Department of Defense
Legacy Resource Management Program

PROJECT NUMBER: NR-20-002

Building Capacity for Managing At-risk Species to Enable Mission Readiness on Military Installations: Spotted Turtle Status Assessment and Surveys

Smithsonian Institution

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Final Technical Report
September 11, 2022

Department of Defense Legacy Natural Resource Program Project No. NR-20-002
Cooperative Agreement No. N62470-20-2-2010

Prepared for:

Department of Defense Legacy Natural Resources Management Program
&
Department of Defense Partners in Amphibian and Reptile Conservation

Prepared by:

Thomas S. Akre and Jessica Meck, Smithsonian Conservation Biology Institute

With contributions from:

John Garrison, Molly Parren, and Lisabeth Willey, American Turtle Observatory
Lori Erb, The Mid-Atlantic Center for Herpetology and Conservation
Houston Chandler, The Orianne Society

Supported by:

Department of Defense Legacy Natural Resources Management Program grant to the Department Defense Partners in Amphibian and Reptile Conservation

Suggested citation:

Akre, T.S. and J. Meck. 2022. Building Capacity for Managing At-Risk Species to Enable Mission Readiness on Military Installations: Spotted Turtle Status Assessment and Surveys. Technical Report to the Department of Defense Legacy Natural Resources Management Program and Department of Defense Partners in Amphibian and Reptile Conservation. 103 pp.

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Introduction

Project Synopsis

Spotted Turtle (*Clemmys guttata*) populations have declined across their range in the eastern United States, and this is particularly true in coastal areas where Department of Defense (DoD) installations represent an opportunity for conservation of the species through effective monitoring and management of populations and their habitats. This project conducted a brief but thorough status assessment of Spotted Turtle populations on nine military sites, from Massachusetts to Georgia, through a standardized monitoring protocol developed for an ongoing conservation research effort supported by the U.S. Fish and Wildlife Service (USFWS) and participating states from Maine to Florida. The project aim was to determine Spotted Turtle population distribution and abundance, and to evaluate habitat management opportunities on military sites. Expanding current knowledge of at-risk species on installations, such as the Spotted Turtle, enables natural resource personnel to improve Integrated Natural Resource Management Plans (INRMP), thereby promoting mission readiness through support of Spotted Turtle conservation and improved habitat management.

Background

The Spotted Turtle is a small, charismatic, and wide-ranging North American freshwater turtle. The species is readily distinguished by a small size (ca.125 mm carapace length), a black carapace with bright yellow spots, and a black head with orange face markings (Figure 1). The Spotted Turtle range is more or less discontinuous along the Atlantic coast, from southern Maine to northern Florida, and discontinuous around the Great Lakes, from Ohio through Illinois to Ontario (Figure 2). Historically, the Spotted Turtle was among the most abundant of Northeast turtles, and populations were probably fairly continuous within the known range (Ernst and Lovich, 2009; Willey et al., 2022). Today, presumably much more fragmented populations are found in remnant shallow wetlands, including vernal pools and other seasonal wetlands, bogs, marshes, forested floodplain wetlands, estuaries, and coastal wetlands (Willey et al., 2022). Spotted Turtles typically emerge from brumation, mate and feed in the cooler months of the year, such as the winter or early spring, beginning with precipitation and warming days that also stimulate a pulse of invertebrate and amphibian breeding and feeding activity that serves as a food source. Later in the spring or summer as their shallow wetlands dry, they become inactive and may aestivate in wetland remnants or on land, where they may remain dormant, other than for nesting, until precipitation replenishes local wetlands after the end of the growing season in late fall through late winter (Ernst and Lovich, 2009).

Like many turtle species, Spotted Turtles face numerous threats across their range, including habitat loss and fragmentation, road mortality, illegal collection, and climate change. Due to these threats, the species is considered a Species of Greatest Conservation Need in all 21 U.S. states where they occur, it is Red Listed as Endangered by the International Union for Conservation of Nature (van Dijk, 2011) and is currently under consideration for Federal listing

on the U.S. Endangered Species Act (ESTWG, 2019) as a result of being petitioned a decade ago (Giese et al. 2012). Lastly, the Spotted Turtle is a DoD Mission Sensitive Species.

In response to a growing awareness of these threats and an emerging view that certain threats were accelerating in frequency and magnitude (e.g., wetland loss from development and sea-level rise, and poaching for the pet trade), as well a dearth of knowledge on the status of the Spotted Turtle over much of its range, members of Partners in Amphibian and Reptile Conservation (PARC) formed an Eastern Spotted Turtle Working Group (ESTWG) in 2017 (ESTWG, 2019; https://www.northeastturtles.org/spotted-turtle.html). The ESTWG has been comprised of leadership, management and scientist personnel from state and federal agencies, universities and Non-governmental Organizations (NGOs) from Maine to Florida. The ESTWG has a few primary goals in response to growing threats, a lack of knowledge, and a consideration for listing: 1) to coordinate among state and federal agencies and private institutions to determine the collective state of understanding of threats and impacts to Spotted Turtle populations from Maine to Florida, 2) to identify and address gaps in awareness and knowledge of the threats and status of the Spotted Turtle in the eastern U.S., and 3) to provide information from gap analyses and assessments to the states and federal agencies and private institutions to improve science, policy and practice for the conservation of the Spotted Turtle at the national, regional and local level (ESTWG, 2019; Willey et al., 2022). An objective that developed from these goals was to conduct an eastern regional status assessment on the Spotted Turtle as a baseline of information in support of a pending listing decision. Two major grants, a USFWS Competitive State Wildlife Grant (CSWG), and a Northeast Association of Fish and Wildlife Agencies Regional Conservation Needs grant, were awarded to the ESTWG in 2018 to complete the assessment. A further aim of the status assessment was to develop a conservation plan for maintenance of Spotted Turtle populations on public and private lands through management and preservation of suitable habitat at high priority sites throughout the region (Willey et al., 2022), like has been done for the Wood Turtle (*Glyptemys insculpta*) in the Northeast U.S. (Jones et al., 2018). In addition to the foundation provided by personnel from state and federal wildlife agencies (e.g., VA DWR, USFWS) and those that manage natural resources (e.g., DoD), the Smithsonian Institution ([SI]; i.e., the National Zoo and Conservation Biology Institute [NZCBI]) and three NGOs (American Turtle Observatory [ATO; https://www. americanturtles.org/], Mid-Atlantic Center for Herpetology and Conservation [MACHAC; https://www.machac.org/], the Orianne Society [TOS; https://www.oriannesociety.org/]) have been central to development, implementation, support and evaluation of this status assessment and conservation plan, primarily through PARC and its regional and topical groups.

The Cooperative Agreement between the Department of Defense and the Smithsonian Institution

Department of Defense manages more than 30 million acres, much of which is important habitat for threatened and endangered species, including the Spotted Turtle (Petersen et al., 2018). DoD is well known for its stewardship of herpetofauna on military lands through installation INRMPs,

the Legacy Resource Management Program (DoD LRMP) and DoD PARC (Petersen et al., 2018; DoD PARC, 2020). As part of this approach to stewardship, DoD and Department of Interior developed a Memorandum of Understanding to establish a "Recovery and Sustainment Partnership Initiative" to promote species conservation and recovery in support of mission readiness (C. Petersen, pers. comm.). At around that same time, personnel from DoD LRMP and DoD PARC conducted a range-wide inventory of installations to document confirmed and possible Spotted Turtle populations to compliment a conservation outreach document on best management practices (BMPs) (C. Petersen and R. Lovich, pers. comm.; Petersen et al., 2018). This exercise confirmed Spotted Turtle records on 39 installations of all military services (i.e., Air Force, Army, Army National Guard, Marine Corps, and Navy) and possible presence on an additional 60 installations of all services (DoD PARC, 2019). The development of "Recommended Best Practices for the Spotted Turtle on Department of Defense Installations" (DoD PARC, 2019) was led by C. Petersen and R. Lovich and included consultation from installation personnel, NZCBI and leaders of the ESTWG (e.g., T. Akre of SI, L. Willey of ATO, L. Erb of MACHAC and H. Chandler of TOS). Like the many other BMP documents produced by DoD LRMP (https://www.denix.osd.mil/dodparc/parc-resources/index.html), the Spotted Turtle document brings together the perspectives of essential stakeholders from DoD, other federal agencies, state agencies and NGOs to address conservation science, policy and practice of an at-risk species in support of military mission readiness. Therefore, it continues to be a key objective of the ESTWG to work closely with DoD to support mission readiness through development of knowledge on the status and conservation of the Spotted Turtle on DoD lands (Willey et al., 2022).

In view of this need and opportunity, SI submitted a proposal to C. Petersen and R. Lovich at Naval Facilities Engineering Systems Command (NAVFAC) in July 2020. Nine DoD installations and three partner organizations (i.e., ATO, MACHAC, TOS) (Table 1) would join SI to conduct a status assessment of the Spotted Turtle on military sites to determine distribution and abundance and evaluate habitat management opportunities. In October 2020, a cooperative agreement (CA) was executed by NAVFAC and SI to work with DoD representatives, installation personnel, and project partners to build capacity for managing at-risk species to enable mission readiness on military installations by conducting such an assessment. This CA, hereafter referred to as the "Spotted Turtle (*Clemmys guttata*) Management for Mission Readiness Cooperative Agreement", had the following aims: 1) improve the understanding of the abundance and distribution of Spotted Turtles on installations, 2) raise awareness for the standard assessment protocol for the information to be disseminated to other military installations, and 3) create a replicable model for a conservation approach for other military installations (both installations with confirmed observations and those with potential habitat). The overarching goal of these aims is to improve information on the status of the Spotted Turtle on DoD lands in support of mission readiness by integrating this information into installation INRMPs. Financial support for this project was provided through the CA by funding from DoD LNRMP to DoD PARC.

This report details the methods used to meet the aims of the CA that can serve as a replicable model for the additional 30 installations with Spotted Turtle records, as well as the 60 with potential habitat and populations (DoD PARC, 2019). Furthermore, this report presents the results of status assessments from 2018 to 2021 to provide a baseline for population trends and habitat best management practices across the nine sampled installations. Lastly, it discusses the results from 2019 and 2021 in the context of aims of the CA, to evaluate the status of the Spotted Turtle among the nine installations and inform a provisional conservation plan with habitat management best practice recommendations for all nine installations.

Methods

Study Area: DoD Installations

Nine DoD installations participated in the Spotted Turtle (*Clemmys guttata*) Management for Mission Readiness Cooperative Agreement (Table 1) from November 2020 to November 2021 (Table 2), with continued support to the present day. Installations included Camps Curtis Guild and Edwards in Massachusetts, Fort Indiantown Gap in Pennsylvania, Joint Base McGuire-Dix Lakehurst in New Jersey, Forts Belvoir and A.P. Hill, Marine Corps Base Quantico, and Naval Support Activity Northwest Annex in Virginia, and Fort Stewart in Georgia (Figure 3). Below, a brief description of the location and mission, and landscape and wetland ecology is provided for each installation. Likewise, each paragraph documents any historical and current activity with Spotted Turtles, where relevant, as well as installation and CA partner organization representatives, and the objectives for the CA related to its current INRMP and mission readiness.

Camp Curtis Guild (CCG)

Camp Curtis Guild (est. 1926) is a U.S. Army National Guard training facility located 29 km north of Boston, MA and directly north of Interstate-95 (I-95) (Figure 3) in the Northeastern Coastal Zone Level 3 ecoregion (CEC, 2021) (Table 1). At 283 ha, CCG is the second largest training site for the Massachusetts Army National Guard (MNG, 2020). Approximately 35 percent of the installation (ca. 99 ha) is wetlands categorized as freshwater forested/shrub wetlands (USFWS, 2020) (Figure 4). Spotted Turtles have been confirmed on the installation (DoD PARC, 2019) and in recent years (2016-17) natural resource staff have trapped wetlands on the installation (Figure 4) to sample distribution and abundance, and they have also radio-telemetered individual turtles to understand movement and habitat use patterns (A. Curtis, pers comm.). For the Spotted Turtle CA, the installation was represented by A. Curtis, who coordinated with M. Parren of ATO (Table 1). The primary objective(s) of this CA for CCG was to understand the distribution and abundance of the Spotted Turtle on the installation to better inform INRMP priorities and the implementation of best management practices that support mission readiness.

Camp Edwards (CPED)

Camp Edwards (est. 1935) is a U.S. Army National Guard training facility located in Barnstable County, MA, approximately 89 km south of Boston (MNG, 2020) (Figure 3) in the Atlantic Coastal Pine Barrens ecoregion (CEC, 2021) (Table 1). The installation comprises 6070 ha that include Pitch Pine (*Pinus rigida*) stands, shrublands, mixed-deciduous forests, grasslands, and wetlands located within Joint Base Cape Cod (8903 ha). Dominant wetland types include sphagnaceous cranberry bogs, emergent wetlands, vernal pool complexes, and freshwater ponds (Figure 5). Spotted Turtles have been confirmed on the installation (DoD PARC, 2019) and observed by personnel over the last few decades. However, incidentally encountered individuals have not been measured or marked for demographic information and no sampling has been undertaken (A. Curtis, pers comm.). For the Spotted Turtle CA, the installation was represented by A. Curtis, who coordinated with J. Garrison of the ATO (Table 1). The primary objective(s) of this CA for CPED was to understand the distribution and abundance of the Spotted Turtle on the installation to better inform INRMP priorities and the implementation of best management practices that support mission readiness.

Fort Indiantown Gap (FIG)

Fort Indiantown Gap (est. 1931) is a U.S. Army National Guard training facility located in Lebanon County, 37 km northwest of Harrisburg, PA (Figure 3) in the Ridge and Valley ecoregion (CEC, 2021) (Table 1). The installation is 7284 ha with deciduous forests, grasslands, shrublands, and both emergent and forested wetlands (PNG, 2021). Spotted Turtles have been a focal species for the installation for some time, with a relatively long history of inventory and monitoring sampling on the installation (DoD PARC, 2019). Surveys were conducted by installation personnel in the early 2000s and again in 2019, as part of the regional CSWG efforts (D. McNaughton, pers. comm.). During the 2019 monitoring effort, 16 Spotted Turtles were captured in traps, four of which were females originally captured in the early 2000s (R. Picone, pers comm.). For the Spotted Turtle CA, the installation was represented by R. Picone, who coordinated with L. Erb of the MACHAC (Table 1). The primary objective(s) of this CA for FIG was to understand the distribution and abundance of the Spotted Turtle on the installation to better inform INRMP priorities and the implementation of best management practices that support mission readiness.

Joint Base McGuire-Dix-Lakehurst (JBMDL)

Joint Base McGuire-Dix-Lakehurst (est. 1921) serves all six-armed forces and is the only tri-serve base in the United States. The installation is located in Burlington County, New Jersey, 29 km southeast of Trenton, NJ (Figure 3), in the Atlantic Coastal Pine Barrens ecoregion (CEC, 2021) (Table 1) The Base consists of 16,997 contiguous hectares of Pine (*Pinus* spp.) barrens, Atlantic White Cedar (*Chamaecyparis thyoides*) swamps, emergent wetlands, and streams (DoD, 2021) (Figure 6). Spotted Turtles have been confirmed on the installation (DoD PARC, 2019), but no previous inventory and monitoring sampling has taken place (M. Stevenson and P. Mahoney, pers comm.). For the Spotted Turtle CA, the installation was represented by M. Stevenson, who coordinated with L. Erb of the MACHAC (Table 1). The primary objective(s) of

this CA for JBMDL was to understand the distribution and abundance of the Spotted Turtle on the installation to better inform INRMP priorities and the implementation of best management practices that support mission readiness.

Fort Belvoir (FB)

Fort Belvoir (est. 1912) is a U.S. Army training facility located in Fairfax County, VA, 23 km south of Washington D.C. (Figure 3) in the Southeastern Plain ecoregion (CEC, 2021) (Table 1). The installation is 3503 ha and has two designated refuges: the Accotink Bay Wildlife Refuge and Jackson Miles Abbott Wetland Refuge. The installation is dominated by mixed Oak-Pine (*Quercus* spp. – *Pinus* spp.) forests, American Beech (*Fagus grandifolia*)/mixed Oak forests, and numerous wetland types, including riparian habitats associated with Dogue, Accotink, and Pohick Creeks, forested and scrub-shrub and emergent wetlands, and vernal pools (Keough and Eberly 2004) (Figure 7). Spotted Turtles are widespread and moderately abundant on the installation and have been observed regularly and occasionally captured, measured and marked for demographic information (DoD PARC, 2019; T. Akre, pers. obs., J. Pilcicki, pers. comm.). Most recently, E. Lassiter, a doctoral student at the University of Arkansas, has been evaluating Spotted Turtle population size and demography, and spatio-temporal movement patterns based upon recent data collection (2017-2019) on the installation and surrounding area, (E. Lassiter, pers. comm.). For the Spotted Turtle CA, the installation was represented by J. Pilcicki, who coordinated with J. Meck of SI (Table 1). The primary objective(s) of this CA for FB was to understand the distribution and abundance of the Spotted Turtle on the installation to better inform INRMP priorities and the implementation of best management practices that support mission readiness.

Marine Corps Base Quantico (MCBQ)

Marine Corps Base Quantico (est. 1917) is located in Triangle, VA, approximately 56 km south of Washington D.C. (Figure 3), in the Southeastern Plain ecoregion (CEC, 2021) (Table 1). The installation is primarily a Marine Corp training facility, but also supports training for the Federal Bureau of Investigation and Drug Enforcement Administration. MCBQ is 22,318 ha with a variety of habitats, including Pine-Oak savannas, post-agricultural lands, mixed hardwood and conifer forests, and tidal and non-tidal wetlands (Klopfer and Kane, 2017). Freshwater wetland types include vernal pools, emergent wetlands, streams and associated riparian habitat (Figure 8). Spotted Turtles have historically been a focal species over the last decade, with multiple inventory efforts, including radiotelemetry research on movements and habitat use on the eastern portion of the installation (DoD PARC, 2019; K. Erwin, pers. comm.). For the Spotted Turtle CA, the installation was represented by K. Erwin, who coordinated with J. Meck of SI (Table 1). The primary objective of this CA for MCBQ was to understand Spotted Turtle distribution on the installation to support the development of best management practices and strategic conservation planning. With no specific management plan for Spotted Turtles under the current INRMP, the species falls under the general nongame management section. The long-term objective for

MCBQ is to implement land management programs that will support the goals for the Spotted Turtle in the Virginia Wildlife Action Plan, to support mission readiness.

Fort A.P. Hill (FAPH)

Fort A.P. Hill (est. 1941) is a U.S. Army training and maneuver center in Bowling Green, VA, approximately 64 km north of Richmond, VA (Figure 3) in the Southeastern Plain ecoregion (CEC, 2021) (Table 1). The installation is 30,756 ha and is 80 percent forested, primarily with mixed Pine and hardwood forests, Pine-dominated stands, and some grasslands (Vilgats et al., 2021). Wetlands on Fort A.P. Hill include shrub swamps, emergent wetlands, freshwater ponds, forested wetlands, and vernal pools (Figure 9). Spotted Turtles have been confirmed on the installation and were briefly inventoried by J. Mitchell in the 1990s (DoD PARC, 2019; A. Satterwhite, pers. comm.). Since the 1990s, the only evaluation of Spotted Turtle distribution and abundance on the installation was conducted by SI personnel in 2019 in support of the regional CSWG efforts (T. Akre, unpubl. data). For the Spotted Turtle CA, the installation was represented by K. Crafts, who coordinated with J. Meck of the SI (Table 1). The primary objective(s) of this CA for FAPH was to understand the distribution and abundance of the Spotted Turtle on the installation to better inform INRMP priorities and the implementation of best management practices that support mission readiness.

Naval Support Activity Northwest Annex (NSANA)

Naval Support Activity Northwest Annex (est. 1975) is located in Chesapeake, VA and adjacent North Carolina (Figure 3) in the Middle Atlantic Coastal Plain ecoregion (CEC, 2021) (Table 1). The installation, consisting of 1457 ha, provides and coordinates multi-service shore activity support. NSA Northwest Annex consists primarily of mixed hardwood and conifer (*Pinus* spp.) forests and agricultural fields (USN, 2021). Wetlands include Red Maple (*Acer rubrum*) swamps, vernal pools, and forested wetlands (Figure 10). Spotted Turtles have been a focal species for the installation in recent years, including a brief inventory and radiotelemetry project by C. Petersen in the last decade (DoD PARC, 2019; C. Petersen, pers. comm., T. Austin, pers. comm.) and standardized trapping assessments by Smithsonian personnel in 2019 in support of the regional CSWG efforts (T. Akre, unpubl. data). For the Spotted Turtle CA, the installation was represented by T. Austin, who coordinated with J. Meck of SI (Table 1). The primary objective of participation in this CA for NSANA is to identify the activity areas and associated habitats for the Spotted Turtle population complex on the installation to mitigate potential impacts from military readiness activities, such as clearing zones for antenna arrays. In addition, the installation wants to continue supporting Spotted Turtle population assessments to develop greater knowledge and awareness of the species' status (i.e., distribution, abundance, threats and conservation opportunities) on DoD lands (T. Austin, pers. comm.).

Fort Stewart (FS)

Fort Stewart (est. 1940) is a U.S. Army infantry training facility located in southeastern Georgia, approximately 20 km west of Savannah, GA (Figure 3) in the Southern Coastal Plain ecoregion

(CEC, 2021) (Table 1). At 113,312 ha, Fort Stewart is the largest Army installation east of the Mississippi River (USA, 2021). The installation has a variety of habitats typical of the region, including extensive Longleaf Pine (*Pinus palustris*) forests with isolated ephemeral wetlands found throughout, and broadly distributed floodplain swamps (Figure 11). Spotted Turtles have been reported on the installation for many years, but no previous inventory or monitoring efforts have been undertaken (L. Carlile and R. Burke, pers. comm.; H. Chandler, pers. obs; DoD PARC, 2019). For the Spotted Turtle CA, the installation was represented by L. Carlile, who coordinated with H. Chandler of TOS (Table 1). The primary objective of participation in this CA for Fort Stewart is to understand Spotted Turtle distribution on the installation to better inform management priorities and needs related to the INRMPs (L. Carlile, pers. comm.).

Coordination Among Study Participants

Conference Calls Among CA Representatives, Installation and Partner Personnel

Following delivery of the CA in October 2020, CA representatives from DoD, SI, and CA partner organizations coordinated the project through ad-hoc email, telephone and video communications, as well as planned series of conference calls from October 2020 to November 2021. These communications, especially the conference calls, were designed to orient CA DoD installation and partner personnel to the objectives, standards and management of the project in order to organize, implement, report and evaluate the main phases of the CA project across the period of performance. Conference calls were held for an hour each at regular intervals across the year. All calls consisted of an agenda to promote and support the CA project, including a question-answer session with regular follow up on descendant or derivative topics that refined project management.

Reconnaissance – Site Visitation on DoD Installations

Following remote coordination, project partners and installation personnel arranged reconnaissance through site visitation. Site visitations enabled project partners to orient to the installation and its procedures, discuss CA goals and opportunities with installation personnel, and learn about the installation's natural resources and resource management tools, in preparation for Spotted Turtle sampling in select wetlands across installations. To select assessments sites, partner and installation personnel used Geographic Information System (GIS) data and on-site surveillance to evaluate wetlands with historic and recent records, as well as data-deficient areas with suitable or potential habitats with trapping and visual encounter survey potential. GIS (e.g., ESRI, 2020) was used to evaluate installation infrastructure, landcover (e.g., using National Land Cover Database [NLCD] 2016; Dewitz, 2019) and access routes in complement to National Wetlands Inventory (NWI; USFWS, 2020) data layers and other natural resource landcover layers, as available. Sampling sites for standardized assessments and inventory sampling were chosen based upon the needs of the installation and the objectives of the CA. Representative natural resource personnel at each installation wanted to improve the understanding of the distribution of Spotted Turtle populations in their natural and mission-

oriented areas. Thus, in most cases they wanted both focused standardized sampling in known or suspected areas of suitable habitat and inventory sampling in other areas across the installations, to determine occupancy in both and abundance where possible. In all cases, natural resource personnel sought information from the trapping returns to inform a Spotted Turtle monitoring and management program that would balance mission-oriented activities and species and habitat management within the installation's INRMP.

After sites were selected and evaluated, ongoing surveillance continued and trapping began as scheduling between installation and partner personnel permitted, with adaptation to access, weather and hydrologic conditions. In most cases, installation personnel conducted surveillance and trapping themselves through consultation with project partners and/or, they joined project partners in the field to lend support while sampling, learn and refine techniques and protocols, and to further discuss long-term needs and potential challenges. In addition, efforts to bring DoD LRMP and DoD PARC leadership representatives together with installation and SI personnel were made in order to support the CA and its objectives more effectively. However, partner and installation personnel were unable to join each other in the field on site for an ideal amount of time in most cases. Although the CA objectives were developed to improve collaborative capacity among partner institution personnel and installation personnel in order to learn, refine, promote and replicate ecological assessment protocols for Spotted Turtles to determine their distribution, abundance and habitat requirements on DoD lands, the ability to coordinate collective field work and site visitation was somewhat hampered by illness and the preventative social distancing practices associated with COVID-19.

Spotted Turtle Sampling on DoD Installations

Standardized Assessments and Inventory Sampling

The ESTWG standardized assessment guidelines (ESTWG, 2019) were followed to conduct standard or high-density trap rapid assessments (TRA or HD-TRA), demographic assessments (DA), visual rapid assessments (VRA), and/or adaptive inventory-based trapping. These assessment techniques are a set of guidelines and protocols to sample for Spotted Turtle detection, distribution, and abundance, as well as population demography (i.e., age structure and sex ratios), and record multi-scale habitat covariates. These guidelines describe the spatial arrangement used for each assessment type listed above (Figure 12) and provide detail on standard trap types used for sampling the Spotted Turtle in the Eastern U.S., as well as the timing and process of their deployment, monitoring, and maintenance (Figures 12-13).

As shown in Fig. 12, the standard spatial arrangement is four reference plots, each with five traps placed within a radius of 200m that is centered on suitable Spotted Turtle habitat (i.e., 20 traps per trapping assessment), with 400-800m between plot centers. The standard TRA event is run for four nights per trap and 12 nights per trap for the DA (i.e., 80 trap nights per TRA and 240 per DA) during the optimal trapping and visual encounter portion of the Spotted Turtle activity season (i.e., February – June within and among regions from Florida to Maine). The spatial

implementation of the HD-TRA is adaptive, with fewer reference plots, each with more than 5 traps, to intensely sample a few focal sites across four nights per trap (e.g., 1-3 reference plots with 8-15 traps each). Inventory-based trapping is also adaptive, designed to respond to needs and opportunity not accommodated by standard assessments (i.e., the spatial and temporal configuration of the plots and traps can very according to conditions). The VRA is conducted while checking traps or independently; in either case, search distance and area are recorded along with search time and effort (i.e., number of person hours).

The assessment techniques (i.e., TRAs, HD-TRAs, DAs, adaptive inventory trapping, and VRAs) were conducted singularly or in combination in response to objectives and opportunity at each installation. For all trapping, Promar TR502 traps or modified crab traps (Chandler et al., 2017) were baited with canned sardines placed in a small, punctured plastic container, deployed for 3 to 12 nights in a sampling area, and checked every 24 hours (Figures 12-13). Traps were affixed to adjacent rooted woody vegetation using rope and floated with empty plastic bottles and/or pool noodle sections to ensure adequate space for access to air under all conditions (e.g., flooding and/or turtle loading). The location of each trap was fixed with a GPS, and all traps were flagged and inconspicuously labeled with the organization's contact information. A "Trap Set" form (Appendix A) was completed at the time of deployment to record location and characterize site level habitat features. A "Trap Check" form (Appendix B) was completed every 24 hours during deployment to record environmental conditions, identify and enumerate Spotted Turtle captures, record bycatch by species, and disturbance by predators. Any indication of predator or other disturbance (e.g., Racoon [*Procyon lotor*], Muskrat [*Ondatra zibethicus*]) resulted in the trap being reset nearby or removed from the reference plot. A "Spotted Turtle Individual" form (Appendix C) was completed for each Spotted Turtle capture, with denotation of the capture method (i.e., trap or hand capture) (Figure 14). Hand captures were recorded as part of a VRA, and as opportunistic encounters, including during habitat evaluation, trap setting or monitoring.

The assignment of sex and age class to an individual turtle was based on evaluation of three criteria, where at least two were met for certainty. The first criterion was a field-based assessment of sex and age class (i.e., adult or juvenile; females have orange chins and flat or slightly convex plastrons, males have brown chins and plastral concavity). The second criterion was also a field-based assessment, where those individuals with a straight plastron length (SPL) of 88 mm or greater were classified as adult. The third criterion for age class assignment was the enumeration of plastral annuli, where individuals with 10 or more were classified as adult (ESTWG, 2019). While size and apparent age at sexual maturity vary among individuals and populations, ca. 88 mm SPL is the mean size and 7 to 12 years is the age range (i.e.., 10 annuli) for Spotted Turtles (Ernst and Zug, 1994; Litzgus and Brooks, 1998) (Figures 15-16).

Bycatch of Syntopic Species

As traps were monitored for Spotted Turtle captures during deployment, select bycatch encountered during trap checks was also recorded. Bycatch organisms were identified to the

species level, with specific assignment by name when possible, or generic assignment when less certain (e.g., *Kinosternon subrubrum*, *Kinosternon* spp.). Otherwise, organisms were identified and recorded at the lowest possible taxonomic level, which was often a generic assignment but sometimes was a larger taxonomic group (e.g., family; Kinosternidae). All bycatch was released at the site of capture after identification (Figure 17).

Analyses

Data Management, Enumeration and Summarization

All tabular data (e.g., installations, DoD Branch, Representatives, conference calls, reconnaissance dates and personnel, personnel and roles, trap nights and captures, bycatch, etc.) were collated, organized, and analyzed in MS Excel and R (R core team, 2021). All spatial data were collated, organized, and analyzed in ArcGIS Desktop 10.8 (ESRI, 2020) using National Land Cover Database (NLCD) 2016 products (Dewitz, 2019), relevant mission management and natural resource data layers provided by the installations, and National Wetlands Inventory data (NWI; USFWS, 2020).

Trap nights were calculated for each trapping method at each installation by multiplying the total number of traps by the number of nights deployed for that method (i.e., one trap night = 1 trap deployed on site for 24 hours). When a trap was disturbed by predator or other activity, the number of nights that trap was inactive was subtracted from the total number of deployment nights for that trap. Trap nights were calculated for all standardized assessment methods (i.e., TRA, DA) and for all trapping methods (i.e., TRA, DA, inventory trapping) for each installation by summing the adjusted trap night totals for each method for standardized and all trapping, respectively. When appropriate, VRA efforts were summed as total visual survey hours for the relevant installation.

Total captures and total individual Spotted Turtles were enumerated and summed by sex and age class (i.e., Female, Male, Juvenile) per each trapping and encounter method (i.e., VRA, incidental hand capture), such that totals were calculated for each installation for sex/age class for all standardized assessment methods, all trapping methods, and all trapping/encounter methods for each installation. Catch Per Unit Effort (CPUE) (i.e., captures/trap nights) was calculated by installation for all captures and for standardized assessment trapping methods only. Totals, means and variance were calculated for select trapping effort and Spotted Turtle capture, individual, and sex/age class category samples for all nine installations.

In order to provisionally explore trends among installations, a covariation and determination among trapping effort and demographic variables in a semi-structured framework was examined. Covariation of variables in the same class [i.e., trapping effort, demography] were explored first in MS excel to reveal the sign and strength of a relationship. From there, subordinate covariates that were highly correlated ($r > 0.7$) were excluded and a linear regressions in MS Excel was run to explore responses within and across classes to trap nights as an explanatory variable.

The select bycatch that was identified and named to the most precise taxonomic classification and working common name (i.e., named, uncertain or unnamed morphospecies) for the total trapping effort at each installation in 2021 was then enumerated by taxon and installation to produce totals for each taxon and each installation. These totals were then cross tabulated.

Population Abundance Estimation

Population abundance estimates were calculated for each installation sample that had five or more captures and one or more recaptures using the M0 model and the function closedp.bc in the Rcapture package (Baillargeon and Rivest, 2007, 2012) in R (R Core Team, 2021). The model assumes that populations are closed (i.e., no mortality, recruitment, emigration, or immigration during the sampling period; Baillargeon and Rivest, 2007) and all individuals have an equal chance of being captured. This first assumption is based upon the inference that recruitment and mortality are unlikely during the field season because Spotted Turtles are very long-lived with relatively high annual survival (Ernst and Zug, 1994; Litzgus and Brooks, 1998; Ernst and Lovich, 2009). The assumption that all individuals have an equal chance of being captured is likely unmet; it is not likely that all ages and sexes of Spotted Turtles have an equal chance of being trapped in any given trap (Ernst and Zug, 1994; Litzgus and Brooks, 1998; Ernst and Lovich, 2009). The function applies a bias correction as described in Rivest and Levesque (2001) to Poisson regression models without any sources of variation in capture probabilities. The M0 model was used to ensure consistent model application across all sampling sites. Only trap captured individuals from a DA or TRA were included in the analysis. Two installations, FAPH and NSANA, had trap captures from regional CSWG efforts in 2019 included as data substitution or addition to improve abundance model fitting. Population estimates were displayed graphically using package ggplot2 (Wickham, 2016) (Appendix D).

Coordination with ESTWG

In keeping with the network, platforms and guidelines/protocols that enabled the Spotted Turtle (*Clemmys guttata*) Management for Mission Readiness CA to implement on nine installations across five states, field data were collected and managed per installation by installation and CA partner personnel and then collected, managed, analyzed and reported for each and all installations by J. Meck, M. Parren, J. Garrison, L. Willey, and T. Akre. These data and their results were then shared among CA partner personnel, and interpretations, conclusions and recommendations were reported by each and all coauthors. In all cases, the methods, data and results used and produced herein were incorporated in the Status Assessment and Conservation Plan for the Spotted Turtle in the eastern United States (Willey et al., 2022). These data and results were then further shared with appropriate staff at the USFWS (e.g., Julie Slacum) for consideration in the current status assessment and listing determination of the Spotted Turtle (ESTWG, 2019; Willey et al., 2022).

Results

Coordination Among Study Participants

Conference Calls Among CA Representatives, Installation and Partner Personnel

Six formal conference calls led by DoD and SI representatives for the Spotted Turtle CA (i.e., C. Petersen, R. Lovich, T. Akre and J. Meck), as well as several follow-up calls and email communications, were held between November 2020 and November 2021 (Table 2), with follow up communication to the present day. Across the project period, calls included pertinent CA representatives, installation representatives and CA partner representatives most of the time. Calls were focused on orientation of personnel to the objectives, standards and management of the project in order to organize, implement, report and evaluate the main phases of the CA project across the period of performance. Topics covered across the project period include: 1) introduction of personnel and orientation to the objectives, standards and management of the project, 2) coordination of CA partners with installation personnel to support site access and selection for evaluation of suitable habitat and assessments, 3) fiscal and field work logistic management and reporting for CA partners and installation personnel to support field work, real-time evaluation and feedback of assessments and implications for the project and installations, 4) data management, analyses, reporting and evaluation, and 5) CA review and technical reporting preparation, delivery and evaluation (Table 2).

Reconnaissance – Site Visitation on DoD Installations

Project partner and installation personnel conducted reconnaissance and site-visitations beginning, for the most part, in late winter-early spring 2021 (see below). This included installation visits for orientation by partner personnel, followed by remote reconnaissance of potential assessments sites in GIS, and then on-site evaluations of wetlands with historic and recent installation records as well as data-deficient areas with suitable or potential habitats for optimal trapping potential. On-site habitat evaluations by partner and installation personnel took place on four field days from March 3 to April 12, 2021, at Camp Edwards, Joint Base McGuire-Dix-Lakehurst, Fort Belvoir and Marine Corps Base Quantico (Table 3). At Camp Curtis Guild, Fort Indiantown Gap, Fort A.P. Hill, NSA Northwest Annex and Fort Stewart, installation and partner personnel had cooperatively and independently identified and evaluated known and suspected habitats based historic records and recent records, relatively recent trapping efforts (T. Akre, unpubl. data; A. Curtis, pers. comm.; R. Picone, pers. comm.; K. Crafts, pers. comm.; T. Austin, pers. comm., L. Carlile, pers. comm.; H. Chandler, pers. obs.) and NLCD and NWI layers, among other GIS data. Therefore, based upon existing site, habitat, and access familiarity at these five installations, partner and installation personnel did not select trapping sites until the first trapping day at each installation, in most cases. Thereafter, standardized assessment trapping and visual assessments, as well as inventory trapping, began at each installation, often led by partner personnel with logistic and technical support from installation natural resource specialists and managers (Table 4).

Spotted Turtle Sampling on DoD Installations

Sampling, Bycatch and Abundance by DoD Installation

Camp Curtis Guild (CCG). – Reconnaissance for standardized assessments and additional sampling, as relevant, was conducted at CCG on the first day of trapping, April 24, 2021 (Table 3). On that day, M. Parren and J. Garrison joined A. Curtis and M. Penella. One DA was conducted across three independent visits from April 24 to June 11, 2021 (Figures 18-19). Reference plots were established primarily in Red Maple swamps and shallow wetlands dominated by White Pine (*Pinus strobus*) and Oak (Figure 4) in the southern portion of the installation (Figure 18). The first trapping event ran from April 24-28, the second trapping event ran from May 25- 29, and the third trapping event ran from June 7-11. Traps were placed in approximately the same location in April and June. However, in late May, low water levels required placement of traps closer to each other (i.e., <30 m apart) in deeper water. Traps were deployed for 240 trap nights (i.e., 20 traps x 12 nights); during that time only five traps were predated, presumably by racoons based upon the apparent removal of bait bags from inside the trap.

Fifteen individual Spotted Turtles were trap-captured 23 times (i.e., seven recaptures), and an additional seven individuals were hand-captured eight times (Table 5). Combined, a total of 22 individuals were captured 31 times at CCG (Table 6). This sample consisted of nine females, six males, and seven juveniles (four apparent females, one apparent male, and two of undetermined sex) (Table 6). Two juveniles were too small to be given a unique identification by notching, so while they were counted as individuals in this project, they may not be readily identifiable as a recapture in future assessments.

During the trapping period, from late April to early June 2021, select bycatch sampled across 240 trap nights was recorded for the four reference plots. Among the bycatch for this sampling period, the following eight species, represented by an unrecorded number of individuals, were recorded: Giant Water Bug (*Lethocerus americanus*), Predaceous Diving Beetle (*Dytiscus* spp.), Crayfish (*Cambarus*? spp.), Gray Tree Frog (*Dryophytes versicolor*), Bull Frog (*Lithobates catesbeianus*), Green Frog (*Lithobates clamitans*), Wood Frog (*Lithobates sylvaticus*), and Painted Turtle (*Chrysemys picta*) (Table 7).

CPUE at CCG was 0.129 for all captures (Table 5) and 0.096 for DA trap captures only (Table 8). The sex ratios (F:M:J) for all captures and individuals were 2:1:1.4 and 1.5:1:1.2, respectively (Table 6). The estimate of population abundance from the CCG sample is 26.6 (±6.6 SE) individuals (Table 8; Figures 41-42) in the reference plot area (Figures 18-19).

Camp Edwards (CPED). – Reconnaissance for standardized assessments and additional sampling, as relevant, was conducted at CPED on April 12, 2021 (Table 3). On that day, M. Parren and J. Garrison joined A. Curtis and M. Penella. Thereafter, one DA and one TRA were conducted at CPED, with the minor protocol modification of closer than indicated reference plot locations due to drought conditions on the installation. Reference plots were established in emergent wetlands, shrub wetlands and freshwater ponds (Figure 5) in the northern and

southwestern portions of the installation (Figure 20). The DA was conducted across three independent visits from April 17 to June 18, 2021 (Figures 20-22). Prior to this sampling period, Spotted Turtles had been observed in the wetland complexes where the DA reference plots were placed. However, no demographic information was collected, and individuals were not marked. The first trapping event ran from April 17-21, the second trapping event ran from May 24-28, and the third trapping event ran from June 14-18. The TRA was conducted from June 1 to 5, 2021 (Figures 20 & 22). Throughout the sampling period of both assessment types, traps were moved a few meters of their original set location to accommodate drying conditions. Traps were deployed for 316 nights. Eight traps were removed from deployment during assessments due to drying conditions and predator activity.

Spotted Turtles were captured only in the DA reference plots. Thirty individuals were trap-captured 32 times, and an additional 17 individuals were hand-captured 18 times (Table 5). Combined, a total of 47 individuals were captured 50 times at CPED (Table 6). This sample consisted of 15 females, 18 males, and 14 juveniles (five apparent females and nine of undetermined sex) (Table 6). Most captures occurred in Monument Swamp (Figures 5 & 20-22).

During the trapping period from mid-April to late June 2021, select bycatch sampled across 316 trap nights was recorded for the eight reference plots. Among the bycatch for this sampling period, the following eight species, represented by an unrecorded number of individuals, were recorded: Dragonfly larvae (*Odonata* spp.), Predaceous Diving Beetle, Golden Shiner (*Notemigonus crysoleucas*), American Toad (*Anaxyrus americanus*), Grey Treefrog, Bull Frog, Green Frog, and Common Snapping Turtle (*Chelydra serpentina*), (Table 7).

CPUE at CPED was 0.158 for all captures (Table 5) and 0.101 for DA trap captures only (Table 8). The sex ratios for all captures and individuals were 1.2:1.4:1 and 1.1:1.3:1, respectively (Table 6). The estimate of population abundance from the CPED sample is 156.9 (±83.9 SE) individuals (Table 8; Figures 41-42) in the reference plot area (Figures 20-21).

Fort Indiantown Gap (FIG). – Reconnaissance for standardized assessments and additional sampling, as relevant, was conducted at FIG on the first day of trapping, April 12, 2021 (Table 3). On that day, L. Erb joined R. Picone and A. Haines at FIG. Thereafter, FIG personnel conducted standardized assessments primarily on their own, in consultation with Erb. Reference plots were established in both emergent and forest and shrub-swamp wetlands in the northeastern portion of the installation (Figure 23). One DA with five reference plots was conducted by FIG personnel across three independent sampling periods from April 12 to June 25, 2021. The first trapping event ran from April 12-23, with trapping in reference plots 1-3 on April 12-16 and plots 4-5 from April 19-23. The second trapping event ran from May 17-21 with trapping in all five reference plots, and the third trapping event ran from June 21-25 with trapping in only plots 3-4 because of low water due to drying conditions. DA sampling occurred in both new and previously sampled areas (R. Picone, pers. comm.). The new areas had both historic and recent (2017-2018) records of Spotted Turtle observations by installation personnel (R. Picone, pers.

comm.; DoD PARC, 2019). Traps were deployed for 232 trap nights; 22 incidents of trap disturbance by turtle bait predators were recorded, with four instances where the trap was ripped completely open and had to be removed from deployment.

Twenty-four individuals were trap-captured 30 times, and one individual was hand-captured once (Table 5). Combined, a total of 24 individuals were captured 31 times at FIG (Table 6). This sample consisted of eight females, nine males and seven juveniles (three apparent females, three apparent males and one of undetermined sex) (Table 6). Four females captured during the 2021 season were originally captured early in the 2000s, nearly 20 years ago, and again in 2019.

During the trapping period, from mid-April to late June 2021, FIG personnel recorded select bycatch sampled across 232 trap nights in the five reference plots. Among the bycatch for this sampling period, the following five species, represented by an unrecorded number of individuals, were recorded: Crayfish, Minnows (*Cyprinidae spp*.), American Toad, Green Frog, and Northern Watersnake (*Nerodia sipedon*) (Table 7).

CPUE at FIG was 0.134 for all captures (Table 5) and 0.129 for DA trap captures only (Table 8). The sex ratios for all captures and individuals were 1:1.4:1 and 1.1:1.3:1, respectively (Table 6). The estimate of population abundance from the FIG sample is 50.5 (±14.2 SE) individuals (Table 8; Figures 41-42) in the reference plot area (Figures 23-24).

Joint Base McGuire-Dix-Lakehurst (JBMDL). – Reconnaissance for standardized assessments and additional sampling, as relevant, was conducted at JBMDL on March 3, 2021 (Table 3). On that day, L. Erb, B. Ruhe and J. White joined P. Mahoney, M. Luna and M. Stevenson at JBMDL. Thereafter, four types of assessments were conducted at JBMDL from April 20 to May 27, 2021: four VRA, one DA, one TRA, and inventory trapping at 20 independent locations. VRAs were conducted in four reference plots, established in both emergent and forest and shrub-swamp wetlands (Figure 6) in the eastern portion of the installation (Figures 25-26), to determine if VRAs would be useful for estimating Spotted Turtle abundance and to locate suitable trapping sites. One DA was conducted across two independent visits from April 21 to May 27. The first two trapping events ran consecutively from April 21-29. Traps were placed in the same locations for the first two events, April 21-25 and 25- 29, respectively. The third trapping event ran from May 23-27, with traps moved to different locations than those for the first two DA trapping events. The TRA trapping event took place in a separate reference plot, west of the DA array, and ran from April 23-27. In total, 85 traps were deployed for 300 trap nights. This included 60 traps for 237 DA trap nights, five traps for 20 TRA trap nights, and 20 inventory traps deployed for 43 trap nights in wetlands outside the five reference plots. No traps were depredated during the study period and no traps were relocated within a trapping session.

Among the four assessment types, 34 individual Spotted Turtles were trap-captured 43 times, and one additional turtle was hand-captured once (Table 5). Combined, a total of 35 individuals were captured 44 times at JBMDL (Table 6). This sample consisted of 14 females, 15 males and

six juveniles (four apparent females, one apparent male and one of undetermined sex) (Table 6). No turtles were captured during the VRAs or TRA. Twenty individuals were captured 25 times during the DA (Figure 26). Fourteen individuals were captured 18 times during the inventory trapping event at locations outside of the reference plots (Figure 26), and one individual was hand captured by P. Mahoney as it crossed a road on May 27, 2021.

During the trapping period, from late April to late May 2021, select bycatch sampled across 300 trap nights in the five reference plots and 20 inventory traps was recorded for JBMDL. Among the bycatch for this sampling period, the following 12 species, represented by an unrecorded number of individuals, were recorded: unidentified Catfish sp. (*Ameiurus catus*?), Chain Pickerel (*Esox niger*), Bluegill (*Lepomis macrochirus*), Fowler's Toad (*Anaxyrus fowleri*), Bull Frog, Carpenter Frog (*Lithobates virgatipes*), Green Frog, Common Snapping Turtle, Southeastern Mud Turtle (*Kinosternon subrubrum*) Eastern Musk Turtle (*Sternotherus odoratus*), the non-native Red-eared Slider (*Trachemys scripta elegans*) and Painted Turtle (Table 7). Other species observed incidentally while surveying the base include the Northern Racer (*Coluber constrictor*) and the Eastern Fence Lizard (*Sceloporus undulatus*).

CPUE at JBMDL was 0.147 for all captures (Table 5) and 0.097 for DA trap captures only (Table 8). The sex ratios for all captures and individuals were 3.2:3.2:1 and 2.3:2.5:1, respectively (Table 6). The estimate of population abundance from the JBMDL sample is 43.7 (±14.3 SE) individuals (Table 8; Figures 41-42) in the reference plot area (Figures 25-26).

Fort Belvoir (FB). – Reconnaissance for standardized assessments and additional sampling, as relevant, was conducted at FB on March 4, 2021 (Table 3). On that day, J. Meck and E. Sikora joined J. Pilcicki at FB. Due to drying conditions that were unfavorable to trapping, only one high-density TRA (HD-TRA) was conducted at FB from May 24 to May 26, 2021. One reference plot was established in an emergent and shrub-swamp wetland (Figure 7) in the southwestern portion of the installation (Figure 27). This protocol adaptation was designed to suit existing hydrologic conditions – most wetlands on the installation were unsuitable for trapping due to drying, low water conditions – by placing 15 traps within one reference plot in designation area T9 (Figures 27-28). Traps were deployed for only 23 trap nights in three days; all traps were either predated by racoons or were pulled in response to rapid wetland drying.

Ten individuals were trap-captured 11 times, and no turtles were hand-captured (Tables 5 & 6). This sample consisted of three females, one male and six juveniles (one apparent female and five apparent males) (Table 6); one of the six juveniles was recaptured once.

During the trapping period in late May 2021, select bycatch sampled across 23 trap nights in the single reference plot with the high-density traps was recorded for FB. Among the bycatch for this sampling period, the following six species, represented by an unrecorded number of individuals, were recorded: Crayfish, Sunfish (*Lepomis* spp.), Green Frog, Common Snapping Turtle, Southeastern Mud Turtle and Painted Turtle (Table 7).

CPUE at FB was 0.478 for HD-TRA captures (Tables 5 & 8), since no other approaches were taken, or captures made. The sex ratios for all captures and individuals were 3:1:7 and 3:1:6, respectively (Table 6). The estimate of population abundance from the FB sample is 19.4 (±9.4 SE) individuals (Table 8; Figures 41-42) in the reference plot area (Figures 27-28). FB will soon have published estimates of population size and demography, as well as spatio-temporal movement patterns based upon recent research (2017-2019) by doctoral student E. Lassiter, for Spotted Turtle population complex in the installation area (E. Lassiter, pers. comm.).

Marine Corps Base Quantico (MCBQ). – Reconnaissance for standardized assessments and additional sampling, as relevant, was conducted at MCBQ on March 3, 2021 (Table 3). On that day, J. Meck and E. Sikora joined K. Erwin at MCBQ. Thereafter, one TRA and inventory trapping at 20 independent locations were conducted at MCBQ from May 10 to 15, 2021. Reference plots and independent inventory trapping locations were established in emergent and forested and shrub-swamp wetlands (Figure 8) in the northwestern and southeastern portions of the installation (Figure 29). The TRA was conducted south of Russell Road from May 11-15, on the eastern portion of the installation where previous inventory efforts had occurred (K. Erwin, pers. comm.) (Figure 29-31). Inventory trapping was conducted from May 10-14 in areas where Spotted Turtles had been observed historically (K. Erwin, pers. comm.) as well as data deficient areas with suitable habitat, both primarily in the northwestern portion of the installation. The deployment length varied for the inventory traps due to limited access time at the trap location or predation; eight traps were disturbed by predators, resulting in removal from the sample effort. All told, traps were deployed for 134 trap nights, with 80 nights of deployment for the TRA and 54 trap nights for inventory trapping.

Sixteen individuals were trap-captured 18 times during the TRA only, and no turtles were hand-captured at MCBQ (Tables 5 & 6). This sample consisted of two females, nine males, and five juvenile individuals (three apparent females and two apparent males); two males were recaptures from previous trapping efforts (K. Erwin, pers. comm) (Table 6).

During the trapping period in mid May 2021, select bycatch sampled across 134 trap nights in the four reference plots and 20 independent trapping locations was recorded for MCBQ. Among the bycatch for this sampling period, the following 11 species, represented by an unrecorded number of individuals, were recorded: Crayfish, Creek Chub (*Semotilus atromaculatus*), Channel Catfish (*Ictalurus punctatus*), Bluegill, Sunfish, Red-Spotted Newt (*Notophthalmus viridescens*), Green Frog, Common Snapping Turtle, Southeastern Mud Turtle, Eastern Musk Turtle, and Painted Turtle (Table 7).

CPUE at MCBQ was 0.134 for all captures (Tables 5 & 8) and 0.225 for TRA trap captures only (Table 8). The sex ratios for all captures and individuals were 1:5.5:2.5 and 1:4.5:2.5, respectively (Table 6). The estimate of population abundance from the MCBQ sample is 43.6 (±21 SE) individuals (Table 8; Figures 41-42) for the reference plot area (Figures 29-31).

Fort A.P. Hill (FAPH). – Reconnaissance for standardized assessments and additional sampling, as relevant, was conducted at FAPH in February 2018 and March 2019 (T. Akre unpubl. data; Table 3). During those periods, T. Akre, J. Newman and J. Meck joined A. Satterwhite and K. Crafts at FAPH. Thereafter, three assessment types at FAPH were conducted from April 26 to May 4, 2021, including one HD-TRA, one TRA, and inventory trapping at 25 independent locations. Reference plots were established in emergent wetlands, shrub wetlands and vernal pools (Figure 9) in the northern and western portions of the installation (Figures 33 & 35). The HD-TRA and TRA trapping events ran from April 30 to May 4. The HD-TRA was composed of two reference plots with 10 traps each, and the TRA was conducted as one reference plot with five traps (Figures 33-34). The inventory sampling with 25 traps took place in data deficient areas with suitable habitat, during two consecutive trapping events, April 26-29 and 27-30 (Figure 35). Traps were deployed for 130 nights; only four traps were disturbed by removal of bait by predators.

In 130 trap nights among 40 traps, only two individuals were sampled once each with two captures (Tables 5 & 6). The sample consisted of one female captured during the TRA (Figure 34) and one male captured during inventory trapping in training area 14B (Figure 35). The latter represents a new record for that training area on FAPH.

During the trapping period from late April to early May 2021, select bycatch sampled across 130 trap nights in the three reference plots 25 inventory trapping locations was recorded for FAPH. Among the bycatch for this sampling period, the following 15 species, represented by an unrecorded number of individuals, were recorded: Giant Water Bug, Predaceous Diving Beetle, Bowfin (*Amia calva*), Common Shiner (*Luxilus cornutus*), unidentified Catfish sp., Bluegill, Sunfish spp., Marbled Salamander (*Ambystoma opacum*), Green Frog, Wood Frog, Common Snapping Turtle, Southeastern Mud Turtle, Eastern Musk Turtle, Painted Turtle, and Brown Water Snake (*Nerodia taxispilota*) (Table 7).

CPUE for all captures at FAPH in 2021 was 0.015 (Table 5), and the sex ratio for both captures and individuals in that sample was 1:1:0 (Table 6). Due to the very small sample in 2021, population abundance for FAPH was estimated from a TRA sampling of wetlands by SI personnel in 2019 (T. Akre, unpubl. data), some of which were the same as those sampled in 2021 (Figures 34 & 36). The 2019 TRA ran for 80 trap nights from April 29 to May 3, 2019. Five individuals (three females and two males) were trap-captured six times for a CPUE of 0.075 (Table 8) and an abundance estimate of 8 (±3.7 SE) individuals (Table 8; Figures 41-42) in the reference plot area (Figure 36).

Naval Support Activity Northwest Annex (NSANA). – Reconnaissance for standardized assessments and additional sampling, as relevant, at NSANA on February 27, 2019 (Table 3). On that day, J. Meck and E. Sikora joined T. Austin at NSANA. Thereafter, one TRA was conducted at NSANA from March 31 to April 4, 2021 (Figure 37). Reference plots were established in a small ditch adjacent to a communications antenna and a nearby Red Maple swamp (Figure 10) in

the southwestern portion of the installation (Figures 37-38); the same location as trapping by SI personnel in 2019 (Figure 39). Traps were deployed for 80 trap nights; no trap disturbance by predators occurred during the sampling period.

Twenty-three individuals were trap-captured 25 times, and one of the same individuals was hand captured once (Table 5). Combined, a total of 23 individuals were captured 26 times at NSANA (Table 6). This sample consisted of six females, seven males, and 10 juveniles (two apparent females and eight apparent males) (Table 6). Six individuals in the 2021 sample were originally marked by SI personnel in 2019.

During the trapping period from late March to early April 2021, select bycatch sampled across 80 trap nights in the three reference plots was recorded for NSANA. Among the bycatch for this sampling period, the following eight species, represented by an unrecorded number of individuals, were recorded: Predaceous Diving Beetle, Crayfish, Bowfin, Pickerel, Sunfish, Amphiuma (*Amphiuma means*), Common Snapping Turtle, and Southeastern Mud Turtle (Table 7).

CPUE at NSANA was 0.325 for all captures in 2021 (Table 5). The sex ratios for all captures and individuals were 1:1:1.6 and 1:1.2:1.7, respectively (Table 6). Population abundance was estimated for NSANA from combined TRA captures in 2021 and 2019. Two TRA events were run from March 25-29 and May 13-17, 2019, for a total of 120 trap nights (Figure 39). Twenty-two individuals were trap-captured 27 times and hand captured 6 times. This sample consisted of five females, 13 males, and four juveniles (two apparent females and two apparent males). Combined, at total of 39 individuals were captured 52 times at NSANA in 2019 and 2021 (i.e., seven recaptures). The combined sample yields a CPUE of 0.26 (Table 8) and an abundance estimate of 76.3 (±15.8 SE) individuals (Table 8; Figures 41-42) in the reference plot area (Figures 37-39).

Fort Stewart (FS). – Reconnaissance for standardized assessments and additional sampling, as relevant, at FS on March 15, 2021 (Table 3). On that day, H. Chandler, B. Stegenga and A. Colton joined L. Carlile and R. Rourke at FS. Thereafter, three types of assessments at nine different sites were conducted on FS from March 15 to May 27, 2021: four TRAs, eight modified TRAs (i.e., 3 nights/trap) and 113 VRAs (Figure 40). VRAs were performed while checking traps and as separate surveys. TRAs, both modified and unmodified, and VRAs were conducted for 630 trap nights and 114 person hours, respectively, in forested and shrub wetlands across the northern extent of the installation (Figure 40). Predator activity was not recorded at FS because the modified crab trap of hardened metal wire used there (Figure 12; Chandler et al. 2017) afforded protection against disturbance and trapping disruption. Attempts to survey additional suitable habitat across the installation were constrained by access restrictions and wetland drying toward the end of the survey period in May.

Despite this spatially and temporally extensive effort across an abundance of apparently suitable habitat, Spotted Turtles were not detected, by trap-capture or visual encounter, at FS in 2021

(Table 5-6 & 8). Therefore, CPUE for all assessments is 0.00 and there is no estimation of abundance for the sampling areas at FS, currently (Tables 5-7 & 8; Figures 40-42).

During the trapping period from mid-March to late May 2021, select bycatch sampled across 630 trap nights in the 12 reference plots at nine locations was recorded for FS. Among the bycatch for this sampling period, the following 16 species, represented by an unrecorded number of individuals, were recorded: Crayfish, Bowfin, Creek Chub, unidentified Catfish sp., Pickerel, Bluegill, Redbreast Sunfish (*Lepomis cyanellus*), Warmouth (*Lepomis gulosus*), Yellow Perch (*Perca flavescens*), Amphiuma, Bull Frog, Green Frog, Pickerel Frog, Striped Mud Turtle (*Kinosternon baurii*), Brown Water Snake and Eastern Mud Snake (*Farancia abacura*) (Table 7).

Coordination Among Study Participants: Summary for all Installations

Altogether, 26 installation and CA partner personnel spent approximately 260 person days across approximately 12 field days, and unrecorded office days, in support of reconnaissance of known and potentially suitable habitat and sampling sites at all nine installations, from Massachusetts to Georgia (Figure 3) in 2018-2019 and 2021(Table 3). Further, when including reconnaissance and sampling efforts at the installations across the three years, approximately 37 personnel from 12 institutions (Table 4) were involved in support of CA coordination, installation visitation, reconnaissance and sampling for a minimum of approximately 360 cumulative field days, and at least 10 additional office days, in support of the CA, primarily in 2021.

Spotted Turtle Sampling: Summary for all Installations

All Trapping Effort and Returns

Based upon this foundation of collective action across the nine installations, twenty-three TRAs (including eight modified and two HD-TRAs), four DAs (including one modified DA), 45 inventory trapping events, and 117 VRAs were conducted by roughly 17 CA partner and DoD personnel in 2019 and 2021, for a minimum of approximately 2300 trap nights and approximately 120 visual survey hours across approximately 360 field days (Figures 12-40). From this effort, 213 total captures, comprised of 184 trap captures and 29 incidental hand captures of 179 individuals, were made in 2085 trap nights in 2021 and an additional ca. 200 trap nights in 2019 (Tables 5 & 8). No turtles were captured during VRAs. Trap nights across the installations in 2021 ranged from 23-630 at FB and FS, respectively, with a mean of 231.7 (±179.2 SE). All captures across the installations in 2021 ranged from 0-50 at FS and CPED, respectively, with a mean of 23.7 (±17.5 SE). Trap captures across the installations ranged from 0-43 at FS and JBMDL, respectively, with a mean of 20.4 (±14.2 SE). Hand captures ranged from 0-18 at FB, MCBQ, FAPH, FS and CPED, respectively, with a mean of 3.2 (±6.1 SE). CPUE across the installations ranged from 0-0.478 at FS and FB, respectively, with a mean of 0.169 (±0.149 SE). The count of individuals captured among the several methods across the installations ranged from 0-47 at FS and CPED, respectively, with a mean of 19.9 (±15.1 SE) (Table 5).

All Trapping Returns: Capture and Individual Demographics

These captures were composed of 72 captures of females, 79 captures of males and 62 of juveniles, representing 58 females, 66 males, and 55 juveniles (Table 6). Female captures across the installations ranged from 0-17 at FS and CPED, respectively, with a mean of 8.0 (±7.2 SE). Female individuals captured across the installations ranged from 0-15 at FS and CPED, respectively, with a mean of 6.4 (±5.5 SE). Male captures across the installations ranged from 0-19 at FS and CPED, respectively, with a mean of 8.8 (±7.4 SE). Male individuals captured across the installations ranged from 0-18 at FS and CPED, respectively, with a mean of 7.3 (±6.3 SE). Juvenile captures across the installations ranged from 0-14 at FS, FAPH and CPED, respectively, with a mean of 6.9 (±4.8 SE). Juvenile individuals captured across the installations ranged from 0-14 at FS, FAPH and CPED, respectively, with a mean of 6.1 (±4.4 SE). The sex ratio (F:M:J) of all captures across the installations ranged from 3.2:3.2:1 to 1:1:0 at JBMDL and FAPH, respectively, when FS was excluded. The sex ratio for the total sample of captures from eight installations was 1.2:1.3:1 with an average of 1:1.25:1.2. The sex ratio of all individuals captured across the installations ranged from 2.3:2.5:1 to 1:1:0 at JBMDL and FAPH, respectively, when FS was excluded. The sex ratio for the total sample of individuals from eight installations was1.1:1.2:1 with an average of 1:1.1:1.2 (Table 6).

Bycatch of Syntopic Species

From the twenty-three TRAs (including eight modified and two HD-TRAs), four DAs (including one modified DA) and 45 inventory trapping events for 2085 trap nights from March to June of 2021, 36 taxa in 13 orders of five classes of two major groups were recorded: arthropods and chordates (Table 7). Examples from across the nine installations include Dragonfly larvae, Giant Water Bugs and Predaceous Diving Beetles, Crayfish, Bowfin, five species of minnow and ally species and five perch and ally species, Marbled Salamander and Amphiuma, American Toads, Bull Frogs and Carpenter Frog, and six turtle and three snake species, such as Southeastern Mud Turtles and Eastern Mud Snake. The representation of these species in bycatch varied from Massachusetts to Georgia, with relatively rare, incidental, or difficult-to-sample or identify species being represented by one record, and common species, such as Green Frog, being recorded on eight installations (Table 7).

Standardized Assessment Returns and Population Abundance

Among the trapping effort across the installations in 2019 and 2021, twenty-seven standardized trapping assessments were made from 23 TRAs (including eight modified and two HD-TRAs) and four DAs (including one modified DA) (Figures 12-40). From this effort, 198 trap captures of 160 individuals were recorded in approximately 1408 trap nights in 2019 and 2021 (Table 8). Trap nights across the installations in 2019 and 2021 ranged from 23-630 at FB and FS, respectively, with a mean of 176 (±102.1 SE). Standardized trap captures across the installations ranged from 0-32 at FS and CPED, respectively, with a mean of 24.8 (±14.3 SE). CPUE across the installations ranged from 0-0.478 at FS and FB, respectively, with a mean of 0.185 (±0.136

SE). The count of individuals captured among standardized trapping across the installations ranged from 0-39 at FS and NSANA, respectively, with a mean of 20 (±10.9 SE) (Table 8). Abundance estimated from standardized captures at eight installations ranged from 8-156.9 at FAPH and CPED, respectively with a mean of 53.1 (±46.9 SE) with standard error for the estimate ranging from 3.7 to 83.9 at FAPH and CPED, respectively (Table 8, Figures 41-42).

Capture Trends Among Installations

Both trap nights for all trapping events and trap nights for only standardized trapping assessments were explored to explain responses among capture metrics (i.e., trap captures, hand captures, individuals, CPUE) and demography of captures (i.e., Female, Male and Juvenile captures, Female-Male Ratio and Adult-Juvenile Ratio) and standardized capture metrics and estimates (i.e., trap captures, individuals, CPUE, abundance, and standard error-abundance ratio) (14 interactions: nine among all trapping events and five among standardized trapping events; Table 9). Twenty-six interactions among additional covariates in Tables 5-6 and 8 were removed from further analyses after strong correlations ($r > 0.7$) were recorded. Among all trapping events, trap nights explained trap captures, individuals, female captures and male captures reasonably well as these variables significantly differed from 0 at $\alpha = 0.05$ (Table 9). Recaptures of Spotted Turtles were generally uncommon (see Table 5), and individuals, rather than recaptures, appear to influence the growing sample across installations as indicated by the slope, intercept, and the coefficient of determination (R^2) for the equation. These data suggest that open and in some cases, quite large, populations are present on some of the military sites. Since recaptures were consistently low, they were highly correlated with individual captures, which is reasonably explained by all trap nights ($p = 0.02$) with the equation $y = 0.104x + 3.55$ ($R^2 = 0.61$). Hand captures, CPUE, and juvenile captures were not well explained by trap nights (Table 9). A strong relationship between any of these variables and trap nights was not anticipated, but it was of interest to see if either hand captures or juvenile trap captures was partially explained by effort. Likewise, it was of interest to see if CPUE declined with trap nights, as might be expected with growing experience among targeted individuals or changing environmental conditions over time. Among sex/age class ratios, only adult-juvenile ratio was potentially influenced by trap nights ($p = 0.06$), but the slope and R^2 do not indicate a growing proportion of juveniles with trap nights, as might be expected. Among standardized trapping events there were no significant relationships and R^2s did not exceed 0.45. Likewise, standardized trap nights did not influence abundance estimation, or the ratio of the standard error to the abundance estimate, as might be expected if increasing trap nights allowed for recaptures that refined the estimate (Table 9).

Discussion

The Cooperative Agreement and Coordination Among Study Participants

The opportunity for members of the ESTWG to come together with DoD LRMP and DoD PARC personnel in service of Spotted Turtle conservation and military mission readiness on DoD lands

is an important and potentially essential component of the long-term conservation of the Spotted Turtle in the United States. With the assets managed by DoD (i.e., hundreds of thousand hectares on 39 installations with known populations and 60 additional installations with potential habitat and populations), the primary goal of the ESTWG (i.e., development of a conservation plan for maintenance of Spotted Turtle populations on public and private lands through management and preservation of suitable habitat at high priority sites throughout the region [Willey et al., 2022]) and the primary goal of DoD (i.e., management of at-risk species and their habitats to promote mission readiness) cannot be accomplished without each other. Therefore, it has been and continues to be a key objective of the ESTWG to work closely with DoD to support mission readiness through development of knowledge on the status and conservation of the Spotted turtle on DoD lands. The ESTWG as represented by SI and partners is pleased to provide technical and leadership support to DoD through this CA. In that sense, the overall goal of the CA - to improve information on the status of the Spotted Turtle on DoD lands in support of mission readiness through integration of this information into installation INRMPs - has and will continue to serve Spotted Turtle conservation and its agents in the ESTWG and DoD well. The CA enabled nearly 40 people from 12 DoD and federal and NGO institutions to work together from October 2020 to nearly the present day (Tables 1-4), all to provide technical and leadership capacity to promote conservation science and management for the Spotted Turtle on nine installations from Massachusetts to Georgia (Figure 3). As such, it is a general model for future collaborations among at-risk species conservation science groups and large land stewards such as DoD.

Spotted Turtle Sampling on DoD Installations

Sampling Spotted Turtles on DoD lands presents a few serious challenges. First, they are inherently challenging to sample and detect. Spotted Turtles are notoriously difficult to sample compared to other turtle species because they are cryptic and their shrub and forested swamp land habitats can be difficult to access and maneuver (Ernst and Lovich, 2009; Willey et al., 2022). Furthermore, they typically do not respond to baited trapping in the winter and early spring when their densities are relatively high, and later in the season, when they respond better to bait, they have generally dispersed as a result of warmer weather. Second, across their range, Spotted Turtle habitat is naturally dynamic as wetlands fill and dry across a year, with lesser or greater magnitude depending on precipitation and ambient temperatures. In some years, Spotted Turtles may aestivate for a large portion of the year in response wetland conditions (Ernst and Lovich, 2009). Third, instead of limiting reconnaissance and sampling in time and space, the extensive, complex, and dynamic wetland systems of the Southeast (Akre, pers. obs.), can overwhelm sampling resources and lead to under sampling (Willey et al., 2022). Lastly, sampling on installations is hampered under the best of circumstances as mission-oriented activities alter habitats, fragment landscapes, and limit access to habitat due to temporary or permanent restrictions. All told, these issues present real challenges to sampling, monitoring, and habitat management of Spotted Turtle populations on DoD installations and the surrounding landscapes that can include important populations segments and upland and wetland features.

These issues are particularly relevant on large installations with extensive habitats, such as Fort Stewart, and on those installations with dynamic and pervasive mission-oriented access restrictions, such as Fort A.P. Hill and Marine Corps Base Quantico. However, despite all these issues challenging the project, and the general challenge of prematurely drying wetlands from unusually low precipitation in 2021 (Figure 3), sampling returns were quite good except at Fort Stewart, and to a lesser degree at Fort A.P. Hill (Tables 5-6, 8-9). At FS, 630 trap nights and 114 VRA survey hours from March 15 to May 27 produced no Spotted Turtles at 12 TRA locations across the installation, a result completely unexpected by the expert H. Chandler, even given the extensive habitat at FS. Likewise, at Fort A.P. Hill, 130 trap nights in TRAs and inventory trapping only produced two Spotted Turtles: one female and one male (Table 6). Again, this was surprising given the relatively well-known presence of Spotted Turtles across the installation and the recent success with site reconnaissance and trapping in 2019 (T. Akre, unpubl. data). At FS, the weather was generally good for observation and trapping of Spotted Turtles even though sampling began relatively late in the season for southeastern Georgia. The complete lack of Spotted Turtle captures at FS is likely due to an interaction of the factors mentioned above, diminishing detection to zero in the intense but limited sampling period. For example, although many of the trapping sites on FS were geo-referenced to historic records, it appears that the large scale of installation wetlands, as well as their overall complexity and dynamism, may make it difficult to repeat successful detection under changing seasonal and annual conditions (i.e., available habitat may not be limiting, and low-density turtle population segments may move across the landscape over seasons and years). While it is likely that the general trapping protocol underserves the goals of the project on this installation in particular, access restrictions were also hampering at FS. The standard four-night TRA and it's 12-night extension, the DA, were excluded from application due to time limits on access. Additionally, many sites were not accessible until the end of the season when wetlands were drying, due to restrictions. At Fort A.P. Hill, the factors that limit the detection of Spotted Turtles across the installation are less clear, but further assessment of known sites, suitable sites and potential sites with existing and new detection technologies is the only way to answer these questions as it does seem like there is an abundance of suitable habitat and no apparent shortage of occasionally detectable turtles on and near the installation (T. Akre, unpubl.data).

Elsewhere, from Camp Curtis Guild in Massachusetts to Naval Support Activity Northwest Annex in southern Virginia, 11 to 50 turtles were captured in 23 to 316 trap nights at Fort Belvoir and Camp Edwards, respectively (Table 5). These results are not astonishingly good, but they are comparable to results recorded elsewhere from Maine to Florida in 2018-2021 (Willey et al., 2022) and are acceptable given the drought conditions that strongly limited trapping in time and space on installations, especially those in Virginia. Likewise, the trapping returns and demographic patterns across the installations are comparable to other sites in Virginia and across the range (Willey et al., 2022). Nevertheless, to develop a more sensitive and precise approach to determining occupancy and abundance on DoD installations, it is important to incorporate improvements to detection, since trapping, while generally considered to be among the best ways

to detect Spotted Turtle occupancy and abundance, is not very effective for Spotted Turtles compared to other species. As a group, ESTWG has or is testing other trapping approaches as well as other detection methods such as camera trapping, environmental DNA, and radiotelemetry. A composite and positive feedback approach to sampling, with eDNA, cameras, visual surveillance, trapping and radiotelemetry may be required to improve detection and refine its relation to abundance over time, across habitats and ecoregions. As such, longer-term inventory and monitoring projects with multiple contemporary and sequential detection techniques are needed to overcome the inherent and circumstantial difficulty with detection of individuals and populations due to their cryptic nature, and the scale, complexity dynamism and accessibility of their habitats. This is where DoD LNRMP program and DoD PARC can support the development and/or adaptation of the leading-edge tools and integrated sampling-modelling techniques (i.e., multiple trapping approaches, camera trapping, environmental DNA, and radiotelemetry) that will greatly improve the understanding of at-risk species such as the Spotted Turtle and their habit requirements in service of INRMPs and mission readiness.

As mentioned above, bycatch of syntopic species ranged from 1-8 representatives of 36 taxa of arthropods, bony fishes, amphibians, and reptiles, including six other turtle species, sampled across the nine installations (Table 7). Capture patterns among taxa across the installations generally represent expectations for frequent detection of seemingly common species, such as Green Frogs and Snapping Turtles, to limited detection of relatively rare, incidental, or difficult-to-detect species such as Carpenter Frog and Eastern Mud Snake. Patterns of detection also followed biogeographic expectations for species distributions, with some species found exclusively in the north or the south and the majority of frequently detected species found across most or all of the trapping range (Table 7).

Like trap-capture rates across installations, estimates of abundance and their standard errors for installations are not positively overwhelming for the most part, but they are generally not immediately concerning for the most part either (Table 8; Figures 41-42). Only at FS where Spotted Turtles were not captured, and FAPH, where only two individuals were sampled in 2021 and five individuals were sampled among six captures in 2019, was an estimate inapplicable or very low (Table 8). Elsewise, abundance estimates are comparable to other regional sites that were sampled from 2018 to 2021 (Willey et al., 2022). Similarly, standard errors for the estimates are reasonable except for CPED, where the large sample size and low number of recaptures suggest a small sample of a potentially large and open population (Table 8; Figures 41-42). Likewise, but to a lesser degree at NSANA and MCBQ, population estimates and standard errors suggest large and fairly open populations. It is also possible to interpret those values as the result of relatively small sampling efforts, but the capture-recapture information from 2019 suggest it is more likely that there are relatively large and open, if partially fragmented, populations on those installations.

Not surprisingly, trap nights significantly influenced trap captures, captures of individuals and female and male captures (Table 9). Furthermore, it was also unsurprising that juvenile captures

did not accumulate over trap nights at the same rate as adult captures. However, it was surprising that there were no significant relationships between trap nights and any response variable for standardized assessments, suggesting that, as mentioned above, limited sampling is an important effect in these results, and that more sampling with more effective means is needed to improve detection and refine population estimates.

Best Practices and Recommendations for Spotted Turtle Sampling and Habitat Management on Installations

Not surprisingly, given the challenges of detecting Spotted Turtles because of their crypsis, difficulty with access to their habitats, and regional variation in spatial scale, complexity and dynamism of their wetland habitats, best practices for sampling vary by geography. Similarly, best practices for habitat management also vary by geography. In a fairly coarse fashion, installations maybe be grouped by their geography and ecoregion for the purpose of collating best practices for sampling and habitat management. The first group in the northeast includes Camp Curtis Guild in the Northeastern Coastal Zone and Fort Indiantown Gap in the Ridge and Valley and Camp Edwards and Joint Base McGuire-Dix-Lakehurst in the Atlantic Coastal Pine Barrens. The second group includes the four Virginia installations, Fort Belvoir, Marine Corps Base Quantico and Fort A.P. Hill in the Southeastern Plain and NSA Northwest Annex in the Middle-Atlantic Coastal Plain. The third group is Fort Stewart in the Southern Coastal Plain.

Best practices for Spotted Turtle sampling in the northern group in Massachussetts, Pennsylvania, and New Jersey should include upscaling the temporal and spatial extent and intensity of sampling at Camp Curtis Guild and Fort Indiantown Gap, as possible. In this case, standardized and adaptive sampling approaches (ESTWG, 2019) can continue to be used where effective, but the additional methods and integrated approaches mentioned above should be used where they can improve both snapshot detection of occupancy and long-term monitoring to refine estimates of abundance and trends in population size and distribution. In both cases, installation and partner personnel are familiar with the opportunities and limitations of the standard approaches and the improved and integrated approaches, so they can deploy their staff and the appropriate methods as possible to improve their knowledge of the species for mission readiness. At Camp Edwards and Joint Base McGuire-Dix-Lakehurst it appears that the methods and effort employed in the project resulted in reasonably good returns and population estimates, suggesting that continuation of the same approach at regular intervals is appropriate to develop relatively precise population estimates in the long-term. However, at both installations, capture returns, and abundance estimates and errors suggest that populations are fairly large and open. Therefore, upscaling the spatial extent of sampling with standard and additional integrated approaches can also improve the resolution of distribution and abundance information. Best practices for habitat management at these installations would necessarily include all or most of the 16 recommended conservation implementation strategies and best practices for Spotted Turtles on military sites (DoD PARC, 2019; Appendix E). Like with the best practices for sampling, installation personnel are familiar with the opportunities, responsibilites and

limitations of their administration and INRMP implementation, so they and partner personnel can taylor these BMPs to their sites and deploy their staff with the appropriate methods as possible to improve their knowledge and the habitat of the species for mission readiness.

Best practices for Spotted Turtle sampling in the central group in Virginia can include upscaling the temporal intensity and spatial intensity and extent of sampling at Fort A.P. Hill and NSA Northwest Annex, as possible. In this case, standardized and adaptive sampling approaches can continue to be used where effective, but the additional and integrated approaches mentioned above should also be used where they can improve both snapshot detection of occupancy and long-term monitoring to refine estimates of abundance and trends in population size and distribution. For both military sites, installation and partner personnel are familiar with the opportunities and limitations of the standard approaches as well as the improved and integrated approaches, so they can deploy their staff and the appropriate methods as possible to improve their knowledge of the species for mission readiness. At Fort Belvoir and Marine Corps Base Quantico it appears that efforts employed prior to this project resulted in reasonably good returns and a decent understanding of distribution and population estimates (e.g., Ruther, pers. comm.), suggesting that continuation of the same approach at regular intervals is appropriate for reasonably precise long-term population estimates. Nevertheless, the additional and integrated approaches mentioned above should also be used where they can improve both snapshot detection of occupancy and long-term monitoring to refine estimates of abundance and trends in population size and distribution. For example, a recent investigation of distribution and abundance on and around FB using capture-recapture information from visual and trap sampling and movement information from radiotelemetry is leading to a refined, spatially explict model of population distribution among habitats across the site (E. Lassiter, pers. comm.). Likewise, further investigation of distribution and abundance across MCBQ would result in a better understanding of the patterns of habitat use and resulting conservation management needs. Best practices for habitat management at these installations would necessarily include all or most of the 16 recommended conservation implementation strategies and best practices for Spotted Turtles on military sites (DoD PARC, 2019; Appendix E). Both FB and MCBQ are impacted by urbanization in the surrounding landscape, so best practices for management should focus on those that mitigate the effects of urbanization on water quality and wetland habitat (DoD PARC, 2019). Like with the best practices for sampling, installation personnel are familiar with the opportunities, responsibilites and limitations of their administration and INRMP implementation, so they and partner personnel can taylor these BMPs to their sites and deploy their staff with the appropriate methods as possible to improve their knowledge and the habitat of the species for mission readiness.

Best practices for Spotted Turtle sampling on the southern installation, Fort Stewart, should include upscaling the temporal intensity and spatial extent and intensity of sampling, as possible. This includes sampling earlier in the season and more broadly across the installation. At FS, historic records and abundance of apparently suitable habitat suggest that Spotted Turtle

individuals and groups could use much of the extensive forested wetlands across the installation at any given time and may also move in response to seasonal and successional changes to wetlands. As such, the ratio of potentially occupied habitat to the area that can be readily surveyed in a given season may be so large that much more and more diverse survey efforts are needed, especially considering the other important detection challenges such as their cryptic nature and site access issues due to habitat features and/or military activity constraints. Therefore, standardized and adaptive sampling can continue to be used where effective, but the additional and integrated approaches mentioned above should also be used where they can improve both snapshot detection of occupancy and long-term monitoring to refine estimates of abundance and trends in population size and distribution. Further investigation of distribution and abundance across the installation would result in much improved understanding of the patterns of habitat use and resulting conservation management needs, which may turn out to be regionally important to the long-term persistance of the Spotted Turtle, given the large size of FS and the apparently extensive habitat available to Spotted Turtles. As above, installation and partner personnel are familiar with the opportunities and limitations of the standard approaches as well as the improved and integrated approaches, so they can deploy their staff and the appropriate methods as possible to improve their knowledge of the species for mission readiness. Best practices for habitat management at FS would necessarily include all or most of the 16 recommended conservation implementation and best practices on military sites (DoD PARC, 2019; Appendix E). Installation personnel are familiar with the opportunities, responsibilites and limitations of their administration and INRMP implementation, so they and partner personnel can taylor these BMPs to their sites and deploy their staff with the appropriate methods as possible to improve their knowledge and the habitat of the species for mission readiness.

Conclusions

Results from this study on nine military installations from Massachusetts to Georgia in 2018-2019 and 2021 strongly suggest that **geographically and demographically important Spotted Turtle populations occur on DoD lands on the eastern seaboard**. These results indicate that mission-related activity on these installations may be compatible with population viability, especially when there are no external factors that mitigate the benefit of habitat set-asides, protection and management. **More work is needed to expand and refine an understanding of the Spotted Turtle on DoD lands**, but a very important set of initial steps has begun to improve knowledge on the distribution and abundance of and correlated habitat features for the Spotted Turtle on military lands. Furthermore, when these data are considered among those for dozens of Spotted Turtle populations sampled from Maine to Florida in 2018-2021 (i.e., the Status Assessment and Conservation Plan for the Spotted Turtle in the eastern United States; Willey et al., 2022), the relationship of regionally important Spotted Turtle populations on and off DoD lands, as well as the opportunities and challenges to maintaining population viability and habitat connectivity at the landscape level, begin to emerge. **While DoD lands may encompass Spotted Turtle populations that are essential to landscape-level conservation of a regional**

population complex, effective conservation of such a complex may not be possible through installation level INRMP-based maintenance alone. Although not well known for Spotted Turtles, it seems likely that few installations are large enough to circumscribe the ebb and flow of wildlife populations in response to land use and land cover changes. Therefore, **there is a need for a complementary approach to landscape level conservation of Spotted Turtles and their wetland habitat that includes public-private partnerships among DoD, state agencies, private companies, NGOs and small holders**. In total, this project, led by DoD and SI representatives, has successfully begun the essential task of developing capacity for managing the Spotted Turtle on military and other public and private lands by coordinating the development of information, awareness and will for Spotted Turtle conservation across a network of stakeholders within and among the relevant jurisdictions for Spotted Turtle conservation science and management in the eastern U.S (e.g., ESTWG, DoD LNRMP, and DoD PARC).

Overall, **the CESU cooperative agreement approach to working with DoD representatives from Massachusetts to Georgia, as well as DoD LRMP and DoD PARC leaders, for conservation management of at-risk species has been very productive for SI and ATO, MACHAC, and TOS partners**. All aspects of the project were well supported by DoD personnel and CA project partner personnel, from delivery of the CA to the completion of the final technical report. This is especially true regarding support for orientation of personnel to the objectives, standards, and management of the project to organize, implement, report and evaluate the main phases of the CA project across the period of performance. All aspects of the project were well managed by DoD and NGO partners, especially those at the installations who supported each of the key phases needed to achieve the aims of the CA.

In particular, reconnaissance and site visitation and Spotted Turtle sampling at participating installations was well supported by coordination with DoD CA representatives and earnest interest and follow through by installation natural resource managers. **This process and its outputs, including this report, will serve the aims of the CA by improving information on the status of the Spotted Turtle on DoD lands and integration of this information into installation INRMPs in support of mission readiness. This ideal outcome for the Spotted Turtle on DoD lands aligns well with the goals and actions of the Eastern Spotted Turtle Working Group (ESTWG, 2019; Willey et al., 2022), the SI (i.e. NZCBI) and project partners.** The existing network that this project brought to DoD, in combination with the network built with support from the CA with DoD, will enable the SI and partners in the ESTWG to continue providing technical and leadership support to the nine participating installations as well as the 30 additional installations with known Spotted Turtle populations, and as possible, the other 60 installations with potential for Spotted Turtle populations. **Continued support for this cooperative network approach is strongly recommended to leverage the mutual interests of the ESTWG and DoD LRMP and DoD PARC for Spotted Turtle conservation. As such, the Smithsonian and its partners stand ready to continue to support**

DoD in its mission to protect at-risk species, such as the Spotted Turtle, for the purpose of mission readiness on the hundreds of thousands of hectares managed by DoD.

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Table 1. A general summary table for the nine installations participating in the Spotted Turtle (*Clemmys guttata*) Management for Mission Readiness Cooperative Agreement (CA) between the Department of Defense (DoD) and the Smithsonian Institution (SI).

DoD Installation	DoD Branch	Ecoregion	State	DoD Representative	CA Partner Representative*
Camp Curtis Guild (CCG)	Army National Guard	Northeastern Coastal Zone	Massachusetts	Annie Curtis	Molly Parren
Camp Edwards (CPED)	Army National Guard	Atlantic Coastal Pine Barrens	Massachusetts	Annie Curtis	John Garrison
Fort Indiantown Gap (FIG)	Army National Guard	Ridge and Valley	Pennsylvania	Rebecca Picone	Lori Erb
Joint Base McGuire-Dix-Lakehurst (JBMDL)	Air Force	Atlantic Coastal Pine Barrens	New Jersey	Mark Stevenson	Lori Erb
Fort Belvoir (FB)	Army	Southeastern Plain	Virginia	John Pilcicki	Jessica Meck
Marine Corps Base Quantico (MCBQ)	Marine Corps	Southeastern Plain	Virginia	Kenneth Erwin	Jessica Meck
Fort A.P. Hill (FAPH)	Army	Southeastern Plain	Virginia	Kyle Crafts	Jessica Meck
NSA Northwest Annex (NSANA)	Navy	Middle-Atlantic Coastal Plain	Virginia	Taylor Austin	Jessica Meck
Fort Stewart (FS)	Army	Southern Coastal Plain	Georgia	Lawrence Carlile	Houston Chandler
Total 9	**5**	**6**	**5**	**8**	**5**

*CA is an abbreviation of convenience in this table for Cooperative Agreement.

Table 2. A coordination and planning summary table for representatives of the Spotted Turtle (*Clemmys guttata*) Management for Mission Readiness CA, Department of Defense (DoD) personnel, and CA partner personnel. The table summarizes topics discussed on six conference calls from fall 2020 to 2021 in support of the CA scope of work.

Date	Topic	CA Representatives (DoD & SI)*	DoD Installation Personnel	CA Partner Personnel*
November 18, 2020	Cooperative Agreement orientation: DoD, SI and NGO partner personnel. Introductions, cooperative agreement overview, objectives, standards, timelines.	Chris Petersen Robert Lovich Thomas Akre Jessica Meck	(0)	Lisabeth Willey Lori Erb Houston Chandler
December 15, 2020	Cooperative Agreement orientation: DoD, SI, NGO personnel with DoD installation representatives and technicians. Introductions, project overview, objectives, timelines, and coordination with installations for on-site access and site selection.	Chris Petersen Robert Lovich Thomas Akre Jessica Meck	Annie Curtis Matthew Panella Joseph Hovis Mark Stevenson John Pilcicki Christa Nye Kenneth Erwin Kyle Crafts Taylor Austin Lawrence Carlile	Lisabeth Willey Molly Parren John Garrison Lori Erb Houston Chandler
February 25, 2021	Cooperative Agreement fiscal management: subaward and contractor establishment updates.	Chris Petersen Robert Lovich Thomas Akre Jessica Meck	(0)	(0)

*CA is an abbreviation of convenience in this table for Cooperative Agreement.

Table 2 Cont'd.

Date	Topic	CA Representatives (DoD & SI)*	DoD Installation Personnel	CA Partner Personnel
March 29, 2021	Cooperative Agreement early season field work updates: project communication, coordination and field sampling updates.	Chris Petersen Robert Lovich Thomas Akre Jessica Meck	(0)	Lisabeth Willey Molly Parren John Garrison Lori Erb Houston Chandler
June 28, 2021	Cooperative Agreement late season field work and data management updates: project communication, coordination, field sampling efforts and challenges. Next steps for data entry, analysis, and technical reporting.	Chris Petersen Robert Lovich Thomas Akre Jessica Meck	(0)	Lisabeth Willey Molly Parren John Garrison Lori Erb Houston Chandler
November 10, 2021	Cooperative Agreement communication, data, review and technical reporting updates: updates from CA partners and installation representatives, and technical report requirements.	Chris Petersen Thomas Akre Jessica Meck	Taylor Austin Kenneth Erwin Annie Haines	Molly Parren John Garrison Lori Erb Houston Chandler
Total 6	**6**	**4**	**11**	**5**

*CA is an abbreviation of convenience in this table for Cooperative Agreement.

Table 3. A project development summary table for nine installations participating in the Spotted Turtle (*Clemmys guttata*) Management for Mission Readiness CA. The table summarizes installation reconnaissance dates and Department of Defense (DoD) and CA partner personnel involved in coordination and initial site visitation.

DoD Installation	Date	DoD Personnel	CA Partner Personnel*
Camp Curtis Guild	April 24, 2021	Annie Curtis, Matthew Penella	Molly Parren, John Garrison
Camp Edwards	April 12, 2021	Annie Curtis, Matthew Penella	Molly Parren, John Garrison
Fort Indiantown Gap	April 12, 2021	Rebecca Picone, Annie Haines	Lori Erb
Joint Base McGuire-Dix-Lakehurst	March 3, 2021	Paul Mahoney, Michael Luna, Mark Stevenson	Lori Erb, Brandon Ruhe, James White
Fort Belvoir	March 4, 2021	John Pilcicki	Jessica Meck, Emily Sikora
Marine Corps Base Quantico	March 3, 2021	Kenneth Erwin	Jessica Meck, Emily Sikora
Fort A.P. Hill	Feb. 2018 & Mar. 2019	Andrew Satterwhite, Kyle Crafts	Thomas Akre, Jessica Meck, Jill Newman
NSA Northwest Annex	February 27, 2019	Taylor Austin	Jessica Meck, Emily Sikora
Fort Stewart	March 15, 2021	Lawrence Carlile, Rachel Rourke	Houston Chandler, Ben Stegenga, Andrea Colton
Totals 9	**ca. 12 days**	**14**	**12**

*CA is an abbreviation of convenience in this table for Cooperative Agreement.

Table 4. A personnel summary table for individuals participating in the Spotted Turtle (*Clemmys guttata*) Management for Mission Readiness CA. Thirty-seven people occupying 18 positions at 12 institutions, including nine Department of Defense (DoD) installations, directly supported this project from 2018-2022.

Name	Affiliation	Location/Installation	Position	Cooperative Agreement Role
Chris Petersen	Naval Facilities Systems Engineering Command/DoD PARC	Norfolk, VA	Senior Natural Resources Specialist	DoD Cooperative Agreement Lead
Robert Lovich	Naval Facilities Systems Engineering Command/DoD PARC	San Diego, CA	Senior Natural Resources Specialist	DoD Cooperative Agreement Lead
Ryan Orndorff	DoD Natural Resource Program	Alexandria, VA	Director	Cooperative Agreement Sponsor
Elizabeth Galli-Noble	DoD Natural Resource Program	Alexandria, VA	Program Manager	DoD Legacy Resource Management Program Manager
Thomas Akre	Smithsonian Institution	Front Royal, VA	Research Ecologist	SI Cooperative Agreement Research Lead
Jessica Meck	Smithsonian Institution	Front Royal, VA	Research Coordinator	Cooperative Agreement Coordinator
Emily Sikora	Smithsonian Institution	Front Royal, VA	Research Technician	Research Technician
Jillian Newman*	Smithsonian Institution	Front Royal, VA	Research Technician	Research Technician
Lisabeth Willey	American Turtle Observatory	New Salem, MA	Research Ecologist	Organization Research Lead
Molly Parren	American Turtle Observatory	New Salem, MA	Research Associate	Research Technician
John Garrison	American Turtle Observatory	New Salem, MA	Research Associate	Research Technician
Brandon Ruhe	MidAtlantic Center for Herpetology & Conservation	Oley, PA	Principal	Organization Lead
Lori Erb	MidAtlantic Center for Herpetology & Conservation	Oley, PA	Turtle Specialist	Organization Research Lead
James White	MidAtlantic Center for Herpetology & Conservation	Oley, PA	Research Technician	Research Technician
Houston Chandler	The Orianne Society	Tiger, GA	Director of Science	Organization Research Lead
Ben Stegenga	The Orianne Society	Tiger, GA	Research Technician	Research Technician
Andrea Colton	The Orianne Society	Tiger, GA	Research Technician	Research Technician
Annie Curtis	Army National Guard	Camps Curtis Guild & Edwards	Biologist	Installation Representative
Matthew Penella	Army National Guard	Camps Curtis Guild &Edwards	Biologist	Project Technician

*This person supported the cooperative agreement through support given to the objectives in years prior to 2020.

Table 4 Cont'd.

Name	Affiliation	Location/Installation	Position	Cooperative Agreement Role
Jacob McCumber	Army National Guard	Camps Curtis Guild & Edwards	National Resources Manager	Project Technician
Joseph Hovis	Army National Guard	Fort Indiantown Gap	Wildlife Biologist	Installation Representative
Annie Haines	Army National Guard	Fort Indiantown Gap	Natural Resources Manager	Installation Representative
Rebecca Piccone	Army National Guard	Fort Indiantown Gap	Wildlife Technician	Project Technician
Mark Stevenson	Air Force	Joint Base McGuire-Dix-Lakehurst	Natural Resources Biologist	Installation Representative
Paul Mahoney	Air Force	Joint Base McGuire-Dix-Lakehurst	Biologist	Project Technician
Michael Luna	Air Force	Joint Base McGuire-Dix-Lakehurst	Biologist	Project Technician
Dorothy Keough	Army	Fort Belvoir	Conservation Branch Chief	Installation Representative
John Pilcicki	Army	Fort Belvoir	Wildlife Biologist	Project Technician
Christa Nye	Marine Corps	MCB Quantico	Natural Resources Manager	Installation Representative
Joseph Larose	Marine Corps	MCB Quantico	Natural Resources Manager	Installation Representative
Kenneth Erwin	Marine Corps	MCB Quantico	Biologist	Project Technician
Jason Applegate	Army	Fort A.P. Hill	Natural Resources Specialist	Installation Representative
Andrew Satterwhite*	Army	Fort A.P. Hill	Natural Resources Specialist	Project Technician
Kyle Crafts	Army	Fort A.P. Hill	Natural Resources Specialist	Project Technician
Taylor Austin	Navy	NSA Northwest Annex	Natural Resources Manager	Installation Representative
Lawrence Carlile	Army	Fort Stewart	Fish & Wildlife Branch Chief	Installation Representative
Rachel Rourke	Army	Fort Stewart	Wildlife Biologist	Project Technician
Personnel	**Institutions**	**Installations**	**Positions**	**Roles**
37	**12**	**9**	**18**	**9**

*This person supported the cooperative agreement through support given to the objectives in years prior to 2020.

Table 5. A general summary table of sampling effort and results from the 2021 field season of the Spotted Turtle (*Clemmys guttata*) Management for Mission Readiness CA. Hand captures occurred incidentally while setting or checking traps. Catch per unit effort (CPUE) represents total captures divided by trap nights.

Installation	Trap Nights	Captures	Trap Captures	Hand Captures	CPUE	Individuals
Camp Curtis Guild	240	31	23	8	0.129	22
Camp Edwards	316	50	32	18	0.158	47
Fort Indiantown Gap	232	31	30	1	0.134	24
Joint Base McGuire-Dix-Lakehurst	300	44	43	1	0.147	35
Fort Belvoir	23	11	11	0	0.478	10
Marine Corps Base Quantico	134	18	18	0	0.134	16
Fort A.P. Hill	130	2	2	0	0.015	2
NSA Northwest Annex	80	26	25	1	0.325	23
Fort Stewart	630	0	0	0	0.000	0
Total	**2085**	**213**	**184**	**29**		**179**
Mean (± STD)	**231.7 (±179.2)**	**23.7 (±17.5)**	**20.4 (±14.2)**	**3.2 (±6.1)**	**0.169 (±0.149)**	**19.9 (±15.1)**

Table 6. A demographic summary table for captures and individuals from the 2021 field season of the Spotted Turtle (*Clemmys guttata*) Management for Mission Readiness CA. Individuals include both trap and hand captures.

Installation	Captures	Individuals	Females C : I*		Males C : I		Juveniles C : I		Captures (F:M:J)^	Individuals (F:M:J)
Camp Curtis Guild	31	22	14	9	7	6	10	7	2:1:1.4	1.5:1:1.2
Camp Edwards	50	47	17	15	19	18	14	14	1.2:1.4:1	1.1:1.3:1
Fort Indiantown Gap	31	24	9	8	13	9	9	7	1:1.4:1	1.1:1.3:1
Joint Base McGuire-Dix-Lakehurst	44	35	19	14	19	15	6	6	3.2:3.2:1	2.3:2.5:1
Fort Belvoir	11	10	3	3	1	1	7	6	3:1:7	3:1:6
Marine Corps Base Quantico	18	16	2	2	11	9	5	5	1:5.5:2.2	1:4.5:2.5
Fort A.P. Hill	2	2	1	1	1	1	0	0	1:1:0	1:1:0
NSA Northwest Annex	26	23	7	6	8	7	11	10	1:1.1:1.6	1:1.2:1.7
Fort Stewart	0	0	0	0	0	0	0	0	-	-
Total	**213**	**179**	**72**	**58**	**79**	**66**	**62**	**55**	**1.2:1.3:1**	**1.1:1.2:1**
Mean (±STD)	**23.7 (±17.5)**	**19.9 (±15.1)**	**8.0 (±7.2)**	**6.4 (±5.5)**	**8.8 (±7.4)**	**7.3 (±6.3)**	**6.9 (±4.8)**	**6.1 (±4.4)**	**1.2:1.3:1**	**1.1:1.2:1**

*C : I = number of Captures : number of Individuals.
^F:M:J is the ratio of females, males and juveniles.

Table 7. A general summary table of select trap bycatch from the 2021 field season of the Spotted Turtle (*Clemmys guttata*) Management for Mission Readiness CA. Bycatch is named to most precise taxonomic identity, grouped by systematic classification and ordered alphabetically by common name. Installations are presented from left to right in the same north to south order as prior tables, with abbreviations from Methods text.

Common Name	Scientific Name	CCG	CPED	FIG	JBMDL	FB	MCBQ	FAPH	NSANA	FS	Total
Dragonfly spp. (larvae)	*Odonata spp.*		X								**1**
Giant Water Bug	*Lethocerus spp.*	X						X			**2**
Predaceous Diving Beetle	*Dytiscus spp.*	X	X					X	X		**4**
Crayfish spp.	*Cambarus*(?) *spp.*	X		X		X	X		X	X	**6**
Bowfin	*Amia calva*							X	X	X	**3**
Common Shiner	*Luxilus cornutus*							X			**1**
Creek Chub	*Semotilus atromaculatus*						X			X	**2**
Golden Shiner	*Notemigonus crysoleucas*		X								**1**
Minnow spp.	*Cyprinidae spp.*			X							**1**
Catfish spp.	*Ameiurus* (*catus*?)				X		X	X		X	**4**
Channel Catfish	*Ictalurus punctatus*						X				**1**
Pickerel	*Esox niger*				X				X	X	**3**
Bluegill	*Lepomis macrochirus*				X		X	X		X	**4**
Redbreast Sunfish	*Lepomis cyanellus*									X	**1**
Sunfish spp.	*Lepomis spp.*					X	X	X	X		**4**
Warmouth	*Lepomis gulosus*									X	**1**
Yellow Perch	*Perca flavescens*									X	**1**
Subtotal	**17**	**3**	**3**	**2**	**3**	**2**	**6**	**7**	**5**	**9**	**40**

Table 7 Cont'd.

Common Name	Scientific Name	CCG	CE	FIG	JBMDL	FB	MCBQ	FAPH	NSANA	FS	Total
Marbled Salamander	*Ambystoma opacum*							X			**1**
Red-spotted Newt	*Notophthalmus viridescens*						X				**1**
Amphiuma	*Amphiuma means*								X	X	**2**
American Toad	*Anaxyrus americanus*		X	X							**2**
Fowler's Toad	*Anaxyrus fowleri*				X						**1**
Grey Treefrog (adult & larvae)	*Dryophytes versicolor*	X	X								**2**
Bull Frog (adult & larvae)	*Lithobates catesbeianus*	X	X		X					X	**4**
Carpenter Frog	*Lithobates virgatipes*				X						**1**
Green Frog (adult & larvae)	*Lithobates clamitans*	X	X	X	X	X	X	X		X	**8**
Pickerel Frog	*Lithobates palustris*									X	**1**
Wood Frog	*Lithobates sylvaticus*	X						X			**2**
Common Snapping Turtle	*Chelydra serpentina*		X		X	X	X	X	X		**6**
Southeastern Mud Turtle	*Kinosternon subrubrum*				X	X	X	X	X		**5**
Striped Mud Turtle	*Kinosternon baurii*									X	**1**
Eastern Musk Turtle	*Sternotheros odoratus*				X		X	X			**3**
Red-eared Slider	*Trachemys scripta*				X						**1**
Painted Turtle	*Chrysemys picta*	X			X	X	X	X			**5**
Brown Water Snake	*Nerodia taxispilota*							X		X	**2**
Northern Watersnake	*Nerodia sipedon*			X							**1**
Eastern Mud Snake	*Farancia abacura*									X	**1**
Subtotal	**20**	**5**	**5**	**3**	**9**	**4**	**6**	**8**	**3**	**7**	**50**
Total	**37**	**8**	**8**	**5**	**12**	**6**	**12**	**15**	**8**	**16**	**90**

Table 8. A sampling effort and abundance summary table for the 2021 field season of the Spotted Turtle (*Clemmys guttata*) Management for Mission Readiness CA. Population abundance estimates, catch per unit effort (CPUE), and total individuals are based on returns from standardized sampling (i.e., demographic or trap rapid assessments) for the nine participating installations. CPUE represents trap captures divided by trap nights. Captures from standardized sampling at Fort A.P. Hill (2019) and NSA Northwest Annex (2019 and 2021) were included in abundance estimates.

Installation	Trap Nights	Trap Captures	CPUE	Individuals	Abundance	STE	Upper CI	Lower CI
Camp Curtis Guild	240	23	0.096	15	26.6	6.6	39.536	13.664
Camp Edwards	316	32	0.101	30	156.9	83.9	321.34	-7.544
Fort Indiantown Gap	232	30	0.129	23	50.5	14.2	67.392	11.728
Joint Base McGuire-Dix-Lakehurst	257	25	0.097	20	43.7	14.3	71.728	15.672
Fort Belvoir	23	11	0.478	10	19.4	9.4	55.249	18.401
Marine Corps Base Quantico	80	18	0.225	16	43.6	21	84.76	2.44
Fort A.P. Hill	80	6	0.075	5	8	3.7	15.252	0.748
NSA Northwest Annex	200	52	0.26	39	76.3	15.8	107.27	45.332
Fort Stewart	630	0	0.00	0	-	-	-	-
Total	**2058**	**197**	**-**	**143**	**-**	**-**	**-**	**-**
Mean (±STD)	**229 (±179)**	**22 (±16)**	**0.162 (±0.142)**	**18 (±13)**	**53.1 (±46.9)**	**-**	**-**	**-**

Table 9. A sampling effort, demography and abundance summary table for 2021 field season of the Spotted Turtle (*Clemmys guttata*) Management for Mission Readiness CA. Trap captures, individuals and captures per sex/age class, catch per unit effort (CPUE), and abundance values are based on returns from standardized sampling (i.e., demographic or trap rapid assessments), inventory trapping and hand captures for the nine participating installations. Captures from standardized sampling at Fort A.P. Hill (2019) and NSA Northwest Annex (2019 and 2021) were included in abundance estimates.

Explanatory Variable^	Response Variable[#]	*df*	Slope	Intercept	R^2	P^*	Reference
All Trap Nights	Trap Captures	6	0.089	6.88	0.54	0.04*	Table 5
All Trap Nights	Hand Captures	6	0.38	-3.2	0.39	0.1	Table 5
All Trap Nights	Individuals	6	0.104	3.55	0.61	0.02*	Table 5
All Trap Nights	CPUE	6	-0.001	0.34	0.36	0.12	Table 5
All Trap Nights	Female Captures	6	0.057	-1.32	0.74	0.01*	Table 6
All Trap Nights	Male Captures	6	0.055	-0.09	0.68	0.01*	Table 6
All Trap Nights	Juvenile Captures	6	0.015	5.09	0.13	0.38	Table 6
All Trap Nights	Female-Male Ratio	6	-0.003	1.76	0.13	0.38	Table 6
All Trap Nights	Adult-Juvenile Ratio	6	0.013	-0.03	0.48	0.06	Table 6
SA Trap Nights	SA Trap Captures	6	0.085	9.49	0.36	0.1	Table 8
SA Trap Nights	SA Individuals	6	0.067	7.82	0.41	0.09	Table 8
SA Trap Nights	SA CPUE	6	-0.001	0.33	0.41	0.09	Table 8
SA Trap Nights	Abundance	6	0.302	-0.79	0.45	0.07	Table 8
SA Trap Nights	STE-Abundance Ratio	6	-0.001	0.46	0.14	0.36	Table 8

^SA indicates Standardized Assessment (SA) trapping only.
[#]STE indicates the standard error of the abundance estimate.
*Indicates the slope of the line is significantly different from 0 at $\alpha = 0.05$.

Figure 1. An adult female Spotted Turtle (*Clemmys guttata*) showing the characteristic carapace, head and leg markings that distinguish the species. Photograph taken by Smithsonian Institution (SI) personnel, spring 2019.

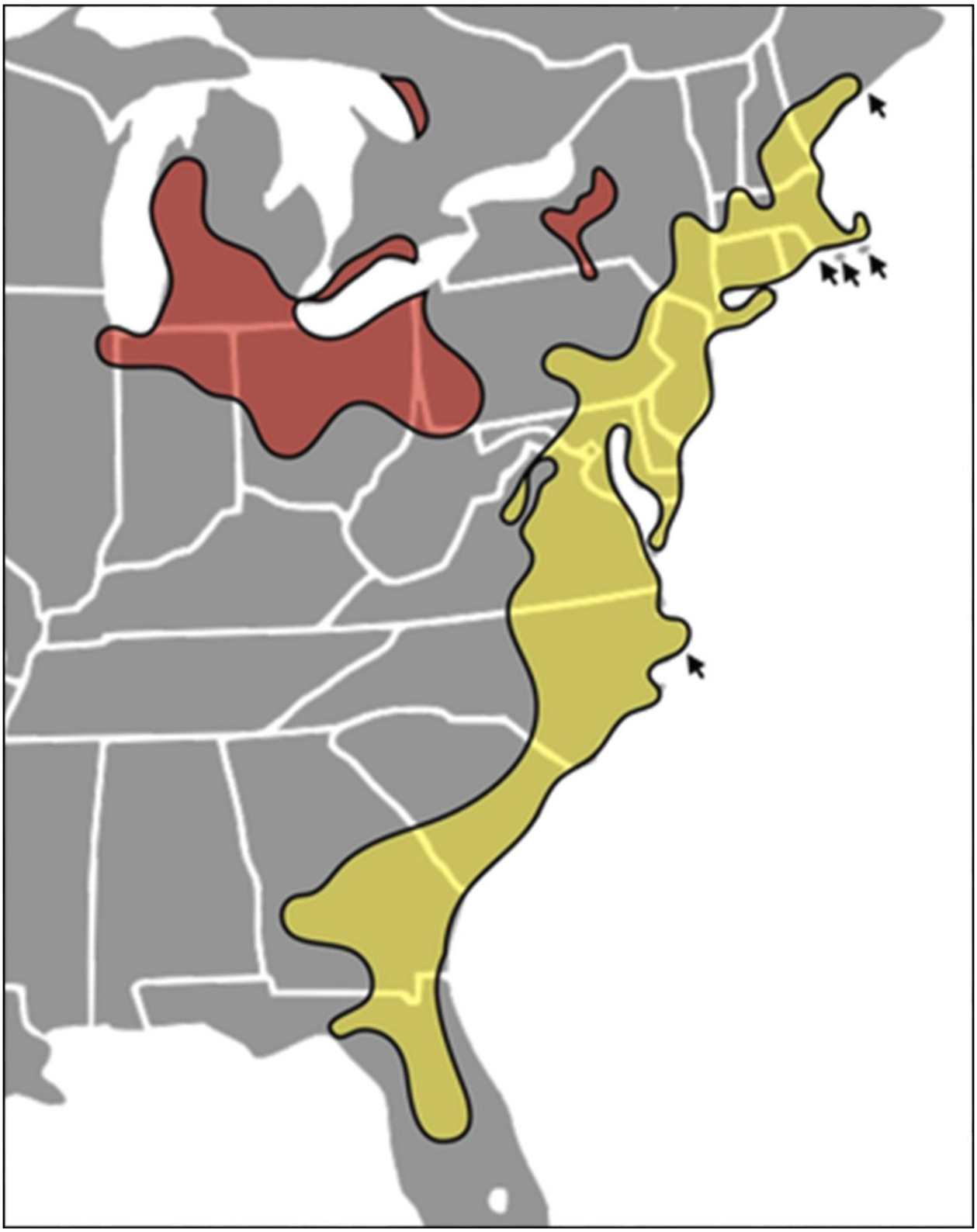


Figure 2. A general range map for the Spotted Turtle (*Clemmys guttata*) showing the eastern coastal range (yellow) and the Great Lakes range (red). Figure adapted from Northeastturtles.org.

Figure 3. The general location of each of the nine Department of Defense (DoD) installations participating in the Spotted Turtle Management for Mission Readiness Cooperative Agreement (CA) between DoD and SI.

Figure 4. A forested wetland associated with Spotted Turtles on Camp Curtis Guild, Massachusetts. Photograph taken by American Turtle Observatory (ATO) personnel, spring 2021.

Figure 5. Wetland habitats associated with Spotted Turtles at Camp Edwards, Massachusetts. Emergent wetlands (A, C, and D) and ponds (B) are shown in the four images. Photographs taken by ATO personnel, spring 2021.

Figure 6. An emergent wetland at Joint Base McGuire-Dix-Lakehurst, New Jersey, where Spotted Turtle traps were deployed spring 2021. Photograph taken by Mid-Atlantic Center for Herpetology and Conservation (MACHAC) personnel, spring 2021.

Figure 7. An emergent wetland at Fort Belvoir, Virginia, where Spotted Turtles have been observed and captured. Photograph taken by SI personnel, spring 2021.

Figure 8. Wetland habitats associated with Spotted Turtles at Marine Corps Base Quantico, Virginia. (A) emergent wetland, (B) ditches/channel, (C) shrub-swamp wetland, and (D) forested wetland. Photographs taken by SI personnel, spring 2021.

Figure 9. Wetland habitats associated with Spotted Turtles at Fort A.P. Hill, Virginia. (A and D) emergent wetland, (B) shrub-swamp wetland, and (C) forested wetland. Photographs taken by SI personnel, spring 2019 & 21.

Figure 10. A Red Maple swamp associated with Spotted Turtles at Naval Support Activity (NSA) Northwest Annex, Virginia. Photograph taken by SI personnel, spring 2021.

Figure 11. A river floodplain swamp associated with Spotted Turtles at Fort Stewart, Georgia. Photograph taken by The Orianne Society (TOS) personnel, spring 2021.

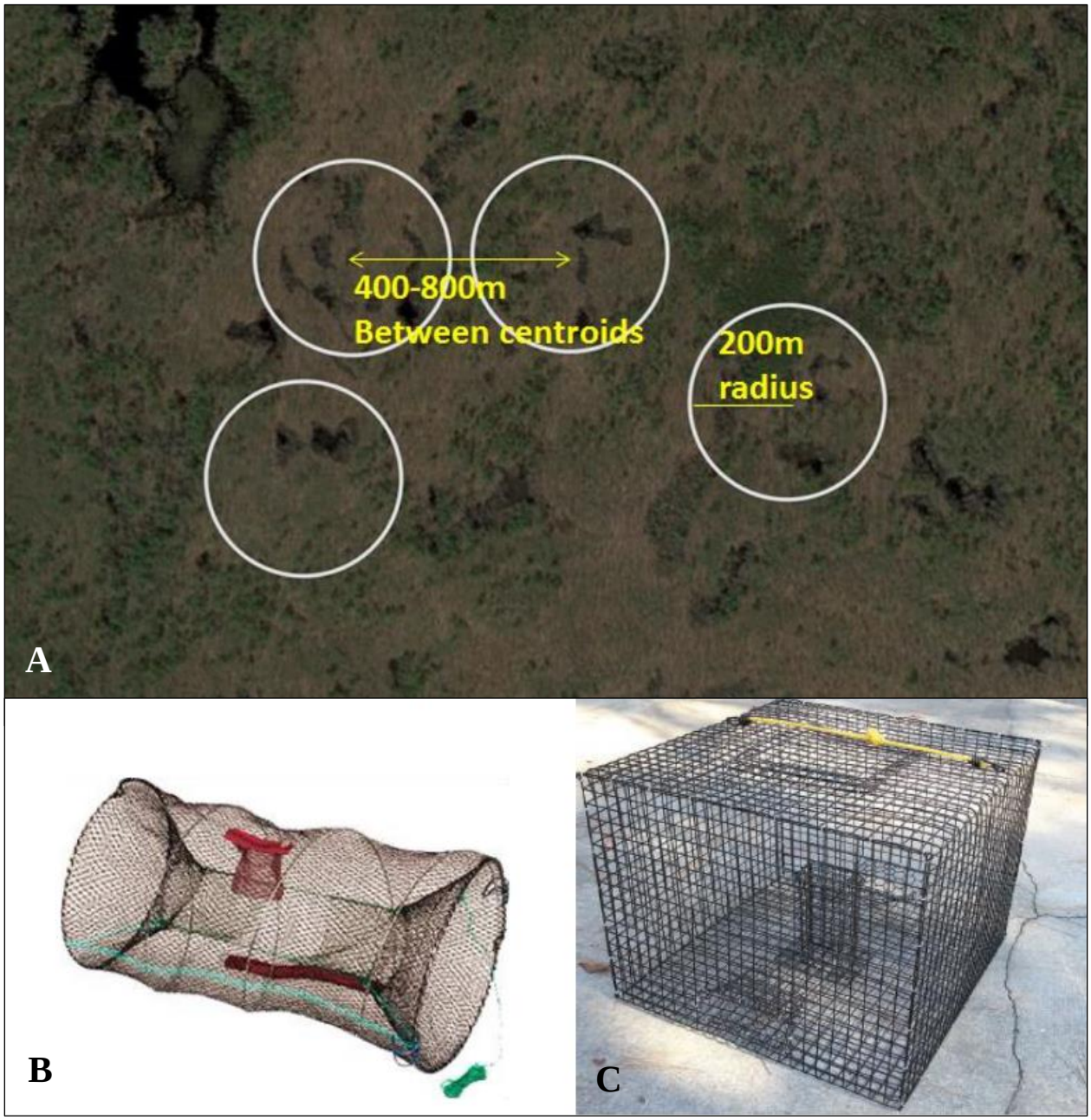


Figure 12. (A) Distribution of Spotted Turtle study site delineation in Google Earth. Reference points are centered on areas of suitable (or potentially) Spotted Turtle habitat, surrounded by 200 m radius reference plots (white circles). Promar TR502 (B) and modified crab trap (C) from Chandler et al.(2017). Images and figure legend adapted from Northeastturtles.org.

Figure 13. A Promar TR502 trap baited, buoyed by a plastic bottle and attached to a tree, for capturing Spotted Turtles in habitat. Photograph taken by SI personnel, spring 2021.

Figure 14. (A) A Promar trap with Spotted Turtles being inspected by SI Research Technician Emily Sikora. (B) DoD Natural Resources Manager Taylor Austin, holding several Spotted Turtles after capture at NSA Northwest Annex, Virginia. Photographs taken by SI and DoD personnel, spring 2021.

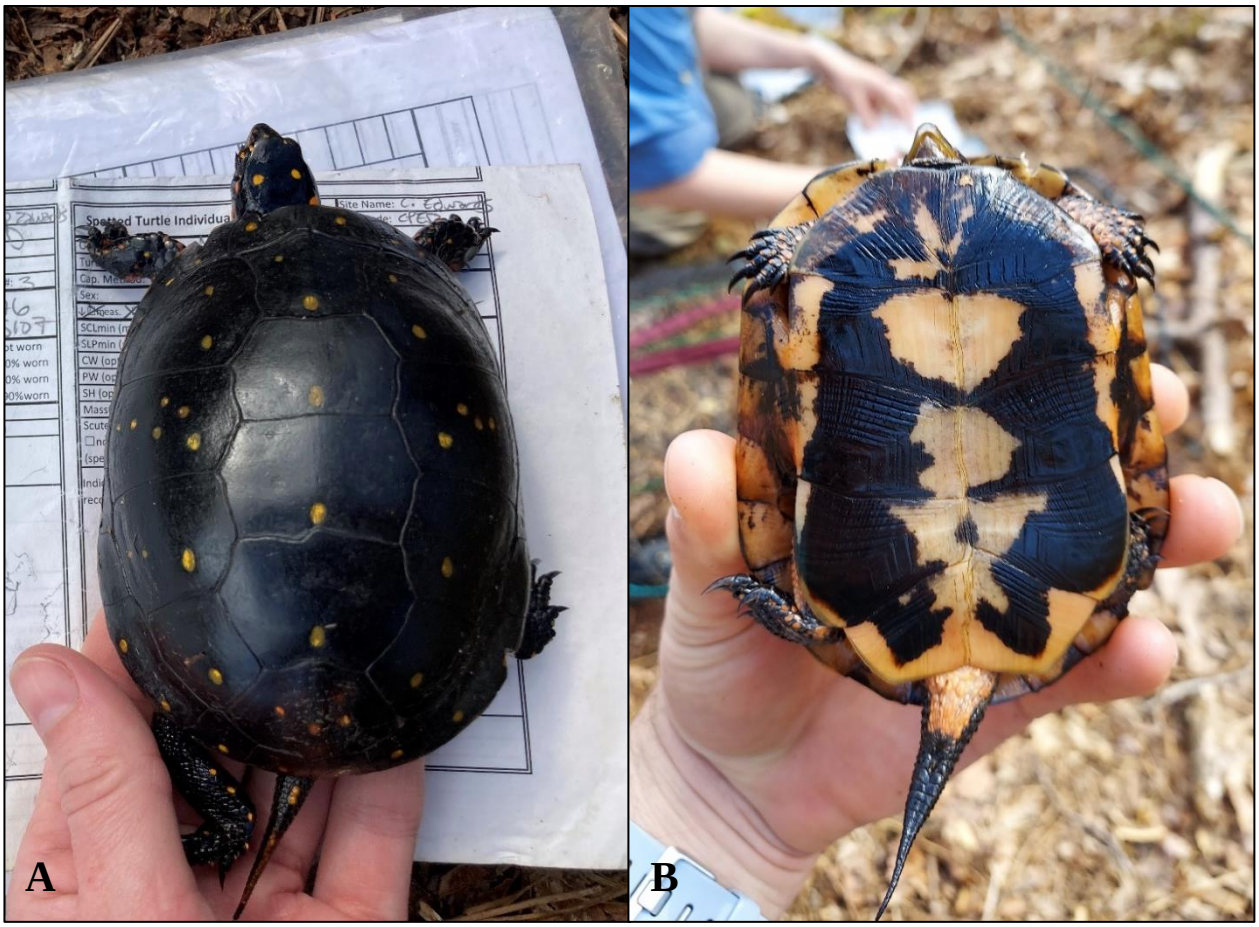


Figure 15. Trap-captured female (A) and male (B) Spotted Turtles from Camp Curtis Guild, Massachusetts. Note the relatively domed carapace of the female and the concave plastron and relatively enlarged tail and posterior cloaca of the male. Photographs taken by ATO personnel, spring 2021.

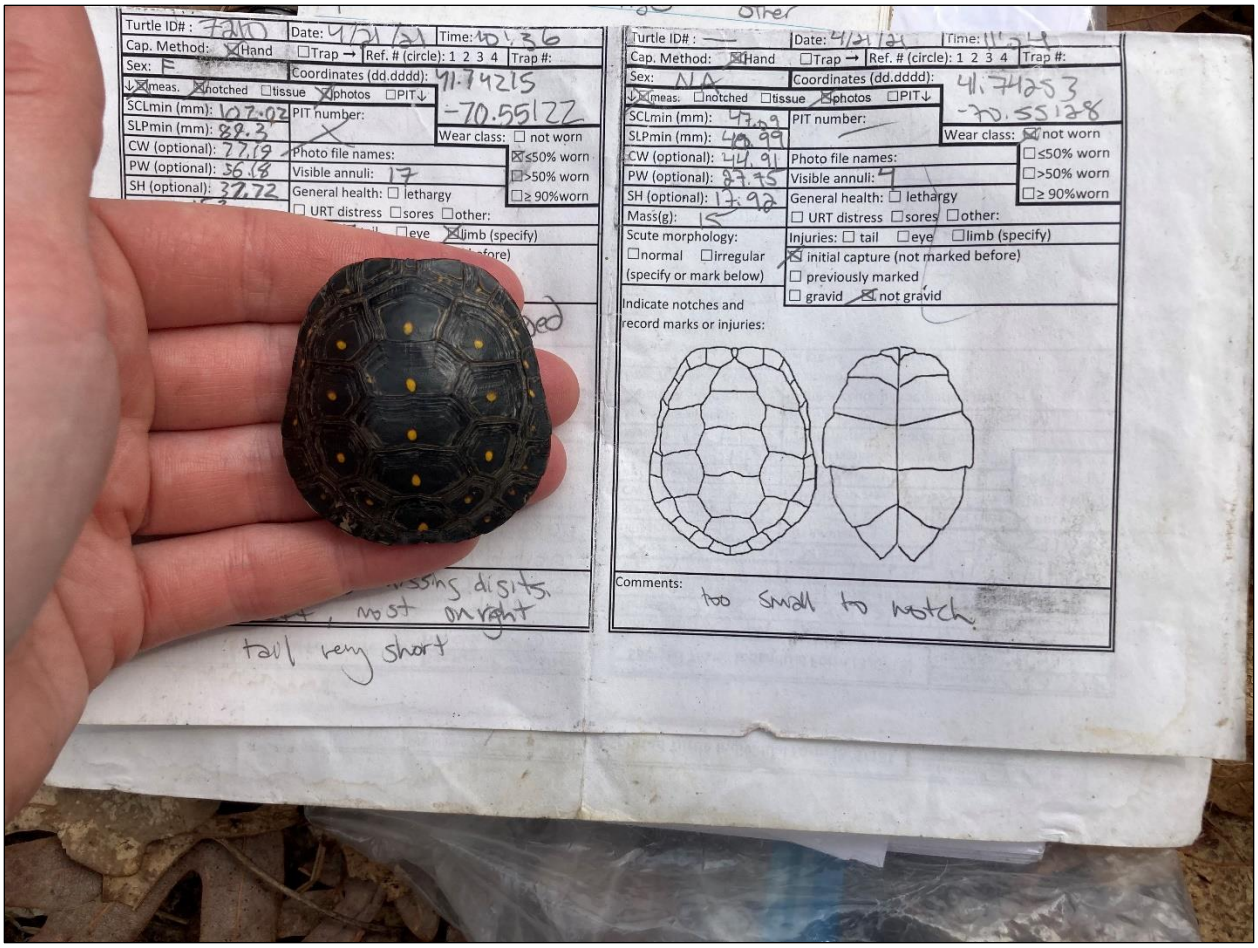


Figure 16. A young juvenile Spotted Turtle from Camp Edwards, Massachusetts. Photograph taken by ATO personnel, spring 2021.

Figure 17. An example of bycatch from Spotted Turtle trapping; two Southeastern Mud Turtles (*Kinosternon subrubrum*) captured at MCB Quantico, Virginia. Photograph taken by SI personnel, spring 2021

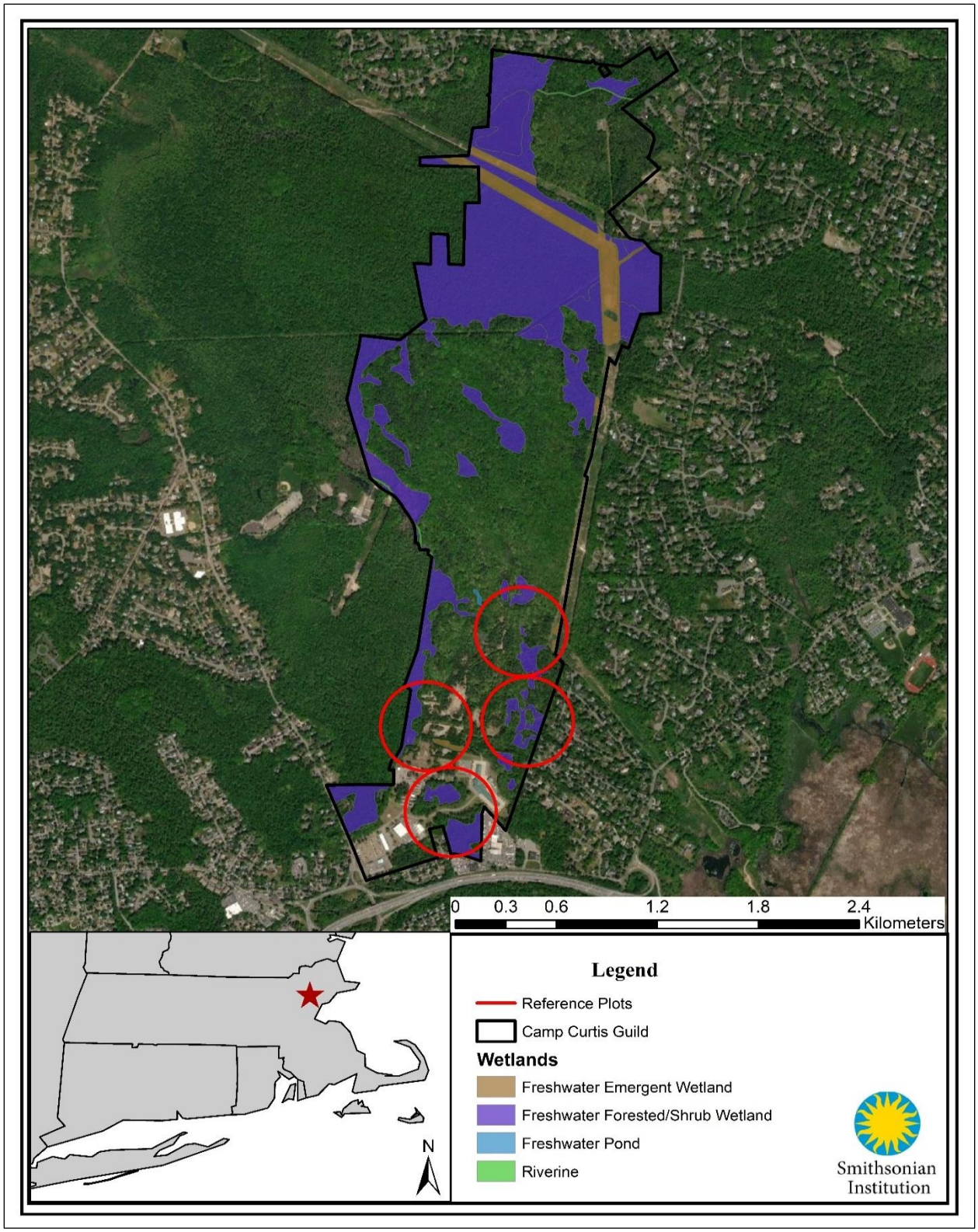


Figure 18. A map of Camp Curtis Guild showing the geographic extent of wetland types and the reference plot locations for a Demographic Assessment (DA) in 2021.

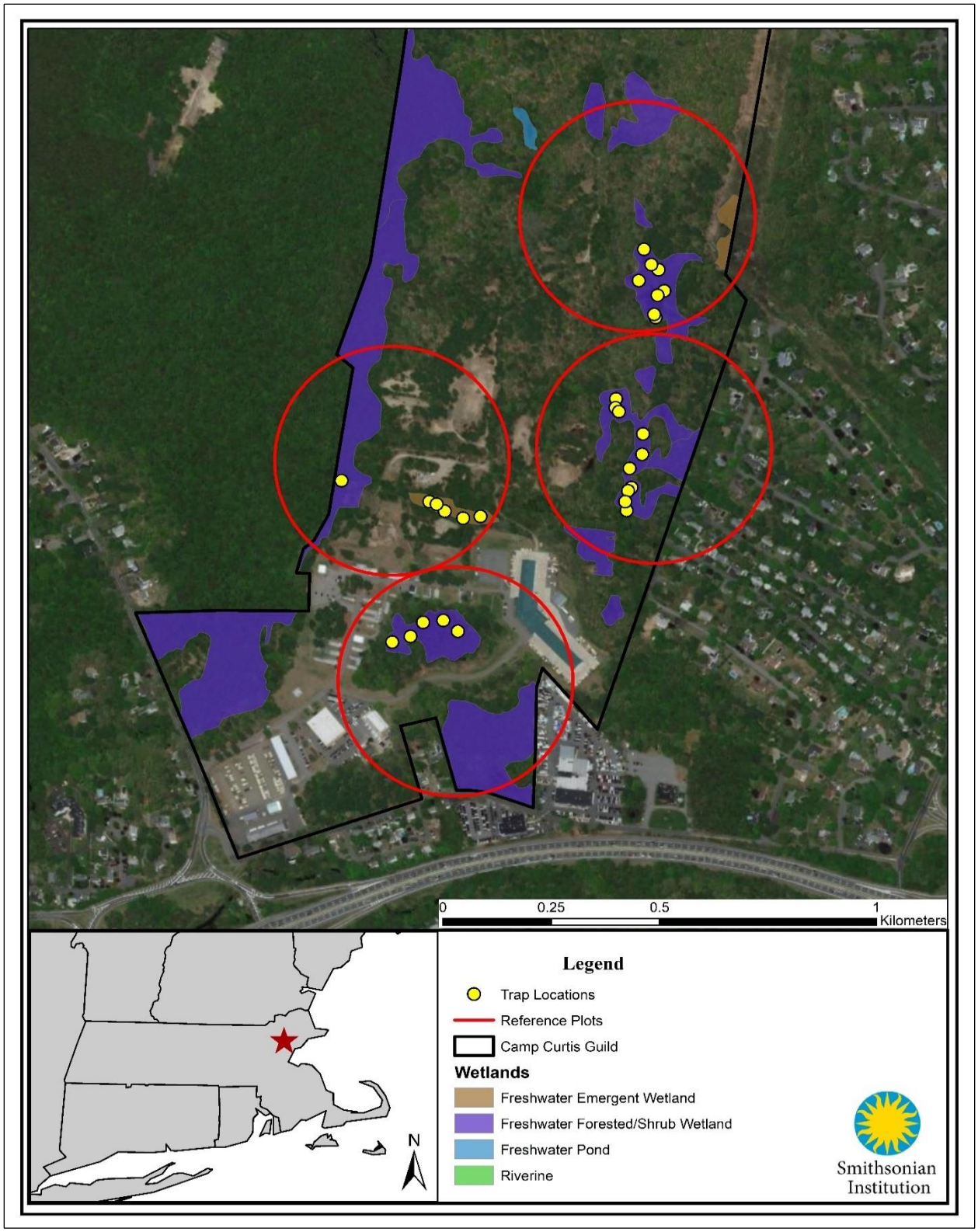


Figure 19. A map of Camp Curtis Guild showing the wetland types and reference plots with trapping locations for a DA in 2021.

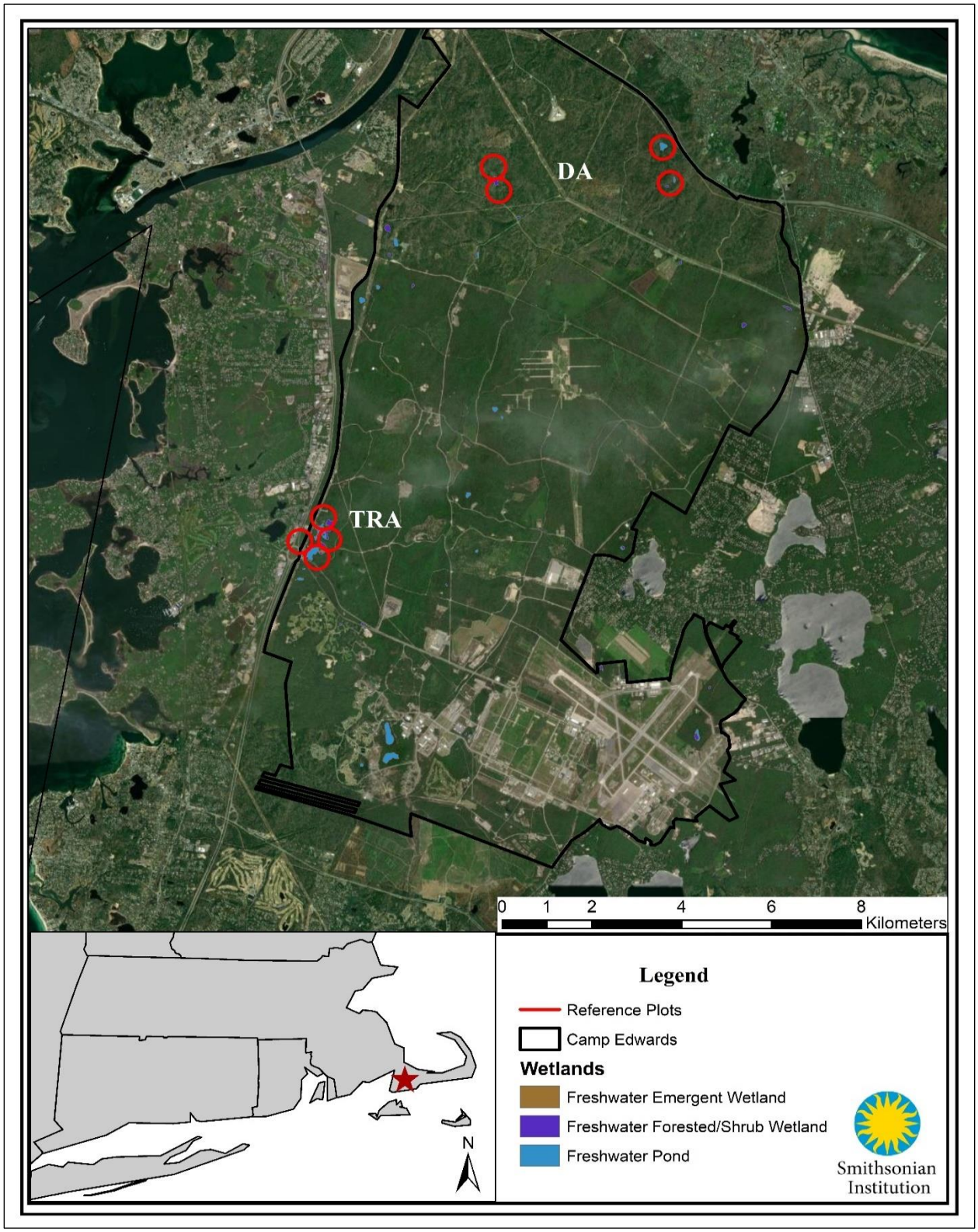


Figure 20. A map of Camp Edwards showing the geographic extent of wetland types and reference plot locations for a DA and Trap Rapid Assessment (TRA) regimes in 2021.

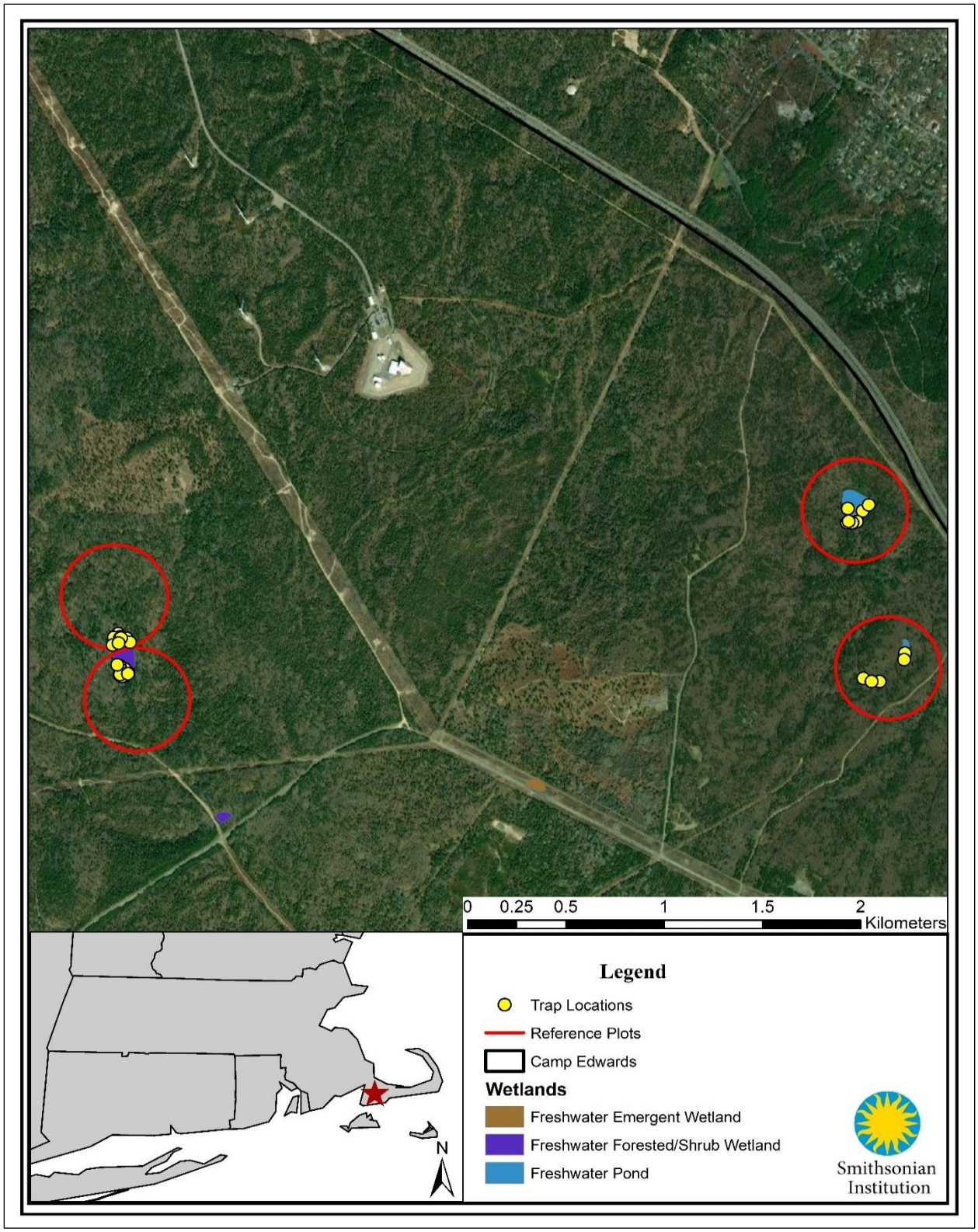


Figure 21. A map of Camp Edwards showing the wetland types and reference plots with trapping locations for a DA in 2021.

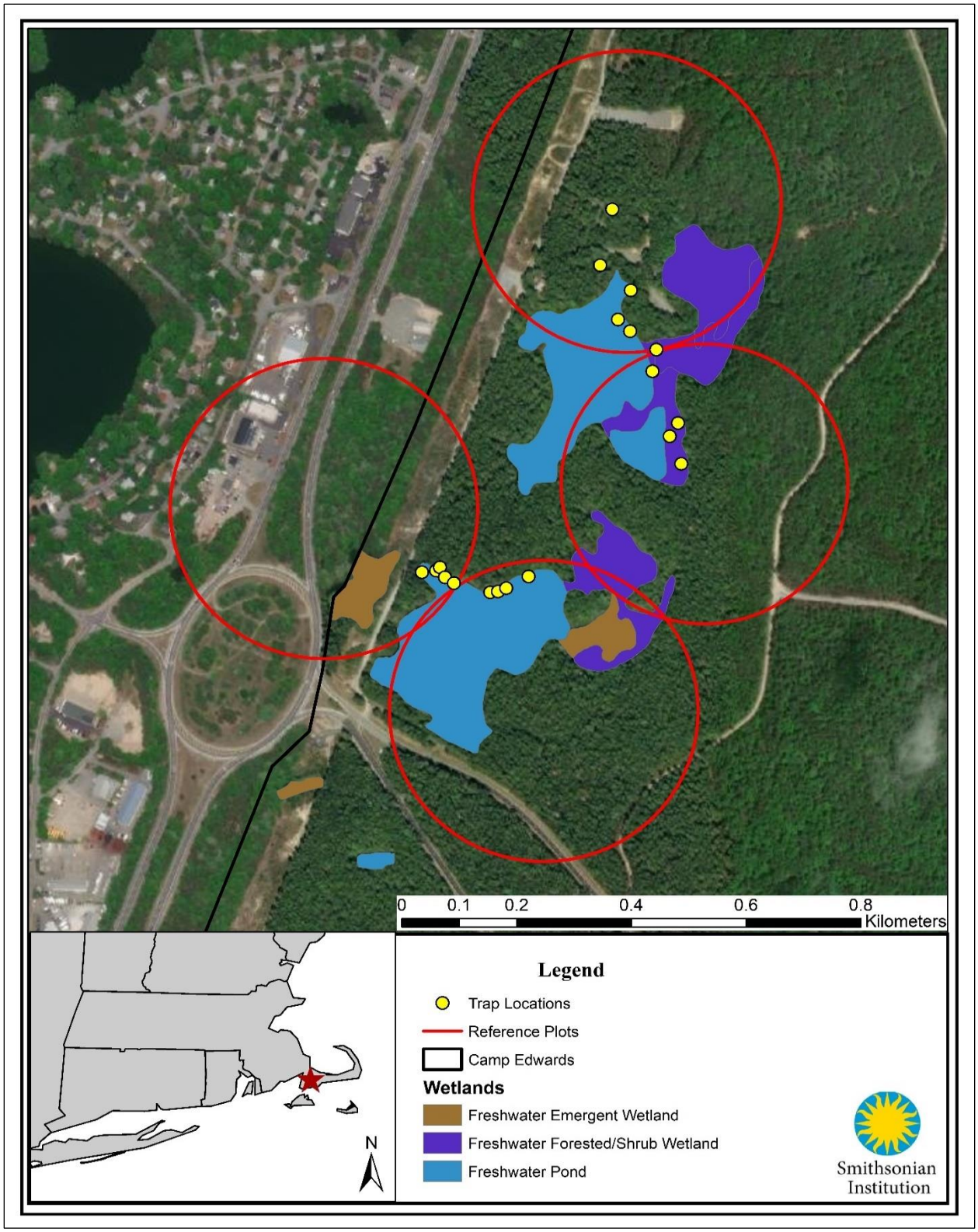


Figure 22. A map of Camp Edwards showing the wetland types and reference plots with trapping locations for a TRA in 2021.

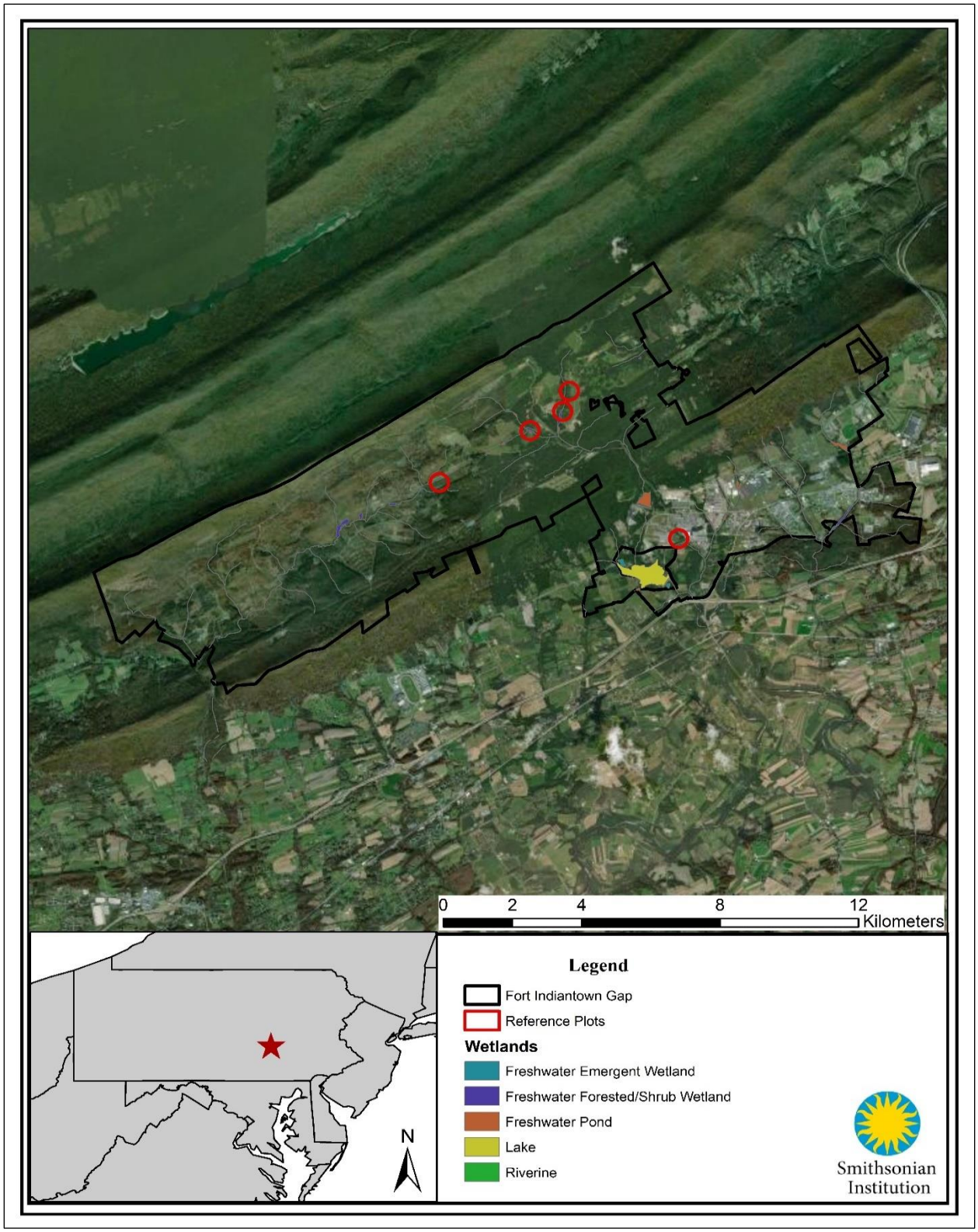


Figure 23. A map of Fort Indiantown Gap showing the geographic extent of wetland types and reference plot locations for a modified DA in 2021.

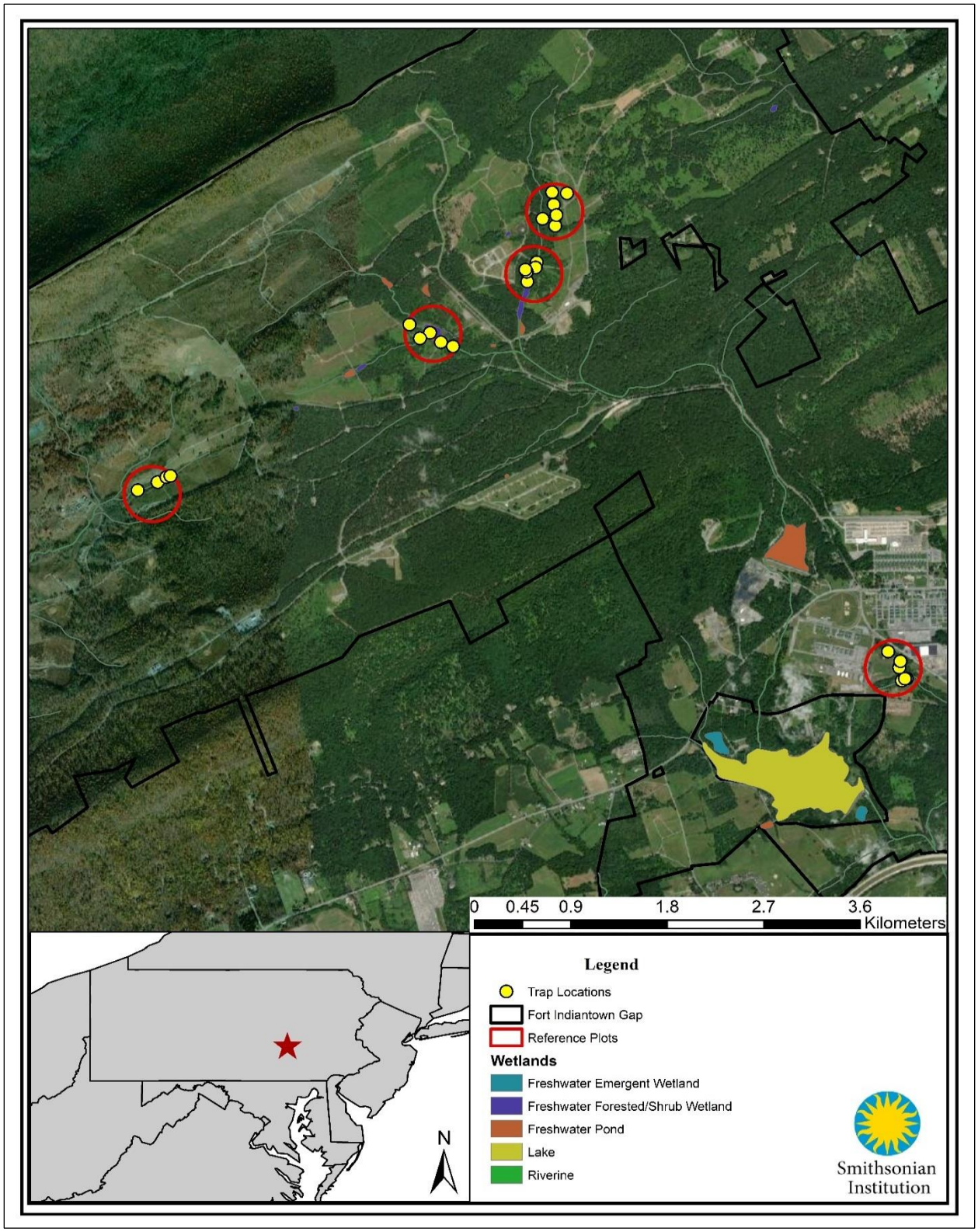


Figure 24. A map of Fort Indiantown Gap showing the wetland types and reference plots with trapping locations for a modified DA in 2021.

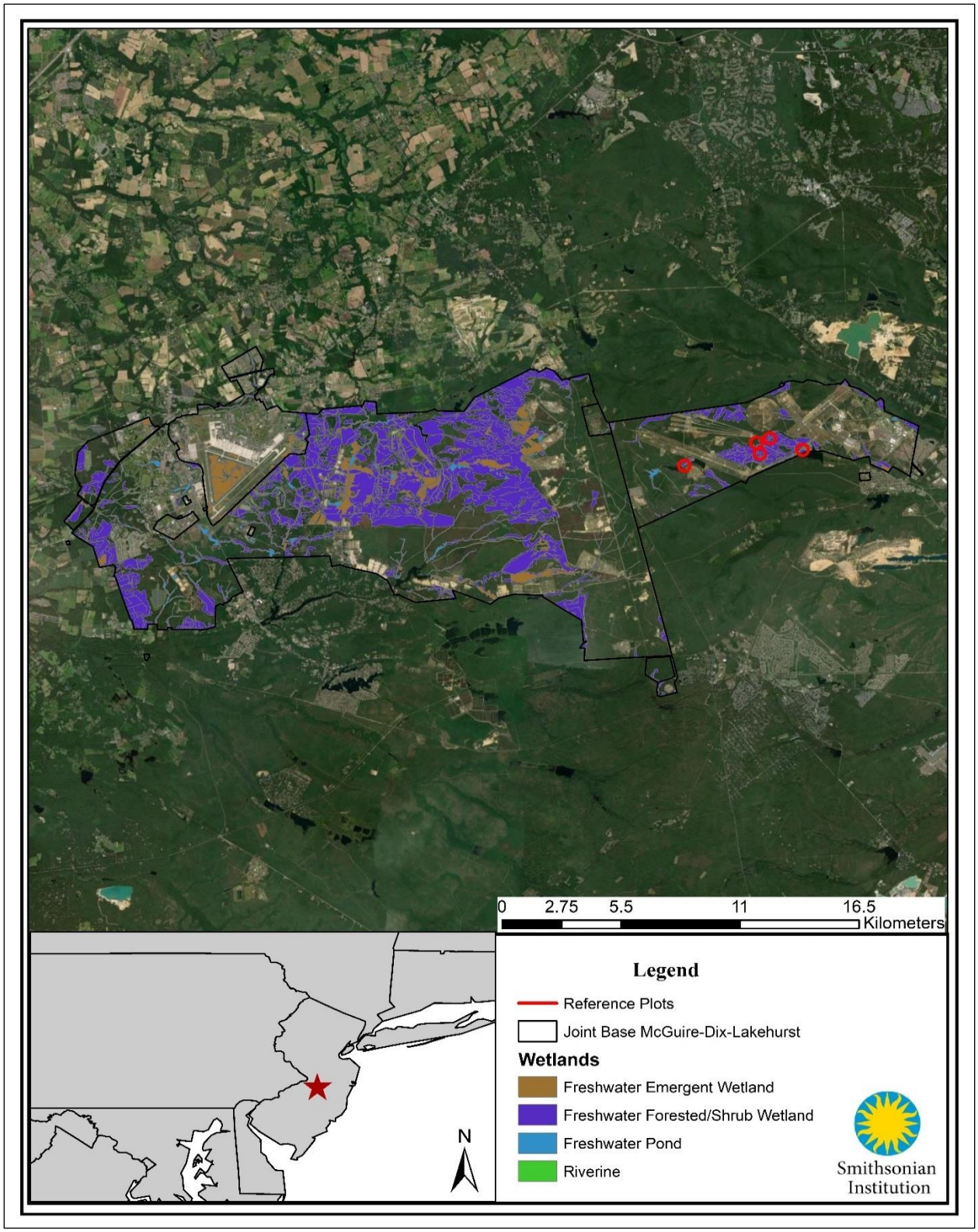


Figure 25. A map of Joint Base McGuire-Dix-Lakehurst showing the wetland types and reference plots for DA and TRA regimes in 2021.

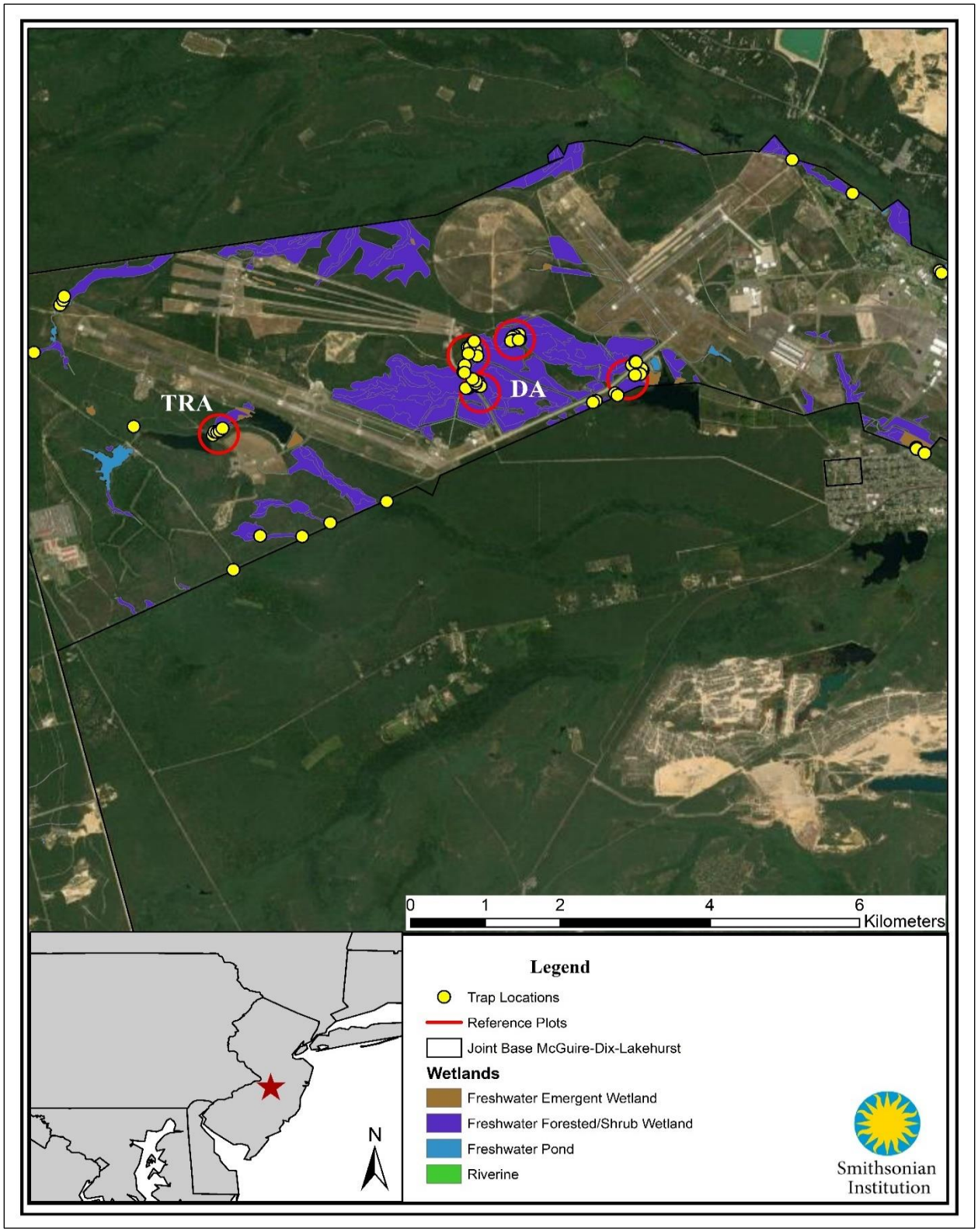


Figure 26. A map of Joint Base McGuire-Dix-Lakehurst showing the wetland types and reference plots with trapping locations for DA and TRA regimes, as well as inventory trapping (outside of reference plots), in 2021.

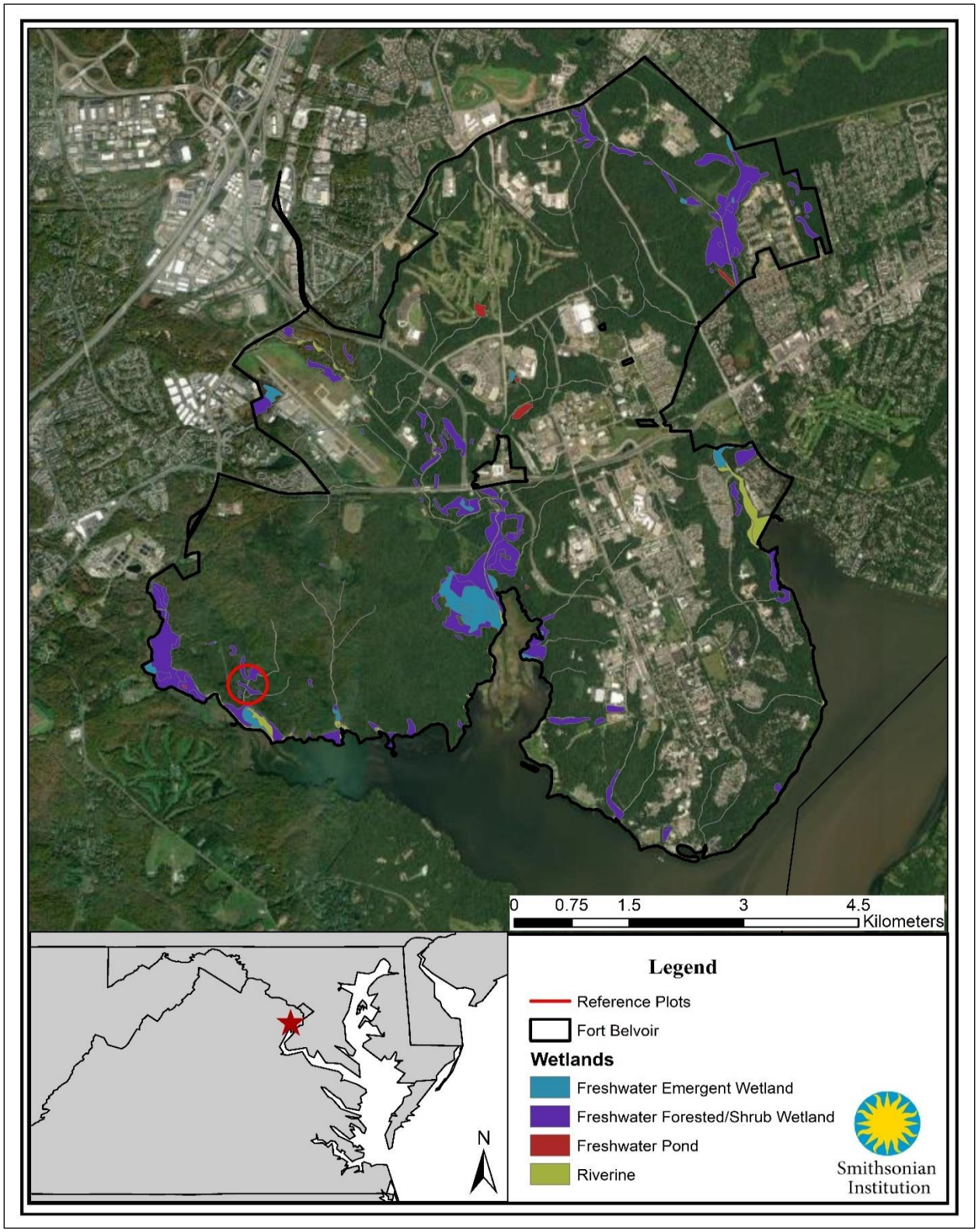


Figure 27. A map of Fort Belvoir showing the geographic extent of wetland types and reference plot locations for a high-density (HD) TRA in 2021.

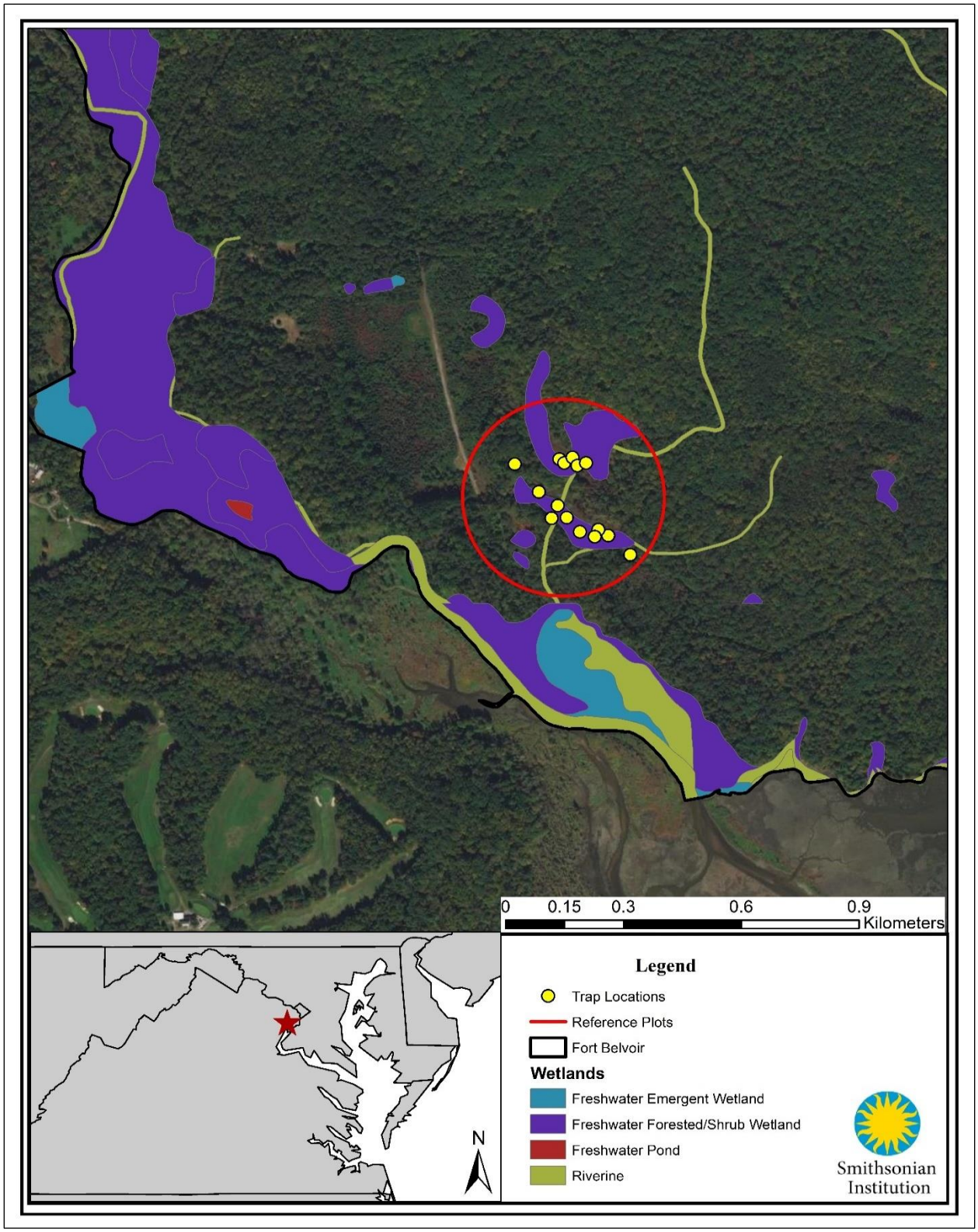


Figure 28. A map of Fort Belvoir showing the wetland types and reference plots with trapping locations for a HD-TRA in 2021.

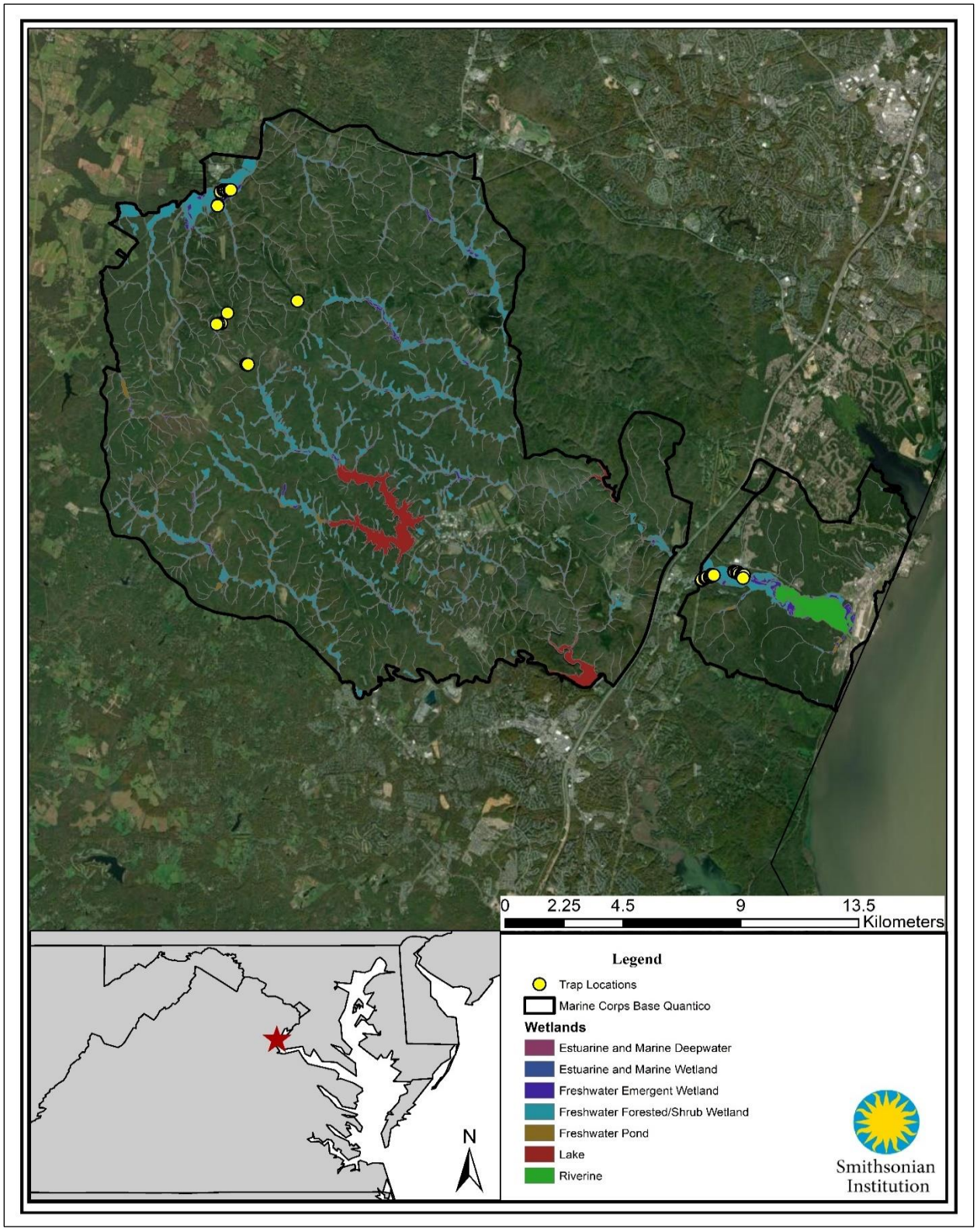


Figure 29. A map of Marine Corps Base Quantico showing the geographic extent of wetland types and locations of a TRA (eastern cluster) and inventory trapping (northwestern clusters) in 2021.

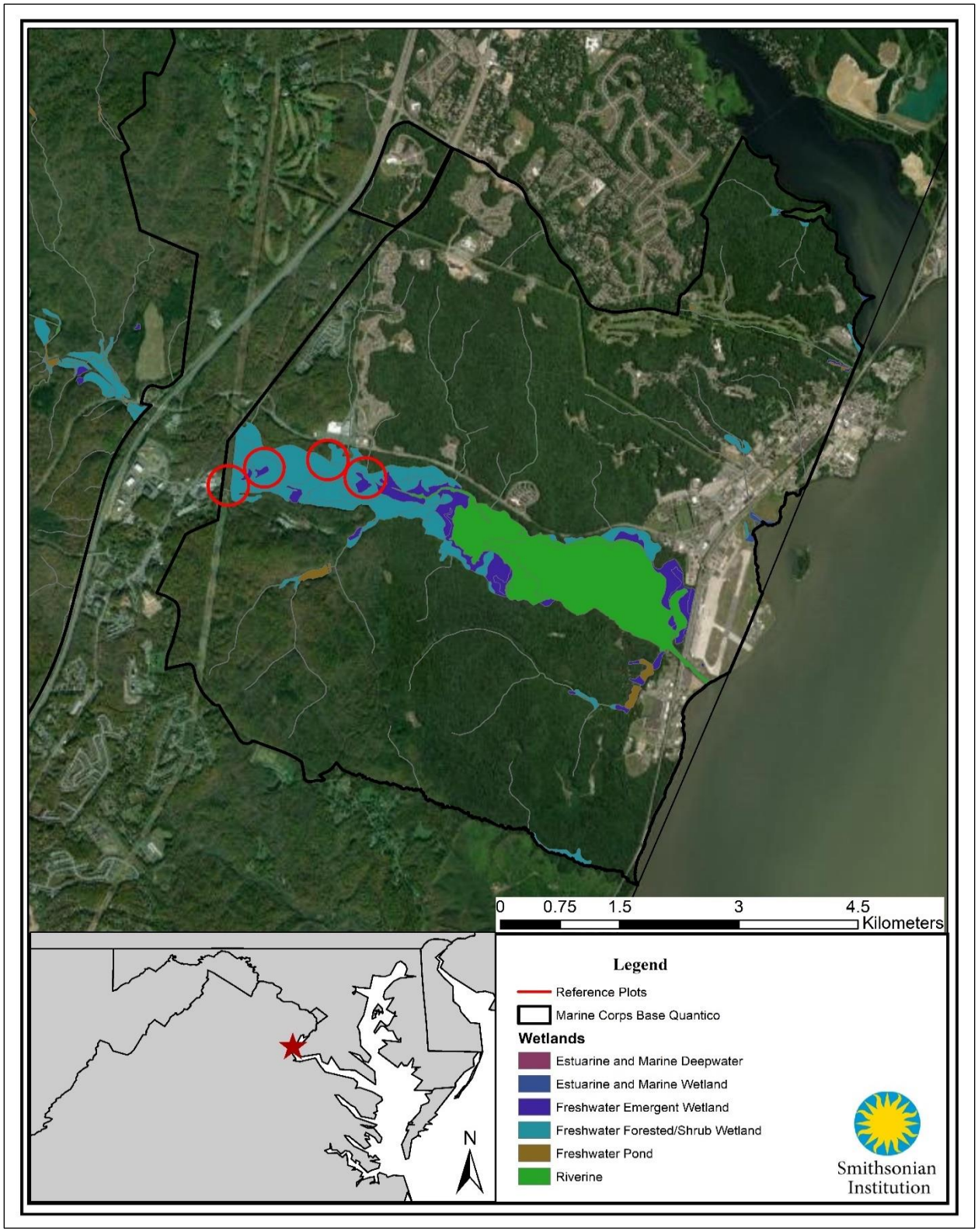


Figure 30. A map of Marine Corps Base Quantico showing the wetland types and reference plots for a TRA in 2021.

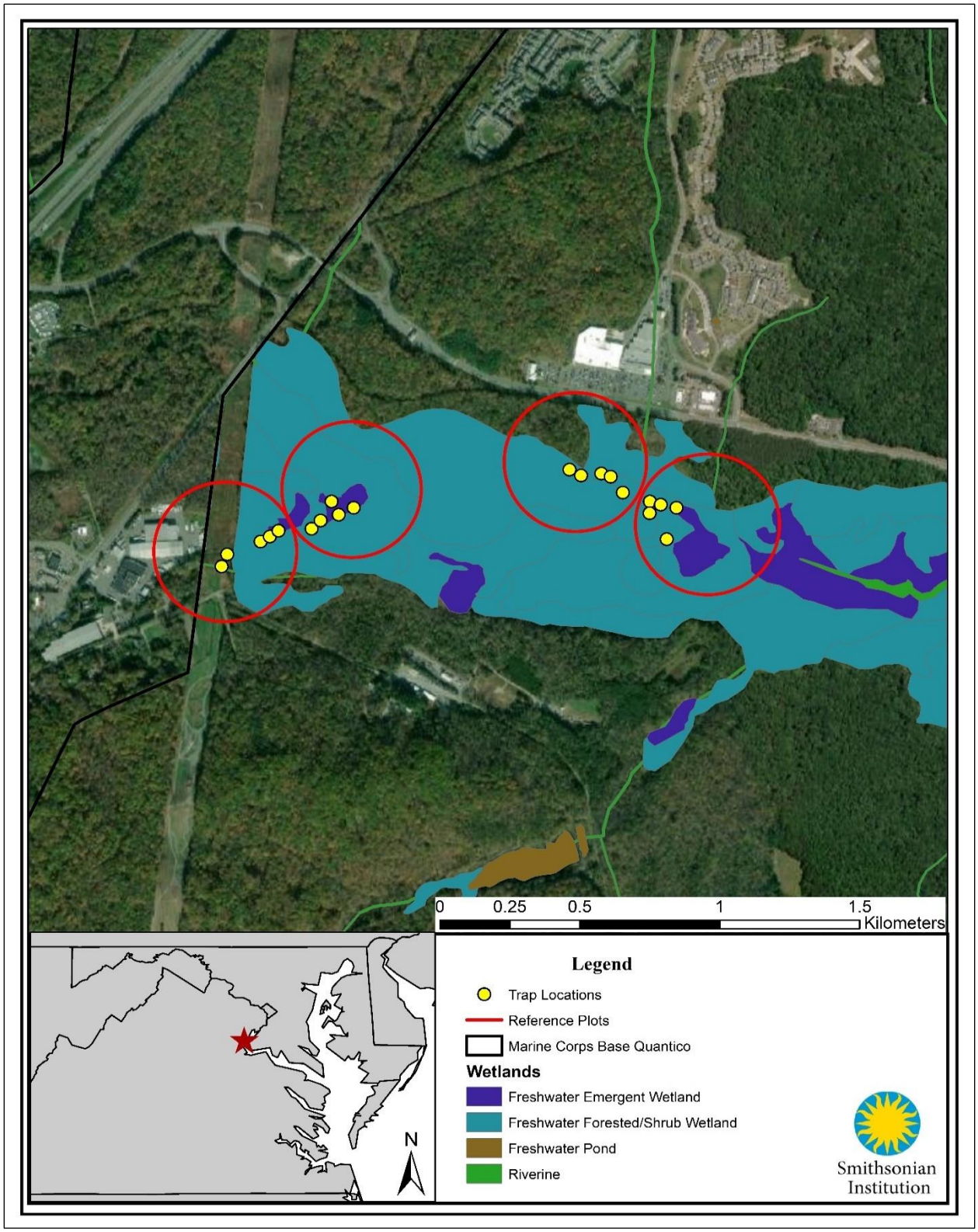


Figure 31. A map of Marine Corps Base Quantico showing the wetland types and reference plots with trapping locations for a TRA in 2021.

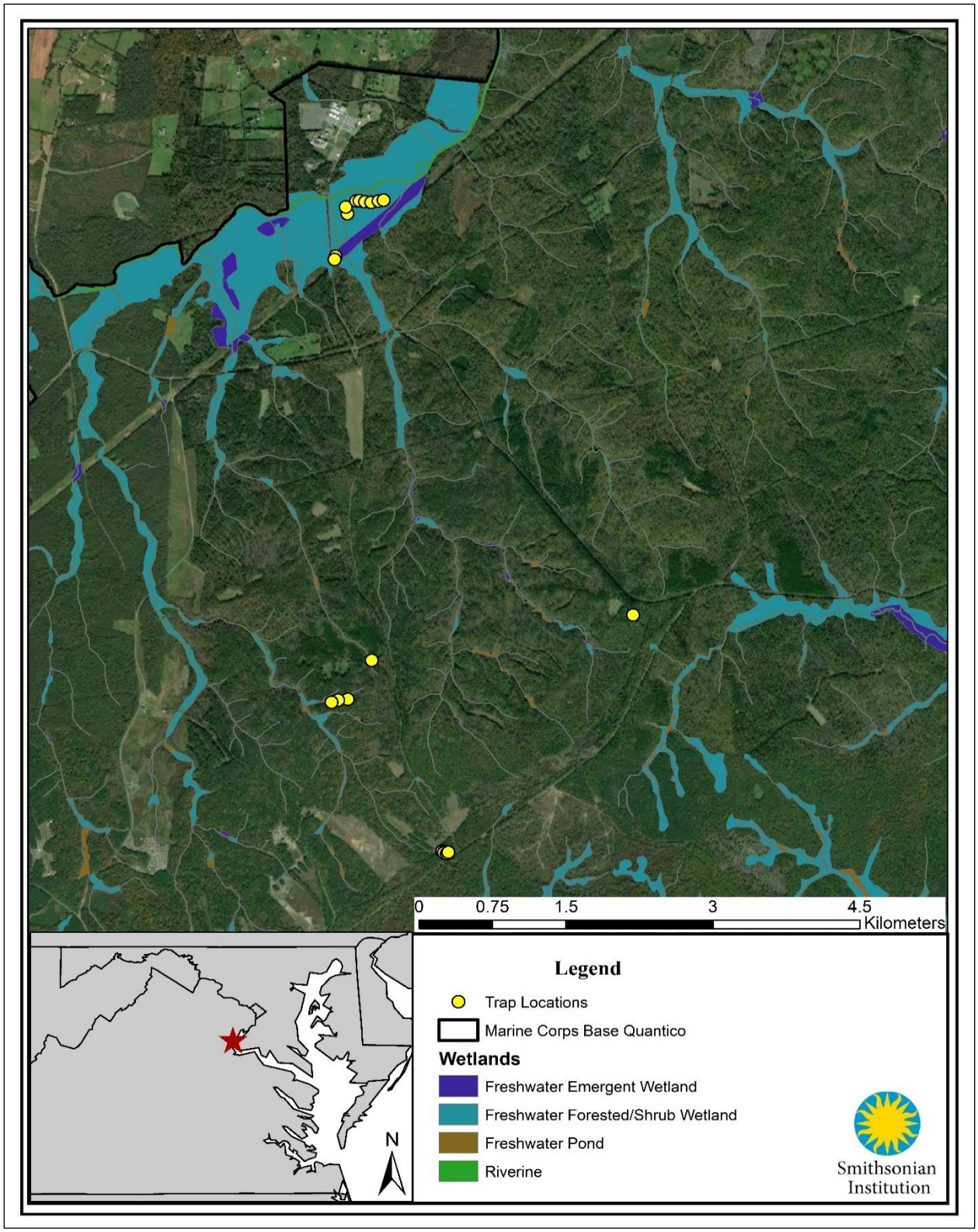


Figure 32. A map of Marine Corps Base Quantico showing the wetland types and locations of inventory trapping in 2021.

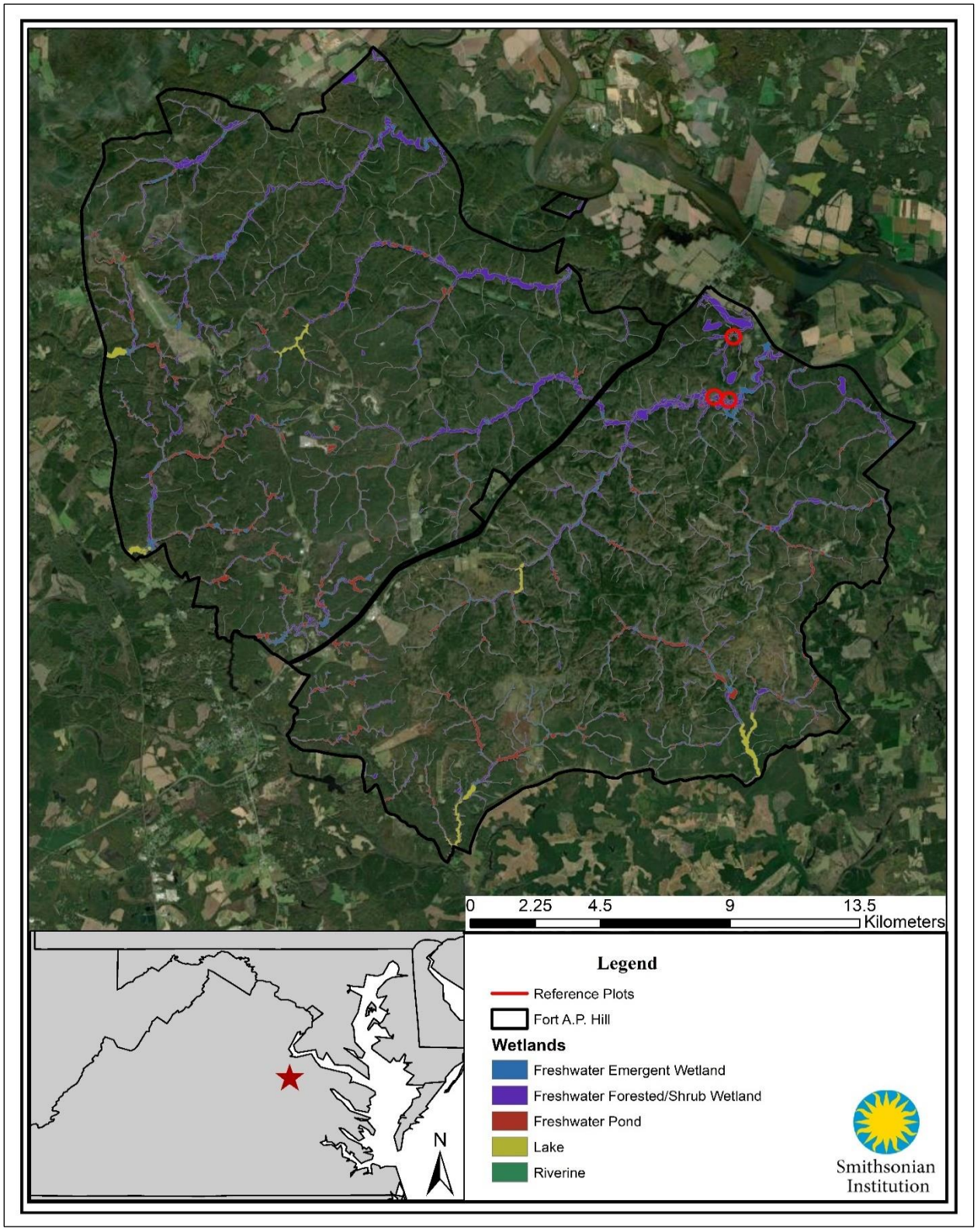


Figure 33. A map of Fort A.P. Hill showing the geographic extent of wetland types and reference plot locations for standard and modified TRA and HD-TRAs in 2019 and 2021.

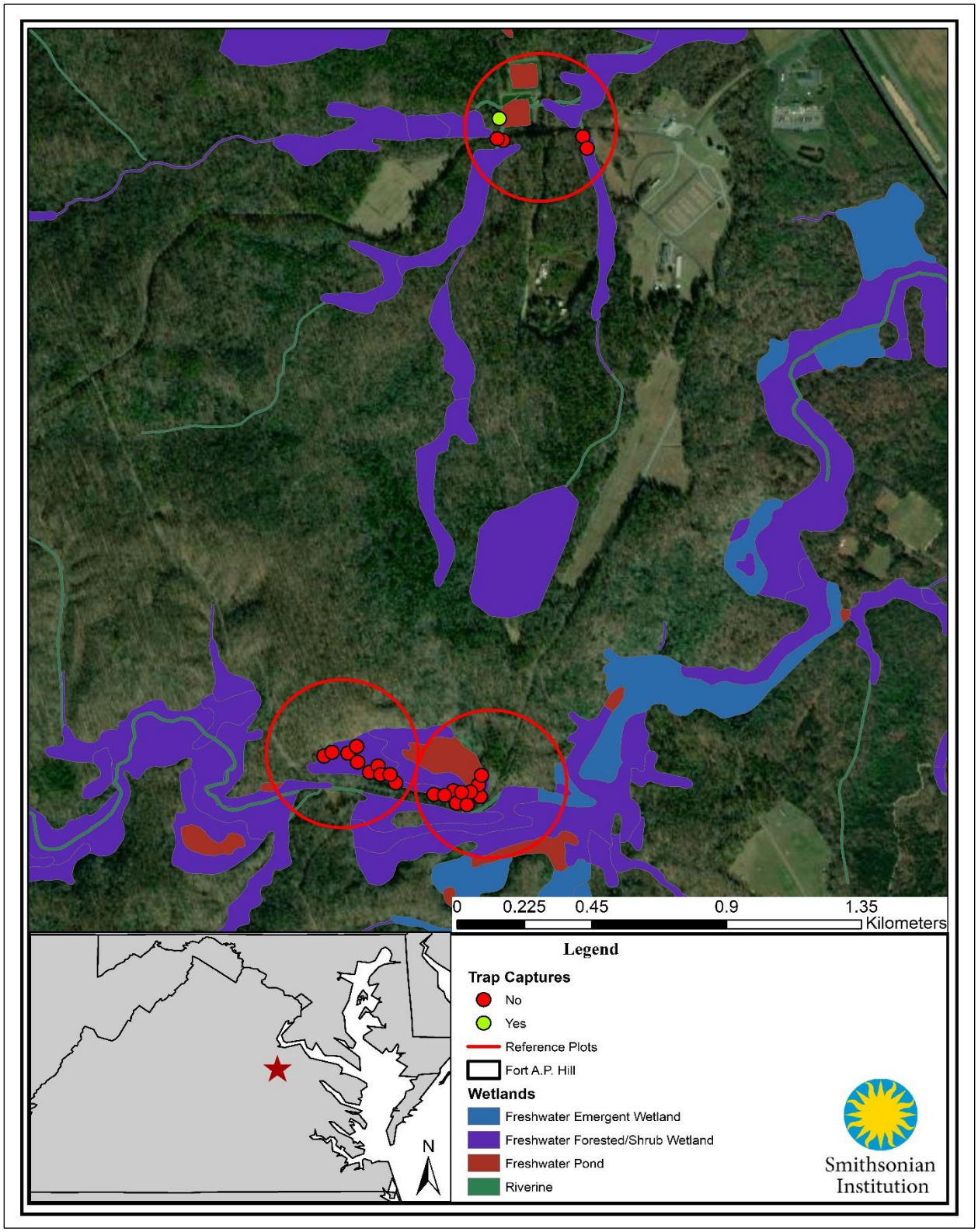


Figure 34. A map of Fort A.P. Hill showing the wetland types and reference plots with trapping locations for a modified TRA (northern plot) and a HD-TRA (southern plots) and in 2021. The single trapping location with positive returns is shown in green.

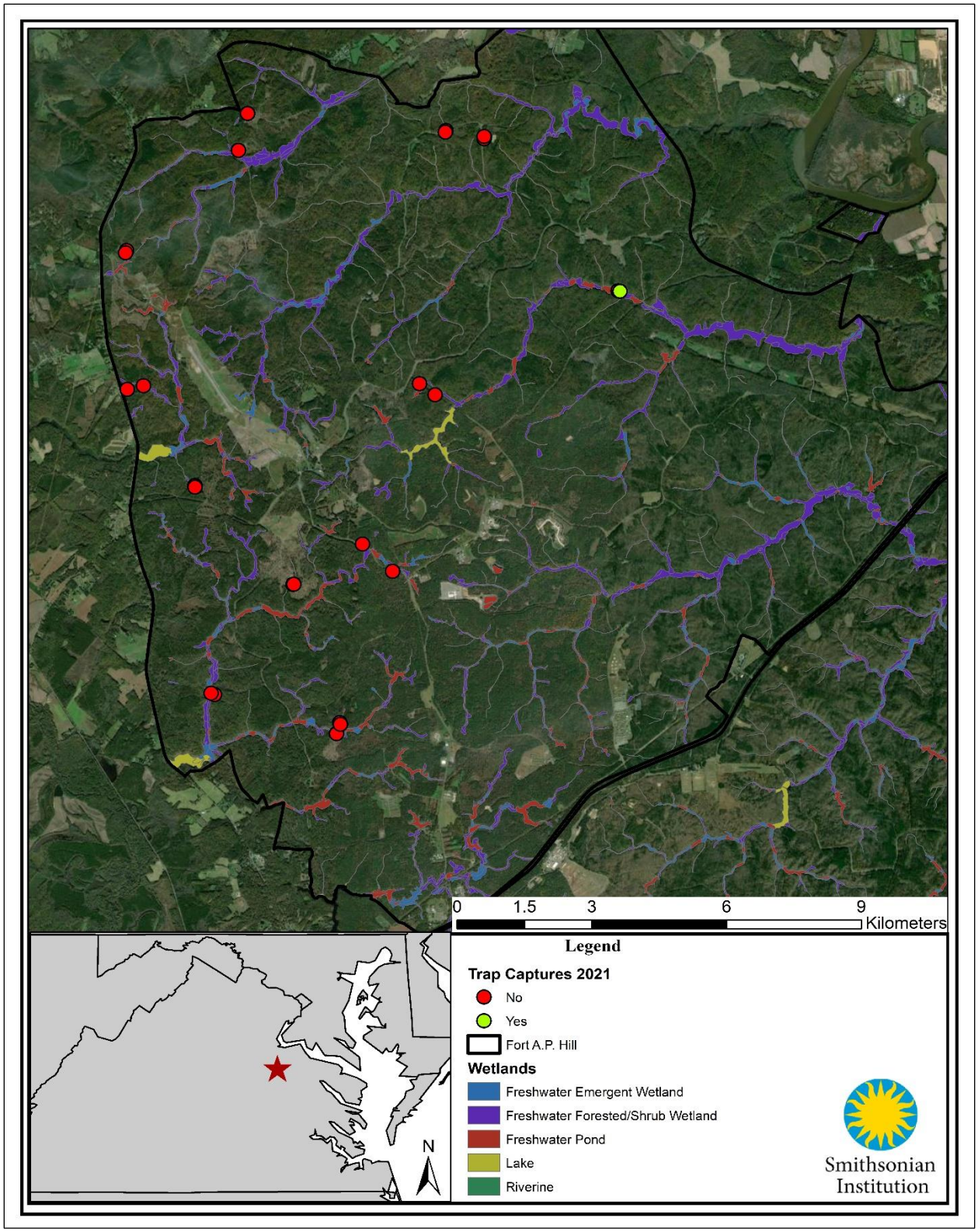


Figure 35. A map of Fort A.P. Hill showing the wetland types and locations of inventory trapping in 2021. The single trapping location with positive returns is shown in green.

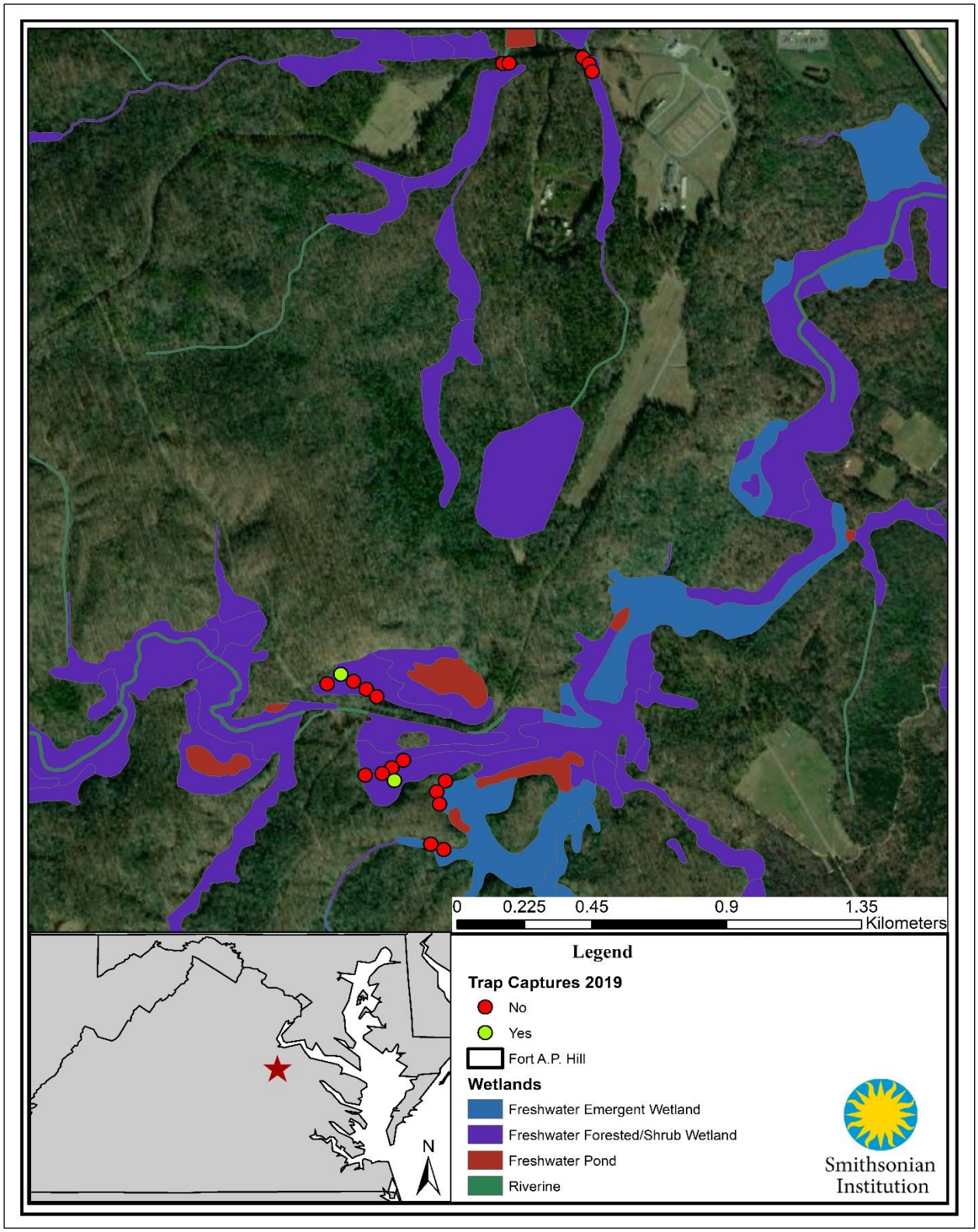


Figure 36. A map of Fort A.P. Hill showing the wetland types and TRA locations in 2019. The trapping locations with positive returns are shown in green.

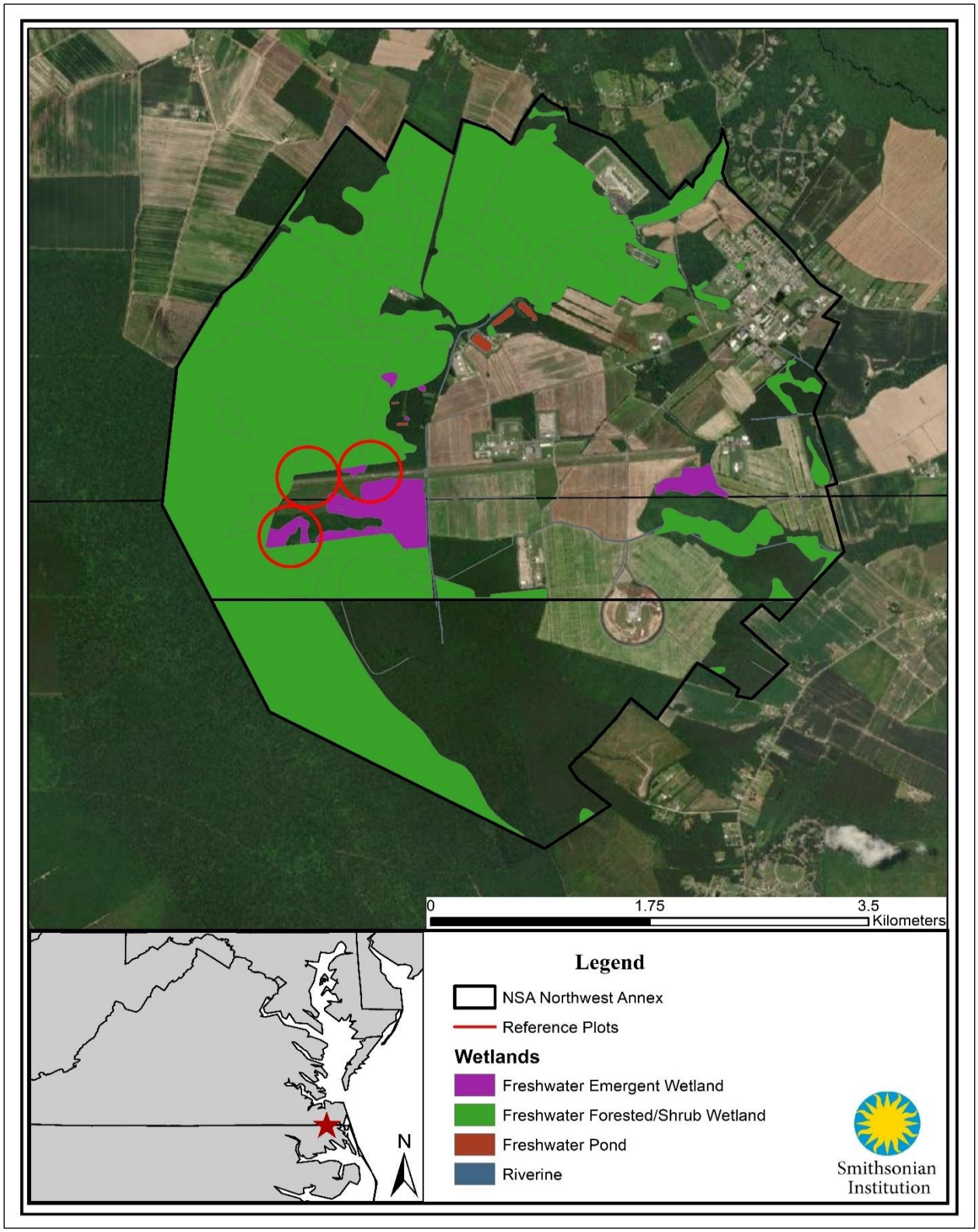


Figure 37. A map of Naval Support Activity Northwest Annex showing the geographic extent of wetland types and reference plot locations for a TRA in 2021.

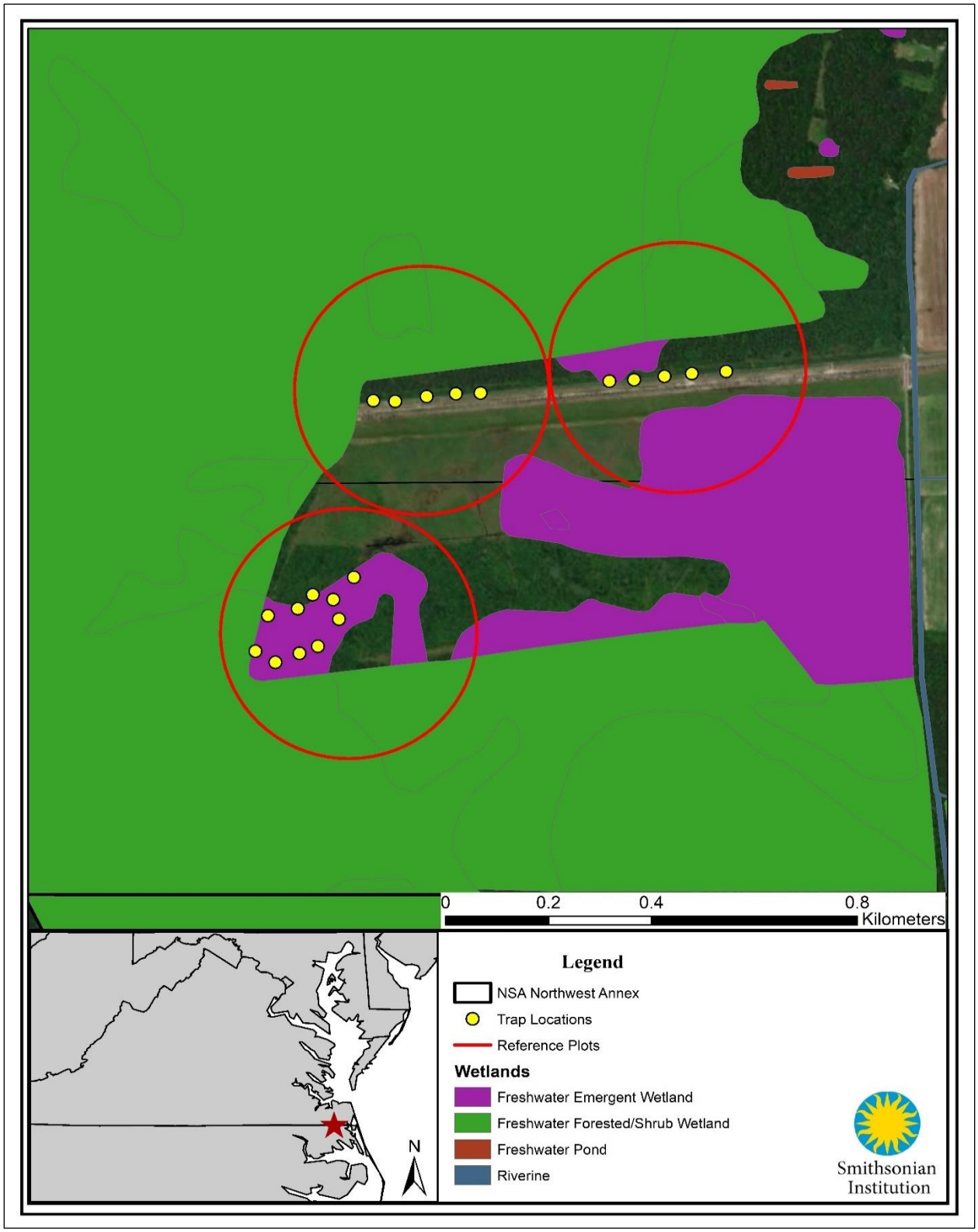


Figure 38. A map of Naval Support Activity Northwest Annex showing the wetland types and reference plots with trapping locations for a TRA in 2021.

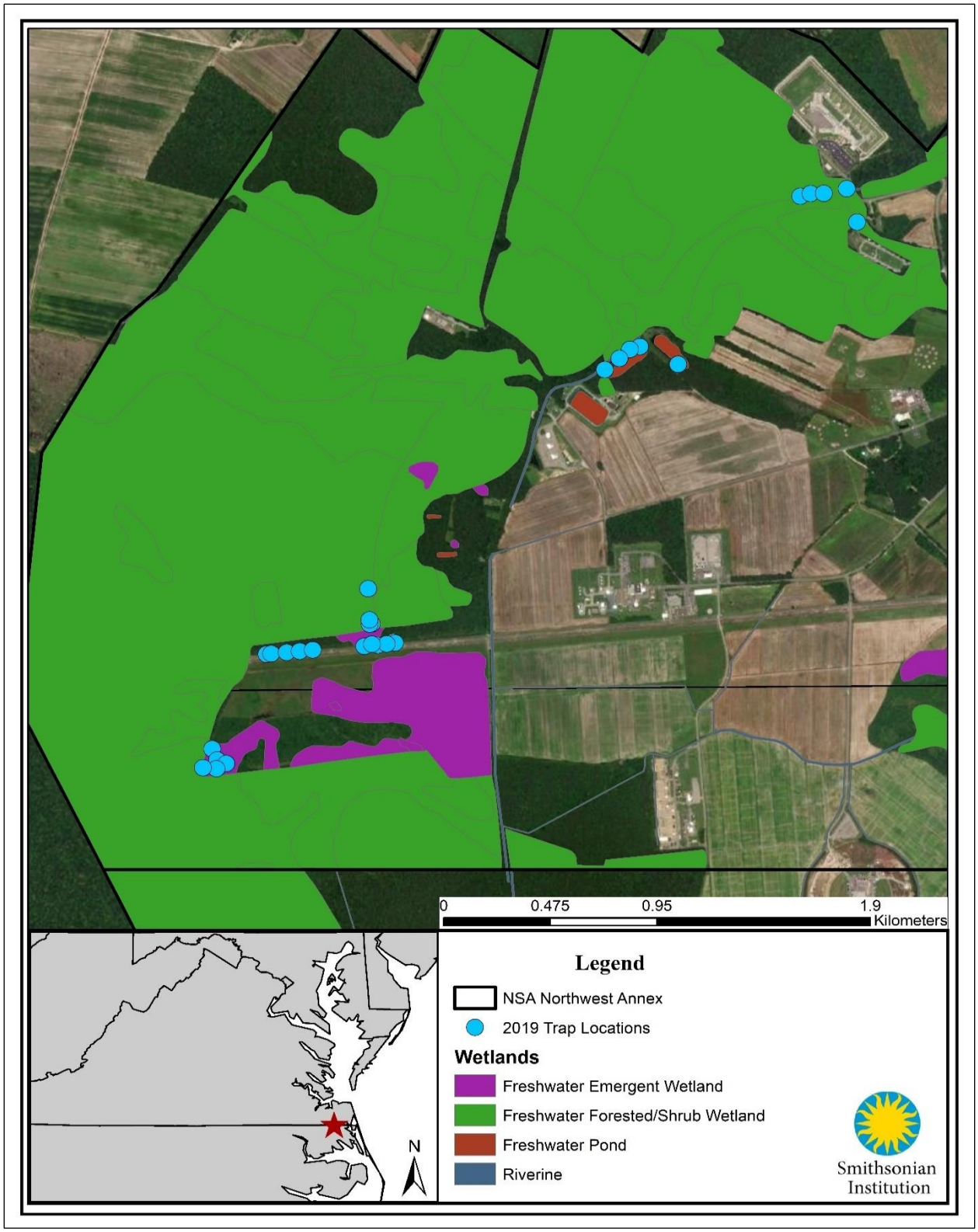


Figure 39. A map of Naval Support Activity Northwest Annex showing the wetland types and TRA locations in 2019.

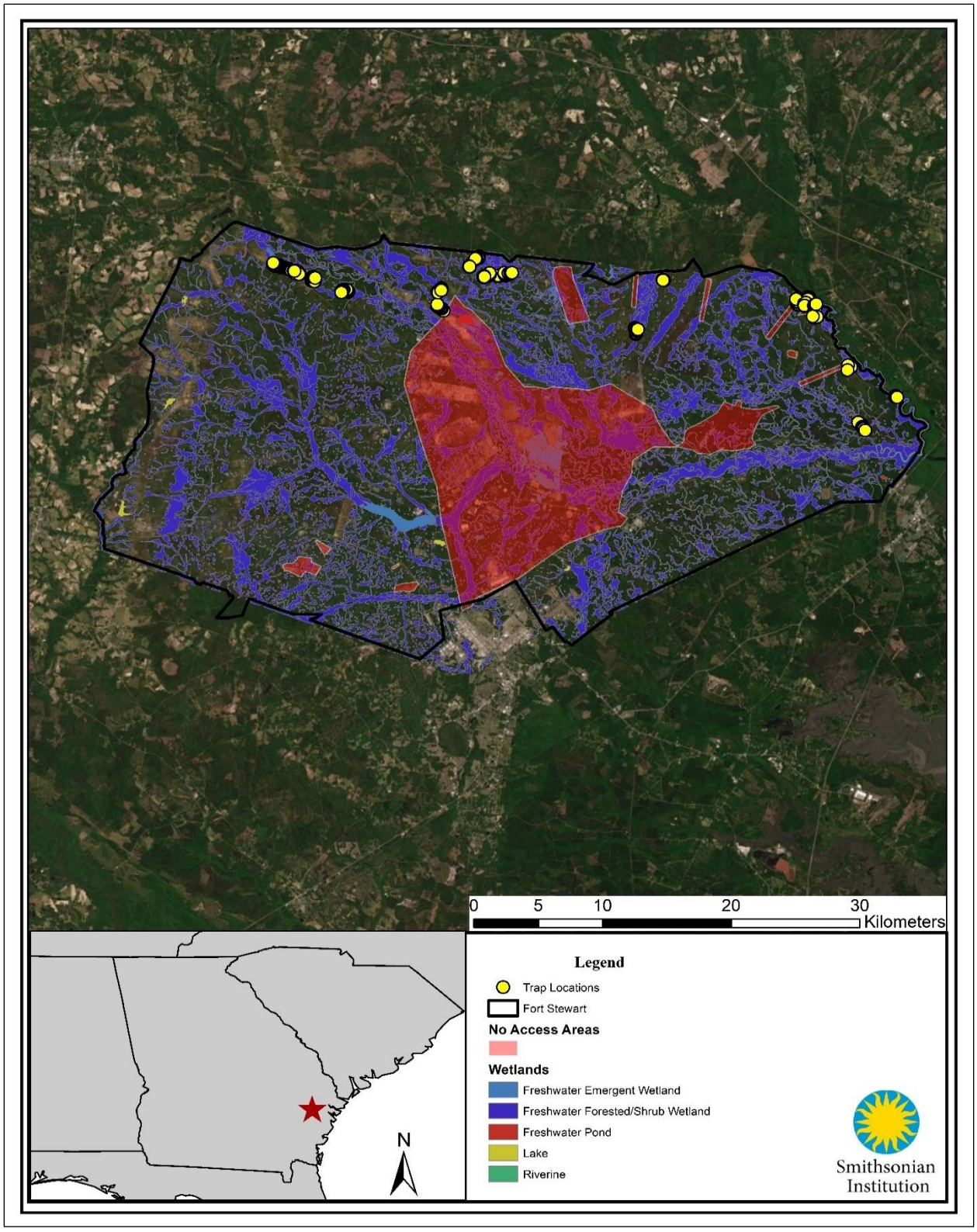


Figure 40. A map of Fort Stewart showing the geographic extent of wetland types and 12 TRA locations in 2021.

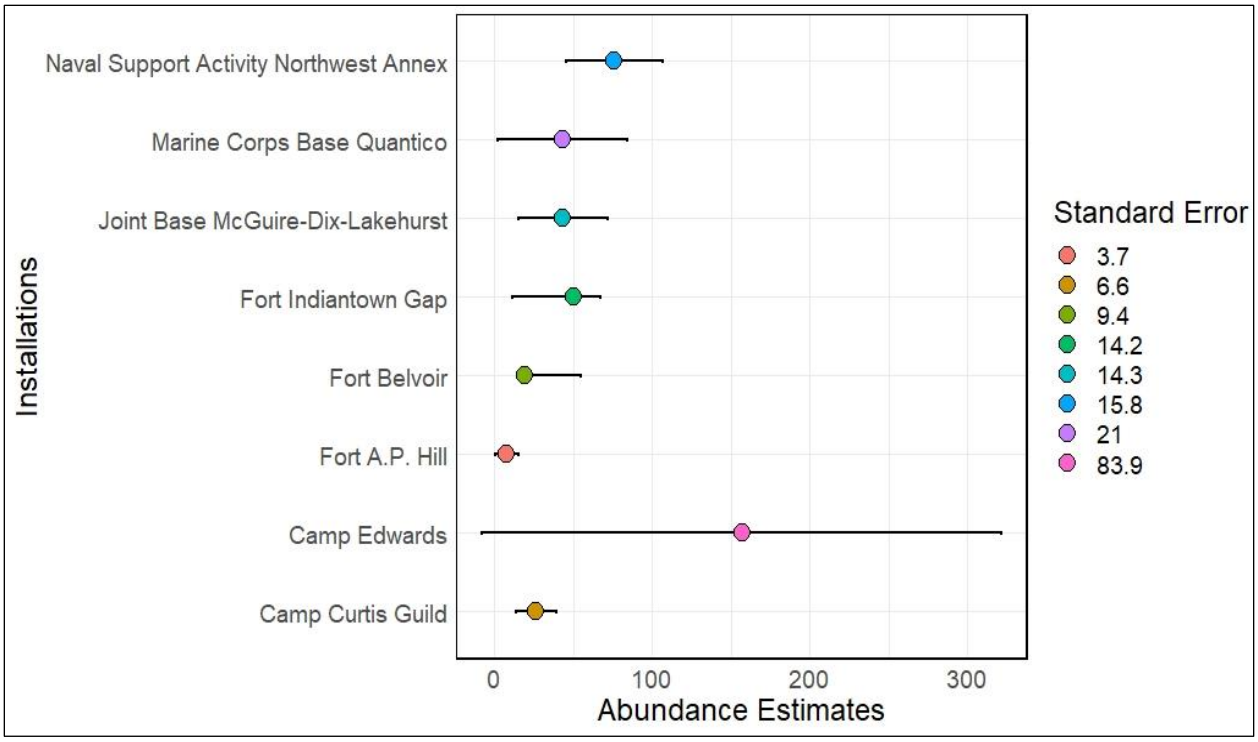


Figure 41. Population abundance estimates with standard error for eight participating DoD installations with sufficient capture data. Fort Steward Georgia is not included because no Spotted Turtles were captured. Note the relatively large estimates of population and standard error for Camp Edwards.

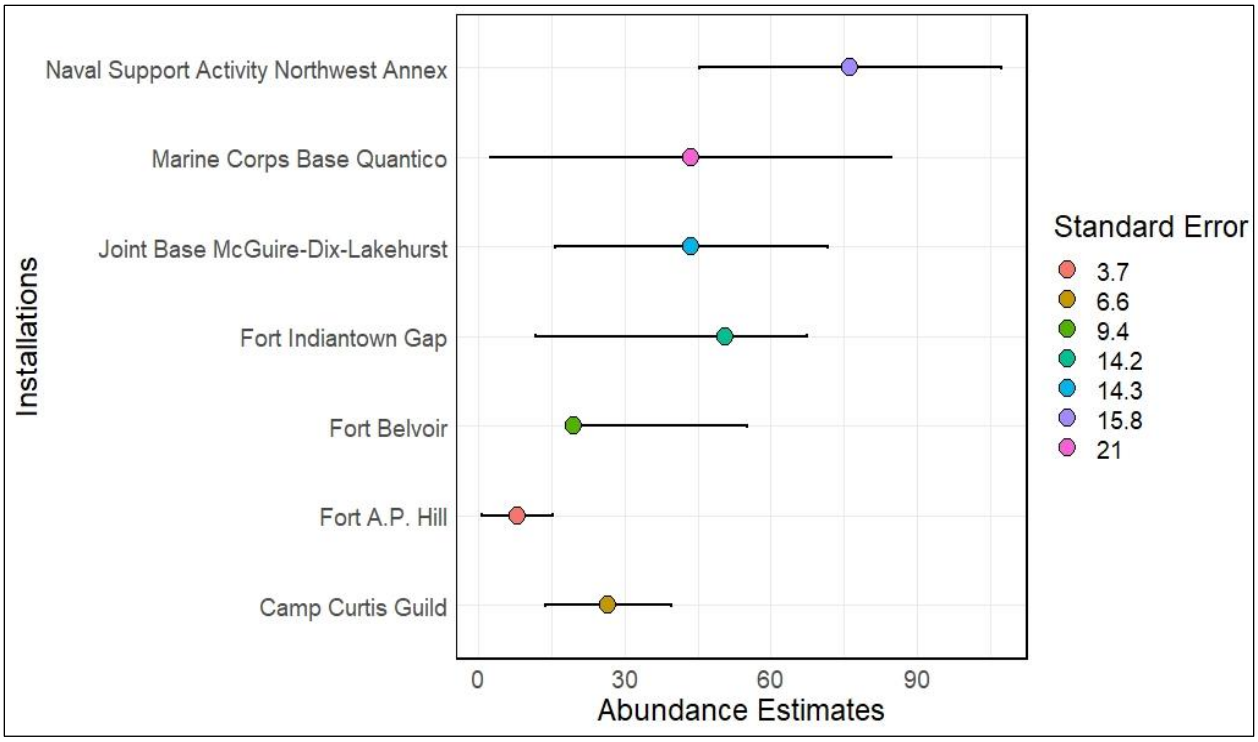


Figure 42. Population abundance estimates with standard error for seven participating DoD installations with sufficient capture data. Camp Edwards was not included because of a relatively large standard error of the abundance estimate (see Fig. 41).

APPENDICES

Appendix A. Trap Set Field Form

Appendix B. Trap Check Field Form

Appendix C. Spotted Turtle Individual Form

Appendix D. R code for population abundance estimation

Appendix E. Best Management Practices

Appendix A. Trap Set Field Form

Spotted Turtle Trap Assessment	☐ TRA	Observer(s):	Site Code:
2019 TRAP SET FIELD FORM (2/24/2019)	☐ DA	Site Name:	
Ref Pt # (circle): 1 2 3 4	Date set:	Date pulled:	
Bait type: ☐sardines ☐catfood ☐none ☐other:_____	Trap event: ☐1st ☐2nd ☐3rd ☐TRA		

Trap #1	Coord. (dd.dddd, -dd.dddd):		
Time set:	H20 depth (m):	**Habitat (within 5m)**	% canopy cov.:
Trap type: ☐ ProMar ☐w/hard sides ☐Crab ☐D ☐Other.		% em. herb. cov:	% sub. herb cov.:
Dominant Sp (5m):	Dist. Upland(m):	Wetland type: ↓	% shrub cov.:
		☐ VP ☐ em ☐ ss ☐ d fo wet ☐ pond ☐ riv ☐ ditch ☐ wetland ecotone ☐ other :	

Trap #2	Coord. (dd.dddd, -dd.dddd):		
Time set:	H20 depth (m):	**Habitat (within 5m)**	% canopy cov.:
Trap type: ☐ ProMar ☐w/hard sides ☐Crab ☐D ☐Other		% em. herb. cov:	% sub. herb cov.:
Dominant Sp (5m):	Dist. Upland(m):	Wetland type: ↓	% shrub cov.:
		☐ VP ☐ em ☐ ss ☐ d fo wet ☐ pond ☐ riv ☐ ditch ☐ wetland ecotone ☐ other :	

Trap #3	Coord. (dd.dddd, -dd.dddd):		
Time set:	H20 depth (m):	**Habitat (within 5m)**	% canopy cov.:
Trap type: ☐ ProMar ☐w/hard sides ☐Crab ☐D ☐Other		% em. herb. cov:	% sub. herb cov.:
Dominant Sp (5m):	Dist. Upland(m):	Wetland type: ↓	% shrub cov.:
		☐ VP ☐ em ☐ ss ☐ d fo wet ☐ pond ☐ riv ☐ ditch ☐ wetland ecotone ☐ other :	

Trap #4	Coord. (dd.dddd, -dd.dddd):		
Time set:	H20 depth (m):	**Habitat (within 5m)**	% canopy cov.:
Trap type: ☐ ProMar ☐w/hard sides ☐Crab ☐D ☐Other		% em. herb. cov:	% sub. herb cov.:
Dominant Sp (5m):	Dist. Upland(m):	Wetland type: ↓	% shrub cov.:
		☐ VP ☐ em ☐ ss ☐ d fo wet ☐ pond ☐ riv ☐ ditch ☐ wetland ecotone ☐ other :	

Trap #5	Coord. (dd.dddd, -dd.dddd):		
Time set:	H20 depth (m):	**Habitat (within 5m)**	% canopy cov.:
Trap type: ☐ ProMar ☐w/hard sides ☐Crab ☐D ☐Other		% em. herb. cov:	% sub. herb cov.:
Dominant Sp (5m):	Dist. Upland(m):	Wetland type: ↓	% shrub cov.:
		☐ VP ☐ em ☐ ss ☐ d fo wet ☐ pond ☐ riv ☐ ditch ☐ wetland ecotone ☐ other :	

Spotted Turtle Trap Assessment	☐ TRA	Observer(s):	Site Code:
2019 TRAP SET FIELD FORM (2/24/2019)	☐ DA	Site Name:	
Ref Pt # (circle): 1 2 3 4	Date set:	Date pulled:	
Bait type: ☐sardines ☐catfood ☐none ☐other:_____	Trap event: ☐1st ☐2nd ☐3rd ☐TRA		

Trap #1	Coord. (dd.dddd, -dd.dddd):		
Time set:	H20 depth (m):	**Habitat (within 5m)**	% canopy cov.:
Trap type: ☐ ProMar ☐w/hard sides ☐Crab ☐D ☐Other		% em. herb. cov:	% sub. herb cov.:
Dominant Sp (5m):	Dist. Upland(m):	Wetland type: ↓	% shrub cov.:
		☐ VP ☐ em ☐ ss ☐ d fo wet ☐ pond ☐ riv ☐ ditch ☐ wetland ecotone ☐ other :	

Trap #2	Coord. (dd.dddd, -dd.dddd):		
Time set:	H20 depth (m):	**Habitat (within 5m)**	% canopy cov.:
Trap type: ☐ ProMar ☐w/hard sides ☐Crab ☐D ☐Other		% em. herb. cov:	% sub. herb cov.:
Dominant Sp (5m):	Dist. Upland(m):	Wetland type: ↓	% shrub cov.:
		☐ VP ☐ em ☐ ss ☐ d fo wet ☐ pond ☐ riv ☐ ditch ☐ wetland ecotone ☐ other :	

Trap #3	Coord. (dd.dddd, -dd.dddd):		
Time set:	H20 depth (m):	**Habitat (within 5m)**	% canopy cov.:
Trap type: ☐ ProMar ☐w/hard sides ☐Crab ☐D ☐Other		% em. herb. cov:	% sub. herb cov.:
Dominant Sp (5m):	Dist. Upland(m):	Wetland type: ↓	% shrub cov.:
		☐ VP ☐ em ☐ ss ☐ d fo wet ☐ pond ☐ riv ☐ ditch ☐ wetland ecotone ☐ other :	

Trap #4	Coord. (dd.dddd, -dd.dddd):		
Time set:	H20 depth (m):	**Habitat (within 5m)**	% canopy cov.:
Trap type: ☐ ProMar ☐w/hard sides ☐Crab ☐D ☐Other		% em. herb. cov:	% sub. herb cov.:
Dominant Sp (5m):	Dist. Upland(m):	Wetland type: ↓	% shrub cov.:
		☐ VP ☐ em ☐ ss ☐ d fo wet ☐ pond ☐ riv ☐ ditch ☐ wetland ecotone ☐ other :	

Trap #5	Coord. (dd.dddd, -dd.dddd):		
Time set:	H20 depth (m):	**Habitat (within 5m)**	% canopy cov.:
Trap type: ☐ ProMar ☐w/hard sides ☐Crab ☐D ☐Other		% em. herb. cov:	% sub. herb cov.:
Dominant Sp (5m):	Dist. Upland(m):	Wetland type: ↓	% shrub cov.:
		☐ VP ☐ em ☐ ss ☐ d fo wet ☐ pond ☐ riv ☐ ditch ☐ wetland ecotone ☐ other :	

Appendix B. Trap Check Field Form

Spotted Turtle Trap Assessment
2019 TRAP CHECK FIELD FORM (2/24/2019)

☐ TRA
☐ DA

Site Code/Name:

Observers:

Bait type used last night:

Check this column if the trap is not working. ↓

State:

Today's date:

Set date:

Check this column if predated by racoon ↓

Ref Pt	Trap #	# CLGU	List CLGU ID #s	Other turtle spp.			Other bycatch	↓	↓	Air Temp (C)	H20 Temp (C)
1	1										
	2										
	3										
	4										
	5										
2	1										
	2										
	3										
	4										
	5										
3	1										
	2										
	3										
	4										
	5										
4	1										
	2										
	3										
	4										
	5										

Comments (include additional notes on bycatch, if necessary):

Spotted Turtle Trap Assessment
2019 TRAP CHECK FIELD FORM (2/24/2019)

☐ TRA
☐ DA

Site Code/Name:

Observers:

Bait type used last night:

Check this column if the trap is not working. ↓

State:

Today's date:

Set date:

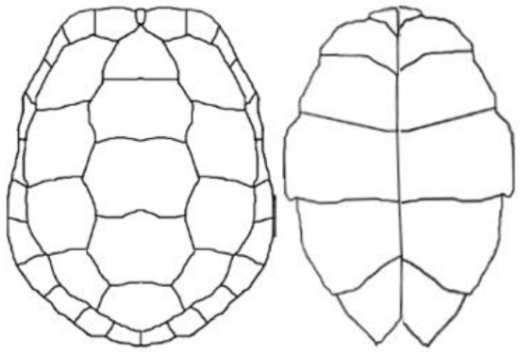
Check this column if predated by racoon ↓

Ref Pt	Trap #	# CLGU	List CLGU ID #s	Other turtle spp.			Other bycatch	↓	↓	Air Temp (C)	H20 Temp (C)
1	1										
	2										
	3										
	4										
	5										
2	1										
	2										
	3										
	4										
	5										
3	1										
	2										
	3										
	4										
	5										
4	1										
	2										
	3										
	4										
	5										

Comments (include addtn notes on bycatch, if necessary):

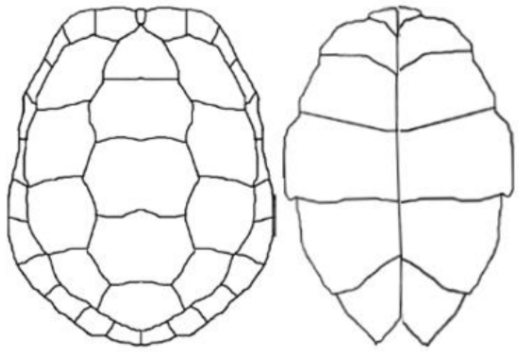
Appendix C. Spotted Turtle Individual Form

Spotted Turtle Individual Form (2/24/19)		Site Name:	
		Site Code:	
Observer(s):			
Turtle ID# :	Date:	Time:	
Cap. Method: ☐Hand ☐Trap →	Ref. # (circle): 1 2 3 4	Trap #:	
Sex:	Coordinates (dd.dddd):		
↓☐meas. ☐notched ☐tissue ☐photos ☐PIT↓			
SCLmin (mm):	PIT number:		
SPLmin (mm):		Wear class: ☐ not worn	
CW (optional):	Photo file names:		☐≤50% worn
PW (optional):	Visible annuli:		☐>50% worn
SH (optional):	General health: ☐ lethargy		☐≥ 90%worn
Mass(g):	☐ URT distress ☐sores ☐other:		
Scute morphology:	Injuries: ☐ tail ☐eye ☐limb (specify)		
☐normal ☐irregular	☐ initial capture (never marked before)		
(specify or mark below)	☐ previously marked → ☐In 2018/2019 ☐Before 2018		
	☐ gravid ☐ not gravid		
Indicate notches and record marks or injuries:			



Comments:

Spotted Turtle Individual Form (2/24/19)		Site Name:	
		Site Code:	
Observer(s):			
Turtle ID# :	Date:	Time:	
Cap. Method: ☐Hand ☐Trap →	Ref. # (circle): 1 2 3 4	Trap #:	
Sex:	Coordinates (dd.dddd):		
↓☐meas. ☐notched ☐tissue ☐photos ☐PIT↓			
SCLmin (mm):	PIT number:		
SPLmin (mm):		Wear class: ☐ not worn	
CW (optional):	Photo file names:		☐≤50% worn
PW (optional):	Visible annuli:		☐>50% worn
SH (optional):	General health: ☐ lethargy		☐≥ 90%worn
Mass(g):	☐ URT distress ☐sores ☐other:		
Scute morphology:	Injuries: ☐ tail ☐eye ☐limb (specify)		
☐normal ☐irregular	☐ initial capture (never marked before)		
(specify or mark below)	☐ previously marked → ☐In 2018/2019 ☐Before 2018		
	☐ gravid ☐ not gravid		
Indicate notches and record marks or injuries:			



Comments:

Appendix D. R code for population abundance estimation

```
##install.packages("Rcapture")
library(Rcapture) #load Rcapture package into your current working space
library(readr)
setwd("C:/CMR/SCBI_Sites") #set working directory

?closedp.bc #best fit M0, applies a bias correction to the abundance estimations obtained by closed population models

#calculating population estimates
#MACPED
Camp_Edwards <- read_csv("Camp_Edwards.csv")
Camp_Edwards<-Camp_Edwards[,4:12]
closedp.bc(Camp_Edwards)

#MACCG
Camp_Curtis_Guild <- read_csv("Camp_Curtis_Guild.csv")
Camp_Curtis_Guild<-Camp_Curtis_Guild[,4:13]
closedp.bc(Camp_Curtis_Guild)

#Joint Base mcguire dix lakehurst
JBMDL <- read_csv("JBMDL.csv")
JBMDL<-JBMDL[,4:11]
closedp.bc(JBMDL)

#PALBFI
Fort_IndianTown_Gap <- read_csv('Fort_IndianTown_Gap.csv')
Fort_IndianTown_Gap<-Fort_IndianTown_Gap[,4:15]
closedp.bc(Fort_IndianTown_Gap)

#Fort AP Hill
Fort_AP_Hill <- read_csv("Fort_AP_Hill.csv")
Fort_AP_Hill<-Fort_AP_Hill[,4:6]
closedp.bc(Fort_AP_Hill)

#NW Annex
NW_Annex <- read_csv("NW_Annex.csv")
NW_Annex<-NW_Annex[,4:13]
closedp.bc(NW_Annex)

#MCB Quantico
MCB_Quantico <- read_csv("MCB_Quantico.csv")
MCB_Quantico<-MCB_Quantico[,4:7]
closedp.bc(MCB_Quantico)
```

```
## Fort belvoir
Fort_Belvoir <- read_csv("Fort_Belvoir.csv")
Fort_Belvoir <-Fort_Belvoir[,4:5]
closedp.bc(Fort_Belvoir)

#displaying the data
install.packages("ggplot2")
install.packages("tidyverse")
install.packages("DescTools")

library(ggplot2)
library(dplyr)
library(DescTools)

SCBI_Summary <- read.csv ("SCBI_Summary.csv", header = TRUE) #all sites

ggplot(SCBI_Summary, aes(x= factor(Site), y=Abundance))+
  geom_errorbar(aes(ymin=Lower, ymax=Upper), width=0.04, lwd = 0.75)+
  geom_point(aes(fill=factor(Stderr)), pch = 21, color = "black", size=4.5)+
  labs(x="Installations", y="Abundance Estimates", fill = "Standard Error")+
  theme_minimal()+
  theme(axis.line = element_line(color ="black"))+
  theme(legend.position = "right")+
  theme(text = element_text(size=18))+
  coord_flip()+
  theme(panel.border = element_rect(color="black",
                                    fill= NA,
                                    size=1))

SCBI_Summary_No_cped <- read.csv ("SCBI_Summary_No_cped.csv", header = TRUE) #all
sites, excluding CPED

ggplot(SCBI_Summary_No_cped, aes(x= factor(Site), y=Abundance))+
  geom_errorbar(aes(ymin=Lower, ymax=Upper), width=0.04, lwd = 0.75)+
  geom_point(aes(fill=factor(Stderr)), pch = 21, color = "black", size=4.5)+
  labs(x="Installations", y="Abundance Estimates", fill = "Standard Error")+
  theme_minimal()+
  theme(axis.line = element_line(color ="black"))+
  theme(legend.position = "right")+
  theme(text = element_text(size=18))+
  coord_flip()+
  theme(panel.border = element_rect(color="black",
                                    fill= NA,
                                    size=1))
```

Appendix E. Recommended Conservation Implementation Strategies and Best Management Practices for Spotted Turtles on Military Sites

In general, implementation of the specific BMP's listed below should not be performed at the expense of an existing spotted turtle population. Implementation of habitat management practices can be performed when the turtles are not active to reduce potential negative impacts. Make sure to document performance of any of the following BMP's, whether current or future, in your installation's INRMP. The USFWS may consider these proactive conservation actions prior to making a listing determination for this species.

1. **Identify and protect spotted turtle wetland patches and contiguous upland habitats on military properties.** Review aerial photography and installation Geographical Information System (GIS) data to identify potentially suitable wetland patches and contiguous upland habitats. As mentioned above, wetland habitat for spotted turtles typically consists of a wide range of slow moving, shallow, or ponded water habitats. Keep in mind that a population of spotted turtles tend to occupy an array of wetland patches, rather than a single wetland. Follow-up by ground-truthing prospective areas, and if they appear to support suitable habitat, or are known to support spotted turtles, post as necessary with official signage along roads and other human travel corridors to inform personnel about the actual or potential presence of spotted turtles and their vulnerability to military operations and other human activities. This is particularly important on roads with high turtle mortality. Include a contact number on signage to report observations of illegal and/or unauthorized operations and activities. If you have concerns the signs will bring attention to sites where spotted turtles could be illegal collected, posting generic turtle crossing signs is recommended.

2. **Prohibit collection of spotted turtles on your installation.** Collection of spotted turtles for commercial or scientific purposes can have negative impacts to local populations due to their longevity and delayed sexual maturity and is an illegal activity in many states where they occur. It is recommend that military natural resource managers prohibit collection of spotted turtles on military sites, even in the few states where collection is not prohibited.

3. **Develop fact sheets and outreach tools**. Educational fact sheets and pamphlets, like the one at the following link (https://www.denix.osd.mil/dodparc/parc-resources/education-and-outreach/spotted-turtle-fact-sheet/) can be shared with military and civilian personnel to inform them about this at-risk species.

4. **Control subsidized predator populations.** Subsidized predators are species whose populations have increased in part due to enhancement of food and habitat provided directly or indirectly by humans. Raccoons, fox, coyotes, and crows are well-known natural predators of spotted turtles and their nests. Installation residents should limit access to food, garbage and shelter for subsidized predators. In addition, pets such as cats and dogs can also be predators of spotted turtles. Installation residents should limit pet access to spotted turtle habitats, where they might prey upon nests and turtles, and keep pets leashed near these habitats.

5. **Survey existing spotted turtle populations on military sites.** Monitoring existing spotted turtle populations is critical to understanding if a population is increasing or decreasing. Survey methods (see inventory and monitoring techniques for spotted turtle below) and level of effort

are variable and can be tailored to available time and funding constraints. Consider conducting surveys for this species on your military installation.

6. **Maintain upland forested buffer habitat between wetland patches and along stream riparian zones.** As mentioned above, a population of spotted turtles tends to occupy an array of wetland patches, rather than a single wetland, in order to respond to variation in resource availability. So they are equally dependent on aquatic environments and terrestrial corridors between wetland patches. Protection of upland habitats between wetland patches is recommended and ensure that the landscape between wetlands does not impede movements and the turtles have suitable habitat for aestivation. Ensure that the forest floor structure (logs, snags, leaves and woody debris) is maintained as natural as possible.

7. **Avoid the use of all vehicles in wetland habitats used by spotted turtles.** If possible, avoid use of military vehicles (including all-terrain vehicles) in wetland habitats and establish a vehicle-free buffer zone of at least 300 meters around the edges of all known spotted turtle wetland sites. Install barriers in areas where unauthorized stream crossings or wetland incursions occur to minimize wetland damage. Operation of vehicles in the soft soils around or in wetlands can cause significant rutting damage to the ground, kill sensitive vegetation, and lead to serious erosion issues. Any area that is impacted as such should be restored towards its original condition. The use of tracked equipment for mechanical wetland restoration projects during dry conditions is preferred.

8. **Control or remove invasive and non-native species.** Invasive species may include various plants that grow at unnaturally high densities, particularly in the absence of fire and in both wetlands and uplands, thereby changing physical habitat structure and decreasing wetland hydroperiod, both of which adversely impact the turtles. Non-native aquatic plants such as water hyacinth, alligator weed, hydrilla, Phragmites, purple loosestrife and reed canary grass can have negative impacts to wetlands by outcompeting native wetland plants. Invasive species may also include animals such as fire ants, armadillos, coyotes, feral hogs and red-eared sliders (*Trachemys scripta elegans*) that depredate or compete with spotted turtles for resources. The best procedures for controlling invasive species are those that both effectively limit their proliferation, as well as minimize potentially harmful impacts to turtles, and will vary according to the invasive species in need of control, and numerous criteria specific to each installation. Therefore, consult your natural resources staff for invasive species control guidelines for your installation.

9. **Prevent wetland habitat succession.** Wetland sites can be threatened by encroachment of woody shrubs and trees that alter the hydrology or change the thermal characteristics of spotted turtle habitat. The use of mechanical thinning or prescribed fire may be necessary to combat succession. The mode and seasonality of habitat management chosen should be reflective of historic regimes for the area and should not impede military training operations or cause lasting damage to sensitive wetland soils. Managers must consider varying conditions to determine appropriate timing of mechanical thinning or prescribed fire at each site. If possible, avoid these actions when adults are likely to be active or outside of wetland sites (for example during the nesting season or summer aestivation).

10. **Mechanical/Chemical restoration of wetlands.** Absence of fire for prolonged periods may lead to encroachment of woody vegetation that would be difficult to restore using prescribed fire alone. In those cases, mechanical and/or chemical treatment may be appropriate to restore wetlands to suitable conditions. Experts should be consulted before undertaking mechanical or chemical control of woody vegetation for restoration, and timing should try to avoid upland movements of turtles in mid-to-late spring or during summer aestivation.

11. **Retain snags, logs, rocks and other structure along the perimeter and inside of wetlands.** These natural habitat elements provide basking and shelter sites for spotted turtles. However, it is recommended that unnatural debris (e.g., tires, trash) be removed.

12. **Avoid ditching, draining and drawdown of seasonal wetlands.** Any activities such as ditching, draining and drawdown that result in a decrease in the natural hydroperiod of wetlands in which spotted turtles are present should be avoided. Lowering water levels during the winter could expose spotted turtles to freezing temperatures or force them out of suitable habitat.

13. **Maintain or improve water quality.** Prevent input of sediment, erosion and chemicals (fertilizers) in wetlands in order to maintain or improve water quality. Where feasible, minimize soil disturbance when using heavy equipment around wetlands. Use native woods chips or hay bales to slow or prevent intrusion of sediments into wetlands at construction sites. Use the minimum amount of fertilizers, herbicides and pesticides necessary to achieve management objectives, especially on lawns and golf courses.

14. **Maintain beaver presence.** Where feasible, maintain beaver pools as they can slow the movement of sediments eroded by military training. For turtles, these pools and ponds are excellent habitat and provide better year-round temperatures for activities, including foraging and breeding. Beavers also leave a lot of debris for underwater brumation structures and above-water basking sites.

15. **Consider spotted turtles when conducting wetland mitigation.** Spotted turtles will quickly adapt to new wetland features, even if artificially constructed. Wetlands that have some open water and wet meadow conditions are excellent habitat and fairly easy to construct. Wetland mitigation sites are typically sited in areas less prone to human interference and military training and can be constructed in areas adjacent to known spotted turtle populations.

16. **Protection and maintenance of nesting habitats.** Nesting occurs typically from late May through July in open, canopy free areas such as fields and power line corridors. It is recommended that mowing does not take place in known nesting sites during this period. Mowing is encouraged during the dormant season when possible to maintain open conditions.

Acknowledgments

This project was conceived through conversations between Chris Petersen and Tom Akre, along with Robert Lovich, and many others in PARC's Eastern Spotted Turtle Working Group (ESTWG). Development of the ideas that came from those early conversations in 2018 and 2019 was supported by the Department of Defense's Legacy Natural Resources Management Program (DoD LNRMP) and DoD PARC, as well as the members of the ESTWG who represent the American Turtle Observatory (ATO), the Mid-Atlantic Center for Herpetology (MACHAC) and the Orianne Society (TOS). We are grateful to Lisabeth Willey and Michael Jones of ATO, Lori Erb of MACHAC and Houston Chandler of TOS for their help in the development of this project. Liz and Mike led a USFWS Competitive State Wildlife Grant (C-SWG) on Spotted Turtle from Maine to Florida, from 2018 to the present. Lori was a central part of the C-SWG process and supported the development and implementation of a Northeast Association of Fish and Wildlife Agencies (NEAFWA) Regional Conservation Needs (RCN) grant for the Spotted Turtle from 2019 to present. Houston has also been an essential member of the ESTWG and played outsized role in the C-SWG, representing portions of the Southeast where the Spotted Turtle is poorly known. Separately and together, they brought their networks, skills and capacity to set-up, role-out and implementation from 2018 to present. Additionally, we are grateful to Mike Jones, also of MassWildlife, Brandon Ruhe of MACHAC and Chris Jenkins of TOS for support of the mission and strategy of the ESTWG.

Across nine installations in five states, represented by all five DoD branches, we are most grateful to DoD leadership for their permissions and support, as well as the natural resource program managers and biologists for their time, attention, and enthusiasm. In particular, we would like to thank Annie Curtis, Joseph Hovis, Annie Haines, Mark Stevenson, Dorothy Keogh, John Pilcicki, Christina Nye, Joseph LaRose, Kenneth Erwin, Jason Applegate, Taylor Austin and Lawrence Carlile for installation representation and field and logistic support, and Matthew Penella, Jacob McCumber, Rebecca Piccone, Paul Mahoney, Michael Luna, Andrew Satterwhite, Kyle Crafts and Rachel Rourke for logistic and technical field support. Likewise, for general support, networking and permits, we thank Mike Jones at MassWildlife, Chris Urban and Kathy Gipe at the Pennsylvania Fish and Boat Commission, Brian Zarate at the New Jersey Division of Fish and Wildlife, J.D. Kleopfer at the Virginia Department of Wildlife Resources, and Daniel Sollenberger and Thomas Floyd at the Georgia Department of Natural Resources.

Many of the above spent tens of hours in the field with the teams from SI, ATO, MACHAC and TOS during the 2021 sampling season. Among those teams, we would like to thank Emily Sikora, Jillian Newman, James White, Ben Stegenga and Andrea Colton for their hard work, perseverance, and follow through in support of this often challenging project.

Lastly and most importantly, we are grateful to Ryan Orndorff and Elizabeth Galli-Noble of the DoD LNRMP for their support of this project, DoD PARC, and PARC's conservation mission across the Department of Defense.