Regional Assessments and Life-history Investigations of Problematic Birds on Military Airfields

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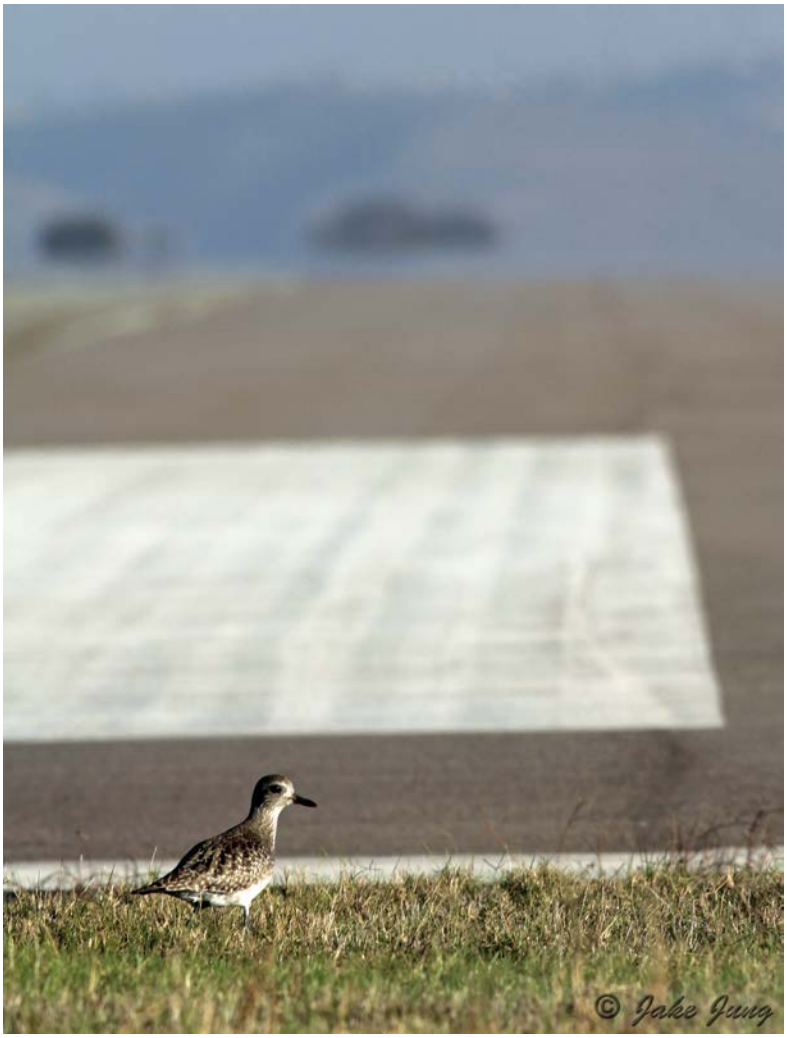

Jacob F. Jung, PhD
Richard A. Fischer, PhD

U.S. Army Engineer Research and Development Center
Environmental Laboratory
Vicksburg, MS

Introduction

Bird and other wildlife strikes to aircraft on Department of Defense (DoD) airfields continue to be a major concern in terms of both cost of damage to aircraft and loss of life, despite an extensive array of active and passive management techniques applied on and near airfields. Installation managers are actively seeking improved tools and better science to improve airfield management as a means to reduce wildlife/aircraft collisions. Details on which species pose the highest bird/wildlife aircraft strike hazard (BASH) risk on a regional basis, and in some cases on individual airfields, is needed to improve management that reduces BASH risk.

The presence of birds that contribute to BASH problems results from a complex array of interactions among their primary life history needs-- food, cover, and/or presence of water. Large birds that inhabit airfields typically are searching for prey (e.g., raptors that seek mammalian prey; Long-billed Curlews seeking insect prey). Smaller birds, such as grassland passerines (e.g., sparrows, meadowlarks) typically are present for food and cover resources. Wetlands and open water habitats on or near airfields attract flocks of both large (e.g., waterfowl) and small (e.g., blackbirds) birds. Both the Air Force and the Navy have comprehensive programs with extensive expertise to assist installations with these issues. The U.S. Navy is interested in how vegetation of varying heights on airfields might influence avian communities, and thus bird strikes, on and proximal to military airfields across the United States.

We hypothesized that life histories of most bird species attracted to airfield habitats do not largely include vegetation heights within the 7-14" (18-35 cm) range; and this range is what is most commonly implemented for airfield vegetation management. The 7-14" vegetation height regime often can be viewed as a suitable comprise for reducing bird use of airfields, and hence strikes, when viewed from a national perspective as most birds species in native habitats either prefer short or tall vegetation, and often do not heavily utilize the range in-between. That said, this range of heights is suitable for some species, but not for others, which is one factor contributing to a continuation of bird strikes on and near airfields. By conducting detailed life-history investigations of the most problematic birds on airfields, we further hypothesized that shifting to a tall-grass management regime may lead to further reduction in problematic bird use of airfields. For this study, references to "grass" generally refers to typical vegetation communities composed primarily of grasses (i.e., monocots) as well as other types of vegetation (e.g. forbs, legumes, and other non-woody vegetation). Our goal is to make vegetation height recommendations based on empirical strike data, and life-history information, in an attempt to minimize suitable habitat for problematic species on a regional or even individual airfield basis.

In this report, we have addressed the following objectives: 1) Examine the top ranking species groups and individual priority BASH species within each Landscape Conservation Cooperative (LCC; Figure 1) and classify each according to general life history and habitat use as either occupying short (< 18 cm) or tall (>35 cm) grass habitats, 2) provide vegetation height recommendations for each LCC, Navy Region and installation according to the best available science associated with bird/aircraft collisions on military airfields, and 3) indicate which species

are most likely to be impacted by varying vegetation management scenarios according to life history accounts.

We evaluated bird species that pose the highest BASH risks on airfields among LCC regions by investigating strike records obtained from the U.S. Air Force (USAF) Safety Center (1995-2016), U.S. Navy Safety Center (2009-2016), and the Federal Aviation Administration (FAA) (1995-2016) databases. We developed criteria to classify taxonomic groups of birds and applied a ranking system that incorporates life history traits, habitat use, and hazard scores derived from a previous study (Devault et al. 2011) to determine, by region, the highest priority species for management attention. Our regional recommendations address management of airfield vegetation, particularly with respect to vegetation height, and provide a general approach for hypothesis testing via future replicated vegetation management treatments. Our goal is to provide improved science that can better inform installation managers of spatial and temporal BASH and reduce probability of strike occurrences, regionally and on a seasonal basis, by problematic birds.

Background

This investigation centers on the paradigm that vegetation on military and civil airfields should be managed between 7-14 in (18-35cm) in height. This paradigm stems from work conducted in the United Kingdom in the late 20th century by Brough and Bridgeman (1980) and Deacon and Rochard (2000), and has largely been adopted by the FAA, U.S. Air Force, and on many U.S. Navy airfields. There is a general belief that vegetation management (i.e., typically maintenance of grass height by mowing) in the 7-14" range reduces the amount of seed production that attracts granivorous birds and mammals, reduces some flocking species due to reduction in ability to avoid predators, and minimizes habitat quality for small mammals, ground-nesting birds, and insects (Milroy 2007). While this vegetation height recommendation has some scientific underpinnings, many feel that guidelines should have a wider degree of latitude and allow for variance of vegetation heights on a site-specific basis. For example, there are multiple references available in the popular and scientific literature that illustrate how airports face different wildlife hazard issues, based on location, proximity to wildlife attractants, and types and frequency of aircraft flights. Often, there are suggestions that airfields should tailor their grass and wildlife management strategies to best suit their local airports conditions. For example, if species such as Canada Goose or Horned Lark are problematic, an airfield might consider increasing grass height to discourage these species from foraging, loafing, or nesting on the airfield.

The 7-14" vegetation regime has been debated extensively, and the subject of multiple investigations, including those that studied birds, insects, and small mammals. As examples of the variation in recommendations for grass height on airfields, below are summaries of a variety of studies that specifically focused on heights relative to bird communities:

- Buckley and McCarthy (1994) showed that fewer Laughing Gulls used tall vegetation (i.e., 18 in [46 cm]) than short vegetation (2 in. [5 cm]) at JFK International Airport, NY. The airport then initiated a tall vegetation management program- mowing once in fall or winter. A subsequent and more comprehensive study at JFK found higher presence of birds in unmowed vegetation (Barras et al 2000), but that regularly mowed grass did not pose a strike risk.

- Seamans et al (1998) showed no difference in bird use between mowed and un-mowed grass plots, except for Red-winged Blackbirds that appeared to prefer taller grass. Subsequently, Seamans et al. (2007) noted that "many interpret airport grasslands, especially when maintained at about 15 to 25 cm (6 to 10 in) in height by mowing, as the safest possible land cover with regard to its degree of attractiveness to bird species that are hazardous to aircraft."

- Fitzpatrick (2003) found that American Kestrels, Red-shouldered and Red-tailed Hawks foraged in mowed grassland plots more than in un-mowed plots in the Eastern United States. Similarly, Bechard (1982) found that Swainson's Hawks foraged more frequently in shorter less densely vegetated fields and that vegetation cover was more important than prey densities.

- Barras and Seamans (2002) stated that "maintaining tall herbaceous vegetation may reduce the availability or attractiveness of loafing and feeding sites for some species of birds such as gulls. However, this management strategy also may increase cover and food resources for other hazardous species. Thus, optimum vegetation height management strategies require further research and may be site-specific."

- Peters et al. (2012) conducted an extensive investigation of birds on military airfields in the Northeast and Mid-Atlantic United States. Their results suggested that at intensely managed airfields, the abundance of high strike risk species was generally greatest in shorter vegetation. They also found that strike-risk based on bird density during the breeding and spring migration seasons decreased with increasing vegetation heights from about 0 to 20 inches. They recommended that management decisions should be made on a site-by-site basis due to geographic differences in avian response to vegetation.

Methods

We obtained BASH records for bird/aircraft incidents from the USAF Safety Center (1995-2016), Navy Safety Center (2009-2016), and the FAA database (1995-2016). Military records obtained from Navy and USAF were combined based on common fields (e.g., dates, location, species) for further analysis. We generated an additional column in the database for LCC and placed each strike location in the associated LCC Region (e.g., Naval Air Station (NAS) Pensacola within Gulf Coastal Plains and Ozarks LCC). We included a hazard score for each species according to a previous study investigating BASH hazards within the FAA dataset by Devault et al. (2011). Devalult et al. (2011) used FAA National Wildlife Strike Database records for the United States from 1990-2009 for species strikes occurring ≤500 ft AGL which represented 23,503 reports from 77 species-groups. The database was used to calculate the

percentage of total strikes for each species-group for 3 criteria: 1) any level of damage to the aircraft ranging from minor repairs to total loss; 2) substantial damage to aircraft that adversely affected structural strength, performance, or flight characteristics and which generally required major repair or replacement of components; 3) strikes that resulted in an effect on flight such as aborted take-off or emergency landing. The 77 species-groups were ranked for each of the 3 hazard criteria from 1 (most hazardous) to 77 (least hazardous). A composite rank resulted from summing the category ranks and ordering species-groups from most to least hazardous including tied ranks (Devault et al. 2011). A relative hazard score resulted from summing the scores of the 3 hazard criteria for each species-group and scaling to a maximum of 100 (Devault et al. 2011). For our investigation, we calculated an overall hazard index score for ranking each species based on the number of reported strikes multiplied by the hazard score from Devault et al. (2011).

We filtered strike database records to limit analysis to relevant records only, and eliminated from further analysis those records (1) with insufficient data (i.e. missing or unknown data, such as unknown bird species), (2) where the incident occurred off-base, or (3) those strikes occurring at altitudes greater than 500 feet AGL. From the remaining records, military and civil (FAA) strike records were queried separately to compare problematic species within each LCC, based on location of reported incident. These records then were assigned a hazard index score for each species according to Devault et al. 2011. This allowed the data to be queried and analyzed in a variety of ways.

To better evaluate grass height management recommendations relative to bird species, we conducted queries for each month of the year and by each LCC. We again only included records for incidences involving military aircraft on-base with strikes occurring less than 500 AGL. We only included those bird species in which grass height manipulation could possibly alter their habitat use based on life history, and restricted our reporting to those species in which 3 or more incidents occurred each month in order to focus efforts on priority BASH species. We included general habitat use (short, medium, or tall grass habitats), the number of strikes, hazard score from Devault et al. (2011), and a weighted score calculated by multiplying the hazard score by the total number of strikes for each species. We used the queried results for species incidents within each LCC by month to generate tables to better inform our decision on grass height recommendations. We made general grass height recommendations (implement shorter or taller grass conditions compared to the standard 7-14 in vegetation height) for each LCC by month according to the weighted scores. For instance if 3 small passerine species that all utilize short grass habitats collectively have a total weighted hazard score of 240, but a single species of raptor that utilizes tall grass for hunting small mammals has a total overall score of 360, managing for short grass around the airfield would be recommended.

We also obtained the Air Traffic Control flight operations data from the Navy (2009-2016) and USAF (2006-2016). Navy and USAF datasets contained total number of flight operations at major airfields each year. We linked the total number of strikes and the total number of flight operations for airfields that reported both values. From these values, we calculated the percent of operations that involved a BASH strike for both individual airfields and for LCCs. We also

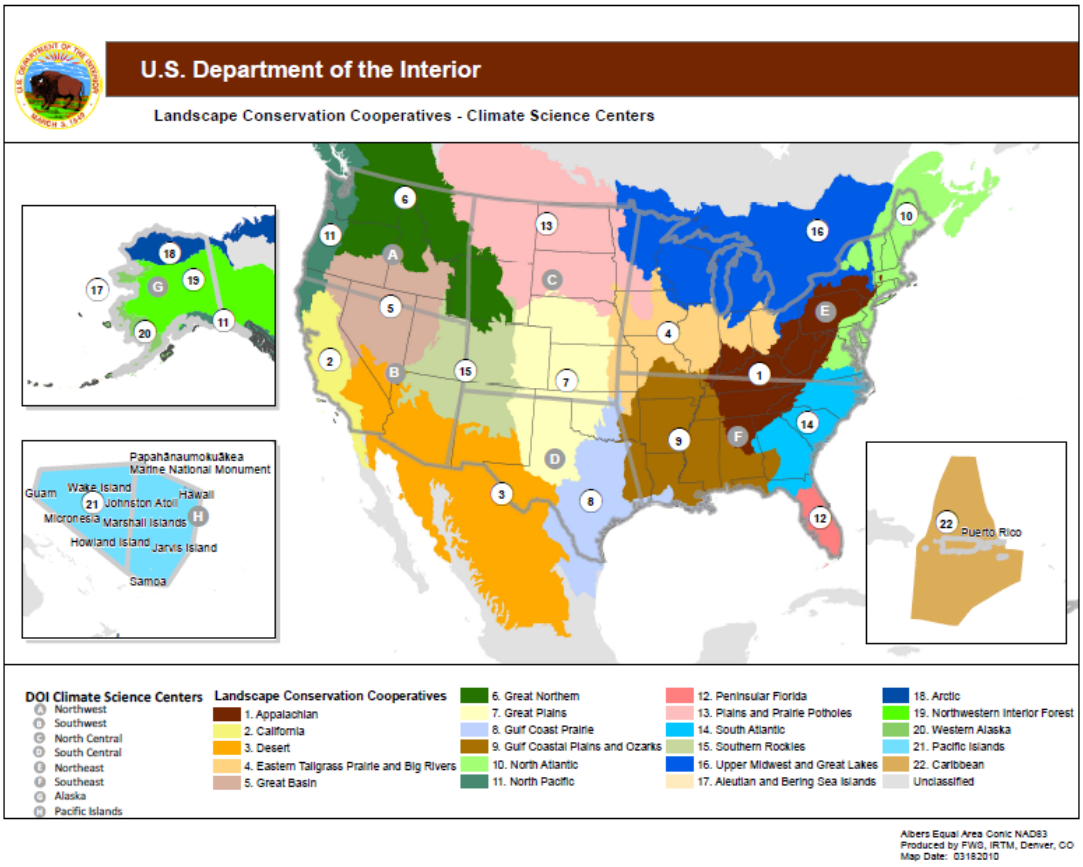

Figure 1. Map of the Landscape Conservation Cooperatives (LCC) used for analysis of BASH species to define regionally which species pose the most significant risks to aircraft.

compared the number of operations per strike between Navy and USAF according to LCC to determine if BASH incidence were similar between Navy and USAF.

Results

We acquired 228,585 records (97,063 USAF; 7,320 U.S. Navy; 124,202 FAA) for incidents involving wildlife/bird strikes to aircraft in the United States. Five LCC regions comprised 84% of Naval aircraft strikes, with the highest numbers of strikes occurring in the Gulf Coast Prairie (25%), South Atlantic (20%), Gulf Coastal Plains and Ozarks (17%), North Atlantic (12%), and California (10%) LCC's (Figure 2). Navy and USAF exhibited similar strike rates when comparing among LCC regions (Tables 1 and 2; Figure 3). Navy aircraft reported low strike rates, with aircraft not striking wildlife 99.98% or more of flights (Table 3). Among NASs, Kingsville and Corpus Christi both experienced the highest incident rate among all reporting Navy airfields (Table 4).

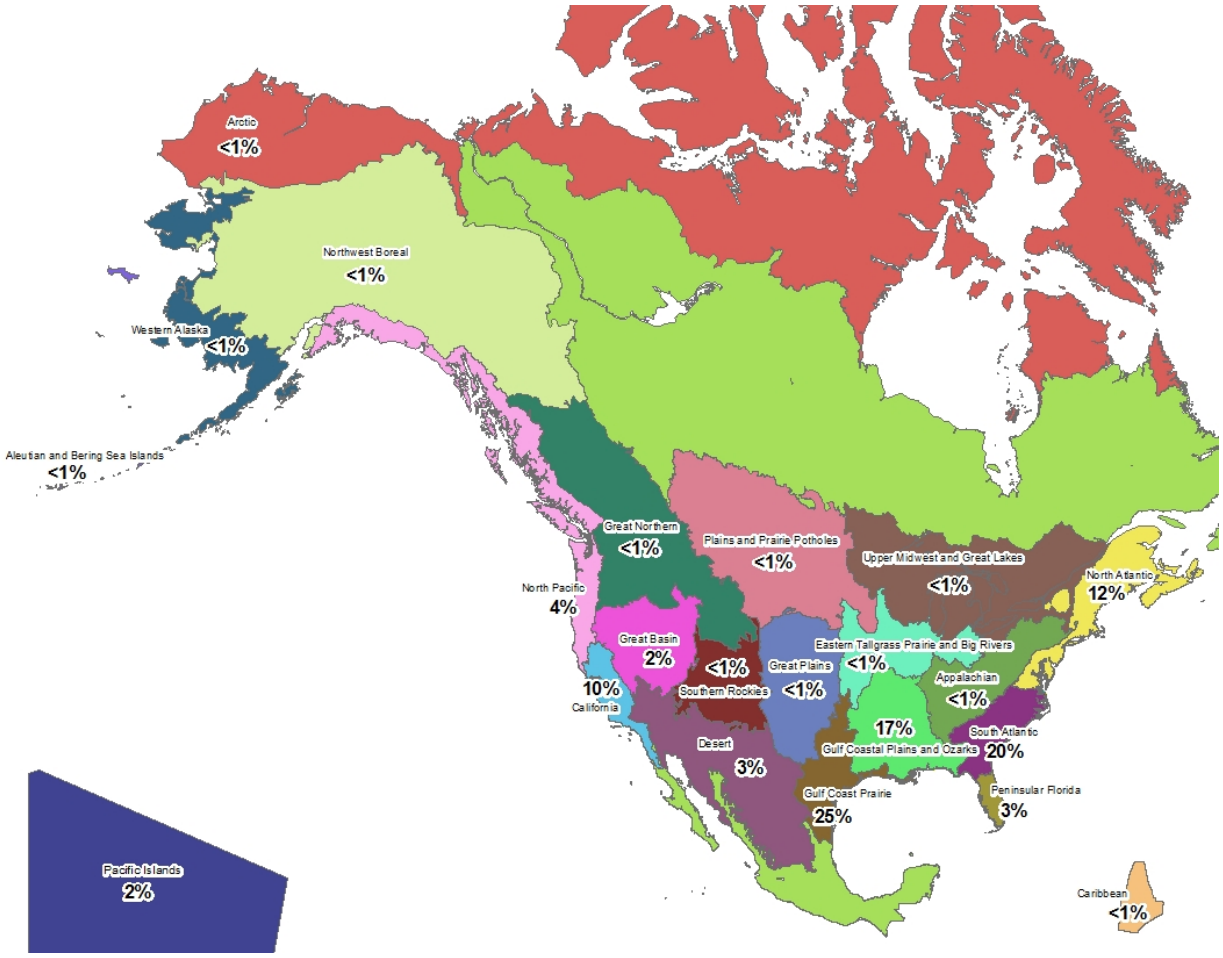

Figure 2. Percent of strikes to Naval aircraft for each LCC region.

Table 1. Number of flight operations and number of strikes for Navy aircraft for all LCCs in which airfields reported both operations and strikes, 2009-2016.

LCC	Total Operations	Total Strikes	Percent of Total with Strikes	Percent without Strikes
California	6,166,296	539	0.009	99.991
Desert	2,119,223	143	0.007	99.993
Great Basin	579,208	107	0.018	99.982
Gulf Coast Prairie	4,188,069	1247	0.030	99.970
Gulf Coastal Plains and Ozarks	11,464,821	859	0.007	99.993
North Atlantic	2,572,502	668	0.026	99.974
North Pacific	14,037,323	207	0.001	99.999
Pacific Islands	508,945	37	0.007	99.993
Peninsular Florida	750,479	152	0.020	99.980
South Atlantic	41,636,387	1048	0.003	99.997

Table 2. Number of flight operations and number of strikes for USAF aircraft for all LCCs in which airfields reported both operations and strikes, 2006-2016.

LCC	Total Operations	Total Strikes	Percent of Total with Strikes	Percent without Strikes
Appalachian	264,339	9	0.003	99.997
California	3,363,311	1883	0.056	99.944
Desert	9,541,709	2655	0.028	99.972
Eastern Tallgrass Prairie and Big Rivers	2,563,696	2883	0.112	99.888
Great Basin	897,541	281	0.031	99.969
Great Northern	204,666	273	0.133	99.867
Great Plains	10,429,823	3234	0.031	99.969
Gulf Coast Prairie	7,400,059	2089	0.028	99.972
Gulf Coastal Plains and Ozarks	12,575,646	6965	0.055	99.945
North Atlantic	3,758,524	2678	0.071	99.929
North Pacific	299,233	404	0.135	99.865
Northwest Boreal	647,170	129	0.020	99.980
Pacific Islands	1,394,980	1	0.000	100.000
Peninsular Florida	1,270,013	589	0.046	99.954
Plains and Prairie Potholes	2,130,909	643	0.030	99.970
South Atlantic	4,588,323	2405	0.052	99.948
Upper Midwest and Great Lakes	953,420	253	0.027	99.973

Large-bodied birds, mostly raptors and waterbirds, as well as Mourning Doves, pose the most serious risks to aircraft within CNIC regions (Tables 5-9). However, most strikes to both military and civil aircraft were with small-bodied birds (Appendix A). The top 10 species most often struck were reported for each LCC according to the weighted score for both the military and civil datasets. For military installations, Mourning Dove, Killdeer, American Kestrel, Horned Lark, Red-tailed Hawk, Rock Pigeon, and Turkey Vulture all were included in Top 10 strike lists in > 50% of LCC's, and occurred in > 80% of LCC's in general. American Kestrel, Horned Lark, Mallard, and Barn Swallow were struck in all LCC's. A comparison of species within the Top 10 strike lists between military (Appendix B) and civil (Appendix C) datasets had ~47% overlap for all LCC's. Species and total number of strikes varied among NAS (Appendix D). Passerines comprised the majority of records for incidents for both military and civil aircraft; however, civil aircraft struck raptors and gulls more frequently compared to military aircraft. Mourning Doves and Horned Larks were the two most common species occurring in short grass habitats throughout the year according to monthly reports, while Red-tailed Hawk was the most common species occurring in tall grass habitats (Appendix E). Recommendations according to monthly strike data (see Appendix E), revealed managing for tall vegetation would likely alleviate some BASH issues according to current life history traits of problematic species (Table 10).

Table 3. Number of flight operations and number of strikes for Navy aircraft for airfields in which both operations and strikes were reported, 2009-2016.

USN ATC Facilities	Total Operations 2009-2016	Total Strikes 2009-2016	Percent of Total with Strikes	Percent without Strikes
FACSFAC San Diego	35,232	8	0.0227	99.9773
NAS Lemoore, CA	1,269,739	179	0.0141	99.9859
NAS North Island, CA	660,671	85	0.0129	99.9871
NALF San Clemente Is, CA	134,301	4	0.0030	99.9970
NOLF Imperial Beach, CA	1,537,156	11	0.0007	99.9993
NBVC Point Mugu, CA	924,934	197	0.0213	99.9787
NBVC San Nicolas, CA	20,805	4	0.0192	99.9808
NAWS China Lake, CA	110,844	26	0.0235	99.9765
NAF El Centro, CA	481,393	76	0.0158	99.9842
NAS Fallon, NV	579,208	107	0.0185	99.9815
NAS Corpus Christi, TX	779,918	548	0.0703	99.9297
NAS JRB Ft. Worth, TX	191,436	29	0.0151	99.9849
NAS Kingsville, TX	1,378,586	567	0.0411	99.9589
NALF Orange Grove, TX	311,658	28	0.0090	99.9910
NOLF Cabaniss, TX	609,173	40	0.0066	99.9934
NOLF Waldron, TX	528,387	8	0.0015	99.9985
NOLF Goliad, TX (No Tower)	241,247	25	0.0104	99.9896
NAS JRB New Orleans, LA	164,148	88	0.0536	99.9464
NAS Meridian, MS	1,309,971	330	0.0252	99.9748
NAS Pensacola, FL	558,756	110	0.0197	99.9803
NAS Whiting Field, FL (N&S)	1,476,341	279	0.0189	99.9811
NOLF Joe Williams, MS	189,013	3	0.0016	99.9984
NOLF Barin, FL (No Tower)	366,130	4	0.0011	99.9989
NOLF Brewton, FL (No Tower)	547,091	4	0.0007	99.9993
NOLF Choctaw, FL (No Tower)	194,289	3	0.0015	99.9985
NOLF Pace, Fl (No Tower)	1,211,944	7	0.0006	99.9994
NOLF Santa Rosa, FL (No Tower)	2,018,388	11	0.0005	99.9995
NOLF Silverhill, FL (No Tower)	96,554	1	0.0010	99.9990
NOLF Spencer, FL (No Tower)	2,313,580	15	0.0006	99.9994
NAS JRB Willow Grove, PA	29,284	6	0.0205	99.9795
NAS Norfolk, VA	248,219	176	0.0709	99.9291
NAS Oceana, VA	1,132,118	350	0.0309	99.9691
NAS Patuxent River, MD	826,732	132	0.0160	99.9840
NOLF Webster, MD	105,751	2	0.0019	99.9981
NAS Whidbey Island, WA	1,275,278	201	0.0158	99.9842
NOLF Coupeville, WA (No Tower)	54,483	6	0.0110	99.9890
NAS Key West, FL	750,479	152	0.0203	99.9797
NAS Jacksonville, FL	358,915	253	0.0705	99.9295
NAS Mayport, FL	664,817	110	0.0165	99.9835
NOLF Whitehouse, FL	135,836	7	0.0052	99.9948
NALF Fentress, VA (No Tower)	606,684	132	0.0218	99.9782

Table 4. Naval airfields that reported greater than 50 strike incidents (all strikes reported regardless of aircraft's flight AGL) during the period from 2009 to 2016, including three Marine Corps Air Stations and one Air Force base where Navy aircraft frequently land.

Airfield	Total Number of Strikes
Location Not Specified	659
NAS KINGSVILLE	567
NAS CORPUS CHRISTI	548
NAS OCEANA	350
NAS MERIDIAN NAS	330
WHITING FIELD	279
NAS JACKSONVILLE	253
NAS WHIDBEY ISLAND	201
NAS POINT MUGU	197
CECIL FIELD	190
NAS LEMOORE	179
NORFOLK NS	176
CHERRY POINT MCAS[1]	167
NAS KEY WEST	152
NAS PATUXENT RIVER	132
FENTRESS NALF	132
NAS PENSACOLA NAS	110
NS MAYPORT NS	110
NAS FALLON NAS	107
NEW RIVER MCAS[1]	106
TINKER AFB[2]	104
NAS JRB NEW ORLEANS	88
NAS NORTH ISLAND	85
BEAUFORT MCAS[1]	77
NAF EL CENTRO	76
SIGONELLA*	65
ROTA NS*	55

*Location outside of U.S.

[1]Marine Corps Air Station

[2] Air Force Installation

Table 5. Summary of the top 10 BASH species struck by Naval aircraft in the CNIC Mid-Atlantic region from 2009-2016 based on a weighted score (calculated by multiplying the number of strikes by the hazard score from Devault et al. (2011) and listed in descending order of risk.

Species	# of Strikes	Hazard Score	Weighted Score
Mourning Dove	49	10	490
Turkey Vulture	7	44	308
Bats	28	8	224
Great Horned Owl	5	44	220
Laughing Gull	12	18	216
Gulls, Kittiwakes, And Terns	11	18	198
Killdeer	24	7	168
Ring-billed Gull	7	23	161
Osprey	4	32	128
Red-tailed Hawk	5	25	125

Table 6. Summary of the top 10 BASH species struck by Naval aircraft in the CNIC Naval District Washington region from 2009-2016 based on a weighted score (calculated by multiplying the number of strikes by the hazard score from Devault et al. (2011) and listed in descending order of risk.

Species	# of Strikes	Hazard Score	Weighted Score
Bald Eagle	5	36	180
Turkey Vulture	4	44	176
Osprey	3	32	96
Laughing Gull	3	18	54
Red-tailed Hawk	2	25	50
Eurasian Green-winged Teal	1	48	48
Hooded Merganser	1	48	48
Horned Lark	11	4	44
Black Vulture	1	44	44
Double-crested Cormorant	1	43	43

Table 7. Summary of the top 10 BASH species struck by Naval aircraft in the CNIC Northwest region from 2009-2016 based on a weighted score (calculated by multiplying the number of strikes by the hazard score from Devault et al. (2011) and listed in descending order of risk.

Species	# of Strikes	Hazard Score	Weighted Score
Bald Eagle	3	36	108
Red-tailed Hawk	3	25	75
Shorebirds	6	10	60
Hawks, Eagles, Vultures,	3	18	54
Ring-necked Duck	1	48	48
Black Vulture	1	44	44
Gulls, Kittiwakes, And Terns	2	18	36
Barn Swallow	16	2	32
Mourning Dove	3	10	30
Mallard	1	29	29

Table 8. Summary of the top 10 BASH species struck by Naval aircraft in the CNIC Southeast region from 2009-2016 based on a weighted score (calculated by multiplying the number of strikes by the hazard score from Devault et al. (2011) and listed in descending order of risk.

Species	# of Strikes	Hazard Score	Weighted Score
Turkey Vulture	42	44	1848
Black Vulture	20	44	880
Mourning Dove	62	10	620
Hawks, Eagles, Vultures,	27	18	486
Laughing Gull	22	18	396
Blue-winged Teal	8	48	384
Brown Pelican	9	40	360
Redhead	7	48	336
Killdeer	47	7	329
Osprey	10	32	320

Table 9. Summary of the top 10 BASH species struck by Naval aircraft in the CNIC Southwest region from 2009-2016 based on a weighted score (calculated by multiplying the number of strikes by the hazard score from Devault et al. (2011) and listed in descending order of risk.

Species	# of Strikes	Hazard Score	Weighted Score
Red-tailed Hawk	15	25	375
Horned Lark	68	4	272
Shorebirds	17	10	170
Great Horned Owl	3	44	132
Gulls, Kittiwakes, And Terns	6	18	108
Northern Shoveler	2	48	96
Northern Pintail	2	48	96
Hawks, Eagles, Vultures,	5	18	90
Turkey Vulture	2	44	88
Mourning Dove	8	10	80

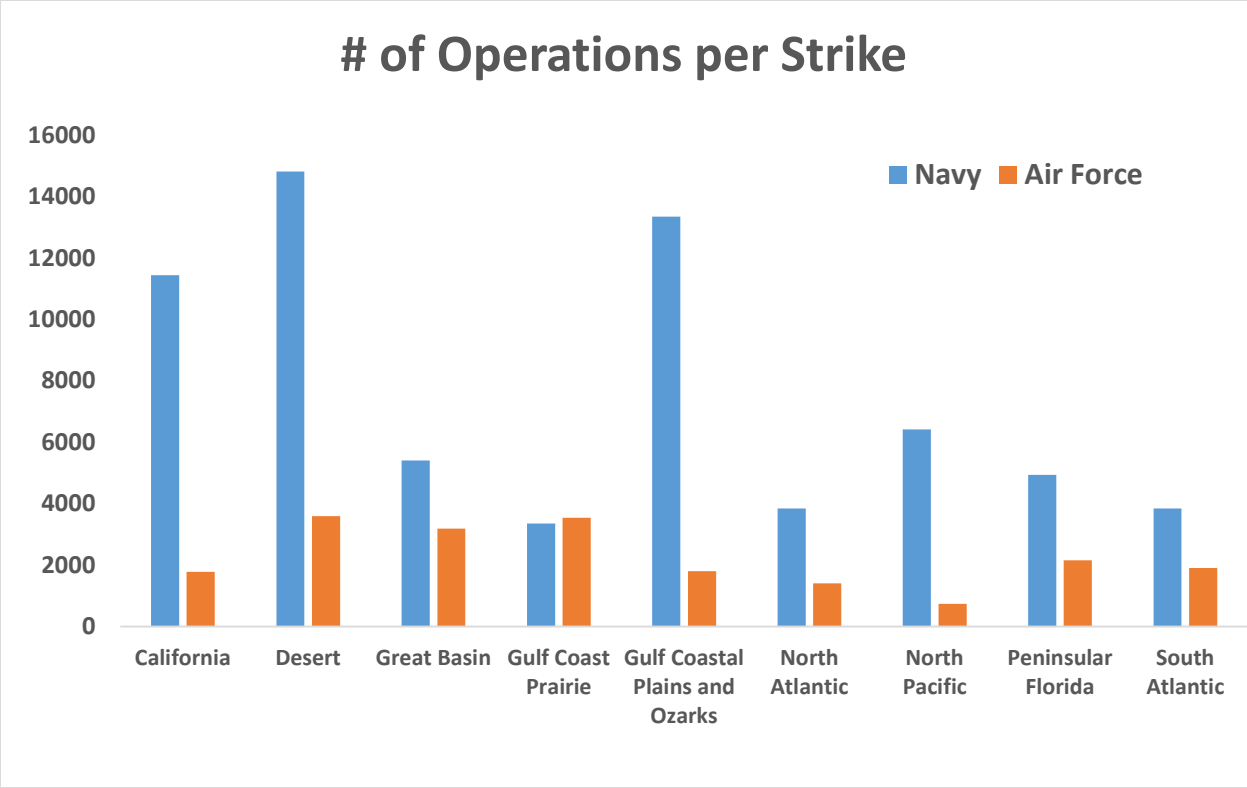

Figure 3. Total number of flight operations for every BASH strike within LCC's that reported data for Navy (2009-2016) and USAF (2006-2016). Note, greater values represent lower strike rates.

Table 10. Grass height recommendations for each LCC by month according to data records in Appendix E. Grass height recommendations were based on habitat preferences for top avian BASH species reported in life history section. Recommendations for "tall" grass management is for grass heights >35 cm and "short' grass management represents grass heights <18 cm.

Month	Appalachian	California	Desert	Eastern Tallgrass Prairie and Big Rivers	Great Basin	Great Plains	Gulf Coast Prairie	Gulf Coastal Plains and Ozarks
January	Tall	Tall	Tall	Tall	-	Tall	Tall	Tall
February	-	Short	Tall	-	-	Tall	Tall	Tall
March	-	-	Tall	Short	-	Tall	Tall	Tall
April	-	Short	Tall	Tall	-	Tall	Tall	Short
May	-	Tall	Tall	Tall	Tall	Tall	Tall	Tall
June	-	Tall	Tall	Tall	Tall	Tall	Tall	Tall
July	Tall	Tall	Tall	Tall	Tall	Tall	Tall	Tall
August	Tall	Short	Tall	Short	Tall	Tall	Tall	Tall
September	Tall	Tall	Tall	Tall	Tall	Tall	Tall	Tall
October	Tall	Tall	Tall	Tall	Tall	Tall	Tall	Tall
November	Tall	Short	Tall	Tall	Tall	Tall	Tall	Tall
December	-	Tall	Tall	Tall	-	Tall	Tall	Tall

Table 10. Continued.

Month	North Atlantic	North Pacific	Peninsular Florida	Plains and Prairie Potholes	South Atlantic	Southern Rockies	Upper Midwest and Great Lakes
January	Tall	Short	-	-	Tall	-	Tall
February	Tall	-	Tall	-	Tall	-	-
March	Tall	-	-	Tall	-	-	Tall
April	Tall	-	-	-	Tall	-	Tall
May	Tall	-	Tall	-	Tall	-	Short
June	Tall	-	Tall	-	-	-	Tall
July	Tall	Tall	Tall	Tall	Tall	-	Tall
August	Tall	Tall	Tall	Tall	Tall	-	Tall
September	Tall	-	Tall	Tall	Tall	Tall	Tall
October	Tall	-	Tall	-	Tall	-	Tall
November	Tall	-	Tall	-	Tall	-	-
December	Tall	-	Tall	-	Tall	-	Tall

Discussion

Grass Height Management Recommendations

In Table 10, we suggest vegetation regime changes within LCCs to either short (<7" [18cm]) or tall (>14" [>35cm]) and do not include the current "default" guidance of 7'-14" (medium) as a management option. Under the default management regime, the DoD continues to strike significant numbers of birds on airfields, and one of our goals was to determine whether data suggest that vegetation height regimes that are shorter, or taller, than the default regime might reduce habitat suitability for problematic species. Our recommendations for grass height management in Table 10 are based on life history traits (Appendix F) of the most problematic BASH species that use grassland habitat relative to month and by LCC (Appendix E), and these include those involved in the most strikes as well as species that are most likely to cause significant damage in the event of an impact with aircraft. Our analyses, as reported in Table 10 for short or tall grass habitats on airfields, largely suggests that tall grass management (i.e., >35 cm or 14 in) throughout the year is preferable for all LCC regions and would reduce suitable habitat for most birds inhabiting airfields and struck by aircraft. However, data suggest that short grass management during some months could aid in reducing BASH incidences (Table 10). We do not suggest that all airfields immediately abandon the 7-14" current guidelines, but do recommend that individual Navy airfields consult our data tables for strikes within their geographical LCC, and their own BASH data, and consider the merits of attempting taller grass management, particularly on installations with the majority of strikes attributable to species with short-grass habitat preferences.

While BASH assessments based on bird strikes within individual LCCs provides important information and insight into problematic bird species at the regional level, individual airfields also should ensure they are addressing locally abundant bird species that may not have been identified at the regional level. For example NAS Key West is within the Peninsular Florida LCC; many of the significant BASH species on that installation differ from the remaining airfields within Florida. Similarly, there can be different micro-habitats (e.g., grasslands interspersed with wetlands) within individual airfields that require different vegetation management regimes to reduce BASH risk. Therefore, it is still crucial for airfield managers and base biologists to constantly be aware of which problematic species are present around their airfields, and why they are present, to best manage vegetation and other wildlife attractants for BASH reductions. Promising research by USDA (Devault et al. 2013) suggests that alternative vegetation cover on airfields, such as agricultural crops or switchgrass (*Panicum virgatum*), may assist in reducing BASH hazards. As results of new research become available, we recommend that suggested alterations to vegetation communities also be considered along with changes to vegetation height.

The number of strikes occurring at an airfield should not be the only metric used to assess the BASH risk. Vegetation management practices, such as managing for taller grass at an airfield, may promote the presence of other problematic species, such as raptors, utilizing the airfield (e.g. for hunting small mammals concealed within the vegetation). Larger raptors, such as Red-tailed or Swainson's Hawks, pose a much higher BASH risk than do many of the smaller passerines

that are abundant in short grasses (Devault et al. 2011). Additionally, having tall grass on the airfield, but mowing areas immediately adjacent to the runway for visibility of runway and taxiway lights may create edge habitat that provides greater hunting opportunities for raptors due to increased visibility of small mammals and more efficient capture. Raptors are not the only predators to potentially benefit from such management. Mammalian species, such as coyotes and foxes, may also take advantage of these conditions. Though difficult, vigilance with fencing around airfields, and active removal of medium-sized mammals, can assist in minimizing this risk. For airfields that do pursue modifications to vegetation height regimes, long-term seasonal monitoring of bird communities, and continuing to collect detailed post-flight BASH data, will be necessary to test the efficacy of such management regime changes. Where applicable, natural resources managers should work with onsite USDA and Air Operations staff to design a suitable monitoring program. It would be especially important to know whether longer-grass management might attract species that previously avoided the airport (e.g., Deacon and Rochard 2000), or if this vegetation regime increased numbers of previously low-abundance BASH risk species. To reiterate, shifts in bird communities should be monitored closely if grass heights are increased to ensure that BASH risks do not actually increase as a result of the altered landscape.

Even if tall grass would result in a reduced BASH risk, not all airfields will be able to efficiently adopt this strategy. For example, military airfields within arid regions such as the Desert LCC would have difficulty establishing taller vegetation without the use of widespread irrigation. BASH incidents in more arid LCCs may also be a result of irrigated lands adjacent to the airfield that attract birds that might subsequently fly across the airfield. In addition, some birds on the airfield may utilize lower vegetation with interspersed bare areas and drought-tolerant shrubs. In fact, two USAF airfields (Luke AFB, AZ; Sheppard AFB, TX) that occur in arid and semi-arid environments requested waivers from the USAF 7-14” policy to mow grasses short (i.e., 5-12” at Sheppard; <7” at Luke) as a means to increase visibility of mourning doves and meadowlarks so that control measures could be implemented more efficiently. In arid and semi-arid environments where vegetation rarely grows tall, and also grows in clumps interspersed with bare ground, it may be prudent to fully investigate reductions in grass height below 7” if it is thought that this will reduce attractiveness to problematic BASH species, as well as increase visibility for effective hazing.

Not all problematic BASH species are influenced by airfield management. Vultures are a major flight risk as their large size often causes significant damage to aircraft and occasionally can result in complete operational failure that poses life-threatening circumstances to crew members. Because of this increased risk, vultures are a high BASH concern; however, managing against this species is difficult. Vultures often soar on thermals created, in part, by large expanses of asphalt that are typically present at airfields. Of 714 vulture strikes to military aircraft at altitude, 97% occurred above 500 AGL and 50% at or above 1,000 AGL. Red-tailed Hawks are another large BASH risk with threats to aircraft similar to vultures. Red-tailed Hawks also were struck most often while soaring rather than hunting at lower altitudes near runways as ~ 70% of collisions were reported at greater than 500 AGL. Vegetation management is unlikely to significantly lower raptor and vulture strikes while soaring on thermals within higher altitude

airspace. Additional research is warranted to determine if there are methods that would deter vultures and raptors from soaring within approach and departure zones near airfields.

Another issue that needs to be considered when managing airfields for taller grass height is mowing regime. There likely is an upper limit to "tall grass management" but available science does not provide sufficient insight for a concise recommendation. We hypothesize this upper limit is likely 18-24", but further research will be necessary to refine that recommendation. Unchecked growth of airfield vegetation on installations outside of arid and semi-arid LCCs likely would result in overgrowth of vegetation, significant seed production, encroachment by woody species, and possibly invasion of non-native invasive plants (e.g., Johnsongrass in the eastern U.S.). As such, we suggest that airfields be mowed at least once per year during the non-growing season to remove decadent growth, invasion by woody species, and to keep vegetation height within desirable ranges. The height of this mowing will be dictated by equipment capabilities and recommendations by the installation BASH team. A possible approach on most airfields would be to mow in early spring prior to the avian nesting season, and this would allow vegetation to grow to desired height during the growing season. If vegetation does not exceed desired height during or at the end of the growing season, no additional mowing should be necessary until the following spring. Otherwise, decisions will need to be made as to if and when additional mowing would be required. Decisions for mowing during the nesting season should be made with care, though recent interpretations by the Department of Interior regarding the Migratory Bird Treaty Act allow for incidental take of birds during otherwise lawful activities. However, the DoD has taken a proactive stance to migratory bird conservation, and a recent Memorandum from the Deputy Assistant Secretary of Defense (DASD) for Environment, Safety, and Occupational Health (6 February 2018) encourages the Military Services to continue following DoD Guidance to avoid and minimize incidental mortality of migratory birds. Each installation should investigate "safe dates" that include information on when nesting commences for airfield birds. This will reduce likelihood of incidental mortality of migratory birds. In addition, the DASD recently released a document titled, "Addressing Migratory Bird Management in Integrated Natural Resources Management Plans – Guidance." Installation managers should consult this guidance as reference to support proper management of migratory birds, but ultimately management decisions on the airfield clearly should be made to reduce BASH risk and protect pilot safety. Any changes to mowing regimes based on our recommendations should be a joint decision among the Natural Resources Manager, installation BASH team, and Air Operations staff, documented in the installation BASH Plan, and incorporated properly into the installations INRMP.

Impact of Insufficient Strike Reporting Data on Airfield Vegetation Management

During the course of this study to investigate problematic BASH species, and to make recommendations for grass height management around airfields, we encountered numerous issues within the military BASH data sets acquired from the Navy and Air Force Safety Centers. Thus, our results and ability to make robust recommendations for grass height management are somewhat hampered by the lack of sound data and science. Significant problems we encountered included: 1) lack of reporting for damage costs, particularly within the Navy dataset;

2) inaccurate determination of where incidents occurred (if unknown then need to be stated as such); 3) numerous accounts of on-base bird strikes of species that would be classified as "vagrants", suggesting that strikes occurred at locations other than the reporting airfield; and 4) contradictions among fields in dataset (e.g., one-liner indicates a situation that occurred differently based on other fields).

Additionally, inaccurate reporting of altitudes (e.g., >130 records of birds/bats struck above 15,000 AGL; ~ 60,000 of 97,000 Air Force records indicated strikes while still on runway as altitude was reported as "0") is problematic. Some species, such as raptors and vultures, soar at relatively high altitudes on thermals. During migration, many species also will fly at higher altitudes, but typically at less than 500 feet AGL. Birds generally do not fly at higher altitudes as more energy is expended due to exposure to higher winds or increased chances of predation from raptors. Military flight records that include AGL data indicated that ~63% of strikes (12,122 of 19,248) occurred at altitudes above 500 AGL. If altitude estimates by pilots are reasonably accurate, this would suggest that most strikes occurred during migration events; however, a large number of strikes (> 40%) occured at high altitudes outside of the spring and fall migration seasons suggesting imprecision in strike altitude reporting. This further illustrates the need for better records to conduct sound scientific investigations with the need to identify records as "unknown" if data are not available to accurately report values for predetermined fields within the dataset.

Many of these issues likely arise due to pilots being unaware of strikes until a post-flight inspection is conducted at which time species is identified by taking feathers or a DNA swab of remains from aircraft parts (otherwise referred to as "snarge") and submitting to the Smithsonian Institution, Feather Identification Lab, for genetic testing. It is impossible to know where the strike took place if pilots did not see, hear, or feel impact. For example, NAS Meridian is one of two training facilities for fighter jets, and training flights occur along specific flight paths that often encompass numerous states with take-off/landing occurring at other NASs before returning to home base. Striking a bird in a different state from the originating base offers little in determining resolution to BASH analysis and management. Limited data can be obtained from this style of reporting; however, knowledge of no impact to aircraft and first detection upon post-flight inspection would be extremely useful in filtering out records that are not satisfactory for use in risk analyses. Future attention to standardized reporting and recording of BASH incidents will greatly increase our ability to analyze data to further make recommendations on how best to reduce BASH risks on airfields.

As a result of imprecise or missing records, we had to make some assumptions to assist in determining which species pose the greatest threats to aircraft immediately surrounding the airfield. For instance, we assumed that strikes reported on-base at altitudes less than 500 feet AGL were struck in the vicinity of the airfield. Only ~17% of records in the military databases (17,875 of 104,384) met this criteria. Nonetheless, we feel sufficient data from our large sample size were available to draw inferences on problematic species, and based on life history information, to make general recommendations to airfield managers for various LCC regions. In addition, we had no data to indicate grass height management conditions (i.e., grass height when

strikes occurred) on airfields for individual strikes and made the assumption that most airfields within the majority of LCC's where vegetation grows tall in the absence of mowing, had mowing operations that maintained heights between 7-14."

BASH Management Recommendations

- Our analyses suggest tall grass management (i.e., >35 cm or 14 in) throughout the year is preferable for all LCC regions. Data does suggest that short grass management during some months in a few LCC's could aid in reducing BASH incidences.
- Change in grass height regimes should include monitoring of avian communities during all seasons. USDA biologists working on military airfields do monitor avian communities and historical data are in process of being provided to the ERDC-EL. However, we had little information on vegetation heights on military airfields, or mowing regimes, during the timeframe included in BASH databases.
- Despite the widespread use of the 7-14" vegetation paradigm, both the military and civil aviation communities continue to experience high numbers of bird strikes, often leading to very costly repairs (and in some cases, total loss of aircraft and life). We seek to field-test our research hypothesis that taller grass management on DoD airfields across LCC's throughout the continental United States, as measured at the regional or even individual airfield level, will reduce abundance (and assumed risk) of problematic BASH species identified for each region. We are working to develop a proposal for the Environmental Securities Technology Certification Program (ESTCP) that would test avian response to various vegetation height regimes (primarily tall-grass management) in a randomized block design at various airfields across the United States, with the general design of providing both tall (treatment) and medium (control) vegetation regimes in ~30 acre blocks. If proposed, ERDC-EL would coordinate with CNIC N32 Airfield Operations for selection of appropriate Navy installations to include in the design. A similar effort is just being initiated on Joint Base McGuire-Dix-Lakehurst by the USAF, and ERDC-EL is communicating with USAF on study design, monitoring techniques, and results.
- Shifts in bird communities should be monitored closely if grass heights are increased to insure that BASH risks do not actually increase as a result of the altered landscape. For instance, larger raptors such as Red-tailed or Swainson's Hawks pose a much higher BASH risk than do many of the smaller passerines that are abundant in short grasses. Other mammalian species such as coyotes and foxes may also take advantage of these conditions, and further management actions may be required to control these species.
- While BASH assessments based on bird strikes within individual LCCs provides important information and insight into problematic bird species at the regional level, individual airfields also should ensure they are addressing locally abundant bird species that may not have been identified at the regional level.
- There likely is an upper limit to "tall grass management" but available science does not provide sufficient insight for a concise recommendation. This also could be addressed in the aforementioned ESTCP proposed study.
- Decisions for mowing during the nesting season should be made with care, particularly to assist in avoiding or minimizing avian mortality. Each installation should investigate "safe dates" that include information on when nesting commences and ends for local bird communities on airfields. No such protection is needed for non-native species such as European Starling,

House Sparrow, or Rock Pigeon, but if found nesting on airfields, they typically are in buildings and hangars rather than nesting in vegetation.

- Changes to mowing regimes should be developed and approved by the installation BASH working group, documented in the wildlife hazard management plan, and incorporated properly into the installations INRMP.

Recommendations for Pilot Reporting on BASH Incidences

- Add a column in BASH spreadsheet for whether strike was reported in real-time or post inspection. It would be useful to know whether the pilot was aware that a strike occurred, and if not, specify the strike was discovered at a later time such as during post-inspection.
- If the strike was detected by the pilot during flight, better information on general occurrence to runway would be useful (e.g., take-off/landing while on runway, immediately before/after the approach/take-off, 100 m from runway, 100-500 m from runway, 500-1000 m of runway, > 1000 m from runway during approach/take-off).
- Provide accurate estimate of flight altitude, and if unknown, then specify. This will assist in elimination of guesswork during data analyses.
- Do not report a value of "0" for altitude unless strike truly occurred during take-off/landing on runway. If unknown, specify as such.
- Provide more information on damage cost estimates; the more detailed the better.
- Provide details of flight plan (multi-state training mission, other air stations visited, etc.).
- Note the general habitat, whenever feasible, for each strike (e.g., urban, agriculture, forest, water body)
- Note when possible, the number of individuals associated with each reported strike (e.g., 1, 2-5, 5-10, 20-30). If unknown, specify.

The first bullet is key; we really need to be able to filter out records for which the accuracy and details of the strike are unknown. Imprecise or missing records limits the ability to analyze data. Providing details as "unknown" is useful. We realize that many of these suggestions for collecting data for each flight are not possible, but any data that could be collected relative to our recommendations would assist in future analyses.

Appendix A

Total number of Navy, Air Force, and civil aircraft strikes for the top 25 species or species groups.

Navy

SPECIES	Total Number of Strikes
UNKNOWN	3978
PASSERINE	249
BARN SWALLOW	163
SONGBIRD	141
MOURNING DOVE	136
HORNED LARK	124
BAT	92
CLIFF SWALLOW	88
CHIMNEY SWIFT	88
SHOREBIRD	84
KILLDEER	82
YELLOW-RUMPED WARBLER	72
EASTERN MEADOWLARK	69
TURKEY VULTURE	58
AMERICAN KESTREL	57
SAVANNAH SPARROW	53
RAPTOR	44
GRAY CATBIRD	42
LAUGHING GULL	40
SEABIRD	39
RED-TAILED HAWK	38
RUBY-THROATED HUMMINGBIRD	37
TREE SWALLOW	37
BLUE-GRAY GNATCATCHER	34
PURPLE MARTIN	34

Air Force

SPECIES	Total Number of Strikes
Unknown	39212
Perching Birds	5648
Horned Lark	3434
Mourning Dove	2977
Barn Swallow	2524
Killdeer	1583
Eastern Meadowlark	1376
Chimney Swift	1238
Cliff Swallow	1213
American Kestrel	1120
American Robin	1066
Savannah Sparrow	837
Common Nighthawk	723
Brazilian Free-tailed Bat	719
Yellow-rumped Warbler	669
Bats	660
Red-tailed Hawk	571
House Sparrow	562
Vesper Bats	561
Rock Pigeon	560
Turkey Vulture	518
Red Bat	505
Common Swift	486
Western Meadowlark	448
Swallows And Martins	440

Civil

SPECIES	Total Number of Strikes
Mourning dove	6647
American kestrel	4053
Gulls	3720
Killdeer	3673
Barn swallow	3553
Horned lark	3338
European starling	3107
Rock Pigeon	2405
Sparrows	2188
Red-tailed hawk	1933
Eastern meadowlark	1516
Ring-billed gull	1291
Cliff swallow	1192
Herring gull	1111
Barn owl	1032
Western meadowlark	958
Canada goose	904
Hawks	825
Swallows	809
Pacific golden-plover	808
Blackbirds	792
Doves	754
Mallard	721
American robin	717
Bats	620

Appendix B

Top BASH species within each Landscape Conservation Cooperative (LCC) in descending order according to a weighted score (calculated as the number of aircraft strikes multiplied by the hazard score); Devault et al 2011. Only records for species that were reported to be struck on-base at Air Force or Naval airfields and at ≤500 AGL were used in analysis. The below tables provide summaries for each LCC region.

Appalachian

Species	# of Strikes	Hazard Score	Weighted Score
Mourning Dove	21	10	210
Killdeer	17	7	119
Rock Pigeon	5	20	100
White-tailed Deer	1	88	88
Horned Lark	17	4	68
Eastern Meadowlark	12	5	60
Redhead	1	48	48
Ring-billed Gull	2	23	46
Turkey Vulture	1	44	44
Great Horned Owl	1	44	44

California

Species	# of Strikes	Hazard Score	Weighted Score
Red-tailed Hawk	23	25	575
Horned Lark	135	4	540
Rock Pigeon	20	20	400
Northern Pintail	7	48	336
Brazilian Free-tailed Bat	38	8	304
Barn Owl	27	11	297
Canada Goose	6	46	276
Great Horned Owl	6	44	264
Turkey Vulture	6	44	264
Western Meadowlark	40	5	200

Desert

Species	# of Strikes	Hazard Score	Weighted Score
Mourning Dove	135	10	1350
Horned Lark	105	4	420
Red-tailed Hawk	7	25	175
Turkey Vulture	2	44	88
American Kestrel	11	6	66
Coyote	3	22	66
Swainson's Hawk	3	19	57
Pigeons and Doves	3	15	45
Great Horned Owl	1	44	44
White-winged Dove	4	10	40

Eastern Tallgrass Prairie and Big Rivers

Species	# of Strikes	Hazard Score	Weighted Score
Mourning Dove	83	10	830
Red-tailed Hawk	33	25	825
Killdeer	117	7	819
Horned Lark	150	4	600
American Kestrel	63	6	378
Eastern Meadowlark	67	5	335
Barn Swallow	141	2	282
Canada Goose	6	46	276
Great Horned Owl	6	44	264
European Starling	29	9	261

Great Basin

Species	# of Strikes	Hazard Score	Weighted Score
Horned Lark	44	4	176
Red-tailed Hawk	4	25	100
Great Horned Owl	2	44	88
Mourning Dove	7	10	70
Ducks, Geese, And Swans	1	55	55
American Kestrel	8	6	48
Great Blue Heron	1	31	31
Mallard	1	29	29
American Coot	1	27	27
Bats	3	8	24

Great Northern

Species	# of Strikes	Hazard Score	Weighted Score
Red-tailed Hawk	3	25	75
Ducks, Geese, And Swans	1	55	55
American Wigeon	1	48	48
Ring-billed Gull	2	23	46
Horned Lark	9	4	36
Gulls, Kittiwakes, And Terns	2	18	36
Osprey	1	32	32
Mallard	1	29	29
American Coot	1	27	27
Rock Pigeon	1	20	20

Great Plains

Species	# of Strikes	Hazard Score	Weighted Score
Mourning Dove	208	10	2080
Horned Lark	260	4	1040
Rock Pigeon	44	20	880
Red-tailed Hawk	29	25	725
Eastern Meadowlark	132	5	660
Western Meadowlark	84	5	420
Upland Sandpiper	25	13	325
American Kestrel	50	6	300
Killdeer	41	7	287
Turkey Vulture	6	44	264

Gulf Coast Prairie

Species	# of Strikes	Hazard Score	Weighted Score
Mourning Dove	130	10	1300
White-winged Dove	62	10	620
Turkey Vulture	12	44	528
Rock Pigeon	16	20	320
Barn Swallow	118	2	236
Killdeer	27	7	189
White-tailed Deer	2	88	176
Eastern Meadowlark	29	5	145
American Kestrel	22	6	132
Red-tailed Hawk	5	25	125

Gulf Coastal Plains and Ozarks

Species	# of Strikes	Hazard Score	Weighted Score
Mourning Dove	247	10	2470
Turkey Vulture	13	44	572
Killdeer	76	7	532
Eastern Meadowlark	99	5	495
Cattle Egret	14	23	322
Black Vulture	6	44	264
Red-tailed Hawk	10	25	250
Rock Pigeon	12	20	240
American Kestrel	34	6	204
American Robin	36	5	180

North Atlantic

Species	# of Strikes	Hazard Score	Weighted Score
Herring Gull	26	29	754
White-tailed Deer	7	88	616
Mourning Dove	57	10	570
Ring-billed Gull	21	23	483
American Kestrel	77	6	462
Turkey Vulture	8	44	352
Eastern Meadowlark	67	5	335
Laughing Gull	18	18	324
Killdeer	44	7	308
Gulls, Kittiwakes, And Terns	17	18	306

North Pacific

Species	# of Strikes	Hazard Score	Weighted Score
Red-tailed Hawk	5	25	125
American Kestrel	10	6	60
Mallard	2	29	58
Hooded Merganser	1	48	48
Canada Goose	1	46	46
Turkey Vulture	1	44	44
Killdeer	6	7	42
Horned Lark	10	4	40
American Crow	3	12	36
Gulls, Kittiwakes, And Terns	2	18	36

Northwest Boreal

Species	# of Strikes	Hazard Score	Weighted Score
Bald Eagle	2	36	72
Mew Gull	3	19	57
Canada Goose	1	46	46
Great Horned Owl	1	44	44
Mallard	1	29	29
Rock Pigeon	1	20	20
Bank Swallow	3	6	18
Rough-legged Hawk	1	18	18
Gulls, Kittiwakes, And Terns	1	18	18
Savannah Sparrow	4	4	16

Pacific Islands

Species	# of Strikes	Hazard Score	Weighted Score
Pigeons And Doves	4	15	60
Barn Owl	3	11	33
Herring Gull	1	29	29
Laysan Albatross	1	18	18
Common Myna	2	6	12
Shorebirds	1	10	10
Mourning Dove	1	10	10
Pacific Golden Plover	4	2	8
Sparrows, Buntings, Finches	2	4	8
Killdeer	1	7	7

Peninsular Florida

Species	# of Strikes	Hazard Score	Weighted Score
Osprey	11	32	352
Mourning Dove	31	10	310
Laughing Gull	14	18	252
Cattle Egret	8	23	184
Black-bellied Plover	11	15	165
Killdeer	22	7	154
Blue-winged Teal	2	48	96
Great Blue Heron	3	31	93
Shorebirds	9	10	90
Gulls, Kittiwakes, And Terns	5	18	90

Plains and Prairie Potholes

Species	# of Strikes	Hazard Score	Weighted Score
Ring-billed Gull	6	23	138
Mourning Dove	11	10	110
Northern Shoveler	2	48	96
Great Horned Owl	2	44	88
White-tailed Deer	1	88	88
Killdeer	9	7	63
Horned Lark	15	4	60
Mallard	2	29	58
Franklins Gull	3	19	57
Ducks, Geese, And Swans	1	55	55

South Atlantic

Species	# of Strikes	Hazard Score	Weighted Score
Mourning Dove	47	10	470
Turkey Vulture	7	44	308
Eastern Meadowlark	44	5	220
Killdeer	30	7	210
Rock Pigeon	7	20	140
Cattle Egret	5	23	115
Great Horned Owl	2	44	88
Black Vulture	2	44	88
White-tailed Deer	1	88	88
American Robin	16	5	80

Southern Rockies

Species	# of Strikes	Hazard Score	Weighted Score
Rock Pigeon	7	20	140
Mourning Dove	5	10	50
Lesser Scaup	1	48	48
Ring-necked Duck	1	48	48
Golden Eagle	1	36	36
Horned Lark	7	4	28
Bats	2	8	16
Pigeons And Doves	1	15	15
American Kestrel	2	6	12
European Starling	1	9	9

Upper Midwest and Great Lakes

Species	# of Strikes	Hazard Score	Weighted Score
American Kestrel	60	6	360
Ring-billed Gull	15	23	345
Killdeer	48	7	336
Red-tailed Hawk	13	25	325
Mourning Dove	17	10	170
Snow Bunting	15	10	150
Barn Swallow	52	2	104
Great Blue Heron	3	31	93
European Starling	10	9	90
Herring Gull	3	29	87

Appendix C

Top BASH species within each Landscape Conservation Cooperative (LCC) at FAA airports in descending order according to a weighted score (calculated as the number of aircraft strikes multiplied by the hazard score); Devault et al 2011. Only records for species that were reported to be struck at ≤500 AGL were used in analysis.

Appalachian

Species	# of Strikes	Hazard Score	Weighted Score
Mourning dove	340	10	3400
European starling	225	9	2025
Hawks	82	18	1476
Red-tailed hawk	56	25	1400
White-tailed deer	14	88	1232
Gulls	62	18	1116
Canada goose	22	46	1012
Blackbirds	101	9	909
Rock Pigeon	45	20	900
Killdeer	110	7	770

California

Species	# of Strikes	Hazard Score	Weighted Score
Gulls	285	18	5130
Rock Pigeon	229	20	4580
Red-tailed hawk	172	25	4300
Canada goose	43	46	1978
Ducks	30	48	1440
Hawks	77	18	1386
Barn owl	118	11	1298
Turkey vulture	25	44	1100
Great blue heron	33	31	1023
American kestrel	160	6	960

Desert

Species	# of Strikes	Hazard Score	Weighted Score
Mourning dove	70	10	700
Doves	35	15	525
Rock Pigeon	23	20	460
Coyote	13	22	286
Black-tailed jackrabbit	13	13	169
Hawks	9	18	162
Red-tailed hawk	4	25	100
Northern pintail	2	48	96
Rabbits	7	13	91
Sparrows	18	4	72
Brazilian free-tailed bat	9	8	72

Eastern Tallgrass Prairie and Big Rivers

Species	# of Strikes	Hazard Score	Weighted Score
Red-tailed hawk	205	25	5125
Canada goose	79	46	3634
Mourning dove	339	10	3390
Gulls	171	18	3078
European starling	247	9	2223
Rock Pigeon	101	20	2020
Hawks	92	18	1656
Killdeer	220	7	1540
Ducks	25	48	1200
Ring-billed gull	50	23	1150

Great Basin

Species	# of Strikes	Hazard Score	Weighted Score
Mallard	24	29	696
Ducks	13	48	624
Canada goose	11	46	506
Red-tailed hawk	19	25	475
Horned lark	115	4	460
California gull	17	22	374
Gulls	19	18	342
American kestrel	51	6	306
Swainson’s hawk	16	19	304
Hawks	11	18	198

Great Northern

Species	# of Strikes	Hazard Score	Weighted Score
Ducks	3	48	144
Gulls	6	18	108
Hawks	4	18	72
Sparrows	17	4	68
Killdeer	8	7	56
Red-tailed hawk	2	25	50
Northern shoveler	1	48	48
Ruddy duck	1	48	48
Canada goose	1	46	46
American kestrel	5	6	30

Great Plains

Species	# of Strikes	Hazard Score	Weighted Score
Horned lark	443	4	1772
Rock Pigeon	81	20	1620
Mourning dove	113	10	1130
Red-tailed hawk	41	25	1025
Coyote	43	22	946
Canada goose	13	46	598
Great horned owl	11	44	484
Hawks	25	18	450
Gulls	21	18	378
Sparrows	93	4	372

Gulf Coast Prairie

Species	# of Strikes	Hazard Score	Weighted Score
Rock Pigeon	247	20	4940
Mourning dove	369	10	3690
Doves	98	15	1470
Gulls	55	18	990
Red-tailed hawk	32	25	800
Hawks	32	18	576
Blackbirds	57	9	513
Coyote	21	22	462
Killdeer	62	7	434
Meadowlarks	77	5	385

Gulf Coastal Plains and Ozarks

Species	# of Strikes	Hazard Score	Weighted Score
Doves	102	15	1530
Mourning dove	150	10	1500
Gulls	69	18	1242
Rock Pigeon	56	20	1120
Killdeer	96	7	672
Red-tailed hawk	24	25	600
Hawks	28	18	504
Blackbirds	55	9	495
European starling	53	9	477
Sparrows	114	4	456

North Atlantic

Species	# of Strikes	Hazard Score	Weighted Score
Gulls	1006	18	18108
Canada goose	224	46	10304
Herring gull	286	29	8294
European starling	531	9	4779
Ring-billed gull	206	23	4738
White-tailed deer	52	88	4576
Rock Pigeon	145	20	2900
Mourning dove	252	10	2520
Ducks	52	48	2496
Mallard	86	29	2494

North Pacific

Species	# of Strikes	Hazard Score	Weighted Score
Red-tailed hawk	71	25	1775
Gulls	66	18	1188
Glaucous-winged gull	29	39	1131
Great blue heron	32	31	992
Canada goose	18	46	828
Mallard	25	29	725
Barn owl	57	11	627
Ducks	11	48	528
European starling	56	9	504
American kestrel	58	6	348

Northwest Boreal

Species	# of Strikes	Hazard Score	Weighted Score
Great horned owl	4	44	176
Mallard	5	29	145
Gulls	8	18	144
Mew gull	7	19	133
Snow goose	2	61	122
Herring gull	4	29	116
Bald eagle	3	36	108
Ducks	2	48	96
Canada goose	2	46	92
Red fox	6	14	84

Pacific Islands

Species	# of Strikes	Hazard Score	Weighted Score
Barn owl	70	11	770
Doves	49	15	735
Spotted dove	72	10	720
Pacific golden-plover	292	2	584
Common myna	61	6	366
Zebra dove	68	5	340
Short-eared owl	25	12	300
Rock Pigeon	15	20	300
Cattle egret	10	23	230
Mallard	7	29	203

Peninsular Florida

Species	# of Strikes	Hazard Score	Weighted Score
Gulls	240	18	4320
Turkey vulture	83	44	3652
Cattle egret	124	23	2852
Egrets	93	23	2139
New World Vultures	35	44	1540
Mourning dove	137	10	1370
Sandhill crane	36	37	1332
Doves	85	15	1275
Great blue heron	34	31	1054
Osprey	32	32	1024

Plains and Prairie Potholes

Species	# of Strikes	Hazard Score	Weighted Score
Gulls	33	18	594
Franklins gull	15	19	285
Ring-billed gull	12	23	276
Canada goose	6	46	276
Mallard	8	29	232
Snow goose	3	61	183
White-tailed deer	2	88	176
Ring-necked pheasant	5	29	145
Ducks	3	48	144
Geese	2	61	122

South Atlantic

Species	# of Strikes	Hazard Score	Weighted Score
Gulls	129	18	2322
Rock Pigeon	109	20	2180
Mourning dove	165	10	1650
Canada goose	26	46	1196
White-tailed deer	13	88	1144
European starling	127	9	1143
Red-tailed hawk	34	25	850
Killdeer	87	7	609
Coyote	27	22	594
Hawks	31	18	558

Southern Rockies

Species	# of Strikes	Hazard Score	Weighted Score
Coyote	9	22	198
Rock Pigeon	6	20	120
Mourning dove	9	10	90
Red-tailed hawk	2	25	50
Sparrows	12	4	48
Doves	2	15	30
Horned lark	7	4	28
European starling	3	9	27
Hawks	1	18	18
Pigeons, doves	1	15	15

Upper Midwest and Great Lakes

Species	# of Strikes	Hazard Score	Weighted Score
Gulls	340	18	6120
Ring-billed gull	151	23	3473
Canada goose	53	46	2438
Herring gull	64	29	1856
Red-tailed hawk	73	25	1825
White-tailed deer	15	88	1320
European starling	141	9	1269
Ducks	20	48	960
Rock Pigeon	41	20	820
Killdeer	110	7	770

Appendix D

Summary of species most often struck by aircraft at Naval airfields reporting at least 50 strikes from 2009-2016.

NAS Kingsville

SPECIES	# of Strikes
UNKNOWN	238
PASSERINE	33
BARN SWALLOW	29
CLIFF SWALLOW	25
BLUE-GRAY GNATCATCHER	16
CAVE SWALLOW	14
RUBY-THROATED HUMMINGBIRD	14
BAT	9
TURKEY VULTURE	8
MOURNING DOVE	7

NAS Corpus Christi

SPECIES	# of Strikes
UNKNOWN	276
PASSERINE	33
SONGBIRD	15
BARN SWALLOW	14
MOURNING DOVE	11
INDIGO BUNTING	8
BLUE-GRAY GNATCATCHER	7
CLIFF SWALLOW	7
COMMON NIGHTHAWK	7
HORNED LARK	7

NAS Oceana

SPECIES	# of Strikes
UNKNOWN	145
PASSERINE	21
YELLOW-RUMPED WARBLER	14
CHIMNEY SWIFT	13
BAT	12
MOURNING DOVE	12
KILLDEER	10
AMERICAN KESTREL	9
PURPLE MARTIN	9
TREE SWALLOW	7
HORNED LARK	7
BARN SWALLOW	7

NAS Meridian

SPECIES	# of Strikes
UNKNOWN	185
NORTHERN YELLOW BAT	12
BATS	12
SONGBIRD	8
INDIGO BUNTING	6
AMERICAN ROBIN	6
CLIFF SWALLOW	5
BARN SWALLOW	5
RUBY-THROATED HUMMINGBIRD	4
PASSERINE	4
GRAY CATBIRD	4
CHIMNEY SWIFT	4

NAS Whiting Field

SPECIES	# of Strikes
UNKNOWN	177
PASSERINE	13
SONGBIRD	7
CHIMNEY SWIFT	7
RED-EYED VIREO	6
YELLOW-BILLED CUCKOO	5
EASTERN MEADOWLARK	4
KILLDEER	4
MOURNING DOVE	4
RAPTOR	4

NAS Jacksonville

SPECIES	# of Strikes
UNKNOWN	143
BARN SWALLOW	7
CHIMNEY SWIFT	6
KILLDEER	6
GRAY CATBIRD	5
PASSERINE	5
LEAST TERN	4
YELLOW-RUMPED WARBLER	4
SONGBIRD	4
CEDAR WAXWING	4

NAS Whidbey Island

SPECIES	# of Strikes
UNKNOWN	114
SONGBIRD	20
BARN SWALLOW	15
PASSERINE	5
AMERICAN KESTREL	4
HORNED LARK	3
SHOREBIRD	3
BALD EAGLE	3
MOURNING DOVE	3
BAT	2
DUNLIN	2
RAPTOR	2

NAS Point Mugu

SPECIES	# of Strikes
UNKNOWN	58
CLIFF SWALLOW	19
HORNED LARK	13
SONGBIRD	13
PASSERINE	8
WATERFOWL	7
WESTERN MEADOWLARK	6
BARN SWALLOW	6
AMERICAN KESTREL	4
WESTERN SANDPIPER	4

Cecil Field

SPECIES	# of Strikes
UNKNOWN	91
BARN SWALLOW	16
PASSERINE	8
KILLDEER	7
YELLOW-RUMPED WARBLER	5
MOURNING DOVE	4
AMERICAN KESTREL	4
BRAZILIAN FREE-TAILED BAT	4
TREE SWALLOW	4
CHIMNEY SWIFT	4
SHOREBIRD	4

NAS Lemoore

SPECIES	# of Strikes
UNKNOWN	115
HORNED LARK	13
PASSERINE	6
BURROWING OWL	5
BAT	4
SONGBIRD	4
RED-TAILED HAWK	4
BARN OWL	3
BRAZILIAN FREE-TAILED BAT	3
MOURNING DOVE	3
SAVANNAH SPARROW	3

NS Norfolk

SPECIES	# of Strikes
UNKNOWN	111
BAT	6
YELLOW-RUMPED WARBLER	6
GULL	5
MOURNING DOVE	3
KILLDEER	3
SEABIRD	3
AMERICAN ROBIN	2
CHIMNEY SWIFT	2
LAUGHING GULL	2
ROYAL TERN	2
YELLOW-BILLED CUCKOO	2

MCAS Cherry Point (Navy Operations Only)

SPECIES	# of Strikes
UNKNOWN	26
MOURNING DOVE	26
EASTERN MEADOWLARK	13
BARN SWALLOW	7
BAT	7
KILLDEER	5
AMERICAN KESTREL	5
YELLOW-RUMPED WARBLER	5
PASSERINE	5
HORNED LARK	4
LAUGHING GULL	4

NAS Key West

SPECIES	# of Strikes
UNKNOWN	55
LEAST TERN	9
AMERICAN KESTREL	9
BARN SWALLOW	7
BROWN PELICAN	6
RAPTOR	4
RED-EYED VIREO	3
WHITE-CROWNED PIGEON	3
TURKEY VULTURE	3
ROYAL TERN	3

NAS Patuxent River

SPECIES	# of Strikes
UNKNOWN	52
HORNED LARK	10
SONGBIRD	8
RED-WINGED BLACKBIRD	4
TURKEY VULTURE	4
MOURNING DOVE	4
BALD EAGLE	4
CHIMNEY SWIFT	4
OSPREY	3
EASTERN MEADOWLARK	3
BARN SWALLOW	3
AMERICAN ROBIN	3

NALF Fentress

SPECIES	# of Strikes
UNKNOWN	77
YELLOW-RUMPED WARBLER	9
PASSERINE	6
TREE SWALLOW	5
KILLDEER	5
WHITE-THROATED SPARROW	3
GRAY CATBIRD	2
AMERICAN REDSTART	2
RUBY-CROWNED KINGLET	2
BAT	2

NAS Pensacola

SPECIES	# of Strikes
UNKNOWN	38
MOURNING DOVE	9
CHIMNEY SWIFT	6
SONGBIRD	5
BARN SWALLOW	5
EASTERN MEADOWLARK	5
AMERICAN ROBIN	3
PASSERINE	3
BAT	2
GAMEBIRD	2
KILLDEER	2
COMMON NIGHTHAWK	2
SAVANNAH SPARROW	2
GREAT HORNED OWL	2
SWAINSONS THRUSH	2
RUBY-THROATED HUMMINGBIRD	2

NS Mayport

SPECIES	# of Strikes
UNKNOWN	58
GRAY CATBIRD	5
LAUGHING GULL	5
PASSERINE	4
SORA	3
SHOREBIRD	3
GULL	2
OSPREY	2
OVENBIRD	2
COMMON YELLOWTHROAT	2
NORTHERN PARULA	2
RING-BILLED GULL	2
BLACK-THROATED BLUE WARBLER	2

NAS Fallon

SPECIES	# of Strikes
UNKNOWN	40
HORNED LARK	32
PASSERINE	6
SONGBIRD	5
BARN SWALLOW	3
HOUSE FINCH	2
SHOREBIRD	2
RED-TAILED HAWK	2

MCAS New River (Navy Operations Only)

SPECIES	# of Strikes
UNKNOWN	51
PASSERINE	6
YELLOW-RUMPED WARBLER	4
RED-EYED VIREO	3
GRAY CATBIRD	3
AMERICAN REDSTART	2
NORTHERN PARULA	2
OVENBIRD	2
PURPLE MARTIN	2
RING-BILLED GULL	2
PRAIRIE WARBLER	2

NAS New Orleans

SPECIES	# of Strikes
UNKNOWN	41
KILLDEER	9
BARN SWALLOW	5
EASTERN MEADOWLARK	4
BLACK VULTURE	3
CATTLE EGRET	2
PASSERINE	2
TURKEY VULTURE	2

NAS North Island

SPECIES	# of Strikes
UNKNOWN	55
SHOREBIRD	6
SONGBIRD	2
GULL	2
HORNED LARK	2

MCAS Beaufort (Navy Operations Only)

SPECIES	# of Strikes
UNKNOWN	29
SONGBIRD	8
SEMIPALMATED PLOVER	3
BARN SWALLOW	3
SHOREBIRD	3
DUNLIN	3
WESTERN SANDPIPER	2
BAT	2
TREE SWALLOW	2
PASSERINE	2
YELLOW-RUMPED WARBLER	2

NAF El Centro

SPECIES	# of Strikes
UNKNOWN	48
WHITE-THROATED SWIFT	5
CLIFF SWALLOW	5
TREE SWALLOW	3
PASSERINE	3
SONGBIRD	2
SAVANNAH SPARROW	2

Appendix E

Bird species struck by aircraft by month during the period 1995–2016 at Navy and Air Force airfields. Only records that indicate the strike was on-base, the incident occurred at less than 500 AGL, and with at least 3 incidents are reported. Species with life histories that would not likely be impacted by grass height management (e.g., swallows, wood warblers) or that utilize a wide range of grass heights (e.g., Meadowlarks, Red-winged Blackbirds) were not reported in table. According to the life history of each species, birds were grouped as likely to occur in grassland habitats with one or more grass heights [Short (S; 0-7"), Medium (M; 7-14"), or Tall (T; >14")].

January

LCC	Species	Habitat	# of Strikes	Hazard Score	Weighted Score
Appalachian	Horned Lark	S	3	4	12
California	Horned Lark	S	15	4	60
	American Kestrel	S, M	4	6	24
Desert	Horned Lark	S	13	4	52
	Mourning Dove	S	5	10	50
Eastern Tallgrass Prairie and Big Rivers	Horned Lark	S	3	4	12
Great Plains	Rock Pigeon	S	4	20	80
	Mourning Dove	S	3	10	30
	Lapland Longspur	S	4	4	16
	Smith's Longspur	S	3	1	3
Gulf Coast Prairie	Mourning Dove	S	6	10	60
	White-winged Dove	S	3	10	30
	Horned Lark	S	4	4	16
Gulf Coastal Plains and Ozarks	Red-tailed Hawk	M, T	3	25	75
	Mourning Dove	S	7	10	70
	Killdeer	S	8	7	56
	Savannah Sparrow	S, M, T	6	4	24
	Horned Lark	S	4	4	16
North Atlantic	Horned Lark	S	7	4	28
North Pacific	Red-tailed Hawk	M, T	3	25	75
South Atlantic	American Robin	S, M	3	5	15
Upper Midwest and Great Lakes	Snow Bunting	S	6	10	60

February

LCC	Species	Habitat	# of Strikes	Hazard Score	Weighted Score
California	Barn Owl	M, T	4	11	44
	Horned Lark	S	6	4	24
Desert	Mourning Dove	S	6	10	60
	Horned Lark	S	7	4	28
Great Plains	Horned Lark	S	23	4	92
	Northern Harrier	M, T	3	5	15
Gulf Coast Prairie	Mourning Dove	S	3	10	30
	American Kestrel	S, M	3	6	18
Gulf Coastal Plains and Ozarks	Mourning Dove	S	3	10	30
	Killdeer	S	4	7	28
	American Pipit	S	3	2	6
North Atlantic	Snow Bunting	S	4	10	40
	Horned Lark	S	6	4	24
Peninsular Florida	American Robin	S, M	4	5	20
	Dunlin	S	4	3	12
	Short-billed Dowitcher	S	3		0
South Atlantic	Mourning Dove	S	3	10	30
	Horned Lark	S	4	4	16

March

LCC	Species	Habitat	# of Strikes	Hazard Score	Weighted Score
Desert	Mourning Dove	S	6	10	60
	Horned Lark	S	4	4	16
Eastern Tallgrass Prairie and Big Rivers	Red-tailed Hawk	M, T	5	25	125
	European Starling	S	3	9	27
	American Robin	S, M	4	5	20
	American Kestrel	S, M	3	6	18
Great Plains	Rock Pigeon	S	4	20	80
	Red-tailed Hawk	M, T	3	25	75
	Mourning Dove	S	6	10	60
	American Kestrel	S, M	6	6	36
Gulf Coast Prairie	Mourning Dove	S	7	10	70
	Killdeer	S	3	7	21
	American Kestrel	S, M	3	6	18
Gulf Coastal Plains and Ozarks	Killdeer	S	4	7	28
	American Robin	S, M	4	5	20
North Atlantic	Ring-billed Gull	S, M	4	23	92
	European Starling	S	4	9	36
	American Kestrel	S, M	5	6	30
	Horned Lark	S	4	4	16
Plains and Prairie Potholes	Horned Lark	S	3	4	12
Upper Midwest and Great Lakes	Horned Lark	S	3	4	12

April

LCC	Species	Habitat	# of Strikes	Hazard Score	Weighted Score
California	Rock Pigeon	S	5	20	100
	Red-tailed Hawk	M, T	4	25	100
	Horned Lark	S	6	4	24
	American Goldfinch	S, M, T	3	4	12
Desert	Mourning Dove	S	11	10	110
	Horned Lark	S	6	4	24
Eastern Tallgrass Prairie and Big Rivers	European Starling	S	4	9	36
	American Robin	S, M	6	5	30
	Horned Lark	S	7	4	28
	American Kestrel	S, M	3	6	18
Great Plains	Mourning Dove	S	24	10	240
	Rock Pigeon	S	5	20	100
	Horned Lark	S	17	4	68
	American Kestrel	S, M	6	6	36
	Killdeer	S	3	7	21
	Savannah Sparrow	S, M, T	4	4	16
	American Robin	S, M	3	5	15
	Baird's Sandpiper	S	3		0
Gulf Coast Prairie	Mourning Dove	S	17	10	170
	White-winged Dove	S	4	10	40
	Upland Sandpiper	S, M	3	13	39
	American Robin	S, M	3	5	15
	Scissor-tailed Flycatcher	S, M, T	7	1	7
Gulf Coastal Plains and Ozarks	Broad-winged Hawk	M, T	3	18	54
	American Robin	S, M	4	5	20
North Atlantic	Herring Gull	S, M	3	29	87
	Ring-billed Gull	S, M	3	23	69
	Mourning Dove	S	4	10	40
	European Starling	S	3	9	27
South Atlantic	Mourning Dove	S	5	10	50
Upper Midwest and Great Lakes	Ring-billed Gull	S, M	4	23	92
	American Kestrel	S, M	3	6	18
	Horned Lark	S	3	4	12

May

LCC	Species	Habitat	# of Strikes	Hazard Score	Weighted Score
California	Horned Lark	S	5	4	20
Desert	Horned Lark	S	6	4	24
Eastern Tallgrass Prairie and Big Rivers	Mourning Dove	S	4	10	40
	European Starling	S	4	9	36
	Horned Lark	S	8	4	32
	American Kestrel	S, M	5	6	30
	Savannah Sparrow	S, M, T	5	4	20
	American Robin	S, M	4	5	20
Great Basin	Horned Lark	S	3	4	12
Great Plains	Red-tailed Hawk	M, T	5	25	125
	Franklin's Gull	S, M	6	19	114
	Horned Lark	S	20	4	80
	American Robin	S, M	5	5	25
	Killdeer	S	3	7	21
	Lark Bunting	S	4	4	16
	Scissor-tailed Flycatcher	S, M, T	6	1	6
Gulf Coast Prairie	Scissor-tailed Flycatcher	S, M, T	12	1	12
	Western Kingbird	S, M, T	3	1	3
Gulf Coastal Plains and Ozarks	Red-tailed Hawk	M, T	3	25	75
	Laughing Gull	S, M	4	18	72
	Mourning Dove	S	7	10	70
	Horned Lark	S	8	4	32
North Atlantic	Gulls, Kittiwakes, And Terns	S, M	5	18	90
	Herring Gull	S, M	3	29	87
	Ring-billed Gull	S, M	3	23	69
	European Starling	S	7	9	63
	American Kestrel	S, M	5	6	30
	Horned Lark	S	4	4	16
	Semipalmated Plover	S	3	3	9
North Pacific	Horned Lark	S	3	4	12
Peninsular Florida	Laughing Gull	S, M	5	18	90
South Atlantic	Rock Pigeon	S	3	20	60
Upper Midwest and Great Lakes	Red-tailed Hawk	M, T	3	25	75

June

LCC	Species	Habitat	# of Strikes	Hazard Score	Weighted Score
California	Rock Pigeon	S	4	20	80
	Horned Lark	S	13	4	52
Desert	Mourning Dove	S	12	10	120
	Horned Lark	S	3	4	12
Eastern Tallgrass Prairie and Big Rivers	American Kestrel	S, M	13	6	78
	Mourning Dove	S	7	10	70
	Killdeer	S	6	7	42
	European Starling	S	3	9	27
	Horned Lark	S	4	4	16
	American Robin	S, M	3	5	15
Great Basin	Mourning Dove	S	3	10	30
	Horned Lark	S	6	4	24
Great Plains	Rock Pigeon	S	7	20	140
	Horned Lark	S	22	4	88
	Red-tailed Hawk	M, T	3	25	75
	Killdeer	S	4	7	28
	American Kestrel	S, M	3	6	18
	American Robin	S, M	3	5	15
	Western Kingbird	S, M, T	7	1	7
	Scissor-tailed Flycatcher	S, M, T	4	1	4
Gulf Coast Prairie	Turkey Vulture	S, M	3	44	132
	Mourning Dove	S	13	10	130
	White-winged Dove	S	11	10	110
	Rock Pigeon	S	4	20	80
	Horned Lark	S	3	4	12
	Western Kingbird	S, M, T	5	1	5
Gulf Coastal Plains and Ozarks	Rock Pigeon	S	5	20	100
	Killdeer	S	3	7	21
	Horned Lark	S	3	4	12
North Atlantic	Mourning Dove	S	6	10	60
	European Starling	S	4	9	36
	American Kestrel	S, M	4	6	24
	Killdeer	S	3	7	21
	Horned Lark	S	5	4	20
Peninsular Florida	Laughing Gull	S, M	4	18	72
	Mourning Dove	S	5	10	50

Plains and Prairie Potholes	Savannah Sparrow	S, M, T	3	4	12
Upper Midwest and Great Lakes	Savannah Sparrow	S, M, T	8	4	32
	American Kestrel	S, M	3	6	18
	Horned Lark	S	3	4	12

July

LCC	Species	Habitat	# of Strikes	Hazard Score	Weighted Score
Appalachian	Mourning Dove	S	4	10	40
California	Rock Pigeon	S	3	20	60
	American Kestrel	S, M	7	6	42
	Horned Lark	S	6	4	24
Desert	Mourning Dove	S	22	10	220
	White-winged Dove	S	3	10	30
Eastern Tallgrass Prairie and Big Rivers	Mourning Dove	S	15	10	150
	American Kestrel	S, M	19	6	114
	Red-tailed Hawk	M, T	4	25	100
	Horned Lark	S	17	4	68
	European Starling	S	3	9	27
Great Basin	Horned Lark	S	6	4	24
	American Kestrel	S,M	3	6	18
Great Plains	Rock Pigeon	S	7	20	140
	Red-tailed Hawk	M, T	4	25	100
	Horned Lark	S	19	4	76
	Killdeer	S	7	7	49
	American Kestrel	S, M	8	6	48
	Pigeons And Doves	S	3	15	45
	Upland Sandpiper	S, M	3	13	39
	Western Kingbird	S, M, T	12	1	12
	Scissor-tailed Flycatcher	S, M, T	5	1	5
Gulf Coast Prairie	Mourning Dove	S	22	10	220
	American Robin	S, M	3	5	15
	Western Kingbird	S, M, T	6	1	6
	Scissor-tailed Flycatcher	S, M, T	6	1	6
Gulf Coastal Plains and Ozarks	Killdeer	S	11	7	77
	American Kestrel	S, M	3	6	18
	Scissor-tailed Flycatcher	S, M, T	4	1	4
	Eastern Kingbird	S, M, T	3	1	3
North Atlantic	Mourning Dove	S	19	10	190
	Laughing Gull	S, M	6	18	108
	American Kestrel	S, M	14	6	84
	Rock Pigeon	S	4	20	80

	Upland Sandpiper	S, M	4	13	52
	Killdeer	S	7	7	49
	European Starling	S	3	9	27
	Horned Lark	S	4	4	16
North Pacific	American Kestrel	S, M	4	6	24
Peninsular Florida	Killdeer	S	5	7	35
	Mourning Dove	S	3	10	30
Plains and Prairie Potholes	Mourning Dove	S	4	10	40
	Killdeer	S	3	7	21
South Atlantic	Mourning Dove	S	12	10	120
Upper Midwest and Great Lakes	American Kestrel	S, M	29	6	174
	Killdeer	S	8	7	56

August

LCC	Species	Habitat	# of Strikes	Hazard Score	Weighted Score
Appalachian	Mourning Dove	S	8	10	80
	Rock Pigeon	S	3	20	60
	Killdeer	S	4	7	28
California	Barn Owl	M, T	7	11	77
	Red-tailed Hawk	M, T	3	25	75
	Rock Pigeon	S	3	20	60
	Horned Lark	S	11	4	44
	Mourning Dove	S	3	10	30
	American Kestrel	S, M	3	6	18
Desert	Horned Lark	S	3	4	12
Eastern Tallgrass Prairie and Big Rivers	Great Horned Owl	M, T	3	44	132
	Red-tailed Hawk	M, T	5	25	125
	Horned Lark	S	22	4	88
	Shorebirds	S	7	10	70
	American Kestrel	S, M	7	6	42
	Western Kingbird	S, M, T	3	1	3
Great Basin	Horned Lark	S	5	4	20
	Western Kingbird	S, M, T	3	1	3
Great Plains	Red-tailed Hawk	M, T	4	25	100
	Horned Lark	S	12	4	48
	Killdeer	S	6	7	42
	Upland Sandpiper	S, M	3	13	39
	American Kestrel	S, M	6	6	36
	Brown-headed Cowbird	S	3	9	27
Gulf Coast Prairie	Mourning Dove	S	15	10	150
	White-winged Dove	S	5	10	50
	Great-tailed Grackle	S	4	9	36
	Scissor-tailed Flycatcher	S, M, T	8	1	8
Gulf Coastal Plains and Ozarks	Upland Sandpiper	S	4	13	52
	Least Sandpiper	S	3	3	9
North Atlantic	Killdeer	S	17	7	119
	Laughing Gull	S, M	5	18	90
	American Kestrel	S, M	11	6	66
	Brown-headed Cowbird	S	3	9	27
	Orioles, Blackbirds,	S	3		0

	Oropendolas, Caciques				
North Pacific	American Kestrel	S, M	6	6	36
Peninsular Florida	Mourning Dove	S	11	10	110
	Killdeer	S	4	7	28
Plains and Prairie Potholes	Mourning Dove	S	3	10	30
	Killdeer	S	4	7	28
South Atlantic	Mourning Dove	S	11	10	110
	Killdeer	S	4	7	28
	European Starling	S	3	9	27
	Horned Lark	S	3	4	12
Upper Midwest and Great Lakes	Killdeer	S	21	7	147
	American Kestrel	S, M	17	6	102
	Red-tailed Hawk	M, T	3	25	75
	Shorebirds	S	4	10	40
	European Starling	S	4	9	36
	Mourning Dove	S	3	10	30

September

LCC	Species	Habitat	# of Strikes	Hazard Score	Weighted Score
Appalachian	Mourning Dove	S	5	10	50
	Killdeer	S	3	7	21
	Horned Lark	S	3	4	12
California	Canada Goose	S, M	4	46	184
	Horned Lark	S	7	4	28
	Killdeer	S	3	7	21
	American Kestrel	S, M	3	6	18
Desert	Mourning Dove	S	7	10	70
	Horned Lark	S	7	4	28
Eastern Tallgrass Prairie and Big Rivers	Killdeer	S	27	7	189
	Red-tailed Hawk	M, T	7	25	175
	Horned Lark	S	43	4	172
	Mourning Dove	S	14	10	140
	European Starling	S	5	9	45
	American Kestrel	S, M	7	6	42
	Shorebirds	S	3	10	30
Great Basin	Horned Lark	S	4	4	16
Great Plains	Mourning Dove	S	18	10	180
	Turkey Vulture	S, M	3	44	132
	Horned Lark	S	23	4	92
	Swainson's Hawk	M, T	4	19	76
	American Kestrel	S, M	8	6	48
	Killdeer	S	5	7	35
Gulf Coast Prairie	Mourning Dove	S	9	10	90
	Killdeer	S	6	7	42
	Horned Lark	S	6	4	24
	Scissor-tailed Flycatcher	S, M, T	3	1	3
Gulf Coastal Plains and Ozarks	Mourning Dove	S	20	10	200
	Killdeer	S	12	7	84
	Horned Lark	S	5	4	20
	Black Tern	S	3	2	6
North Atlantic	American Kestrel	S, M	15	6	90
	Killdeer	S	11	7	77
	Red-tailed Hawk	M, T	3	25	75
	Rock Pigeon	S	3	20	60
	Laughing Gull	S, M	3	18	54
	Mourning Dove	S	5	10	50
	Horned Lark	S	3	4	12
Peninsular Florida	Mourning Dove	S	5	10	50

	Killdeer	S	3	7	21
Plains and Prairie Potholes	Ring-billed Gull	S, M	3	23	69
	Franklins Gull	S, M	3	19	57
South Atlantic	Mourning Dove	S	5	10	50
Southern Rockies	Horned Lark	S	4	4	16
Upper Midwest and Great Lakes	Killdeer	S	13	7	91
	Mourning Dove	S	6	10	60
	American Kestrel	S, M	5	6	30
	Horned Lark	S	3	4	12

October

LCC	Species	Habitat	# of Strikes	Hazard Score	Weighted Score
Appalachian	Mourning Dove	S	4	10	40
	Killdeer	S	4	7	28
	Horned Lark	S	3	4	12
California	Northern Pintail	S, M	5	48	240
	American Kestrel	S, M	4	6	24
	Killdeer	S	3	7	21
	Savannah Sparrow	S, M, T	5	4	20
	American Pipit	S	4	2	8
Desert	Mourning Dove	S	11	10	110
	Horned Lark	S	12	4	48
Eastern Tallgrass Prairie and Big Rivers	Red-tailed Hawk	M, T	3	25	75
	Horned Lark	S	17	4	68
	Killdeer	S	9	7	63
	Mourning Dove	S	3	10	30
Great Basin	Horned Lark	S	6	4	24
Great Plains	Mourning Dove	S	13	10	130
	Red-tailed Hawk	M, T	3	25	75
	Rock Pigeon	S	3	20	60
	Killdeer	S	6	7	42
Gulf Coast Prairie	Turkey Vulture	S, M	3	44	132
	Mourning Dove	S	8	10	80
	American Kestrel	S, M	6	6	36
	Killdeer	S	5	7	35
	Horned Lark	S	4	4	16
	American Robin	S, M	3	5	15
	Scissor-tailed Flycatcher	S, M, T	5	1	5
Gulf Coastal Plains and Ozarks	Mourning Dove	S	20	10	200
	Killdeer	S	8	7	56
	American Kestrel	S, M	8	6	48
	Horned Lark	S	5	4	20
	American Robin	S, M	3	5	15
North Atlantic	Ring-billed Gull	S, M	4	23	92
	Herring Gull	S, M	3	29	87
	Mourning Dove	S	4	10	40
	Snow Bunting	S	3	10	30
	Horned Lark	S	7	4	28
	American Kestrel	S, M	4	6	24
	Northern Harrier	M, T	3	5	15

	American Robin	S, M	3	5	15
	Savannah Sparrow	S, M, T	3	4	12
Peninsular Florida	Mourning Dove	S	3	10	30
South Atlantic	American Kestrel	S, M	5	6	30
	American Robin	S, M	3	5	15
	Horned Lark	S	3	4	12
Upper Midwest and Great Lakes	Ring-billed Gull	S, M	3	23	69
	Mourning Dove	S	3	10	30
	Killdeer	S	4	7	28
	Horned Lark	S	4	4	16

November

LCC	Species	Habitat	# of Strikes	Hazard Score	Weighted Score
Appalachian	Horned Lark	S	3	4	12
California	Red-tailed Hawk	M, T	5	25	125
	Barn Owl	M, T	5	11	55
	Horned Lark	S	13	4	52
	Mourning Dove	S	5	10	50
	American Kestrel	S, M	4	6	24
	American Pipit	S	6	2	12
Desert	Horned Lark	S	21	4	84
	Mourning Dove	S	6	10	60
	American Kestrel	S, M	3	6	18
Eastern Tallgrass Prairie and Big Rivers	American Kestrel	S, M	4	6	24
	Horned Lark	S	4	4	16
Great Basin	Horned Lark	S	5	4	20
Great Plains	Rock Pigeon	S	6	20	120
	Horned Lark	S	22	4	88
	Killdeer	S	5	7	35
	European Starling	S	3	9	27
	American Kestrel	S, M	4	6	24
	Lapland Longspur	S	3	4	12
Gulf Coast Prairie	Mourning Dove	S	14	10	140
	Rock Pigeon	S	3	20	60
	Killdeer	S	5	7	35
	American Pipit	S	3	2	6
Gulf Coastal Plains and Ozarks	Cattle Egret	S, M, T	5	23	115
	American Kestrel	S, M	8	6	48
	American Robin	S, M	8	5	40
	Savannah Sparrow	S, M, T	5	4	20
North Atlantic	Herring Gull	S, M	4	29	116
	Mourning Dove	S	6	10	60
	Horned Lark	S	11	4	44
Peninsular Florida	Black-bellied Plover	S	3	15	45
	Killdeer	S	4	7	28
South Atlantic	American Robin	S, M	6	5	30
	Killdeer	S	3	7	21

December

LCC	Species	Habitat	# of Strikes	Hazard Score	Weighted Score
California	Horned Lark	S	21	4	84
	American Pipit	S	8	2	16
Desert	Mourning Dove	S	9	10	90
	Horned Lark	S	21	4	84
Eastern Tallgrass Prairie and Big Rivers	Horned Lark	S	5	4	20
	American Robin	S, M	3	5	15
Great Plains	Horned Lark	S	17	4	68
	Rock Pigeon	S	3	20	60
	Lapland Longspur	S	6	4	24
	Chestnut-collared Longspur	S	3	4	12
Gulf Coast Prairie	White-winged Dove	S	6	10	60
	American Kestrel	S, M	3	6	18
Gulf Coastal Plains and Ozarks	Mourning Dove	S	9	10	90
	Pigeons And Doves	S	3	15	45
	Killdeer	S	4	7	28
	American Kestrel	S, M	4	6	24
	American Pipit	S	3	2	6
North Atlantic	Herring Gull	S, M	3	29	87
	Gulls, Kittiwakes, And Terns	S, M	4	18	72
	Horned Lark	S	5	4	20
Peninsular Florida	Dunlin	S	3	3	9
South Atlantic	Mourning Dove	S	3	10	30
Upper Midwest and Great Lakes	Snow Bunting	S	4	10	40

Appendix F

Life History for the most problematic avian BASH species

Below are literature reviews of the life histories of the most problematic BASH species on Navy airfields. Descriptions focus mainly on the relative importance of vegetation height to various life-history needs.

1. Vultures. There are two North American vulture species of concern on military airfields; turkey vultures (*Cathartes aura*) and black vultures (*Coragyps atratus*).

Turkey vultures typically use low vegetation (0-20 cm) when on the ground. Home ranges contain more open areas than forested habitat than based on availability (Coleman and Fraser 1989). Vultures are most often observed soaring on thermals, including higher altitude flights. Turkey vultures are associated more with open landscapes than forest, but do nest within forests, along cliffs, or abandoned buildings (Mossman 1998). Roosts in large, tall trees that are isolated from human disturbance, though often close to roads and open fields. Winter habitat generally the same as other seasons. Recommended vegetation management: Tall; however, vegetation height likely does not influence soaring flights over and near airfields.

The Turkey Vulture is the most common and widely distributed vulture in North America. The Black Vulture (*C. aura*) is less abundant, but a more aggressive species found in the eastern and southeastern United States. The western race of the Turkey Vulture is the most migratory, and is known to form large migratory flocks, potentially numbering in the thousands, while migrating to Central and South America (Kirk and Mossman 1998). During migration, this species typically soars on atmospheric thermals, and may be susceptible to aircraft strike at any time while in flight. The Black Vulture is largely non-migratory, but like the Turkey Vulture, can form large communal roosts. Both species are largely scavengers and are therefore dependent upon a significant population of vertebrate prey in an area. The Turkey Vulture tends to be more solitary, while the Black Vulture tends to from larger feeding and roosting groups; however, both species may form large roosting flocks during the year (especially during migration for the Turkey Vulture), or many individuals may congregate around prey items, typically along roadways, where they often form mixed flocks. As a group, both vultures received the highest hazard rank for military aircraft by Zakrajsek and Bissonette (2005).

Abundance/Distribution: The Turkey Vulture breeds throughout much of the United States and into some sections of Canada (Kirk and Mossman 1998). It is a year-round resident species throughout much of the Northeastern United states, south through Florida, and west all the way through Mexico. The species is also resident throughout much of California. In the Pacific Northwest, through the Midwestern portion of the U.S., and around the Great Lakes region, this species is present during the breeding season, but will migrate during the fall and spring seasons.

Habitat Preferences/Reproductive Behavior: Turkey vultures prefer mixed farmland and forest habitat. Mixed farmland provides suitable foraging areas, while forest patches provide opportunities for nesting and roosting sites. This species will nest in a variety of locations, including vacant buildings, rocky outcrops and fallen trees (Kirk and Mossman 1998). Forest

stands, even small forest patches, may provide habitats for roosting flocks, especially during the migratory seasons. This species may also roost on rock outcrops and large trees; in the southwest, this species has been reported to roost in large cactus. While this species may be found in urban and suburban habitats, it is more likely to avoid such areas than the Black Vulture. Home range studies have suggested that these birds cover more open than forested habitat on a daily basis, and daily habitat use often includes roads; this is to be expected as a scavenger species that typical feeds upon road kill. This species is socially monogamous and will mate for life; usually does not associate with its mate after breeding until the following breeding season. Turkey vultures usually arrive on breeding grounds in mid-March, and begin breeding in mid-April with young hatching by late-May and early June. The species is usually single brooded, but replacement nests may begin as late as mid-June. This bird will usually depart the breeding grounds around mid-October; at this time migrants will proceed southward.

Prey Items/Foraging and Perching Behaviors: The Turkey Vulture is an opportunistic scavenger that will feed on a wide-variety of wild and domestic carrion, especially along roads. These birds have a highly developed sense of smell and can locate prey when hidden from view; even under a forest canopy (Kirk and Mossman 1998). In most parts of the range, mammals constitute the largest prey, with approximately equal proportions of domestic versus wild prey depending upon availability. Predation often occurs on birds, especially domestic chickens, again depending upon availability. In the southwestern United States, turkey vultures will shift their diet to reptiles when other prey are scarce. Typical foraging flight altitude is around 30 – 50 m above ground level (AGL) (Rodriguez-Estrella 1994). On rare occasions, this bird will attempt to take live prey, such as hatchling turtles or sickly domestic animals. In one documented event, a Turkey Vulture attached a juvenile Great Blue Heron (*Ardea herodias*) and consumed the food regurgitated by the heron (Temple 1969). This species communally roosts in the evenings, often with Black Vultures. Roosting groups are often greater than 100 individuals, but groups over 300 are not uncommon. They may roost more often in conifers during the fall and winter for better thermal regulation, then shift back to deciduous trees during the spring and summer. Before arriving at roosts in the evenings, or leaving roosts during the morning, turkey vultures may use a pre- or post-roosting perch (approx. 1 km from roost site) for preening and other maintenance behaviors (Kirk and Mossman 1998). In the morning, they may often exhibit a spread-wing posture for thermal regulatory purposes. They engage in foraging flights 1 to 5 hours after sunrise, and may spend 1 to 3 hours in a pre-roosting flight. Birds are observed flying more often during the afternoon than during the morning. During soaring behavior, individuals use low-level atmospheric winds or high-altitude thermals, with flapping occurring during take-off or just before perching, rarely during actual flight. Average flight altitude is approximately 500 m AGL, but individuals have been observing soaring on thermals at around 6,400 m (Kirk and Mossman 1998).

Migratory Behavior, Timing and Patterns: The eastern and Mexican races of this vulture are only partially migratory. The western race is the most migratory, and is capable of forming large migratory flocks, especially during fall passage to winter grounds in Central and South America (Kirk and Mossman 1998). Fall migration typically begins in mid-October and early November, and spring migration typically begins in early March. Largely a diurnal migrant and often

observed in mixed migrant flocks with Swainson's Hawks (*Buteo swainsoni*) and Broad-winged Hawks (*B. lagopus*) (Kerlinger 1985). Huge flocks of Turkey Vultures, sometimes numbering in the thousands, can be observed in areas with narrow migratory corridors (e.g., Isthmus of Panama) (Kirk and Mossman 1998). They may winter as far south as Venezuela and the greatest migratory distance observed for this species is 980 miles.

Black vultures typically use low vegetation (0-20 cm) when on the ground. Black vultures share similar life history traits to that of Turkey Vultures, and often follow turkey vultures as black vultures have a much poorer sense of smell. Black vultures nest in forests in large hollow trees, snags or stumps. They also nest in crevices and brush piles or in abandoned buildings (Buckley 1999). Non-migratory species with winter habitat generally the same as other seasons (Buckley 1999). Recommended vegetation management: Tall; however, vegetation height likely does not influence soaring flights over and near airfields.

Abundance/Distribution: The Black Vulture is a common species in the eastern United State north to Pennsylvania and New Jersey, and throughout the southeastern states and west to Texas; a small population extends north from Mexico into southern Arizona (Buckley 1999). This species is considered a resident throughout its range and is rarely known to exhibit migratory behavior, except short-distance movements south in response to specific cold periods or winter storms (Buckley 1999).

Habitat Preferences/Reproductive Behavior: This vulture most often breeds in dense woodlands, but forages in open habitat. Open habitats dominate the home range of this bird, especially open areas with significant roads. It usually roosts in mature forest stands near water, but will roost on other structures including telephone poles and towers. No nests are constructed; eggs are laid directly on ground. Locations of nests are often on hollow logs, caves, abandoned buildings, brush piles or rock crevices (Buckley 1999). Pair-bonding occurs in late January to early February and egg laying begins in mid-February. Hatching typically occurs in March through May, and fledglings are observable through June to early August (Buckley 1999). These birds are socially monogamous and generally mate for life; will often have year-round association with mate.

Prey Items/Foraging and Perching Behaviors: This vulture is an opportunistic scavenger, but possesses poorly developed olfactory capabilities. This species usually locates prey by following Turkey Vultures. Much more numerous and aggressive than Turkey Vultures, this species will outcompete others for access to available prey. Unlike the Turkey Vulture, this species utilizes large animals more often in its diet. Large flocks of Black Vultures can be observed around white-tailed deer or feral hogs, especially along roads. When available, this bird may consume domestic animal carcasses, such as chickens and cattle. More than the Turkey Vulture, this species will attack and consume live prey including newborn domestic pigs and lambs; they have also been observed eating turtle hatchlings and juvenile night-herons out of nests (Buckley 1999 and reference therein). Large numbers of Black Vultures have also been observed attacking large live prey (Buckley 1999).

These birds form active communal roosts, typically consisting of related individuals and can range seasonally between 358 individuals (winter) to 242 individuals (summer) (Rabenold 1986). Roosting sites are used regularly year-after-year, and some roosting site may have histories extending back 100 years or more (Buckley 1999). Within an individual's home range, there may be several roost sites that are used regularly. Home ranges vary widely, but most birds are often found in a 20 km area around the nest site and various available roost sites (Rabenold 1986). As with Turkey Vultures, this bird will exhibit a spread-wing posture for thermal regulatory purposes, though this behavior occurs more often on the ground than seen with other vultures. Black Vultures also soar on high-altitude thermals; gliding is the most important feature in the foraging behavior of this species. The Black Vulture possesses shorter wings and flaps more when flying than does the Turkey Vulture. Black Vultures spend less time flying and fly consistently at higher altitudes than Turkey Vultures; greater than 60 percent of flying occurred 4 to 9 hours after sunrise, and most flights were less than 200 m AGL (Avery et al. 2011).

Migratory Behavior, Timing and Patterns: The Black Vulture does not show significant migratory behavior. Roosting flock may be larger in the winter seasons, and thus may constitute greater BASH risk for military aviation operations for those installations that support roost areas within close proximity to the air field.

2. Birds of Prey. Buteos are a genus of medium-sized raptors with robust bodies and broad wings. Raptors, or birds or prey (hawks, owls, eagles), are a routine problem BASH species for military installations (Zakrajsek and Bissonette 2005). Although not as large as vultures, pelicans, or geese, and not likely to form large flocks (except in some areas during migration), Buteos typically forage in large open areas and soar on thermals, leading them to frequent air fields and fly at altitudes that often create BASH concerns. Buteos are large enough to cause significant damage to aircraft and have the potential to cause serious accidents that endanger the lives of civilians and military personnel. There are 10 species of Buteos native to North America (Wheeler and Clark 1996). Of all Buteos, the Red-tailed Hawk (*Buteo jamaicensis*) is by far the most abundant and wide-spread.

Red-tailed hawks may use a wide range of grass heights (0-100 cm), and often are observed on perches where they sit-and-wait on prey. Red-tailed hawks often are associated with open grasslands and agricultural fields where they hunt for mammals (Leyhe and Ritchison 2004). Fitzpatrick (2003) found that red-tailed hawks foraged in mowed grassland plots more than in un-mowed plots in the Eastern US. Red-tailed hawks will use thermals to soar for either foraging bouts or during migration. Red-tailed hawks nest in large, tall mature trees (Preston and Beane 1993). Home ranges require significant amounts of open grasslands or fallow fields; however, plowed fields and areas with suitable foraging habitat, but few or no perches are usually avoided (Preston and Beane 1993, Leyhe and Ritchison 2004). Recommended vegetation management: Tall; however, vegetation height likely does not influence soaring flights over and near airfields

Abundance/Distribution: The Red-tailed Hawk is a resident species throughout much of the conterminous United States and Mexico, with resident population also in Central America and

the Caribbean. Breeding populations exist throughout much of Canada and Alaska, but are largely absent for arctic regions (Preston and Beane 1993).

Habitat Preferences/Reproductive Behavior: Red-Tailed Hawks inhabit open fields and grasslands that possess scattered, elevated perches, including trees, cliffs and telephone poles. Home ranges are more closely associated with the presence of trees than most other western Buteos, but inhabit more open areas than eastern Buteos. There are few differences between basic breeding and winter habitats. Red-tailed Hawks are usually monogamous, but observations of 3 adults raising young have been recorded (Preston and Beane, and references therein). Both sexes engage in elaborate courtship displays that entail soaring at high altitudes and conducting a series of rises and descents, then locking legs and/or talons, they spin downward releasing each other before hitting the ground. These displays are often accompanied by screams and soft, raspy hissing calls. Once a pair-bond has formed, it is usually maintained until the death of one of the pair. A pair will often re-use old nests from prior seasons. Multiple nests sites may be visited before final selection of nest site. Nesting sites vary widely throughout range, but typically they are located in the canopy of tall trees. In the absence of trees, this hawk will construct nests on building or cliff edges and artificial structures. In southern portions of the range, Red-tailed Hawks may begin breeding in early February, but in most areas, peak breeding begins in mid-to-late March and lasts? through mid-June. Incubation takes about 28-35 days; altricial young hatch with eyes closed and unable to lift their head (Preston and Bean 1993). Young develop quickly and usually leave the nest after ~46 days. Females generally take care of brooding the hatchlings, while the male provides food items for the first 30 days. Both parents may continue to provide food for the juveniles up to 8 weeks after leaving the nest.

Prey Items/Foraging and Perching Behaviors: The Red-tailed Hawk is generally a sit-and-wait predator. Most forage attempts occur from an elevated perch, although foraging by flight has been observed. The diet is almost entirely carnivorous and prey consists largely of small to medium mammals, birds and reptiles (Preston and Beane 1993). Juvenile hawks may occasionally take insects. Small prey may be swallowed whole, while other prey (e.g., passerines) may be taken to a perch and consumed. Larger prey are consumed on the ground. Red-tailed Hawks may also opportunistically feed on fresh carrion. Foraging perches are usually elevated and possess an excellent view of the surrounding landscape. During various times of the year, these hawks will form roosting sites, usually located in a protected stand of dense trees. Single or small groups of hawks may use a roost site for multiple nights during the year (Preston and Bean 1993).

Migratory Behavior, Timing and Patterns: Migration patterns of Red-tailed Hawks are complex and sometimes unpredictable. Generally, northern most breeding populations will migrate south for the winter. However, even in periods of intense cold weather, some birds will remain close to the breeding territory (Preston and Beane 1993). Spring migration may begin as early as February, but peak migration usually begins in late March through mid-April; some birds have arrived on the breeding grounds as late as June (Preston and Beane 1993). Fall migration may begin as early as August, but peak migration occurs from mid-October to mid-November (Preston and Beane 1993). These hawks are largely diurnal migrants. In the eastern United

States, various topological features funnel Red-tailed Hawks in large numbers during fall migration (e.g., Hawk Mountain, PA; and the Cape May Peninsula, NJ). Since 1934, over 3,000 Red-tailed Hawks have been observed annually during the fall migration season; western migration is more diffuse (Preston and Beane 1993, and references therein). During migration, Red-tailed Hawks will soar on atmospheric thermals, reaching altitudes of up to 895 m AGL (Kerlinger et al. 1985).

Swainson's hawks generally hunt in taller vegetation that supports higher densities of prey, especially mammals. They hunt mostly over grassland areas, sparse open shrublands, and agricultural fields. They do not generally utilize vegetation types taller than native grasslands, and typically forages in crop agriculture before and after harvest when vegetation is lowest and prey is highest (England et al. 1997). They utilize isolated trees for nesting (England et al. 1997). Hawks often perch in scattered trees located in open grassland/agricultural landscapes. Swainson's hawks migrate to South America for the winter.

American kestrels (*Falco sparverius*) use mostly low vegetation (2.5-10.5 cm) in grassland habitats and in areas with small trees and shrubs (Smallwood and Bird 2002). Fitzpatrick (2003) found that American kestrels foraged in mowed grassland plots more than in un-mowed plots in the Eastern US. Kestrels are a secondary cavity nester that utilize old woodpecker excavations, rocky crevices, or human-made nest boxes. They require large areas of open grassland, semi-open habitats, deserts, meadows, old fields, parklands, or urban/suburban areas. Suitable areas also require availability of perches for foraging (Smallwood and Bird 2002). While kestrels require significant portion of open areas for foraging, this species is considered an edge species that readily utilizes forest/grassland or shrubland edges for foraging (Johnson and Anderson 2002). Heavy cover is avoided, but kestrels will forage in a variety of grassland and cropland habitats. Kestrels generally migrate singularly or in small groups; however, passages of kestrels in the thousands have been observed at Hawk Mountain, PA, and other sites. Kestrels often follow mountains to take advantage of updrafts; also along coasts of Great Lakes and along the Atlantic Coast (Smallwood and Bird 2002). *Recommended vegetation management: Medium to Tall***.**

Great horned owls sight most prey from perches, but hunt mammals and birds over woodland edges, meadows, open and semi-open grasslands, and sagebrush habitats; in interior of open, mature forests; along margins of wetlands, ponds, and lakes; and over open water for waterfowl (Artuso et al. 2013). Nest sites for great horned owls are extraordinarily variable with wider range of nest sites than any other bird in the Americas (Artuso et al. 2013). Most commonly uses tree nests of other species in whatever tree is available, but also uses cavities in trees and snags, cliffs, deserted buildings, artificial platforms, ledges, pipes, and will lay eggs on the ground. Most great horned owls are permanent residents with winter habitat similar to that of breeding/foraging habitat.

3. Passerines. There are numerous small-bodied passerines (i.e., perching birds) that specialize in grassland habitats and are common on military airfields. Most are not of significant concern, though those that form large flocks during the non-breeding season can and do cause significant BASH risk and aircraft damage.

Horned larks (*Eremophila aplestris*) prefer bare ground and other low vegetation areas, with vegetation over a few centimeters avoided (Wiens et al. 1987). Areas suitable for nesting in early spring often unsuitable by late spring or early summer because vegetation grows too tall; in these situations, the birds generally abandon the area or forego further nesting (Beason 1970). Open areas including beaches, sand dunes, and airfields often attract horned larks because of the low or bare ground cover. Highest population densities coincide with greatest amount of bare ground. Use of mowed areas around airstrips has allowed species to colonize regions where no other suitable habitat may exist nearby. Recommended vegetation management: Medium to Tall

The Horned Lark is a small passerine that inhabits grasslands with short grass and open bare ground. This habitat preference, plus its tendency to form large flocks, can create problems for operational airports. While single birds will generally not do any significant damage to aircraft, a collision with a flock of hundreds of individuals is a threat to the safety of civilians and military personnel. One subspecies, the Streaked Horned Lark (*E. a. strigata*), breeds and winter in OR and WA; this subspecies is currently a candidate species under ESA (Pearson and Altman 2005).

Abundance/Distribution: The Horned Lark is a common small grassland passerine that is found virtually throughout much of the conterminous United States; it extends north into Canada and reaches the Arctic, and south into some areas of Mexico and Central and South America (Beason 1995).

Habitat Preferences/Reproductive Behavior: An abundant bird in open barren country habitats, the Horned Lark is found in short, sparse grasslands, pastures and deserts. It is very common in disturbed agricultural lands and heavily grazed ranges. After strip-mining activities, it is one of the first species to recolonize the bare ground habitat. Little is known about breeding behavior, but the species is likely monogamous during the breeding season; there are no data on polygynous behavior or extra-pair copulations (Beason 1995). The breeding season can begin as early as February, especially in desert habitats, but peak breeding begins in mid-March and can extend through late April/early May (Beason 1995). Males perform a complex courtship display that includes a nuptial flight up to about 100 m in altitude. Nests are placed directly on the ground, usually at the base of vegetation or a rock. The nest cavity is dug ino the earth, and the female then constructs the nest using grass, roots and other vegetative material. The nest may be lined with downy feathers. Incubation of eggs takes about 11-12 days. The young are altricial but are capable of leaving nest after 10 days. Like many grassland species, the young Horned Lark fledglings can walk and run before they can fly. After leaving nest, the young are capable of flight around the 27th day after hatching (Beason 1995). Horned Larks produce at least 2 broods per season and sometimes more; higher altitude birds usually only have time for only one brood. Usually the first brood is produced before Brown-headed Cowbirds breed; however, late broods or second broods may be parasitized by cowbirds.

Prey Items/Foraging and Perching Behaviors: The Horned Lark forages year-round on the ground, and feeds largely on grasses and seeds; it will feed on waste grain in agricultural and livestock settings. However, during the breeding season, the young are fed insects.. This species does not form roosts per se, but by late summer/early fall, they will form post-breeding flocks in

open fields generally in or near fields where breeding occurred. During the winter, Horned Larks may form mixed-species flocks numbering in the hundreds that will travel over a large area to forage. Mixed flocks may include Tree Sparrows (*Spizella arborea*), Dark-eyed Juncos (*Junco hyemalis*), Lapland Longspurs (*Calcarious lapponicus*) and Snow Buntings (*Plectrophenax nivalis*) (Beason 1995, and references therein).

Migratory Behavior, Timing and Patterns: Usually only far north populations migrate; elsewhere, Horned Larks are likely a partial migrant or year-round resident. For those populations that do migrate, fall migration begins by September; peak fall migration usually begins in mid-October through mid-November (Beason 1995). In areas as far south as AZ, birds may move southward into Mexico by late June or early August (Beason 1995). Numerous Horned Larks winter in the Southeastern United States, usually arriving by November; however, northern breeding populations of these winter birds are not precisely known (Beason 1995). Spring migration usually begins by mid-February and peak migration usually begins in mid-March through the end of April (Beason 1995). The Horned Lark is a diurnal migrant during both fall and spring. Flight altitude during migration is not reported; however, foraging flocks likely remain under 100 m AGL. Movement of flocks through active airports during seasonal migration, post-breeding periods, and during the winter, constitutes that largest threat for BASH.

Eastern meadowlarks mostly occur in grassland; however, they may use a wide range of grass heights (2.5-75 cm) with preferred heights near 30 cm (Lanyon 1995, Hull 2001, Seamans et al. 2007). Meadowlarks nest on the ground in dense vegetation, particularly graminoid cover (Vickery et al. 1994). Meadowlarks forage on the ground in grassland habitat; forage largely on insects and may feed on seeds, grains, and other animal sources in winter or periods of resource scarcity (Lanyon 1995). Winter habitat generally is similar to other season with birds often forming small flocks (Lanyon 1995). *Recommended vegetation management: Tall*

Western meadowlarks prefer lower vegetation during the breeding season and will feed on bare ground in winter, but they avoid areas with taller, denser vegetation (Fritcher et al. 2004). Western meadowlarks nest in pasture, prairie, or other grassland habitat; rarely in cultivated fields, and seem to prefer grass heights in the 30-50cm range based on review of multiple studies throughout their range. They feed on the ground in open areas, including cultivated fields and feedlots. Winter habitat is similar to breeding season, occupying a variety of grassland types; will make local movements to shrubby habitats (Davis and Lanyon 2008). Meadowlarks are diurnal migrants, travelling mostly in small flocks, but larger flocks may be observed. *Recommended vegetation management: Medium to Tall*

American robins showed a clear preference for foraging in short vegetation (Seamans et al. 2007); however they occasionally occur in taller grass. Robins show clear preference for short grass lawns, especially those that recently have been mowed (Eiserer 1980). Robins typically nest in woody vegetation, often in tree or shrub branches, but will use artificial structures such as house gutters or light fixture (Vanderhoff et al. 2016). Winter habitat is similar to breeding range except most populations migrate to more southerly latitudes where they winter in forests and also feed in openlands (Vanderhoff et al. 2016). Overwintering numbers may vary significantly from year to year in many (especially northern) areas and flock size can range from

a dozen to several hundred individuals (Vanderhoff et al. 2016). *Recommended vegetation management: Medium to Tall*

4. Shorebirds and Waterbirds

Killdeer occupy areas with short vegetation, often <1 cm in height during all months of the year (Jackson and Jackson 2000). During breeding season, nests on ground in gravel, short grass, or sand habitats including parking lots and driveways with little or no vegetation. If vegetation is present, 40% of the vegetation will be short grass (Kantrud and Higgins 1992). Often nests in proximity to open water areas. Killdeer forage in open sandbars, mudflats, heavily grazed pastures, and human-altered habitats such as parking lots, roads, athletic fields and golf courses (Laubhan and Gammonley 2000, Long and Ralph 2001). They also use fresh and saltwater habitats. Loafing or roosting habitat use is likely no different than foraging and nesting habitats. Only most northern United States and Canada killdeer populations migrate. *Recommended vegetation management: Medium to Tall*

Cattle egrets use a wide range of grassland conditions from short to tall grass (Telfair 2006). They usually nests in heronries established by native ardeids, with varied habitats and diverse vegetation (Telfair 2006). They generally forage in close association with grazing cattle or other livestock. Native foraging sites were short grass meadows subject to periodic flooding but in North America will follow cattle in tall pastures for invertebrates, especially grasshoppers (Telfair 2006). Winter habitat typically is similar to foraging habitat, especially in spring and fall. They often will winter in more coastal environments (Telfair 2006). Roost in large colonies, typically with other species of colonial waterbirds. In North America, populations can be either migratory or sedentary; sedentary especially in Florida, coastal Louisiana and Texas, and Salton Sea area, California. They often flock with other herons and egrets during migration and are known to fly as high as 3500 m.

Upland sandpipers nest in a wide range of grass heights, typically 10-64 cm with avoidance of areas with grasses over 85 cm (Dechant et al. 1999, Vickery et al. 2010). Upland sandpipers prefer grassland areas less than 30 and 15 cm to forage and for brooding, respectively (Dechant et al. 1999). They prefer short vegetation for foraging, largely on insects (95%) and seeds (5%) (Houston and Bowen 2001). They are an indicator species for native tall grass prairie and require tall grass to conceal nest. Shrubs or small trees are necessary for perches during mating season (Dechnant et al. 1999, Houston and Bowen 2001). They winter largely in Argentina and during migration use a variety of habitats as staging areas, including plowed fields, shrub-grasslands, dry salt-hay marsh, agricultural fields, and beach habitats (Houston and Bowen 2001). *Recommended vegetation management: Tall*

5. Doves and Pigeons

White-winged doves use a wide range of habitat conditions from feeding in grasslands and agricultural feeds to nesting in the interior of forest. White-winged doves will feed in agricultural fields, but unlike mourning doves will feed on items elevated above ground, such as seed heads of corn, grain sorghum, or sunflower (Schwertner et al. 2002). White-winged doves live in dense, thorny forests, streamside woodlands, and deserts full of cactus and palo verde,

and, more recently, urban and suburban areas of the southern US. They tend to breed in the interiors of forests rather than near the edges. Winter habitat similar to breeding habitat: mixture of brushland, woodland, and desert shrub/cacti interspersed with fields of grain sorghum, corn, sesame, rice, and other agricultural crops (Waggerman and Sorola 1977).

Rock Pigeons generally use low vegetated areas or may perch on trees and more often man-made structures. Rock pigeons are often associated with urban environments, nesting on buildings, rooftops, and ledges in urban environments. In non-urban settings, will nest in crevices and rocky ledges (Johnston 1992). Rock pigeons typically forage on pavement and open gravel habitats, open lawns in parks, suburban areas, and golf courses. They rarely forage in trees or shrubs. Winter habitat is generally the same as other seasons; urban birds may be more dependent upon human handouts and other sources of food (e.g., litter) during the winter period (Weber 1972). Rock pigeons are largely non-migratory; however, birds may move widely in the non-breeding seasons. *Recommended vegetation management: Medium to Tall*

6. Waterfowl. There are 16 dabbling and diving duck species native to North America. These birds migrate in large flocks along well-known migratory flyways throughout the conterminous United States. Ducks are considerably smaller than geese, but nevertheless, are large enough to potentially cause significant damage to aircraft during a collision. If a duck were to be ingested into the engine intake, or if an aircraft were to strike multiple ducks during a migratory passage, the collision would be a serious threat to the safety and lives of civilians and military personnel. The Mallard (*Anas platyrhynchos*) is one of the most common, abundant, and recognizable dabbling ducks in North America. This duck is found on most all waterways, ponds, lakes and rivers, and estuaries; it is abundant in both inland and coastal habitats.

Mallards (*Anas platyrhynchos*) are most often located on or around aquatic habitats. During the breeding season, nests are usually located in dense vegetation including grasslands, marshes, bogs, shrubland, fence lines, rock piles, pastures, and cropland (Drilling et al. 2002). Mallards generally forage in open shallow water and mudflats but will occasionally forage in agricultural fields, parks, and golf courses. Mallards are the most common and widely distributed dabbling duck in North America with many of the other dabblers such as Northern Pintails sharing similar life histories.

Abundance/Distribution: The Mallard is a common dabbling duck that is a resident species throughout much of the conterminous United States. It breeds throughout much of Canada and Alaska. Wintering ranges include the southeastern United States, Texas, interior and western coast of Mexico and Baja California (Drilling et al. 2002). As with most duck species during the fall and winter months, Mallard numbers increase throughout the United States as the species migrates from Canada southward.

Habitat Preferences/Reproductive Behavior: Like all dabbling ducks, the Mallard is a highly aquatic species that spend much of its time on lakes, reservoirs, ponds, and large rivers. Mallards are a common breeding species in the Prairie Pothole region of Canada, which consists of boreal forests and prairie habitat interspersed with a large number of ephemeral ponds and permanent large lakes (Drilling et al. 2002). Localized breeding areas often consist of ephemeral

or seasonal ponds and marshes. Mallards also breed in vegetated wetlands of boreal forest regions. Nest sites generally are in upland grass area, but close to water (Drilling et al. 2002). High breeding densities occur on islands, but the species is not considered a colonial species. Nest sites can show significant variability with some birds nesting in rock piles, old hay fields, and rafts of vegetation in open water habitats. The Mallard is generally monogamous, but the males will regularly engage in extra-pair copulations. Numerous males will perform a courtship display to one or more females in open water. Pair-bonding occurs during the fall (September to November), and males will generally desert the female during the incubation of the eggs. During the breeding season, a mated pair will occasionally attempt more than one brood, but often a female will attempt a second nesting with another male. Repeated pairings between the same individuals over multiple breeding seasons can occur in resident populations, but this is not common in highly migratory populations. Forced extra-pair copulations by one or many males against a single female is a common and well documented breeding behavior in this species (Drilling et al. 2002). Unmated males and/or males that have deserted their mate can form small groups during the breeding season. During the non-breeding season, Mallards form large flocks in the hundreds and thousands (and mixed waterfowl flocks can number in the tens of thousands). The breeding season occurs from mid-April to mid-September. Females usually select nest sites about 5-10 days after reaching breeding area. Nests are usually in upland grass habitat, but relatively close to open water, and are usually simple depressions in the ground with material obtained to complete the nest often within reach of the immediate surrounding habitat. The nest is usually lined with grasses, leaves, and downy feathers from the female's breast. Incubation usually lasts about 28 days; chicks hatch precocial, are capable of moving to the water within 12 to 24 hours after hatching, and can feed themselves without assistancefrom parents. The female generally remains with the young until they are capable of flight; usually at about 50 days (Drilling et al. 2002). Wild Mallards are generally single brooded per year, but Mallards in urban/suburban area may attempt multiple broods per season. Urban/suburban Mallards also more likely to re-nest if initial nesting attempt fails (Drilling et al. 2002).

Prey Items/Foraging and Perching Behaviors: Mallards are opportunistic foragers and show significant variability in food items consumed. Type and amount of food consumed frequently depends on seasonal availability and nutritional needs. During the breeding season, females consume larger amounts of animal prey, including insects, gastropods, earthworms, and crustaceans (Drilling et al. 2002). During the fall, diet will usually shift towards a higher vegetative content and may include duckweed, wild millet, tubers and a variety of seeds and grains. At stopover locations, waste corn can dominate the diet. In the Mississippi Alluvial Valley, acorns are an important element in the diet, especially during the winter. Foraging generally takes place in the open water or old fields, pastures, and agricultural lands. Open water foraging can include skimming food from the water surface, or diving to capture prey items. Groups of birds can be observed on shorelines of open water habitats, but generally, large flocks roost together in open water of large lakes and ponds.

Migratory Behavior, Timing and Patterns: Mallards, like many other dabbling ducks, use well-defined migration flyways, including the Pacific, Central, Mississippi and Atlantic Flyways. Within these flyways are well-travel corridors and individual Mallards generally use the same

corridor for spring and fall migration (Drilling et al. 2002). Peak spring migration generally begins in Mid-February to late March, while peak fall migration begins in early September to and lasts until late November (Drilling et al. 2002). During migration, Mallards will utilize semi-permanent wetlands, shallow marshes, ponds, wetlands, and flooded agricultural fields. Mallards will often migrate in mixed species flocks; large fall flocks of hundreds to thousands of ducks can occur during the migration period. Mass migration may take place after the first winter storm (Drilling et al. 2002, and references therein). Flying altitude during migration has not been reported.

Canada geese prefer open areas with shorter vegetation, but will use a wide range of grass heights (4-70 cm). Canada geese are solitary or semi-colonial nesters, with nesting habitat in grass or pastures within 100 m of open water lake, pond, river or other water habitat. They will also nest on small islands and bays; will utilize raptor nests, including man-made platforms (Mowbay et al. 2002). Canada geese are herbivorous and forage in pastures, grasslands, wetland marshes, parks, golf courses, suburban/urban lawns, and agricultural fields. They often forages in shallow lakes, ponds and rivers on submergent vegetation. Geese will loaf in grasslands, meadows, parks, golf courses, airfields, suburban/urban lawns, and shoreline habitats. Recommended vegetation management: Tall

The Canada Goose has become an increasing danger nation-wide for BASH concerns because of increasing populations and larger proportions of individuals becoming part of year-round resident populations in urban/suburban settings. These birds are attracted to food resources available in many human-modified environments, including agricultural fields and urban/suburban parks, golf courses, and lawns. Open water and grass habitats can also attract these birds to many civil and military airfields requiring continued vigilance to control numbers and safeguard the operation of aircraft. Routine movements of Canada Geese to various foraging and roosting areas can be problematic as these birds often fly at altitudes used by aircraft as illustrated by the 2009 collision of a civil aircraft with a flock of geese resulting in a forced landing in the Hudson River.

Abundance/Distribution: The Canada Goose is our most wide-spread and abundant goose species. It breeds throughout the conterminous United States and into the northern tundra region of Canada; some southern populations extend into Mexico. Originally, this species bred throughout most of the northern United States, and wintered in the southwestern and southeastern regions. However, most areas of the country now include an increasing proportion of year-round residents that have become a nuisance because of (a) large flock sizes, (b) the accumulation of fecal material in parks and suburbs, and (c) the eutrophication of some ponds and lakes due to runoff of feces into water bodies.

Habitat Preferences/Reproductive Behavior: Canada Geese are found in virtually all habitats, except perhaps desert regions in the southwestern United States. In general, this species is very tolerant of human-disturbance and is a common species in open grassland areas formed through agriculture, parks, golf courses, and lawns. The species is monogamous, with life-time pairs forming during the second year; they usually breed as solitary pairs or semi-colonially on small islands. Breeding usually begins in early-to-mid April and lasts through July, depending on

region. They often build nests near permanent water sources, such as lakes or ponds, with an open view of potential predators and a clear flight path for quick departure if needed (Mowbray et al. 2002). This bird will also readily use nesting platforms and vacant raptor nest sites. Canada Geese tend to show significant site philopatry, particularly females, and may repeatedly use the same nest site for many years. Typically, each pair only raises a single brood per year, but females may re-nest after nest loss. The young are precocial (they are covered in down, can walk, and can feed themselves soon after hatching) and develop rapidly, but usually remain dependent and/or associated with parents during the first year. Most post-breeding flocks consist of related individuals.

Prey Items/Foraging and Perching Behaviors: During the spring, adults are vegetarian, grazing in grasslands, pastures and alfalfa fields. Later, juveniles and adults typically consume fresh green leaves of native graminoids (MowBray et al. 2002). During the fall, some individuals may shift their diet towards sedge seeds and native berries; perhaps to increase protein for preparation of migration (MowBray et al. 2002). Winter residents in northern latitudes? have become increasingly dependent upon agricultural grains, especially corn, but also sorghum, and winter wheat. In grasslands and hayfields, their diet consists of oats, timothy grass and brome grass. When available, waste corn in agricultural fields? can dominate their diets. Geese typically walk or hop in groups while foraging. This bird is a string flier, and can quickly take flight off land or water when disturbed. During the spring, presence of predators is a strong predictor of flight frequency. During the winter, individuals usually leave roosting sites in the morning to feed in agricultural and suburban habitats, and return in the evening. Daily movements from roosting to foraging and breeding sites can vary widely, from <1 km to over 100 km depending on season and habitat conditions (VerCauteren and Marks 2004). On daily feeding movement flights, altitude rarely exceed 400 m AGL, and are usually less than 200 m AGL.

Migratory Behavior, Timing and Patterns: Generally, migratory populations migrate south from Canada into the northern and eastern United States during the winter, and then return the following spring. While a significant proportion of the wintering population has shown a tendency to remain year-round when food sources are available (e.g., agriculture fields with corn), large numbers still migrate throughout much of the United States. Some areas, such as Blackwater National Wildlife Refuge, MD, can support over 35,000 birds during the winter months. Spring migration occurs in early April, while fall migration begins in mid-September and may last until mid-November (Mowbray et al 2002). The birds often congregate at various staging areas along coasts or inland marshes before migration flight. The Canada Goose exhibits specific preflight behavior generally thought to synchronize pairs, family members, and the rest of the flock in preparation for long-distance flight (Mowbray et al. 2002). During flight, these birds often use the characteristic 'V' formation, thought to increase aerodynamics of flight efficiency and/or to increase communication among individuals while flying. Migration flight altitude is generally between 300-1,000 m AGL, but may go higher to 1,300 m AGL and above on some occasions. When flying south, these birds typically follow high-pressure weather systems, and low-pressure systems when flying north.

7. Blackbirds and Starlings: Although passerines, we consider blackbirds and starlings separate here since they can be of significant BASH concern and often demand specialized attention for management and/or control. The Red-winged Blackbird (*Agelaius phoeniceus*) and the introduced European Starling (*Sturnus vulgaris*), are two of the most abundant and wide-spread passerines in North America. Both species are relatively small and individual birds are not likely to cause much damage or threat to aircraft. However, the main issue of concern is the extremely large flocks that seasonally occur, particularly during the non-breeding season, which can cause significant BASH issues and may threaten the safety of both civilians and military personnel. While several species of blackbirds are native to North America, the Red-winged Blackbird is by far the most abundant and wide-spread. The European Starling was introduced into Central Park, NY, during the early 20th century, and is now ubiquitous across North America.

European starlings prefers to forage and loaf in short grass, likely for increased visibility to avoid predators, and avoid taller grass heights, likely due to predation risks (Whitehead et al 1995). Starlings are cavity nesters, nesting in multiple types of cavities from trees, cliffs, buildings, or nest boxes (Cabe 1993). Adults spend much of their foraging time in open areas with short vegetation (Dunnet 1955, Williamson and Gray 1975, Feare 1984). Starlings migrate mostly during daylight, with numbers peaking several hours after dawn. Starlings routinely fly at elevations over 1000 m (Cabe 1993). Recommended vegetation management: Medium to Tall

Abundance/Distribution: The European Starling was introduced from England into Central Park, NY, around 1890. From an initial introduction of about 100 individuals, this species has spread throughout North America and numbers are now estimated at over 200 million (Cabe 1993). Most all areas support resident populations, except some breeding only populations in Mexico, Central America, and Cuba/other Caribbean islands.

Habitat Preferences/Reproductive Behavior: The European Starling is a cavity nesting species that can outcompete many native species. Generally, starlings avoid large expanses of non-disturbed grasslands and forests. Disturbed and human-modified landscapes provide foraging opportunities and nest sites. Nest sites typically are found in cavity-like features of buildings and nest boxes, but they will readily occupy cliffs, burrows, and natural and woodpecker-made tree cavities. Some populations of woodpeckers, including the Red-Headed Woodpecker (*Melanerps erythrocephalus*), may be experiencing declines because of competition with the European Starling. Starlings are usually monogamous, but polygynous matings can be common in some populations. Adult males may out-number females 2-to-1, increasing likelihood of a polygynous strategy in such situations; the non-primary female often experiences lower reproductive success. Most populations begin breeding efforts in early-to-mid April. Males will defend a territory and sing to attract a mate. Singing and wing-flapping displays by the male represents the initial pair-bonding process. Females initiate copulation; pair-bonds generally only last one nesting attempt (Cabe 1993). Incubation and brooding duties are performed by both sexes, though the female provides most of the effort. Incubation usually takes about 12 days; chicks are altricial but develop quickly and are ready to leave the nest after 21-23 days. Both parents feed the young; feeding also occurs for 10-12 days after leaving nest. On some occasions, females may begin a

second nest attempt shortly after initial chicks fledge; double- brooding is common in this species and may occur among approximately 60% of females (Cabe 1993). Most breeding activity ends by mid-July.

Prey Items/Foraging and Perching Behaviors: European Starlings are largely insectivorous during the breeding season; they will shift diet to seeds, grains, fruits and berries during the non-breeding season. Starlings are opportunist feeders and will forage on garbage and agriculture waste (e.g., livestock feed) when available (Cabe 1993). Foraging often takes place in open fields, pastures and mowed lawns; most prey items in these habitats consist of soil invertebrates. Starlings usually forage on the ground and in large flocks. Small flocks can occur during the breeding season, but during the winter non-breeding season, flocks may be comprised of thousands of individuals. Starlings often forage in mixed-species flocks with Common Grackles, Brown-headed Cowbirds, and Red-winged Blackbirds during the September through January period. Between February and August, starlings may forage in mixed flocks with the American Robin (Turdus migratorius), Rock Pigeon (Columba livia), House Sparrow (Passer domesticus), and American Crow (Corvus brachyrhynchos) (Cabe 1993). Individuals often forage close to the roost site in the early and late part of the day, although they will fly relatively long distances to exploit an abundant, yet ephemeral resource when conditions are favorable (Cabe 1993). Foraging flights of individuals and flocks are generally under 100 m (AGL or distance from point A to B?).

Migratory Behavior, Timing and Patterns: Significant variation exists among starling populations in regard to migratory behavior. Some individuals migrate, while others do not; some individuals migrate one year, but not the next. Migratory behavior is most observed in eastern and mid-western North American populations, including the Great Lakes region (Cabe 1993). Spring migration generally begins mid-February and lasts until mid-March. Fall migration begins in early October and can last through? late-November. Starlings generally follow river valleys during migration, such as the Mississippi, Ohio and Missouri valleys. Migrants fly during the day-time and flight altitudes are usually over 1,000 m AGL. Migratory flocks can range from a few individuals to >100,000 individuals (Cabe 1993, and references therein).

Red-winged Blackbird (*Agelaius phoeniceus*)

Abundance/Distribution: The Red-winged Blackbird ranges coast-to-coast in the conterminous United States and Canada. Throughout the United States, the species is a year-round resident, and typically, only a spring-summer breeder in Canada. Wintering and resident populations occur in Mexico and the northern portions of Central America (Yasukawa and Searcy 1995).

Habitat Preferences/Reproductive Behavior: This species largely breeds around freshwater marshes and grassy wetland habitats; however, it also utilizes upland? and estuarine and saltwater marsh habitats, as well as agricultural lands, old fields, and meadows (Yasukawa and Searcy 1995). This species is sexually dimorphic with black males supporting a bright red and yellow wing patch, while drabber brown females possess mottled cryptic coloration. Male Red-winged Blackbirds are the most polygynous of all North-American birds, with some males

having as many as 15 nesting females (mean = 5) in their territory (Yasukawa and Searcy 1995). However, DNA studies have shown that territorial males do not sire all young produced, indicating that females participate in extrapair copulations. Breeding generally begins in early April through July. Females move quickly into a territory upon arrival on breeding grounds. Males will perform various displays, including a Song Spread, Symbolic Nest-site Selection and a chasing pre-coitus chasing display (Yasukawa and Searcy 1995). Generally, females produce a single brood per year, double brooding does occur rarely. Altricial young hatch after about 11-13 days of incubation; both parents assist feeding of young. Young leave the nest after approximately 9-12 days and remain in the territory for another ~2 weeks. Parents continue to feed fledglings after leaving nest for up to about 5 weeks.

Prey Items/Foraging and Perching Behaviors: During the breeding season, Red-winged Blackbirds are largely insectivorous, but will also consume seeds and other plant materials. During the non-breeding season, this species shifts to a largely plant and seed diet. In agricultural settings, winter diets include grains from corn, sorghum, seeds from grass and other weedy annuals, and sunflower seeds, with occasional insect prey (Yasukawa and Searcy 1995). Foraging habitats include marshes, pastures, meadows, agricultural lands, and various substrates including vegetation, bare ground, snags and logs, and other wetland substrates (Yasukawa and Searcy 1995). Blackbirds frequently forage on the ground, though they care capable of gleaning insects from vegetation or fly-catching insects on the wing. While defending their breeding territory, it is common to see them perched on vegetation. Large flocks can move over 70 km from roosting to feeding sites, but on average, individual birds fly much less (White et al. 1985). During the breeding season, blackbirds will forage alone or in small groups. During the non-breeding season, most all foraging takes place in large flocks.

Migratory Behavior, Timing and Patterns: Only populations in Canada and the northern United States migrate; populations in western, southern, and Midwestern United States are year-round residents (Yasukawa and Searcy 1995). When Red-winged Blackbirds do migrate, spring migration generally begins in mid-to-late February, and fall migration begins mid-to-late October. Large roosting populations can form during any month of the year. Breeding season roosts are generally composed of second year males that roost at night and foraging during the day. During the late summer and early fall, some roosting populations consist of transients and wintering individuals. Winter roosts can comprise a few individuals to millions of individual birds (Yasukawa and Searcy 1995). Large roosting flocks typically winter in common reed (Phragmites spp.), but can form in any wetland or agricultural, grassland habitat. Winter flocks are often formed with other species including Common Grackle (*Quicalus quiscula*), European Starling, and the Brown-headed Cowbird (*Molothrus ater*). Migration largely occurs during the day. Flight altitudes of migrants and flocks are generally under 100 m AGL and often under 50 m AGL. Large flocks of blackbirds and associated species constitute one of the largest threats to military aircraft.

8. Gulls. Approximately 17 species of gulls can be found regularly in the conterminous United States. Most of these species are found in coastal habitats, and about 13 are found predominantly during the winter. Gulls are often attracted to human-disturbed landscapes, and can become

significant BASH problems because of the large flocks that form. While many gulls are found along the coast, they can form large inland flocks when food is plentiful (e.g., at inland landfills, fish ponds, tourist areas). Most gulls are medium-sized birds, yet a single gull can do considerable damage if it is ingested into an aircraft engine; a flock of could potentially bring down an aircraft. The largest BASH concern for gulls is the large flocks that can form along coastal habitat near active airfields on military installations. There are numerous, common gulls species throughout the United States, but few as wide-spread and abundant as the Ring-billed Gull (*Larus delawarensis*).

Herring gulls use short vegetation including bare ground and paved areas. They nest predominantly on islands, including major offshore islands, rocky islets, dredge tailings, marshy hummocks, barrier beaches (Pierotti and Good 1994). Herring gulls prey on marine invertebrates, fish, insects, smaller seabirds, and even on adults, young, and eggs of other gulls. Along rocky shores, they take mussels, crabs, sea urchins, and crayfish. On mudflats, they seek worms, small clams, and mussels. In open water, they follow large predators (including fishing boats) that bring small fish, squid, and zooplankton to the surface. Newly plowed fields provide ready supplies of earthworms and other invertebrate prey. Herring gulls are opportunistic scavengers on fish, carrion, and trash. Outside breeding season, nearly all individuals associated with foraging habitats, especially during daylight, and roost in areas adjacent to foraging sites (Pierotti and Good 1994). Herring gulls will use open areas as roosting sites, including parking lots, fields, helipads, and airfeild runways (Pierotti and Good 1994). *Recommended vegetation management: Medium to Tall*

Laughing gulls use short vegetation including bare ground and paved areas. They nest in wide range of habitats, including salt marshes in northeast and mid-Atlantic region, rock and vegetated islands in Maine and Massachusetts, sandy beaches and islands in Florida and along Gulf Coast, and rocky and vegetated islands in Caribbean (Burger 2015). They normally feed on coast at edge of water or in wrack; goes inland during high winds and on high tides, and to find insects in grassy meadows and worms in plowed fields (Burger 2015). During post breeding period, laughing gulls (particularly young) concentrate near garbage dumps and on wet, open fields, including those at airports (Burger 2015). *Recommended vegetation management: Medium to Tall*

Ring-billed gulls (*Larus delawarensis*) use short vegetation including bare ground and paved areas. They nest on the ground near water, mostly on low elevation (2–30 m) islands with a variety of sparse or woody vegetation; occasionally on peninsulas in large freshwater lakes. Ring-billed gulls are often found in and around urban, suburban, and agricultural areas. In coastal areas, ring-billed gulls frequent estuaries, beaches, mudflats, and coastal waters. In winter, these birds are common around docks, wharves, and harbors. Ring-billed gulls are more commonly seen inland than most other gull species. They can be found at reservoirs, lakes, ponds, streams, landfills, parking lots, and shopping malls (Pollet et al. 2012). *Recommended vegetation management: Medium to Tall*

Abundance/Distribution: The Ring-billed Gull breeds across central and northern United States and Canada. It winters along both the western and eastern United States, through the southeast

and all through TX, OK, into northeast Mexico. Along the western coast, the wintering range extends throughout Baja California and along the west coast of Mexico. Among gulls, it is one of the most abundant winter species, forming large flocks in garbage dumps, parking lots and along beaches (Ryder 1993).

Habitat Preferences/Reproductive Behavior: This gull typically nests on isolated islands in lakes or off-coast islands near peninsulas and estuaries. Nesting sites are almost always associated with aquatic habitats. The Ring-billed Gull is a common nesting species in the Great Lakes and Prairie Pothole regions of the U.S. and Canada. A colonial nester, this species will share nesting sites with Herring Gulls (*L. argentatus*) on the east coast, and the California Gull (*L. californicus*) on the west coast. In the Great Lakes region, this gull nests in mixed colonies with Caspian Terns (*Stern caspia*) and Common Terns (*S. hirundo*). Nesting colonies can range from 20 to over 70,000 individual birds (Ryder 1993). Peak breeding season generally begins in early May and can extend through early August (Ryder 1993). Pair bonds are formed just before arrival at the nesting site, or during territory establishment (Ryder 1993). Both males and females perform a courtship display to initiate the pair bond. Usually, a pair will nest for at least 2 breeding seasons. The nest site is located on low open areas with sparse vegetation, usually sand-bars, beaches with rocks or driftwood; they will also nest on concrete and bare rock areas. Ring-billed Gulls show strong fidelity to colony sites and locations within colonies. Pairs will construct a nest together using vegetative material such as leaves, sticks, twigs, lichen and mosses. Incubation takes about 23-28 days and chicks are semi-precocial at hatching. Fledging takes place after about 30 days. After fledging, young birds are independent and no longer fed by adults; pair-bond ends and the family disperses (Ryder 1993). This species is single brooded, but will re-nest after nest failure.

Prey Items/Foraging and Perching Behaviors: The Ring-billed Gull is an opportunistic forager that will feed on fish, insects, earthworms, small mammals and seeds or grain in agricultural settings. This species is a well-known landfill feeder and other areas associated with human activities. Populations of the Ring-billed Gull are thought to have increased significantly after the introduction of the rainbow smelt (*Osmerus mordax*) in the Great Lakes. This fish is a common prey item in the Ring-billed Gull's diet, especially during the breeding season. This gull forages by walking on the ground, skimming its bill in open water to fish, and also by diving or dipping to capture fish. Ring-billed Gulls have also been known to capture insects on the wing, and to forage for earthworms and grains in disturbed agriculture fields, especially after a strong rain event (Ryder 1993). The Ring-billed Gull is an aggressive species that will pirate food from other avian species when expedient.

Migratory Behavior, Timing and Patterns: Initiation of fall migration typically occurs in response to shortages of food or drinking water. Fall migration takes place over a longer time period than spring migration. Peak period for fall migration begins in early August and extends through the end of November. The peak period for spring migration is in early March through mid-April. Migrating Ring-billed Gulls follow coasts or large river systems (e.g., Mississippi River) (Ryder 1993). Routes may sometimes be found? farther inland to take advantage of foraging opportunities in agricultural fields or landfills. Birds usually return to roosting sites near water in

the evenings (Ryder 1993). During fall migration, gulls may form large flocks at staging areas along the Great Lakes before moving southward to the winter range. This species will migrate in flocks ranging from 6 to over 400 individuals; flight altitude during migration is usually 400 m AGL or greater (Ryder 1993).

9. Pelicans: Two species of pelicans are found in North America. The American White Pelican (*Pelicanus erythrorhynchos*) and the Brown Pelican (*P. occidentalis*). The American White Pelican is associated with coastal areas during the non-breeding season, but is found in large inland lakes and rivers during the breeding season. The Brown Pelican is largely confined to coastal areas and breeds primarily on off-shore islands. Both species can form large aggregations, and because of their size, represent significant hazards for military and civilian aircraft. Striking one of these birds in flight is likely to cause significant and costly damage to the craft and injury or death to personnel.

American White Pelican *(Pelecanus erythrorhynchos)*

Abundance/Distribution: A large and abundant species, this pelican breeds on inland lakes and rivers in north-central Canada and extends to some inland habitats in the western and central United States. Wintering range includes the coastal areas of southwestern California and Baja, Mexico, and east towards the coastal areas of Texas, Florida and the southeastern United States. Winter range extends south through much of Mexico and into Central America. Breeding and roosting colonies can consist of hundreds to thousands of individuals.

Habitat Preferences/Reproductive Behavior: In North America, this species usually breeds on isolated islands in freshwater lakes and rivers. Breeding colonies are typically 50 miles or more from foraging sites (Evans and Knopf 1993). This species exhibits low colony site philopatry that permits behavioral flexibility to exploit areas of cyclic or irregular food supplies. The species is monogamous and performs complex courtship displays during the pair-bonding period shortly after arrival onto the breeding site (Evans and Knopf 1993). Breeding begins in early April and can last until late August or even early September. Young are altricial at hatching but develop quickly; they generally take first flight and leave colony at around 10 weeks.

Prey Items/Foraging and Perching Behaviors: The American White Pelican is an opportunistic piscivorous species that typically forages in shallow waters in marshes, along lake shores, or river banks, and coastal shorelines during winter (Evans and Knopf 1993). Unlike the Brown Pelican that plunge-dives for prey, the American White Pelican forages on the water by dipping its large bill and scooping prey into its pouch. Location of prey is likely a combination of visual and tactical sensation through the bill. Foraging can occur in solitary or in a group. This species is unusual in utilizing a cooperative feeding strategy when in groups; several pelicans can coordinate bill dipping and wing-flapping behaviors that push fish towards the shore where capture is more likely. This behavior can significantly improve foraging efficacy (Evans and Knopf 1993). In mixed species flocks, this pelican is aggressive and known to steal prey from other birds. Roosting and/or loafing sites are usually located on exposed inlets and sandbars, small islands, beaches and lake/river shorelines near or immediately adjacent to foraging sites.

Migratory Behavior, Timing and Patterns: Except for resident populations in Texas and Mexico, most American White Pelicans migrate to northern breeding sites in the spring and

return to coastal areas during the winter. They usually migrate in flocks of at least 100-200 birds. Spring migration may begin as early as late February, with arrival on the breeding grounds beginning in early-to-mid March. Fall migration generally begins in early-to-mid September, yet autumn migration occurs more leisurely with some birds not arriving on the winter grounds until mid-December (Evans and Knopf 1993, and citations therein). This species often flies in groups; when foraging or gliding over water, they are generally about 12-15 m in altitude. During longer-distance flights, or during migration, individuals use atmospheric thermals and are known soar above 500 m, occasionally $\geq$ 1,000 m. As with the Canada Goose, migrating pelicans often fly in a 'V' formation (Evans and Knopf 1993).

Brown Pelican *(P. occidentalis)*

Abundance/Distribution: The Brown Pelican is almost entirely coastal in distribution and habitat preferences. Breeding ranges extend from the Chesapeake Bay along the eastern United States, south around the entire coastline of Florida and west through the Gulf coastal southeastern states with some breeding occurring south into Mexico (Shields 2002). This species is also found on the west coast, from around the San Francisco Bay south into Baja California, Mexico. Brown Pelicans are very sensitive to the pesticide DDT and populations were once severely reduced. The Atlantic/Gulf Coast and California populations both were federally listed under the Endangered Species Act (ESA) in 1970, but eventually both removed from ESA protection due to recovery.

Habitat Preferences/Reproductive Behavior: Brown Pelicans are largely restricted to costal marine and estuarine waters, but occasionally move inland in the southeastern United States during the non-breeding season. Breeding colonies are usually located on barrier, bay/estuarine and dredged material islands. In Florida, this species utilizes mangrove inlets for nesting?. Western populations breed mostly on rocky off-shore islands. As with the American White Pelican, the Brown Pelican is monogamous and performs complex courtship displays (Shields 2002). This species is sensitive to cold weather and prey availability, but if conditions are good, the breeding season can start as early as January, though usually breeding does not start until March in most portions of the range. The breeding season can extend to late September (Shields 2002). Usually, only one brood per season is produced, but females will re-nest if the first nest fails. Young are altricial at hatching. After hatching, the young begin to fly beginning at 11-12 weeks.

Prey Items/Foraging and Perching Behaviors: The Brown Pelican is a large opportunistic, piscivorous, plunge-diving species that feeds largely on small, surface schooling oceanic fish. Over 40 species of fish and invertebrates were consumed in the Gulf of California (Shields2002, and references therein). The Brown Pelican employs a head-first dive into the water to capture fish, a foraging strategy very different from other pelicans. However, it can also forage while sitting on the water surface, much as the American White Pelican, but no coordinated foraging has been observed. This species often takes prey from other species while foraging in mixed species flock; however, it can also be the victim of prey theft by gulls and other species, plus, its head-first dives can attract other birds into the area.

Migratory Behavior, Timing and Patterns: The Brown Pelican is largely resident throughout much of its range, but some populations undertake considerable post-breeding movements. Northward or southward movements are sometimes observed directly after breeding, but peak of southward movement during fall migration usually does not begin until November. Spring migration back to breeding sites usually occurs in late March to early April. California and Baja, Mexico breeding populations also move northward after breeding. Individuals crossing the Baja peninsula will ride wind thermals (Shields 2002). Individuals often fly above the water surface, and flocks frequently use the 'V' formation in flight. While gliding over water, these birds usually fly no more than 3 m above the surface. When plunge-diving for fish, birds often climb to20 - 35 m above the water before diving (Shields 2002; and reference therein). When flying on thermals, Brown Pelicans likely fly at altitudes similar to the American White Pelican (approx. 500 m and above).

10. Swallows: Large foraging aerial flocks of swallows can constitute a significant BASH problem for active airports. Seven species of swallows are common in the conterminous United States. Swallows are small aerial songbirds and several species are known to nest in colonies. They are well-known for their mud and grass nests that are usually attached to man-made structures like building ledges, bridges and converts. At least one species (Bank Swallow, *Riparia riparia*), excavates nests in sand banks, and several swallows are cavity nesters (e.g., Tree Swallow, *Tachycineta bicolor*). The Cliff Swallow (*Petrochelidon pyrrhonota*) is common throughout the United States and is selected as representative of the group because it can pose a BASH problem when large nesting colonies form on man-made structures in and around active airports. Because this bird is listed under the Migratory Bird Treaty Act (MBTA), airport managers should consider reducing nesting by removing nests during the non-breeding season. Once breeding begins, it may be difficult to obtain the necessary permits for nest removal.

Cliff Swallow (*Petrochelidon pyrrhonota*)

Abundance/Distribution: The Cliff Swallow is a common aerial songbird that breeds throughout North America and into Mexico and Central America. It is a long-distance migrant that flies to South America during the winter season (Brown and Brown 1995).

Habitat Preferences/Reproductive Behavior: Cliff Swallows historically nested near rock cliffs and ledges in western North America. With the expansion of urban areas and the construction of bridges, culverts, buildings, and other man-made structures, the species has expanded breeding populations to nearly all regions is the United States and Canada (Brown and Brown 1995). Cliff Swallows generally forage over grasslands, pastures, meadows, agricultural fields, and lake and ponds. The Cliff Swallow is a highly social species that typically occupies large colonies, sometimes numbering in the thousands. However, the sexes only interact at the nest site. While outwardly monogamous, genetic studies have shown that the Cliff Swallow is highly polygynous with both sexes participating in extra-pair copulations (Brown and Brown 1995). The peak breeding season begins in mid-May through mid-June; however, breeding in some colonies can start in early April. During the pair-bonding process, the birds make no courtship displays and little singing is performed. The pair works to build a nest from mud from a nearby source. Most extra-pair copulations occur during the nest construction phase. Young are altricial at hatching

(about 13 days of incubation). Both sexes feed the young until fledging, usually around 20-21 days (Brown and Brown 1995). After fledging, the parents may continue to feed young, even during mid-flight, for about another 3 to 5 days. After fledging, juvenile birds may congregate in large groups called 'creches', which can consist of up to a thousand juveniles (Brown and Brown 1995). Parents return to feed their young in these creches; parents and juveniles locate each other in these large groups by identifying call and potentially, unique facial markings (Brown and Brown 1995). Sometime after fledging, the family unit breaks up, but no information is available on this feature for this species. The Cliff Swallow is generally single brooded during the season, but it will readily re-nest if the first nest fails.

Prey Items/Foraging and Perching Behaviors: Other then the rare consumption of seeds or grit for digestion, the Cliff Swallow is entirely insectivorous, catching swarming, flying insects on the wing. Cliff Swallows often forage in large groups (e.g., 50 to hundreds of individuals), riding thermals to capture rising insects up to about 50 m AGL. When the weather is calm, these birds may forage at varying altitudes just over grasslands and open water. While foraging in large groups, birds communicate using calls to indicate where areas of dense prey items are available; swallows that forage in groups have significantly higher foraging success rates than those that forage alone (Brown and Brown 1995). Cliff Swallows rest in their nests, but are known to perch on telephone wires, tree branches and other structures (Brown and Brown 1995). If their colony supports large numbers of ectoparasites, these birds may spend the night roosting in nearby trees rather than their nests.

Migratory Behavior, Timing and Patterns: The Cliff Swallow is a diurnal migrant. During the spring, peak migration periods begin in early February and may last until mid-May; peak fall migration begins in early August and extends to early December (Brown and Brown 1995). These birds migrate in large flocks numbering in the hundreds to thousands. They typically forage enroute, and will sometimes stopover and forage for several days over lakes, ponds or rivers. During the evenings, enroute migrants may rest in vegetation. Some migrant flocks may be greater than 5,000 birds and extend for up to 1-2 km; spectacular migrant flocks have been observed in Panama (Brown and Brown 1995). Migrant flocks are often composed of several different swallow species. Because migrating swallows often forage during migration, they likely are under 100 m AGL; however, they may utilize thermals and fly at much higher altitudes, especially when crossing over a landscape barrier (e.g., hills, Gulf of Mexico, etc.).

11. Cranes: There are 2 species of cranes native to North America, the Sandhill Crane (*Grus canadensis*) and the Whooping Crane (*G. americana*). The Whooping Crane is an endangered species with very low population levels. Therefore, this species is not likely to pose a BASH threat. The Sandhill Crane is much more abundant and was listed as the 10th highest BASH threat on military installations by Zakrajsek and Bissonette (2005). Cranes are very large birds that have caused significant damage to aircraft; collisions with this species are a direct threat to the safety and lives of civilians and military personnel. These birds can migrant in flocks numbering several dozen individuals and they fly at altitudes (under 500 m AGL) that can pose a threat to aircraft.

Sandhill Crane (*Grus canadensis*)

Abundance/Distribution: The Sandhill Crane is a common crane species that breeds throughout much of Siberia, Canada and Alaska, with scattered breeding areas in the western United States (Tacha et al. 1992). Their wintering distribution includes much of southern and coastal Texas, south into Mexico and west in New Mexico and a small portion of Arizona. A wintering and resident population exists in Florida, and a resident population can be found along the Gulf Coast in Mississippi and Alabama; plus, a resident population is known in Cuba (Tacha et al. 1992).

Habitat Preferences/Reproductive Behavior: Sandhill Crane nesting habitats include open marshes and bogs surrounded by shrubs and forested areas. Sandhills will also breed in large, expansive grasslands with scattered ponds and sandy peat soils (Tacha et al. 1992, and references therein). Breeding areas tend to be far from human inhabited landscapes. Non-breeding members of the Sandhill populations usually roost and loaf in open grassland habitats. These birds are well known for their elaborate courtship displays. Once a pair-bond is formed, usually during spring migration,pairs are perennially monogamous. Unless a mate dies, remating among individuals is rare. Peak breeding begins in late March and lasts through late April; juveniles are highly dependent upon parents after fledging, and the family group will remain a cohesive unit for the next 10 months or more. After this time, the juveniles will leave and the family disperses. During the breeding season, both sexes build a mound of material consisting of sticks and debris; a small nest cup is generally lined with twigs and plant material. Within a territory, a pair may begin several nests, but only one nest will be used during the season; other nest sites may be used for brooding or feeding the young. The female lays 2 eggs; usually only one egg will lead to a successful fledging. Incubation begins after the first egg is laid, and lasts for approximately 30 days. Both males and females develop an incubation patch and both will share incubation duties (Tacha et al. 1992, and references therein). Young are nidifugous after hatching and are able to leave the nest in about 24 hours (Tacha et al. 1992). Females generally brood the young after hatching and both parents feed the young. In wild birds, fledging is demarcated when the young can fly, which is generally at about 67 to 75 days after hatching (Tacha et al. 1992, and references therein). Nesting pairs show strong site fidelity and will use the site repeatedly during their lifetimes.

Prey Items/Foraging and Perching Behaviors: Sandhill Cranes are omnivorous and usually feed in marshes with standing water, as well as on land. Diet can be variable with food availability. Domestic grains in agricultural fields can be a major portion of the diet during the migration and winter periods. During the breeding season, Sandhills are predatory and feed on small mammals, reptiles, amphibians, snails and small birds. In some areas, cranes supplement their diets with insects and larvae, and tubers of aquatic plants during the spring and summer. These birds forage while walking through water or grasslands; they generally perch only at the nest site.

Migratory Behavior, Timing and Patterns: Family units stay within the vicinity of the nest site and usually migrate together. Several family units may migrate together; generally flocks consist of kin that combine with non-breeding individuals that form groups during migration and winter. Groups are usually small, numbering between 3 and 20 individuals. Peak spring migration period begins early March and lasts through mid-April, and peak fall migration begins in early

October and extends to late November (Tacha et al. 1992). Migrating flocks fly in a standard 'V' formation, often soaring on thermals and/or gliding. Migration altitudes can reach up to 3,600 m AGL, but most flights are under 1,600 m AGL, and approximately 75% of flights are between 150 to 750 m AGL (Tacha et al. 1992).

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