Delineation of the West Texas Potential Breeding Areas of the Mountain Plover (Charadrius montanus)

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Abstract

Mountain Plovers have become rare during the last tow decades. Their traditional nesting habitat, Prarie Dog towns and buffallo wallows on the short-grass prairies, has been largely replaced by cultivated fields and cattle pastures. Since 1997 Texas Parks & Wildlife biolgists have been attempting to identify nesting colonies. Also starting in 1997 the U.S. Fish and Wildlife Service has repeatedly attempted to elevate the species status to endangered.

In far-west Texas, where Mountain Plovers have nested, little cultivation has taken place and the short-grass prairie still occurs over much of the area it did a century ago. Still, numbers even there, have declined to where they are rarely found anymore.

It is possible to model the desirable plover nestsite characteristics to localize which part of west Texas is most likely to be suitable nesting habitat and most likely to have nesting colonies today.

In this paper, the nestsite attributes of flatness, elevation, barrenness, landcover type, and soil type are modeled as overlays to find the most desirable habitat.

Within the 70000 square kilometer study area, 9 areas comprising about 2600 square kilometers were found as most favorable with several additional zones of incrementally less desirable habitat. The results of the GIS model application greatly facilitate focusing the search for additional Mountain plover colonies in west Texas.

Introduction

Mountain Plover numbers have dropped over sixty percent during the period from 1966 to 1993(Russell 2004) and are down over ninety percent now from what their numbers were sixty years ago. This decline caused an effort in 1998 and again in 2002 by the U.S. Fish and Wildlife Service to list the species as threatened under the Endangered Species Act. (Leachman 2002)

Portions of the breeding area as it existed around 1950 extended into Texas. Recent efforts have been made to determine the current Texas breeding population. These survey efforts have not been satisfactory due to the lack of landowner cooperation. Potential breeding areas are almost entirely on private land and neither the Texas Parks and Wildlife personnel nor concerned knowledgeable individuals have been allowed enough access to adequately survey the area to date (Leachman 2002; Seyffert 2004).

Correspondence and data provided by Ken Seyffert indicates that the Mountain Plovers that once nested on short grass prairie in the northwest Texas panhandle have entirely switched to cultivated fields as their chosen colony sites. However these nests have are commonly plowed under during the nesting season, destroying eggs and hatchlings year after year drastically reducing nest success of those colonies.

Recent reports of nesting Mountain Plover in far west Texas rangeland indicate they still form colonies in that region. Failure to gain the trust of local landowners access to their lands in that area has prevented state biologists from directly mapping and counting the nest locations and breeding success rates. A combination of remote sensing and GIS modeling can greatly reduce the area of interest for the biologists to focus on obtaining landowner cooperation.

Purpose of the Study

The objective of this study is to define areas that are suitable west Texas breeding habitat for Mountain Plovers through the application of remote sensing and GIS, using existing available data and guided by literature published on the bird's breeding site characteristics.

Area of the Study

The area of the study will comprise most of west Texas. (See figure 1.) It will also include soil data derived from the southern high plains of the Texas Panhandle, Oklahoma panhandle, southwest Kansas, and eastern Colorado. This will cover the southern high plains Mountain Plover breeding regions studied by Shackford, (Shackford 1995), Horner, (Horner 1997), and Russell, (Russell 2004), as well as the spring sightings obtained from Ken Seyffertt (Seyffert 2004). The southern high plains nest sites from which only soil data is extracted are shown in figure 2.

Mountain Plover Nestsite Study Area

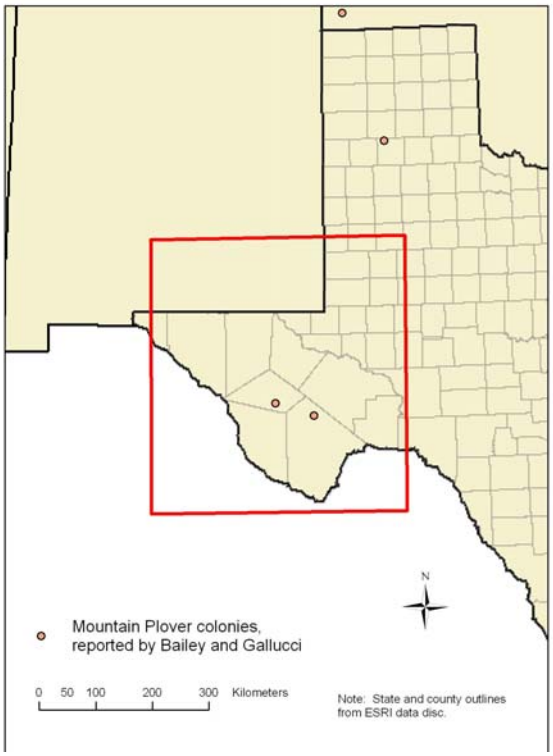


Fig. 1.

Mountain Plover South High Plains Nestsites

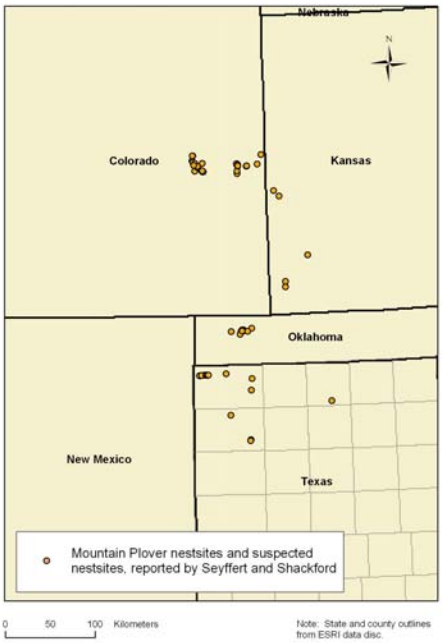


Fig. 2.

Literature Review

A great deal of work has been published on the Mountain Plover (Russell 2004). Knopf studied many aspects of the bird's wintering and breeding habitats (Knopf 1994), (Knopf 1996). Knopf and others have identified many characteristics that Mountain Plovers prefer for nestsite location (Graul 1975), (Russell 2004).

Historically the plovers have preferred short grass prairie for nest colony sites. Within the short grass they used to prefer even shorter grass such as what was found within buffalo wallows or Prairie Dog towns. Today within short grass prairie they prefer either large Prairie Dog towns or severely overgrazed cow pastures. If the chosen site is an overgrazed cow pasture, the nests are where the overgrazing is greatest, usually near the cattle trough or cattle tank(Higgertan 1989), (Russell 2004). A new habitat being used just the last two decades for nest sites is barren cultivated fields (Shackford 1995; Shackford 1999; Shackford 2000). A view of the recent south high plains nest locations and the satellite images covering them shows that nearly all the south high plains colonies have now shifted onto the cultivated fields. Here their nest success is drastically decreased as the eggs and young are commonly plowed under during late spring. This has lead to a steady decrease in surviving mountain Plovers in this region.

In west Texas, Bailey identified a Plover colony in Brewster county(Bailey 1905). Much more recently nesting was reported in Jeff Davis county during 1979 through 1989(Collins 2004), (Gallucci 1980), (Higgertan 1989).

The Environmental Research staff at Oak Ridge Laboratory have put together a list of some of the GIS modeling efforts in the literature (Environmental Sciences Division Oak Ridge Laboratory *Habitat models* 2004). They break down the efforts into three categories, inductive, deductive, and mixed. Based on that breakdown, this effort on Mountain Plover nesting habitat would fall under a mixed approach. The barrenness factor is obtained from the nestsites as is the clay content so these factors would be inductive. The slope, elevation range, and vegetation cover are from the literature and would fall under a deductive approach. The mixed approach was used by the Oak Ridge team on the habitat for Henslow's Sparrow (Environmental Sciences Division Oak Ridge Laboratory *Henslow's Sparrow habitat model* 2004) and the Cerulian Warbler. For the sparrow study, soil type was used deductively while remote-sensed landcover was used inductively from known nestsites. For the Cerulian Warbler habitat prediction (Laboratory 2004), the team again used soils deductively but used ground-mapped landcover(tall trees) deductively as well. They then used remote-sensed spectral response at known nestsites inductively.

Beauvais modeled Mountain Plover habitat preferences to determine where else they might occur in eastern Wyoming (Beauvais 1999). He used overlays of landcover, soil

type, and slope in his model. A few years later Beauvais constructed predictive models for other species occurrence in which he added additional habitat preferences to better refine the models (Beauvais 2004).

Lauver used GIS modeling to to predict suitability of habitat forLoggerhead shrikes nesting in Kansas. (Lauver, Busby, and Whistler 2002). His model was restricted to landcover classes and nesting density.

Data

Regardless which of three favored areas, overgrazed cow pasture, Prairie Dog towns, or barren fields is chosen, the Mountain Plovers prefer consistent characteristics. These are, low or no slope, clay rich soil, a degree of barrenness between 30 percent and 80 percent, and elevations below 6500' but above 2000' (May 2001). They also prefer areas that do not contain even occasional bush or tree species. Their preferred landcover, before cultivated fields became available, was some type of grassland as opposed to open savanna.

These five factors were modeled in GIS. The data for these factors were obtained from various sources.

Normalized Vegetation Index (NDVI), rasters were substituted for barrenness. These were obtained from processed Landsat images. The seven Landsat images were obtained from Texas Synergy (Texas Synergy 2004). They are 30-meter resolution images and they are of high quality, no haze or clouds.

Elevation range data was obtained from 11 U.S.G.S.1-degree National Elevation Datasets (NEDs) available at the website for Texas Natural Resources Information System (TNRIS) (Texas Natural Resources Information System 2004). This data is excellent in quality. Resolution was approximately 28 meters. It was reprojected and resampled to 30-meter resolution UTM NAD83 zone 13 data.

Slope data came from reprojecting, resampling, and processing the NED data mentioned above. Results of the processes looked very good.

Clay content of soils came from U.S.G.S. STATSGO digital data available at the U.S.G.S. website (National Resource Conservation Service 2004). This was vector data. It was clipped to the study extents and rasterized in the appropriate resolution and projection, using the attribute clay content as the raster value. This data looked very appropriate.

Landcover data came from a vector map available from the Texas Parks & Wildlife Department (Frye, Brown, and McMahan 1984). This map was originally produced at 1:500000 in a custom state-wide projection. The digital vector map was reprojected to UTM NAD83. It was clipped to the study area and rasterized to a 30-meter resolution using the vegetation code attribute as the raster value. Within the study area, the map contained 29 vegetation types and was deemed adequately detailed to serve this study.

Known nestsites were obtained from many sources. Texas panhandle locations were provided by Ken Seyffert (Seyffert 2004) and were accurate to 50 meters. Oklahoma, Kansas, and Colorado nestsites came from various publications authored by Shackeford (Shackford 1995), (Shackford 1999), (Shackford 2000). The Shackford nestsites are of about 400-meter accurracy. Jeff Davis nestsites were provided by Fred Collins (Collins 2004), Gallucci, (Gallucci 1980)and Higgertan (Higgertan 1989). The Jeff Davis nestsites are described to about 400-meter accuracy. The Brewster county colony site was reported by Vernon Bailey (Bailey 1905) and is the lowest accuracy of the set, approximately 1000 meters.

Methods of Analysis

The nesting habitat model was based on raster overlays of the five datasets mentioned above. A flow diagram is provided in figure 3.

The model was a simple five-raster overlay in which each raster had equal weight and was multiplied together.

The first step was to put each dataset into the UTM NAD83 zone 13 projection. The second step was to rasterize the two vector datasets, vegetation cover and the soil map. As mentioned above, the vegetation vector map was rasterized using the vegetation code as the raster value while the soil map was rasterized using the clay content as the raster value. Both of these rasters were sampled at 30-meter resolution to be compatible with the NDVI dataset. Also mentioned above, the elevation raster data was not projected so was projected and resampled in 30-meter resolution.

Slope data was calculated in the Spatial Analyst extension of ArcGis (ESRI *ArcGis* 2004)from the reprojected re-sampled NED data. The resulting slope data appeared excellent for this application.

The NDVI data set was calculated within the Image Analysis extension (Leica 2004) of ArcView 3.3 (ESRI *ArcView 3.3* 2004) and saved in an ESRI Grid format.

Optimum values for each of the five rasters was determined by noting values at known breeding sites. The five raster sets were then classed individually for suitability. A model was constructed to calculate the optimum areas for breeding.

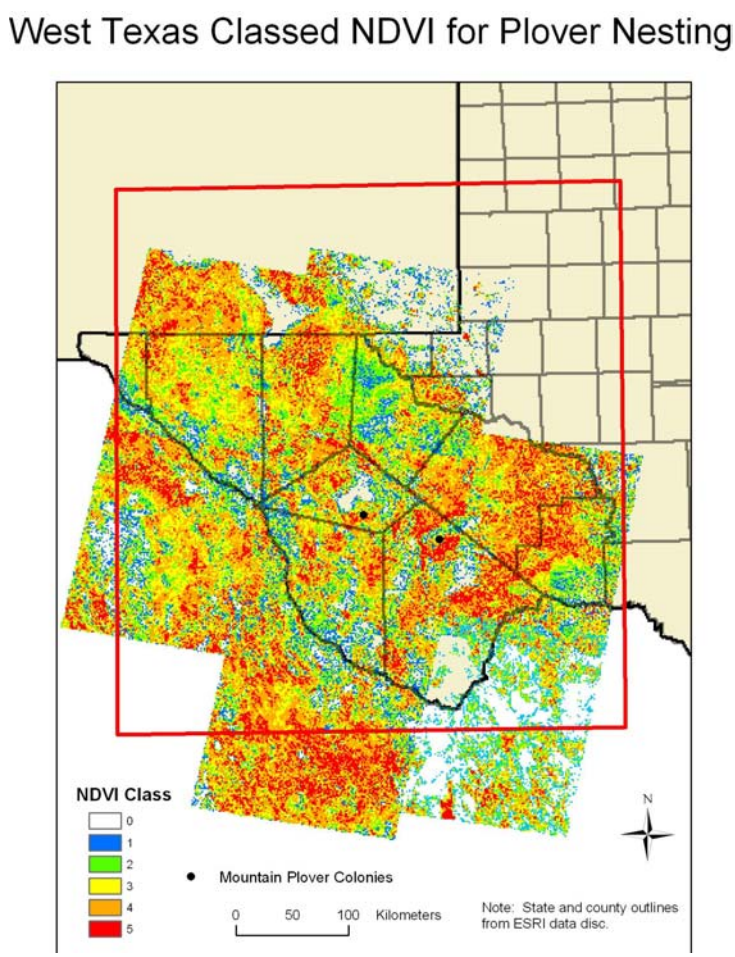
The seven west Texas NDVI rasters were classed based on the NDVI values at known west Texas nest sites. Because west Texas is very barren and has in places reddish soil, most areas were skewed slightly toward negative values. NDVI values ranged between –0.04 to +0.02 around known nests. Looking throughout the area, the NDVI rasters were reclassified into five classes as seen in table 1. The classed barrenness rasters are shown in figure 4.

Table 1.

NDVI Reclassification

NDVI Range	Class
-1.00 to -0.13	0
-0.13 to -0.11	1
-0.11 to -0.09	2
-0.09 to -0.07	3
-0.07 to -0.04	4
-0.04 to 0.02	5
0.02 to 0.05	4
0.05 to 0.07	3
0.07 to 0.09	2
0.09 to 0.11	1
0.11 to 1.00	0

Fig. 4.



Digital Soil maps were underlain on known south high plains nest sites (Fig. 2.). Soil polygons containing nest sites were selected with a spatial query and the clay-content statistics extracted. Clay-content for the west Texas nest sites was added to the clay content data set. From this data set the clay content for nesting habitat was classed as shown in table 2. The Soil layer covering west Texas was converted to raster and reclassified according to values in table 2. The classed clay content for west Texas is shown in figure 5.

Soils

Nestsite Clay

Area	Clay%
Jeff Davis Tx.	25.20%
Brewster Tx.	27.60%
Swisher Tx.	44.00%
Colorado	30.00%
Colorado	39.00%
Colorado	26.00%
Colorado	26.00%
Colorado	26.00%
Colorado	26.00%
Colorado	23.00%
Colorado	24.00%
Colorado	22.50%
Colorado	27.50%
Colorado	24.00%
Tx. Panhandle	24.00%
Tx. Panhandle	30.00%
Tx. Panhandle	39.00%
Tx. Panhandle	24.00%
Tx. Panhandle	30.00%
Tx. Panhandle	30.00%
Tx. Panhandle	27.00%
Tx. Panhandle	28.00%

Classification

Clay	Class
0 to 18%	0
18 to 20%	1
20% to 22%	2
22% to 24%	3
24% to 26%	4
26% to 30%	5
30% to 34%	4
34% to 38%	3
38% to 42%	2
42% to 46%	1
46% to 100%	0

Table 2.

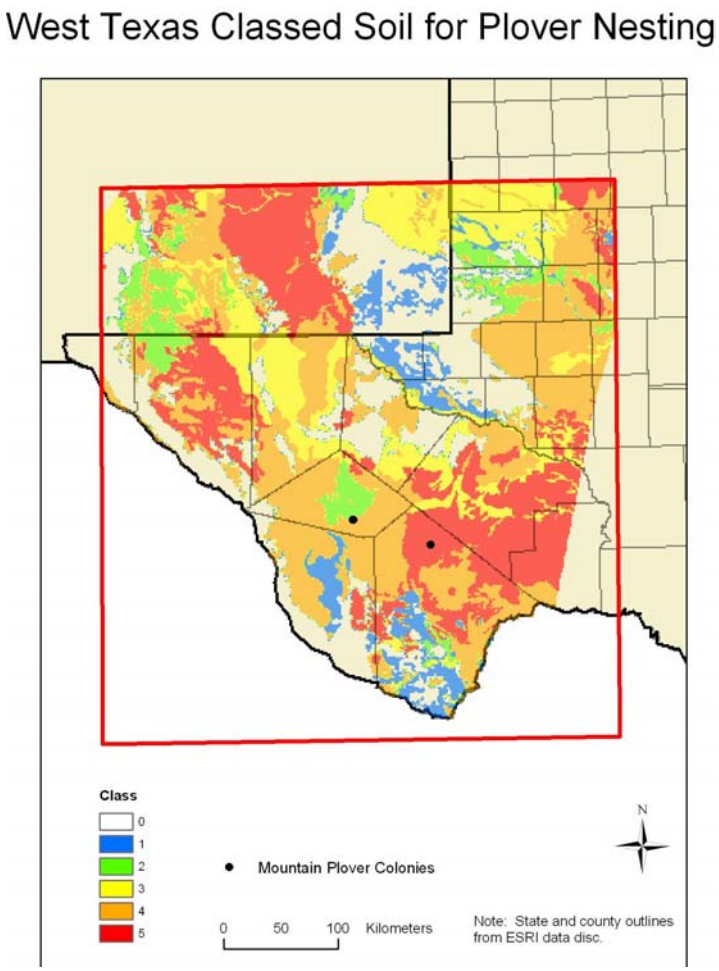


Fig. 5.

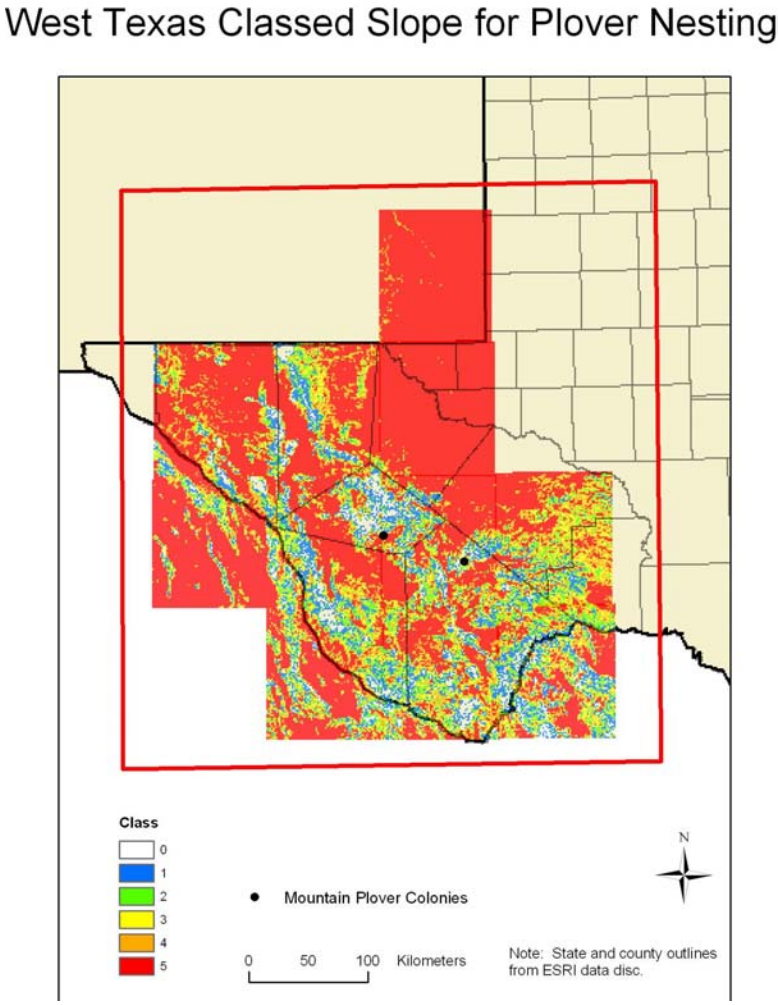
Slope was calculated from the 11 west Texas NEDs available through Texas Natural Resource Institute, (TNRIS). From the literature and the west Texas nestsites it was known that a slope of less than 2 degrees was desirable but that sites having slopes up to 5 degrees were occasionally used. Slope was reclassed according to values shown in table 3. The classed slope rasters are shown in figure 6.

Table 3.

Slope Classification

Slope	Class
0 to 2 deg.	5
2 to 3 deg.	4
3 to 4 deg.	3
4 to 5 deg.	2
5 to 6 deg.	1
above 6 deg.	0

Fig. 6.



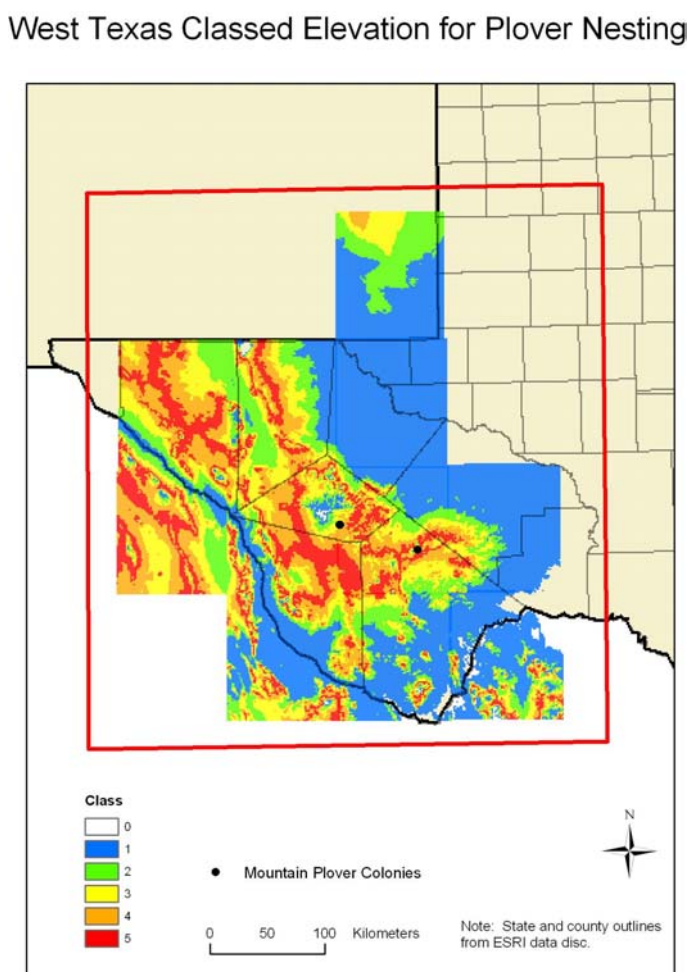
The eleven DEMs were also reclassed for the optimum elevation range. Again from the literature mentioned in the literature review, the elevation range was reclassified into suitability classes as shown in table 4. The optimum elevation class was purposely skewed towards the high end of the range found in the literature. This was because in going from Montana, through Wyoming, eastern Colorado and on down into west Texas, the similar habitat climbs in elevation, as the climate becomes warmer at constant elevation. The resulting elevation class rasters were merged into the single elevation range classed raster shown in figure 7.

Table 4.

Elevation Classification

Elevation	Class
0 to 700 m.	0
700 to 1100 m.	1
1100 to 1200 m.	2
1200 to 1300 m.	3
1300 to 1400 m.	4
1400 to 1500 m.	5
1500 to 1600 m.	4
1600 to 1700 m.	3
1700 to 1800 m.	2
1800 to 2000 m.	1
above 2000 m.	0

Fig. 7



Landcover for Texas was reprojected to UTM NAD83, converted to raster and clipped to west Texas. The resulting raster with 29 landcover types was classed from preferred cover as reported in Knopf (Knopf 1994), May (May 2001), and Russell , (Russell 2004). The reclassification is shown in table 5.

Table 5.

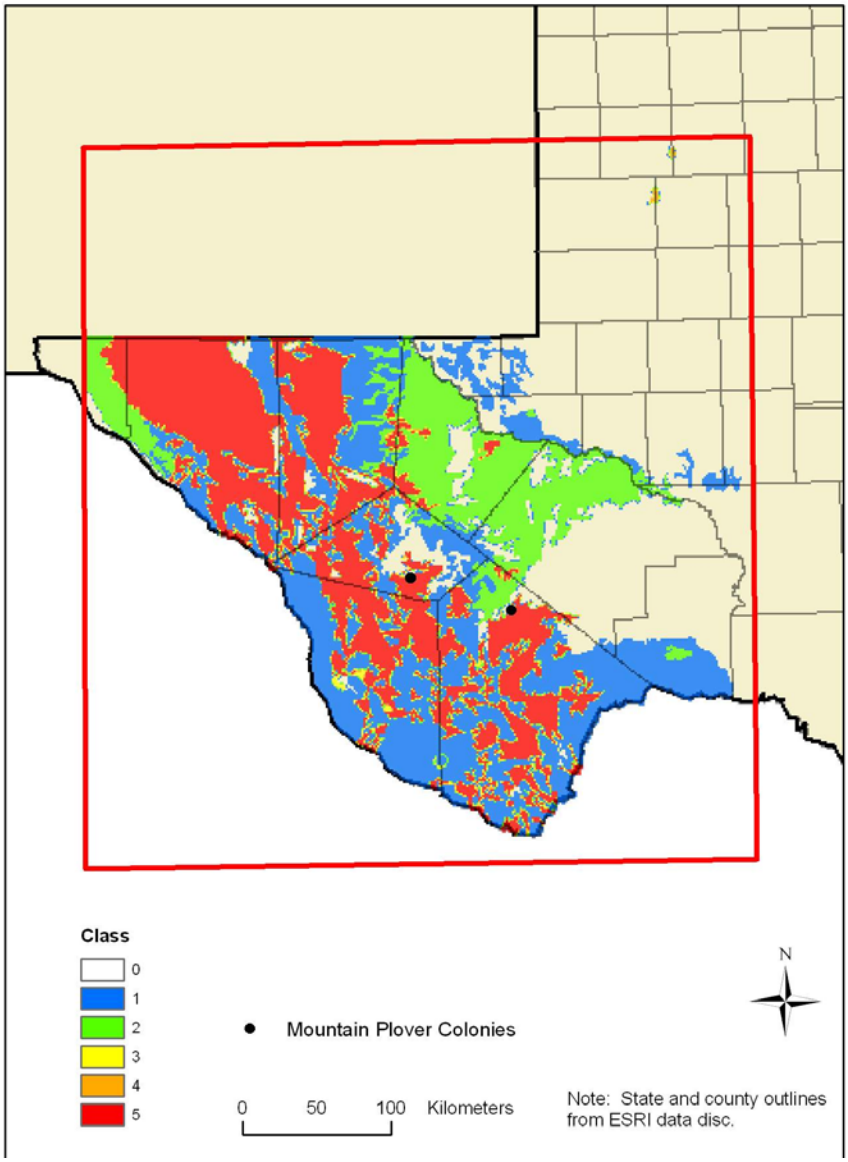
Landcover Classification

VEGCOVER	COUNT	code	class
4wing_salt_creo	7	9	1
blue_buffalo_gr	2	2	4
cedar_lake	1	47	0
cen_black_creo	1	10	0
cowood_berry_sc	1	37	0
creo_lech_sh	30	7	1
creo_mesq_sh	3	8	1
creo_mesqu_sh	16	8	1
creo_tarbush_sh	7	6	2
crops	41	44	0
goak_ppine_alju	15	29	0
hav_shin_oak_br	6	28	0
hsoak_mes_br	15	21	0
juniper	1	34	0
lake	1	47	0
mes_hackb_brwo	1	19	0
mes_jun_loak_br	9	13.3	0
mes_sandsage_sh	2	14	2
mes_scedar_brwo	5	18	0
mesq_junip_br	12	13.2	0
mesq_junip_sh	8	13.1	0
mesq_loteb_br	10	12.2	0
mesquite_brush	1	11.2	0
mesquite_shrub	13	11.1	0
popine_dfir	1	40	0
red_bluff_res.	1	47	0
tobosa_blackgr	29	1	5
urban	2	46	0
yucca_ocotil_sh	7	5	3

The resulting classed landcover for west Texas is shown in figure 8.

Fig. 8.

West Texas Classed Landcover for Plover Nesting



Finally, the five classed rasters were multiplied together to determine the optimum nestsite locations for Mountain Plovers. Multiplication was used because a low class in any one of the five categories would probably preclude that area from being used for a nestsite, in spite of all the other factors. Each of the five factors was given equal weight.

The result of the raster math was then reclassed into 8 classes to better represent the results. The reclassification table for this is shown in table 6.

Table 6.

Overlay Reclassification

product	new class
2400 to 3200	7
1950 to 2400	6
1450 to1950	5
1000 to 1450	4
500 to 1000	3
200 to 500	2
1 to 200	1
0 to 1	0

Results

The reclassed result is the objective of the study. It is shown in figure 9 and represents the best places to expect Mountain Plover nesting today in West Texas. The habitat model found seven to ten good habitat areas comprising about 2600 square miles. This map should facilitate locating additional Mountain Plover colonies in west Texas.

West Texas Suitable Habitat for Plover Nesting

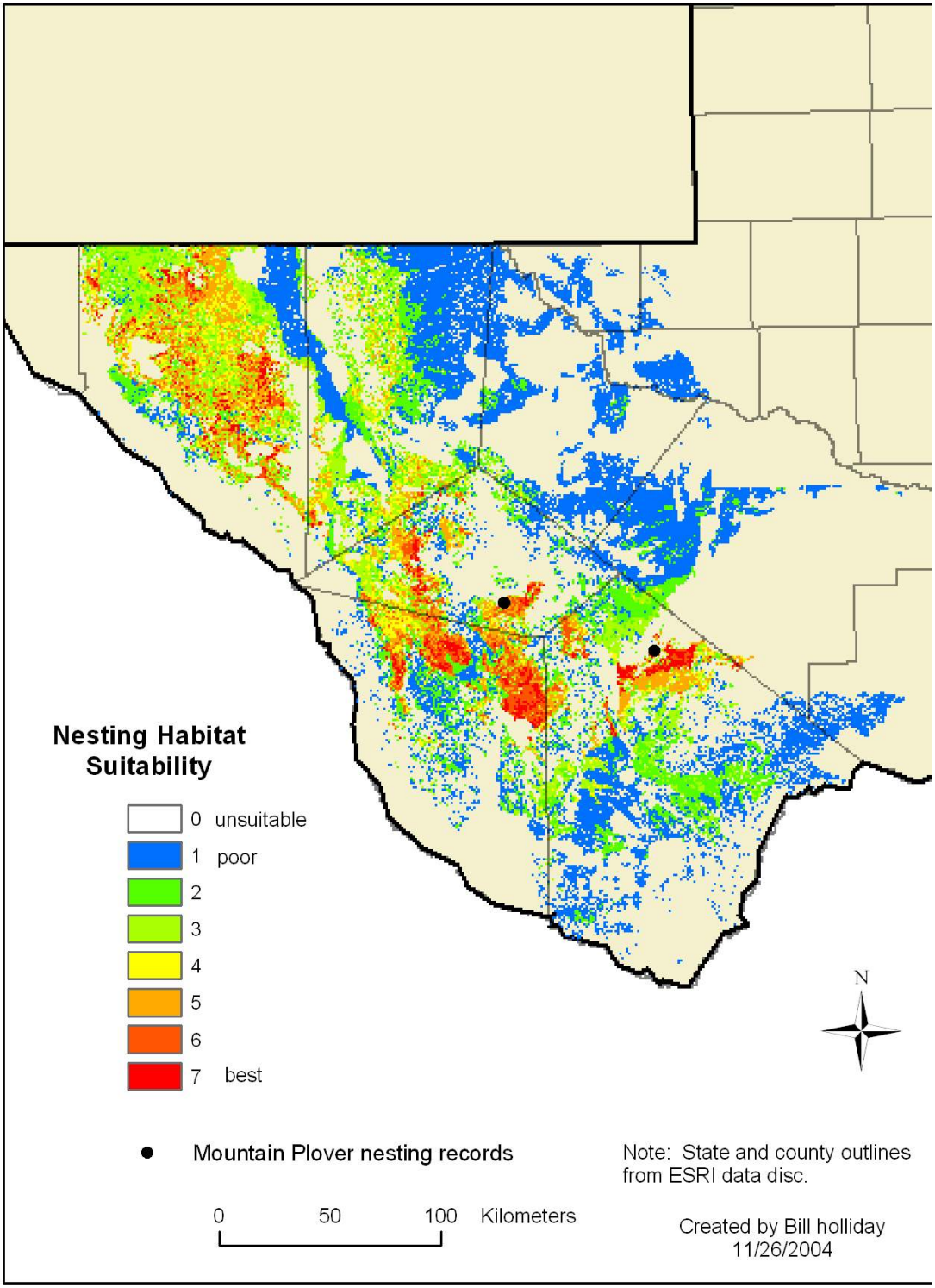


Fig. 9.

Discussion

One aspect of this study is the weak model verification. The study area was distant and most of the likely nestsite habitats were on private land, not accessible, ground-truthing was not practical. However, since three of the habit factors used in the model were deductive (slope, landcover and elevation range), it is reassuring that the known nestsites did fall within the optimum classes of those factors.

Considerable thought went into the use of NDVI rasters for barrenness. Because the plovers choose nestsites in late April to May 30th, the most useful images are those taken around late May. Because some years are wetter and so less barren than others, it would be ideal to obtain images taken each late May for a dozen years and to average these. Had a large source of money been available, this could have been done by purchasing all the appropriate images. However a search of available free 30-meter data, turned up only one or two years of images for each area needed. This was not enough to apply averaging to account for annual variation. An alternative source of NDVI data, that was derived from AHRR satellite sources, was checked into. That data, in addition to being of lower resolution (1 kilometer), was in a projection that would have been difficult to reproject to the common projection. That data appeared to be of lower quality as well. It was decided to go ahead with just one late May Landsat image as a source for each NDVI calculation. As a check on this, two different late May-early June images, separated by a year were transformed to NDVI rasters in Jeff Davis county. The optimum NDVI values

at the nestsites varied by 0.04 between the two NDVI data sets. The NDVI reclassification table reflects this variation. As can be seen in the table, the optimum NDVI value is set purposefully broad (-0.04 to +0.02) to account for the rainfall variation from year to year as was seen in the two images of the Jeff Davis nestsites. This treatment causes the barrenness factor to be slightly less discriminatory than it could have been had many more years of images been available for averaging. It should be noted Beavis, (Beauvais 1999), did not use NDVI or a remote sensed barrenness indicator in his Mountain Plover habitat model for Wyoming. It has been noted in the literature that the plovers will shift their colony locations with the wetness of the year, but usually remain in the same general area. Nevertheless year to year rainfall variations make the barrenness indicator (NDVI) problematic to apply in spite of its importance.

An additional criterion, the presence of Prairie Dog towns would have been useful. The Texas Parks & Wildlife Department has this detailed map and used it in a presentation at the Wildlife Diversity Conference, held August 18th to 20th, 2004 at San Marcos Texas. The map was constructed from 1-meter orthophotos so is very high resolution. However it is not available to researchers. Parks & Wildlife personnel indicate the map may be available in a year or two for researchers and the public(Whitlaw 2004). This layer could refine the optimum habitat somewhat but would be of lesser weight to those used here because other barren areas are equally preferable to the plovers.

Conclusions

The raster overlay technique used here for habitat modeling worked well. Approximately 2600 of the 70000 square kilometer study area was found to be suitable for Mountain Plover nestsites. The model provided discrete accurately located areas in which to search for additional Mountain Plover nest activity. Because the classed rasters were small in file size, it was possible to cover the entire west Texas at 30-meter resolution. Although the figures used in this report might look similar if the rasters had been of 500-meter cell size, the 30-meter resolution will allow the habitat prediction to be used on a much more local scale if needed in the future.

The use of five criteria in the model rather than two to four aided in defining suitable habitat.

Today, with digital data available from a variety of sources, suitable models can be built and processed with current GIS software and hardware relatively quickly. Models can be applied to large areas while still providing maps at relatively high detail.

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