



# Department of Defense Legacy Resource Management Program

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## **Landscape Analysis for Grassland Bird Conservation in the Eastern US**

### **Conservation Potential for Grassland Birds on Eastern United States Department of Defense Installations**

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**CONSERVATION POTENTIAL FOR GRASSLAND BIRDS ON  
EASTERN UNITED STATES DEPARTMENT OF DEFENSE  
INSTALLATIONS**



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## **Abstract**

Grassland birds have experienced greater population declines than any other group of birds, and population declines have been attributed to the dramatic decrease of native grasslands through clearing of non-forested land for agriculture or development, discontinued use of fire and fragmentation of large grasslands. Military lands comprise over 10 million ha of land in the US, and offer unique management opportunities to provide breeding and wintering habitat for birds in areas maintained in native grasses to facilitate military training through the use of prescribed burning and mowing. We used a coarse-filter approach to determine which military installations have the potential to provide grassland habitat. We also conducted a buffer analysis to determine if the extent of grassland within the military installation was representative of grassland habitat within the surrounding landscape, and determine how much potential the surrounding landscape (within 30 km) had for grassland restoration. Of the 186 land areas in the eastern US managed by the DOD, 45 contained at least 1 large (40 ha) patch of grassland, including 1 port managed by the Army Corps of Engineers, 23 Army, 3 Air Force, 3 Marine Corps, 11 Navy, and 4 National Guard installations, providing at least 65,000 ha of grassland in patches greater than 40 ha. The selected installations included 33 within 300 km of either the Atlantic Ocean or the Gulf of Mexico, most found in the southeastern US. The buffer analysis identified installations with different landscape composition than the surrounding landscape, indicating installations with greater grassland cover and other installations with less grassland cover. This analysis helps to target areas for conservation efforts that maximize limited funding for wildlife management while providing open areas needed for military activities and grassland bird habitat.

## **Introduction**

Grassland birds have experienced greater population declines than any other group of birds monitored by the Breeding Bird Survey (BBS; Askins 1993, Peterjohn and Sauer 1999). Reported population declines have been attributed to the dramatic decrease of native grasslands during the 20th Century through clearing of non-forested land for agriculture or development, discontinued use of fire and fragmentation of large grasslands (Herkert et al. 2003).

Land areas managed by the US Department of Defense (military lands) in the eastern US are one exception to the trend in loss of native grasslands. Some installations have maintained areas in native grasses to facilitate military training through the use of prescribed burning and mowing. There is an opportunity to provide training needs for the military and habitat needs for grassland birds simultaneously on Department of Defense (DOD) managed lands. Military lands comprise over 10 million ha of land in the US, and offer unique management opportunities to provide breeding and wintering habitat for birds (Cohen 1996, Eberly 2002). For example, military exercises that occur on Fort Campbell Army Base on the state border of Kentucky and Tennessee include airborne training into open “drop zones,” ground-based infantry, light-mechanized training, and various artillery ranges. These exercises require large areas of open lands to facilitate related training activities. Native grasslands provide ideal conditions for such training exercises because the grasslands are durable, provide great visibility, and can be managed cheaply and effectively using fire. Thus, the habitat conditions that provide suitable conditions for training activities also could provide breeding and wintering grassland bird habitat (Figure 1). Natural resource management can be integrated with the military mission to provide open habitats for military training and contribute to grassland conservation goals. Understanding

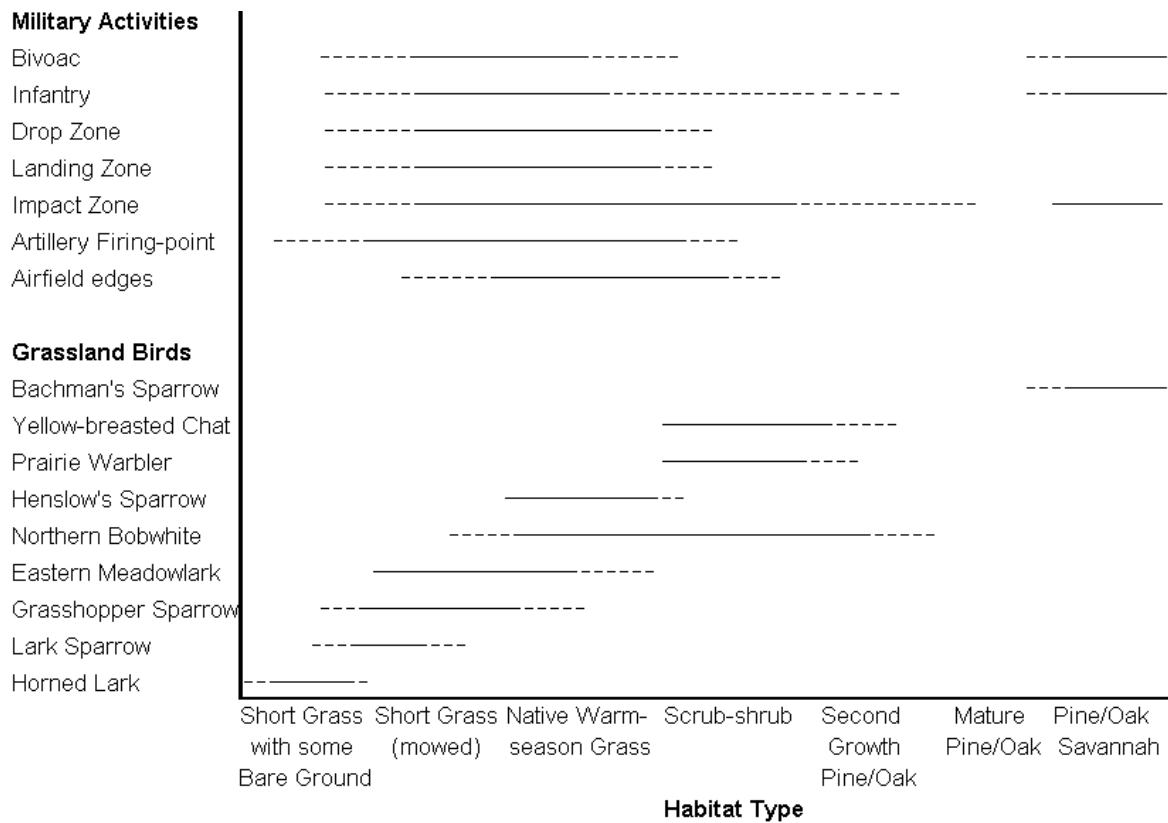


Figure 1. Ideal habitats for military training needs by activity type, and grassland bird habitat by species.

how military lands can contribute to the conservation of vulnerable grassland species is vital because of the extent and intensity of current management practices on these lands.

Management recommendations for grassland bird habitat include grassland patches of 40 ha or greater in a landscape matrix of at least 40% open (non-forested) habitat, preferably grassland (Sample and Mossman 1997, Fitzgerald et al. 2000, Ford et al. 2000, Knutson et al. 2001, Burhans 2002). The 40-ha patches allow for the management (e.g., prescribed burning, mowing) of between one-third (~13 ha) and one-half (20 ha) of the field in any 1 year while providing habitat for species needing conditions created 1 or 2 years after disturbance.

Because of security concerns and safety buffers maintained adjacent to active training areas, many military lands “exist as oases habitat in the midst of [habitat] fragmentation and developed landscapes (Eberly 2002).” This creates 2 challenges for the DOD when land managers try to maintain habitats needed for military training. First, as urban development around military installations pushes closer to the boundaries of the installation, the effective area that can be used for training is reduced to maintain safety buffers. Second, as grassland habitats outside the installations are converted because of urbanization and agriculture, grasslands within the installations become more important for species of concern. There is a need to understand how the landscape composition within military installations compares with lands near military installations. This understanding should help to prioritize areas for targeted grassland management outside the installation to reduce the military’s perceived “management burden” inside the installation.

Our first objective was to use a coarse-filter approach to determine (1) which military installations have the potential to provide grassland habitat by identifying military installations that contain large grassland patches ( $\geq 40$  ha) in the eastern US, (2) identify areas where open habitats (e.g., grassland, hayfields, agriculture) occupy a substantial portion of the landscape military installations occur in, and (3) overlay the areas of high diversity for obligate grassland birds during the breeding and wintering seasons in the eastern US. This coarse-filter approach helped identify which DOD installations in the eastern US could provide important wintering or breeding habitat for grassland bird conservation by examining landscape context and species diversity in installations containing at least 1 large grassland patch.

The second objective was to (1) conduct a buffer analysis to determine if the extent of grassland within the military installation was representative of grassland habitat within the surrounding landscape, and (2) determine how much potential the surrounding landscape (within 30 km) had for grassland restoration. This analysis helped to identify areas where military installations already contain more

grassland than the surrounding landscape and areas where partnerships with surrounding landowners would be most effective for the DOD and for grassland bird populations.

## **Methods**

***Characterizing grassland habitat-*** This study includes all DOD managed lands and military bases located in 26 states in the eastern US (east of the Mississippi River) with contiguous grassland patches greater than 40 ha within their boundaries. Using a GIS coverage of US federal lands, all military installations were mapped (US Geological Survey 2002). Using US Geological Survey (1992) National Land-use/Land-cover data (NLCD; 30 by 30-m pixels), we examined the presence and distribution of grassland habitats within generally open habitats (i.e., grasslands, barrens, scrub-shrub) in the eastern US.

We reclassified the NLCD values to reflect the potential value as grassland bird habitat of the land-cover type (Table 1). Land-cover types that provided some value as grassland habitat were assigned values greater than zero depending upon how much potential early-successional habitat occurred in each pixel. For example, areas classified as grasslands were assigned a value of 100 and areas classified as hay or pasture were assigned a value of 50. Areas that were generally treeless but provide no habitat value, like urban grasslands and agricultural lands, were assigned a value of 0. Finally, areas that did not provide any potential habitat value for grassland birds (e.g., forests, high-density urban, and commercial areas) were assigned a value of negative 100.

Table 1. National Land-use/Land-cover Data (NLCD) codes and habitat types used for analysis. The re-classification values indicate how relatively useful each habitat is as grassland bird habitat. Values greater than zero indicate grassland habitats. Values less than zero indicate hostile habitats. Habitat values equal to zero indicate neutral open habitats that do not provide habitat, but contribute to the "openness" of the landscape. Potential grassland habitats include all habitats that could be converted to native grasslands through various government programs or current grassland habitats.

<b>NLCD code</b>	<b>Habitat type</b>	<b>Re-classification value</b>	<b>Potential grassland habitats</b>
11	Water	0	
21	Low intensity residential	0	*
22	High intensity residential	-100	
23	Comercial/industrial/transportation	-100	
31	Bare rock/sand/ clay	0	
32	Quarries/strip mines/gravel pits	0	
33	Transitional	50	*
41	Deciduous forest	-100	
42	Evergreen forest	-100	
43	Mixed forest	-100	
51	Shrubland	50	*
61	Orchards/vineyards/other non-natural woody	0	
71	Grassland/herbaceous	100	*
81	Pasture/hay	50	*
82	Row crops	0	*
83	Small grains	0	*
84	Fallow	0	*
85	Urban/recreational grasslands (air strips)	0	*
91	Woody wetlands	-100	
92	Emergent herbaceous wetlands	100	*

For each group of 9 pixels, I calculated a regional sum for a 3-pixel by 3-pixel square (9 pixels, 0.81 ha) by adding the reclassified values of each of the 9 pixels and assigning the total to the group of pixels. This was done to reduce the amount of data to be processed across the eastern US by reducing the overall grain size of the analysis. Areas with values greater than zero were considered potential grassland habitat; areas with a value of 900 were considered optimal grassland habitat.

We then selected all open areas (0.81 ha) with values greater than 300 to ensure that selected areas had at least some existing grassland habitat. Adjacent grid-cells with open areas were aggregated into patches, and patches  $\geq 40$  ha were selected as potential grassland bird habitats. These patches represented grassland habitat availability. To obtain a measure of potential habitat (areas that could be restored to grasslands), all open, early-successional habitats were combined with all agricultural habitats (e.g., row crops and small grains; Table 1).

We examined grassland habitat availability and potential within military bases and in 3 concentric 10-km buffers around each of the DOD installations with at least 1 grassland patch  $\geq 40$  ha. We also calculated the proportion of open habitats within 30 km of the boundary of each selected installation including the interior of the installation to represent a measure of landscape context for each installation. The 30-km distance was assumed to be a maximum distance a bird would disperse within a breeding season from an initial nesting attempt. Finally, we calculated the proportion of each county in the eastern US providing grassland habitat or potential grassland habitat.

***Characterizing grassland bird distributions-*** We mapped the ranges of selected obligate grassland birds (Table 2) that have a major portion of their wintering and breeding range in the eastern US. We defined obligate grassland birds as any upland birds that use grasslands as their primary habitat for the breeding and wintering seasons, and place their nests within 0.5 m of the ground in grasses (Vickery et al. 1999).

Table 2: Obligate grassland bird species found in the eastern US during the breeding and wintering seasons (Vickery et al. 1999).

<b>Common name</b>	<b>Scientific name</b>	<b>Breeding</b>	<b>Wintering</b>
Upland Sandpiper	<i>Bartrama longicauda</i>	*	
Northern Harrier	<i>Circus cyaneus</i>	*	*
Short-eared Owl	<i>Asio flammeus</i>	*	*
Horned Lark	<i>Eremophila alpestris</i>	*	*
Sedge Wren	<i>Cistothorus platensis</i>	*	*
Bachman's Sparrow	<i>Aimophila aestivalis</i>	*	*
Vesper Sparrow	<i>Pooecetes gramineus</i>	*	*
Savannah Sparrow	<i>Passerculus sandwichensis</i>	*	*
Grasshopper Sparrow	<i>Ammodramus savannarum</i>	*	*
Henslow's Sparrow	<i>Ammodramus henslowii</i>	*	*
Le Conte's Sparrow	<i>Ammodramus leconteii</i>	*	*
Lapland Longspur	<i>Calcarius lapponicus</i>		*
Snow Bunting	<i>Plectrophenax nivalis</i>		*
Dickcissel	<i>Spiza americana</i>	*	*
Bobolink	<i>Dolichonyx oryzivorus</i>	*	
Eastern Meadowlark	<i>Sturnella magna</i>	*	*

Breeding range maps were produced for each species by compiling state breeding bird atlases where available to map counties where the birds were documented to exist (Laughlin and Kibbe 1985, Illinois Department of Natural Resources 1986-1991, Adamus 1987, Andrlle and Carroll 1988, Carolina Bird Club 1988-1995, Virginia Society of Ornithology 1989, Brewer et al. 1991, Peterjohn and Rice 1991, Brauning 1992, Enser 1992, Veit and Petersen 1993, Bevier 1994, Buckelew 1994, Foss 1994, Palmer-Ball 1996, Robbins 1996, Nicholson 1997, Castrale et al. 1998, Hess et al. 2000, Wiedenfeld and Swan 2000, Peterjohn 2001, Wisconsin Society for Ornithology 2002, Florida Fish and Wildlife Conservation Commission 2003). Some states did not have breeding bird atlases (Alabama, Georgia, and Mississippi), so data from the Breeding Bird Survey and other state map summaries were used (Turcotte and Watts 1999, Sauer et al. 2004). For wintering bird ranges, Christmas Bird Count summary range

maps were used to make county level maps of each of the grassland species (Audubon Society 1959 – 1988, Root 1988). From these range maps, we calculated the number of species potentially found in each county of the 26 states in the eastern US to determine areas of high grassland bird richness in the breeding and wintering seasons.

**Priority DOD installations-** To create a list of priority DOD installations for grassland conservation, each installation was classified by the amount of area in patches  $\geq 40$  ha (AREA), proportion of open habitats within 30 km of the installation (LANDSCAPE), number of potential wintering bird species (WINTERING), number of potential breeding bird species (BREEDING), number of high-priority breeding (HIGH PRIORITY BREEDING) and wintering (HIGH PRIORITY WINTERING) grassland bird species. Installations were categorized as having high, medium, or low values for AREA, LANDSCAPE, WINTERING, and BREEDING and were assigned values of 1 (high), 0.5 (medium) and 0 (low) (Table 3). HIGH PRIORITY BREEDING was calculated by summing the number of species on the Partner's in Flight Watch List (Pashley et al. 2000) divided by the maximum number at any 1 installation (3 species) to obtain values between 0 and 1. Watch list species included Henslow's Sparrow, Bachman's Sparrow, Dickcissel, Short-eared Owl, and Bobolink. HIGH PRIORITY WINTERING was calculated in a similar manner, but the maximum number of species at any 1 installation was 4.

Table 3. Definitions for priority scores used to calculate overall scores for conservation potential. Area is the number of hectares of large (> 40 ha) grassland patches within the installation boundaries. Landscape represents the proportion of open habitat within 30 km of the outside border of the installation. Species diversity represents the number of species of grassland birds within the county occupied by the installation as indicated by state Breeding Bird Atlases, Breeding Bird Surveys, Christmas Bird Counts, and other range maps as needed. Installations assigned to the high category are assigned a value of 1, medium are assigned a value of 0.5 and low are assigned a value of 0.

	<b>High</b>	<b>Medium</b>	<b>Low</b>
<b>Area (Ha)</b>	>500 ha	300-500 ha	<300 ha
<b>Landscape (%)</b>	>40%	20 to 40%	<20%
<b>Species richness, breeding (# species)</b>	>4	4	<4
<b>Species richness, winter (# species)</b>	>10	9 to 10	<9

Final priority scores were calculated on a scale from 0 to 10 using the following formulas:

**Overall Score** = (3 \* AREA) + (3 \* LANDSCAPE) + BREEDING + WINTERING + HIGH PRIORITY BREEDING + HIGH PRIORITY WINTERING;

**Breeding Score** = (3 \* AREA) + (3 \* LANDSCAPE) + (2 \* BREEDING) + (2 \* HIGH PRIORITY BREEDING);

**Wintering Score** = (3 \* AREA) + (3 \* LANDSCAPE) + (2 \* WINTERING) + (2 \* HIGH PRIORITY WINTERING);

The overall score represents the capacity of the installation to support breeding and wintering grassland birds, whereas the breeding score and the wintering score represent the capacity of the installation to

support grassland birds during the respective seasons. The scores weight the potential of the base to provide habitat (60%) greater than the richness of grassland species potentially present (40%). These scores reflect the assumption that the existence of the ideal land configuration (area and landscape) is generally more important than the species presence for the potential management of grassland species.

## **Results**

Of the 186 land areas in the eastern US managed by the DOD, 45 contained at least 1 large patch of grassland, including 1 port managed by the Army Corps of Engineers, 23 Army, 3 Air Force, 3 Marine Corps, 11 Navy, and 4 National Guard installations (Table 4). Military installations with significant grassland habitat were found throughout the eastern US providing at least 65,000 ha of grassland in patches greater than 40 ha (Figure 2). Selected installations were found in most states in the eastern US, except West Virginia, Illinois, Delaware, and all New England states. Most of the selected installations were concentrated in the Southeast, although there were a few installations clustered in Indiana, Kentucky, and Tennessee. Single installations were selected in Wisconsin, Michigan, New York, Ohio and Pennsylvania.

Table 4. Grassland bird conservation priority scores for selected military installations in the eastern US. Included are scores for the area of grassland large (>40 ha) patches, landscape composition, grassland bird species richness in the breeding and wintering seasons and a score for the presence of species of high conservation concern (Partners in Flight watch list). The overall (O), breeding (B) and winter (W) season scores represent the conservation potential for grassland birds with a score of 10 representing greatest potential.

Installation	Species richness		High concern		Scores <sup>1</sup>				
	Area	Landscape	Breeding	Wintering	Breeding	Wintering	O	B	W
Fort Campbell	1.0	1.0	1.0	1.0	1.0	0.5	9.5	10	9.0
Avon Park Bombing and Gunnery Range	1.0	1.0	0.5	1.0	0.3	1.0	8.8	7.7	10
Letterkenny Army Depot	1.0	1.0	1.0	0.5	1.0	0.3	8.8	10	7.5
Naval Weapons Support Center, Crane	1.0	1.0	1.0	0.5	0.7	0.5	8.7	9.3	8.0
Redstone Arsenal	1.0	1.0	1.0	0.5	0.7	0.3	8.4	9.3	7.5
Fort McCoy	1.0	1.0	1.0	0.0	1.0	0.3	8.3	10	6.5
Fort Jackson	1.0	0.5	1.0	0.5	0.7	0.8	7.4	7.8	7.0
Fort Bragg	1.0	0.5	0.5	1.0	0.3	1.0	7.3	6.2	8.5
Fort Detrick	0.5	1.0	1.0	0.5	0.7	0.5	7.2	7.8	6.5
Fort Rucker	0.5	1.0	0.0	1.0	0.3	1.0	6.8	5.2	8.5
Marine Corps Combat Development Command, Quantico	1.0	0.5	1.0	0.0	0.3	1.0	6.8	7.2	6.5
Fort Drum	1.0	0.5	1.0	0.0	1.0	0.3	6.8	8.5	5.0
Naval Submarine Base, Kings Bay	1.0	0.5	0.0	1.0	0.3	0.8	6.6	5.2	8.0
Fort Gordon	1.0	0.5	0.5	0.5	0.3	0.8	6.6	6.2	7.0
Fort A. P. Hill	1.0	0.5	0.5	1.0	0.0	0.5	6.5	5.5	7.5
Blue Grass Army Depot	1.0	0.5	0.5	0.5	0.7	0.3	6.4	6.8	6.0
Fort Stewart	1.0	0.5	0.0	1.0	0.3	0.5	6.3	5.2	7.5
Camp Blanding	1.0	0.5	0.0	1.0	0.3	0.3	6.1	5.2	7.0

Table 4. Continued.

Installation	Species richness				High concern		Scores <sup>1</sup>		
	Area	Landscape	Breeding	Wintering	Breeding	Wintering	O	B	W
Camp Atterbury	0.0	1.0	1.0	0.5	1.0	0.5	6.0	7.0	5.0
Fort Benning	1.0	0.0	0.5	1.0	0.3	1.0	5.8	4.7	7.0
Fort Polk	1.0	0.0	0.0	1.0	0.7	1.0	5.7	4.3	7.0
Eglin Air Force Base	1.0	0.0	0.0	1.0	0.3	1.0	5.3	3.7	7.0
Polaris Missile Facility	1.0	0.0	0.0	1.0	0.3	1.0	5.3	3.7	7.0
Fort Pickett	0.0	1.0	0.5	1.0	0.0	0.5	5.0	4.0	6.0
Naval Air Development Center, Warminster	0.0	0.5	1.0	1.0	0.3	1.0	4.8	4.2	5.5
Milan Army Ammunition Plant	0.0	0.5	1.0	1.0	0.7	0.5	4.7	4.8	4.5
Naval Air Station, Oceana	0.0	1.0	0.0	1.0	0.0	0.5	4.5	3.0	6.0
Fort Knox	0.0	0.5	1.0	1.0	0.7	0.3	4.4	4.8	4.0
Marine Corps Base, Camp Lejune	0.5	0.0	0.5	1.0	0.3	0.8	4.1	3.2	5.0
Fort Eustis	0.0	1.0	0.0	0.5	0.0	0.5	4.0	3.0	5.0
Port of Savannah	0.0	0.5	0.0	1.0	0.3	0.8	3.6	2.2	5.0
Hunter Army Airfield	0.0	0.5	0.0	1.0	0.3	0.8	3.6	2.2	5.0
Marine Corps Logistics Base, Albany	0.0	0.5	0.5	0.5	0.3	0.8	3.6	3.2	4.0
Ravenna Training and Logistics Site	0.0	0.5	1.0	0.5	0.3	0.3	3.6	4.2	3.0
Camp Grayling	0.5	0.0	1.0	0.0	0.7	0.3	3.4	4.8	2.0
Camp Peary	0.0	0.5	0.5	0.5	0.0	0.5	3.0	2.5	3.5
Naval Weapons Station, Yorktown	0.0	0.5	0.5	0.5	0.0	0.5	3.0	2.5	3.5
Earle Naval Complex	0.0	0.5	0.0	0.5	0.3	0.5	2.8	2.2	3.5
Camp Shelby	0.0	0.0	0.0	1.0	0.7	1.0	2.7	1.3	4.0
Langley Air Force Base	0.0	0.5	0.0	0.5	0.0	0.5	2.5	1.5	3.5
Craney Island US Naval Reservation	0.0	0.0	0.5	1.0	0.0	0.5	2.0	1.0	3.0
Little Creek Naval Amphibious Base	0.0	0.0	0.0	1.0	0.0	0.5	1.5	0.0	3.0
Fort Story	0.0	0.0	0.0	1.0	0.0	0.5	1.5	0.0	3.0
Volunteer Army Ammunition Plant	0.0	0.0	0.0	0.5	0.3	0.5	1.3	0.7	2.0
Naval Surface Warfare Center, Dahlgren	0.0	0.0	0.5	0.0	0.0	0.3	0.8	1.0	0.5

<sup>1</sup> O = Overall score, B = Breeding Score, W = Wintering Score; Shading indicates high (dark shading) and medium (gray shading) scores.

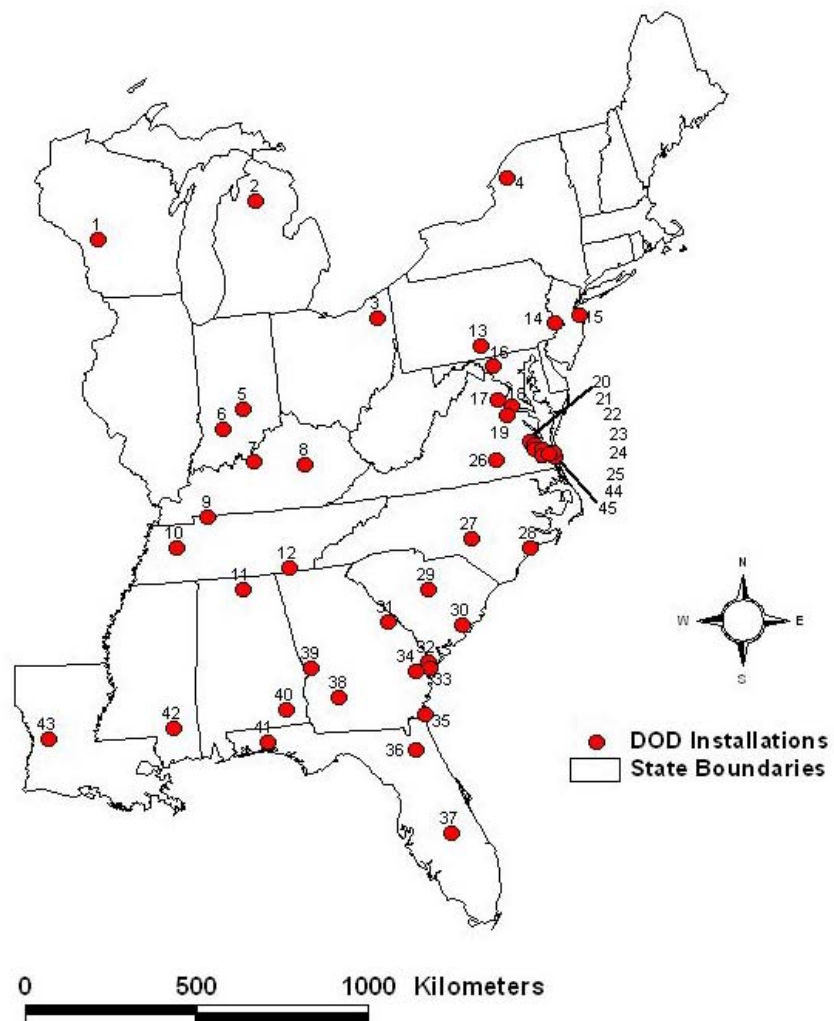


Figure 2. Department of Defense installations in the eastern US with at least on large (>40 ha) patch of grassland habitat (see table 4 for installation names and identification numbers).

The selected DOD installations were grouped into 4 regions including northern, inland central, northern-coastal, and southern-coastal (Figure 2). The northern region included installations from Wisconsin, Michigan, Ohio, and New York including 1 National Guard and 3 Army installations. The inland central region included 8 installations concentrated in Kentucky, Tennessee, southern Indiana, and northern Alabama in areas with relatively high proportions of existing grassland habitats including 1 National Guard, 1 Navy, and 6 Army installations (Figure 2).

The last 2 regions included 33 installations within 300 km of either the Atlantic Ocean or the Gulf of Mexico. The northern-coastal region included 16 installations in Virginia, Maryland, New Jersey, and southern Pennsylvania: 1 Marine Corps, 1 Air Force, 6 Army, and 8 Navy installations. Thirteen out of the 16 installations were relatively small (<15,000 ha). The southern-coastal region included 17 installations within 300 km of the coast in North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, and Louisiana: 1 port managed by the Army Corp of Engineers, 2 Air Force, 2 National Guard, 2 Navy, 2 Marine Corps, and 8 Army installations. Eleven of the 17 selected installations were greater than 20,000 ha in total area, including the 5 largest selected installations.

Overall, the installations ranged in size from 583 to 184,00 ha (Table 5). The proportion of large grassland patch habitats ranged from 0.6 to 51.2% of the installation with the proportion of potential grassland ranging from 4.8 to 71.2% of the installation. The difference between the proportion of grassland patches and proportion of potential grassland habitats represents the amount of habitat available for grassland restoration. This difference ranged from 2.8% to 46.6% (see Table 5).

Table 5. Selected military installations in the eastern US with the potential to provide significant grassland habitat for bird conservation.

Installation	ID		State	Region	Total area (Ha)	% 40-ha patches	% Open habitat	Species richness*	
	number	Type						Wintering	Breeding
Fort McCoy	1	Army	Wisconsin	Northern	25558	7.4	23.3	5	11
Camp Grayling	2	National Guard	Michigan	Northern	16100	2.9	12.1	7	9
Ravenna Training and Logistics Site	3	Army	Ohio	Northern	8295	1.0	17.9	9	8
Fort Drum	4	Army	New York	Northern	44009	17.7	32.0	8	10
Camp Atterbury	5	National Guard	Indiana	Inland central	16191	1.6	29.6	9	10
Naval Weapons Support Center, Crane	6	Navy	Indiana	Inland central	25165	3.3	14.0	9	9
Fort Knox	7	Army	Kentucky	Inland central	44389	0.6	6.2	11	5
Blue Grass Army Depot	8	Army	Kentucky	Inland central	6014	17.3	54.6	9	4
Fort Campbell	9	Army	Kentucky	Inland central	42772	6.3	20.5	11	7
Milan Army Ammunition Plant	10	Army	Tennessee	Inland central	10092	1.8	48.4	11	5
Redstone Arsenal	11	Army	Alabama	South-coastal	15740	4.8	25.2	9	5
Volunteer Army Ammunition Plant	12	Army	Tennessee	Inland central	2859	4.5	11.0	10	3
Letterkenny Army Depot	13	Army	Pennsylvania	North-coastal	7823	14.7	36.0	9	9
Naval Air Development Center, Warminster	14	Navy	Pennsylvania	North-coastal	1363	11.8	58.1	11	5
Earle Naval Complex	15	Navy	New Jersey	North-coastal	4065	2.0	4.8	10	3
Fort Detrick	16	Army	Maryland	North-coastal	852	51.2	71.2	9	8
Quantico Marine Corps CDC	17	Marines	Virginia	North-coastal	25070	3.5	11.1	8	6
Naval Surface Warfare Center, Dahlgren	18	Navy	Virginia	North-coastal	1159	5.6	25.3	8	4
Fort A. P. Hill	19	Army	Virginia	North-coastal	30304	2.3	9.3	11	4
Camp Peary	20	Navy	Virginia	North-coastal	3838	3.7	17.7	10	4
Naval Weapons Station, Yorktown	21	Navy	Virginia	North-coastal	4237	4.6	15.7	10	4
Fort Eustis	22	Army	Virginia	North-coastal	3262	6.7	35.2	10	3
Langley Air Force Base	23	Air Force	Virginia	North-coastal	1185	10.5	45.9	10	3
Craney Island US Naval Res	24	Navy	Virginia	North-coastal	1286	9.3	19.5	11	4

Table 5. Continued.

Installation	ID		State	Region	Total area (Ha)	% 40-ha patches	% Open habitat	Species richness*	
	number	Type						Wintering	Breeding
Naval Air Station, Oceana	25	Navy	Virginia	North-coastal	2136	5.7	38.3	12	3
Fort Pickett	26	Army	Virginia	North-coastal	15374	1.1	9.9	11	4
Fort Bragg	27	Army	North Carolina	South-coastal	53365	10.9	18.9	11	4
Marine Corps Base, Camp Lejune	28	Marines	North Carolina	North-coastal	41329	1.1	7.2	12	4
Fort Jackson	29	Army	South Carolina	South-coastal	21331	6.4	18.1	10	5
Polaris Missile Facility	30	Navy	South Carolina	South-coastal	7308	8.8	26.2	14	2
Fort Gordon	31	Army	Georgia	South-coastal	22384	7.0	21.8	10	4
Port of Savannah	32	Port	Georgia	South-coastal	583	10.4	21.0	11	3
Hunter Army Airfield	33	Army	Georgia	South-coastal	2064	9.4	36.3	11	3
Fort Stewart	34	Army	Georgia	South-coastal	113135	2.8	9.8	11	3
Naval Submarine Base, Kings Bay	35	Navy	Georgia	South-coastal	5614	12.7	31.6	12	2
Camp Blanding	36	National Guard	Florida	South-coastal	29932	23.0	33.1	12	2
Avon Park Bombing and Gunnery Range	37	Air Force	Florida	South-coastal	34084	29.3	51.4	11	4
Marine Corps Logistics Base, Albany	38	Marines	Georgia	South-coastal	1438	8.6	33.8	10	4
Fort Benning	39	Army	Georgia	South-coastal	74199	1.1	6.8	12	4
Fort Rucker	40	Army	Alabama	South-coastal	23920	1.7	11.3	12	3
Eglin Air Force Base	41	Air Force	Florida	South-coastal	184793	7.6	14.0	12	3
Camp Shelby	42	National Guard	Mississippi	South-coastal	3203	3.0	18.7	12	3
Fort Polk	43	Army	Louisiana	South-coastal	46036	3.0	8.2	13	3
Fort Story	44	Army	Virginia	North-coastal	599	13.0	21.5	12	3
Little Creek Naval Amphibious Base	45	Navy	Virginia	North-coastal	660	9.6	24.6	12	3
<b>AVERAGE</b>					<b>22780</b>	<b>8.3</b>	<b>24.6</b>	<b>10.4</b>	<b>4.7</b>

\* Species richness is the maximum number of species possible in the county or counties occupied by the installation. Darker shading indicates high species richness, light gray shading indicates medium species richness and white indicates low species richness.

Existing grassland patches were concentrated in 5 different areas including southern Wisconsin, southern Florida, southern Louisiana, central Pennsylvania to northern Virginia, and a line from southern Illinois and Kentucky extending northeast to northwest New York (Figure 3). Areas considered potential grassland habitat were concentrated in the prairie peninsula extending from central Illinois to central Ohio and the Atlantic coastal plain including Florida (Figure 4).

Species richness for obligate grassland birds during the breeding season was concentrated in the northern states from Wisconsin south to Illinois and east to New York (Figure 5). Species richness ranged from 2 to 11 (mean = 5.4) breeding obligate grassland species in the counties containing the selected military installations (Table 5). Species richness for obligate grassland birds during the wintering season was concentrated in the southern states along the Gulf of Mexico (Louisiana, Alabama, Mississippi, and northern Florida) and along the coast of the Atlantic Ocean (South Carolina, through North Carolina to Virginia; Figure 6). Species richness in the wintering season ranged from 5 to 14 (average 10.4) in the counties containing each of the selected military installations (Table 5). Most installations contained  $\geq 9$  wintering grassland species (out of 14 total). Individual potential breeding and wintering species for each base are included in Appendix 1 and 2.

Prioritization of the 45 selected military installations resulted in 24 installations with relatively high ( $>5$ ) scores for the overall capacity to provide habitat for grassland birds during the breeding and wintering seasons (Table 4). Scores for breeding habitat were relatively high for 20 installations, and scores for wintering habitat were relatively high for 30 installations. The top 20 installations included 16 Army, 1 Marine Corps, 1 Air Force, and 2 Navy installations.

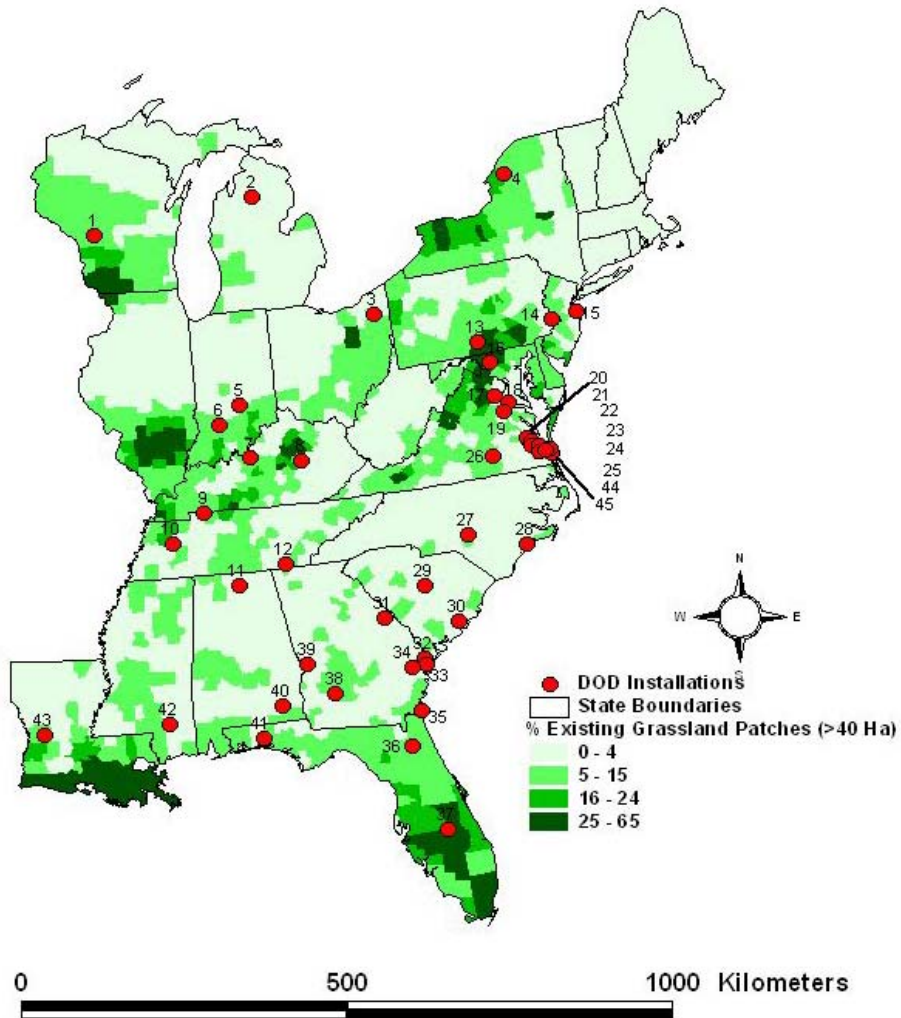


Figure 3. Proportion of existing large (>40 ha) grassland patches in the eastern US by county. Darker areas represent higher proportions. The red dots represent selected Department of Defense installations (see table 5 for installation names and identification numbers).

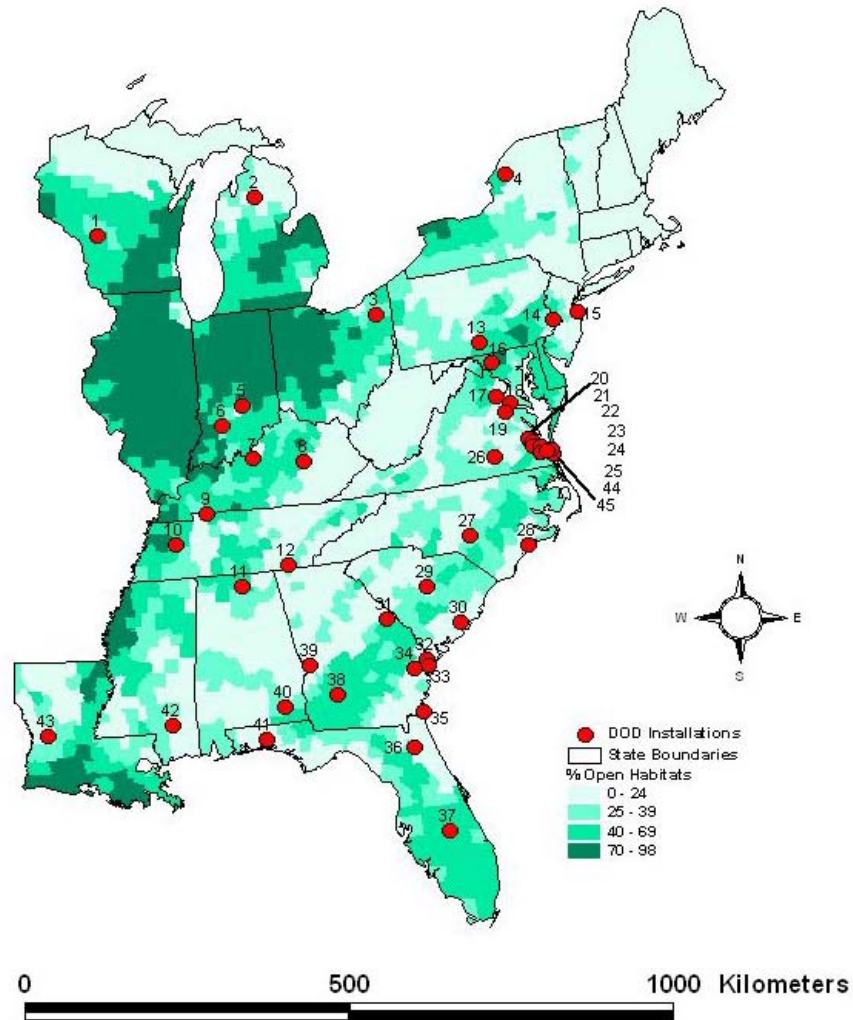


Figure 4. Proportion of open habitats (e.g., native grasslands, hay-fields, and other agricultural lands) in the eastern US by county. The open habitats represent potential areas for grassland restoration. Darker areas represent higher proportions. The red dots represent selected Department of Defense installations (see table 5 for installation names and identification numbers).

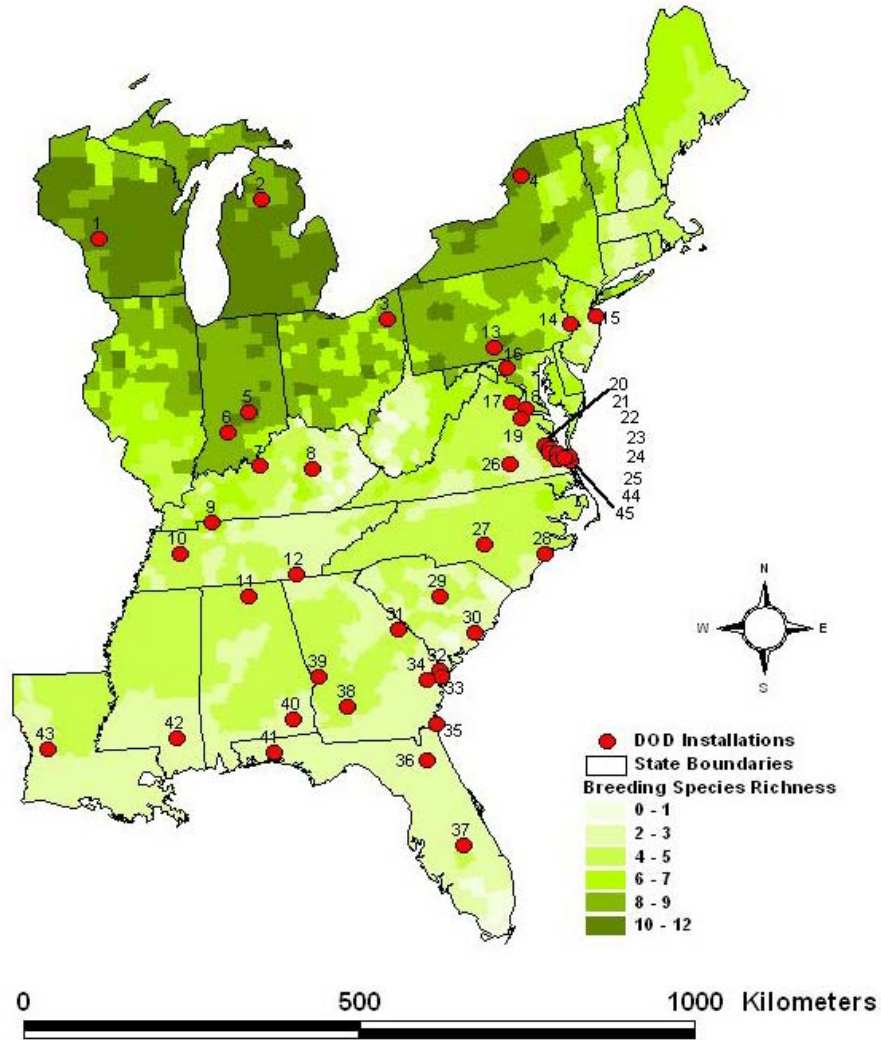


Figure 5. Species richness of breeding grassland birds in the eastern US by county. Range maps were compiled from Laughlin and Kibbe 1985, Illinois Department of Natural Resources 1986-1991, Adamus 1987, Andrie and Carroll 1988, Carolina Bird Club 1988-1995, Virginia Society of Ornithology 1989, Brewer et al. 1991, Peterjohn and Rice 1991, Brauning 1992, Enser 1992, Veit and Petersen 1993, Bevier 1994, Buckelew 1994, Foss 1994, Palmer-Ball 1996, Robbins 1996, Nicholson 1997, Castrale et al. 1998, Hess et al. 2000, Wiedenfeld and Swan 2000, Peterjohn 2001, Wisconsin Society for Ornithology 2002, Florida Fish and Wildlife Conservation Commission 2003, Turcotte and Watts 1999, Sauer et al. 2004 (see table 5 for installation names and identification numbers).

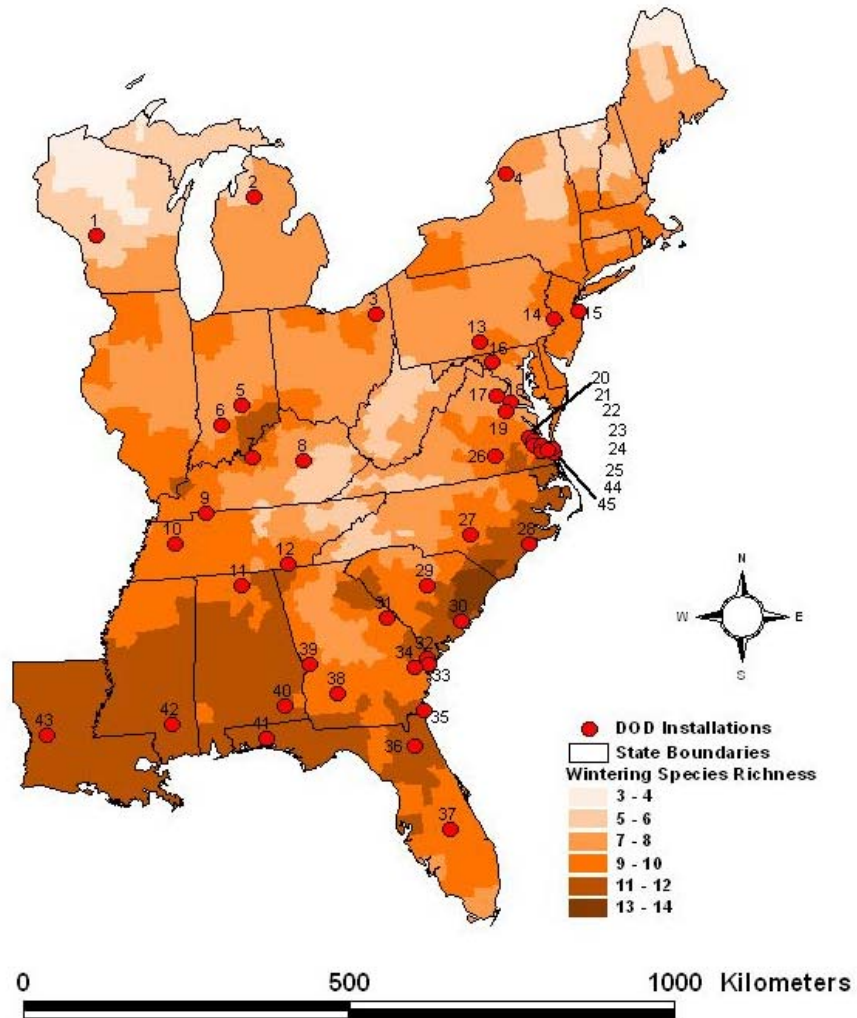


Figure 6. Species richness of wintering grassland birds in the eastern US by county. Range maps were compiled from Christmas Bird Count summary range maps (Audubon Society 1959 – 1988, Root 1988; see table 5 for installation names and identification numbers).

Overall, the average proportion of large grassland patches was generally similar within the installations to the proportion outside the military installation (up to 30 km), but the proportion of potential habitat was generally greater outside the military installations (Appendix 4). For installations >7,500 ha, the proportion of large grassland patches within the military installations was generally similar (plus or minus 5%) to the proportion of grassland patches in each of the 3 concentric 10-km buffer areas around the bases. For these larger installations, the proportion of potential habitats was generally greater outside the installation than inside the boundaries. Installations <7,500 ha showed a different pattern; smaller installations had a greater proportion of potential habitat inside the boundaries (Table 6).

Table 6. Buffer analysis for selected military installations in the eastern US. Percent patches (Patches) represents the proportion of large (>40 ha) existing grassland patches within the installation and in each of the three 10-km buffers around the installation. Percent potential (Potential) includes all agricultural lands as well as existing grasslands indicating the potential for grassland restoration. The difference indicates how different the proportion of landcover within the installation is from the average proportion of landcover in the three buffers. Negative numbers indicate the installation has less grassland (Patches) or open habitat (Potential) than the surrounding landscape, while positive numbers indicate the installation has more grassland or open habitat than in the surrounding landscape.

Name	Total area											
	(ha)	Patches	Potential	Patches	Potential	Patches	Potential	Patches	Potential	Patches	Potential	
Eglin Air Force Base	184793	7.6	14.0	3.7	18.9	2.7	17.6	4.0	20.9	4.1	-5.2	
Fort Stewart	113135	2.8	9.8	2.0	25.6	3.9	26.7	4.8	30.9	-0.7	-17.9	
Fort Benning	74199	1.1	6.8	2.5	14.0	2.2	16.8	2.4	18.1	-1.3	-9.5	
Fort Bragg	53365	10.9	18.9	0.3	23.2	0.3	31.1	0.6	33.6	10.5	-10.4	
Fort Polk	46036	3.0	8.2	3.4	12.3	8.6	18.2	5.5	14.7	-2.8	-6.9	
Fort Knox	44389	0.6	6.2	7.9	39.0	7.8	44.0	8.8	43.7	-7.6	-36.0	
Fort Drum	44009	17.7	32.0	15.0	29.5	14.2	29.6	14.4	30.5	3.2	2.2	
Fort Campbell	42772	6.3	20.5	11.1	50.3	11.8	44.0	10.0	40.6	-4.7	-24.4	
Marine Corps Base, Camp Lejeune	41329	1.1	7.2	0.8	11.0	1.6	13.8	1.4	13.6	-0.2	-5.6	
Avon Park Bombing and Gunnery Range	34084	29.3	51.4	35.0	53.9	36.7	53.0	43.4	59.2	-9.1	-4.0	
Fort A. P. Hill	30304	2.3	9.3	5.0	30.3	3.0	24.4	3.0	21.6	-1.4	-16.1	
Camp Blanding	29932	23.0	33.1	10.7	25.6	8.6	24.1	4.5	19.6	15.1	10.0	
Fort McCoy	25558	7.4	23.3	12.8	45.5	10.5	42.5	10.2	41.3	-3.8	-19.8	
Naval Weapons Support Center, Crane	25165	3.3	14.0	11.9	56.1	9.3	61.8	8.2	63.9	-6.5	-46.6	
Marine Corps Combat Development Command, Quantico	25070	3.5	11.1	7.0	22.4	6.7	23.8	9.2	28.5	-4.1	-13.8	
Fort Rucker	23920	1.7	11.3	2.3	32.6	4.0	38.3	4.0	43.1	-1.8	-26.6	
Fort Gordon	22384	7.0	21.8	2.4	32.1	2.1	31.5	1.3	30.6	5.0	-9.6	
Fort Jackson	21331	6.4	18.1	0.5	17.1	0.7	22.0	0.3	21.1	5.9	-1.9	
Camp Atterbury	16191	1.6	29.6	4.1	60.4	4.4	67.0	4.9	63.1	-2.8	-33.9	
Camp Grayling	16100	2.9	12.1	2.4	10.0	1.9	15.3	1.8	15.1	0.9	-1.4	

Table 6. Continued.

Name	Total area (ha)	Installation		10-Km buffer		20-Km buffer		30-Km buffer		Difference*	
		Patches	Potential	Patches	Potential	Patches	Potential	Patches	Potential	Patches	Potential
Redstone Arsenal	15740	4.8	25.2	0.8	36.2	1.9	47.1	3.8	44.3	2.7	-17.4
Fort Pickett	15374	1.1	9.9	6.0	27.1	5.8	24.9	5.7	23.8	-4.8	-15.4
Milan Army Ammunition Plant	10092	1.8	48.4	4.6	59.6	5.7	53.5	13.0	62.4	-6.0	-10.1
Ravenna Training and Logistics Site	8295	1.0	17.9	5.0	43.6	5.3	41.8	6.1	37.6	-4.5	-23.1
Letterkenny Army Depot	7823	14.7	36.0	36.6	58.6	26.4	45.5	23.4	41.9	-14.0	-12.7
Polaris Missile Facility	7308	8.8	26.2	5.0	18.9	3.5	16.4	0.7	12.3	5.8	10.3
Blue Grass Army Depot	6014	17.3	54.6	15.0	50.3	5.5	27.8	9.7	30.6	7.2	18.4
Naval Submarine Base, Kings Bay	5614	12.7	31.6	18.3	28.0	13.0	20.9	14.8	22.9	-2.7	7.7
Naval Weapons Station, Yorktown	4237	4.6	15.7	0.5	15.6	2.7	17.5	3.4	19.6	2.4	-1.9
Earle Naval Complex	4065	2.0	4.8	4.0	23.1	1.1	11.6	2.7	16.3	-0.7	-12.2
Camp Peary	3838	3.7	17.7	2.0	18.5	2.9	19.1	3.9	19.8	0.8	-1.4
Fort Eustis	3262	6.7	35.2	1.4	14.1	2.2	22.5	3.1	21.1	4.5	15.9
Camp Shelby	3203	3.0	18.7	3.4	24.1	2.7	18.6	2.6	20.4	0.1	-2.3
Volunteer Army Ammunition Plan	2859	4.5	11.0	1.7	19.1	4.5	20.7	3.8	20.1	1.1	-9.0
Naval Air Station, Oceana	2136	5.7	38.3	1.7	20.0	2.0	21.1	3.0	21.2	3.5	17.6
Hunter Army Airfield	2064	9.4	36.3	14.1	29.2	12.1	25.1	3.9	13.9	-0.7	13.6
Marine Corps Logistics Base, Albany	1438	8.6	33.8	7.7	55.9	5.8	58.2	6.1	54.3	2.1	-22.3
Naval Air Development Center, Warminster	1363	11.8	58.1	0.4	30.3	1.3	26.8	4.6	30.2	9.7	29.0
Craney Island US Naval Res	1286	9.3	19.5	1.5	11.5	2.1	19.3	2.5	23.0	7.3	1.6
Langley Air Force Base	1185	10.5	45.9	4.3	13.3	1.5	7.3	1.3	15.3	8.1	34.0
Naval Surface Warfare Center, Dahlgren	1159	5.6	25.3	1.7	18.5	1.4	21.7	2.8	23.0	3.7	4.2
Fort Detrick	852	51.2	71.2	39.3	61.1	37.7	60.7	34.2	61.5	14.1	10.1
Little Creek Naval Amphibious Base	660	9.6	24.6	0.5	8.2	0.8	9.0	3.0	21.6	8.2	11.7
Fort Story	599	13.0	21.5	0.6	5.2	1.1	10.8	2.9	16.1	11.4	10.8
Port of Savannah	583	10.4	21.0	10.6	24.4	6.5	21.5	6.5	20.5	2.5	-1.2
<b>AVERAGE</b>		<b>8.3</b>	<b>24.6</b>	<b>7.3</b>	<b>29.4</b>	<b>6.6</b>	<b>29.2</b>	<b>6.9</b>	<b>29.9</b>	<b>1.3</b>	<b>-4.9</b>

\*- Dark shading indicates differences less than -5%, gray shading indicates differences between -5% and 5%, no shading indicates differences greater than 5%.

## Discussion

Installations in each region in the US shared basic characteristics related to the proportion of existing large grassland patches and potential grassland (generally open, early-successional and agricultural habitats) in the landscape, and species richness during the wintering and breeding seasons. Very few selected military installations were located in the northern region, and all were relatively large (>8000 ha). The low number may reflect that the northern states are dominated by forested habitats, and there are generally few installations in the northern states. Installations in this region generally had low species richness for wintering birds, but some of the greatest breeding species richness values recorded for any of the installations in this analysis. Fort Drum in New York and Fort McCoy in Wisconsin were among the top 12 installations in the prioritization list (Table 4). Both Army installations were located in landscapes with relatively large proportions of existing grasslands (see Figure 3), relatively great breeding grassland bird richness (see Figure 5), and potentially contain 3 out of the 5 high-priority grassland species during the breeding season (including Henslow's Sparrows, Dickcissels [Ft. McCoy only], Short-eared Owls [Ft. Drum only], and Bobolinks). The buffer analysis indicated the proportion of grassland habitats within Fort Drum was similar to the proportion of grasslands within 30 km of the base (Appendix 4). On the other hand, Fort McCoy was surrounded by an agricultural landscape (potential habitat > 40%), but the installation contained less grassland (existing and potential) habitat than the 3 surrounding 10-km buffers (Appendix 4). This suggests that past management at Fort McCoy allowed some of the grassland habitats to succeed to forests, and forest clearing for grassland restoration may be warranted.

The inland central region included 8 installations concentrated in Kentucky, Tennessee, southern Indiana, and northern Alabama in areas with relatively great proportions of existing grassland habitats, including 1 National Guard, 1 Navy, and 6 Army installations (Figure 2). These installations were located in an area with a relatively great proportion of existing grassland patches and relatively medium to

high species richness for wintering and breeding grassland species. On average, installations in this region had the smallest proportion of existing grassland patches, but the greatest proportion of potential grassland habitat (Table 4). These installations are at the southern extent of many of the breeding ranges and at the northern extent of many of the wintering ranges, which contributes to their disproportionate importance. The installations in this central region also may serve as important stopover sites for migrating birds during the fall and spring (Figure 2).

In the inland central region, Fort Campbell on the border of Kentucky and Tennessee, Redstone Arsenal in northern Alabama, and the Naval Weapons Support Center, Crane, Indiana were among the top 12 installations. These 3 installations had some of the greatest scores for breeding species because of the great overall grassland bird species richness. Also, at least 2 out of the 5 breeding species of high concern have been found in the county the installations occupy: Henslow's Sparrows (Fort Campbell and Crane only), Bachman's Sparrow (Fort Campbell and Redstone only), and Dickcissels (all 3). Fort Campbell is also at the northern extent of the range of the southern-breeding Bachman's Sparrow and near the southern extent of the range of the northern-breeding Henslow's Sparrow.

The buffer analysis indicated Fort Campbell and Crane had relatively low proportions of grassland habitat within the installation compared with the proportion of grassland habitat in the three 10-km buffers. This result implies these installations could manage for a greater proportion of grassland habitats. In contrast, Redstone in Alabama had relatively more grassland within the installation than in the surrounding landscape although the proportion was low (>5% of the total area). All 3 of these installations were located in landscapes with relatively high potential for grassland management; 36-64% potential grassland habitat in the surrounding buffers.

Fort Knox in Kentucky also deserves mention because it had the lowest proportion of existing grassland habitats of any of the 45 installations considered. This was true despite the relatively great proportion of potential grassland habitats within the inland central region; 20-68% potential grassland habitat in the surrounding buffers of all 8 installations. Even with the relatively low proportion of

grassland habitat within Fort Knox, small populations of Henslow's Sparrows, Eastern Meadowlarks, and Grasshopper Sparrows persist in the small patches of available habitat (personal observation). Local habitat conditions may be more important for habitat selection for these species, when the landscape has a relatively great proportion of potential grassland habitats (Giocomo 2005).

The last 2 regions included 33 installations within 300 km of either the Atlantic Ocean or the Gulf of Mexico. The northern coastal region included 16 installations in Virginia, Maryland, New Jersey, and southern Pennsylvania: 1 Marine, 1 Air Force, 6 Army, and 8 Navy installations. Thirteen of the 16 installations were relatively small (<15,000 ha). These installations were located in an area with relatively great proportion of existing grassland habitats, relatively low breeding species richness, and great wintering species richness.

Letterkenny Army Depot in Pennsylvania, Marine Corps Combat Development Command, Quantico in Virginia, and Fort Detrick in Maryland were among the top 12 installations on the priority list. Both Letterkenny and Fort Detrick potentially contain Bobolinks and Dickcissels, and Letterkenny and Quantico may also provide breeding habitat for Henslow's Sparrows. Letterkenny and Quantico were relatively large (>7,500 ha) installations within a relatively open landscape (high potential grassland). Fort Detrick on the other hand was the smallest (852 ha) installation in the top 12, located in a landscape with the highest proportion of existing (~50%) and potential (>60%) grassland habitat. The inclusion of Fort Detrick in the top 12 demonstrates even a small military installation could be important for the conservation of grassland birds in the appropriate landscapes.

The southern coastal region included 17 installations within 300 km of the coast in North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, and Louisiana: 1 port managed by the Army Corp of Engineers, 2 Air Force, 2 National Guard, 2 Navy, 2 Marine Corps, and 8 Army installations. Eleven of the 17 selected installations were greater than 20,000 ha in total area, including the 5 largest selected installations. Most of these installations were located in areas with very little existing grassland, but great potential for grassland restoration because of the extensive agricultural

development in the region. These installations also had relatively low richness of breeding species, but the wintering species richness was among the greatest possible for the grassland obligate species considered in this analysis. Therefore, installations in this region may be especially important for wintering grassland species.

Avon Park in Florida, Fort Jackson in South Carolina, Fort Bragg in North Carolina, and Fort Rucker in Alabama were among the top 12 installations. All 4 installations had medium to large proportion of grassland habitats, low breeding species richness, and very high wintering species richness. Also, these installations potentially provide breeding and wintering habitat for Bachman's Sparrows.

Avon Park and Fort Rucker were located in landscapes with relatively great proportion of grassland and potential grassland habitats, but they both contained relatively less grassland habitat than the surrounding landscape (Appendix 4). Fort Jackson and Fort Bragg were on the other end of the landscape cover spectrum. Each contained relatively greater proportion of grassland habitat than the surrounding landscape (Appendix 4), thus providing an island of grassland habitat within a generally inhospitable landscape for grassland obligate birds.

Army installations made up the bulk of the land areas with significant grassland areas, because they tend to be large bases with open habitats for training. Several relatively small Navy and Marine installations were also selected, but this may be a product of including herbaceous wetlands in the landcover classification of grasslands. Installations in coastal areas contain large areas of herbaceous wetlands, as classified by the NLCD. These wetland areas were included as grassland because this habitat could not be differentiated from inland herbaceous wetland used by some of the obligate grassland birds considered in this analysis (e.g., Henslow's Sparrows), and because herbaceous wetlands may provide wintering habitat in the southeastern US.

The priority scoring did have some inherent limitations, which should be considered before using this kind of a scheme to rank priority areas for conservation investment. By grouping species richness and percent cover of large grassland into counties, I may be under-estimating or over-estimating the

importance of certain areas within the county. For example, certain parts of the county may have greater importance than others, and averaging within counties may obscure the importance. Averaging within counties was necessary because of the different mapping scales used by the various state breeding bird atlases. The county level was the most fine-grained resolution at which I could reliably map all of the atlas records. Mapping species richness and available habitat on a landscape scale was appropriate for the kind of coarse filter analysis conducted in this study to indicate areas that would require further consideration.

Savannah habitats, which are particularly prevalent in the Southeast, are difficult to detect in this analysis, but are important habitats for several grassland birds in the winter (Plentovich et al. 1999). This analysis may be underestimating the amount of potential wintering habitat by classifying these savannahs as forested habitats. This underestimation may be most important when trying to predict Bachman's Sparrow breeding habitat from NLCD, because Bachman's Sparrows use these habitats extensively for nesting (Tucker et al. 1998).

Finally, very little is known about wintering ranges and wintering habitat use (Herkert and Knopf 1998). Christmas Bird Count sampling for grassland birds is difficult at best, inaccurate at worst. The nomadic habits of some of these species and temperature-induced movements are problematic for mapping distribution and habitat use. Species, such as Dickcissels, are known to migrate to the Neotropics but are sometimes found within the US during the winter months. These individuals may not ultimately survive, thus at the population level their presence in the US may be insignificant.

Many breeding species specializing in grassland habitats are considered area sensitive, and tend to be found only in large habitat patches. For example, breeding Henslow's Sparrows, Grasshopper Sparrows, Eastern Meadowlarks and Dickcissels usually are found in larger (>40 ha) field habitats (Zimmerman 1988, Herkert 1994, Herkert et al. 2002). All 4 species have been affected by the changes in land use and land management that has reduced the amount and quality of habitat available to these bird species (Lanyon 1995, Vickery 1996, Temple 2002, Burhans 2002, Herkert et al. 2002). Farmers

converted native grasslands to cool-season forages for livestock and to small grains, which reduced nesting habitat quality. More recently, increasing urbanization and a shift from pastures and small grains to row crops of corn and soybeans have continued the decline in grass-dominated habitats (Rodenhoe et al. 1995). Military lands can be important for wildlife conservation because of the lack of urbanization or intensive agriculture (Quist et al. 2003). Another advantage of military installations is the relatively large areas with limited public access (Cohen 1996).

Military training can have negative impacts on the grassland bird populations and grassland habitats. Military training activities can cause direct mortality either by destroying nests or adult mortality (e.g., bird strikes with aircraft), although direct nest mortality can be minimized by avoiding important breeding areas during the breeding season (Giocomo 2005). Additionally, heavy track vehicles can cause soil compaction. This compaction can, in turn, change the plant communities and indirectly affect the grassland bird populations (Quist et al. 2003).

Military installations on lands managed by the DOD could have major positive impacts on the declining populations of bird and other wildlife species, which depend on frequent habitat disturbance to maintain early-successional habitats. Because many military activities require or cause the maintenance of large areas of open, grassy or shrubby habitats, tailoring habitat management to enhance grassland populations would not require major changes in existing management plans. The location of some of the larger eastern US military installations in landscapes with relatively large amounts of open habitats may also serve as a refuge for many grassland species displaced by modern, “clean” farming practices (Peterjohn 2003, Murphy 2003). With a few considerations to the type and timing of disturbances, military installations could serve as a model for other federal and private land management for the conservation of grassland habitats, and may even serve as control sites for comparison with grassland restoration efforts (Cohen 1996, Dykes 2005).

Successional transformation because of the suppression of fire is also a serious threat to the maintenance of grassland habitats. In eastern grasslands, succession from grassland habitats to forest

habitats can occur relatively fast, within 1 or 2 decades (DeSelm and Murdock 1993). If regular disturbance is not introduced to open habitats at least every few years through burning, mowing, grazing, or use of herbicides, forest will quickly overtake an area to make it unsuitable for use by grassland birds. On the other hand, increasing the amount of grassland habitat could ultimately reduce the amount of forest habitat provided by the military installations. There is a need to recognize the balance between forested habitats and grassland habitat on each base. There may be a unique mix of forest and grassland based on military training needs and needs of various species.

With the dramatic decrease of native grasslands during the 20th century, regional planning is becoming more important to restore populations of declining grassland bird populations (Pashley et al. 2000). Large-scale management recommendations call for a “core area” of native grassland surrounded by management zones measured in the thousands of hectares (Burhans 2002). In the eastern US, there are very few land areas containing grassland habitats that are not actively managed for agricultural production. There is not enough land area under public ownership to provide habitat for all grassland birds, but federally managed lands, especially DOD lands, could provide large enough core areas to build grassland conservation efforts around. Cooperation with private landowners will be important for the development of any successful plans.

This analysis will help to target areas where private lands could be managed for the benefit of grassland bird populations and the military. Targeting management and conservation efforts for grassland habitats in these installations could help to maximize limited funding for wildlife management while providing open areas needed for military activities.

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## **APPENDICIES**

Appendix 1. Potential wintering grassland bird species in selected military installations in the eastern U.S.

<b>Installation</b>	<b>State</b>	<b>Northern Harrier</b>	<b>Short-eared Owl</b>	<b>Horned Lark</b>	<b>Sedge Wren</b>	<b>Bachman's Sparrow</b>	<b>Vesper Sparrow</b>	<b>Savannah Sparrow</b>	<b>Henslow's Sparrow</b>	<b>Grasshopper Sparrow</b>	<b>Leconte's Sparrow</b>	<b>Lapland Longspur</b>	<b>Snow Bunting</b>	<b>Dickcissel</b>	<b>Eastern Meadowlark</b>	<b>Total</b>
Avon Park Bombing and Gunnery Range	Florida	1	1	0	1	1	1	1	1	1	1	0	0	1	1	<b>11</b>
Blue Grass Army Depot	Kentucky	1	1	1	0	0	1	1	0	0	0	1	1	1	1	<b>9</b>
Camp Atterbury	Indiana	1	1	1	0	0	1	1	1	0	0	1	1	0	1	<b>9</b>
Camp Blanding	Florida	1	1	1	1	1	1	1	1	1	1	0	1	0	1	<b>12</b>
Camp Grayling	Michigan	1	1	1	0	0	1	0	0	0	0	1	1	0	1	<b>7</b>
Camp Peary	Virginia	1	1	1	1	0	1	1	0	0	0	1	1	1	1	<b>10</b>
Camp Shelby	Mississippi	1	1	0	1	1	1	1	1	1	1	1	0	1	1	<b>12</b>
Craney Island US Naval Res	Virginia	1	1	1	1	0	1	1	0	0	1	1	1	1	1	<b>11</b>
Earle Naval Complex	New Jersey	1	1	1	0	0	1	1	0	1	0	1	1	1	1	<b>10</b>
Eglin Air Force Base	Florida	1	1	0	1	1	1	1	1	1	1	1	0	1	1	<b>12</b>
Fort A. P. Hill	Virginia	1	1	1	1	0	1	1	0	1	0	1	1	1	1	<b>11</b>
Fort Benning	Alabama	1	1	1	1	1	1	1	1	1	1	0	0	1	1	<b>12</b>
Fort Bragg	North Carolina	1	1	1	1	1	1	1	1	0	0	1	0	1	1	<b>11</b>
Fort Campbell	Kentucky	1	1	1	1	0	1	1	0	0	1	1	1	1	1	<b>11</b>
Fort Detrick	Maryland	1	1	1	0	0	1	1	0	1	0	1	1	0	1	<b>9</b>
Fort Drum	New York	1	1	1	0	0	1	1	0	0	0	1	1	0	1	<b>8</b>
Fort Eustis	Virginia	1	1	1	1	0	1	1	0	0	0	1	1	1	1	<b>10</b>
Fort Gordon	Georgia	1	0	1	1	1	1	1	1	1	0	1	0	0	1	<b>10</b>
Fort Jackson	South Carolina	1	0	1	1	1	1	1	1	1	0	0	0	1	1	<b>10</b>
Fort Knox	Kentucky	1	1	1	1	0	1	1	0	1	1	1	1	0	1	<b>11</b>
Fort McCoy	Wisconsin	1	1	1	0	0	0	0	0	0	0	1	1	0	0	<b>5</b>
Fort Pickett	Virginia	1	1	1	1	0	1	1	0	1	0	1	1	1	1	<b>11</b>

Appendix 1.Continued.

<b>Installation</b>	<b>State</b>	<b>Northern Harrier</b>	<b>Short-eared Owl</b>	<b>Horned Lark</b>	<b>Sedge Wren</b>	<b>Bachman's Sparrow</b>	<b>Vesper Sparrow</b>	<b>Savannah Sparrow</b>	<b>Henslow's Sparrow</b>	<b>Grasshopper Sparrow</b>	<b>Leconte's Sparrow</b>	<b>Lapland Longspur</b>	<b>Snow Bunting</b>	<b>Dickcissel</b>	<b>Eastern Meadowlark</b>	<b>Total</b>
Fort Polk	Louisiana	1	1	1	1	1	1	1	1	1	1	1	0	1	1	<b>13</b>
Fort Rucker	Alabama	1	1	0	1	1	1	1	1	1	1	1	0	1	1	<b>12</b>
Fort Stewart	Georgia	1	0	1	1	1	1	1	1	1	1	0	0	1	1	<b>11</b>
Fort Story	Virginia	1	1	1	1	0	1	1	0	1	1	1	1	1	1	<b>12</b>
Hunter Army Airfield	Georgia	1	0	1	1	1	1	1	1	1	1	0	0	1	1	<b>11</b>
Langley Air Force Base	Virginia	1	1	1	1	0	1	1	0	0	0	1	1	1	1	<b>10</b>
Letterkenny Army Depot	Pennsylvania	1	1	1	0	0	1	1	0	1	0	1	1	0	1	<b>9</b>
Little Creek Naval Amphibious Base	Virginia	1	1	1	1	0	1	1	0	1	1	1	1	1	1	<b>12</b>
Marine Corps Base, Camp Lejune	North Carolina	1	1	1	1	1	1	1	1	1	0	0	1	1	1	<b>12</b>
Marine Corps Combat Development Command, Quantico	Virginia	1	1	1	0	0	1	1	0	0	0	1	1	0	1	<b>8</b>
Marine Corps Logistics Base, Albany	Georgia	1	0	1	1	1	1	1	1	1	0	0	0	1	1	<b>10</b>
Milan Army Ammunition Plant	Tennessee	1	1	1	1	0	1	1	0	0	1	1	1	1	1	<b>11</b>
Naval Air Development Center, Warminster	Pennsylvania	1	1	1	0	0	1	1	1	1	0	1	1	1	1	<b>11</b>
Naval Air Station, Oceana	Virginia	1	1	1	1	0	1	1	0	1	1	1	1	1	1	<b>12</b>
Naval Submarine Base, Kings Bay	Georgia	1	1	0	1	1	1	1	1	1	1	0	1	1	1	<b>12</b>
Naval Surface Warfare Center, Dahlgren	Virginia	1	1	1	0	0	1	1	0	0	0	1	1	0	1	<b>8</b>
Naval Weapons Station Yorktown	Virginia	1	1	1	1	0	1	1	0	0	0	1	1	1	1	<b>10</b>
Naval Weapons Support Center, Crane	Indiana	1	1	1	0	0	1	1	0	0	0	1	1	1	1	<b>9</b>
Polaris Missile Facility	South Carolina	1	1	1	1	1	1	1	1	1	1	1	1	1	1	<b>14</b>
Port of Savannah	Georgia	1	0	1	1	1	1	1	1	1	1	0	0	1	1	<b>11</b>
Ravenna Training and Logistics Site	Ohio	1	1	1	0	0	1	1	0	1	0	1	1	0	1	<b>9</b>
Redstone Arsenal	Alabama	1	1	1	1	0	1	1	0	0	1	1	0	0	1	<b>9</b>
Volunteer Army Ammunition Plant	Tennessee	1	1	1	1	0	1	1	1	1	1	0	0	0	1	<b>10</b>

Appendix 2. Potential breeding grassland bird species in selected military installations in the eastern U.S.

<b>Installation</b>	<b>State</b>	<b>Upland Sandpiper</b>	<b>Northern Harrier</b>	<b>Short-eared Owl</b>	<b>Horned Lark</b>	<b>Sedge Wren</b>	<b>Bachman's Sparrow</b>	<b>Vesper Sparrow</b>	<b>Savannah Sparrow</b>	<b>Henslow's Sparrow</b>	<b>Grasshopper Sparrow</b>	<b>Leconte's Sparrow</b>	<b>Dickcissel</b>	<b>Bobolink</b>	<b>Eastern Meadowlark</b>	<b>Total</b>
Avon Park Bombing and Gunnery Range	Florida	0	1	0	0	0	1	0	0	0	1	0	0	0	1	<b>4</b>
Blue Grass Army Depot	Kentucky	0	0	0	0	0	0	0	0	1	1	0	1	0	1	<b>4</b>
Camp Atterbury	Indiana	0	1	0	1	1	0	1	1	1	1	0	1	1	1	<b>10</b>
Camp Blanding	Florida	0	0	0	0	0	1	0	0	0	0	0	0	0	1	<b>2</b>
Camp Grayling	Michigan	1	1	0	1	1	0	1	1	0	1	0	1	1	1	<b>10</b>
Camp Peary	Virginia	0	1	0	1	0	0	0	0	0	1	0	0	0	1	<b>4</b>
Camp Shelby	Mississippi	0	0	0	0	0	1	0	0	0	0	0	1	0	1	<b>3</b>
Craney Island US Naval Res	Virginia	0	1	0	1	0	0	1	0	0	0	0	0	0	1	<b>4</b>
Earle Naval Complex	New Jersey	0	0	0	0	0	0	0	0	0	1	0	0	1	1	<b>3</b>
Eglin Air Force Base	Florida	0	1	0	0	0	1	0	0	0	0	0	0	0	1	<b>3</b>
Fort A. P. Hill	Virginia	0	0	0	1	0	0	1	0	0	1	0	0	0	1	<b>4</b>
Fort Benning	Alabama	0	1	0	0	0	1	0	0	0	1	0	0	0	1	<b>4</b>
Fort Bragg	North Carolina	0	0	0	1	0	1	0	0	0	1	0	0	0	1	<b>4</b>
Fort Campbell	Kentucky	0	1	0	1	0	1	0	0	1	1	0	1	0	1	<b>7</b>
Fort Detrick	Maryland	0	1	0	1	0	0	1	1	0	1	0	1	1	1	<b>8</b>
Fort Drum	New York	1	1	1	1	1	0	1	1	1	1	0	0	1	1	<b>11</b>
Fort Eustis	Virginia	0	1	0	1	0	0	0	0	0	0	0	0	0	1	<b>3</b>
Fort Gordon	Georgia	0	0	0	1	0	1	0	0	0	1	0	0	0	1	<b>4</b>
Fort Jackson	South Carolina	0	0	0	1	0	1	0	0	0	1	0	1	0	1	<b>5</b>
Fort Knox	Kentucky	0	0	0	1	0	0	0	0	1	1	0	1	0	1	<b>5</b>
Fort McCoy	Wisconsin	1	1	0	1	1	0	1	1	1	1	1	1	1	1	<b>12</b>
Fort Pickett	Virginia	0	1	0	1	0	0	0	0	0	1	0	0	0	1	<b>4</b>
Fort Polk	Louisiana	0	0	0	0	0	1	0	0	0	0	0	1	0	1	<b>3</b>

Appendix 2. Continued.

<b>Installation</b>	<b>State</b>	<b>Upland Sampiper</b>	<b>Northern Harrier</b>	<b>Short-eared Owl</b>	<b>Horned Lark</b>	<b>Sedge Wren</b>	<b>Bachman's Sparrow</b>	<b>Vesper Sparrow</b>	<b>Savannah Sparrow</b>	<b>Henslow's Sparrow</b>	<b>Grasshopper Sparrow</b>	<b>Leconte's Sparrow</b>	<b>Dickcissel</b>	<b>Bobolink</b>	<b>Eastern Meadowlark</b>	<b>Total</b>
Fort Rucker	Alabama	0	0	0	0	0	1	0	0	0	1	0	0	0	1	<b>3</b>
Fort Stewart	Georgia	0	0	0	0	0	1	0	0	0	1	0	0	0	1	<b>3</b>
Fort Story	Virginia	0	1	0	1	0	0	0	0	0	0	0	0	0	1	<b>3</b>
Hunter Army Airfield	Georgia	0	0	0	0	0	1	0	0	0	1	0	0	0	1	<b>3</b>
Langley Air Force Base	Virginia	0	1	0	1	0	0	0	0	0	0	0	0	0	1	<b>3</b>
Letterkenny Army Depot	Pennsylvania	1	1	0	1	0	0	1	1	1	1	0	1	1	1	<b>10</b>
Little Creek Naval Amphibious Base	Virginia	0	1	0	1	0	0	0	0	0	0	0	0	0	1	<b>3</b>
Marine Corps Base, Camp Lejeune	North Carolina	0	1	0	1	0	1	0	0	0	0	0	0	0	1	<b>4</b>
Marine Corps Combat Development Command, Quantico	Virginia	0	0	0	1	0	0	1	1	1	1	0	0	0	1	<b>6</b>
Marine Corps Logistics Base, Albany	Georgia	0	0	0	1	0	1	0	0	0	1	0	0	0	1	<b>4</b>
Milan Army Ammunition Plant	Tennessee	0	0	0	1	0	1	0	0	0	1	0	1	0	1	<b>5</b>
Naval Air Development Center, Warminster	Pennsylvania	0	1	0	0	0	0	0	1	0	1	0	0	1	1	<b>5</b>
Naval Air Station, Oceana	Virginia	0	1	0	1	0	0	0	0	0	0	0	0	0	1	<b>3</b>
Naval Submarine Base, Kings Bay	Georgia	0	0	0	0	0	1	0	0	0	0	0	0	0	1	<b>2</b>
Naval Surface Warfare Center, Dahlgren	Virginia	0	0	0	1	0	0	1	0	0	1	0	0	0	1	<b>4</b>
Naval Weapons Station Yorktown	Virginia	0	1	0	1	0	0	0	0	0	1	0	0	0	1	<b>4</b>
Naval Weapons Support Center, Crane	Indiana	0	1	0	1	1	0	1	1	1	1	0	1	0	1	<b>9</b>
Polaris Missile Facility	South Carolina	0	0	0	0	0	1	0	0	0	0	0	0	0	1	<b>2</b>
Port of Savannah	Georgia	0	0	0	0	0	1	0	0	0	1	0	0	0	1	<b>3</b>
Ravenna Training and Logistics Site	Ohio	1	1	0	1	1	0	1	1	0	1	0	0	1	1	<b>9</b>
Redstone Arsenal	Alabama	0	0	0	1	0	1	0	0	0	1	0	1	0	1	<b>5</b>
Volunteer Army Ammunition Plant	Tennessee	0	0	0	0	0	0	0	0	0	1	0	1	0	1	<b>3</b>