An Ecological Model to Classify and Monitor Mountain Plover Nesting Habitat on Grasslands in Colorado

Daniel W. Uresk, USDA Forest Service, Rapid City SD 57701

Abstract

A multivariate statistical model based on vegetation and soil surface characteristics was developed to classify and monitor mountain plover (*Charadrius montanus*) habitat groupings and nest selection. Data were collected on the shortgrass prairie, Pawnee National Grassland, Colorado. Vegetation and soil surface characteristics were sampled from late April to early June of 1999 and 2000 during the nesting season. Samples were collected on random sites in 43 sections and at 54 nest sites within adjacent townships. Random data were clustered into three habitat groups consisting of high, mid and low nesting habitat. Key variables in the model for classifying and monitoring nest habitat were percent bare ground, percent canopy cover for blue grama (*Bouteloua gracilis*) and buffalograss (*Bouteloua dactyloides*). The three nest habitat groupings were quantitatively identified with an estimated 97 percent accuracy. The model classified the 54 mountain plover nest sites as either high, mid or low nesting habitat. High mountain plover nest preference (39 nests) for bare ground was 46 percent, with blue grammar 27 percent and buffalograss at 2 percent (n = 39 nest sites). Mid classified nests (12) selected 23 percent bare ground, 60 percent blue grama and 1 percent buffalograss. Three nests were classified as low nesting habitat, which exhibited 25 percent bare ground, 41 percent buffalograss and 17 percent blue grama. Mountain plovers selected nest sites that had short plant structure, a mean visual obstruction reading (VOR) of 0.25 cm at nesting and ranged from 0 to 1.6 cm. Nest selection was similar for VOR among the three groups ($P > 0.10$). Plant structure (VOR) from 499 random sites was grouped into three categories; tall, intermediate and short and ranged from 0.6 to 11.4 cm. Short VOR plant structure of 2.2 cm or less (<1-inch) is potential nesting habitat and may be achieved by fall or winter grazing within high plover nesting habitat. This multivariate model along with visual obstruction groupings for classifying and monitoring mountain plover habitat on the shortgrass prairie are simple to use, reliable, repeatable and cost effective to meet management objectives and monitoring plans.

Key words: Habitat classification, monitoring, nest selection, plant structure, visual obstruction reading.

Introduction

The mountain plover (*Charadrius montanus*) generally nests in the shortgrass prairies on level sites with sparse, short vegetation and patches of bare ground associated with heavy herbivore grazing (Graul and Webster 1976, Olson and Edge 1985, Dreitz et al. 2005, Plumb et al 2005, Augustine and Derner 2012, Javersak et al. 2012). Bradbury (1918) described a mountain plover nesting area 20 miles east of Denver, Colorado (CO) as cattle range with buffalo and grama grasses, some prickly pear and few shrubs or weeds. In Weld County, CO, Graul (1975) reported mountain plovers were nesting in short grass habitat primarily consisting of blue grama (*Bouteloua gracilis*) and buffalograss (*Buchloe dactyloides*) with dispersed clumps of plains prickly pear (*Opuntia polyacantha*). In 1999, the mountain plover was originally proposed as threatened or endangered according to the Endangered Species Act of 1973 (Federal Register 2011) and withdrawn in 2003. However, in 2010, the mountain plover was again proposed as a threatened species but was withdrawn May 12, 2011. The mountain plover was not determined to be threatened or endangered throughout all or a substantial portion of its range. Nevertheless, the mountain plover should receive continued investigation and monitoring to maintain or enhance existing populations. Restoring or maintaining areas for mountain plover nesting habitat through livestock grazing can be achieved through plant succession and defining seral stages that meet the desired nesting requirements on the short grass prairie in Colorado (Ryder 1980, Uresk 1990, Knopf and Miller 1994, Knopf 2008, Augustine and Derner 2012). There is little information focusing specifically on the use of heavy livestock grazing to meet the nesting habitat requirements through plant succession and defining the optimal nest habitat groupings for selection of nest sites. The purpose of this study was to develop a habitat model for habitat classification and monitoring based on plant succession within the short grass prairie to determine optimum nesting habitat for mountain plovers.

Study Area

This study was located near Briggsdale and Keota in Weld County, CO, within the western unit of the Pawnee National Grassland. The grassland includes 78,162 ha of publicly owned tracts of land intermixed with private farms and ranches. Average precipitation from 1981-2010 at Briggsdale was 34 cm (13.4 inches) (CLIMOD 2017). Average length of the growing season ranges from 151 to 178 days. Mean monthly temperatures range from a low in December of - 4^0C to 22^0C in July. The area is classified as a shortgrass steppe (US Department of Agriculture Natural Resources Conservation Service [USDA NRCS] 2017) with blue grama, buffalograss, plains prickly pear, western wheatgrass (*Pascopyrum smithii*) and sun sedge (*Carex inops*) as the primary plant species. Soils are an Ascalon-sandy loam, a deep well-drained Ustollic Haplargid (Crabb 1982, USDA NRCS 2017).

Methods

Mountain plovers were most frequently found on loamy plains range sites with less than 2 percent slope and a southern to southwestern aspect in the study area. Searching for individual plovers began at sunrise and continued through sunset during the nesting period. Searching for nests and all other data collections was completed from late April to early June during 1999 and 2000. Mountain plover nesting was documented from May 14 through June 8 for the two year study. Once a plover was located, it was observed until it settled on the nest. Later, the nest was located and visual obstruction readings (VOR) with the modified Robel pole and cover estimates were completed in a very short time frame, less than 10 minutes (Daubenmire 1959, Uresk and Benzon 2007, Uresk and Juntti 2008).

The experimental design consisted of sampling within a 2 m diameter area around nest sites located on random transects within 1 square mile sections (259 ha). Major plant species, total grasses, total forbs, total cover, bare ground and ground litter were sampled following methods for canopy cover described by Daubenmire (1959). A quadrat (20 cm x 50 cm) was placed in four cardinal directions (North, South, East, West) within the 2 m diameter area for data collections. One quadrat was placed over the nest area for a total of five quadrats per nest area. This experimental design was applied at each stratified random site on the grasslands. All canopy data estimated from the five quadrats were summarized into one mean per site. Therefore, all nests and random sites were unique for analyses.

The modified Robel pole (2.54 cm) had alternating 1.27 cm white and gray bands. These bands were numbered beginning with 0 (white band) at the bottom and the pole was placed at the edge of the nest, but at stratified random points in the center of the 2 m diameter area. The lowest visible band was read 4 m from the pole and at a 1 m height following procedures described by Uresk and Benzon (2007) and Uresk and

Juntti (2008). Four VOR measurements were collected at each pole station in each cardinal direction. The 4 VOR measurements were summarized into one mean for analyses.

Random sampling as well at mountain plover nest sites was conducted in three areas on the Pawnee grasslands for the Robel pole, VOR and canopy cover estimates of vegetation and bare ground. Three areas were located, two at Briggsdale: (1) Northwest, Townships 10 and 11 north, Range 64; (2) West,Townships 8 and 9 north, Range 62 and 63. A third area was located south of Keota: (3) Township 8 north, Range 59 and 60. A total of 43 sections were surveyed in these three areas during 1999, but only 28 of the same sections (Area 1 and 3) were sampled for both canopy cover and Robel pole measurements (VOR) in 2000. An additional 15 sections (area 2) were sampled for Robel pole measurements only. Limited sampling within sections was constrained by fences and rough terrain.

Random transects were selected for each land section prior to data collection and new random sites were selected during the second year of sampling. An all-terrain vehicle (ATV) was driven within each section in a line coordinated with Global Positioning System (GPS) units. Sites were sampled on the random 1.6 km (1 mile) transect beginning at 0 and 0.3 km (0.2 mile) increments thereafter within each section. Six sampling sites for canopy cover and visual obstruction readings were collected per transect for 416 sites on the 43 sections. An additional 83 sites were collected for visual obstruction measurements in area 2 for a total of 499 sites during the two-year period.

All random data for cover variables and visual obstruction readings were combined for both years (1999, 2000) for analyses. Preliminary examination of 21 variables from data analysis for cover data removed minor plant species, annuals, total cover, graminoids and forbs resulting in 10 variables, including bare ground, following procedures described by Uresk (1990) and Uresk and Mergen (2014). These 10 variables were further reduced by principal component analysis to five variables. A non-hierarchical cluster analysis (ISODATA) defined three groupings based on five variables to evaluate potential mountain plover nesting habitat based on plant successional seral stages (Ball and Hall 1967, del Morel 1975). Cover variables for 416 cover sites and 499 VOR sites were used to develop potential nest resource grouping and guideline based minimum variances within a cluster. Clusters are unsupervised and are defined by the ISODATA algorithm. Stepwise discriminant analysis was used to estimate compactness of the cluster and identified key variables, estimated differences between and among clusters, to develop Fisher classification coefficients for model development (Uresk 1990, SPSS 2003). Discriminant analyses identified three key variables for classifying plover nest habitats and for monitoring based on plant succession and surface soil characteristics. Cluster groupings based on vegetation successional status were defined for plover nest habitats as high, mid and low. Misclassification error rates were estimated with a cross validation using a jackknife or "leave one site out" procedure (SPSS 2003, Uresk and Mergen 2014).

The developed Fisher coefficients from discriminate analyses based on the three clusters and key variables from random sites classified the 54 nest sites into three nest groupings. The three nest groupings characterized by major variables provide information on the selection of nest sites. Robel pole VOR among nest grouping were evaluated by analysis of variance (SPSS 2003).

Results

Random Sites

A total of 21 variables were sampled on 416 sites. This included graminoids, forbs, shrubs, total cover, litter and bare ground. The 21 variables were reduced to five variables: blue grama, buffalograss, plains pricklypear, sun sedge and bare ground.

These five variables were then evaluated by a non-hierarchical cluster analyses (ISODATA) resulting in three groupings (high, mid and low) defined as nesting habitats. Stepwise discriminant analysis of the groupings resulted in three variables; bare ground, blue grama and buffalograss, that evaluated compactness (*P*<0.05) of clusters and development of Fisher model coefficients (Table 1).

Fisher classification discriminant coefficients by size show the importance for each of the three variables (bare ground, blue grama and buffalograss). These coefficients provide the information for classifying plover nesting habitat on the grasslands and monitoring mountain plover habitat (Table 1). Cross validation (jackknife procedure) results for the three nesting habitats showed a misclassification rate of 3 percent. Overall accuracy for nest assignment was 97 percent. When key canopy cover variables (%) are collected from a site, multiplied by Fisher coefficients and summed accounting for the constants, the most positive score assigns the classification of nesting habitat based on the three defined variables. An example of calculating scores from Fisher coefficients and assigning it to the nest habitat groupings is presented in Uresk and Mergen (2014).

Table 1. Fisher's discriminant function coefficients and constants used in model. Classification and monitoring of three mountain plover nesting habitats (high, mid, low) (n = 416 random sites) on the Pawnee National Grassland, 1999-2000. See Uresk and Mergen (2014) Table 3 for an example of assigning nesting habitat from new data collected on the grasslands.

Variable	High	Mid	Low
Bare ground	0.330	0.268	0.357
Blue grama	0.247	0.455	0.263
Buffalograss	0.246	0.233	1.471
Constant	-10.088	-17.884	-45.416

The estimated number of random transects required per section (six sites per transect) to achieve a precision of 20 percent of the mean with 80 percent confidence is three.

The dynamics of these three key variables for plover nesting habitat based on plant succession and bare ground for 416 sites throughout the three nesting habitats are illustrated in Figure 1, Table 2. Key variables for high plover nesting habitat on the grasslands were dominated by bare ground (33%), followed by blue grama (25%) and buffalograss (3%). The mid nesting habitat was greatest for blue grama with 64 percent canopy cover followed by bare ground (5 %) and buffalograss (2 %). Low nesting habitat was dominated by buffalograss with 53 percent canopy cover followed by blue grama (16 %) and bare ground (19 %).

High Nesting Habitat

Canopy cover within the high nesting stage is dominated by blue grama (25%) and Fendler threeawn (*Aristida purpurea*) (7%), followed by western wheatgrass (5%) and buffalograss (3 %) (Table 2). Total canopy cover and graminoid cover was 51 percent and 45 percent, respectively. Forb and shrub cover was five and 4 percent, respectively. Bare ground represented 33 percent and was the greatest of the three nest habitat stages.

Mid Nesting Habitat

Blue grama exhibited 64 percent cover, the greatest of all three stages (Table 2). All other species were minor with less than 4 percent cover. Total plant cover and graminoid cover were 75 and 72 percent, correspondingly. Bare ground was low with 15 percent cover and ground litter with 19 percent cover.

Low Nesting Habitat

Buffalograss was dominant with 53 percent cover, while the other two stages were less than 3 percent (Table 2). Cover for blue grama, a co-dominant, was 16 percent. Low cover values were exhibited by all other grass and sedge species, ranging from 2 to 4 percent.

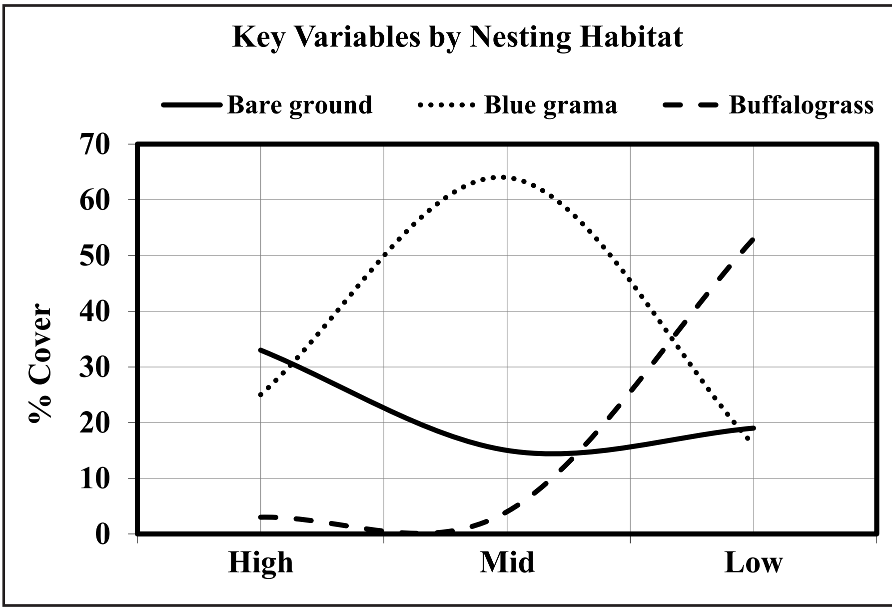

Figure 1. Key variables displayed throughout the three grouping for nest habitat in a blue grama, buffalograss, and western wheatgrass ecological type from late April to early June. Grouping of mountain plover nest habitat based on data from random sites, Pawnee National Grassland, Colorado.

Visual Obstruction Readings

Visual obstruction readings for 499 random sites ranged from 0 to 15.2 cm with an overall mean of 1.7 cm. Means of three VOR categories ranged from 0.6 to 11.4 cm (Table 3). Random areas on the grasslands with a mean VOR of 0.6 cm for the short category, ranging from 0 to 2.2 cm, is considered the most probable category for plover nesting habitat.

Nest Site Selection

Mountain plover nests assigned to the three seral nesting categories by the developed Fisher coefficients show that they are highly selective for nests in patches of high bare ground (Table 4). Thirty-nine out of 54 nests selected by plovers were characterized by 46 percent bare ground, 27 percent blue grama cover and 2 percent cover for buffalograss. Twelve plover nests were selected in sites with 23 percent bare ground, 60 percent blue grama and 1 percent cover for buffalograss. Only three nests were selected in areas dominated by buffalograss (41%), followed by blue grama (17 %) and bare ground (25 %). The optimal nest selection sites for mountain plovers on grassland habitats are located within the high nesting habitat with greater amounts of bare ground in areas dominated with blue grama. Visual obstruction readings for the 54 nests ranged from 0 to 1.6 cm and averaged 0.25 cm among the three nest categories. There were no VOR differences among the three nest categories ($P > 0.10$). Additional canopy cover (%) for all 13 major variables by nest habitat selection is presented in Table 5.

Discussion

Monitoring the dynamics of bare ground, blue grama and buffalograss on the grasslands can be used to describe successional changes between and among seral stages defined as plover nesting habitat. Disturbances such as livestock grazing, fire and climatic changes can shift the three variable association or abundance with respect to the quality of the nesting habitat (low, medium or high). The multivariate model provides natural resource managers a tool for monitoring the status of the vegetation and bare ground on the

Table 2. Mean canopy cover (%) and standard errors (parentheses) of common plant species and other variables by plover nesting habitat (high, medium, low) on the grasslands from late April to early June (n = 416 random sites) on the Pawnee National Grassland, 1999-2000.

Species or variable	High [1]	Mid	Low
Western wheatgrass *Pascopyrum smithii*	5.1(0.7)	2.6(0.3)	1.5(0.6)
Blue grama *Bouteloua gracilis*	25.1(1.0)	64.3(0.9)	15.6(2.0)
Buffalograss *Bouteloua dactyloides*	3.1(0.5)	1.5(0.3)	52.9(3.0)
Fendler threeawn *Aristida purpurea*	6.6(1.0)	1.9(0.4)	1.5(0.6)
Sun sedge *Carex inops*	3.3(0.6)	4.1(0.4)	3.7(1.7)
Plains pricklypear *Opuntia polyacantha*	3.8(0.5)	3.8(0.4)	3.6(1.2)
Sixweeks fescue *Vulpia octoflora*	2.4(0.5)	2.4(0.5)	1.7(0.6)
Total plant cover	50.5(1.3)	75.0(0.8)	75.2(2.3)
Graminoid cover [2]	45.3(1.3)	71.8(0.9)	73.2(2.4)
Forb cover [2]	4.6(0.5)	3.1(0.3)	3.7(0.8)
Shrub cover	3.9(0.5	3.8(0.5)	4.9(1.8)
Litter cover [3]	11.8(0.9)	19.0(1.2)	8.2(1.8)
Bare ground	33.4(1.3)	14.7(0.5)	18.8(2.3)

[1] Sample size: High =153; Medium =238; Low =25
[2] Two dimension cover and not the sum of the individual plant species.
[3] Ground litter.

Table 3. Robel pole VOR for vegetation structure on random sites for the short grass prairie from late April to early June. Mean and range (cm) on the Pawnee National Grassland, 1999-2000.

VOR	Sites [1]	Mean (SE) [2]	Range
Tall	15	11.4(0.6)	8.3 – 15.2
Intermediate	106	4.2(0.1)	2.5 – 7.6
Short	378	0.6(0.1)	0.0 – 2.2

[1] = number of random sites
[2] = Standard error

Pawnee grasslands within the blue grama, buffalograss, plains prickly pear and western wheatgrass habitat type in an attempt to manage for desired plover nesting habitat. In this study, short structure vegetation (VOR) that ranged from 0 to 2.2 cm had the greatest potential for plover nesting habitat on the grasslands. Both monitoring tools define nesting habitat with percent cover of bare ground, blue grama, buffalograss and VOR for vegetation structure.

Mountain plover nests assigned to the three nesting categories are extremely selective for nests located in the high nesting habitat type (72%) with 46 percent bare ground, 27 percent blue grama and little

Table 4. Mean canopy cover (%) and standard error (parentheses) of key plant species for assigned mountain plover nest sites (n= 54). Classified from Fisher coefficients developed from random sites and assigned to nest habitat on the Pawnee National Grassland, 1999-2000.

MEAN CANOPY COVER (%)				
Nest sites	**Nests [1]**	**Bare Ground**	**Blue Grama**	**Buffalograss**
High	39	46(2.6)	27(2.4)	2(0.7)
Mid	12	23(2.1)	60(2.8)	1(1.0)
Low	3	25(10.9)	17(8.9)	41(7.4)

[1]= number of nests

Table 5 Average canopy cover (%) and standard errors (parentheses) of plover nest sites assigned by Fisher coefficients from random sites by nest habitat from late April to early June (n = 54 nests) on the Pawnee National Grassland, 1999-2000.

Species or variable	**High [1]**	**Medium**	**Low**
Western wheatgrass *Pascopyrum smithii*	0.9(0.4)	0.3(0.2)	1.5(0.9)
Blue grama *Bouteloua gracilis*	26.8(2.4)	58.9(2.8)	17.3(8.9)
Buffalograss *Bouteloua dactyloides*	2.2(0.7)	1.3(1.0)	40.5(7.4)
Fendler threeawn *Aristida purpurea*	1.9(0.6)	0.9(0.6)	0.0
Sun sedge *Carex inops*	0.8(0.3)	3.3(1.2)	4.7(2.1)
Plains pricklypear *Opuntia polyacantha*	1.4(0.5)	1.5(0.5)	0.0
Sixweeks fescue *Vulpia octoflora*	0.5(0.3)	0.1(0.1)	0.0
Total plant cover	40.0(1.9)	62.9(2.8)	59.2(14.7)
Graminoid cover [2]	35.4(1.9)	61.2(1.9)	56.2(15.7)
Forb cover [2]	3.0(0.7)	1.2(0.6)	4.7(3.9)
Shrub cover	0.8(0.3)	0.6(0.3)	0.0
Litter cover	9.0(1.1)	23.4(4.9)	9.0(4.3)
Bare ground	45.8(2.6)	23.4(2.1)	25.3(10.9)

[1] Sample size by nest habitat: High =39, Medium = 12, Low = 3.

[2] Two dimension cover and not the sum of the individual plant species.

or no buffalograss. Only three nests (6%) were in low nesting habitat dominated by buffalograss (41%) and bare ground (25%).

In Colorado, Javersak et al. (2012) reported nesting sites that were primarily located in areas with an average of 24 percent bare ground and Knopf and Miller (1994) reported nests with 32 percent bare ground. In Montana, Olson and Edge (1985) reported 27 % bare ground (erosion pavement) for nest sites. Parrish et al. (1993) and Plumb et al. (2005) reported plover nest selection at areas of 72% and 47% bare ground, correspondingly, in Wyoming.

Visual Obstruction Readings at 54 nest sites were similar for all three nest groupings and averaged 0.24 cm in this study. Javersak et al. (2012) reported an average VOR of 0.6 cm for 16 plover nest sites on the Pawnee grasslands in Colorado. Parrish et al. (1993) in Wyoming reported VOR of 0.13 cm. The reported Visual Obstruction Readings define a range nest sites selected and preferred by mountain plovers on the grasslands.

Livestock grazing on the grasslands can significantly influence and alter vegetation composition and structure for wildlife (Severson 1990, Severson and Urness 1994, Derner et al. 2009). To create or maintain optimal mountain plover habitat, grazing intensity should be heavy within grassland areas dominated by blue grama with sparse buffalograss. Visual Obstruction Readings, ranging from 0.6 cm to 2.2 cm may be achieved by grazing livestock late fall and/or winter months. Livestock numbers and length of time of grazing on the grasslands is ancillary. The objective is to achieve the recommended visual obstruction reading of 2.2 cm (approximately <1-inch) or less, even if it takes a month grazing with few herbivores to several days with a greater number of herbivores. Establishing artificial treatment (burning, mowing) patches (16 ha or 40 acres) is expensive and difficult to manage throughout public grasslands. Grazing these areas will provide bare ground and short structure within areas defined as high nesting habitat that is preferred by mountain plovers. Continued heavy grazing over time of these areas will move the plant successional stage to a sod forming dominant buffalograss with sub dominant blue grama stage (USDA-NRCS 2017, Augustine and Derner 2012) and will require a rotation grazing system to create mountain plover nesting habitat.

Monitoring for VOR and three key variables (bare ground, blue grama, buffalograss) on the short grass prairie will provide information to help determine desired conditions to manage for preferred plover nesting habitat. The developed model for classification and monitoring with three key variables and with VOR are two tools that are simple, cost effective and repeatable. These two tools provide protocols and guidelines for managers to meet, sustain, or improve mountain plover nesting requirements.

Conclusion

Mountain plovers nest in the shortgrass prairie in select areas with a high percentage of bare ground, low canopy cover and low VOR near nests. Specifically, conditions for ideal nesting habitat for mountain plovers include at least 46 percent bare ground, 27 percent blue grama cover and little to no buffalograss. Additionally, vegetation structure (VOR) grazed to approximately 1-inch or less, ranging from 0.6 to 2.2 cm defines potential plover nest site selection on the grasslands when grazed late fall and /or winter months. These guidelines should be beneficial and effective in providing desired nesting conditions to achieve or sustain the habitat for mountain plover conservation. Agricultural land under cultivation, provided some nesting habit for mountain plovers, but mortality was high. Mountain plovers primarily inhabitant the grasslands for nesting and chick rearing.

Acknowledgments

I thank Steve Denison and Hank Henry for project data collections and summaries. Mark Ball, Pawnee National Grassland Ranger District Office, for general assistance with the project. Special thanks is extended to Rudy King (retired) biometrician for statistical input and advice and to Jody Javersak for her help with data analyses. Dr. Fritz L. Knopf, U.S. Fish and Wildlife Service provided additional locations of mountain plover nests during the study. Review comments and suggestions were provided by Dr. Dale Bartos (retired) US Forest Service.

Literature Cited

Augustine, D.J. and J.D. Derner. 2012. Disturbance regimes and mountain plover habitat in shortgrass steppe: Large herbivore grazing does not substitute for prairie dog grazing or fire. Journal of Wildlife Management 76:721-728

Ball, G.H. and D.J. Hall. 1967. A clustering technique for summarizing multivariate data. Behavioral Science 12:153-155.

Bradbury, W. C. 1918. Notes on the nesting of the mountain plover. Condor 20:157-163.

Crabb, J. A. 1982. Soil Survey of Weld County, Colorado, Northern Part. USDA, Soil Conservation Service.

CLIMOD. 2017. High Plains Regional Climate Center. Lincoln, NE. Available at: https://hprcc.unl.edu/ [Cited 14 April 2017].

Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. Northwest Science 33:43-64.

del Moral, R. 1975. Vegetation clustering by means of ISODATA: revision by multiple discriminant analysis. Vegetatio 29: 179-190.

Derner,J.D. W.K. Lauenroth, P. Stapp and D.J. Augustine. 2009. Livestock as ecosystem engineers for grassland bird habitat in the Western Great Plains of North America. Rangeland Ecology and Management 62:111-118.

Dreitz, V.J., M.B. Wunder and F.L. Knopf. 2005. Movements and home ranges of mountain plovers raising broods in three Colorado landscapes. Wilson Bulletin 11: 128-132.

Federal Register 2011. Endangered and threatened wildlife and plants; withdrawal of the proposed rule to list the mountain plover as threatened; proposed rule. Part II Department of the Interior, Fish and Wildlife Service. 50 CFR Part 17. Vol 76, No. 92. May 12, 2011.

Graul, W. D. 1975. Breeding biology of the mountain plover. Wilson Bulletin 87:6-31.

Graul, W. D. and L. E. Webster. 1976. Breeding status of the mountain plover. Condor 78:265-267.

Javersak, J., D.W. Uresk and M.J. Trlica. 2012. Micro-habitat characteristics of mountain plover nest sites. Intermountain Journal of Science 26:26-30.

Knopf, F.L. and B.J. Miller. 1994. Montane, grassland, or bare-ground plover? Auk 111:504-506.

Knopf, F.L. 2008. Mountain plover studies Pawnee National Grassland 1985-2007. Available at: https://cpw.state.co.us/Documents/WildlifeSpecies/ [Cited 5 April 2017].

Olson, S. L. and W. D. Edge. 1985. Nest site selection by mountain plovers in north-central Montana. Journal of Range Management 38:278-280.

Parrish, T. L., S. H. Anderson and W. R. Oelkluas. 1993. Mountain plover habitat selection in the Powder River Basin, Wyoming. Prairie Naturalist 25:219-226.

Plumb, R. E., S. H. Anderson and F. L. Knopf. 2005. Habitat and nesting biology of mountain plovers in Wyoming. Western North American Naturalist 65:223-228.

Ryder, R.A. 1980. Effects of grazing on bird habitats. Pp 51-56. *in* Management of western forests and grasslands for nongame birds. USDA-Forest Service, General Technical Report, INT-86. Ogden Utah

Severson, K. E. 1990. Can livestock be used as a tool to enhance wildlife habitat? 43rd Annual meeting of the Society for Range management, Reno, Nevada, 13 February 1990. K. E. Severson, Technical Coordinator. USDA, Forest Service. GTR RM-194.

Severson, K.E. and P.J. Urness. 1994. Livestock grazing: A tool to improve wildlife habitat. Pp 232-249. in Ecological implications of livestock herbivory in the west. M. Vavra, W.A. Laycock and R.D. Pieper editors. Society for Range Management. Denver, Colorado.

[SPSS] Statistical Procedures for Social Science. 2003. SPSS 12.0 for Windows. SPSS, Inc. Chicago, Illinois, USA.

Uresk, D.W. 1990. Using multivariate techniques to quantitatively estimate ecological stages in a mixed-grass prairie. Journal of Range Management 43: 282-285.

Uresk, D.W. and D.E. Mergen. 2014. Ecological model for classifying and monitoring of green needlegrass/western wheatgrass/blue grama/ buffalograss ecological type. Intermountain Journal of Science 20: 1-3.

Uresk, D. W. and T. A. Benzon. 2007. Monitoring with a modified Robel pole on meadows in the central Black Hills of South Dakota. Western North American Naturalist 67:46-50.

Uresk, D.W. and T.M. Juntti. 2008. Monitoring Idaho fescue grasslands in the Big Horn Mountains, Wyoming, with a modified Robel pole. Western North American Naturalist 68:1–7.

USDA-NRCS. 2017 Ecological site description. R067BY002CO. Central High Plains, Southern Part. Technical Guide Section IIE, MRLA 67-Loamy. Available at: https://efotg.sc.egov.usda.gov/references/public/CO/R067BY002CO-LoamyGr.pdf [Cited 13 April 2017].

Received 22 August 2017
Accepted 15 November 2017