very few plovers with a history of nesting on the PNG remained. Plovers leaving the PNG in the late 1990s and nesting successfully elsewhere, surely returned to those more favorable areas in subsequent

years. Those sites would likely have been tilled fields and heavily grazed prairie in Weld County and contiguous areas. We have no records of a plover moving long distances between our major breeding populations (northern Colorado to southern Colorado, Southern Colorado to South Park, etc.), and I am of the opinion that a similar number of plovers breed in Weld County today as did in 1990, just not on the PNG.

The Future of the Mountain Plover on PNG

Few, if any, of the current on-the-ground agency and academic folks ever saw (as Dr. Graul and I have) 20-30 plover fly off County Road 103 as one drove the last mile into Keota in the 1970s, 1980s, and early 1990s. Such an image is difficult to project, and a population of that magnitude is difficult to imagine given existing vegetative conditions on the PNG.

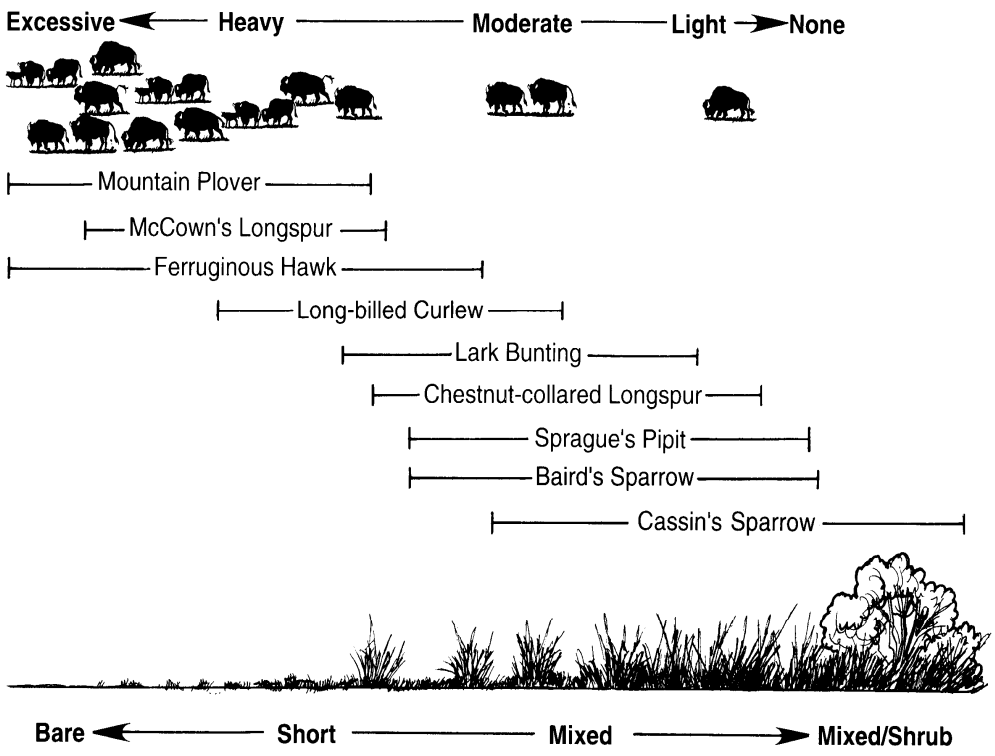
Grazing.--

To recover the Mountain Plover population to some historical level will require reversing vegetative succession on the PNG to increase disturbance of both the native and alien grasses. Grazing programs that:

1/ Are designed to locally remove as much of the available forage as possible by the end of the growing season enhance the landscape for plover nesting activities the following spring.
2/ Measure success by the amount of forage produced run counter to plover conservation.
3/ Favor a gradual evolution of the grassland to a mat of short grasses dominated by blue grama and buffalograss favor the continued decline of the plover population on the PNG, as does expansion of mixed-grass and shrub landscapes.

The foundation of modern range management is to maximize forage and beef production; the methodological 'tool' is fencing of pastures into allotments. Managing cattle under such a paradigm favors generally uniform grazing across the landscape (Samson, F.B. et al. Prairie ecosystems: Past, present, and future. *Wildlife Society Bulletin* 32:6-15, 2004).

Bird species that are endemic to the Great Plains occur across a continuum of grazing impacts, and can be figuratively illustrated as:



(from Knopf, F.L. Prairie Legacies: Birds. Pages 135-148 in F.B. Samson and F.L.Knopf [eds.]. *Prairie Conservation*. Island Press. Covelo, California. 1996)

Grazing uniformly across a landscape is grazing towards the middle of this illustration, loping off potential habitats for species requiring heavier and lighter grazing impacts on vegetation. Reducing the fencing of the PNG would surely improve the potential to support a sustainable plover population by assuring that patches of heavily grazed landscapes will be available in patches within the larger landscape for the plover, while simultaneously providing less heavily grazed patches (generally further from water) favoring other species. I note the obvious, however, that a radical change in grazing management of the PNG designed to push some allotments to the left of the scale will meet intense political (anti-grazing nongovernmental organizations) and economic (the grazing associations given that the intensive grazing of some larger allotments would result in reduced cattle weight gains for targeted permittees) challenges, which likely preclude any hope to again have a Mountain Plover population comparable to that seen in the early 1990s.

For the above reasons, I do not envision seeing a large, sustainable population of plover on the PNG--at least not within current academic range management paradigms that emphasize standardized/uniform grazing pressures across landscapes as implemented with the allotment system.

Burning.--

The burning program on the PNG has been successful in attracting breeding plovers, and now is focused on addressing broader management objectives. Future burning efforts will continue to attract plovers each spring, but burning to the extent required to recover the plover population seen in earlier studies would be expensive and certainly unpopular with the grazing associations. Although plover have used lightning-caused and accidental burns of 32 ha (80 acres) or less, burning an entire section at once appears to be a minimum for attracting birds. The quarter-section burns of 1999 were not successful.

My observations of experimental, natural, accidental, and arson burns over the last decade generally indicate that burns of short grass landscapes are not nearly as effective as burns of landscapes dominated by bunch grasses, exotic grasses, or forbs. Historically, fire was an ecological driver of the mixed and tall grass prairies, which should be the guidance for the burn site selections on PNG: taller grass and forb sites. These latter burns leave a more uniform ‘blacker’ surface due to greater fuel loads, and plover respond much better than to the patchy, ‘gray’ surface seen after burning short grasses. Obviously, these burns also result in exposure of extensive bare ground for plovers to place nests due to the interstitial spaces between individual plants.

From the plover response to burns seen to date, one might conclude that burning is more effective in attracting plovers on the Crow Valley Side of PNG than on the Keota Side. However, given the excellent response to the Keota and two East Keota burns in past years, such a conclusion is simplistic, and perhaps incorrect. Alternatively, I propose that the very successful burns of 2004 were in allotments that had a recent history (the 1992-

1994 surveys) of having concentrations of plovers. As a suggestion, I offer that PNG might find it most effective to select future burn sections within those sites that favored high plover concentrations in the internal PNG-wide plover inventory conducted by Mr. Jerry Godbey and his field crew, 1992-1994. Evidently, some (possibly landscape-level) attribute(s) of those allotments are more attractive to plovers than features at other locales.

The experimental burns on the PNG have always been conducted in a late winter or early spring time frame: just before the plover arrive on the breeding grounds. Where prickly pear densities are high as they currently are in the Raven and Coal allotments, an autumnal burn may kill cactus by removing the waxy coat on the pads resulting in desiccation and death of many plants over the winter. Again, burns should be in taller grass settings as short grass doesn't burn hot enough to remove the waxy coat of cactus that would lead to desiccation/death of the plant over winter. Cactus reduction would enhance forage production for cattle, and I do not foresee any negative consequences to the plover of an autumnal vs. a spring burn effort.

Prairie-dogs.--

My projection for the future of the Mountain Plover on the PNG is for a small population that is concentrated on patches of landscape supporting active prairie-dog colonies. Plovers are known to favor black-tailed prairie-dog towns as habitat throughout their continental range and annual cycle. On the PNG, plovers especially frequent prairie-dog landscapes that include stock watering tanks (which also concentrate cattle activities). Such localized, heavy grazing by both prairie-dogs and cattle results in soil disruption and intensive removal of vegetative that may increase prey abundance, but definitely increases prey detection by plovers. A representation of great plover habitat can currently (August 2008) be seen in the expanding prairie-dog town at the stock watering tank on the east side of Section 7 of the Wildhorse Allotment.

Prairie-dogs (*Cynomys mexicanus*) also provided native habitat during winter for plovers in Mexico. In the absence of prairie-dogs, comparable habitat for plovers wintering in California includes kangaroo rat (*Dipodomys* spp.) precincts grazed by cattle (historically, Tule Elk [*Cervus canadensis nannodes*]) on the Pixley National Wildlife Refuge, Tulare County, California as photographed in February of 1994:

(© f. l. knopf)

This California site is truly characteristic of the magnitude of vegetative disturbance and created micro-relief as seen on many prairie-dog towns, and affirms the attractiveness of such landscapes to plovers.

Plovers do not use all prairie-dog towns on the PNG, but seem to favor some towns over others across years. Research designed to define criteria for town selection by plovers could provide some insight for management actions to favor and promote plover habitat on the PNG.

Conclusions

After 20+ years of working with the Mountain Plover on the PNG and at most other locations where plovers have been reported from Montana to Mexico, I now consider this to be a species of the xeric tablelands of central and western Wyoming; South Park, Colorado; northern and central New Mexico; and Mexico. It occurred historically (and still occurs today more locally) within the short grass prairie biome where the soil surface is highly disturbed. Historically, those areas were grazed by prairie-dogs and bison. Today, such areas include those of locally heavy concentrations of cattle (and sheep in Wyoming and California), tilled agriculture, military maneuver areas, and prairie-dog towns. Ecologically, the plover is *NOT* a grass-associated species.

I am of the opinion that the Mountain Plover population on PNG has been in decline since the late 1930s and early 1940s. Given (1) the large flocks of birds that current ranching families remember in pastures (and even around their barns) in the 1950s and 1960s, (2) the higher numbers of nests/area that Dr. Walt Graul reported in the late 1960s and early 1970s, and (3) the changing predator assemblage, the precipitous decline in the mid 1990s appears to be merely an abrupt end-point of a longer-term process of deteriorating habitat for plover on the PNG. The very wet spring of 1995, followed by another in 1998, effectively precluded plover breeding on the PNG for a period of years over which many plovers that previously bred on the PNG had died before the habitat again became attractive. Surviving plovers relocated to nearby, more favorable locales within the Weld County vicinity in the mid 1990s, then subsequently developed a site fidelity to those new locales that passed to their offspring. The PNG has effectively lost its sustainable breeding population of Mountain Plovers due to (1) slowly declining habitat quality over many years, (2) increases in swift fox numbers as the primary predator on eggs and chicks, and (3) the circumstantial loss of a current population with fidelity to the PNG proper.

Contemporary grazing-management practices are inconsistent with providing potential habitat for breeding Mountain Plovers both on the PNG and elsewhere. The use of

management burns is an effective approach for creating suitable nesting habitat for plovers when those burns are in areas of taller vegetation in non-rolling terrain. Burns are, however, temporary, having an effective benefit to plovers that only lasts until mid May each year. The primary objective in burning is to attract some nesting plovers with the hopes of rebuilding a site-fidelity among some birds for the PNG specifically. However, the ultimate size and sustainability of the attracted population will depend upon the magnitude of annual burn coverage, plus the extent of desirable prairie-dog landscapes. Given my projection that the PNG grasses will continue to evolve towards a short-grass sod amongst stands of taller grasses and shrubs, burning may be the only hands-on management program available to assure a plover presence on the PNG. Management efforts to secure a remnant plover population on the PNG would seem most successful in the vicinities of Keota and Stoneham.

Mountain Plovers show great fidelity to some prairie-dog towns on the PNG. In the early-late 1990s, the small town in the south of Owl Allotment supported 5 breeding pairs of plovers every year. In the early 2000s, the large town in West Stoneham Allotment was the highest density of plover on the PNG. Both towns were eventually destroyed by plague and remain today as remnants of what they were just recently. Given the current (1) underlying paradigm in the range management profession that emphasizes fencing and the allotment system, (2) both political and economic resistance to increasing grazing pressure on the prairie, and (3) the short-term benefits of burning to attract plovers, the only hope for securing a sustainable Mountain Plover population on the PNG will ultimately be driven by a management vision to secure the long-term viability of the black-tailed prairie-dog metapopulation.

Acknowledgments

I thank Dr. James A. Sedgwick for introducing me to the Mountain Plover in 1985, an introduction that led to me leaving the mosquito, tick, fly-infested riparian zones of the West to work in short grass prairie landscapes. I have appreciated the support and cooperation of all mentioned in the text of this document. Elizabeth Humphrey, Wildlife Biologist on the PNG, and her predecessor, Mark Ball, have been ever helpful, as has the entire staff of the PNG District office. Dr. Walt Graul, Eric Odell, Francie Pusateri, and John Wagner deserve special mention for their long term support within the Colorado Division of Wildlife. I thank Hugh Kingery, Polly Reetz, and Margot Wynkoop of the Audubon Societies of Great Denver for their support of Mountain Plover conservation over the last decades. Finally, my greatest pleasure was working with my contemporaries, Drs. Steve Dinsmore (Iowa State University), Victoria Dreitz (Colorado Division of Wildlife) and Michael Wunder (University of Colorado/Denver). They taught me a lot, kept challenging my sometimes wild thoughts about plover biology, and remain special friends.

Appendix I. Locations of sections surveyed for Mountain Plover on the Pawnee National Grasslands, June 1986. Sections were identified by selecting county road intersections at random. Each section touching an identified intersection that was at least 50% PNG ownership and was not cross-fenced was surveyed. Transects were generally oriented along, rather than across, drainages to minimize soil disturbance.

Township	Range	Section	Transect Orientation
T8N	R60W	3	SW-NE
		4	SW-NE
		9	SW-NE
		10	SW-NE
		13	SE-NW
		21	SW-NE
		24	SW-NE
		28	SW-NE
		29	SW-NE
	R63W	3	SW-NE
		4	SE-NW
		6	SW-NE
		7	NW-SE
		9	SW-NE
	R64W	1	SE-NW
		12	NW-SW
T9N	R59W	18	SE-NW
	R63W	7	SW-NE
	R65W	7	SW-NE
		21	SW-NE
T10N	R56W	18	varied
	R63W	6	SE-NW

		7	NW-SE
		27	NE-SW
		28	SE-NW
		33	NE-SW
T10N	R64W	1	SE-NW
		4	SE-NW
		12	NW-SE
		21	SE-NW
		27	SE-NW
		28	SE-NW
	R65W	3	SE-NW
		23	SE-NW
		24	SW-NE
		26	NW-SE
		31	NW-SE (CPER)
	R66W	25	SE-NW (CPER)
T11N	R58W	18	NW-SE
		20	SE-NW
		21	SW-NE
		28	NW-SE
		29	NE-SW
	R59W	13	SW-NE
	R64W	32	SE-NW
	R65W	22	SE-NW
		35	NW-SE

Appendix II. Locations (latitude/longitude) of permanent plot markers for the annual survey of the Mountain Plover population on Pawnee National Grassland (courtesy of Steve Kittrell, USFS).

ALLOTMENT	POINT#	LAT (N)			LONG (W)			GPSmap 60 WAY POINT ID	NOTES
		Deg	Min	Sec	Deg	Min	Sec		
RENO	**184**	40	46	3.5	104	28	34.2	PLV SR 184	Lots of Plover historically
RENO	**183**	40	45	50.3	104	28	21.2	PLV SR 183	south of tank
RENO	**182**	40	45	35.3	104	28	9.1	PLV SR 182	in yucca- never seen plover here
RENO	**181**	40	45	19.5	104	27	54.1	PLV SR 181	Hilltop
RENO	**180**	40	45	18.7	104	27	37.6	PLV SR 180	
RENO	**179**	40	45	13.3	104	27	25.0	PLV SR 179	
RENO	**178**	40	45	2.4	104	27	18.5	PLV SR 178	
RENO	**177**	40	44	50.3	104	27	11.1	PLV SR 177	
RENO	**176**	40	44	34.8	104	27	2.8	PLV SR 176	NW of tank
RENO	**175**	40	45	18.7	104	27	10.7	PLV SR 175	in drainage
RENO	**174**	40	45	20.2	104	26	50.8	PLV SR 174	Hilltop
RENO	**173**	40	45	30.9	104	26	35.7	PLV SR 173	not off FSR 672
RENO	**172**	40	45	39.8	104	26	22.5	PLV SR 172	
RENO	**171**	40	45	51.3	104	26	19.0	PLV SR 171	turnoff FSR 672 onto very faint 2 track
WILDHORSE	**170**	40	40	18.1	104	28	3.8	PLV SR 170	
WILDHORSE	**169**	40	40	29.7	104	28	3.7	PLV SR 169	
WILDHORSE	**168**	40	40	41.7	104	28	3.2	PLV SR 168	
WILDHORSE	**167**	40	40	57.5	104	28	17.7	PLV SR 167	
WILDHORSE	**166**	40	40	57.3	104	28	35.4	PLV SR 166	
WILDHORSE	**165**	40	40	56.6	104	28	53.1	PLV SR 165	
WILDHORSE	**164**	40	40	40.8	104	29	11.4	PLV SR 164	
WILDHORSE	**163**	40	40	29.3	104	29	11.5	PLV SR 163	
WILDHORSE	**162**	40	40	57.6	104	27	48.4		NO WAYPOINT
WILDHORSE	**161**	40	41	15.5	104	28	4.0	PLV SR 161	
WILDHORSE	**160**	40	41	32.9	104	28	4.0	PLV SR 160	
WILDHORSE	**159**	40	41	47.5	104	27	46.0	PLV SR 159	
WILDHORSE	**158**	40	41	47.9	104	27	26.3	PLV SR 158	
WILDHORSE	**157**	40	41	48.4	104	27	11.1	PLV SR 157	
VIVIAN	**141**	40	49	55.9	104	30	18.0	PLV SR 141	WCR 59
VIVIAN	**140**	40	50	11.5	104	30	15.6	PLV SR 140	WCR 59
VIVIAN	**139**	40	50	25.0	104	30	17.7	PLV SR 139	just north of curve
VIVIAN	**138**	40	50	36.3	104	30	16.1	PLV SR 138	just south of curve
VIVIAN	**137**	40	50	52.6	104	30	15.6	PLV SR 137	N of hill
VIVIAN	**136**	40	51	6.2	104	30	15.4	PLV SR 136	
VIVIAN	**135**	40	51	23.9	104	29	57.5	PLV SR 135	
VIVIAN	**134**	40	51	23.6	104	30	21.9	PLV SR 134	
VIVIAN	**133**	40	51	23.9	104	30	58.8	PLV SR 133	

VIVIAN	**132**	40	51	24.2	104	31	17.5	PLV SR 132	
VIVIAN	**131**	40	51	25.8	104	32	31.4	PLV SR 131	
VIVIAN	**130**	40	51	38.7	104	32	31.9	PLV SR 130	
VIVIAN	**129**	40	51	54.0	104	32	31.9	PLV SR 129	
VIVIAN	**128**	40	52	6.6	104	32	32.0	PLV SR 128	bent stake
CENTER	**118**	40	48	52.9	104	27	6.9	PLV SR 118	SE corner near W.Willow Gate
CENTER	**119**	40	49	1.7	104	27	19.7	PLV SR 119	
CENTER	**120**	40	49	13.1	104	27	28.0	PLV SR 120	
CENTER	**121**	40	49	25.4	104	27	36.1	PLV SR 121	
CENTER	**117**	40	50	15.3	104	27	59.4	PLV SR 117	stake W of FS Rd 63
CENTER	**116**	40	50	28.5	104	27	55.4	PLV SR 116	
CENTER	**115**	40	50	41.0	104	27	54.3	PLV SR 115	Hilltop/rise
CENTER	**114**	40	50	54.2	104	27	53.1	PLV SR 114	broken stake
CENTER	**122**	40	49	40.4	104	28	10.5	PLV SR 122	TAG reads "223", off to south
CENTER	**123**	40	49	39.7	104	28	24.8	PLV SR 123	
CENTER	**124**	40	49	41.0	104	28	47.4	PLV SR 124	at top of rise- tag is gone
CENTER	**125**	40	49	41.5	104	29	5.5	PLV SR 125	TAG reads "225", since being replaced
CENTER	**126**	40	49	42.7	104	29	21.1	PLV SR 126	SW of stock tank about 120 yds
CENTER	**127**	40	49	36.8	104	29	35.3	PLV SR 127	about 0.1 mi E of gate
WILLOW	**156**	40	46	33.3	104	22	23.2	PLV SR 156	
WILLOW	**155**	40	46	46.0	104	22		PLV SR 155	
WILLOW	**154**	40	47	6.8	104	22	38.7	PLV SR 154	off FS Rd 110
WILLOW	**153**	40	47	6.3	104	22	50.2	PLV SR 153	stake missing
WILLOW	**152**	40	47	6.2	104	23	8.5	PLV SR 152	due S of windmill
WILLOW	**150**	40	47	5.9	104	23	26.6	PLV SR 150	
WILLOW	**149**	40	47	5.8	104	23	44.1	PLV SR 149	
WILLOW	**148**	40	47	5.6	104	23	58.2	PLV SR 148	
WILLOW	**147**	40	47	5.5	104	24	9.4	PLV SR 147	
WILLOW	**146**	40	47	5.2	104	24	25.1	PLV SR 146	last one to W of FS Rd 110
WILLOW	**145**	40	47	41.1	104	24	39.4	PLV SR 145	east of FS Rd 69
WILLOW	**144**	40	47	52.1	104	24	39.3	PLV SR 144	east of FS Rd 69
WILLOW	**143**	40	48	13.9	104	24	39.1	PLV SR 143	in swale
WILLOW	**142**	40	48	44.1	104	24	40.4	PLV SR 142	S of FS Rd 114, W 300'
KEOTA	**100**	40	39	52.6	104	4	58.5	PLV SR 100	SE of WCR 103 & FS Rd 688
KEOTA	**101**	40	40	42.6	104	5	11.0	PLV SR 101	0.1 mile N of fence, west side WCR 103
KEOTA	**102**	40	40	53.0	104	5	11.0	PLV SR 102	0.2 mile N of fence, west side WCR 103
KEOTA	**103**	40	41	7.8	104	5	11.0	PLV SR 103	0.1 mile N of WCR 96, west side WCR 103
KEOTA	**104**	40	41	22.9	104	5	10.2	PLV SR 104	
KEOTA	**105**	40	41	33.9	104	5	9.9	PLV SR 105	
KEOTA	**106**	40	41	48.0	104	5	9.9	PLV SR 106	SSW of rock about 15 yds
KEOTA	**107**	40	41	56.1	104	4	52.8	PLV SR 107	S of WCR 98
KEOTA	**108**	40	41	12.3	104	4	1.5	PLV SR 108	0.5 mile S of turn on WCR 105 from 390
KEOTA	**109**	40	40	52.1	104	4	1.9	PLV SR 109	telephone pole
KEOTA	**110**	40	40	17.3	104	4	2.8	PLV SR 110	
KEOTA	**111**	40	40	3.2	104	4	15.7	PLV SR 111	FSR 688 (2 track)
KEOTA	**112**	40	39	58.3	104	4	30.3	PLV SR 112	FSR 688 (2 track)
KEOTA	**113**	40	39	54.9	104	4	45.1	PLV SR 113	0.2 mile E of stake #100

SOUTH	**185**	40	38	12.1	104	5	14.8	PLV SR 185	
SOUTH	**186**	40	38	4.0	104	5	14.9	PLV SR 186	Off fence corner
SOUTH	**188**	40	37	33.6	104	6	1.2	PLV SR 188	Off WCR103 & 92
SOUTH	**189**	40	37	33.5	104	6	13.4	PLV SR 189	
SOUTH	**190**	40	37	25.0	104	6	24.3	PLV SR 190	off power line 2 track
SOUTH	**191**	40	37	15.7	104	6	24.6	PLV SR 191	off power line 2 track
SOUTH	**192**	40	37	2.3	104	6	25.0	PLV SR 192	off power line 2 track
SOUTH	**193**	40	36	50.3	104	6	25.8	PLV SR 193	off power line 2 track
SOUTH	**194**	40	37	39.4	104	6	19.2	PLV SR 194	0.1 mile NE WCRs 92/101
SOUTH	**195**	40	37	47.9	104	6	9.2	PLV SR 195	bent over
SOUTH	**196**	40	37	56.7	104	5	59.3	PLV SR 196	
SOUTH	**197**	40	38	7.8	104	5	46.3	PLV SR 197	SW of oil well pump
SOUTH	**198**	40	38	17.7	104	5	32.1	PLV SR 198	160' east of stock tank
SOUTH	**199**	40	38	21.8	104	5	19.8	PLV SR 199	off 2 track
K. STEER	**201**	40	40	3.6	104	1	45.7	PLV SR 201	W of FS Road 109
K. STEER	**202**	40	40	16.3	104	1	45.0	PLV SR 202	To north
K. STEER	**203**	40	40	32.5	104	1	44.8	PLV SR 203	hilltop- 1st
K. STEER	**205**	40	40	53.5	104	1	44.7	PLV SR 204	hilltop- 2nd
K. STEER	**204**	40	41	4.4	104	1	47.6	PLV SR 205	north of windmill
K. STEER	**206**	40	41	12.4	104	1	56.5	PLV SR 206	
K. STEER	**207**	40	41	23.3	104	2	7.5	PLV SR 207	On flat hilltop
K. STEER	**208**	40	41	33.4	104	2	18.4	PLV SR 208	S of stock tank
K. STEER	**209**	40	40	6.0	104	1	57.6	PLV SR 209	0.1 mile SE of windmill
K. STEER	**210**	40	40	12.2	104	2	10.0	PLV SR 210	
K. STEER	**211**	40	40	21.1	104	2	26.6	PLV SR 211	
K. STEER	**212**	40	40	27.5	104	2	37.6	PLV SR 212	
K. STEER	**213**	40	40	33.4	104	2	49.2	PLV SR 213	
K. STEER	**214**	40	40	41.7	104	3	0.7	PLV SR 214	

Appendix III. Published Studies that Include Information on Mountain Plover Collected on Pawnee National Grassland and/or Perspectives on Conservation Arising from Those Studies.

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***Studies solely addressing PNG plovers, and transmitted with this report as PDF files.**

Appendix IV. Calculated density of Mountain Plovers breeding successfully on the Pawnee National Grassland, 1990-2007. Twelve of the 13 plovers recorded in 2002 were on burns in the Keota and Wildhorse allotments. Burns have generally not been situated near the survey points, and the 2002 detections are confounded by plover response to management burns.

Year	No. Birds	*D* ± S.E.
1990	77	4.7 ± 1.2
1991	33	2.0 ± 0.5
1992	67	4.1 ± 0.8
1993	44	2.7 ± 0.6
1994	59	3.6 ± 0.4
1995	3	NA
1996	9	NA
1997	5	NA
1998	24	1.5 ± 0.1
1999	0	NA
2000	8	NA
2001	2	NA
2002	[13]	NA
2003	1	NA
2004	0	NA
2005	12	NA
2006	2	NA
2007	3	NA

Appendix V. Number of plover detected in surveys of each of the 8 grazing allotments annually, 1990-2007.

Year	Center	Keota	Keota Steer	Reno	South	Vivian	Wildhorse	E. Willow	Total
1990	4	20	0	16	1	2	20	14	77
1991	4	5	4	13	9	0	6	1	33
1992	12	10	20	11	0	0	12	7	72
1993	2	11	15	4	0	3	4	5	44
1994	7	8	7	16	0	1	6	1	59
1995	1	2	0	0	0	0	0	0	3
1996	0	0	1	4	2	0	2	0	9
1997	0	0	2	1	0	1	1	0	5
1998	0	5	12	5	0	0	0	2	24
1999	0	0	0	0	0	0	0	0	0
2000	0	1	2	0	0	0	0	5	8
2001	0	0	0	0	0	2	0	0	2
2002	0	2	1	0	0	0	10	0	13
2003	0	0	1	0	0	0	0	0	1
2004	0	0	0	0	0	0	0	0	0
2005	4	0	0	0	0	0	4	4	12
2006	0	0	2	0	0	0	0	0	2
2007	0	1	0	1	1	0	0	0	3