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Rapid Biological Assessment of Terrestrial Vertebrate Species at Wallops Island National Wildlife Refuge

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ABSTRACT In compliance with the goals of the U.S. Fish and Wildlife Service (USFWS) Refuge System, Chincoteague Bay Field Station students worked together with Millersville University to quantify and document terrestrial vertebrate biodiversity (i.e., mammals, birds, amphibians and reptiles) at 3 different terrestrial biological forest communities (i.e., maritime deciduous, conifer and marsh forest) on Wallops Island National Wildlife Refuge (NWR). Species presence was documented based on simple field observations as well as several trapping methods, including an acoustic recording device, remote video and cameras, pitfall traps and Sherman traps. We found 3 new species that had not yet been documented on Wallops Island NWR: short-tailed shrew (*Blarina brevicauda*), woodland vole (*Microtus pinetorum*) and American toad (*Anaxyrus americanus*). The maritime deciduous forest had the greatest amount of species richness and diversity compared to the other forest types examined, and we

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recommend that the deciduous forest should be maintained and managed for its species biodiversity. We also recommend a more long-term survey effort in the future to try and identify other potential species that may not have been previously documented on Wallops Island NWR.

KEY WORDS biodiversity, forest, rapid biological assessment, United States Fish & Wildlife Service, Wallops Island, wildlife refuge

Global anthropogenic environmental changes such as pollution, introduction of invasive species and habitat fragmentation have caused species extinctions and population declines that have led to documented trophic effects, causing a cascade of destructive interactions among global ecosystems (Tylianakis et al. 2008, Kessing and Young 2014). Therefore, the need to assess the biodiversity of ecosystems has become an integral part of conservation biology (Cardinale et al. 2000). In order to combat the irreversible loss of organisms, scientists must document the biodiversity of global ecosystems and biological communities via a variety of survey and trapping techniques. By documenting the presence and abundance of biodiversity, decisions can be made on which conservation strategies to implement to conserve wild species.

The United States National Wildlife Refuge System is the world's largest collection of lands set aside specifically for the conservation of wildlife and protection of ecosystems. The mission of the wildlife refuge system is the conservation, management and where appropriate, restoration of the fish, wildlife and plant resources and their habitats within the United States for the benefit of future generations of Americans. As per this mission, United States wildlife refuge staff are charged to maintain the ecological integrity and thus the biological diversity of life on the refuge system (USFWS 2014). One of the goals for the Chincoteague and Wallops Island National Wildlife Refuges (NWR) is to manage for the biological integrity of upland habitat and maintain the diversity and environmental health of coastal forest and shrub lands to sustain native wildlife. Maritime deciduous, conifer and marsh forests along eastern North America have been heavily impacted by landscape scale anthropogenic activity since European settlement (Thompson et al. 2013, Dyer 2015). The consequences of anthropogenic activities such as habitat loss, overharvesting, and introduction of invasive species have changed the structure and species present in these forests. Historical documentation of forest types in the United States indicated that the Wallops Island NWR was located in an oak-pine region (Braun 1950 and Dyer 2015). Based on the Draft Comprehensive Conservation Plan and Draft Environmental Impact Statement for Chincoteague and Wallops Island NWR (USFWS 2014), there are 21 reptile, 8 amphibian, 24 terrestrial mammal and 295 avian species that utilize these forest communities on both Chincoteague and Wallops Island NWR.

In compliance with the goals of the U.S. Fish and Wildlife Service (USFWS) Refuge System, college students from the Chincoteague Bay Field Station (www.cbfieldstation.org), together with Millersville University, set out to quantify and document terrestrial vertebrate biodiversity (i.e., mammals, birds, amphibians and reptiles) in 3 different forest biological communities (i.e., maritime deciduous, conifer and marsh forests) within Wallops Island NWR along the Eastern Shore of Virginia in Accomack County (Figure 1). Documentation of terrestrial vertebrate biodiversity on Wallop's Island NWR was conducted via a Rapid Biological Assessment (RBA) or Rapid Assessment Program, which is an efficient and cost-effective method used to complete a quick, biological survey of an area (Abate 1992). Multiple survey and trapping methods were used to determine species occurrence on the refuge. Our first objective was to develop a list of terrestrial vertebrate species present on Wallops Island NWR and compare this to a previous list found in the Draft Comprehensive Conservation Plan and Draft Environmental Impact Statement for Chincoteague and Wallops Island NWR (USFWS

2014). Our second objective was to compare species survey results between the maritime deciduous, conifer and marsh forest types to determine if there was segregation between species in each forest community. We hypothesized that there would be a difference in species richness, species diversity and community similarity between the deciduous, conifer, and marsh maritime forests.

STUDY AREA

Our study area was located on Wallops Island NWR (1.51 km^2) Virginia in Accomack County (Figure 1). The site was bordered by Simoneaston Bay on the eastern side and Route 175 and NASA-Wallops Flight Facility on the western and northern side (Figure 2). We divided the refuge into three general forest types; maritime deciduous, maritime conifer, and maritime marsh forest (Figure 3). The maritime deciduous and marsh forest was dominated by red maple (*Acer rubrum*), red oak (*Quercus falcata*), and white oak (*Quercus alba*). The forest floor of the maritime deciduous forest was comprised of wine raspberry bushes (*Rubus phoenicolasius*) and invasive Japanese stiltgrass grass (*Microstegium vimineum*). The marsh forest had less underbrush than the deciduous forest, contained areas of standing water and was juxtaposed to open *Spartina* saltmarsh on Simoneaston Bay. The maritime conifer forest was dominated by loblolly pines (*Pinus taeda*), sassafras (*Sassafras albidum*), and black cherry (*Prunus serotina*). The Conifer floor included species such as; invasive autumn olive (*Elaeagnus umbellata*) and poison ivy (*Toxicodendron radicans*) (USFWS 2014).

MATERIALS AND METHODS

The Rapid Biological Assessment (RBA) of the Wallops Island National Wildlife Refuge was conducted from 29 June 2015 through 8 July 2015. Species presence was documented based on simple field observations as well as several trapping methods, including an acoustic recording device, remote video and cameras, pitfall traps and Sherman traps (Figure 4). Each method was specialized for documenting occurrence for specific types of terrestrial vertebrate fauna.

Advances in acoustic recordings have made it possible to monitor avian and amphibian species in terrestrial and aquatic ecosystems. Acoustic recordings make it possible to accumulate and identify calls over a long period of time (Towsey et al. 2014). The Songmeter SM2+, an acoustic recording device (www.wildlifeacoustics.com), was used to record avian and amphibian species on Wallops Island NWR. The acoustic device was set in three locations (one in each general forest type) and each location was sampled for three days (Figure 3). The acoustic device was set to record calls 10 minutes at sunrise (6:30 AM) to capture bird calls and 10 minutes at sunset (9:00 PM) to capture amphibian vocalizations. Species were identified by call and recorded for each forest type.

Two methods to survey large vertebrate species included automated remote video and camera devices. Recording images can be used to gain insight into species habitat preferences without disrupting natural behavior (Duma and Giurgui, 2011). Leupold® RCX-2 (http://www.leupold.com/) remote motion detection video cameras, were set up in the conifer and deciduous forests (Figure 5). The Leupold® cameras were set to take a 15 second video when motion was detected. The cameras were set on high sensitivity. The Leupold® cameras were baited with doe and buck urine (Code Blue Deer Scents, www.codebluescents.com) to attract large vertebrate activity. The Reconyx® RM45 RapidFire motion sensing cameras (http://www.reconyx.com/), were set in the conifer, deciduous, and marsh forests (Figure 5). The Reconyx cameras were set to take 3 pictures with a 1 second delay when motion was detected. Cameras were set to high sensitivity. One Reconyx® camera was set in the conifer forest and two cameras were set on the edge of the deciduous forest, and one camera was set in the marsh forest (Figure 5). The Reconyx® cameras were baited the first two days with raw chicken staked into the ground in front of the cameras. The relative activity in each forest community was determined by dividing the number of photo captures by the number of trap days that the cameras were operational. Captures were counted as a single occurrence when the previous photograph of the same species was taken greater than 10 minutes prior to the next occurrence. The number of trap days for the cameras in the maritime conifer and marsh forests was 9, equal to the length of the study, while there were 18 trap days for the maritime deciduous forest, because there were two cameras in this forest community.

A common way to survey small vertebrates is using a pitfall trap (Hare, 2012). We set up pitfall traps with a 5 gallon bucket, which served as the pit, flushed to the ground with plastic drift fencing to corral potential small vertebrates (i.e., small amphibians, reptiles and mammals) into the pit (Figure 4). One pitfall trap was set up in the conifer forest and one was set in the deciduous forest (Figure 6). Each trap was equipped with a sponge saturated in water to reduce risk of desiccation to amphibians (Enge 2001, Lannoo et al., 2009). Pitfall traps were checked every morning and closed throughout the day to reduce mortality caused by dehydration and overheating. Amphibians captured and recaptured in the traps were tagged using Visible Implant Elastomer (VIE) (http://www.nmt.us/). VIE was injected under the surface of the dermal layer between the back toes of amphibians. The gel solidified under the skin and was visible for the duration of the study. Recaptures were noted for population density estimation. Pitfall traps were set every evening between 7:00 PM and 8:00 PM and checked the next morning at 8:00 AM.

Sherman box traps (www.Shermantraps.com) were also used to capture and document small terrestrial vertebrates (Vieria et al., 2014) (Figure 6). Sherman traps were placed along a working utility road, where we expected to see a great deal of small vertebrate activity, 46 traps were set in the conifer forest and 44 traps were set in the deciduous forest (Figure 6). Sherman traps were baited using a variety of sunflower seeds, thistle seeds, and peanut butter chips. Traps were set between 7:00 PM and 8:00 PM. Traps were checked each morning at 8:00 AM. Each individual captured was marked with an ear tag, if species had large ears, or with an Animal ID Marker (Muromachi Kikai Co. Ltd. www.muromachi.com/en/) to dye the fur of mammals. Recaptures were noted for population density estimation.

Species Richness and the Jaccard Community Similarity Index were determined and then compared between each general forest type based on each trap type used. The Reciprocal Simpson Diversity Index was used to calculate species diversity for pitfall and Sherman trap data within the deciduous and conifer forest types. The Lincoln-Peterson Estimator [Chapman modified] was used to estimate population size for white-footed mice (*Peromyscus leucopus*) and amphibians in the genus *Anaxyrus*, with 95% confidence intervals (i.e., 95% C.I.). These were the only species for which we obtained robust mark/recapture data. Population density estimates were calculated based on population size estimates, size of the capture area (i.e., 500m x 30m or 0.015 km^2) and size of Wallops Island NWR (1.51 km^2) (USFWS 2014).

RESULTS

The goal of the study was to conduct a RBA of terrestrial vertebrates on Wallops Island NWR. We documented the presence of 90 species within Wallops Island NWR. Of these species, 75 were birds, 9 were mammals, 4 were amphibians and 2 were reptiles (Table 1). Within forest types, we documented 56 species in deciduous forest, 28 species in the conifer forest and 42 species in the marsh forest. Based on survey and trapping technique, we observed 50 species in the field via observation, 31 species were identified using the remote acoustic recording device, 8 species were identified with remote video and cameras, 4 species were documented using pitfall traps and 5 species were documented using Sherman traps. We found 3 new species that had not yet been documented on Wallops Island NWR: short-tailed shrew (*Blarina brevicauda*), woodland vole (*Microtus pinetorum*) and American toad (*Anaxyrus americanus*) (Figure 7).

Results by Trap Type

The data from the acoustic device collected in the conifer, deciduous, and marsh forest found that species richness was greatest in the deciduous forest (n = 19), followed by the marsh forest (n= 16), with the Conifer forest having the lowest species richness (n = 15) (Table 2). The Conifer forest had the highest mean community similarity (Mean CCS= 0.326), while the marsh forest had the lowest mean community similarity (mean CCS= 0.289), making the marsh forest the site with the most unique vocal species (Table 2).

Based on photo and video capture data recorded using the Leupold® cameras and Reconyx® cameras, species richness was greatest in the deciduous forest (n = 7) and similar between the conifer (n = 3) and marsh forests (n = 4). Based on species documented using remote cameras and video, we found that the conifer forest had the most unique species recorded (mean CCS = 0.330) (Table 3). The relative activity of large terrestrial vertebrates was higher on both the deciduous and conifer forests (2.22) compared to the marsh forest (1.22) (Table 3).

The results from the pitfall traps indicated that species richness was equal in the deciduous and conifer forest (n = 4), but species diversity was greater in the deciduous forest (1/D=1.806) compared to the conifer forest (1/D=1.489) (Table 4). Based on the pitfall trap data collected, the conifer and deciduous forest community shared 60% similar species, suggesting these communities did not have major differences in small terrestrial vertebrate species caught in pitfall traps (Table 4). The results from the Sherman traps showed that species richness was greater in the deciduous forest (n = 3) than in the conifer forest (n =1), and species diversity of the deciduous forest (1/D= 1.528) was greater than the species diversity in the conifer forest (1/D= 1.00) (Table 5).

Population Size and Density Estimation

The size of the trapping area for both pitfall and Sherman traps was 500m x 30m or 0.015 km^2, while the total area of Wallops Island NWR was 1.51 km^2 (USFWS 2014). Based on calculations from the Lincoln-Peterson (Chapman Modified) Estimator on the mark and recapture of *Anaxyrus*, the population size of the genus *Anaxyrus* was N = 24 ± 19.6 (95% C.I.), giving us a density estimate of approximately 1,600 *Anaxyrus*/km^2. When extrapolating this density estimation to the whole Wallops Island NWR, it was estimated that there was a population size of 2,416 *Anaxyrus* toads on the refuge. Based on our Sherman box trap effort, the population size estimate using the Lincoln-Peterson (Chapman Modified) Estimator for white-footed mice was N = 7 ± 2.4 (95% C.I.), giving a density estimate of approximately 467 white-footed mice/km^2. When extrapolating the density estimation to the whole Wallops Island NWR, it was estimated that there was a population size of 705 white-footed mice on the refuge.

DISCUSSION

Since its establishment in 1971, Wallops Island NWR has been understaffed with little management and monitoring of natural resources. Management has mainly focused on creating successional habitat for species that prefer edge and old-field habitat (USFWS 2014). The first objective or our RBA at Wallops Island NWR was to develop a list of all documented species and identify any new species that had not yet been documented for the refuge. We found 3 new species that had not yet been documented on Wallops Island NWR (Table 1). These species included the short-tailed shrew, woodland vole and the American toad. We also identified potential hybrid individuals between American and Fowler's toads (*Anaxyrus fowleri*). This would have to be validated with future genetic analysis.

The other objective of our RBA at the Wallops Island NWR, was to evaluate the richness and diversity of terrestrial vertebrate species found within the maritime deciduous, conifer and marsh forests. Our hypothesis was supported that there would be a difference in species occurrence in these forest communities based on different survey and trapping techniques. We found that the maritime deciduous forest community consistently had high species richness compared to the conifer and marsh forests, as well as high species diversity (Tables 2-5). However, we recorded unique terrestrial vertebrate species in both the marsh and conifer forests based on low CCS calculations (Tables 2 and 3). The marsh forest was farther away from the deciduous and conifer forest, which may explain why the marsh forest had a unique terrestrial vertebrate species community.

High species richness and diversity in deciduous forests may be explained by high plant biodiversity and primary productivity in this forest type in comparison to others (Gilliam, 2012). A study conducted by Niedzialkowska et al. (2010) showed that deciduous forests have higher diversity and abundance of small vertebrate species, while species diversity was found to be significantly lower in the conifer forests. Forest productivity (soil, topography, and vegetation) was found to be higher in the deciduous forest and had a positive correlation with small vertebrate abundance (Niedzialkowska et al., 2010). Carey and Johnson (1995) stated that there were many factors that caused species differences in small vertebrate communities. These differences included seed abundance, soil organic matter, humus, fungi, lichens, and presence of deciduous shrubs and ferns. They also suggested that the variety and number of coarse woody debris and understory canopy, which provide cover from predators and weather, also influenced invertebrate numbers, which subsequently determined the forest floor small vertebrate diversity. Carey and Johnson (1995) and Hinkelman and Loeb (2007), suggested that the abundance of woody debris in forest structure is a good predictor of a large biodiversity of a small vertebrate community, thus providing a prey base for a larger predatory vertebrate community. The deciduous forest on Wallops Island NWR exhibited an abundance of woody debris and understory canopy cover in comparison to the other forest types during our study period. In addition, we documented preliminary population density estimates of potentially robust populations of *Permyuscus* and *Anaxyrus* on Wallops NWR.

Rapid Biological Assessments (RBAs) are intended to supplement not replace long-term field work, and they are usually conducted by a team of well experienced researchers (Abate 1992). For a more robust survey of terrestrial vertebrate species, we recommend that the RBA efforts outlined in this study be expanded upon following the trapping recommendations below.

Sampling of species richness using acoustic data could have been more efficient using additional tools and methods. For example, recording calls for 20 minutes each morning, afternoon, and evening over several days could have increased recordings of species (Wimmer et al., 2013). Increasing the duration of the study would have eliminated some biases created by natural conditions such as rainfall and wind, and unnatural conditions such as traffic and aircraft noise pollution (Francis et al. 2009, Towsey et al., 2014). In addition, our survey efforts occurred during mid-summer, amphibian vocalizations and bird vocalizations may be more common during the late spring when weather conditions begin to warm and many breeding birds return from migration. During mid to late spring, breeding activity, and hence call activity, for both birds and amphibians may be higher.

Increasing the number of trap nights in regards to remote camera and video would also increase survey efforts for terrestrial vertebrates. A study conducted by Kelly and Holub (2008) suggested that trapping should occur for at least 1,000 consecutive nights to be truly certain if a species is absent in an area. This type of survey effort method could be conducted to determine if historically present species still occur on the Wallops Island NWR and give more insight into the presence of potentially elusive species that may be present in the area (e.g., Gray fox [*Urocyon cinereoargenteus*]). Also, there was bias between the forest types, because the deciduous forest had two camera stations while the conifer and marsh forests only had one camera. A more even and consist survey effort would lead to better analysis of trapping results.

Success of pitfall traps could have been increased by expanding the number of pitfall trap nights and the number of pitfalls (buckets) along each arm of the drift fence. Increasing the diameter of the pitfall traps could also increase success; aluminum flashing wings on either side of the traps would increase the effective diameter (McKnight et al. 2013). Increased trapping effort using Sherman traps could have also helped survey efforts as well as using different trap locations. For example, Sherman traps can be positioned on trees to be more appealing to tree dwelling species. Whittaker and Feldhamer (2000) outline other trapping methods that could be used to more thoroughly assess biodiversity in a study area using Sherman traps.

Environmental factors such as temperature, humidity, and rainfall can affect trapping success rates (McKnight et al. 2013). Increasing the duration and consistency of this survey effort, while using all trapping methods more effectively, would help eliminate trapping bias and increase the ability to document species presence. Seasonal shifts that could cause changes in species presence should be considered when completing a biological assessment. A long-term assessment of the biodiversity at the Wallops Island NWR would give a more accurate assessment of species that occur in the area, as well as the population densities of these species. Our RBA was a brief survey to help the U.S. Fish and Wildlife Services have a better idea of which vertebrate species occur in the Wallops Island NWR, and our tentative results may help to guide management policies for the refuge as well as serve as a guide for future survey efforts.

MANAGEMENT IMPLICATIONS

We documented species previously not known to occur on Wallops Island NWR and we identified the importance of maintaining and managing the maritime deciduous forest habitat to benefit biodiversity on this refuge. We also provided baseline population density estimates for small vertebrate species that occur on Wallops Island NWR. Further analysis should be done to consider any species that could have been missed during our survey period. For example, seasonal biological assessments should be conducted to observe areas used at the beginning of the breeding season and as migration stopping points. Future survey efforts may identify more species previously not documented on Wallops Island NWR.

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FIGURE LEGENDS

Figure 1. Location of Wallops Island National Wildlife Refuge on the Eastern Shore of Virginia, Accomack County (USFWS 2014).

Figure 2. Wallops Island National Wildlife Refuge bordered by route 175 to the west and north with NASA-Wallops Flight Facility and Simoneaston Bay on the eastern border (USFWS 2014).

Figure 3. Borders of the 3 forest types (maritime deciduous, conifer and marsh) and locations of the Songmeter SM2+ acoustic recording device (www.wildlifeacoustics.com) on Wallops Island National Wildlife Refuge from June 28th-July 8th 2015.

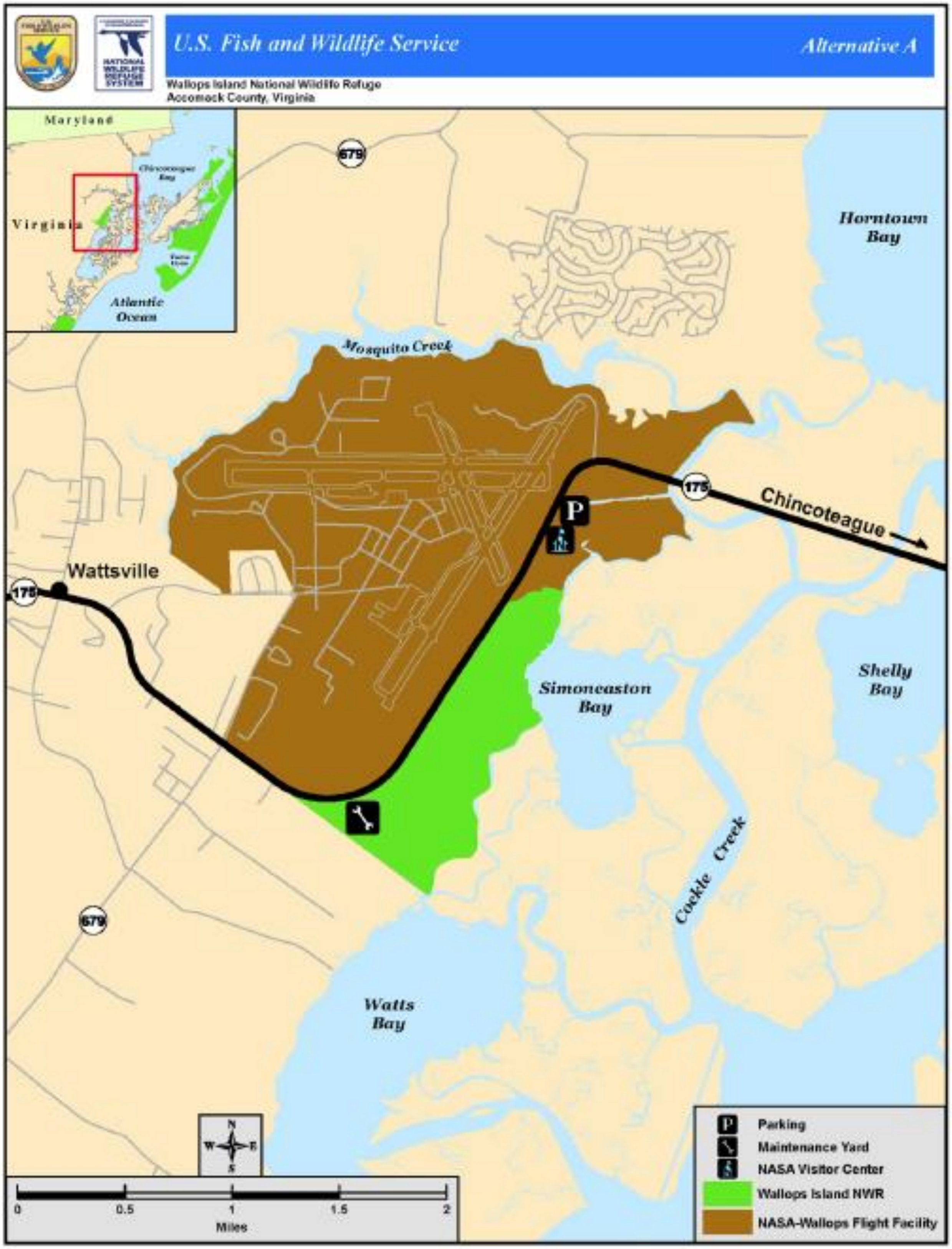
Figure 4. Different trap types used for a Rapid Biological Assessment conducted on Wallops Island National Wildlife Refuge from June 28th-July 8th 2015. A) Leupold RCX-2® remote video camera (www.leupold.com), B) Reconyx® RM45 RapidFire remote camera (www.reconyx.com), C) Sherman traps (www.shermantraps.com), D) Pitfall trap and E) Songmeter SM2+ acoustic recording device (www.wildlifeacoustics.com).

Figure 5. Locations of the Leupold RCX-2® remote video cameras (www.leupold.com) and Reconyx® RM45 RapidFire remote cameras (www.reconyx.com) on Wallops Island National Wildlife Refuge from June 28th-July 8th 2015.

Figure 6. Locations of pitfall traps (P) and Sherman traps (T) (www.shermantraps.com) on Wallops Island National Wildlife Refuge from June 28th-July 8th 2015. Sherman traps in brown are in conifer forest and Sherman traps in green are in deciduous forest.

Figure 7. Three new species documented for Wallops Island NWR. These species included the A) short-tailed shrew (*Blarina brevicauda*), B) woodland vole (*Microtus pinetorum*), and C) the American toad (*Anaxyrus americanus*) [indicated with red arrow, Fowler's toad (*Anaxyrus fowleri*) is on the left; hybrid individuals were also identified, this would need to be further analyzed with genetic techniques].


U.S. Fish and Wildlife Service
Management Units
Chincoteague and Wallops Island National Wildlife Refuges
Accomack County, Virginia and Worcester County, Maryland
Pocomoke City
Stockton
Worcester County
Somerset County
Maryland
Virginia
Greenbackville
Chincoteague Bay
Wildcat Marsh
Pokomoke Sound
Morris Island
Oak Hall
Wattsville
Chincoteague
Saxis
Assateague Island
Atlantic
Toms Cove
Pokomoke Sound
Accomack County
Assateague Island National Seashore
Wallops Island NWR
Assawoman Island
Metompkin Island
Atlantic Ocean
Accomac
Onley
Cedar Island
Wachapreague
Location Map
Refuge Management Units
Assateague Island
Assawoman Island
Cedar Island
Wildcat Marsh and Morris Island
Metompkin Island
Wallops Island NWR
Other Federal Lands
Assateague Island National Seashore
National Park Service Land
Other Features
Major Road/Highway
State Boundary
County Boundary
Miles


U.S. Fish and Wildlife Service
Alternative A
Wallops Island National Wildlife Refuge
Accomack County, Virginia
Maryland
Virginia
Atlantic Ocean
679
Horntown Bay
Mosquito Creek
175
Chincoteague
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Wattsville
Simoneaston Bay
Shelly Bay
Cockle Creek
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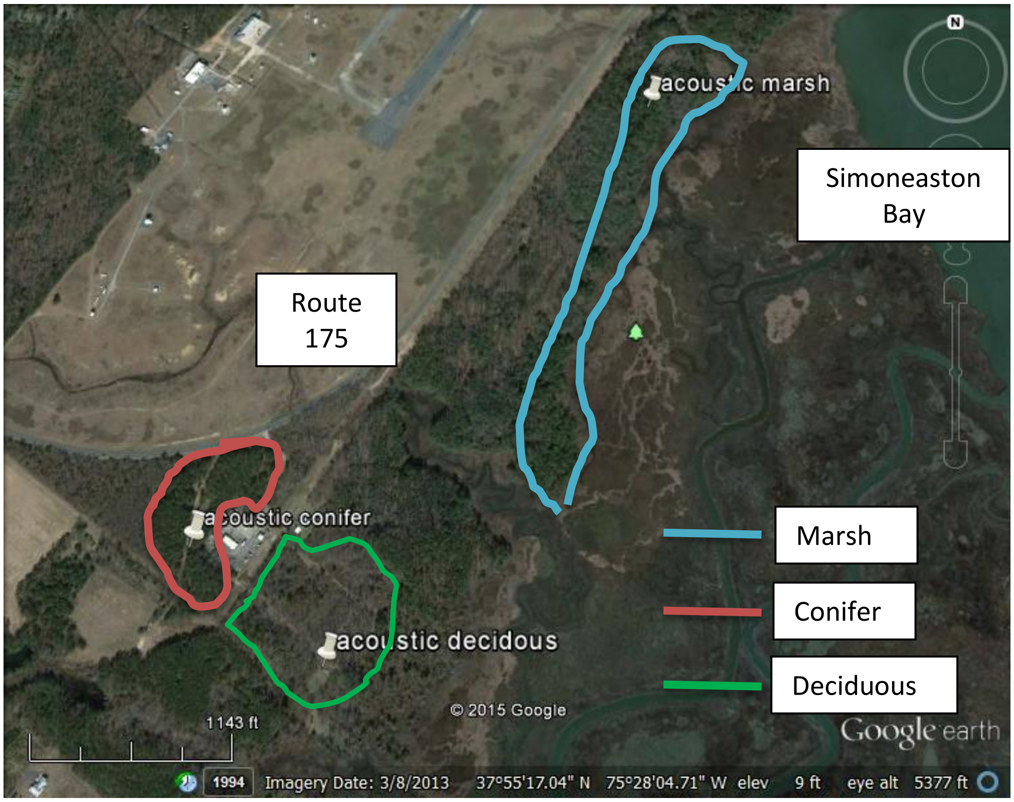
Maintenance Yard
NASA Visitor Center
Wallops Island NWR
NASA-Wallops Flight Facility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Bay
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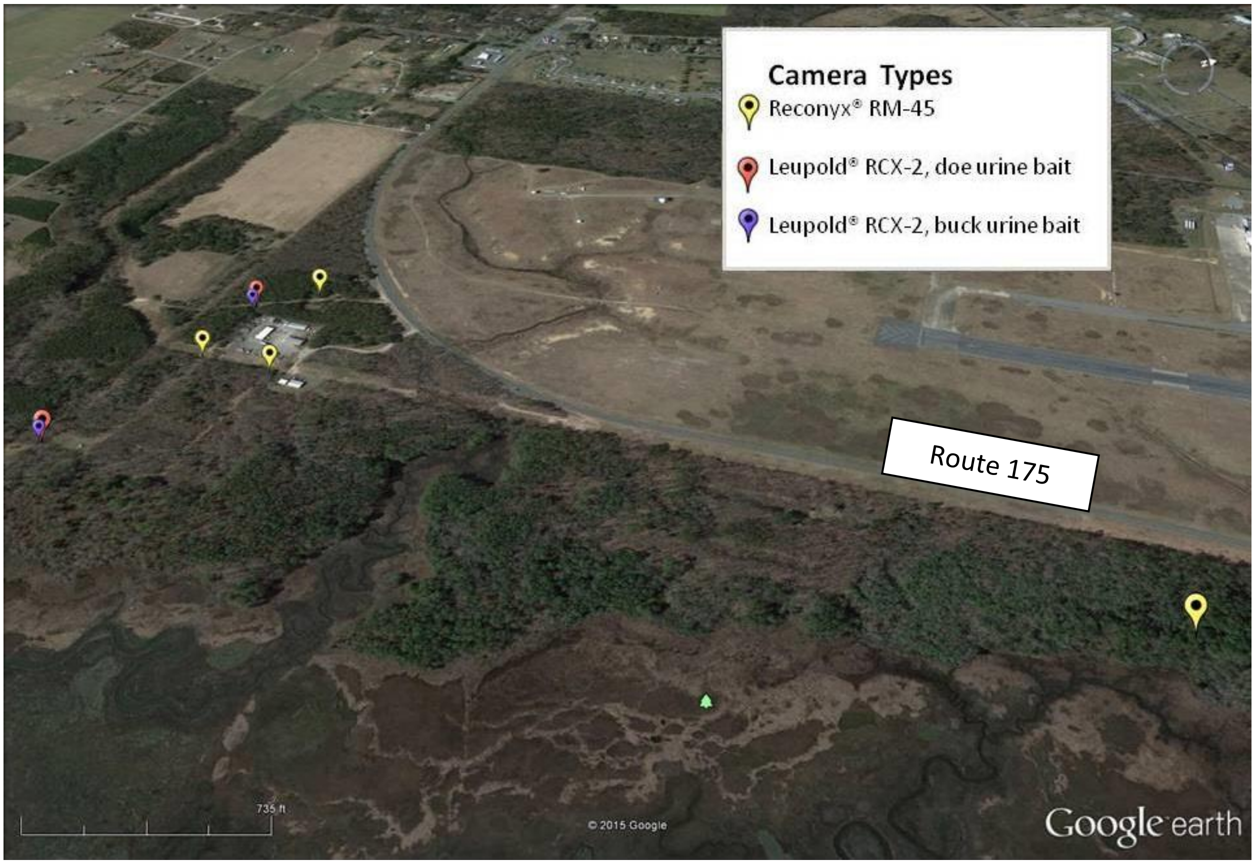
Camera Types
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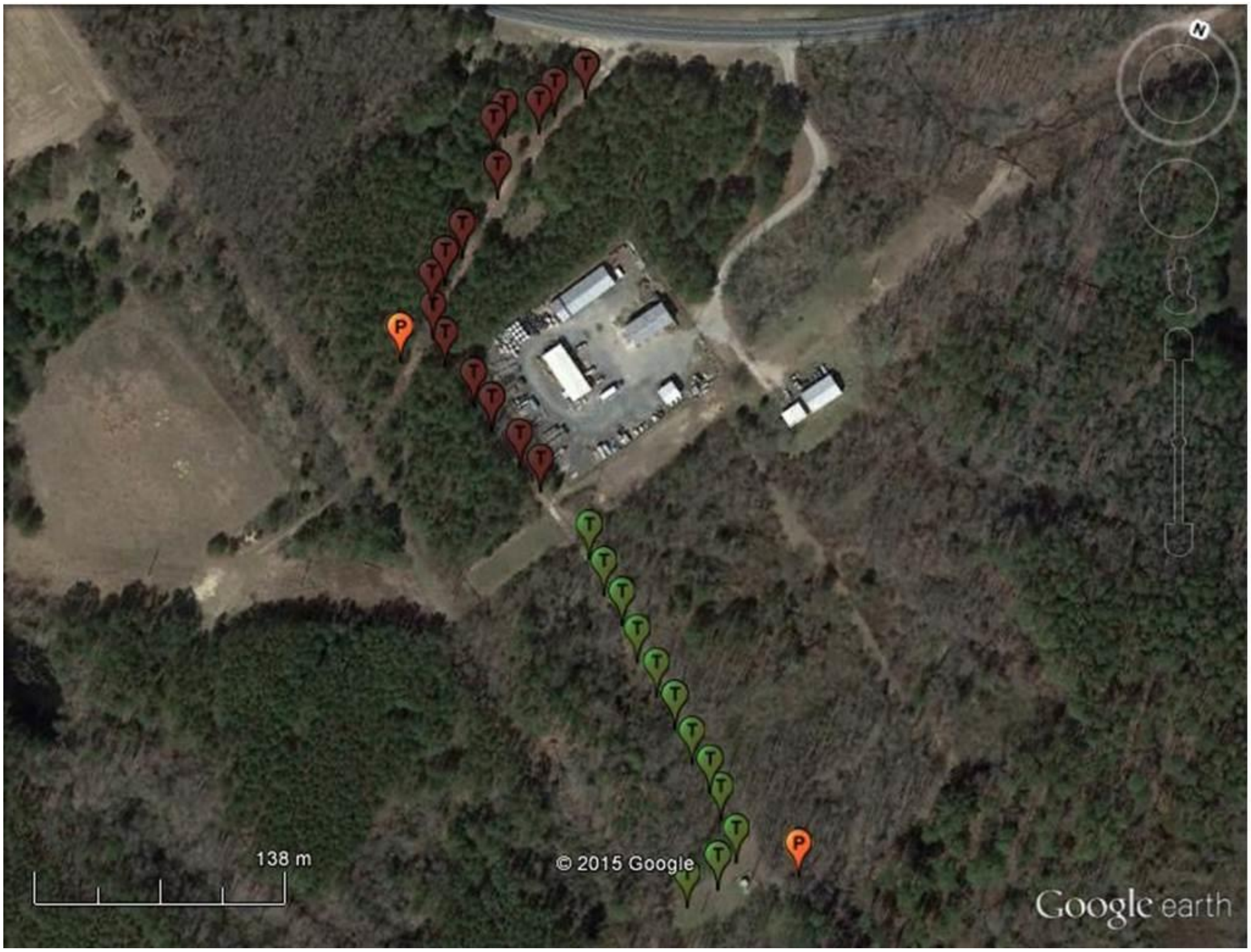
Leupold® RCX-2, doe urine bait
Leupold® RCX-2, buck urine bait
Route 175
735 ft
© 2015 Google
Google earth


138 m
© 2015 Google
Google earth

A)

B)

C)

Table 1. A list of terrestrial vertebrate species observed in the field or caught in traps in different forest habitat types on Wallops Island NWR from June 29 to July 8th 2015.

Common Name/Class	Scientific Name	Trapping Method	Forest Type
CLASS AVES			
Acadian Flycatcher	*Empidonax virescens*	Acoustic Device	Deciduous forest
American Crow	*Corvus brachyrhynchos*	Acoustic Device and Reconyx® camera	Deciduous, conifer, and marsh forest
American Gold Finch	*Spinus tristis*	Acoustic Device	Deciduous and conifer forest
American Kestrel	*Falco sparverius*	Field Observation	Deciduous and conifer forest
American Oystercatcher	*Haematopus palliatus*	Field Observation	Marsh forest
American Robin	*Turdus migratorius*	Acoustic Device	Deciduous forest
Bald Eagle	Haliaeetus leucocephalus	Field Observation	Marsh forest
Barn Swallow	*Hirundo rustica*	Field Observation	Deciduous and conifer forest
Black Skimmer	*Rynchops niger*	Field Observation	Marsh forest
Black Vulture	*Coragyps atratus*	Field Observation	Deciduous and conifer forest
Blue Grosbeak	*Passerina caerulea*	Field Observation	Deciduous forest
Blue Jay	*Cyanocitta cristata*	Acoustic Device	Deciduous forest
Blue-gray Gnatcatcher	*Polioptila caerulea*	Field Observation	Deciduous forest

Boat-tailed Grackle	*Quiscalus major*	Field Observation	Marsh forest
Brown Pelican	*Pelecanus occidentalis*	Field Observation	Marsh forest
Brown Thrasher	*Toxostoma rufum*	Field Observation	Deciduous forest
Brown-headed Cowbird	*Molothrus ater*	Field Observation	Deciduous and conifer forest
Brown-headed Nuthatch	*Sitta pusilla*	Field Observation	Conifer forest
Carolina Chickadee	*Poecile carolinensis*	Acoustic Device/Field Observation	Deciduous and conifer forest
Carolina Wren	*Thryothorus ludovicianus*	Acoustic Device	Deciduous, conifer, and marsh forest
Chipping Sparrow	*Spizella passerina*	Acoustic Device/Field Observation	Deciduous and conifer forest
Clapper Rail	*Rallus longirostris*	Field Observation	Marsh forest
Common Grackle	*Quiscalus quiscula*	Field Observation	Marsh forest
Common Tern	*Sterna hirundo*	Field Observation	Marsh forest
Common Yellowthroat	*Geothlypis trichas*	Acoustic Device	Marsh forest
Double-crested Cormorant	*Phalacrocorax auritus*	Field Observation	Marsh forest
Downy Woodpecker	*Picoides pubescens*	Acoustic Device	Marsh and conifer forest

Eastern Blue Bird	*Sialia sialis*	Acoustic Device	Deciduous forest
Eastern Bluebird	*Sialia sialis*	Field Observation	Deciduous forest
Eastern Kingbird	*Tyrannus tyrannus*	Field Observation	Deciduous forest
Eastern Screech Owl	*Megascops asio*	Acoustic Device/Field Observation	Deciduous forest
Eastern Wood Pewee	*Contopus virens*	Acoustic Device/Field Observation	Conifer forest
European Starling	*Sturnus vulgaris*	Field Observation	Deciduous and conifer forest
Fish Crow	*Corvus ossifragus*	Acoustic Device	Deciduous and marsh forest
Forster's Tern	*Sterna forsteri*	Field Observation	Marsh forest
Glossy Ibis	*Plegadis falcinellus*	Field Observation	Marsh forest
Great Crested Flycatcher	*Myiarchus crinitus*	Acoustic Device/Field Observation	Deciduous, conifer and marsh forest
Great Egret	*Ardea alba*	Field Observation	Marsh forest
Green Heron	*Butorides virescens*	Field Observation	Marsh forest
Herring Gull	*Larus argentatus*	Field Observation	Marsh forest
House Sparrow	*Passer domesticus*	Field Observation	Conifer forest
Indigo Bunting	*Passerina cyanea*	Acoustic	Deciduous and

		Device/Field Observation	conifer forest
King Rail	*Rallus elegans*	Acoustic Device	Marsh forest
Laughing Gull	*Leucophaeus atricilla*	Acoustic Device/Field observation	Deciduous, conifer and marsh forest
Least Tern	*Sternula antillarum*	Field Observation	Marsh forest
Mourning Dove	*Zenaida macroura*	Acoustic Device	Deciduous and marsh forest
Northern Bobwhite	*Colinus virginianus*	Field Observation	Deciduous forest
Northern Cardinal	*Cardinalis cardinalis*	Acoustic Device	Deciduous, conifer, and marsh forest
Northern Flicker	*Colaptes auratus*	Acoustic Device	Deciduous forest
Northern Mockingbird	*Mimus polyglottos*	Field Observation	Deciduous forest
Osprey	*Pandion haliaetus*	Field Observation	Marsh forest
Ovenbird	*Seiurus aurocapilla*	Acoustic Device	Deciduous forest
Pileated Woodpecker	*Dryocopus pileatus*	Field Observation	Deciduous forest
Pine Warbler	*Setophaga pinus*	Acoustic Device/Field observation	Conifer forest
Purple Martin	*Progne subis*	Field Observation	Deciduous, conifer and marsh forest
Red-bellied	*Melanerpes carolinus*	Field Observation	Deciduous forest

Woodpecker			
Red-eyed Vireo	*Vireo olivaceus*	Acoustic Device	Marsh forest
Red-headed Woodpecker	*Melanerpes erythrocephalus*	Field Observation	Deciduous forest
Red-tailed Hawk	*Buteo jamaicensis*	Field Observation	Deciduous forest
Red-winged Blackbird	*Agelaius phoeniceus*	Acoustic Device	Marsh forest
Ring-billed Gull	*Larus delawarensis*	Field Observation	Marsh forest
Rock Pigeon	*Columba livia*	Field Observation	Deciduous forest
Ruby-throated Hummingbird	*Archilochus colubris*	Field Observation	Deciduous forest
Snowy Egret	*Egretta thula*	Field Observation	Marsh forest
Spotted Sandpiper	*Actitis macularius*	Field Observation	Marsh forest
Summer Tanager	*Piranga rubra*	Acoustic Device/Field observation	Deciduous and marsh forest
Tree Swallow	*Tachycineta bicolor*	Field Observation	Marsh forest
Tricolored Heron	*Egretta tricolor*	Field Observation	Marsh forest
Tufted Titmouse	*Baeolophus bicolor*	Acoustic Device	Deciduous and marsh forest
Turkey Vulture	*Cathartes aura*	Reconyx® camera	Deciduous forest
White-eyed Vireo	*Vireo griseus*	Acoustic Device	Deciduous, conifer and marsh forest
Wild Turkey	*Meleagris gallopavo*	Reconyx® and	Deciduous and

		Leupold® camera	conifer forest
Willet	*Tringa semipalmata*	Acoustic Device	Marsh forest
Yellow-billed Cuckoo	*Coccyzus americanus*	Acoustic Device	Deciduous and marsh forest
CLASS MAMMALIA			
Eastern Cottontail	*Sylvilagus floridanus*	Field Observation	Deciduous forest
Gray Squirrel	*Sciurus carolinensis*	Leupold® camera	Conifer forest
Opossum	*Didelphis virginiana*	Reconyx® camera	Deciduous and marsh forest
Raccoon	*Procyon lotor lotor*	Reconyx® camera	Deciduous and marsh forest
Red Fox	*Vulpes vulpes*	Reconyx® camera	Deciduous, conifer, and marsh forest
Short-tailed Shrew*	*Blarina brevicauda*	Pitfall trap/Sherman trap	Deciduous forest
White-footed Mouse	*Peromyscus leucopus*	Sherman trap	Deciduous and conifer forest
White-tailed Deer	*Odocoileus virginianus*	Reconyx® camera	Deciduous forest
Woodland Vole*	*Microtus pinetorum*	Sherman trap	Deciduous forest
CLASS AMPHIBIA			
American Toad*	*Anaxyrus americanus*	Pitfall trap and Sherman trap	Deciduous and conifer forest
Fowler's Toad	*Anaxyrus fowleri*	Pitfall trap and	Deciduous and

		Sherman trap	conifer forest
Green Frog	*Rana (Lithobates) clamitans*	Pitfall trap	Deciduous and conifer forest
Southern leopard Frog	*Rana (Lithobates) pipiens*	Field Observation	Deciduous forest
CLASS REPTILIA			
Rough Green Snake	*Opheodrys aestivus*	Field Observation	Conifer forest
Eastern Box Turtle	*Terrapene carolina carolina*	Field Observation	Deciduous and conifer forest

***** New species records for Wallops Island National Wildlife Refuge

Table 2. Species richness and the Jaccard mean community similarity index (Mean CCS) of vocal terrestrial vertebrate species recorded on a Songmeter SM2+ acoustic recording device (www.wildlifeacoustics.com) on Wallops Island NWR from June 28th-July 8th 2015.

Forest Type	Richness	Mean CCS
Conifer	15	0.326
Deciduous	19	0.323
Marsh	16	0.289

Table 3. Species richness, Jaccard mean community similarity index (Mean CCS) and relative activity of large terrestrial vertebrate species recorded on Leupold RCX-2® video cameras (www.leupold.com) and the Reconyx® RM45 RapidFire cameras (www.reconyx.com) on Wallops Island NWR from June 28th-July 8th 2015.

Forest Type	Richness	Mean CCS	Number of Photo Captures	Relative Activity
Conifer	3	0.330	9	2.22
Deciduous	7	0.410	18	2.22
Marsh	4	0.490	9	1.22

Table 4. Species richness, Reciprocal Simpson Diversity Index and Jaccard community similarity index (CCS) for small terrestrial vertebrate species captured using pitfall traps on Wallops Island NWR from June 28th-July 8th 2015.

Forest Type	Richness	Diversity	CCS
Conifer	4	1.489	0.600
Deciduous	4	1.806	0.600

Table 5. Species richness, Reciprocal Simpson Diversity Index and Jaccard community similarity index (CCS) for small terrestrial vertebrate species captured using Sherman traps (www.Shermantraps.com) on Wallops Island NWR from June 28th-July 8th 2015.

Forest Type	**Richness**	**Diversity**	**CCS**
Conifer	1	1.00	0.333
Deciduous	3	2.45	0.333

APPENDIX (Permits)

OMB Control Number: [illegible]
Expiration Date: 06/30/2017

Research & Monitoring Special Use Permit

Station #: 51570 (For Official Use Only) **Permit #:** 2015-011

Permit Term: From June 29, 2015 To July 16, 2015

1) Principal Investigator Name/Affiliation: Dr. Aaron Haines / Millersville University / CBFS

2) Permit Status: a) Approved: (●) If approved, provide special conditions (if any) in the text box below.

b) Denied: ( ) If denied, provide justification in the text box below.

[Type in additional Special Conditions or Justification for Denied Permit in the space provided]

> All refuge regulations must be followed.
>
> Refuge POC: Kevin Holcomb, Supervisory Wildlife Biologist, 757-894-1659 (cell)

3) Are there additional special conditions attached to the permit? Yes ( ) No (●)

4) Are licenses/permits required, and have they been verified? Yes (●) No ( ) N/A ( )

5) Are Insurance and/or Certification(s) required, and have they been verified? Yes ( ) No ( ) N/A (●)

6) Is an Assurance of Animal Care or Institutional Animal Approval form needed? Yes ( ) No ( ) N/A (●)

If yes, is the form attached? Yes ( ) No ( )

7) Has a Minimum Requirements Decision Assessment been conducted? Yes ( ) No ( ) N/A (●)

If yes, is assessment attached? Yes ( ) No ( )

8) Record of Payments: Exempt (●) Partial ( ) Full ( )

Amount of payment: _____ Record of partial payment: _____

9) Is a surety bond or security deposit required? Yes ( ) No ( ) N/A (●)

This permit is issued by the U.S. Fish and Wildlife Service and accepted by the applicant signed below, subject to the terms, covenants, obligations, and reservations, expressed or implied herein, and to the notice, conditions, and requirements included or attached. A copy of this permit should be kept on-hand so that it may be shown at any time to any refuge staff.

10) **Permit approved/issued by:** (Signature and title) \[signature\]

Date: 6/1/15

11) **Permit accepted by:** (Signature of permittee) \[signature\]

Date: 6/2/15

Virginia Department of Game and Inland Fisheries
4010 West Broad Street, P.O. Box 11104, Richmond, VA 23230-1104
(804) 367-1000 (V/TDD)
Under Authority of § 29.1-412, § 29.1-417, & § 29.1-418 of the Code of Virginia

Scientific Collection Permit

Permit Type: **Renewal** Fee Paid: **$40.00** VADGIF Permit No. **054125**

Permittee: **Anne Armstrong**
Address: **The Marine Science Consortium**
34001 Mill Dam Road
Wallops Island, VA 23337

Office: **(757) 824-5636**
City/County:

Research/Conservation Biology (BIOL 443)

Authorized Collection Methods: By Hand/Live-Traps (Box/Pitfall/Funnel/Bell/Pot)/Deluxe Repeating Sparrow Trap/Electrofishing/Dip Nets/Seine Nets/Traps (Minnow/Pot/Bell)
Authorized Waterbodies: All within the Marine Science Consortium campus & Wallops Island NWR/Chincoteague NWR/Custis Pond/Savage Neck Dunes/Interdune Pools/Swan Gut Creek
Authorized Marking Techniques: Small unique mark shaved on animal's back (small mammals only)/Color Bands for Sparrows.

SPECIAL CONDITION: Trapping authorized for small,nongame mammals ONLY. No Game or Furbearer trapping permitted without additional authorization.

Permittee MUST notify VDGIF a minimum of 7 days prior to each sampling event. Notification must be made via email to: collectionpermits@dgif.virginia.gov

Report Due: 31 January 2016, 31 January 2017

ALL PERMIT REPORTS MUST CONTAIN COORDINATES; PERMITTEE CAN USE THE VIRGINIA FISH AND WILDLIFE INFORMATION SERVICE (VAFWIS) TO OBTAIN COORDINATES BY VISITING: HTTP://VAFWIS.ORG/FWIS

STANDARD CONDITIONS ATTACHED APPLY TO THIS PERMIT.

Authorized Counties / Cities:
Accomack
Northampton

Authorized Species:

Description	ID Number	Scientific Name
Birds		
Freshwater Fish		
Small Mammals		

Annual Report Due End of Each Year

Authorized Sub-Permittees:
Ali Redman, The Marine Science Consortium/Chincoteague Bay Field Station
Aaron Haines, Millersville University
Steve Seiler, Lock Haven University

Virginia Department of Game and Inland Fisheries

4010 West Broad Street, P.O. Box 11104, Richmond, VA 23230-1104

(804) 367-1000 (V/TDD)

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Scientific Collection Permit

Permit Type: **Renewal** Fee Paid: **$40.00** VADGIF Permit No. **054125**

Approved by:

Applicants may appeal permit decisions within 60 days of issuance. The appeal must be in writing to the Director, Department of Game and Inland Fisheries.

Title: **James E. Husband - Permits Manager** **Date:** **5/15/2015**

20 Permit Effective **5/15/2015** through **12/31/2016** **16**