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EXECUTIVE SUMMARY

Unoccupied aircraft systems (UAS, also known as drones) are revolutionizing environmental monitoring along North Carolina’s changing coastline. Drones are already utilized by researchers at the North Carolina Coastal Reserve and National Estuarine Research Reserve (NERR) to monitor intertidal oyster reefs, map submerged and emergent vegetated ecosystems, quantify shoreline change, and identify marine debris, among other projects, but the Reserve Program lacks a comprehensive policy to guide broader use and manage associated risks. As a result, both commercial and recreational drone use present ongoing management challenges for Reserve staff, posing potential hazards to both visitors and wildlife. This project provides relevant policies, key considerations, and tailored recommendations to assist the North Carolina Coastal Reserve and NERR in developing a UAS policy and permitting process.

The following questions guide this work: 1) How are other agencies and organizations managing drone operations? 2) Which “best practices” for environmental management, monitoring, and conservation are especially applicable to the Reserve Program? 3) What components should be considered for inclusion in the N.C. Coastal Reserve and NERR UAS policy?

Based on a literature review of scientific journal articles and policy documents, four major areas of focus emerged, including wildlife protection, visitor safety, flight planning, and human privacy and security. These priority components can serve as a jumping off point for the creation of a Reserve UAS policy. An accompanying resource library, draft permit application, and concept of operations document will support North Carolina Coastal Reserve and NERR staff as they draft and finalize a UAS policy adaptive to rapidly changing technology. The resulting policy has the potential to be shared across the NERR System as a model framework.
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>AGL</td>
<td>Above Ground Level</td>
</tr>
<tr>
<td>ATC</td>
<td>Air Traffic Control</td>
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<tr>
<td>CMAST</td>
<td>Center for Marine Sciences and Technology</td>
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<tr>
<td>ConOps</td>
<td>Concept of Operations</td>
</tr>
<tr>
<td>CZMA</td>
<td>Coastal Zone Management Act</td>
</tr>
<tr>
<td>DEQ</td>
<td>North Carolina Department of Environmental Quality</td>
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<tr>
<td>DCM</td>
<td>North Carolina Division of Coastal Management</td>
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<tr>
<td>DUML</td>
<td>Duke University Marine Laboratory</td>
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<tr>
<td>FAA</td>
<td>Federal Aviation Administration</td>
</tr>
<tr>
<td>IMS</td>
<td>Institute of Marine Sciences</td>
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<tr>
<td>LAC</td>
<td>Local Advisory Committee</td>
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<tr>
<td>LiDAR</td>
<td>Light Detection and Ranging</td>
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<tr>
<td>LiPo</td>
<td>Lithium polymer (battery)</td>
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<tr>
<td>MaRRS</td>
<td>Marine Robotics and Remote Sensing Lab</td>
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<tr>
<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
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<tr>
<td>NCSU</td>
<td>North Carolina State University</td>
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<td>NERRS</td>
<td>National Estuarine Research Reserve System</td>
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<td>NGO</td>
<td>Non-governmental organization</td>
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<tr>
<td>NOAA</td>
<td>National Oceanic and Atmospheric Administration</td>
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<tr>
<td>NOTAM</td>
<td>Notice to Airmen</td>
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<td>NPS</td>
<td>National Park Service</td>
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<tr>
<td>PIC</td>
<td>Pilot in Command</td>
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<tr>
<td>PII</td>
<td>Personally Identifiable Information</td>
</tr>
<tr>
<td>RGB</td>
<td>Red, Green, Blue (bands of light)</td>
</tr>
<tr>
<td>RTH</td>
<td>Return to Home</td>
</tr>
<tr>
<td>SLR</td>
<td>Sea level rise</td>
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<tr>
<td>sUAS</td>
<td>small Unoccupied Aircraft/Aerial System</td>
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<tr>
<td>TFR</td>
<td>Temporary Flight Restriction</td>
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<tr>
<td>TRUST</td>
<td>The Recreational UAS Safety Test</td>
</tr>
<tr>
<td>UAS</td>
<td>Unoccupied Aircraft/Aerial System</td>
</tr>
<tr>
<td>UAV</td>
<td>Unoccupied Aircraft/Aerial Vehicle</td>
</tr>
<tr>
<td>UNC</td>
<td>University of North Carolina</td>
</tr>
<tr>
<td>UTM</td>
<td>Unoccupied Aircraft Systems Traffic Management</td>
</tr>
<tr>
<td>VLOS</td>
<td>Visual Line of Sight</td>
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<tr>
<td>VO</td>
<td>Visual Observer</td>
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1. INTRODUCTION

Unoccupied Aircraft Systems (UAS) for Coastal Monitoring and Conservation

Unoccupied Aircraft Systems (UAS), also known as drones, are transforming how environmental scientists and natural resource professionals study, monitor, and manage the coastal zone (Johnston, 2019).1 Several recent UAS applications include analyzing post-wildfire vegetation damage and recovery in a National Estuarine Research Reserve, assessing the impacts of sea level rise on sea turtle nests, evaluating post-hurricane impacts on shorelines and habitats, and identifying marine debris (Samiappan et al., 2019; Varela et al., 2018; Boger et al., 2020; Martin et al., 2018).

Accelerating rates of sea level rise, as well as more frequent and intense tropical storms and hurricanes, present critical research needs that drones can help address through accurate beach topography modeling (Nagarajan and De Witt, 2019). The high resolution of UAS data is well-suited to documenting dynamic coastal ecosystems, and rapid on-site deployment of drones can be incredibly valuable for post-disaster assessments and surveys (Turner et al., 2016). Additional benefits include cost effectiveness and improved safety for technicians (Koh and Wich, 2012; Jones et al., 2006).

The most recent developments in UAS technology and data analysis stand to benefit estuarine researchers by enabling visualizations at new spatial scales and temporal frequencies with reduced impacts to fragile marsh ecosystems (Gray et al., 2018). As described above, drones can assist with wildlife and ecosystem monitoring, environmental management, and disaster response, among other research needs (López and Mulero-Pázmány, 2019).

Given the relative novelty of UAS in environmental science research, best practices, policies, and laws are still evolving (Nowlin et al., 2019). Concerns about safety, privacy, and wildlife disturbance reflect the need for established regulations, particularly on federal and state land. This project provides relevant policies, key considerations, and tailored recommendations to assist the North Carolina Coastal Reserve and NERR in developing a UAS policy and permitting process. The following questions guide this work: 1) How are other agencies and organizations managing drone operations? 2) Which “best practices” for environmental management, monitoring, and conservation are especially applicable to the Reserve Program? 3) What components should be considered for inclusion in the N.C. Coastal Reserve and NERR UAS policy?

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1 While some pilots and researchers refer to UAS as “unmanned” aircraft systems, increasingly the gender-neutral “unoccupied” is the preferred and accepted term (Johnston, 2019). “UAS” and “drones” will be used interchangeably throughout this policy document to refer to unoccupied aircraft systems. Many best practices outlined here also apply to other autonomous vehicles, such as terrestrial rovers and marine vessels.
Based on a literature review of scientific journal articles and policy documents, four major areas of focus emerged, including wildlife protection, visitor safety, flight planning, and human privacy and security. These priority components can serve as a jumping off point for the creation of a Reserve Program UAS policy and a model framework for sites across the entire NERR System.

North Carolina Coastal Reserve and National Estuarine Research Reserve

The North Carolina Division of Coastal Management, housed under the Department of Environmental Quality (DEQ), oversees the North Carolina Coastal Reserve and National Estuarine Research Reserve. The N.C. National Estuarine Research Reserve (N.C. NERR) is one of 29 reserves across the United States (Figure 1). This network was established by the Coastal Zone Management Act (CZMA) in 1972 to protect and study estuarine ecosystems through four primary pillars of stewardship, research, training, and education. The N.C. Coastal Reserve and NERR protects over 44,000 acres of estuarine habitat across 10 protected sites (Figure 2). This network aims to support the program’s mission of long-term research, education, and stewardship (NCDEQ). Of the 10 sites, four are National Estuarine Research Reserve sites — Currituck Banks, Rachel Carson (Figure 3), Masonboro Island, and Zeke’s Island — managed through a federal-state partnership between the National Oceanic and Atmospheric Administration (NOAA) and the NC Division of Coastal Management. The remaining state Coastal Reserve sites include Kitty Hawk Woods, Emily & Richardson Preyer Buckridge, Buxton Woods, Permuda Island, Bald Head Woods, and Bird Island (NCDEQ).

As outlined in the program mission statement, the N.C. Coastal Reserve and NERR aims to “practice and promote informed management and appreciation of North Carolina’s coastal and estuarine ecosystems and provide protected sites for research, education and stewardship” (NCDEQ). Drones offer a compelling platform for achieving these objectives. UAS and associated geospatial technologies also support the program’s goal to provide “educational opportunities for students, teachers, and the public” and ensure that reserve sites “serve as living laboratories for scientists” (NCDEQ).

Motivation and Vision for UAS Policy Development

UAS technology has the potential to serve as a cost-effective, high-resolution tool to support the North Carolina Coastal Reserve and National Estuarine Research Reserve mission. As stated in the NC NERR Draft Management Plan for 2020-2025, staff identified the need for a fixed-wing UAS with real-time kinematics (RTK) capabilities to “monitor shoreline change and coastal erosion in response to major events and over large spatial extents, map Reserve habitat, and survey flora and fauna” (NC NERR). UAS operations could also assist with Reserve Program’s defined objectives, including conducting vulnerability assessments, communicating coastal resilience benefits of natural infrastructure, and
assessing sea level rise impacts (NC NERR). Additionally, the Draft Management Plan mentions a potential partnership with the Division of Coastal Management (DCM) “to purchase an UAS that could be jointly used by the research program and DCM regulatory program” (NC NERR).

The 2020 NC Climate Risk Assessment and Resilience Plan specifically points to the vulnerability of Reserve sites to climate-driven coastal hazards (NCDEQ). The Plan also notes that during Hurricane Florence (2018), the Department of Transportation (NCDOT) relied on its drones program to provide “real-time imagery and video of affected routes, allowing staff to confirm if roads were passable for the public or accessible as detours for emergency vehicles” (NCDEQ).

Across Reserve sites, researchers have successfully used drones to monitor intertidal oyster reef habitat at the Rachel Carson Reserve, map marshes at Currituck Banks National Estuarine Research Reserve, and identify marine debris at the Rachel Carson Reserve (Duke University Marine Robotics and Remote Sensing Lab; North Carolina Audubon; NOAA Marine Debris Program). Other drone-based studies of Reserve sites have found UAS imagery to be highly effective in training and validating coastal land cover algorithms and accurate in measuring vegetation height to assess salt marsh health (Gray et al., 2018; DiGiacomo et al., 2020).

Despite these notable benefits, Reserve staff have raised several management challenges, including a lack of procedures for responding to media requests to use drones and safety concerns for wild horse populations (Gillikin and Sutton, 2020). In the case of recreational and commercial UAS activity, staff may be unaware of these operations within the Reserve until viewing drone footage online. A proactive approach to establish UAS procedures and norms can mitigate risk before major challenges arise.

This document aims to provide environmental managers and research scientists at the NC Coastal Reserve and National Estuarine Research Reserve with an analysis of key policy considerations, best management practices, and tangible recommendations for implementing an effective UAS policy across this network of 10 protected estuarine sites.

II. OVERVIEW OF EXISTING UAS POLICIES AND APPLICATIONS

UAS policies, regulations, and Concepts of Operations already exist across federal and state agencies, as well as non-governmental organizations (NGOs) and academic institutions, with varying degrees of detail and specificity. This section offers a brief overview of selected plans affiliated with UAS operations, many of which are still being developed and modified. All UAS use is subject to federal law to ensure public safety and minimize interference with air traffic, and drone operations may also be subject to state and local regulations or restrictions.
Federal Agencies

The Federal Aviation Administration (FAA) retains authority over the National Airspace System and establishes regulations for four types of UAS users, including (1) recreational flyers and modeler community-based organizations, (2) certified remote pilots, including commercial operators, (3) public safety and government, and (4) educational users. These categories govern the use of drones weighing less than 55 pounds as part of 14 Code of Federal Regulations (CFR) Part 107. Recreational flyers are those who only operate drones for enjoyment. These hobbyists are exempt from Part 107 restrictions but must abide by their own set of regulations. Certified remote pilots, including commercial operators, must pass the Part 107 aeronautical knowledge test, obtain an FAA tracking number, and register their drone. Public safety and government officers fall under a separate category, given their role in “deter[ing], detect[ing], and investigat[ing] unauthorized or unsafe UAS operations. Educational users, such as teachers and students, are exempt from compliance with Part 107 and can be operated under the same rules as those that govern recreational users. All UAS pilots must abide by standard operating requirements, including keeping drones within unaided Visual Line of Sight (VLOS) and not exceeding an elevation of 400 feet above ground level (AGL) or a velocity of 100 miles per hour (FAA). Additionally, pilots must be at least 16 years old (Ibid.).

The FAA restricts UAS operations within certain airspace classes, and flights are generally limited to uncontrolled airspace below 400 feet above ground level (AGL) (Figure 4). Without special permission, UAS pilots must avoid prohibited areas, restricted areas, and airspace with Temporary Flight Restrictions (TFRs). Drone operators should also avoid flying near airports or manned aircraft. Drone flights are prohibited over emergency or rescue operations, such as those associated with wildfires and hurricanes.

While the National Estuarine Research Reserve System (NERRS) lacks a formalized and universal drone policy, in 2016 the Wells National Estuarine Research Reserve in Wells, Maine, released a roadmap for navigating UAS technology across reserves. Developed in partnership with Grand Bay National Estuarine Research Reserve in Moss Point, Mississippi, the NOAA Unmanned Aircraft System Program, the Office for Coastal Management, and the Northern Gulf Institute, this document aims to “to fully inform the NERRS community about UAS operation, opportunities for applications, its regulatory environment, and UAS program development as it applies to the Reserves.” Preceding the publication of this report was the formation of a Reserve System UAS Working Group in 2014. This group demonstrated a variety of natural resource applications across missions ranging from marsh wildfire management to disaster response projects. In response to the guiding question of whether the “benefits of
using UAS technology outweigh the costs,” the report concludes that Reserves must make their own decisions and emphasize “a culture of safety and compliance.”

The National Oceanic and Atmospheric Administration (NOAA)’s “Unmanned Aircraft Systems Policy” (NAO 216-104A) dictates procedures for UAS management and utilization within the agency. In 2017 the Office of Marine and Aviation Operations released an “Unmanned Aircraft Systems (UAS) Handbook” to supplement this policy and provide “a framework for the safe and efficient operation of UAS operated or sponsored by NOAA.” The policy outlines operational roles and responsibilities, as well as the flight approval process and requirements. Given that NOAA is a federal agency, UAS operators fall under the FAA’s public user designation. Among other responsibilities, the commanding officer of NOAA’s Aircraft Operations Center must conduct Operational Risk Management reviews for each project affiliated with a UAS operation; “ensure safety investigations are conducted for all incidents involving NOAA UAS; develop criteria and approve all NOAA UAS airworthiness, flight operations, and UAS crewmembers designations; ensure that UAS operations do not pose unacceptable risks to persons or property; and develop standards for, monitor and provide oversight of, and delegate authority for field UAS operations and management.”

Additionally, the agency developed an Unmanned Aircraft Systems Privacy Policy to “ensure transparency regarding its activities and that UAS activities do not create undue privacy risks for members of the public” (NOAA). NOAA has committed to “obtain[ing] written permission from landowners when UAS operations has a need to launch and/or land on their property” as part of its privacy protocols (Ibid).

NOAA’s Office of Oceanic and Atmospheric Research (OAR) contains a UAS Program Office – also referred to as the Uncrewed Systems Research Transition Office – charged with facilitating UAS applications and utilization, translating these capabilities from research to practical, applied operations, and offering guidance for further investigation and program development. The Office emphasizes that UAS can fill critical information gaps that satellites and Earth-based instruments do not.

The National Science Foundation (NSF) funds a variety of research projects that utilize drones for data collection and other services. In recent years, NSF has supported a Stanford-led effort to survey Antarctic penguin colonies, a Harvard-led team monitoring volatile organic compounds in the Amazon, and a North Texas University study examining drone applications for post-disaster wireless communications (Shah et al., 2020; Ye et al., 2021).

In 2014, the NSF’s U.S. Antarctic Program (USAP) issued a programmatic notice that prohibits UAS use without explicit approval. The document specifies the “potential operational, environmental and
safety hazards” associated with drone operations in Antarctica (NSF, 2014). In 2019, the program released a formal “Inter-Agency Air Operations Manual,” which features a chapter dedicated to “UAS Procedures.” The Manual also includes a UAS CONOPs template that guides applicants in providing “a full description of planned UAS activities.” The main components of this form include an overview, an implementation plan, launch and recovery plans, airspace management, a recovery contingency plan, pilot certifications, and references.

The Department of the Interior (DOI) offers Aviation Policy Documents for each of its bureaus, including the National Park Service (NPS), the Fish and Wildlife Service (FWS), and the Bureau of Land Management (BLM).

The NPS maintains an Aviation Program, with a UAS specialist on staff. The agency has successfully utilized drones in wildland fire applications, including infrared data collection to support management of the Paradise Fire in Olympic National Park. The NPS may fly drones for other uses approved by regional directors, including search and rescue operations, aerial photography, and scientific study (NPS).

UAS operations by park visitors have resulted in safety concerns, noise and nuisance complaints, and wildlife harassment. Notable incidents included a crash into Yellowstone National Park’s Grand Prismatic Spring, a landing attempt on Mount Rushmore National Monument, and disturbance of a bighorn sheep herd in Zion National Park (Reuters, 2014; NPS, 2017). Due to these incidents and other concerns, in 2014 the NPS implemented a policy to restrict “launching, landing, or operating unmanned aircraft” across all units of the National Park System “to ensure that the use of unmanned aircraft is addressed in a consistent manner by the NPS before a significant level of such use occurs within the National Park System” (Jarvis, 2014).

Like the NPS, the U.S. FWS maintains an aviation department. The agency prohibits “launching, landing, or operating UAS from or on lands and waters administered by the U.S. Fish and Wildlife Service” (USFW). These restrictions on the National Wildlife Refuge System aim “to protect the public from hazards and preserve the refuge’s natural, aesthetic, and scenic values.”

The BLM developed a UAS program in 2015 to support resource program and incident management objectives (Jarvis, 2015). The agency maintains an Office of Fire and Aviation, which manages wildland fire and related public safety, in addition to mission requirements ranging from photo mapping and forest management to law enforcement and search and rescue (BLM). In January 2020, the DOI released Secretary’s Order (SO) 3379, which prohibits “BLM purchase, contract, and operation of UAS except for Emergency UAS Operations and Emergency UAS Readiness.”
In 2017, the FAA specifically restricted unauthorized UAS operations over 10 DOI sites “at the request of U.S. national security and law enforcement agencies.” These sites include five dams, two national memorials, two national historic parks, and a national monument (FAA).

The U.S. Forest Service permits recreational drone operations over national forest lands in compliance with FAA regulations. The agency specifically emphasizes the dangers of flying UAS over areas with Temporary Flight Restrictions (TFRs), namely natural disasters like wildfires (USFS). The Forest Service has established an interdisciplinary UAS working group to “conduct[ ] a thorough review of agency policy, mak[e] policy recommendations, complet[e] a risk assessment, and develop[ ] a strategic plan. UAS technology could assist the agency in accomplishing missions including wildfire suppression, law enforcement, and research on forest health.

State Agencies

North Carolina law prohibits the launch or recovery of UAS from state property without consent (NC General Assembly, § 15A-300.2 “Regulation of Launch and Recovery Sites”). Flights within the state “require written permission from property owners before aerial photography takes place over their land” (NC General Statutes, Chapter 15A Article 16B). Other general prohibitions include unwarranted surveillance, photographs of individuals with the intent of publication, and use of UAS “near a confinement or correctional facility” (NC General Assembly, § 15A-300.1).

The North Carolina Department of Environmental Quality (NCDEQ) recognizes the potential of drones to “substantially refine certain NCDEQ data collection and business practices,” as well as provide “fiscal and labor benefits” to agency missions. The agency places responsibility for policy implementation on the GeoTeam, a “standing group of NCDEQ staff members representing agency business units and Information Technology who are technically knowledgeable regarding the needs and capabilities of their respective programs.” In addition to registering with the FAA, UAS operators must register with the GeoTeam and obtain liability insurance (NCDEQ). The policy outlines specific considerations for private property, personal privacy, and data handling, which are further detailed in Sections VIII (Privacy and Ethics) and XII (Data Management) of this document. The full policy (NCDEQ Policy #UAS001) may also be referenced in the Appendix (Appendix I.).

The North Carolina Department of Transportation (NCDOT) retains authority to “implement and manage regulations pertaining to state laws concerning drone operations within the state.” Requirements differ among recreational, commercial, and government operators. Recreational operators
aren’t required to obtain a license or permit from the Department of Aviation, but they are encouraged to take NCDOT’s UAS Operator’s Knowledge Test. Commercial and government operators must take and pass the NCDOT Knowledge Test in order to apply for a state permit. Most recently, in July 2019, NCDOT solicited public feedback on current and future uses of UAS, including concerns about safety, privacy, and noise.

The North Carolina Division of Parks and Recreation, which administers the state’s system of parks, natural areas, trails, lakes, natural and scenic rivers and recreation areas, prohibits visitors from “ascending or taking-off within or upon any state park area or state park water surface, of any … flying machine (includes drones, UAS, quadcopters)…” In limited cases, the Division grants Special Activity Permits to allow UAS operations; in these instances, users must apply for a Special Activity Permit and describe their planned activities on park property (NCDPR).

While the North Carolina Wildlife Resources Commission lacks a formal drone policy, the agency has responded to questions about drone use for hunting and scouting wildlife by sharing NC Department of Transportation regulations. Specifically, the Commission has highlighted policies that prohibit UAS interference with lawful take or pursuit of wildlife resources and the use of UAS for fishing or hunting. The cited document also states that “under certain conditions, scientists or biologists may utilize UAS for the purpose of research of habitat, timber management, or wildlife” (NCWRC).

The North Carolina Forest Service lacks a formal drone policy, but after agency officials observed UAS operations during manned flights for wildfire prevention and control, Secretary of Agriculture Steve Troxler released a bulletin to remind drone operators that UAS damage or interference with manned flight is a felony. The NC Forest Service Aviation Division website doesn’t include UAS in its resources, only fixed wing airplanes and helicopters.

Non-governmental Organizations (NGOs)

The Nature Conservancy, a global environmental nonprofit, incorporates UAS into a number of different conservation initiatives. The group has used drones to plant trees in Colorado, map endangered poppy populations in Utah, and study nesting waterfowl in North Dakota. More locally, North Carolina’s chapter is exploring development of a framework for UAS use at Nags Head Wood Preserve (Adams, 2020). No formal drone policy exists on the Nature Conservancy website, indicating that the group may not have a unified set of guidelines for UAS operations.
The World Wildlife Fund, an international conservation organization, has utilized drones in a variety of projects — from monitoring endangered black-footed ferret habitat in Montana to dispersing eucalyptus seeds for koala population restoration in Australia. Most recently, the nonprofit has published an introductory guide to UAS operations for conservation that highlights best practices and evolving applications (see Section V.).

Members of the Land Trust Alliance, a national land conservation network, have begun to use drones for detailed aerial assessments of properties and other stewardship activities. For example, the Columbia Land Trust utilized UAS to monitor their progress on a swamp restoration project, creating detailed imagery as part of an orthomosaic. Recent training offered by the Duke University Marine Robotics and Remote Sensing Lab has also focused on UAS applications for land trusts.

The North Carolina Museum of Art, which encompasses 164 acres of fields and forests, restricts UAS flights to those that serve the museum’s educational mission or business needs. Recreational UAS flights are completely banned, while commercial flights must meet the aforementioned criteria and receive consent of the Museum’s Director of Operations.

Academic Institutions

The Duke University drone policy requires a formal review process for all proposed UAS flights on university property. Hobbyist flights must also be authorized. The Duke Marine Lab requires drone operators to undergo an orientation with the Marine Robotics and Remote Sensing Lab prior to any flights. UAS launch and recovery on the Pivers Island campus is restricted to a small area on the southwest end of the island, unless the operators has been granted approval for an exception. The policy is reviewed on an annual basis.

The University of North Carolina at Chapel Hill (UNC) restricts UAS flights to operations that meet the university’s educational interests and serve its business needs. Flights must obtain prior approval from the University Police Department and provide proof of required FAA and NCDOT permits, as well as a flight plan detailing time and location of operations.

Recognizing the “great potential” of drones as “tools for research and teaching,” North Carolina State University established a “framework for identifying, managing, and mitigating risk when using UAS, in order to ensure compliance with all State and Federal laws and regulations, and in furtherance of NC State’s institutional goals and objectives.” Potential pilots must register using a Pilot Registration
Form, in which they provide their FAA Remote Pilot Certificate Number and acknowledge that they have at least five hours of flight experience. Additionally, applicants are required to complete a UAS Flight Plan Notification Form, providing details about flight purpose, dates and time range, location, aircraft type, and funding source, in addition to confirming mandatory aircraft insurance coverage.

III. Potential Allowable UAS Use in NC NERR

As described in Section II, some federal, state, and NGO drone policies restrict UAS operations based on the type of user. The FAA establishes four distinct categories, including recreational users, certified remote pilots, public safety and government officers, and educational users.

*Recreational Users*

Recreational users encompass hobbyists and anyone who operates drones exclusively for fun. While these UAS users must follow many of the standard safety and operational guidelines that other pilots obey, they are only responsible for abiding by a basic set of requirements. The FAA has been developing The Recreational UAS Safety TEST (TRUST), and once it becomes available — likely summer 2021 — recreational users will be required to pass the exam before flying. As mentioned in Section I (Overview of Existing UAS Policies and Applications), both the National Park Service and North Carolina State Parks prohibit recreational drone use, including taking off and landing on park property.

*Certified Remote Pilots*

Certified Remote Pilots fly drones for work or business and include commercial operators. These users must become FAA-certified UAS pilots by passing the Part 107 knowledge test. They are also required to register their drone with the FAA and display this number on the aircraft. Media outlet requests to film at the Reserve would fall under this category.

*Public Safety and Government Officers*

The public safety and government officers category of users primarily applies to law enforcement and emergency responders, but all state, local, and tribal government organizations may operate drones either under the standard Part 107 rules or under statutory requirements for public aircraft. In the latter case, pilots must obtain a Certificate of Authorization (COA) to confirm that flights are performing governmental functions (FAA). The COA application must be submitted for each UAS activity using the UAS COA Online System (Ibid.). For users, such as NERR researchers, who identify as both government employees and commercial operations and intend to conduct numerous UAS-based projects, obtaining a Part 107 license may reduce the administrative burden of completing multiple COA applications.
Educational Users

Students and professors from Duke University’s Marine Robotics and Remote Sensing Lab regularly utilize the Rachel Carson Reserve to conduct practice flights, as do University of North Carolina-Wilmington (UNCW) students at Masonboro Island Reserve and Zeke’s Island Reserve. Other coastal academic institutions, such as University of North Carolina-Chapel Hill’s Institute of Marine Sciences and North Carolina State University’s Center for Marine Sciences and Technology (CMAST), also participate in UAS-based research. A statutory provision allows drones “used for educational purposes” to operate under Exception 49 U.S.C. § 44809, which exempts drones flown for recreational purposes from Part 107 compliance (FAA). In a Reserve setting, this could occur when a Part 107 licensed pilot (e.g., professor, researcher, graduate student) supervises and instructs students in operating a UAS.

State-Specific Regulations

In North Carolina, commercial and government operators must take and pass the NCDOT UAS Operator’s Knowledge Test in order to apply for a state permit from the Department of Aviation. While hobbyist pilots are not required to have a state permit, they’re still encouraged to prepare for and take the exam.

IV. CONCEPT OF OPERATIONS

A Concept of Operations (ConOps, or “CONOPS”) can offer a valuable framework for developing effective policy. Originally derived from engineering, ConOps provide a roadmap by describing the characteristics of a system from the perspective of users, as well as identifying the information required for management. A successful ConOps will answer the questions of “when, where, why, and how” and lay out a blueprint of system components necessary for safety, efficiency, and security (Luxhøj et al., 2017). In the case of UAS, these elements may include aircraft operations, flight logistics, surrounding environment, emergency scenarios, safety and performance considerations, and a possible plan for the execution of the operation (Ibid.).

For example, the Federal Aviation Administration (FAA) released an updated ConOps for UAS traffic management in March 2020 that “present[s] a vision and describe[s] the associated operational and technical requirements for developing a supporting architecture and operating within a UTM ecosystem.” The document describes how the FAA will provide support to UAS operations in low altitude airspace (below 400 feet above ground level). As the FAA ConOps emphasizes, rather than prescribing solutions or detailing precise methods for implementation, the document serves to provide “essential conceptual and operational elements” associated with UAS traffic management (UTM) operations. The ConOps also describes “roles and responsibilities of the various actors and entities that interact with UTM” (FAA).
An example ConOps for UAS operations in the North Carolina Coastal Reserve system might include elements such as requirements, aircraft and ground control details, communications and airspace management, risk assessment, and cybersecurity plan (Figure 4; Appendix IV.). These components will aid managers in developing a standardized and comprehensive protocol for UAS operations across the NC NERR system.

V. Best Practices for Conservation and Environmental Research

Numerous studies have attempted to establish guidelines for UAS operations that involve wildlife, environmental monitoring, and conservation research, but there is no single, widely-adopted standard. In 2016, researchers established seven overarching best practices to guide drone use in biological field research, no matter the target species (Hodgson and Koh, 2016):

1. Adopt the precautionary principle\(^2\)
2. Apply the institutional animal ethics process to oversee drone-delivered animal observations and experiments
3. Adhere to civil aviation regulation and perform equipment maintenance and operator training schedules
4. Select appropriate drone and sensor equipment
5. Exercise minimum wildlife disturbance practice flights
6. Cease operations if they are disruptive
7. Detailed, accurate reporting of methods and results in publications

That same year, Ravich published a review of existing drone legislation and policy around the world. He found that most jurisdictions require that “operators make a safety case by qualifying themselves, their mission, and their operational procedures through a certification or permitting process” (Ravich, 2016). Ravich also emphasizes the overall conservatism of most UAS regulations and the tendency for UAS operations to be evaluated on a case-by-case basis. He recommends that “drone operators be aware of the trajectory and trends of early drone laws, demonstrate compliance, and work zealously to educate regulators and the public about the safety and commercial merits of unmanned aviation” (Ravich, 2016).

\(^2\) The precautionary principle, as applied to decision making in the environmental science context, includes the following core components: 1) “taking preventive action in the face of uncertainty”; 2) “shifting the burden of proof to the proponents of an activity”; 3) “exploring a wide range of alternatives to possibly harmful actions”; and 4) “increasing public participation in decision making” (Kriebel et al., 2001).
More recently, researchers have developed specific operational protocols for UAS operations in coastal and marine environments. Joyce et al., 2018 provides practical guidance for acquiring drone-based data across marine ecosystems that can minimize error and account for wave action, sun glint, and other environmental factors that can affect imagery. Raoult et al., 2020 specifically outlines methodological approaches for studying a range of marine animals. This paper notes the variable responses to drones among marine species, but recommends flights maintain a minimum elevation of 30 meters to reduce disturbance (Raoult et al., 2020). Flight protocols for jellyfish, sharks, marine reptiles, marine birds, pinnipeds, sirenians, odontocetes, and baleen whales offer helpful guidance to pilots and crew members (Figure 8).

This collective guidance provides a broad framework for managing UAS operations related to wildlife, environmental monitoring, and conservation. Ideally, these principles should form the basis of the NC NERR system’s UAS policy, and they are referenced throughout the sections below.

VI. Pilot in Command and Crew Certification

At a minimum, all pilots in command (PICs) should become a certified FAA remote pilot by completing the UAS aeronautical knowledge test, or Part 107, as is legally required for non-hobbyist operators (FAA). Only those individuals holding all necessary FAA remote pilot certifications for commercial operation of sUAS and documentation of passing the NCDOT UAS Knowledge Test should be eligible to serve as PICs for missions conducted within the Reserve. Consistent with FAA regulations, appropriately trained NERR staff and other researchers external to the Reserve Program may operate sUAS under the immediate and direct supervision of an authorized PIC. All PIC must maintain certification documentation, as well as proof of completion of the FAA Recurrent Knowledge Testing.

Training

Beyond these certifications, field experience and flight hours are critical for demonstrating competence. Drone logbooks can provide evidence of missions under similar conditions as those that applicants expect to encounter during flights within the Reserve and display familiarity with specific platforms and data collection methods. As part of the permit application process, Reserve staff should consider asking pilots to list their total flight hours and specifically note which hours have been conducted within the last year to assess currency (Appendix IV.). While training — field, simulated, or otherwise — is not mandatory for Part 107 certification, it is highly encouraged prior to flight operations that could pose safety hazards to people and wildlife.
Crew

While the PIC is not legally required to involve additional crew members as flight support, it is generally good practice to ensure that sUAS missions include a minimum of two personnel: a PIC and a Visual Observer (VO). Additional VOs may be used if personnel are available or where a complex mission requires it. The PIC operates the sUAS while the VO(s) provide critical situational awareness through continuous visual observation of the aircraft and area of operation during the sUAS mission.

Specific mission responsibilities are allocated as follows:

**Pilot in Command**

The PIC ensures that all crew members are aware of the mission and their specific responsibilities by giving a crew briefing prior to commencing operations. The PIC should also ensure that the aircraft is assembled and operated within the manufacturer’s stated limitations. Other pre-flight responsibilities include verifying that weather conditions are within acceptable range for flight operations with the particular aircraft and for mission objectives, accurately completing the mission flight log and checklists, and confirming that crew and bystander welfare will not be compromised by any planned operations. Once the UAS is airborne, the PIC must maintain a visual line of sight (VLOS) throughout the mission and ensure safe and lawful operation of the sUAS.

**Visual Observer**

VOs assist the PIC in maintaining situational awareness during flights, ensuring the position of the UAS is known at all times. Prior to beginning the mission, VOs should aid in flight checklist completion. Once the flight begins, VOs must maintain visual contact with the UAS and constantly scan the area for encroachments by other aircraft, wildlife, or members of the public during the mission. In the case of a potential encroachment, the VO is responsible for communicating the risk to the PIC. Should the PIC become incapacitated at any point during the mission, the VO must be prepared to activate the failsafe “return to home” function of the sUAS.
VII. Equipment Requirements

Human operators, including the pilot in command and the visual observer, interact with a variety of UAS equipment, including the platform, ground control unit, and payload (battery, fuel, sensors, etc.) when conducting operations (Figure 8).

Platforms

Two main types of UAS aircraft include multirotor and fixed wing platforms. Variations on these forms are designed to address different flight patterns, geographic settings, and data collection needs (Figure 6). Multirotor platforms mimic traditional helicopters, with rotating propellers. They are well-suited to high-resolution data collection and easier to operate (WWF, 2020). Fixed wing platforms, which have similar configurations to airplanes, can aid in data collection at high altitudes and across wide survey areas due to longer flight times (WWF, 2020). Customized UAS platforms are growing in popularity, but they pose additional safety risks if they haven’t been field tested under a variety of conditions.

Ground Control Unit

The ground control unit is the link that connects the PIC to the platform. This hardware (e.g., a laptop or tablet) and software enables manual or autonomous UAS operations. By preprogramming the ground control station, the pilot can select “return home” mode in the event of a lost link with the platform to ensure a safe landing (Dobroski, 2019).

Batteries

Lithium-based batteries are most commonly used to power UAS flights. These may include lithium polymer (LiPo) and lithium-ion batteries. Proactive and consistent battery management can alleviate a variety of safety concerns, from unexpected landings to fires. Pilots should ensure that batteries are fully charged prior to flight and stored at or near room temperature in fire-proof pouches. Batteries should also be carefully inspected before use.

Sensors

To facilitate data collection, drones are typically equipped with a sensor, such as a camera. Different sensor types, ranging from basic GoPro cameras to more complex multispectral devices, may be used for a variety of applications (Table 1). Specific applications for salt marsh ecosystems include, but are not limited to, habitat classification and area quantification, canopy height and marsh elevation analysis, and aboveground biomass and density (Dobroski, 2019).
**Table 1:** UAS Sensors and Associated Example Applications for Coastal and Estuarine Research, Monitoring, and Management

<table>
<thead>
<tr>
<th>Sensor Type</th>
<th>Example Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>RGB camera</td>
<td>Habitat mapping, vegetation assessments, elevation modeling (e.g., hurricane effects), estuary health assessments (coastal ecosystem modeling)</td>
</tr>
<tr>
<td>Infrared</td>
<td>Population counts, population growth (oysters), vegetation health</td>
</tr>
<tr>
<td>Multispectral</td>
<td>Surface mapping, normalized difference vegetation index (NDVI), normalized difference water index (NDWI)</td>
</tr>
<tr>
<td>LiDAR</td>
<td>Coastal mapping</td>
</tr>
<tr>
<td>Thermal imaging</td>
<td>Assessing temperature of bird nesting habitat (Mapes et al., 2020)</td>
</tr>
</tbody>
</table>

Depending on the type of sensors permitted in the Reserve, additional privacy concerns may arise, as discussed in Parts VIII (Privacy and Ethics) and XII (Data Management).

**VIII. Privacy and Ethics**

Given that many U.S. residents may have been introduced to UAS by way of military “drone strikes,” it’s unsurprising that this technology is, at times, met with suspicion, distrust, and fear (The Guardian, 2019). The general public may associate drones with surveillance and law enforcement applications, rather than environmental research or management (Cavoukian, 2012). Clear protocols governing drone use and an intentional communications and outreach strategy may help reduce commonly held misconceptions about UAS.

*Personal privacy and security*

Drones present novel privacy implications for Reserve visitors, as well as nearby residents and boaters (Nowlin et al., 2019). As applies to all public lands, visitors should have a reasonable, albeit reduced, expectation of and right to privacy when compared to privately held property (Nowlin et al., 2019). One major privacy concern is that drones may capture Personally Identifiable Information (PII) when collecting imagery. This may include any data that can be traced back to an individual, such as a license plate number or boat registration number.

North Carolina law prohibits the publication or dissemination of “recorded images taken by a person or non-law enforcement entity through the use of infrared or other similar thermal imaging.
technology attached to an unoccupied aircraft system … and revealing individuals, materials, or activities inside of a structure without the consent of the property owner” (GS § 14-401.25).

Best practices for reducing conflict include developing a privacy plan, providing public notice of UAS operations (e.g., signage, online notifications), obtaining landowner consent prior to flights that may capture imagery outside of Reserve boundaries, blurring or removing potentially identifying information, and adhering to a cybersecurity plan (Nowlin, 2020). Public outreach and education can also help to combat disinformation and unreasonable privacy concerns (Ibid).

Prior to implementing the NC Coastal Reserve and NERR drone policy plan, managers should consider seeking feedback from Local Advisory Committees (LACs) to assess their privacy concerns related to UAS operations (NCDEQ). Annual reviews of existing UAS policy by staff and LACs will ensure that regulations and procedures remain adaptive to changing technology and public perceptions. This can also help aid in determining where UAS operations may be legal, but not necessarily ethical or well-received by community members.

_Nuisance and Trespass_

Because members of the public may visit public lands specifically in search of solitude and quiet or for wildlife observation, drone operations should aim to avoid unnecessary disturbance by maintaining distance and not flying directly overhead. Given that the Reserve aims to facilitate recreational uses that are compatible with other aspects of its mission, reducing drone interference — especially from those not collecting imagery for research purposes — can maintain the aesthetic and scenic value that many visitors seek.

Additionally, private property may be inadvertently captured by UAS sensors. The North Carolina DEQ UAS Policy specifically directs drone operators to make “every effort” to avoid flights over private property and to minimize retention of data containing PII (Appendix I). The Policy also outlines data management steps for storage, deletion, and destruction of private information, which are described in more detail in Section XII of this document.

**IX. Permitting and Required Information**

To conduct proposed projects on Reserve Sites, researchers should submit a permit application and obtain approval from the research coordinator and site manager (Appendix III). This form could provide a model for collecting additional information about UAS operations associated with a research proposal (Appendix III). Additions to the existing form may include identification of the UAS owner, as this individual is liable for accidents, as well as a signature indicating agreement to adhere to the Reserve Program UAS policy. Other important components for review prior to issuing a research permit include
participant information, such as contact information, certificates, and prior training for both the Pilot in Command and Visual Observer, as well as any other supporting crew members. Equipment specifications, including platform and battery type, serial and registration number, and sensors and payload should also be listed. The applicant should clearly describe the following aspects of their proposed operations: estimated start and end times, location/area of interest, and data collection methods. Other critical information includes documentation of liability insurance, a pre-flight plan, communications and airspace management considerations, and wildlife precautions.

The U.S. Antarctic Program Interagency Air Operations Manual provides a ConOps template outlining many of these components as part of group UAS proposals (U.S. Antarctic Program, 2019). North Carolina State University offers a more local and simplified example by way of its UAS Pilot Registration and UAS Flight Plan Notification forms (NCSU).

Appendix III. includes a draft UAS permit application form that may accompany the existing NC Coastal Reserve research permit application. Transferring this document to a Google Form could enhance ease of completion and enable long-term data collection into an associated spreadsheet. Over time, this data may provide insight on UAS management challenges, unexpected impacts, and other valuable trends. Appendix IV contains a ConOps template to accompany the draft UAS permit application and provide more details about operations, flight planning, and risk management.

X. Safety and Risk Management

The Association for Unmanned Vehicle Systems International (AUVSI) has developed a Code of Conduct for UAS operators that offers guidelines and best practices for safety, professionalism, and respect. Among other recommendations that signatories agree to adopt are “respect[ing] the concerns of the public as they relate to unmanned aircraft operations” and “ensur[ing that] UAS flights will be conducted only after a thorough assessment of risks associated with the activity” (AUVSI).

Flights over people

One major risk associated with UAS operations is injury to individuals on the ground, including the Pilot in Command and Visual Observer(s). In December 2020, the FAA adopted a rule that allows sUAS flights over people as of April 21, 2021 (FAA, 2021). Former regulations had only allowed flights over people actively participating in the operation or those who were protected by the roof of a structure or vehicle (FAA, 2020).

Some of the dangers posed by drone flights include falling sensors, batteries, propellers, and other parts, as well as UAS crashes or otherwise uncontrolled descents (FAA, 2017).
**Accident Reporting**

The FAA defines a drone accident as any event involving an sUAS that causes either “serious injury to any person or any loss of consciousness” or property damage exceeding $500 in cost for repair. In the event of a crash, the Pilot in Command should immediately call the National Transportation Safety Board’s Response Operations Center to file a report. The PIC must also submit a written report of the event to the FAA within 10 days (FAA). Other events that require reporting include: “flight control system malfunction or failure, inability of any required flight crewmember to perform normal flight duties as a result of injury or illness, failure of structural components of a turbine engine excluding compressor and turbine blades and vanes, inflight fire, and aircraft collide in flight” (FAA ENR 1.16 Safety, Hazard, and Accident Reports).

**Insurance and Liability Coverage**

While UAS insurance is not required by the FAA, it can be incredibly valuable in the event of an accident or loss of control with the aircraft. Because the drone operator assumes all risk and liability, pilots flying over Reserve sites should provide a policy number to demonstrate coverage. NC State, for example, requires all UAS operators to maintain aircraft insurance coverage (NCSU REG 10.10.09, 2018).

**Environmental Impacts**

Leakage and other hazards posed by lithium ion-polymer (LiPo) batteries may contribute to ecosystem pollution and alter water quality within the Reserve. Even if an injury does not occur in the event of a crash, any lost or abandoned materials on-site can pose hazards to visitors and wildlife alike, contributing to marine debris challenges. Similarly, fuel spillage can pollute waterways and contaminate soil and vegetation that local wildlife may rely on. In line with the Reserve’s mission of environmental stewardship, pilots should practice the principles of “Leave No Trace” and create a plan to deal with any UAS-related debris (NYDEC).

All of the elements mentioned above should be addressed in the safety plan and risk assessment required as part of the UAS permit application and ConOps (Appendices III. and IV.).

**XI. Wildlife**

Drones present a variety of potential threats and behavioral impacts to wildlife, including stress, harassment, harm, and death (Mulero-Pázmány, 2017). One of the earliest papers to study wildlife reactions to drones found that bears exhibit a stress response, with elevated heart rates correlated with distance to the airborne UAS (Ditmer et al., 2015). Given that the North Carolina Coastal Reserve
Program “provides essential habitat for wildlife,” UAS operators should minimize disturbance of the species that depend on estuarine ecosystems. Due to the limitations of this document, examples only include species relevant to the NC Coastal Reserve and NERR.

Species-specific considerations

Previous research suggests that UAS disturbance varies by species, as well as factors like type of platform, flight altitude, and proximity. Within the Reserve, particular attention should be devoted to shorebirds, wild horses, sea turtles, and other animals known to reproduce, feed, shelter, or complete critical life stages within NERR sites. Even if researchers intend to collect data on just one species, UAS flights are likely to impact other wildlife, so flight plans should take into account potential impacts on non-target species as well (Raoult et al., 2020).

Shorebirds:

The Atlantic Flyway, a major north-south migratory path, passes over the NC Coastal Reserve and NERR, making these sites an important sanctuary for bird species like red knots, piping plovers, black skimmers, and least terns. Across NC NERR sites, shorebirds generally nest on beaches — often directly on the sand — between April and August. For instance, 10 percent of North Carolina’s American oystercatcher population nests at the Masonboro Island site each year.

Across the country, wildlife managers have documented how poorly managed drone operations can impact behavior and physically harm birds. In response, the National Audubon Society published a best practices brief, entitled “Managing Conflicts between Birds and Unmanned Aerial Systems (UAS)” in 2015. This document recommends that “sensitive areas with extensive bird numbers” be deemed no-fly zones and encourages flight teams to establish a 50 to 100-foot buffer between UAS operations and areas where birds are present. Other researchers demonstrate that UAS approaching bird vertically had a more substantial behavioral impact and suggest that drones be launched at least 100 meters away (Vas et al., 2015). Birds may be especially sensitive to fixed-wing platforms, as the silhouette and wing profile of these aircraft mimics birds of prey; in some instances, these drones have been attacked by raptors (Lyons et al., 2017).

UAS operators should take particular care during nesting and breeding seasons, as disturbance can deplete valuable energy reserves and leave eggs and chicks exposed to the elements, as well as predation (Golden Gate Audubon). Within the Rachel Carson Reserve, for example, gulls, terns, and skimmers are known to nest on the dunes of Bird Shoal, and herons and egrets maintain a rookery “within the Middle Marshes shrub thicket” (Atkinson et al., 1998). The Rachel Carson Reserve, like other Reserve sites, falls within “the primary fall migration route for many species of birds,” and more than 200 species have been observed here, including federally threatened piping plovers (Charadrius melodus) and
state listed significantly rare Wilson’s Plovers (*Charadrius wilsonia*) (Ibid). Additionally, all drone operations must follow the guidelines set forth in the Migratory Bird Treaty Act.

**Birds of Prey:**

In addition to shorebirds and songbirds, there have been numerous documented instances of collisions with birds of prey. Viral videos of hawks and ospreys attacking drones highlight the risk of harm to birds, equipment, and the operator. Specifically, birds of prey may be injured or killed in collisions with drones. Even if no physical harm occurs, these encounters can deplete the birds’ energy, delay nest visitation, or disrupt hunting (Audubon Society). Raptors known to utilize Reserve sites include the osprey (*Pandion haliaetus*) and red-tailed hawk (*Buteo jamaicensis*) (Atkinson et al., 1998). As with shorebirds, policies involving birds of prey must abide by the Migratory Bird Treaty Act. Bald eagles also fall under the Bald and Golden Eagle Protection Act (USFWS).

**Wild horses:**

Since at least the late 1940s, the Rachel Carson Reserve has been home to wild, or feral, horses (*Equus ferus caballus*) (NCDEQ). Today, the herd of roughly 30 individuals is protected by both North Carolina state law and a Town of Beaufort local ordinance (NPS, 2017). These policies prohibit “feeding, touching, teasing, or intentionally disturbing wildlife including horses” (Ibid). Visitors to the Reserve are required to keep approximately 50 feet of distance from horses to minimize behavioral disturbances.

NERR staff have noted commercial drone operations at the Rachel Carson Reserve that appeared to chase horses to capture desired video footage (Gillikin, 2020). Approximately 100 feral horses, specifically “a herd of wild, [free-roaming] Colonial Spanish mustangs” also inhabit the Currituck Banks Reserve in the northern Outer Banks (Corolla Wild Horse Fund). Under its Wild Horse Ordinance, Currituck County prohibits cruelty to feral horses, including “molest[ing],” “torment[ing],” or “subject[ing] to conditions detrimental to [their] health or general welfare” (Currituck County Ord. of 12-18-89, pt. I, § 4, Sec. 3-33). Irresponsible drone use could certainly fall within this definition.

Previous research has documented changes in both individual and group behavior patterns of feral horses during fixed-wing UAS flights (Harshbarger, 2019). More specifically, time spent grazing and standing at rest decreased during UAS flight, while high vigilance behaviors — like standing alert and walking — significantly increased (Ibid.). Based on these documented behavior changes, the use of UAS to monitor feral horses “should be approached with caution” (Ibid.). In addition to behavioral impacts to horses, drone-based disturbances may present visitor safety concerns due to horses fleeing.
Sea turtles:

While drones pose less of a risk to sea turtles, it’s important to keep in mind that green sea turtles (Chelonia mydas) and loggerhead sea turtles (Caretta caretta) nest on the beaches of Reserve sites (NCDEQ). Previous studies have found that green sea turtles in nearshore waters did not have a strong behavioral response to drones flown at or above 10 meters (Bevan et al., 2018). Any night flights should aim to minimize light disturbance of nesting turtles. NOAA Fisheries is in the process of developing “national guidance for drone operations targeting … sea turtles.” Once published, this policy should guide all UAS use in the Reserve with the potential to impact sea turtles. Researchers note that UAS imagery can be a powerful tool for public outreach and education involving sea turtles (Rees et al., 2018).

Marine Mammals:

Drone flights launched from NERR sites may encounter marine mammals, such as bottlenose dolphins (Tursiops truncatus) and West Indian manatees (Trichechus manatus) (Fettermann et al., 2019). Recent studies of dolphin and manatee species noted disturbances and behavioral responses to UAS flights, including “orienting upward and turning toward the aircraft to observe it” and “fleeing the area,” respectively (Ramos et al., 2018). Bottlenose dolphins were “increasingly likely to change behaviour with decreasing drone altitude,” and longer UAS hover times correlated with the likelihood of behavioral response (Giles et al., 2020). NOAA Fisheries recommends that boats avoid approaching marine mammals head-on and instead opt to come from behind the animal. UAS pilots should also abide by this guidance. The forthcoming NOAA Fisheries policy also intends to provide guidelines for UAS operations in proximity to marine mammals (NOAA Fisheries, “Viewing Marine Wildlife”).

Best Practices

Across various species, maintaining an appropriate distance from wildlife during launch and flight remains critical. Particularly in the case of birds, platform selection can affect disturbance, as fixed-wing drones mimic raptors and provoke behavioral responses in prey species. As the Reserve has already set forth with wild horses, staff should consider establishing a minimum distance from at-risk species during UAS operations, as defined by buffers and no-fly zones. While there is no hard and fast rule to establish appropriate distance between airborne UAS and wildlife, field observations suggest that flights at an elevation of 30 meters or more have minimal impacts (Raoult et al., 2020). Additional insight from Reserve managers with more intimate knowledge of local species and populations should influence any distance and elevation requirements placed on UAS operators.
**Relevant legislation**

**Marine Mammal Protection Act**

The Marine Mammal Protection Act (MMPA) prohibits takings — “harassment, hunting, capturing, collecting, or killing” — of marine mammals in U.S. waters. As mentioned above, the species of principal concern for Reserve sites are bottlenose dolphins (*Tursiops truncatus*) and West Indian manatees (*Trichechus manatus*). UAS operations in close proximity to these animals should be avoided, as the sight and sound of drones can cause stress and may be considered harassment. Researchers are only authorized to use drones to study protected marine mammal species if they possess proper permits and authorizations (NOAA Fisheries).

**Endangered Species Act**

The Endangered Species Act (ESA) prohibits the “take,” of any threatened or endangered species, or any actions that "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct” (U.S. FWS, 1973). If conducted recklessly or with malintent, UAS operations could be considered harassment, harm, and/or pursuit of wildlife.

**Migratory Bird Treaty Act**

The Migratory Bird Treaty Act (MBTA) “prohibits the take (including killing, capturing, selling, trading, and transport) of protected migratory bird species without prior authorization by the Department of Interior U.S. Fish and Wildlife Service” (USFWS). The U.S. Fish & Wildlife Service issued an update to the rule in January of 2021, excluding “incidental take” from protections and stating that the MBTA “applies “only to actions directed at migratory birds, their nests, or their eggs” (Federal Register). Therefore, only UAS operations that specifically targeted protected migratory species would fall under the Act.

**Bald and Golden Eagle Protection Act**

The Bald and Golden Eagle Protection Act “prohibits anyone, without a permit issued by the Secretary of the Interior, from "taking" bald or golden eagles, including their parts, nests, or eggs” (USFWS). The Act protects against molestation and disturbance of bald and eagles, meaning that UAS operations that interfere with “normal breeding, feeding, or sheltering behavior,” potentially resulting in decreased productivity or nest abandonment, could be subject to penalty under law (USFWS).

**Other Policies**

The North Carolina Department of Transportation (DOT) has implemented a policy that prohibits operators from using a UAS to disrupt wildlife resources or the lawful taking of wildlife (e.g., permitted hunting). It is also against the law to use a UAS in the process of taking wildlife resources (NCDOT G.S. 113.295).
XII. Data Management

Data Processing and Storage

A data storage and security plan is essential for ensuring privacy, maintaining organization, and informing future UAS policy (Figure 11). Data and metadata, including flight logs and associated images, collected within the Reserve should be securely stored in multiple locations, such as external hard drives or SD cards. Reserve staff who operate drones should note that the North Carolina DEQ prohibits the storage of “raw and intermediate processing data” on agency servers and recommends that “only data pertaining to the original purpose of the UAS flight be retained (NCDEQ, 2019). A similar protocol for archiving UAS-based data, establishing retention schedules, and obscuring incidentally collected PII should be established. Utilizing common and/or open-source data processing software, such as Pix4D, Drone Deploy, and OpenDroneMap, can facilitate interagency analysis and other collaborative research. Offices affiliated with each Reserve site should prepare for large data storage capabilities and understand that some UAS research projects may be limited due to inadequate storage and lack of standardized data processing best practices. Pilots not affiliated with the Reserve should note their plan for maintaining secure data and avoiding the collection of PII (Appendix IV.).

Data Sharing

Data sharing decisions should consider the funding source of the research requesting approval. Any Reserve-funded research should include stipulations that UAS data and results are released to the public and be stored on Reserve servers. If the Reserve only permits, but doesn’t fund, a given UAS-based project, the applicant will have to comply with the data management plan outlined in their grant. The North Carolina DEQ allows for UAS data to be shared “over a secure state-approved medium, such as SharePoint or OneDrive” (NCDEQ, 2019).

XIII. Recommendations

Based on the policy components and best practices described above, I recommend that N.C. NERR staff take into account the following site-specific considerations in the development of a Reserve drone policy.

1. Wildlife protection

All UAS permit applicants should demonstrate that they are aware of species-specific responses (target and non-target), critical life history stages, and potentially antagonistic interactions with wildlife known to inhabit or pass through the intended flight area or study site. Their flight plans should detail
which species might be affected by drone operations and include adaptive strategies to mitigate disturbance and behavior change. Additionally, as part of the application process, the Reserve should require evidence of adherence to state and federal wildlife laws. For reasons previously discussed, shorebirds and wild horses necessitate special precautions from drone exposure. UAS operations that have not specifically been approved for research on shorebirds should not be conducted in the vicinity of nesting, foraging, or resting areas, as defined by Reserve staff.\(^3\) This may be achieved by establishing no-fly areas and/or setting up buffers to restrict launch, flight, and landing operations. Additionally, drones should not be launched in close proximity to wild horses. If the pilot in command or visual observer detects the presence of horses once the drone is airborne, operations should be ceased or the flight path should be altered. As noted by Reserve staff, UNC-Wilmington researchers regularly fly drones at Masonboro Island Reserve. The 8.5-mile-long island offers easy-to-access places, where drone activity is currently concentrated, but the middle section of island experiences less human disturbance and is thereby considered prime wildlife habitat (Sutton, 2020). In this case, Reserve staff should consider restricting UAS operations to areas of the Reserve that have less wildlife density where possible.

2. **Visitor safety**

UAS use should be restricted to operations conducted by certified remote pilots, public safety and government officers, and educational users, as categorized by the FAA. In line with the UAS policies of other agencies that manage public lands, such as the National Park Service and North Carolina State Parks, hobbyists should not be permitted to fly drones within Reserve boundaries, including recreational UAS launch and landing from all Reserve lands. This restriction would minimize disturbance to wildlife and UAS operators using the Reserve for research and education, as well as reduce the total number of flights on any given day. Banning hobbyist flights could also reduce potential ethical and privacy concerns from other recreators at the sites.

It should be noted that North Carolina state parks, which promote recreational activities, presently prohibit the use of drones within their boundaries. While this policy limits recreational opportunities for visitors who wish to capture aerial photos and videos, it ultimately helps fulfill other key objectives of the Research Reserve system, including minimizing interference with research operations, reducing human-wildlife conflict, and protecting the privacy and solitude of other visitors. Non-research related commercial operations should be evaluated on a case-by-case basis to ensure that any filming or data

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\(^3\) Reserve staff may choose to develop a GIS featuring the primary locations of sensitive species across seasons. For more mobile species, such as feral horses, a critical habitat layer could display watering holes and other known resources or areas of congregation.
collection aligns with the Reserve mission. In all cases, UAS applicants must complete a N.C. NERR permit application, detailing their safety protocol and risk management strategies, as well as agreeing to abide by the AUVSI code of conduct. Clear signage, including contact information, should be posted at main entry points to Reserve sites to inform visitors of these regulations and alert them to the presence of drones for research and educational purposes. Reserve staff should work with the FAA to ensure that any Reserve policy updates are included within agency resources, such as the B4UFly mobile app.

3. Flight planning and documentation

All UAS permit applicants must include a detailed flight plan as part of their application. UAS operators should note the purpose of the mission, proposed route and altitude, anticipated timeframe, data collection methods, weather-related requirements, and lost link preparations. UAS platform specifications should be listed, as well as details on the accompanying sensors and payload. Operators who wish to use customized platforms should also provide additional information to Reserve staff in their application to describe modifications, as well as their implications for mission safety. A trend analysis of accidents or wildlife disturbance associated with custom platforms can assess risk over time and support any necessary policy updates. All pilots in command should fly with a visual observer and provide evidence of federal and state licensing, in addition to flight hours with the desired platform and any training to prepare for Reserve conditions. Data collected as part of the UAS permit application form should be stored and analyzed by Reserve managers to identify trends and determine if policies should be altered as a result.

4. Privacy and ethical use

Prior to receiving approval to access the Reserve, UAS operators should affirm that they will take steps to avoid capturing personally identifying information (PII) and securely store any incidental footage on password-protected servers. If data containing PII must be used for analysis or publication, this information should be blurred or otherwise obscured. The Reserve should consider updating its website with notifications to provide adequate notice to visitors of permitted drone flights in the area. Reserve staff should hold periodic stakeholder engagement meetings with Local Advisory Committees (LACs) to assess public perception and concerns of UAS operations. This feedback can inform public outreach and education strategies to combat disinformation and unreasonable privacy concerns. Communications about the policy should be guided by stakeholder concerns, coordinated across the Reserve Program, and adapted to site-specific needs.
XIV. Future Directions

Education and Outreach

Public education materials should be developed to communicate the N.C. NERR drone policy, once adopted, and highlight the importance of UAS data in research and conservation. For example, a potential future master’s student project could use high-resolution imagery collected by drones to create a virtual reality (VR) experience of one or more of the reserve sites. In addition to creating an engaging and immersive platform for learning about estuarine ecosystems and geospatial technology, the VR experience could enhance access to the Reserves for those who are disabled or otherwise unable to visit in person. Similarly, an ArcGIS StoryMap could showcase data and research applications, as well as best practices for UAS missions on the Reserve in adherence to the new policy. The Reserve website and social media platforms could also be updated to highlight UAS-based management applications, including habitat mapping, coastal change and sea level rise monitoring, hurricane impact assessments, wildlife population monitoring, and marine debris identification. By demonstrating the benefits of UAS data collection, such as accessing ecologically fragile areas without the impacts of traditional marsh transects, these educational materials can create a powerful case for the ongoing use of drones. Finally, flight demonstrations, workshops, and training opportunities with local schools and community groups can familiarize the general public with this technology and provide a foundation for future work in the fields of environmental science, robotics, geospatial analysis, and technology development.

Communications

Once the Reserve UAS policy has been finalized, managers should prioritize communicating the policy change and new requirements to local residents and Reserve visitors. Ideally, this communications strategy will emphasize the value of UAS-based research in achieving the Reserve’s mission. A summary of the policy should be made available and easily accessible on the DEQ website, and appropriate signage should be installed and/or updated at main Reserve entrances and access points. The local community should have adequate opportunity to weigh in on the changes via focus groups or online comment, which can assist Reserve managers in assessing public perception of drones at NERRS sites. To ensure that drone imagery isn’t misinterpreted by the public, the Reserve should require approved UAS operators who post drone imagery/videos to social media platforms to include information about permitting.

Partnerships

As drones gain traction and become more common tools for environmental management and monitoring, the Reserve should collaborate with regional partners, including NERRS sites along the southeastern coast. Standardizing policies, offering combined training, and sharing resources can facilitate
long-term UAS-based research projects, increase staff competency, and reduce costs. Other potential partners include state or non-profit organizations, commercial enterprises, and NOAA Cooperative Institutes (Wells NERR). The policy implemented by the N.C. Coastal Reserve and NERR has the potential to serve as a model for NERRS sites across the country, and it can be strengthened by the feedback, insight, and experience of other estuarine research, geospatial analysis, and environmental policy professionals.

Given the growing popularity of drones and the likelihood of emerging safety concerns, new environmental hazards, and evolving public perception, a clear and accessible policy will be essential for effectively regulating UAS operations across the Reserve Program. This guidance stands to enhance research, education and stewardship throughout North Carolina’s coastal and estuarine ecosystems, while demonstrating the responsible use of technology to support complex environmental management decisions under a changing climate.

Acknowledgements

The inspiration for this policy reference guide and accompanying resources came from Dr. Brandon Puckett and his research priorities at the North Carolina National Estuarine Research Reserve. His thoughtful feedback and insight has been essential to the project. My advisor Dr. David Johnston first introduced me to the world of drones in marine science at the Duke University Marine Lab and has provided ongoing encouragement and support throughout my time at the Nicholas School. Students and staff at the Duke University Marine Robotics and Remote Sensing Lab have supplied an endless source of creativity, innovation, and dedication to their research. Paula Gillikin and Hope Sutton graciously shared their personal experiences managing North Carolina Coastal Reserve and National Estuarine Research Reserve sites to better inform this work.
Figures

Figure 1: Map of 29 National Estuarine Research Reserve System sites (Kennish, 2019).

Figure 2: Map of North Carolina Coastal Reserve and National Estuarine Research Reserve sites (N.C. DEQ).
Figure 3: Aerial photograph of the Rachel Carson Reserve in Beaufort, North Carolina (N.C. DEQ).

Figure 4: Federal Aviation Administration Airspace Guidance for Small UAS Operators (FAA).
Figure 5: A National Park Service sign reminding visitors to abide by UAS regulations (NPS).

Figure 6: U.S. National Forest Service (USDA).
Figure 7: Draft ConOps elements for “commercial off the shell” (COTS) and custom UAS (Marine Robotics and Remote Sensing Lab).

Figure 8: Overview of operational protocols used for drone research on marine animals (Raoult et al., 2020).
Figure 9: Elements of an Unmanned Aircraft System (Wells NERR).

Figure 10: The range of aircraft used in coastal research relevant to the NERR. (Johnston, 2019).
Figure 11: Draft ConOps elements for data and metadata (Marine Robotics and Remote Sensing Lab).
References


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Federal Aviation Administration, “ENR 1.16 Safety, Hazard, and Accident Reports.”
Federal Aviation Administration, “FAA Issues Study on UAS Human Collision Hazards.”
Federal Aviation Administration, “FAA Restricts Drones Over Statue of Liberty, Other Landmarks.”
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Federal Aviation Administration, “Operate a Drone, Start a Drone Program.”
Federal Aviation Administration, “Public Safety and Government.”
Federal Aviation Administration, “Recreational Flyers & Modeler Community-Based Organizations.”
Federal Aviation Administration, “Restricted or Special Use Airspace.”
Federal Aviation Administration, “State and Local Regulation of Unmanned Aircraft Systems (UAS) Fact Sheet.”
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World Wildlife Fund, “How Drones Help Black-Footed Ferrets”

Appendix

1. North Carolina Department of Environmental Quality Unmanned Aircraft System Policy (#UAS001)

<table>
<thead>
<tr>
<th>Business Category: Secretary’s Office</th>
<th>Business Area: Unmanned aviation support for environmental quality missions</th>
</tr>
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<tbody>
<tr>
<td>Approval Date: 1/21/2019</td>
<td>Last Revision Date: 1/21/2019</td>
</tr>
<tr>
<td>Next Review Date: 1/21/2020</td>
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**Authorities:**

N.C.G.S. §§ 15A-100.1 (Restrictions on use of UAS), 15A-100.2 (Regulation of launch and recovery sites), 15A-100.3 (Use of UAS near a confinement or correctional facility prohibited), 14-7.45 (Crimes committed by use of UAS), 14-280.3 (Interference with manned aircraft by UAS), 14-401.24 (Unlawful possession and use of UAS (weapon attached)), 14-402.25 (Unlawful distribution of images), 113-295 (Unlawful harassment of persons taking wildlife resources), 63-94 (Applicability of Article), 63-95 (Training required for operation of UAS), 63-96 (License required for commercial operations). Session Laws 2014-100, 2015-232, 2016-90, 2017-160, 2017-179. 14 C.F.R. Part 107 (Federal Aviation Administration (FAA) Small UAS Rule).

**Policy Owner:**

North Carolina Department of Environmental Quality (NCDEQ) GeoTeam - A standing group of NCDEQ staff members representing agency business units and Information Technology who are technically knowledgeable regarding the needs and capabilities of their respective programs.

**Policy:**

The use of Unmanned Aircraft Systems (UAS), also known as Drones, have the potential to substantially refine certain NCDEQ data collection and business processes. Exploiting this technology has significant fiscal and labor benefits to NCDEQ’s diverse agency missions and is in the interest of the State of North Carolina. This policy outlines specific guidelines to facilitate the safe and legal operation of such UAS technology. Compliance with all relevant federal, state, and local regulations and laws is required. The GeoTeam shall develop operational, data collection, processing and storage procedures to implement this policy. The GeoTeam shall report to NCDEQ leadership concerning efficiencies gained by incorporating UAS technology. UAS purchases must be from the approved list, determined by DEQ’s GeoTeam.

**Definitions**

An “Unmanned Aircraft” means an aircraft, as defined in N.C.G.S. 63-1, that is operated without the possibility of human intervention from within or on the aircraft.

An “Unmanned Aircraft System” means an unmanned aircraft and associated elements, including communication links and components that control the unmanned aircraft that are required for the pilot in command to operate safely and efficiently in the national airspace system.

**Purposes of UAS Use**

UAS platforms should only be employed in connection with properly authorized NCDEQ inquiries and activities. Discretionary use may also be made for natural disasters, terrorism, and “hot pursuit” crimes. Data collected by drones shall be subject to existing state and federal laws and regulations regarding the privacy of personal information. The use of private UAS equipment by a NCDEQ employee for NCDEQ business is prohibited. It is the responsibility of each UAS operator to check with local governments to insure compliance with local laws, regulations or ordinances pertaining to the UAS study area. All UAS must be
registered with the FAA, the North Carolina liability insurance plan, and NCDEQ’s GeoTeam.

Data Collection & Handling

Data collected from a UAS platform shall be stored on a Secure Digital (SD) card or other secure portable storage device. Cloud based solutions are not permitted in the field. Once collected, data may be transferred from the SD card to a secure, local Personal Computer for analysis. Following analysis, data may be shared over a secure state approved medium such as SharePoint or OneDrive. Raw and intermediate processing data should not be stored on NCDEQ servers.

Avoidance of Private Property

In planning UAS flight activity, every effort should be made to completely avoid private property, unless the State is granted private property easements. Retention of data should be minimized. If private property is accidently captured during data collection, the data should be deleted from the raw imagery by masking the raw data with a private property raster mask. Current parcel data should be used to identify private property and to generate masking files. Once the mask has been performed and a new raster image has been generated, the original raw data, which included the private property, shall be permanently deleted or destroyed. Video images and other data derived from data collection applications should be minimized in terms of review and retention, consistent with state records retention requirements. Only data pertaining to the original purpose of the UAS flight should be retained. NCDEQ should set retention schedules consistent with the fulfillment of the original purpose of the UAS flight.

Protection of Individual Privacy and Personal Information

NCDEQ UAS flight operation shall respect civil rights. NCDEQ employees and service providers shall limit operations to the specific approved purpose of the data collection project and employ reasonable precautions to avoid capturing images of the public except those that are incidental to the project. UAS platforms should not be used to monitor activities protected by the First Amendment or lawful exercise of other Constitutional rights. NCDEQ personnel should balance use of UAS platforms against other means of gathering data for a particular agency need, assessing whether such alternative means are less intrusive than the deployment of a UAS.

Operational and Training Requirements

NCDEQ UAS operators must attain an FAA airmen certificate under 14 C.F.R. Part 107 and hold a valid State of North Carolina UAS Operator Permit in order to operate a UAS for NCDEQ. NCDEQ UAS operators must demonstrate proficiency with the UAS platform they wish to operate and must do so on an annual basis. All flights must be logged in order to track pilot flight time and to keep current with UAS maintenance requirements.

Reporting

The GeoTeam shall report to NCDEQ leadership concerning efficiencies gained by incorporating UAS technology. New UAS projects within NCDEQ are required to submit quarterly metrics to the GeoTeam. Metrics include achievements, time saved, resources saved etc. Compilation of such metrics facilitate the continued development, sustainment, and future growth of the NCDEQ UAS program.

Policy Management

UAS policy guidelines and agency implementation should be reviewed annually to keep abreast of technology and respond to citizen concerns. NCDEQ, in coordination with the North Carolina Department of
Transportation (NCDOT) UAS program, should strive to conduct public education and outreach regarding NCDEQ UAS policies and operations. NCDEQ may share UAS data with federal and state agencies, as appropriate.

Scope

This Policy applies to all NCDEQ employees and contracted service providers involved in the operation of a UAS platform within the State of North Carolina, including inland and coastal jurisdictional waters.

Web-based References

A summary of Federal Aviation Administration (FAA) part 107 rules regarding Unmanned Aircraft can be found here:
https://www.faa.gov/uas/media/Part_107_Summary.pdf

The North Carolina summary of regulations can be found here:
https://connect.ncdot.gov/resources/Aviation%20Resources%20Documents/UAS_Memo.pdf

Each government employee who wishes to utilize drones, must first attain the following credentials:
FAA Part 107 Remote Pilot Airman Certificate:
https://www.faa.gov/uas/getting_started/part_107/remote_pilot_cert/

NC UAS Operator Permit for Government Use:
https://www.ncdot.gov/aviation/uas/

North Carolina DEQ Standard Operating Procedures
Add link when documents are finalized and hosted

Approved by:

[Signature]

John A. Nicholson
Chief Deputy Secretary
January 21, 2019
II. Literature Database
All relevant scientific journal articles, white papers, and other resources referenced in this document are included as part of a Zotero library. Tags, including “applications,” “birds,” “ConOps,” “FAA,” “federal,” “general,” “horses,” “legal,” “marine mammals,” “media,” “NC,” “NERR,” “NGO,” “NOAA,” “privacy,” and “safety” allows users to sort resources according to their needs. These resources offer more in-depth explanations of the topics outlined in this document. The Zotero resource library has been shared with Reserve Research Coordinator Dr. Brandon Puckett and can be made available to other Reserve staff as needed.

III. Draft UAS Permit Application
This document serves as an example UAS permit application for operations within the Reserve. A Google Form version (shared with Reserve Research Coordinator Dr. Brandon Puckett) allows data to be collected and imported into a database for future reference by Reserve staff, such as hindcasting potential drivers of UAS-derived responses to wildlife. The permit application gathers general information about the pilot, aircraft, and mission, while the ConOps template collects more details about the flight plan and risk management (Appendix IV.).
**UAS Permit Application**
N.C. Coastal Reserve & National Estuarine Research Reserve

All UAS pilots who wish to launch, fly, or land on/over N.C. Coastal Reserve and National Estuarine Research Reserve property are first required to register as a pilot. Each applicant must also submit a Concept of Operations with more details about the mission, data collection methods, pilot experience, operational parameters, risk management, and environmental limitations.

**Basic Contact Information**
Pilot Name:

Principal Investigator (PI) or Supervisor Name:

Institution or Other Professional/Organizational Affiliation:

Advisor Name and Degree Program (Student Applicants Only):

Email:

Phone Number:

Address:

**UAS Details**
U.S. FAA Remote Pilot Certificate Number:

State of NC Pilot Permit Number:

State of NC Permit for:

- [ ] Commercial operator
- [ ] Government operator

Total Hours of UAS Flight Experience:

Aircraft/Platform Type:

For Customized Platforms, Please Provide Additional Details About Your Aircraft and Modifications:

Sensor Type:

Registration Number:

Insurance Policy Number:
**Project Details**

Flight Location:

Proposed Date(s) of Operations:

Estimated Flight Time:

Briefly Describe Proposed Operations:
IV. *ConOps Template*

This draft Concept of Operations template is intended to accompany the draft permit application form and describe the information the Reserve requires in more detail. Pilots can provide specifics on their proposed flight plan and risk management protocols here.
Concept of Operations (ConOps) for UAS-Based Research and Other Applications in the N.C. Coastal Reserve & National Estuarine Research Reserve

I. Executive Summary
Provide a general overview of your mission and objectives.

II. Project Participants
List all members of your flight crew, including pilots, visual observers, and field support, noting their operational roles.

III. Pilot Experience
List total pilot hours (indicate if these were research, hobby, or simulator flights) and any relevant workshops, training, classes, or other UAS experience. Please note recent flight hours (conducted within the last year) to demonstrate currency, and indicate whether platforms were rotary or fixed wing.

IV. Sampling Approach and Data Collection
Describe the data you aim to collect with this mission, including details about sensors and target species or locations.

V. UAS Systems and Operational Parameters
A. Aircraft Type
Describe the make and model of your UAS. If the aircraft is customized, please detail these modifications, their purpose, and any additional safety considerations.

B. Navigation
Describe how you will control the UAS during flight. (Ex: Line of sight manual control, autopilot, etc.).

C. Launch and Recovery
Describe your launch and recovery operations, as well as associated safety protocols.

D. Flight Elevation, Range, and Duration
Describe your anticipated flight plan.

E. Environmental Limitations
Describe your platform’s ability to withstand Reserve conditions (Ex: wind speed, cloud cover, etc.).

F. UAS Command and Control
Describe any other aspects of platform and sensor operations not mentioned in “Navigation” or “Launch and Recovery.”

G. Environmental Safety and Wildlife
Describe how you plan to minimize your impact on the Reserve, including any anticipated effects to wildlife. Note how you plan to abide by relevant laws and policies, including, but not limited to, the Endangered Species Act, the Migratory Bird Treaty Act, and the Marine Mammal Protection Act, as well as local ordinances (e.g., those regarding wild horses).

VI. Mission Description and Proposed Locations
   A. Number and Duration of Flights
      List the number of flights you expect to complete in the given time period, as well as their approximate duration.

   B. Locations
      List the Reserve site(s) you will use for launch/landing and flight, and specify which areas of each site will be targeted.

VII. Airspace Management
     Describe your protocol for avoiding flight interference, managing air traffic, and monitoring relevant communications channels.

VIII. UAS Recovery and Contingency Planning
     Describe your accident reporting procedure, emergency protocol for a loss of power, control, or communications, and your plans for UAS recovery after the event.

IX. Data Management and Cybersecurity
    Describe your data storage plan and any protocols for ensuring security and protecting privacy of Reserve visitors and private property.