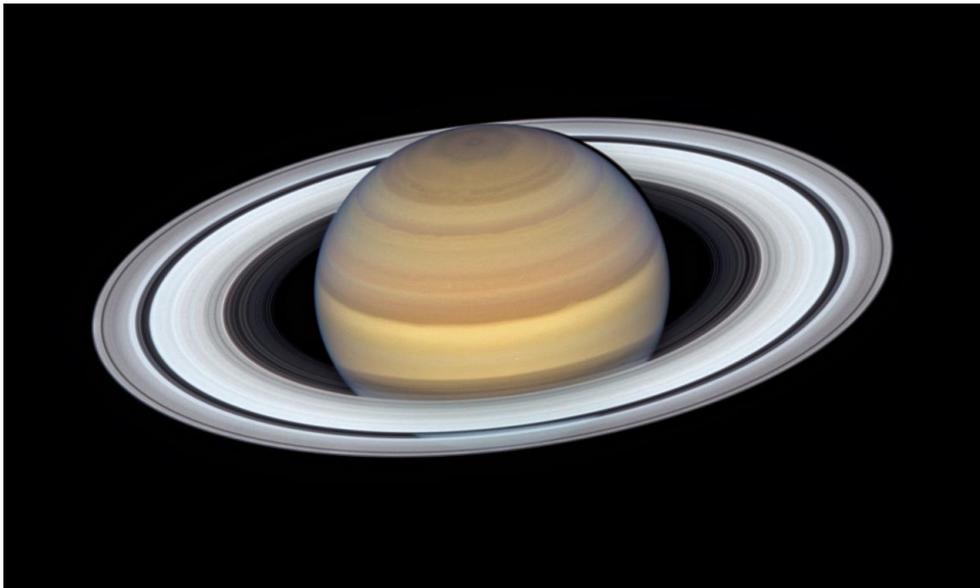


**NIGHT-SCAPE RESOURCES:
NORTHEASTERN NORTH CAROLINA COASTAL SYSTEM**

NORTH CAROLINA LAND OF WATER (NC LOW) & A TIME FOR SCIENCE (ATFS)

www.nclandofwater.org & www.atimeforscience.org



April 3, 2020

**NIGHT-SCAPE RESOURCES:
NORTHEASTERN NORTH CAROLINA COASTAL SYSTEM**

**PART 1: THE NIGHT SKY and NOCTURNAL ENVIRONMENT
OF THE OUTER ALBEMARLE PENINSULA (OAP)**

NORTH CAROLINA LAND OF WATER (NC LOW) & A TIME FOR SCIENCE (ATFS)

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COVER PHOTOGRAPHS. Upper panel is the opening act for the nightscape program: often an awesome light show as the Sun sets over the Alligator River. Photograph is by S. Riggs. Lower panel shows a Hubble Space Telescope view of Planet Saturn taken on 6-20-2019 reveals the details of the ring system and a turbulent, dynamic atmosphere intense pattern of clouds swirling in Saturn's turbulent atmosphere. Image is from NASA, ESA, A. Simon (Goddard Space Flight Center) and M. Wong (University of California, Berkeley), and the OPAL Team.

PART 1: THE NIGHT SKY and NOCTURNAL ENVIRONMENT OF THE OUTER ALBEMARLE PENINSULA (OAP)

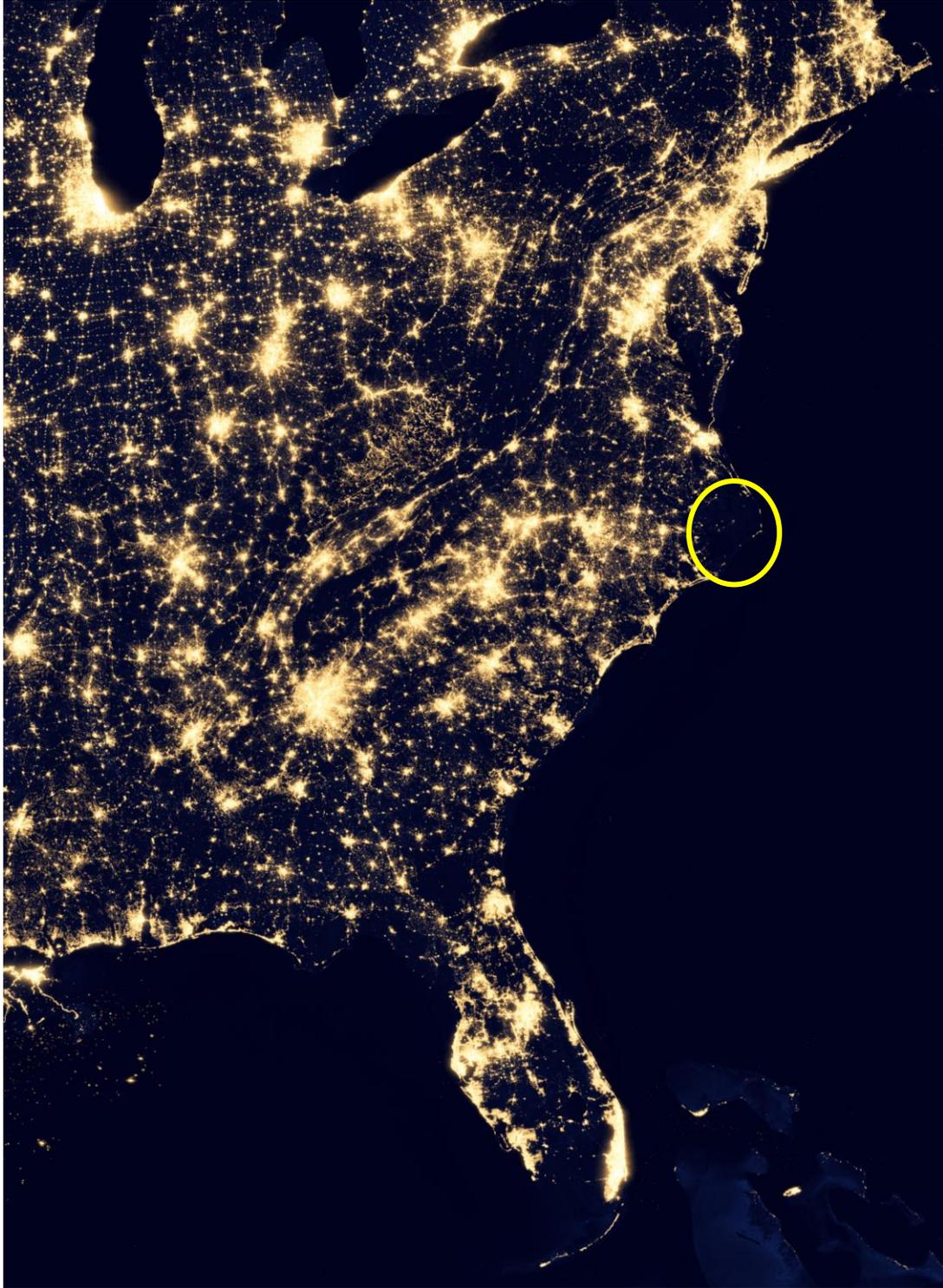
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INTRODUCTION

The night skies of the Outer Albemarle Peninsula (OAP) are among the darkest in the entire US Atlantic coastal system for several primary reasons. First, much of the OAP landscape is very low relative to sea level and is dominated by wetlands that today are preserved as national wildlife refuges, state parks and reserves, and vast acreages of public game lands (over 500,000 acres or 780 mi²). The OAP is surrounded by the 2,900 mi² publically owned buffer region consisting of four large estuarine water bodies (Albemarle Sound to the north, Croatan and Pamlico sounds to the east and southeast, and Pamlico River Estuary to the south), two additional National Seashores (Cape Hatteras and Cape Lookout), and two National Wildlife Refuges (Pea Island and Cedar Island) that provide another 105,000 acres or 163 mi². These huge water bodies are extremely dark in all but one narrow zone including Roanoke Island and the Outer Banks north of Oregon Inlet. The public water bodies are not only extremely dark, but provide expansive no light buffer zones around the north, east, and south sides of the OAP with vast horizons for experiencing the night-scape dynamics. The western side of the OAP is dominated by an enormous region of agricultural fields that extend westward to the western edge of the lower Coastal Plain (demarcated by the ancient Suffolk Shoreline) with minimal light sources and spacious horizons. All together this region provides the largest area of public dark skies along the US Atlantic coastal system between Boston and Miami (Figure 1).

The nocturnal environment and their night skies rotate from the brilliant, big sky of the full moons to the blackness of the new moons when the starry sky opens to a dazzling universe (Figure 2). A large seasonal variation is superimposed upon the vastness of the sky itself. This local overprint ranges between two extremes. The cold, crisp, winter nights are dominated by either the overwhelming sounds of flocks of winter waterfowl (e.g., tundra swans and snow geese by the many tens of thousands) moving from the refuge lakes to the farm fields, the lonesome hoots of owls on their evening hunts, howls of roaming coyote packs, or occasionally the rare red wolf. The summer nights are hot and humid and dominated with a cacophony of insects and frogs and massive light and sound displays derived from the outlines of perfect thunderheads as they move across the Albemarle Peninsula. And of course, the never ending parade of early morning sunrises and evening sunsets (Figure 3) provides new mosaics of sky magic.



*FIGURE 1. City lights of the United States in 2012 by NASA Goddard and created on 12-8-2017.
Visible infrared imaging Radiometer Suite
[https://images.nasa.gov/details-GSFC_20171208_Archive_e001590.](https://images.nasa.gov/details-GSFC_20171208_Archive_e001590)*



FIGURE 2. The night sky photograph looks south over Phelps Lake from the pier at Pettigrew State Park Visitor's Center in Tyrrell County. Photograph is by B. Foley.



FIGURE 3. Winter sunset over Pocosin Lakes National Wildlife Refuge. Photograph is by M. Dunn.

In a quest to better understand the nocturnal environment and dark skies of the region, North Carolina Land of Water (NC LOW) and A Time For Science (ATFS) designed a study to map and characterize the landscapes, soundscapes, and viewscapes of the OAP across four eastern NC counties. The study is led by Dr. Stanley Riggs, Coastal and Marine Geologist at NC LOW and lead investigator in this Night-Scape resource project. Ms. Karen Clough is the Community Outreach Coordinator for NC LOW, Ms. Emily Jarvis is Executive Director of ATFS, and Mr. Brian Baker is Director of Astronomy with ATFS. The project has a working partnership with Dr. Reide Corbett, Oceanographer and Executive Director of the ECU Coastal Studies Institute (CSI). Also, three groups of local volunteers constitute the field mapping teams obtaining night time observations in Tyrrell, Washington, and mainland Dare and Hyde counties. The project also has developed working partnerships with the US Fish and Wildlife Service (Alligator River, Pocosin Lakes, Mattamuskeet, and Swanquarter Wildlife Refuges), the NC Wildlife Resources Commission, and NC State Parks.

NC LOW and ATFS are non-governmental 501 c 3 organizations involved in regional coastal research and science education initiatives in the northeastern NC. The mission of these non-profit programs is to contribute to 1) scientific understanding of the dynamic coastal system, 2) delineate potential sustainable eco-tourism opportunities, and 3) carry out regional K-12 and public science education programs within the coastal region. All of their programs are framed around the unique natural resources and rich cultural history of NC's world-class coastal system and utilized to enhance the quality of life of its residents.

OUTER ALBEMARLE PENINSULA (OAP)

Project Goals

1. What are the night-scape resources for the nocturnal environment and the night sky within the vast public lands of the OAP?
2. How can the OAP region decrease the present levels of light pollution and prevent further light pollution in order to maintain a world-class, dark sky natural resource?
3. How can regional night-scape resource programs be incorporated into a) the developing OAP eco-tourism trail system, b) local K-12 school systems, and c) programs for the public?

The night-scape survey teams are comprised of scientists, educators, and students that live and work in the coastal region. Through their combined effort, starting in July 2018 through May of 2019, the teams have surveyed their county on 11 new and 11 full moon nights and accomplished the following night-scape data collection (Figure 4): Mainland Dare: 97 visits to 22 sites; Mainland Hyde: 67 visits to 27 sites; Tyrrell: 54 visits to 22 sites; Washington: 32 visits to 12 sites; TOTAL = 250 VISITS TO 83 SITES. In addition to describing the surrounding environment, accessibility, and apparent urban noise and light pollution at each site through the four seasons, researchers measure quality of the sky darkness, ambient sound, and meteorological parameters.

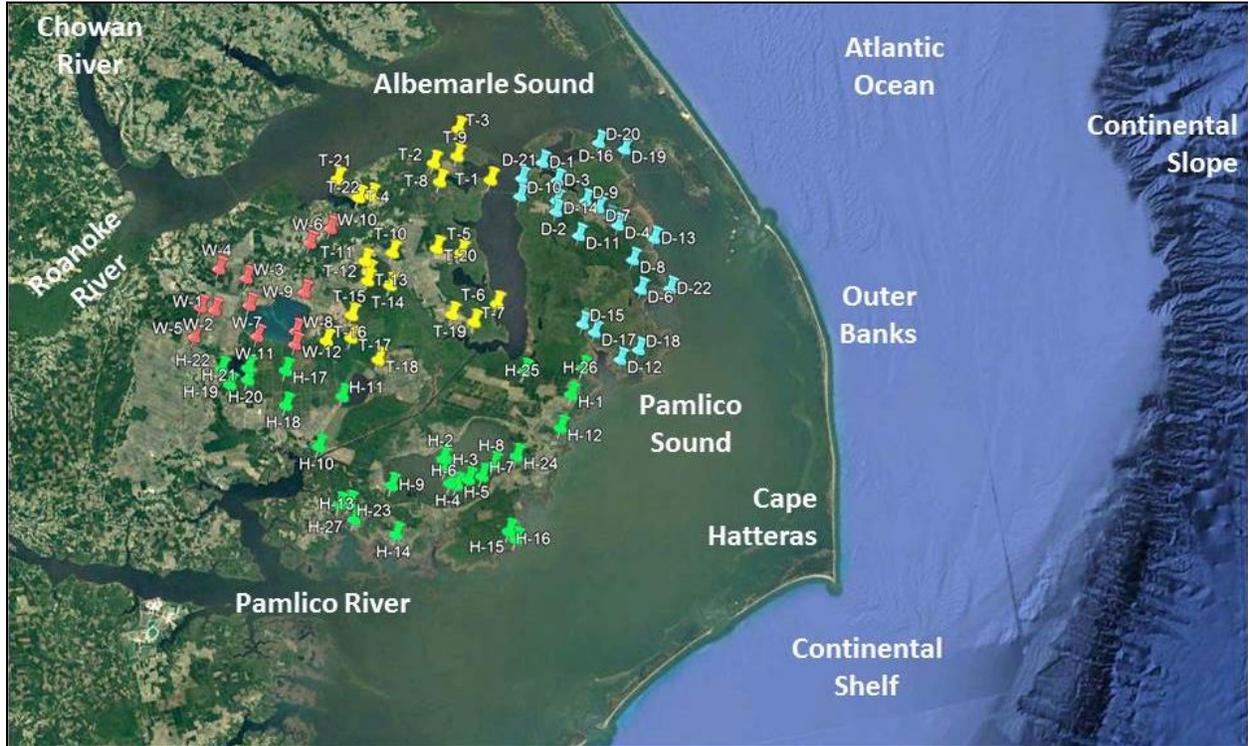


FIGURE 4. A Google Earth image shows the outer Coastal Plain and Continental Margin of northeastern North Carolina. The pins represent the night-scape survey sites on the Outer Albemarle Peninsula: blue pins = mainland Dare County, green pins = mainland Hyde County, yellow pins = Tyrrell County, and red pins = Washington County.

The data from these surveys was used to quantify and map the general night-scape and light pollution in the OAP. This knowledge will help shape plans to protect our unique Night-scape resource, responsibly incorporate the resource into ongoing eco-tourism programs, and potentially enable the OAP to earn regional designation as an “International Dark Sky Place.” The Dark Sky Place title—and accompanying backing of the International Dark Sky Association—helps enhance the visibility of the regional dark sky resource and foster eco-tourism and sustainable economic activity in the OAP.

ATFS, NC LOW, and CSI hosted public **STAR PARTIES** sponsored by the Night-Scape project. The first Star Party was on Tuesday February 5th from 6:00 pm to 9:00 pm at Jennette's Pier in Nags Head, NC with about 500 participants. The second Star Party was on Thursday March 7th from 6:30 pm to 9:00 pm at the Middle School in Windsor, Bertie County, NC with about 300 school participants. The Bertie Star Party followed a two-day science teacher workshop on "Human Time and Geologic Time" that included a major component on the dynamics of our solar system. Each program included the portable planetarium in a large room with 4 project tables around the perimeter that each had a different astronomy related, hands on projects supported by a volunteer teacher. Outside a series of large telescopes were monitored by volunteer astronomers to guide the night sky observations and discussions. Each half hour planetarium program included a 15 minute presentation on light pollution and a 15 minute presentation on our present night sky. The third Star Party on April 13 from 7:00 pm to 9:30 pm at the Pettigrew State Park Visitor's Center in Creswell, NC was totally weathered out. This latter program was to be part of the NC Science Festival's Statewide Star Party. All programs were free and open to the public with a major portion of the participants being K-12 students.

Night-Scape Resource

"North Carolina Land of Water" (NC LOW is a 501 (c) 3 non-profit organization) has developed two relevant programs. First is the "Scuppernong Trail System of Pocosins, Carolina Bays, and Black-Water Streams" (Riggs et al, 2016). The goal of this trail system is to define the natural and cultural resources as the basis for implementing an economically viable trail system within the underserved counties of the OAP. Second is a program for earth and environmental science teachers within the K-12 schools of the OAP counties. The goals of both the NC LOW trails (e.g., paddle, hiking, biking, and vehicle trails) for the past three years and the earth and environmental science teacher education programs for the past year, have focused totally on the potential day-time activities within the more than 758 mi² of public lands and associated 2,900 mi² of public water bodies, and 163 mi² of additional National Seashores and Wildlife Refuges (Figure 5). The night-scape represents an equally important component that has not been previously addressed, but has tremendous potential with enthusiastic young students, general public, and agency interest. Partnering with the 501 (c) 3 non-profit organization **"A Time For Science"** (ATFS) brings their night sky astronomy expertise and science education skills to the OAP.

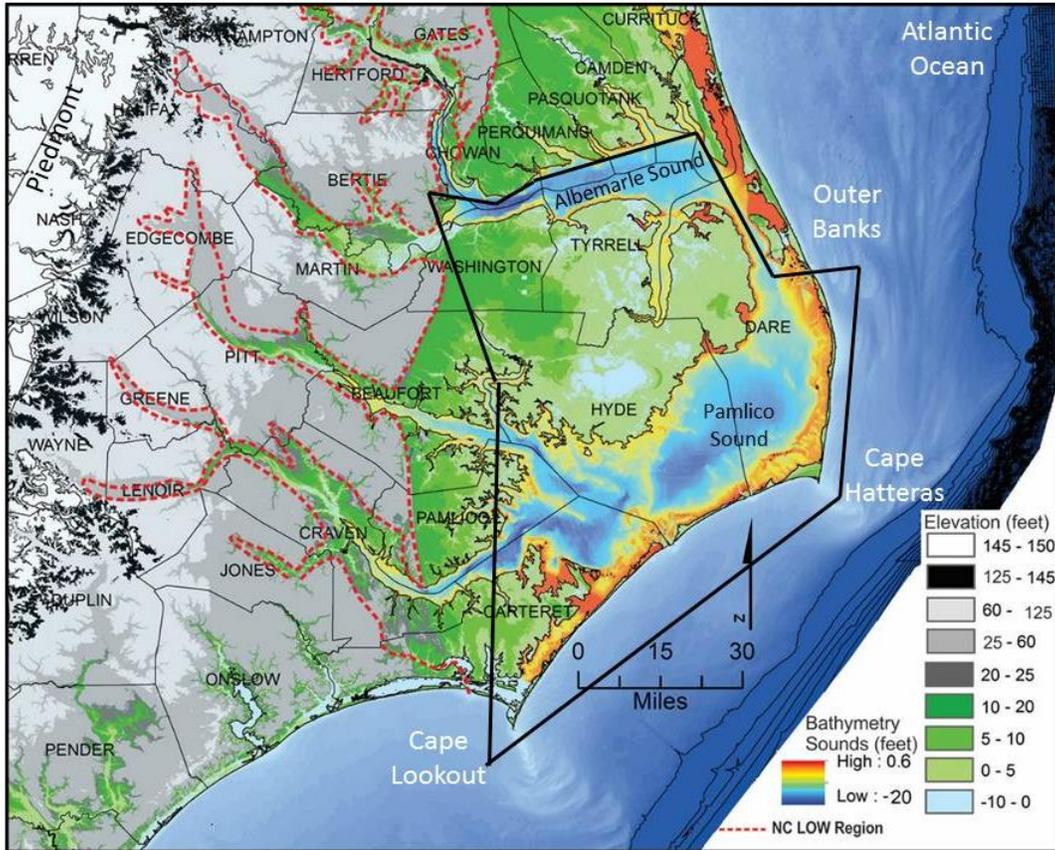


FIGURE 5. Color topography map shows the North Carolina Land of Water (NC LOW) of northeastern North Carolina’s coastal system east of the red dashed line. The Outer Albemarle Peninsula study outlined in a black hexagon includes major portions of Washington, all of Tyrrell and mainland Hyde-Dare counties that are surrounded by the vast areas of the Albemarle Sound to the north, Croatan Sound to the northeast, and the Pamlico Sound to the southeast and south. The Outer Bank, south of Roanoke Island include the Cape Hatteras and Cape Lookout National Seashores are included as critical parts of North Carolina’s dark sky resource.

The night skies within most of the OAP are among the darkest in the entire US Atlantic coastal system. The Albemarle Peninsula is surrounded by four large estuarine water bodies (Figure 5): Albemarle Sound on the north, Croatan and Pamlico sounds on the east and southeast, and Pamlico River Estuary on the southwest. The OAP region consists of Tyrrell, Washington, and mainland Dare-Hyde counties with Columbia, Creswell, Manns Harbor, and Swan Quarter being the largest towns with a total population of about 6,190 in 2010 (~19% of total population) and declining. These towns are located around the outer perimeter of the Peninsula on the highway 64-264-45 corridor (Figure 6). However, most of the population lives in very small, rural crossroads communities (e.g., Goat Neck, Cherry, Kilkenny, East Lake, Stumpy Point, Engelhard, Fairfield, Alligator, Gum Neck, New Holland, etc.). The largest industry is agriculture with vast farm and timber lands along with a small, but growing tourist industry. Four large National Wildlife Refuges occur within the region (Alligator River, Pocosin Lakes, Mattamuskeet, and Swanquarter), vast acreages of NC Wildlife Resources Commission

game lands; a state park (Pettigrew), historic site (Somerset Place), and coastal preserve (Buckridge); and private conservation lands. Thus, over 485,134 acres (758 mi²) of public ecosystems occur within the OAP and contain a unique, complex system of nocturnal environments and associated night skies (Table 1).

TABLE 1.

<u>PUBLIC LANDS: OUTER ALBEMARLE PENINSULA (OAP)</u>	<u>ACRES</u>
1. US National Wildlife Refuges	
A. Alligator River NWR (Dare Co.)	154,453
B. Mattamuskeet (Hyde Co.)	50,174
C. Pocosin Lakes (Tyrrell & Washington Co.)	110,107
D. Swanquarter (Hyde Co.)	16,411
2. NC Wildlife Resources Commission Game Lands	
A. Alligator River (Tyrrell Co.)	14,178
B. US Navy Bombing Range (Dare Co.)	46,055
C. Gull Rock (Tyrrell & Hyde Co.)	28,600
D. Futch (Tyrrell Co.)	600
E. Lantern (Tyrrell Co.)	1,831
F. New Lake (Tyrrell Co.)	1,438
G. Pungo River (Hyde Co.)	472
H. Texas Plantation (Tyrrell Co.)	1,502
I. Van Swamp (Washington Co.)	5,505
4. NC State Parks and Historic Sites	
A. Pettigrew State Park (Tyrrell & Washington Co.)	17,800
B. Somerset Place (Tyrrell Co.)	38
5. NC Coastal Reserve etc.	
A. Buckridge Preserve (Tyrrell Co.)	27,111
6. Conservation Fund	
A. Palmetto Pear-Tree Preserve (Tyrrell Co.)	10,297
7. NC DOT & NC WRC boat ramps, etc.	?
8. The Nature Conservancy & NC Coastal Land Trust	?
9. Miscellaneous Town & County properties	?
TOTAL OAP PUBLIC LAND =	+485,134 ACRES (758 mi²)

PUBLIC BUFFER ZONE WATER+LAND

1. Estuarine Water Bodies (Albemarle, Croatan, & Pamlico Sounds)	1,856,000
2. Cape Hatteras National Seashore (Dare & Hyde Co.)	30,351
3. Pea Island National Wildlife Refuge (Dare Co.)	31,534
4. Cape Lookout National Seashore (Carteret Co.)	28,243
5. Cedar Island National Wildlife Refuge (Carteret Co.)	14,480
TOTAL PUBLIC BUFFER ZONE WATER+LAND =	+1,960,608 ACRES (3,063 mi²)

TOTAL AREA OF PUBLIC NIGHT-SCAPE = 2,445,742 ACRES (3,821 mi²)

The dark-sky survey has generated a detailed map showing three zones of darkness in the OAP region. The primary core, the darkest sky, is the area inside the red highway line on Figure 6. The red highway line represents the secondary ring around the core and contains most of the small villages with widely scattered spots of small light pollution. The third zone surrounds the entire OAP region and is the coastal margin outside the red highway line adjacent to the very large and dark estuarine water bodies (Figure 6). This map outlines the following: 1) defines the possible OAP region that could become the basis for requesting an International Dark Sky Reserve designation, 2) provides a basis for selecting the most ideal viewing sites for promoting the dark sky and nocturnal environment component of a sustainable eco-tourism trail program, 3) produces a baseline to be used for tracking changes in light pollution in the region going forward, and 4) offers an opportunity for developing public and K-12 educational programs. The over-arching goal of this study is to delineate the nocturnal environment and night sky resources and expand the night-scape capabilities for developing educational and sustainable eco-tourism programs in the underserved counties of the OAP and adjoining coastal regions. If successful, it would bring national and international attention to the natural resources and eco-tourism potential of NC's Inner Banks.

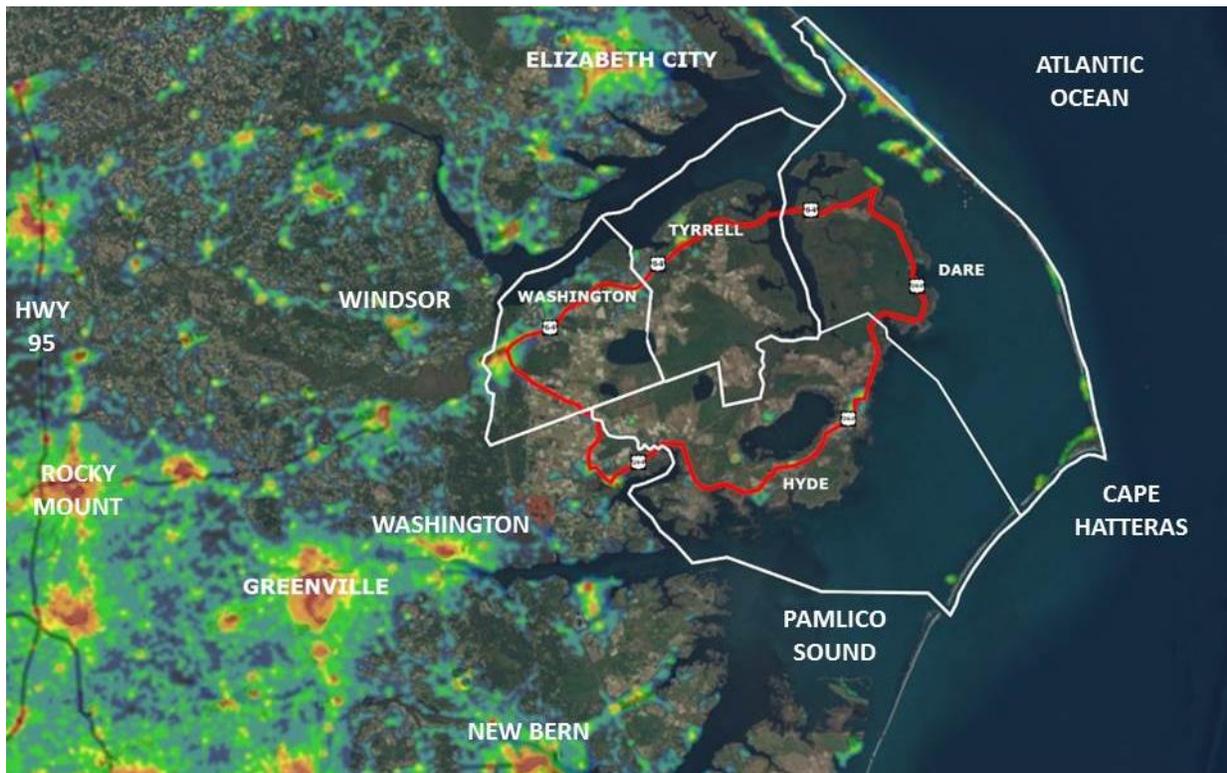


FIGURE 6. A light pollution map shows the four counties of the OAP along with the trace of Highways 64, 264, and 45 (in red) that form a ring around the heart of the dark sky landscape and harbor most of the small villages on the OAP. Seaward of the highway is a coastal rim that also has very dark skies overlooking the estuarine water bodies to the north, east, south, along with vast agricultural fields to the west. Map is modified from Falchi, Fabio, et al. 2016.

The Outer Albemarle Peninsula has an incredible night-scape resource for the following reasons (Figures 5 and 6). 1) The vast area of public wetlands are surrounded by the expansive estuarine system, all of which have minimal human activity. 2) The “Big Night Sky” presents an ideal astronomical wonderland that is generally becoming an endangered environment in the east due to ever increasing light pollution. 3) The 360° horizon vistas provide incredible views of sun rises and sets, moon rises and sets, thunderheads and lightning shows, and glorious zenith and structure of the milky-way. 4) The hot, humid drone of the spring to fall nocturnal soundscape with dramatic, and the cacophony of the winter waterfowl overflights. And 5) the broad open viewscapes provide a pallet for the playmakers of the sky, the clouds, to display an infinite array of forms, patterns, textures, colors, particularly during sun and moon rises and sets.

Sky Quality Meter (SQM-L) readings on the nights of the monthly new moons indicate night sky glow in the survey area ranges between 21.24 to 21.81 mag/arcsec² (Figure 7). Under the International Dark Sky Association (IDA) guidelines for Dark Sky Parks the majority of the OAP falls within a silver rating (21.0 to 21.75 mag/arcsec²) and on cloudless nights many sites have a gold rated dark sky (>21.75 mag/arcsec²). Night sky quality was consistent over the survey duration with location being the primary factor determining SQM-L readings. Numerous sites in the National Wildlife Refuges, State Parks, Wildlife Resources Commission, and Department of Transportation properties have suitable public access with great nightscape viewing.



FIGURE 7. Night sky quality results were taken at each site during the new moon nights. The best readings for each survey date are displayed in the figure. The plot shows the International Dark Sky Association (IDA) designations for night sky quality: Gold (>21.75 = natural, non-polluted, or near natural night), Silver (21.74 to 21.00 = minor light pollution, but still display exemplary night-scapes), and Bronze (20.99 to 20.00 = offering people, fauna, and flora a respite from otherwise degraded nocturnal environments). The OAP falls comfortably within a silver rating, with frequent gold rated dark skies in the core region of the OAP.

The red highway line that borders the core of the OAP in Figure 6 consists of highways 64, 264, and 45 and contains most of the OAP villages. A night sky quality transect was run on a new moon night along highway 64 from west to east through the town of Columbia. The

transect (Figure 8) demonstrates how the high quality dark sky deteriorates from high quality (21 to 22 mag/arc² units) to severe low quality (15 to 20 mag/arc² units) due to light pollution within and adjacent to the town. Figure 9 demonstrates that all 81 of the survey sites within the OAP possess an exceptional or distinguished quality of starry nights and nocturnal environments. The reason there are not more sites that have gold designation is due to 1) the remotest areas of the OAP are low swamplands not accessible by road, 2) some sites are adjacent to one of the major highways but due have minor night traffic, 3) are in close proximity to an individual dwelling, and 4) are located at public boat ramps with minor security lighting.

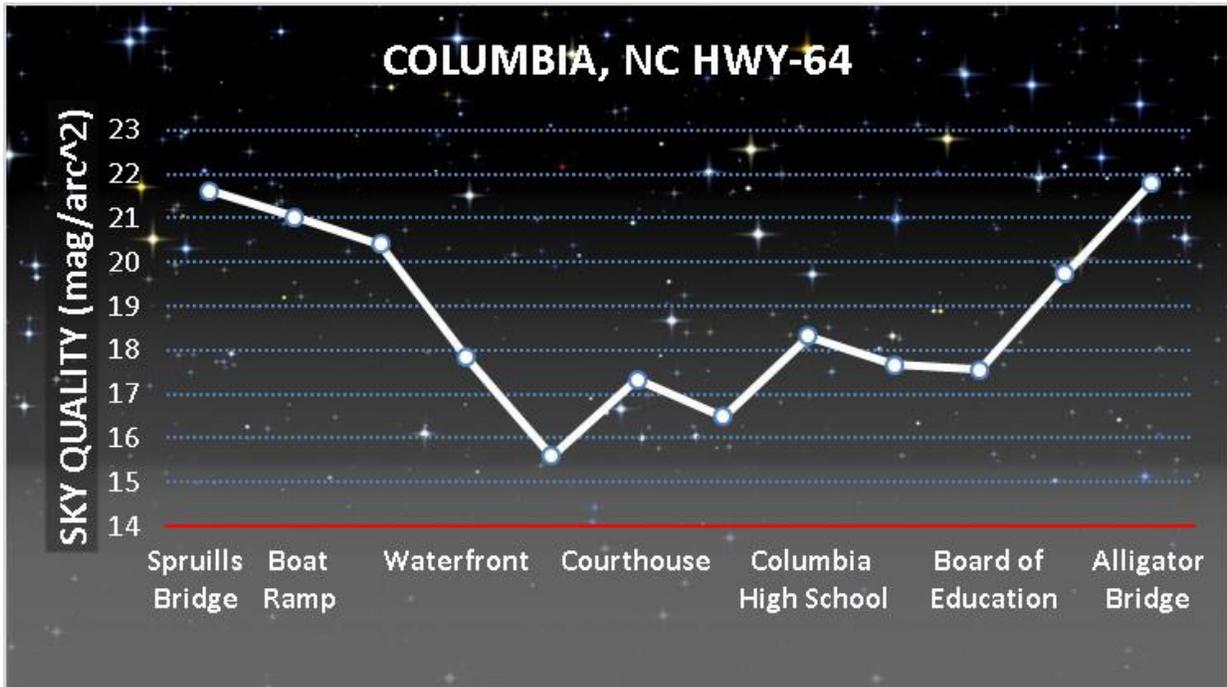


FIGURE 8. Plot shows the change from really dark skies (21 to 22 sky quality units) on both the east and west sides of Columbia with highly variable and major light pollution (15 to 20 sky quality units) within the town limits. The eastern most site is at Futch Gamelands in Alligator and the western most site is Spruill's Bridge in Creswell. The town of Columbia extends from the Tyrrell Co. Board of Education to the town waterfront on the Scuppernon River.

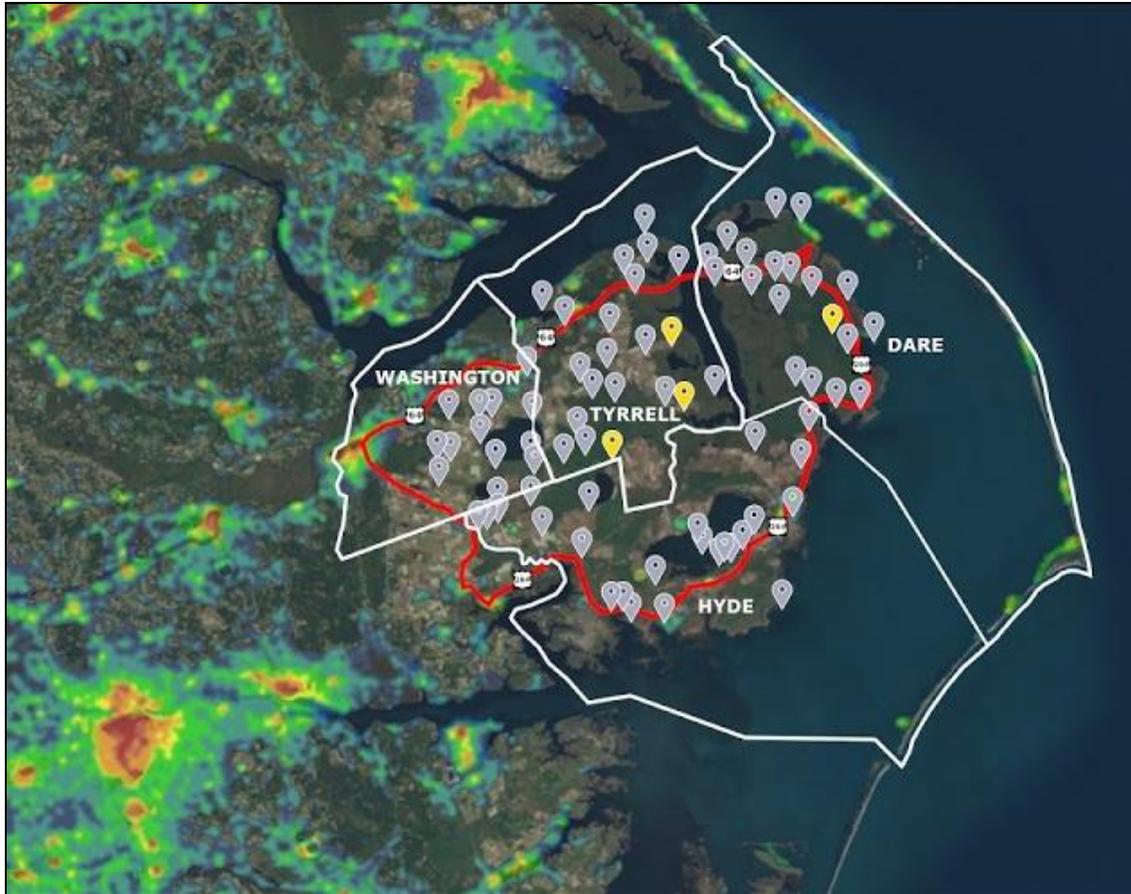


FIGURE 9. Light pollution map of the Outer Albemarle Peninsula study area with the four county boundaries outlined in white. The red line represents highways 64, 264, and 45 that ring the core of the prime night-scape resource area. The pins represent the 81 nightscape study sites none of which are in the villages. The four gold colored pins had night sky quality readings that averaged in the IDSR gold bracket for the new moon surveys and all other survey sites averaged in the silver bracket. The map is modified from Falchi, Fabio, et al. 2016.

An International Dark Sky Reserve (IDSR) (<http://www.darksky.org/idsp/become-a-dark-sky-place/>) requires “a public or private land area of substantial size (270 mi² or 173,000 acres) possessing an exceptional or distinguished quality of starry nights and nocturnal environment and is specifically protected for its scientific, natural, educational, cultural heritage, and/or public enjoyment.” The OAP has almost three times this much public land that is protected for its wildness with almost no urban component. This is a world-class natural resource available for developing “resilient communities and economies” in the poorest and truly-rural coastal region in NC. Success of this project will supply the following: 1) development of an adequate data base, 2) set in motion a local interest support system, and 3) lay the groundwork for OAP organizations and communities to develop a plan for obtaining an “International Dark Sky Reserve” designation by the IDA (the first US reserve was established in 2017 in Idaho and a second reserve in Utah in 2018).

OAP NIGHT SKY ENVIRONMENT

The Sun (Figures 10 and 11)

The best known star is the Earth's Sun. However, it is not a particularly hot or big star; just an average star. All other stars in the night sky are just like the Sun. What makes the Sun remarkable compared to all the thousands of other suns in the dark sky is that it is our Sun that is a mere 100 million miles away. The solar energy from this nearby Sun is what makes Earth a habitable planet.

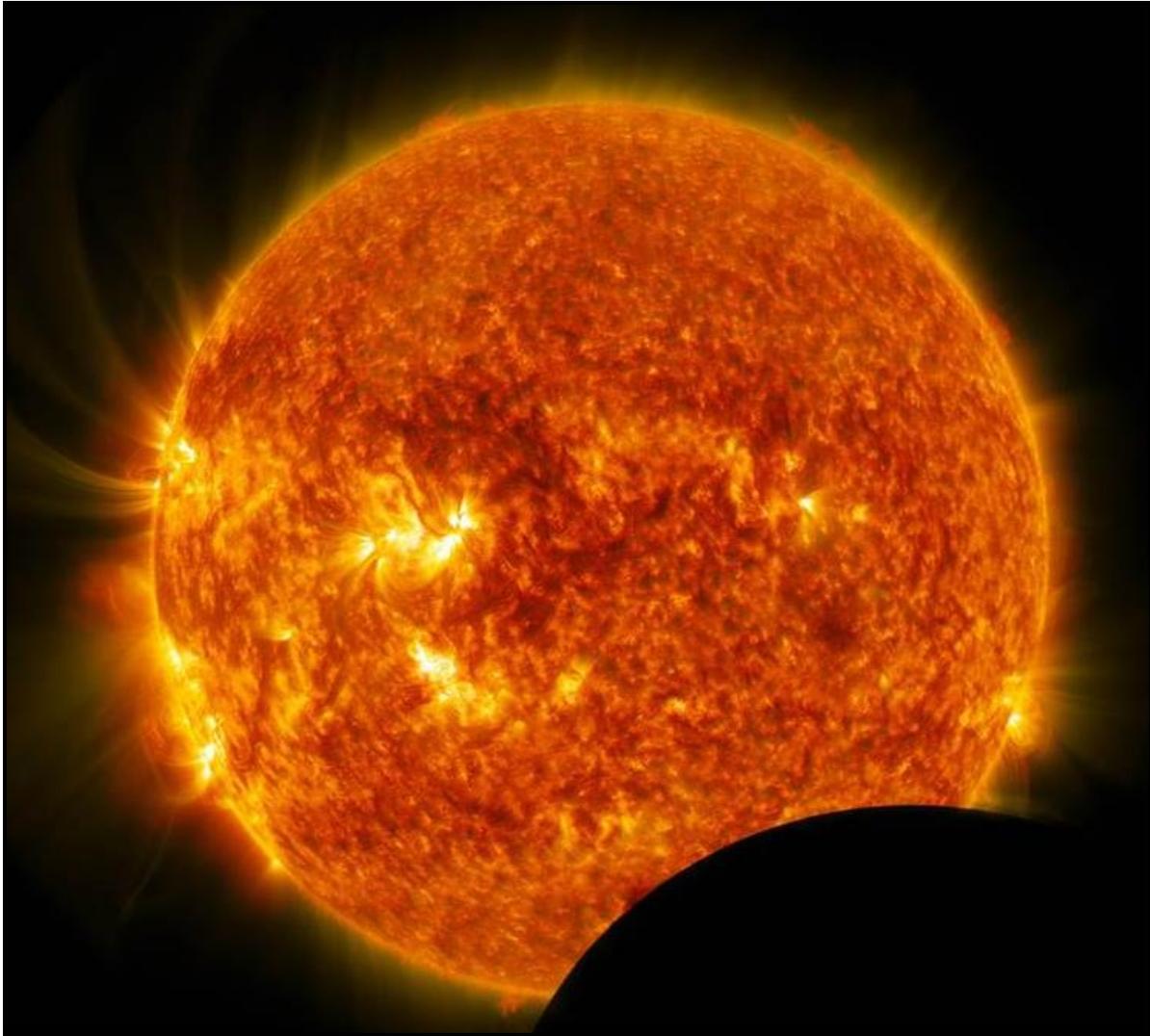


FIGURE 10. On July 26, 2014 the moon crossed between NASA's Solar Dynamics Observatory (SDO) and the sun, a phenomenon called a lunar transit that happens approximately twice a year, causing a partial solar eclipse. The eclipse shows the sun's surface mottled with a series of sun spots (dark spots) and solar flares that eject electromagnetic radiation outward throughout the Solar System. Image is from NASA/SDO.

The sun is located at the center of the Solar System, 93 million miles from the Earth. It is a sphere of hot plasma that generates a magnetic field that streams outward into the Solar System as solar wind. The sun is a ball of gas consisting of 91% hydrogen and 8.9% helium held together by gravitational attraction and creating extreme temperatures in the core (27 million degrees F) that causes thermonuclear fusion (hydrogen fuses into helium and releases extreme amounts of energy). This process is the source of all the heat and light emitted by the sun. The electric currents generate a magnetic field that flows through the Solar System by a stream of electrically charged gas (solar winds). The sun's activity is generally fairly gentle, but changes about every 11 years when the poles change their magnetic polarity. When this happens the sun becomes violently active with solar storms (sunspots, solar flares, and coronal mass ejections; Figure 11) releasing huge amounts of energy that can harm satellites and power grids and cause spectacular auroras on Earth.



FIGURE 11. Photograph shows a violently solar storm episode on the Sun's surface. Notice the solar flare, sun spots, and coronal mass ejection. Photograph of a long filament erupting from the sun is by NASA's Dynamics Observatory on 8-31-2012.

The Moon (Figure 12)

The Moon is a companion to and orbits the Earth similarly to the Earth's orbit around the Sun. As the Moon orbits Earth, we see different amounts of its day side through time producing the different phases of the Moon's appearance. With each day that goes by in a month the Moon waxes from a thin crescent at dusk, to a brilliant full Moon in opposition to the Sun, and then wanes to a thin crescent in the dawn. The Moon rises and sets at specific times of day and night depending on these phases.



FIGURE 12. The Earth's full moon, our closest neighbor in the night sky, was photographed by NASA's Lunar Reconnaissance Orbiter on 10-7-2018.

For some the Moon is never more stunning than when it is glimpsed as a crescent accompanying a bright planet in the glow of twilight, others are captivated by a dimly lit landscape during a full Moon. The Moon can create many different and incredible nightscapes to gaze upon. However, there is a need to avoid the moon for the best stargazing which happens during the new Moon. From Earth's perspective, the new Moon occurs when the moon is positioned closest to the Sun, so it rises and sets with the Sun. The richness of the night sky opens up in the absence of the Moon's brilliant glow. A clear moonless night allows you to see more stars and more of the night sky's obscure deep space treasures.

Eclipses (Figure 13)

Occasionally the Moon will fall into alignment with the Earth and Sun, resulting in a visually stunning phenomenon in the sky. This can happen in two ways, depending on whether the Earth or the Moon is in the middle of the alignment. A solar eclipse occurs when the Moon passes directly in between the Earth and Sun. The shadow of the Moon passes over a small part of the Earth's surface, causing day to turn to night along the shadow's path. A lunar eclipse occurs when the Earth is positioned in between the Sun and Moon, resulting in the Moon being completely shrouded by the Earth's shadow. Sun light passing through the Earth's atmosphere is bent in towards the Moon turning it a crimson color.



FIGURE 13. Full Moon Eclipse of Feb 20, 2019 with a Cannon 6D w/EF 70-300mm f/4-5.6L w tripod in Brook Valley, Greenville, NC. The first image on left was taken at 12:26 AM (full eclipse) and the last exposure on the right was taken at 12:50 AM. Photograph is by P. Gemperline.

The Planets (Figures 14 and 15)

Planets are always a prime target for stargazers. Imagine looking skyward on a dark moonless night. You see hundreds of points of light shimmering in the sky. Each point has a particular brightness and color, but not everyone is a star. To the naked eye Planets look like stars. Usually Planets are brighter and bigger than the other stars that are around them. Unfortunately, they are moving targets, so figuring out when and where to spot them requires some background information or experience. Once found they can offer a deeply rich and satisfying observational experience, that is if you are looking at the right one at the right time.

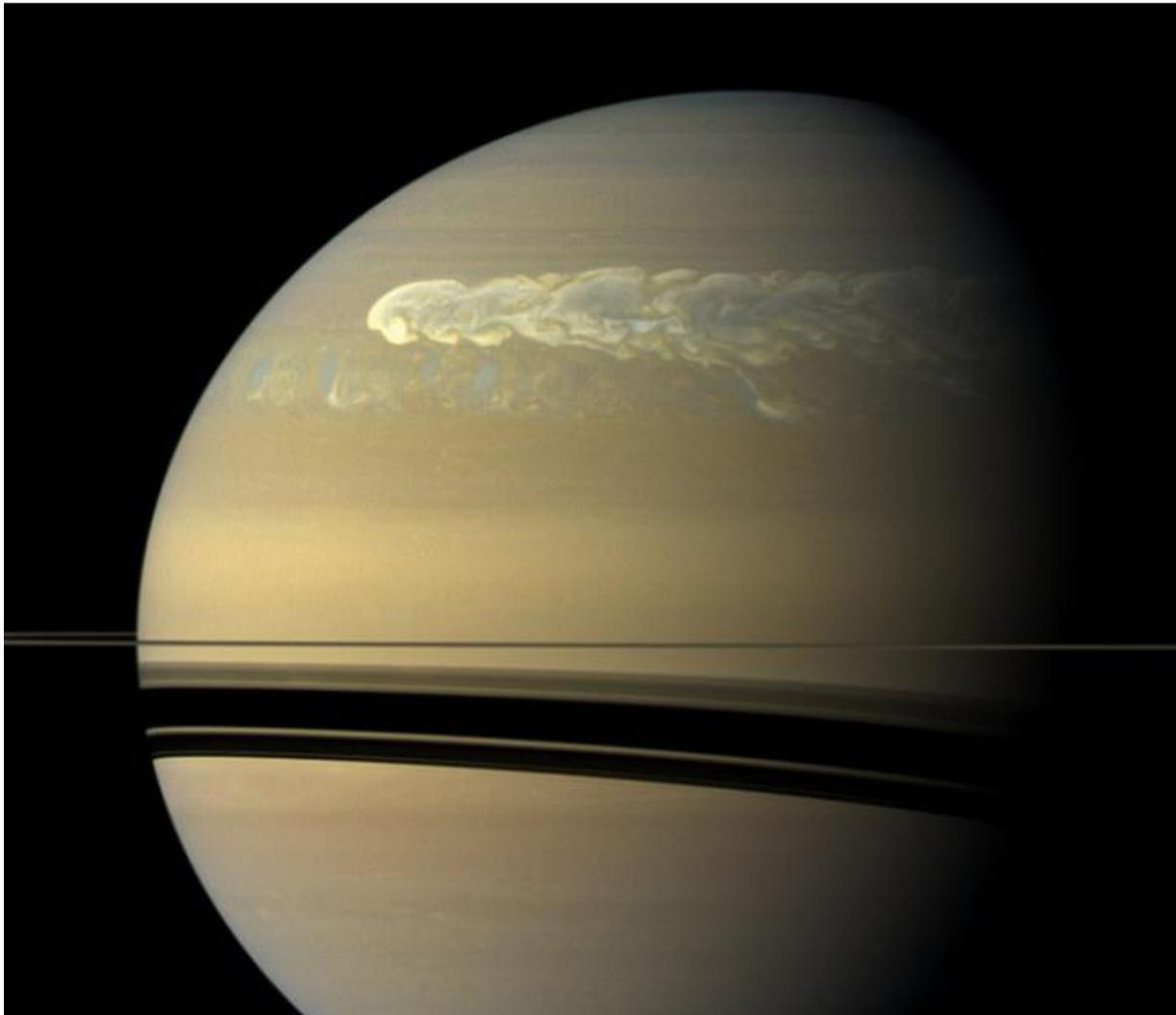


FIGURE 14. Image shows a great white spot, a series of medium sized storms in a sequence, churning through the atmosphere in Saturn's northern hemisphere. This is a true-color view from NASA's Cassini spacecraft. Image was created by JPL-Caltech/Space Science Institute.

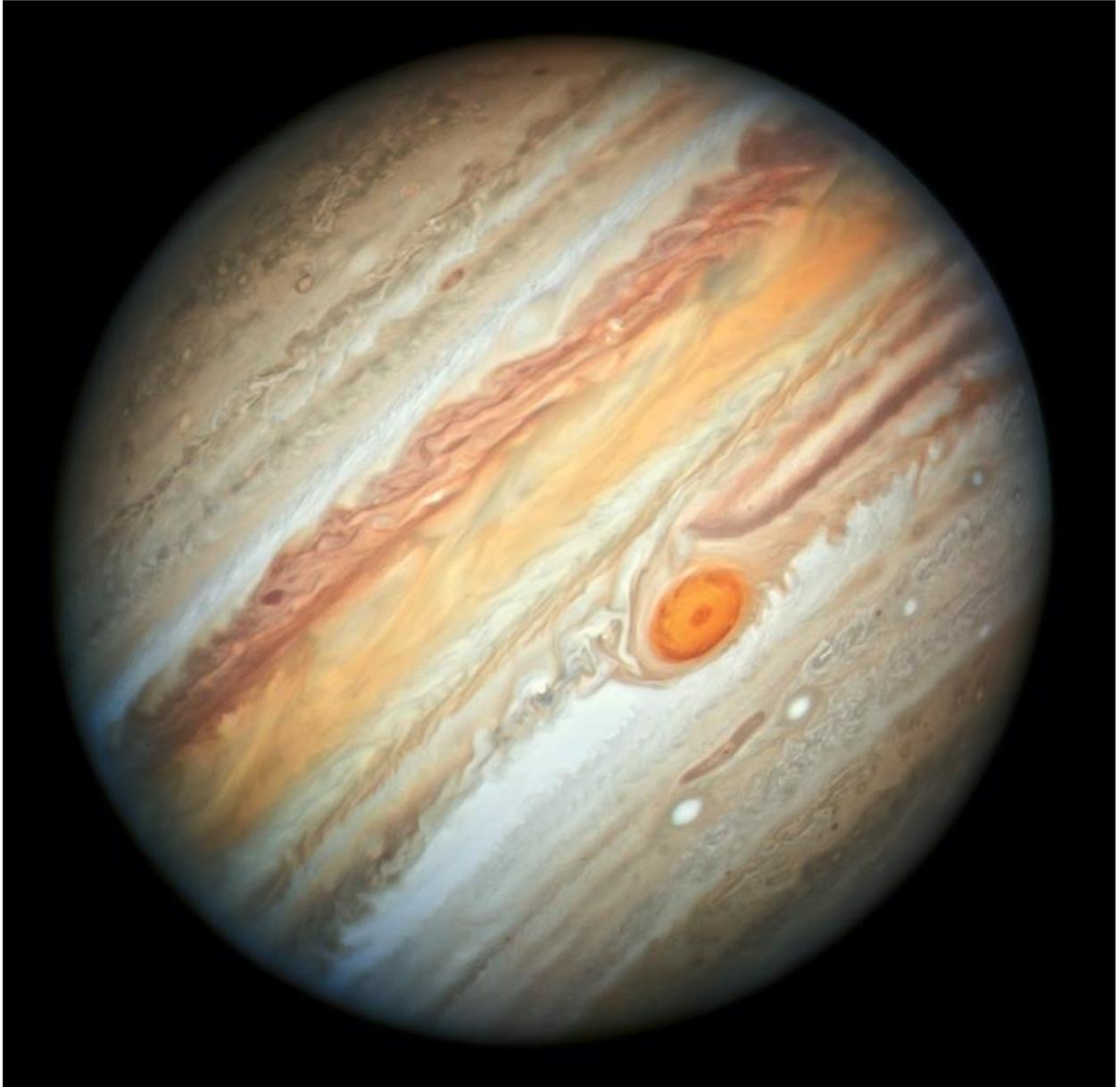


FIGURE 15. A Hubble Space Telescope view of Planet Jupiter taken on 6-27-2019 reveals the giant planet's Great Red Spot and intense pattern of clouds swirling in Jupiter's turbulent atmosphere. Image is from NASA, ESA, A. Simon (Goddard Space Flight Center) and M. Wong (University of California, Berkeley).

The planets are constantly in motion. Sometimes they are close to the Earth, other times far away. No matter where they are in our sky, the planets will be found in a particular set of constellations called the Zodiacs. The Zodiac constellations line a path through the sky that the Sun and Planets follow called the ecliptic.

The best time to view any given Planet is when it is at “opposition”, meaning that the Earth is directly in-between the Planet and Sun. From our perspective on Earth a planet in opposition will rise in the east as the Sun sets in the west. They are on opposite sides of our sky because the Earth is in the middle. After waiting approximately 3 or 4 hours after sunset, you will have the clearest and sharpest view of the Planet.

Not all planets are equally stunning to observe. Jupiter and Saturn are sure to impress anyone who lays eyes on them. Venus and Mercury can be seen waxing and waning with phases just like the Moon. However, with the remaining Planets some perspective might be in order to ensure the observer understands what they are about to witness. When doing amateur astronomy, it is equally important to observe with your mind as it is to observe with your eyes. A little background information and context can turn an underwhelming dot into a distant world just waiting to be explored.

Meteor Showers (Figure 16)

Meteor showers are one of the most well know and anticipated celestial events by the general public. Meteor showers re-occur yearly and produce high rates of “shooting stars”. Two of the most consistent and dramatic meteor showers are the Perseids in mid-August and the Geminids in mid-December. A meteor shower results from the Earth plowing through the debris of a comet. For example, when Halley’s Comet passed through the inner solar system in 1986 it left behind a trail of particles that littered Earth’s orbit in two places creating the Orionids and Eta Aquariids meteor showers.



FIGURE 16. Photograph shows the Eta Aquarids meteor shower and the Milky Way. Photograph is by Li Gang on 5-8-2019.

How a person experiences a meteor shower depends on how dark the night sky is. Light pollution from nearby towns, shopping centers, or streetlights will severely diminish the number of meteors that can be seen. However, there is no greater threat to meteor shower observations than a big moon in the sky. If one is in the middle of the ocean for a meteor shower, the brightness of a full moon would prevent seeing a single “shooting star”.

Ultimately, the best way to view a meteor shower is to lean back in a chair or lay down and look up. You also want a nice big sky with few obstructions like trees or buildings. The goal is to look at as much of the sky as possible. By lying down and looking straight up you are not limited to looking in only one direction and you will increase your chances of seeing more meteors. Telescopes or binoculars are not needed.

Deep Space Objects (Figure 17)

True wonders of the night sky lay far beyond our solar system, deep into the vast expanses of space. Our eyes are not capable of viewing these distant and faint objects, but with the light collecting power of telescopes, they can be unveiled. Among the countless features that reveal the evolution of our universe are nebulae (immense clouds of interstellar gas and dust), supernova remnants (exploded remains of massive stars), and galaxies (the largest star collections in the universe).

The darker the sky and bigger your telescope, the better view you will have of these “faint fuzzies”. The deep space objects represent another example where the importance of observing is not only with your eyes, but with your mind. The implications related to each photon released by one of these objects is profound, and understanding where, when, and how, will allow you to marvel at each photon that strikes your eye.



FIGURE 17. Photograph of deep space nebula (immense clouds of interstellar gas and dust) that is located within the Orion Deep Field. Photograph is by R. Gendler in 2004.

There are many catalogues and surveys of deep space objects. The two most commonly used are the Messier Catalogue: 110 of the brightest objects, and the New General Catalogue: featuring 7,840 objects. Both catalogues are used to guide amateur astronomers to various nebulas, star clusters, and galaxies in the night sky. It is often an entry point for ambitious astronomy enthusiasts to document the observation of the 110 Messier objects.

Constellations (Figure 18)

Constellations are shapes and patterns created by a group of stars in the night sky. Every culture around the world has their own unique way of interpreting the stars, and each individual can determine their own understanding of the night sky. This gives way to infinite constellations with our imagination being the only limit. However, the International Astronomical Society designates 88 official constellations that draw primarily from western Greek culture and depict heroes, creatures, and objects.

As the Earth orbits the Sun, we see different parts of our Milky Way galaxy giving us different constellations to observe over the course of a year. The constellations are broken up into four seasonal groups. During a single night you can see three seasons of constellations. For example, during autumn the summer constellations are visible during the first few hours after sunset, autumn constellations are visible all night long, and winter constellations are visible for a few hours before sun rise. Each group of constellations has its own unique characteristics and produces distinctive viewing experiences.

The winter constellations are known for very bright stars and deep space objects. The most prominent winter constellations are Orion, Canis Major, Gemini, and Taurus. The spring constellations lay in the realm of the galaxies. During spring we look up and out of the Milky Way Galaxy and into intergalactic space, where we observe thousands of other galaxies. Leo, Boötes, and the Big Dipper are among the dominant constellations during spring. Summer constellations hold the center of our galaxy and a treasure trove of deep space objects. It is truly the most impressive part of the sky to view under exceptionally dark conditions. Look for Scorpius, Lyra, Cygnus, and Sagittarius in the summer skies. The autumn constellations lack bright stars, but do contain our largest galactic companions, the Andromeda and Triangulum galaxies. Notable autumn constellations are Pegasus, Cassiopeia, and Pisces.



FIGURE 18. Photograph shows the constellation Orion, a hunter in Greek mythology, during a late fall night sky. The brightest star is Betelgeuse, a red supergiant star that forms the right shoulder as he faces the observer. The second brightest star in Orion is Rigel, a blue-white supergiant that forms the left foot. Photograph is by Pixabay on 11-12-2017.

The Milky Way (Figure 19)

The most visually stunning component of a truly dark, summer night sky is the center of our own galaxy, which stretches across the sky like a massive cloud of stars. The Milky Way is the collective star-light from thousands of stars, each too far away and faint to be individually seen by the human eye. Sweeping through the Milky Way with a telescope reveals a starry wonderland, and a window deep into the center of our galaxy. A trail of darkness composed of interstellar gas and dust constitutes the galaxy's spiral arm as it cuts through the starry cloud. Within this starry cloud is a treasure trove of nebulas and star clusters—a star-gazer's playground.



FIGURE 19. Photograph shows the summertime view of the Milky Way galaxy where the Solar System is located. Photograph is by Brunier in 6-8-2005.

The Milky Way is also on display in the winter skies as it stretches through the constellations of Cepheus, Cassiopeia, Perseus, Auriga, and Puppis. However, during the winter months we look towards the outer edge of the galactic disk. Though it is not as rich and obvious as its summertime counterpart it still offers a starry wonderland worthy exploration.

The Human Component (Figure 20)

The International Space Station (ISS) is a colossal structure flying nearly 248 miles above Earth. It orbits the Earth every 90 minutes at an astonishing speed of about 17,500 mph. The ISS was designed to be a laboratory, observatory, and factory while providing transportation, maintenance, and a low Earth orbit staging base for possible future missions to the Moon, Mars, and asteroids.



FIGURE 20. The fully complete International Space Station as it appeared over the Earth on October 2018. Photograph is by NASA.

The ISS is visible to the naked eye as a slow-moving, bright white dot in the dark night sky. The ISS takes about 10 minutes to pass from the eastern horizon to the western horizon and is only visible part of the time because it moves into or out of the Earth's shadow. Tools are provided by a number of websites such as Heavens-Above.com as well as smartphone applications that use orbital data and the observer's longitude and latitude to indicate when the ISS is visible.

Satellites and the Wallops Flight Facility (Figure 21)

The NASA Wallops Flight Facility is a rocket launch site on the eastern shore of Virginia. The site includes the Mid-Atlantic Regional Spaceport, which can send off interplanetary and International Space Station missions. These rocket launches can be viewed from regions across Eastern North Carolina. Night launches offer the best opportunity to observe a launch. Launch schedules can be found at nasa.gov/centers/wallops/home as well as through the Wallops Mission Status Center Launch App for smart devices.



FIGURE 21. Launch of an Antares A-One space ship at Wallop's Island Flight Facility, VA on April 22, 2013.

OAP NOCTURNAL ENVIRONMENT



FIGURE 22. One can appreciate the beauty of the high level cirrus clouds in the night sky if the star-gazing is limited by these clouds.

Clouds In The Night-Scape

People are programed to think of clouds as characteristics of the day-time sky, but clouds are equally varied and abundant in the night sky. They play a critical role in the beauty and pattern of sun and moon rises and sets, night lightning shows, darkness of the night sky, and the ability to see the astronomical wonderlands. Warm air contains water vapor that rises skyward and cools causing water vapor to turn into tiny water droplets or ice crystals. As more air cools down, more droplets form and eventually a cloud develops. The World Meteorological Organization produced the International Cloud Atlas (2017) with four genera (underlined) and many variant species of clouds that form in the atmosphere and are generally described by their elevation of formation. A fifth category has been added that forms directly in response to human activity.

1. High Level or Cirrus Clouds (Figures 22 and 23): High level clouds form above 20,000 feet where the air is cold, consist mostly of ice crystals, and usually have the prefix "cirro" or "cirrus" in their name (cirrus, cirrocumulus, cirrostratus).
2. Middle Level or Alto Clouds (Figure 23): Middle level clouds form between 6,500 and 20,000 feet, may consist of either water droplets or ice crystals, and usually have the word "alto" in their name (altocumulus, altostratus).
3. Low Level or Strato Clouds (Figures 24, 25, and 26): Low level clouds form below 6,500 feet, are composed mostly of water droplets, and usually have the word "stratus" in their name (stratus, stratocumulus, nimbostratus or "rain cloud").
4. Vertical or Cumulous Clouds (Figure 27): These clouds are dense and tall clouds that may span several cloud levels, and usually have the word "cumulus" in their name (cumulus, cumulonimbus or "thunderheads").
5. Human-Produced Clouds (Figure 28): Airplane condensation trails (contrails) are formed by burning petroleum fuels to produce energy for the plane to fly, plus CO₂ and H₂O are produced as exhaust. With time the upper atmospheric winds blow the contrails into various types of cirrus and altostratus clouds.



FIGURE 23. Left panel is a photograph of high level cirrus cloud and the right panel is of middle level alto clouds. Photographs are by S. Riggs.



FIGURE 24. Initial development of nimbostratus cloud banks (left panel) that soon develop into the big mushroom-shaped cumulonimbus thunderheads. Photographs are by S. Riggs.



FIGURE 25. Image of a cumulonimbus cloud developing in the late afternoon.. Photograph is by S. Riggs.



FIGURE 26. Photograph is of a fast moving and tumultuous frontal system of nimbostratus storm clouds (left panel) and a close-up of the turmoil within the storm cloud. Photographs are by S. Riggs.



FIGURE 27. Left panel is a low-level, rain producing nimbus storm cloud and the resulting rain squalls from the storm cloud. Photograph is by S. Riggs. Right panel is a spectacular night lightning show resulting from a cumulonimbus thunderhead. Photograph is from freeimages.com.



FIGURE 28. Photographs of high level, human formed contrails that with time get blown into high level cirrus clouds. Left panel is by S. Riggs and right panel is from freeimages.com.

Sun Sets and Moon Rises

If the late afternoon sky is partly cloudy and will interfere with star gazing, then there is a pretty good chance of being rewarded with a spectacular sunset drama. Find a western facing location that has a broad open view with low horizons, such as the many unique water bodies of the OAP, and wait for the show to begin. The introduction occurs when the sun is still above the horizon with a broken cloud field that is top lite grading downward to dark gray under-bellies (Figure 29A). As the sun approaches the horizon, lighting slowly shifts from above the clouds to even with the clouds (Figure 29B) and to the under-belly as the fire in the sky is ignited (Figure 29C). As the sun sinks over the waters of Albemarle Sound, the fire builds, filling the sky and brushing orange frosting on ripples in the water (Figure 29D). The sun is now gone and the orange fire in the sky grades into deep red and dark gray (Figure 29E). The sun set finale is a momentary blood red climax that quickly goes black as the dark sky of night settles in (Figure 29F). Now turn towards the east for the encore and watch the full moon rise above the misty horizon over Pungo Lake (Figures 29G and 29H). Photographs in Figures 29A through 29F are by S. Riggs.



FIGURE 29A.



FIGURE 29B.

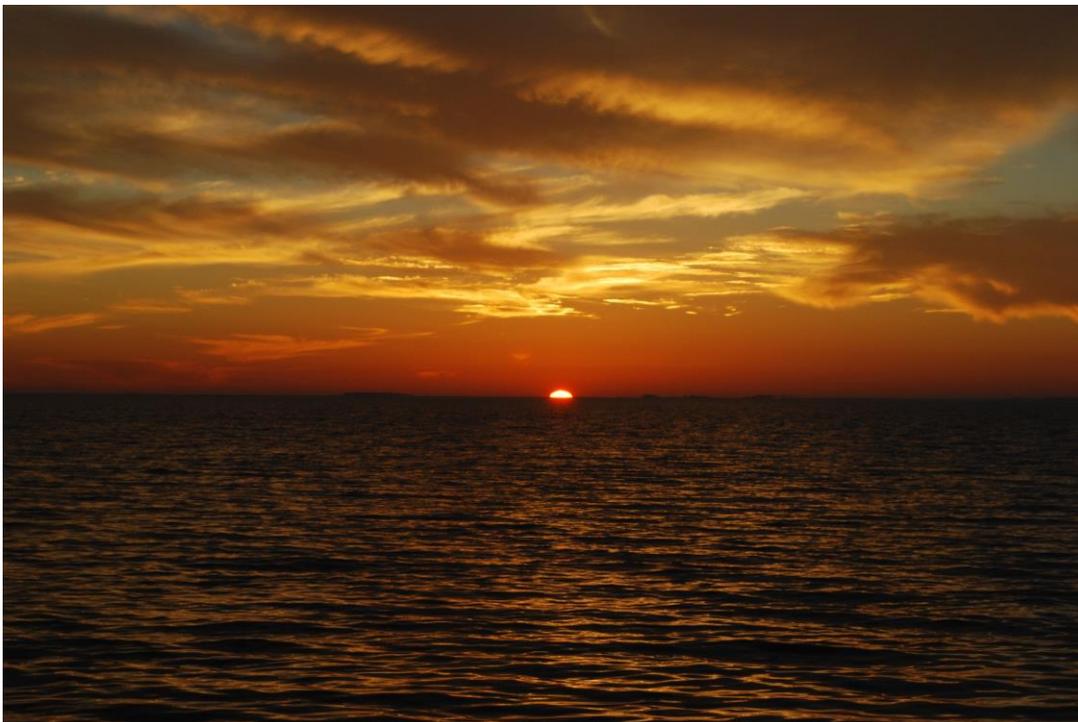


FIGURE 29C.



FIGURE 29D.



FIGURE 29E..



FIGURE 29G. Photograph is by P. Gemperline.



FIGURE 29H. Photograph is by P. Gemperline.

Geologic Resources

The story of the Outer Albemarle Peninsula is an environmental history of a small coastal system through approximately 125,000 years of climate change and landscape evolution. The cultural over-print on these landscapes and their ecosystems represent eleven millennia of human occupation. This OAP story is the natural and cultural history of a dynamic geologic landscape, a complex and highly diverse set of ecosystems, and the human groups who inhabited and modified this region that has always been characterized by dramatic environmental evolution.

The Albemarle-Pamlico coastal sounds are the drowned-river valleys of the Roanoke and Tar Rivers, respectively (Figure 5). A complex set of geologic landscape features comprise the OAP region that includes ancient ocean shorelines, riverine terraces, and a complex network of incised tributary streams and associated pocosin swamp forests. The spectacular black-water tributary streams transition upstream into a series of smaller tributary streams whose headwaters are in the elevated wetlands of perched upland pocosins (Native American name for a “swamp on a hill”). Unique fresh-water, Carolina Bay lakes are situated in the pocosins and on the high inter-stream divide between Albemarle Sound and the Pamlico River estuaries. Numerous small towns and villages are interspersed among vast areas of drained farmland, riverine wetlands and swamp forests.

Figure 30 is a map that shows the location of the A-A’ topographic profile across the North Carolina Coastal Plain as shown in Figure 31. The surface of the Lower Coastal Plain constitutes the Pamlico Terrace that is bounded on the west by the Suffolk Shoreline and on the east by the Outer Banks barrier islands. The Suffolk Shoreline represents sea level during the warm period of the previous interglacial high-stand about 125,000 to 75,000 years before present. To the east of the interglacial Suffolk Shoreline was a large shallow water, ocean embayment now known as the Pamlico Terrace and forms the Lower Coastal Plain.

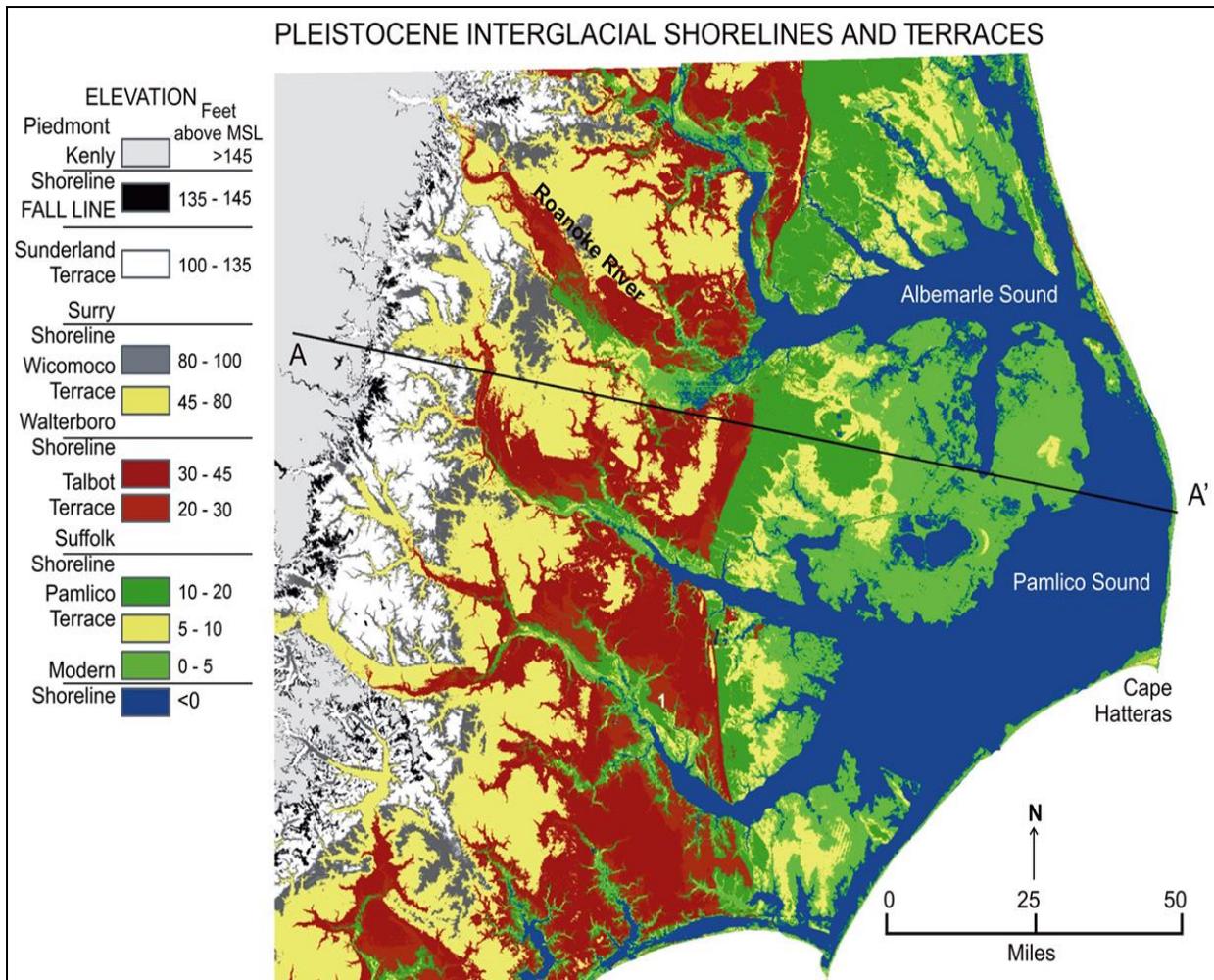


FIGURE 30. This color topography map shows the land elevation for northeastern North Carolina. The location above mean sea level of the Pleistocene interglacial ocean shorelines and associated terraces are color coded. Topographic profile A-A' shown in Figure 31 runs across the Coastal Plain from Rocky Mount (A) on the west to Rodanthe on the Outer Banks (A'). The gray zone is the Piedmont Province and the black zone is the Fall Line between the Piedmont (west) and Coastal Plain Province (east). Geologic data are from Farrell et al. (2013) and topographic map data are from the North Carolina DOT 2007 LiDAR.

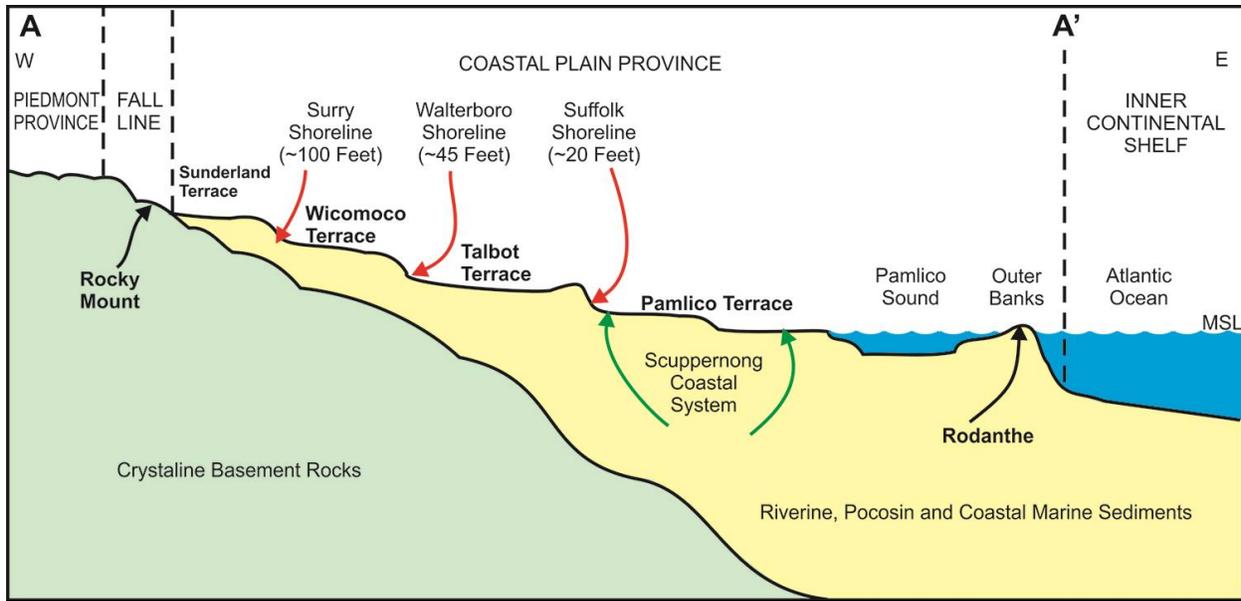


FIGURE 31. A schematic west to east cross-section drawn across the northeastern North Carolina Coastal Plain from Rocky Mount on the Fall Line, through the Albemarle-Pamlico Peninsula to Rodanthe on the Outer Banks (see Figure 30 for cross-section location). The Scuppernong-Alligator coastal system (green arrows) is shown as part of the Pamlico Terrace. Geologic data are from Farrell et al. (2013).

In summary, the OAP region occurs on the Pamlico Terrace of the Lower Coastal Plain as a low, flat plain that is close to and at sea level. It is dominated by swamp forests formed on top of marine clay-rich sediments deposited during the marine occupation of the Paleo-Suffolk Shoreline during the previous interglacial episode. During the subsequent last glacial maximum, tributary streams incised the flanks of the Albemarle-Pamlico interstream divide, which survived as a topographically high erosional remnant. As the climate warmed during the modern interglacial period, increased amounts of water were held on these low sloping, upland clay surfaces. A thick growth of shrub-scrub, swamp forest vegetation developed and produced abundant organic matter that accreted vertically. Thick peat soils accumulated to produce the geologically and ecologically different blackland soils than the peat deposits that formed in riverine valley floodplains or sea level dependent estuarine marshes.

Eco-System Resources

The ecosystems of the OAP are far more diverse than one might imagine. Variations of land topography result from the previously described geologic history. These differences are critical as the land surface interfaces with different types of aquatic systems to produce various landscapes with high biodiversity and variants in ecosystem services. This land-water interface has historically and continues to work together with natural and human disturbances to foster contrasts in ecological conditions.



FIGURE 32. Photograph of the black-water Scuppernong River and its associated floodplain swamp forest from the Columbia boardwalk at sunrise. Photograph is by M. Dunn.

The regions' ecosystems represent continuums that are impacted by both human modification (clearing, agriculture, forestry, and industrial development) and the high-energy natural climate system dynamics (e.g., precipitation, droughts, river floods, storm surge, and sea-level rise). Each ecosystem supplies its own suite of ecosystem services and represents potential components of a healthy social system, as well as a viable and sustainable ecotourism economy. Thus, to maximize both the social and environmental resources into the future it is critical that a solid scientific understanding be integrated with the management policies of an expanding natural resource-based, eco-tourism economy.

The Bertie Peninsula is situated within the middle Coastal Plain with extremely diverse habitats. The natural ecosystems range from old growth forests to black-water streams, riverine swamp forests, and open-water estuaries, and scrub-shrub pocosins. The riverine ecosystems of the Bertie Water Crescent range from the large brown-water drainage basins, to the small black-water tributary stream systems, and end in the tidally influenced, drowned river estuarine water bodies. Integrating the highly diverse natural landscapes with the waterscapes of the Bertie Water Crescent, that determined the cultural history represent an ideal blend of nature, history, and recreation.



FIGURE 33. Photograph shows a typical pocosin swamp forest ecosystem. Photograph is by S. Riggs.



FIGURE 34. Left panel shows a grassy road along the top of a dike built from the sediment dug from the adjacent canal, as well as two different ecosystems dependent upon maintenance of the water levels on either side of the dike. Photograph is by S. Riggs. Right panel is a gravel road in the Pocasin Lakes National Wildlife Refuge. These roads run on top of the dike built with sediment dug from the canals on the side of the road. Photograph is by M. Dunn.



FIGURE 35. Left panel is Phelps Lake fresh water shoreline at Pocosin Overlook in Pettigrew State Park. Right panel is the fresh water marshes at East Lake in Alligator River National Wildlife Refuge. Photographs are by S. Riggs.

Eco-Systems Fauna

North Carolina is ranked ninth in the U.S. in terms of the number of species found within its boundaries (McKerrow et al., 2006). Much of the diversity of vertebrate species (excluding fish) in NC are found within its Coastal Plain as shown in red, pink, purple, and dark blue on Figure 36. The OAP falls within areas of NC that are particularly diverse likely due to the high concentration of natural areas managed by Federal (e.g., Wildlife Refuges), State (NC Game Lands and State Parks), and non-government organizations (The Conservation Fund, etc.).

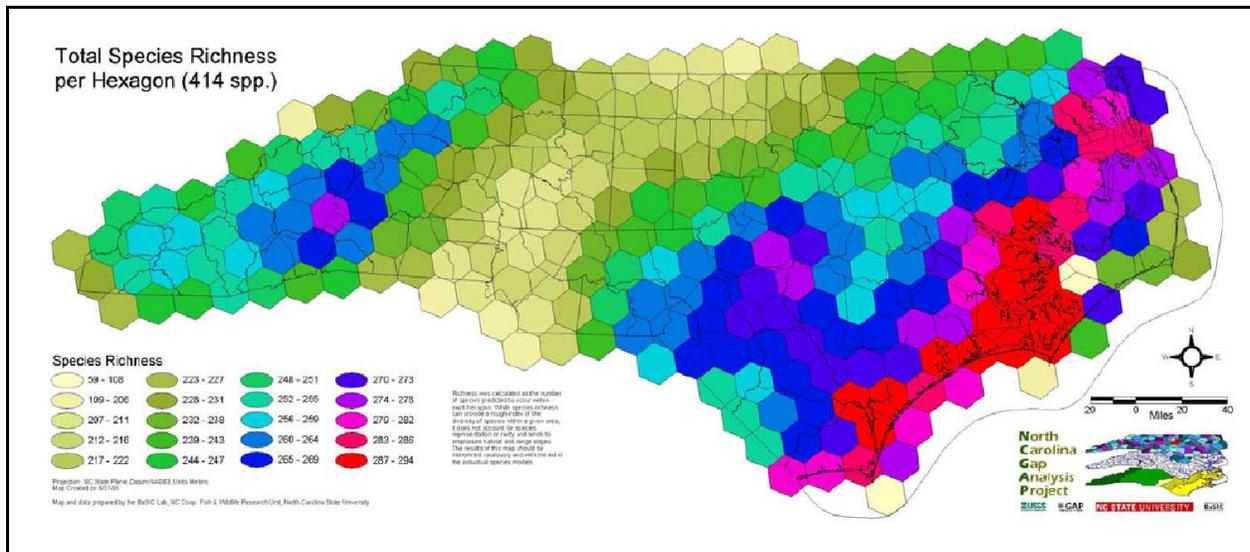


FIGURE 36. Number of vertebrate species (except fish) expected to be found within North Carolina. Expected numbers are based on the predicted distributions of 414 species that are known to reside/breed in North Carolina. Map is from McKerrow et al. (2006).

The high diversity of vertebrate species within the OAP includes a relatively large number of mammals, amphibians, and reptile species (Figure 36). The waterways of the Albemarle-Pamlico estuarine system and the surrounding creeks and lakes provide roosting and foraging habitat for overwintering migratory waterfowl (Figure 37). Hundreds of thousands of birds comprised of approximately 25 species descend on the region in the winter months (November-February). The birds also attract predators; bald eagles (Figure 38B) and harriers are a common sight in the winter; and golden eagles are spotted occasionally. The Pocosin Lakes NWR has a species list of more than 200 birds overall. Much of the diversity of amphibians is represented by frogs (Figure 38C) and toads which can produce thrilling choruses at night under the correct environmental conditions (warm and rainy nights around May). Black bears, otters, (Figure 38A) coyotes, and various endangered species occur within the OAP region in the highest density east of the Mississippi River because of the vast wetland areas within NC's Land of Water. And of course, the nightscape of a warm muggy summer night would not be memberable without the overwhelming chorus of insects and frogs (Figure 38C), along with swarms of biting bugs which is why we always carry netting. In contrast, the same winter nightscape would not be memorable without a bitterly cold and breezy night filled with stars and the cacophony of winter waterfowl (Figure 37) and why we always are layered in down clothing.



FIGURE 37. The nocturnal environment of the winter night sky is frequently dominated by the cacophony of the tundra swans that winter over in the AOP by the many tens of thousands. Photograph is by S. Riggs.



FIGURE 38A. Photographs show common black bears and river otter of the OAP region. Photographs are by M. Dunn.



FIGURE 38B. Left photograph is a flock of snow geese in a field and right panel is a bald eagle standing watch. Photographs are in the Pocosin Lakes National Wildlife Refuge by M. Dunn (left) and T. Earnhardt (right).



FIGURE 38C. Left photograph is a croaking frog in a canal and the right photograph is a green tree frog. Photographs are in the Alligator National Wildlife Refuge by T. Earnhardt (left) and M. Dunn (right).

OBSERVING THE NIGHT SKY



FIGURE 39. Observing the night sky with the Milky Way Galaxy across the vast view scape provided by a water body. Notice the urban glow in the distance. Photograph is by Allen Phelps Photography.

Navigating Around in the Night Sky

Imagine star gazing with friends under a night sky full of thousands of stars (Figure 39). How does one point out iconic constellations or subtle features within that mass of night sky objects? How do you effectively communicate to someone else what you are looking at? After all, there is no measuring stick in the sky. When astronomers measure the sky, they do so in terms of angles and triangles to determine distances. A small triangle relates to larger ones of the same proportions to calculate the size or distance of an object you that can't be measured directly.

This technique can be used in the field to determine distances above the horizon and between the stars. But how can this method be applied to star gazing? The answer is quite “handy”. It turns out that the proportion between an individuals’ hand size and arm length is fairly consistent from person to person. Thus, if two observers stand side by side, each close one eye, hold up an outstretched arm, line up the bottom of a closed fist (thumb tucked inside) on the

distant horizon, both persons will block out the same portion of the sky with the top of the fist measuring about 10 degrees. In this position now extend the little finger which measures about one degree. By extending only the index, middle, and ring fingers together will measure a five degree angle. Stretching your index and little fingers away from each other will measure about fifteen degrees, whereas stretching your thumb and little finger away from each other will measure about twenty five degrees.

Using these angles will allow observers to communicate distances or positions of specific objects in the sky by relating their positions to something easily observable such as a tree or a very bright star. For example, take the big dipper which is easy to recognize and stands out clearly with its seven bright stars, follow the two stars that form the outer edge of the cup 30 degrees upwards (three fists) to locate the North Star. This handy technique allows for the quick and effective way to navigate the sky with an audience in an interactive way. Nothing more is needed than an outstretched hand, a good eye, and a reference point.

Quality of Clear Night Skies

An important question to ask on a clear night is how dark is the night sky? The quality of a clear night sky can vary significantly depending on where you are. To an astronomer “seeing” and “transparency” are two values used to compare quality of the sky from night to night and place to place. “Seeing” is a measure of how stable the sky is and “transparency” is a measure of how clear the sky is. Both “seeing” and “transparency” are easy observations to make, require no special equipment, and can be determined by a simple rating scale with results subject to the observer’s judgment.

How stable the night sky is depends on the Earth’s atmosphere which is both chaotic and turbulent as evidenced by twinkling stars. Before the fine pinpoint of light from a distant star reaches your eye, it must pass through the Earth’s dense atmosphere. In this process the light is scattered, refracted, and distorted, resulting in the stars twinkling. The more the stars twinkle the more atmospheric distortion is taking place. One thing to note is that the stars closer to the horizon twinkle more intensely than the stars near the zenith, the point directly above you. Star light within the zenith passes through significantly less atmosphere than star light lower on the horizon.

SEEING GUIDE: HOW STABLE IS THE SKY?

- E Excellent: Brighter stars are not twinkling at all.
- VG Very Good: Stars are twinkling slightly, but the brighter planets are not twinkling.
- G Good: Brighter planets are twinkling slightly.
- F Fair: Brighter planets are obviously twinkling.
- P Poor: Atmosphere is turbulent making observation not practical.

Transparency is a scale of how clear the sky is or how many stars you can see. This comes down to how much starlight your eye is able to detect amongst all the other light in your environment. For this technique it is important to know how bright a particular star is to understand how much light from the stars you are receiving. To simplify this you can use one well know and simple constellation, the Little Dipper. Four of the seven stars of the Little Dipper

are close to the limit of what the human eye can detect. Any slight variations to transparency and sky quality will hamper your ability to see all seven stars of the Little Dipper and thus the stars in the Little Dipper offer a convenient and consistent way to gauge transparency. To determine transparency, find the Little Dipper (Ursa Minor) and note how many of its' seven stars can be seen (Figures 40 and 41).

TRANSPARENCY GUIDE: HOW CLEAR IS THE SKY?

- Excellent: If stars near the Little Dipper that are not part of the stick figure are visible.
- Very Good: If all 7 stars in the Little Dipper are visible.
- Good: If 6 of the 7 stars in the Little Dipper are visible.
- Fair: If any stars in the handle of the Little Dipper are visible.
- Poor: If the two stars are visible at the outer edge of the Little Dipper cup (Kochab and Pherkad).
- Very Poor: If the North Star Polaris is visible.
- Not Clear: If the North Star Polaris is NOT visible.

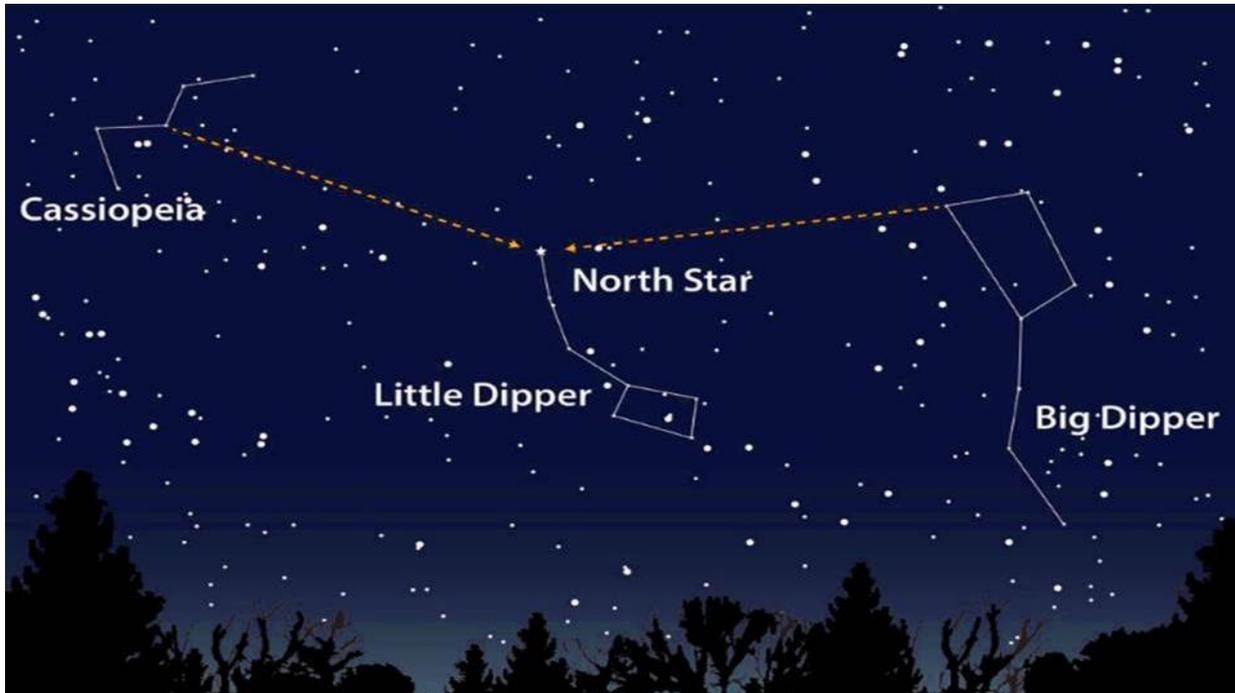


FIGURE 40. Diagram showing the relative location of the Little Dipper in the night sky.

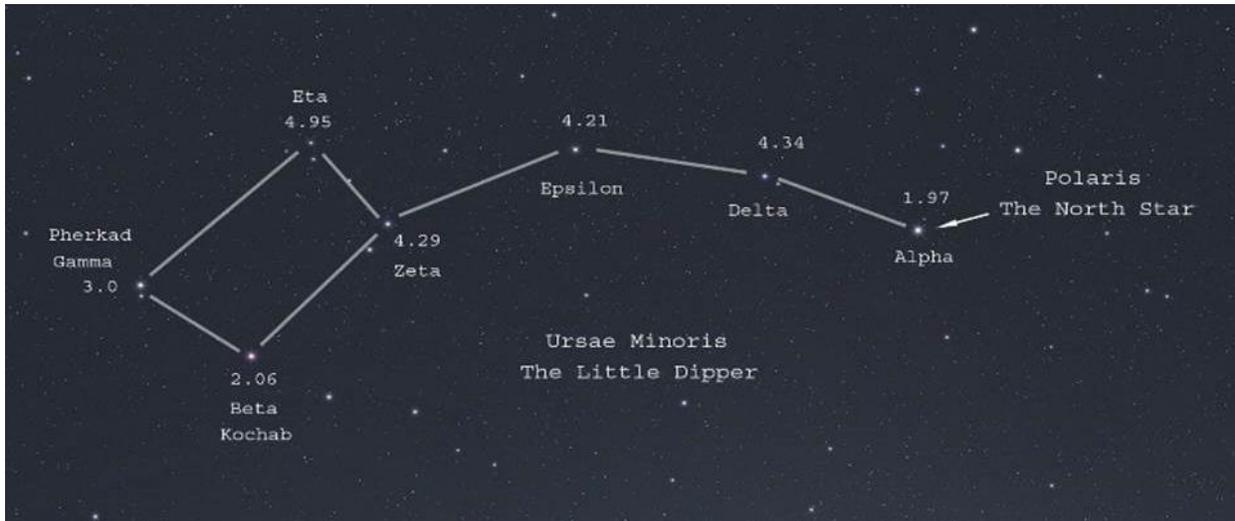


FIGURE 41. Diagram identifies the stars within the Little Dipper constellation .

Telescopes and Binoculars

Telescopes and binoculars (Figure 42) ultimately serve similar functions. They both focus light from distant objects to make far away things seem bigger and brighter. The differences in how this is done with telescopes and binoculars lead to wide ranges of capabilities and many different conditions.



FIGURE 42. Left panel is an example of telescopes at dusk on a clear night sky by M. Quinn on 6-10-13. Right panel is an example of binoculars that are useful for viewing both the nocturnal environment and the night sky.

The main difference between telescopes and binoculars is size and weight. Telescopes are generally large and unwieldy, stationary objects that need time to set up. The advantage to its large size allows it to collect more light, resulting in greater magnification and resolution of images. Binoculars on the other hand are light and nimble and can be used in almost any situation. Since binoculars are smaller, they do not have the light collecting power of a telescope, but do offer a wider field of view and ease of use. There is also a difference between how telescopes and binoculars focus light. Binoculars solely use glass lenses to focus light. They create images that are right side up. In contrast, many telescopes use mirrors to focus light resulting in images that are inverted. This characteristic makes binoculars much more intuitive to use.

Observing Wildlife

Telescopes are generally overkill in observing wildlife. Their narrow field of view and complex mounts make it difficult to view and track moving targets. Telescopes can perform this task well, but require particular types of mount and eyepieces to be practical. If the plan is to be stationary with time to prep, a telescope will allow detailed observations of animals and other natural features.

However, it is hard to imagine a better tool for sightseeing than a good pair of binoculars. Binoculars are portable and ready for use at any moment if they are hung around the neck or sitting in arms reach. Binoculars provide magnification that ranges from 6x up to 15x, meaning that images will appear six to fifteen times larger than with your naked eye. This makes binoculars perfect for resolving fine details at medium range.

Stargazing

Telescopes are made for stargazing! There is no better instrument to explore the wonders of the night sky. Wide telescope apertures allow them to collect significant amounts of light and produces images of objects in the sky that are both incredibly faint and far away. Telescopes provide clear views of the craters on the moon, the planets in our solar system, and even far away stars and galaxies. Many things should be considered when choosing a telescope for stargazing. Telescopes come in a wide verity from small “kiddy” scopes that are less than one hundred dollars to high-end robotic systems that cost tens of thousands of dollars. A 6-inch or 8-inch dobsonian telescope offers a good balance of affordability, capability, portability, and ease of use--a good place for an introductory telescope.

Binoculars are also amazing instruments for stargazing. Binoculars don't have the light collecting power of telescopes, but the magnification they provide dramatically opens up the night sky wonders beyond what the human eye is capable of seeing. The biggest advantage of binoculars over telescopes for stargazing is their field of view. When looking through a pair of binoculars you get a magnified view of a large area of the sky. For example, it is advantageous to use binoculars when trying to get a good look at star clusters.

Photography

Telescopes are remarkable tools for photographers. Since telescopes make far away things look bigger and brighter, allows great shots to be made of subjects off in the distance. However, the most common reason for hooking a camera up to a telescope is to capture images of the night sky. Astrophotography is based on combining a telescope and a camera. With modern equipment and photo processing software stunning images can be made of the most remarkable features of the Universe. Binoculars are not commonly used in photography. However, the image produced by a pair of binoculars does match up well with the aperture of a typical smart phone camera. Smartphone adapters for binoculars are available and greatly improve the capabilities of this combination.

Camping

Telescopes and binoculars are excellent tools to go along with camping trips. Binoculars are most useful for hiking and spotting wildlife. Telescopes can be bulky and cumbersome, however there are smaller portable models designed for quick set ups. These telescopes are great since most camping is in dark areas far from light glow of cities, making possible incredible explorations of the night sky.

On the Water

When on the water, traditional telescopes are almost useless; they need to be steady to have useful observations. Telescopes magnify such small points of the sky that even the slightest motion will move it far from the intended target. Binoculars, on the other hand are great tools to have on boats and in large bodies of water at night. Pristine dark sky conditions occur on larger water bodies since there are very few sources of light pollution and vast horizons. A pair of binoculars in this situation provides an incredible stargazing experience. Also, many models of binoculars have features that improve their performance and durability in wet situations.

LIGHT POLLUTION

This section is largely summarized from the International Dark Sky Association website (<https://www.darksky.org/light-pollution/>), US National Park Service website (<https://www.nps.gov/subjects/night skies/growth.htm>), and US NASA website (<https://images.nasa.gov/details>).

What's the problem?

Over the last 75 years the night sky has been taken over by the glare of city lights (Figure 43). Continued urbanization and population growth have greatly increased the number of artificial lights used to light up the night. We are losing the dark at the speed of light! It is now common to gaze into the night sky only to see a hand-full of stars. Eighty percent of the world's population cannot see the Milky Way and its thousands of stars that stretch across the sky every night. Evidence is mounting that the increased and widespread use of artificial light at night is not only impairing our view of the universe, it is also adversely affecting our environment, our safety, our energy consumption, and our health.

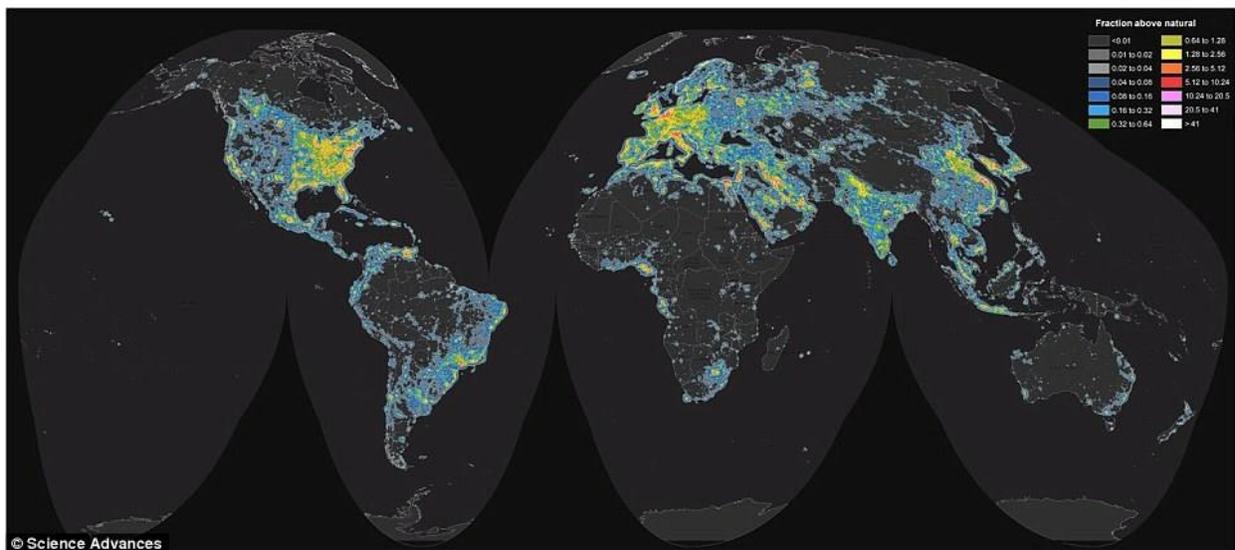


FIGURE 43. Map of the “new world’s atlas” of artificial night sky brightness is by Falchi et al., 2016. In *Science Advances*, v. 2, no. 6, e1600377.

Most of us are familiar with air, water, and land pollution, but light can also be a pollutant. Light pollution is the inappropriate or excessive use of artificial light (Figure 44). Until recently, life on Earth has existed in a rhythm of light and dark by the illumination of the Sun, Moon and stars. Now, artificial lights overpower the darkness, disrupting the natural day-night pattern and eroding the delicate balance of nocturnal environments. The negative effects of the loss of this inspirational natural resource might seem intangible, but a growing body of evidence links the brightening night sky directly to measurable negative impacts on human health, wildlife ecosystems, and energy consumption.



FIGURE 44. The last pristine and public night sky along the Atlantic coastal system between Boston and Miami in 2012 by NASA Goddard and created on 12-8-2017. Visible infrared imaging Radiometer Suite https://images.nasa.gov/details-GSFC_20171208_Archive_e001590.

Types of Light Pollution

Light pollution comes in a verity of forms. *Glare* is excessive brightness that causes visual discomfort leading to loss of contrast, or even temporary blindness. Glare from unshielded lighting is a public-health hazard, especially for older drivers. *Light trespass* is when light falls where it is not intended or needed. Light trespass is often felt by residents who live near shopping centers, gas stations, or in apartment complexes where unwanted light shines into a bedroom window, removing the dark and disrupting one's sleep. *Sky Glow* is the brightening of the night sky over populated areas. Sky glow is a side effect of an industrial civilization where all the reflected, unused, and upward-directed light combines as it escapes up into the sky. Its sources include building exterior and interior lighting, advertising, commercial properties, factories, streetlights, and illuminated sporting venues.

Effects of Light Pollution

The negative impact of artificial lighting on wildlife is well documented. Everything from trees and flowers to frogs and birds, have a delicate relationship with the night. Some trees can be hampered by prolonged exposure of artificial light and fail to respond to seasonal variations. This, in turn, has implications for wildlife that depend on those trees for their natural habitat. Light pollution can also alter behaviors, foraging areas, and breeding cycles of insects, turtles, birds, fish, and reptiles. Sea turtles provide a dramatic and well know example of the interaction between light pollution and animal behavior. Artificial lights on the beach disorient newly hatched turtles causing them to navigate toward the artificial light source and away from the sea (Figure 45).



FIGURE 45. Turtle hatchlings instinctively orient away from the dark silhouette of the nighttime shore. Here hatchlings have been temporarily distracted by a bright lamp. Hatchlings and mother turtles distracted by shorefront lights can wander onto nearby roadways. Photograph is by B. Witherington,

Though the effects are not as well defined as with wildlife, there exists a compelling amount of evidence concerning the relationship between artificial lighting and human health problems. The connection between artificial light and sleep disorders is a fairly intuitive one. Difficulties with adjusting the circadian clock can lead to a number of sleep disorders. In fact, the introduction of artificial lighting has changed our basic concept of a good night sleep. Prior to the beginning of the industrial age people slept in two 4-hour shifts (“first sleep” and “second sleep”) separated by a late-night period of quiet wakefulness. Even more serious are the correlations being found linking artificial lighting to increased risk of cancer. Melatonin, a hormone produced by the pineal gland, is secreted at night and is known for helping to regulate the body’s biologic clock. The body produces melatonin at night, and melatonin levels drop precipitously in the presence of artificial or natural light. Numerous studies suggest that decreasing nocturnal melatonin production levels increases an individual’s risk of developing cancer.

Solutions to the Problem

Unlike other forms of pollution, the effects of light pollution can be reversed instantaneously. Once excessive lighting is removed from an environment the negative impacts cease immediately. It’s not the case that we need to get rid of all outdoor lighting and live in the dark ages. We just need to be more intentional about our outdoor lighting. Fortunately, there are some very simple steps that can be taken to make a big impact on light pollution.

By far the vast majority of the artificial lighting that we use at night goes unutilized (Figure 46). Lights that shine horizontally or upwards towards the sky are wasting energy and disrupting the nocturnal environment. Light in these situations travel freely through the air and illuminate the atmosphere over a large region. This stray light often creates hazardous glare that can affect public safety and diminishes our view of the stars. In many cases it is possible to replace problematic lighting rather than removing the light all together. All that is required is to ensure that any outdoor lighting is fully shielded, meaning that all the light is directed towards the ground, where it would actually be useful. With all the light directed toward the ground you are effectively getting more illumination where it matters, while using less energy.

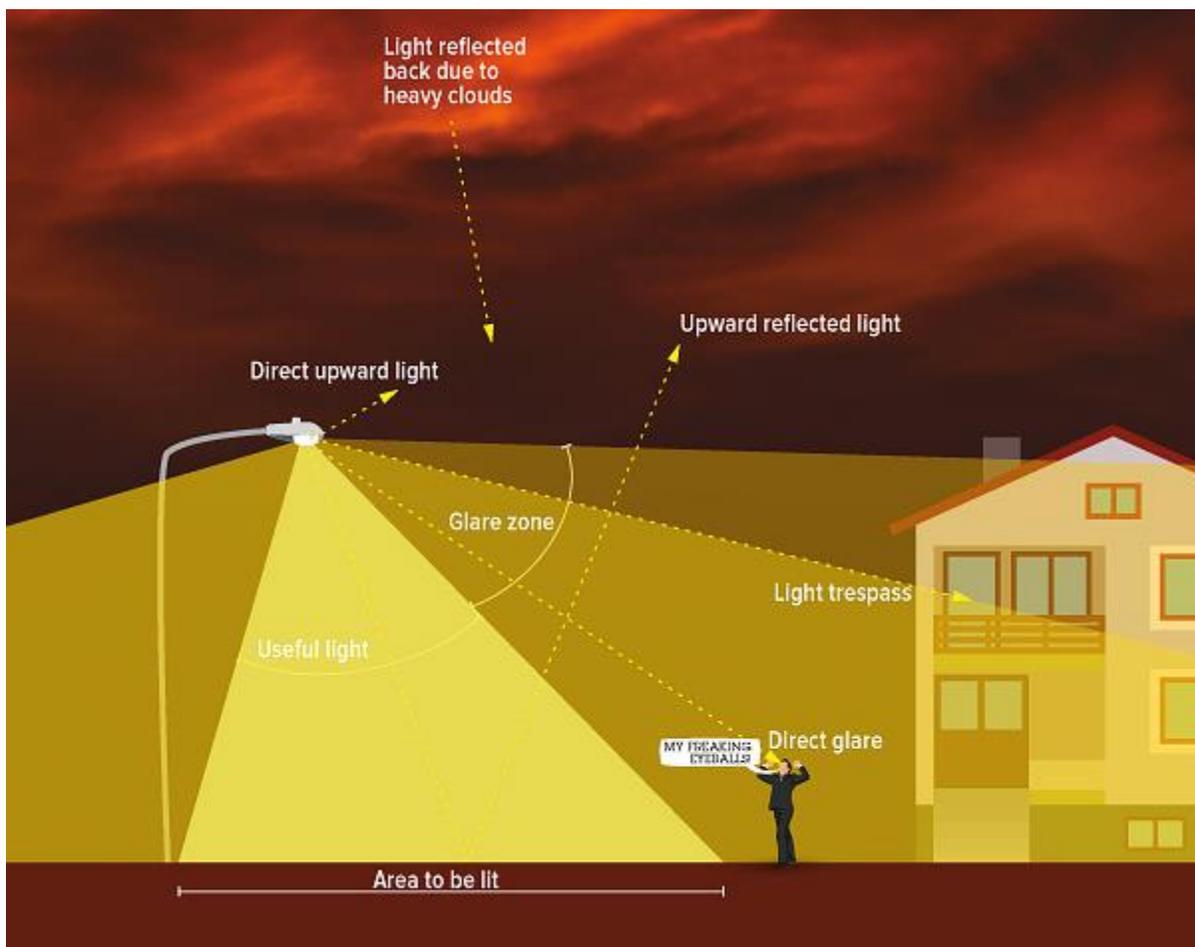


FIGURE 46 The infographic above illustrates the different components of light pollution and what “good” lighting looks like. Image is by Anezka Gocova, in “The Night Issue”, *Alternatives Journal* (2013, v. 39, no. 5).

The choices that are made concerning outdoor lighting are very important. Shielded lights are no more expensive than non-shielded lights. The difference is just having the knowledge of how our lighting impacts the world around us. Outside of shielded and non-shielded lighting there are many different aspects to consider. Common light sources include low-pressure sodium (“LPS”), high-pressure sodium (“HPS”), metal halide, and light emitting diodes (“LEDs”). Each of these light sources produce different colors of light which impact the nocturnal environment differently. Timers and triggers are incredibly important as well. With these features lights can be activated when they are needed and turned off when they are not.

Ultimately, this is a local community issue that is in the hands of each resident. Many people who become concerned about light pollution want to know what they can do to make a difference in their community. Beyond fixing your own lighting, one thing you can do is work to get an outdoor lighting ordinance adopted in your community. Outdoor lighting ordinances or codes are a great tool for ensuring that municipalities implement good, safe outdoor lighting. A well-written ordinance with proper lighting installed will save the public money and increase safety. Thousands of cities have adopted such codes and they can be a great tool for communities to use in controlling light pollution, including glare, light trespass and sky glow (Figure 47).



FIGURE 47. Photographs were taken before and during the 2003 Northeast blackout, a massive power outage that affected 55 million people. Photographs are by T. Carlson on the IDA website <https://www.darksky.org/light-pollution/>.

NIGHT-SCAPE OUTREACH

Communication and Education

The opportunities for building programs around the nocturnal environment and night sky are unlimited for both the public and associated school systems and can readily be integrated with other outdoor programs. Day time lectures can be offered at specific facilities, evening field trips can be taken to various outdoor locations good for night viewing and listening, and course curricula can be implemented within the K-12 regional schools. Multiple day eco-tourism workshops and field programs dealing with the natural and cultural resources of the Albemarle region can include components associated with nocturnal environments and astronomy of the night sky that are integrated into the region's landscape and ecosystem programs.

Natural resource education of the youth, public, and leadership of the Roanoke-Albemarle region is critical not only for the protection and management, but also the potential for developing sustainable eco-tourism for the region's future. The over-arching goal of the nightscape project was to delineate the nocturnal environment and night sky resources and expand the night-scape capabilities into the existing plan for developing educational and sustainable eco-tourism programs for the underserved counties of the northeastern NC. If successful, it would bring national and international attention to the natural resources and eco-tourism potential of NC's Inner Banks. Thus, an important sub-goal of the NC LOW and ATFS nightscape project was the outreach communication and education during the project year (Aug 1, 2018 to July 31, 2019).

1. Educational workshops provide local science teachers with new ideas to incorporate into their lesson plans, having impacts on a vast number of K-12 students of northeastern NC coastal region (Figure 48).
2. A series of eight K-12 science teacher education workshops were held in Bertie County during the year to deal with the natural resource base of the region followed by one evening "night-scape star party". NC LOW, ATFS, and CSI hosted two public **STAR PARTIES** sponsored by the Night-Scape project (Figure 49). The first Star Party was on Tuesday February 5th from 6:00 pm to 9:00 pm at Jennette's Pier in Nags Head, NC with about 500 participants. The second Star Party was on Thursday March 7th from 6:30 pm to 9:00 pm at the Middle School in Windsor, Bertie County, NC with about 300 participants. The third Star Party was to be held on April 13 at the Pettigrew State Park Visitor's Center in Creswell, NC. This latter program was part of the NC Science Festival's Statewide Star Party but had to be canceled on the program day due to severe weather and very cloudy skies at Lake Phelps.

3. The Star Party programs were free and open to the public with a major portion of the participants being K-12 students. Each Star Party had rotating programs every half hour in a portable planetarium that included a 15 minute presentation on light pollution, a tour of the planets and constellations, a film titled “Losing the Dark” to introduce light pollution issues with simple actions to mitigate it. Numerous volunteer astronomers manned their large telescopes and science educators tended four activity tables. The portable planetarium, which holds 45 people, was also utilized for night sky presentations to 4th grade classes at over twenty regional public schools in other northeastern coastal counties.



FIGURE 48. There were eight science teachers workshops focused on “What’s in Your Backyard” which includes the landscapes, waterscapes, and nightscapes. The wrap-ups for these workshops were the regional Star Parties. Photographs are by S. Riggs



FIGURE 49. There were eight science teachers workshops focused on “What’s in Your Backyard” which includes the landscapes, waterscapes, and nightscapes. The wrap-ups for these workshops were the regional Star Parties. This photograph shows the portable planetarium and various activity tables. Photographs are by S. Riggs

4. As an integral part of the communication and education program, the science teachers were taken on 4 major field trips to explore “what’s in your backyard”. These trips all dealt with the water-land intersection. A plan is being developed for a regional K-12 scientific and environmental instruction program titled “From Rivers to Sounds” built on the newly acquired 1,000 acre “Salmon Creek State Natural Area”, now part of the NC Division of State Parks.
5. In September 2018 A Time for Science began a new outreach program serving 10,000 fourth grade students in Eastern North Carolina. STEP into STEM is a traveling interactive science exhibition that visits regional schools to bring the fourth-grade science curriculum alive by letting students blast off to the moon to learn about the lunar cycle, visit a portable planetarium to see programs on our night sky and learn how to limit light pollution, as well as other relevant science topics.

6. Various media organizations produced a series of articles, news releases and documentary films concerning the OAP natural resources and its Dark Skies.

International Dark Sky Reserve

An International Dark Sky Reserve (DSR) (<http://www.darksky.org/idsp/become-a-dark-sky-place/>) requires “a public or private land area of substantial size (270 mi² or 173,000 acres) possessing an exceptional or distinguished quality of starry nights and nocturnal environment and is specifically protected for its scientific, natural, educational, cultural heritage, and/or public enjoyment.” The 758+ mi² of public lands within the OAP (Figure 50) plus the surrounding 2,900 mi² of public estuarine waters totals to over 3,700 mi² of public land and water that is protected for its wildness with almost no urban component. The NC dark sky region is more than 14 times what IDSR requires for designation as an International Dark Sky Preserve. Thus, the Outer Albemarle Peninsula and its associated waterscape is a world-class natural resource available for developing “resilient communities and economies” in the poorest and truly-rural coastal region in NC. The present project has developed a wealth of data about the nightscape resource and obtained local recognition of this vast resource. Now the local communities must lay the groundwork with a plan to obtain an “International Dark Sky Reserve” designation by the IDA (the first US reserve was established in 2017 in Idaho and a second in 2018 in Utah). This designation will put the northeastern coastal section of NC on the national and international map and provide marketing material to help build a nightscape component to complement the daytime recreational and educational opportunities in rural coastal NC.



Figure 50. The path leads into the Albemarle Peninsula’s wildness. Photograph is by P. Gemperline.

PART 2: NIGHT-SCAPE SURVEY SITES



FIGURE 51. When the night sky is cloudy, the nocturnal environment becomes the world-class highlight. Photograph was taken during a cloudy February day of Tundra Swans on Pungo Lake in Pocosin Lakes National Wildlife Refuge. Photograph is by P. Gemperline.

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IMPORTANT NOTICE!

This publication presents the research results of a study funded to define the Night-Scape resources (nocturnal environment and night sky) within northeastern NC’s coastal system. Consequently, this publication shares the resulting information, but does **NOT GIVE PERMISSION TO ACCESS SITES FOR NIGHT-SCAPE VIEWING!** All sites are managed by either local, county, state, and/or federal agencies with specific rules and regulations. For example, the National Wildlife Refuges have a federal law that limits night-time visitation (from ½ hour after sunset to ½ hour before sunrise) to individuals and/or groups that have SUP (special use permits). Hopefully, each relevant land management organization will be working on establishing specific quality sites, as well as permitting procedures, for utilization as Night-Scape observation areas. In the meantime, please contact the appropriate office for specific access information. The only site with public camping facilities is the Pettigrew State Park Visitor’s Center.

INTRODUCTION

The Outer Albemarle Peninsula (OAP) night-scape region consists of over 780 mi² of public land surrounded by about 2,900 mi² of vast estuarine water bodies, and a 163 mi² outer perimeter of land that includes the southern Outer Banks. This dark sky area is the largest coastal segment (over 3,800 mi² or 2.43 million acres) along the US Atlantic coastal system between Boston and Miami (Figure 52). By incorporating the dark buffer zone of NC's vast estuarine system and the southern Outer Banks the area contains the following public lands: six national wildlife refuges (Alligator River, Pocosin Lakes, Mattamuskeet, Swanquarter, Cedar Island, and Pea Island); two national seashores (Cape Hatteras and Cape Lookout); two NC State Parks and Historic Sites (Pettigrew and Somerset Place); vast NC Wildlife Commission game lands and boat ramps; county and conservation group properties; and US Defense properties in the lowlands of Dare, Pamlico, and Carteret counties.

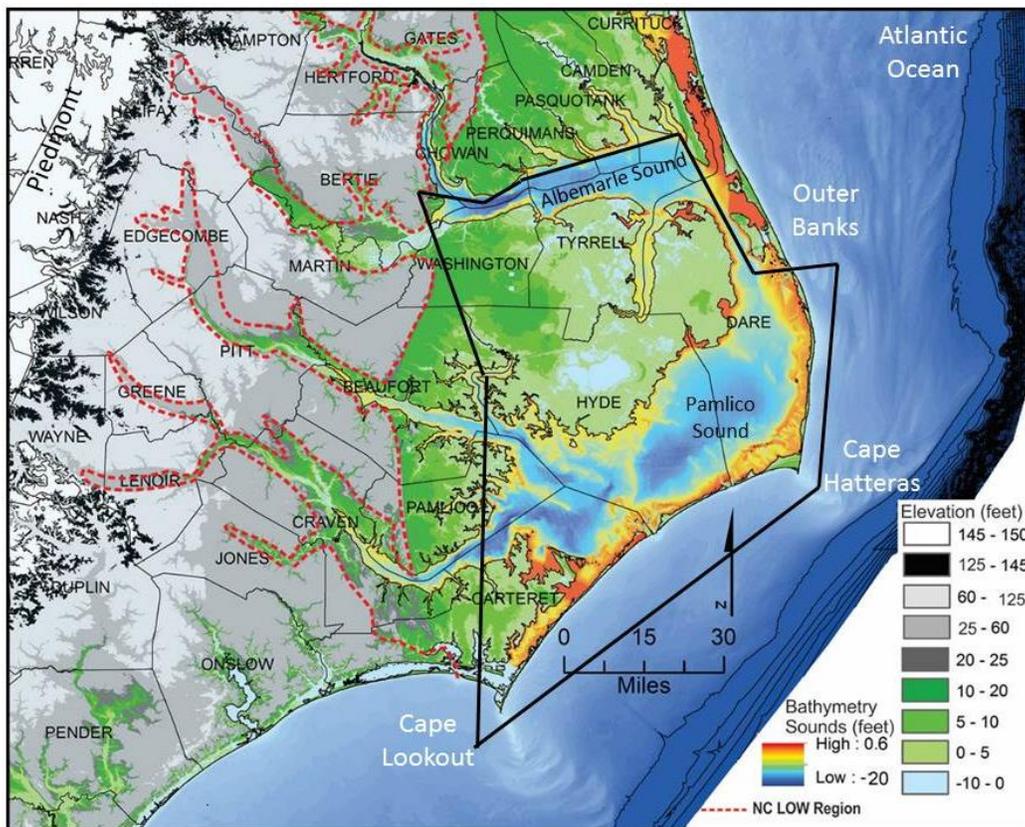


FIGURE 52. Color topography map shows the North Carolina Land of Water (NC LOW) of northeastern North Carolina's coastal system east of the red dashed line. The Outer Albemarle Peninsula study outlined in a black hexagon includes major portions of Washington, all of Tyrrell and mainland Hyde-Dare counties that are surrounded by the vast areas of the Albemarle Sound to the north, Croatan Sound to the northeast, and the Pamlico Sound to the southeast and south. The Outer Bank, south of Roanoke Island include the Cape Hatteras and Cape Lookout National Seashores are included as critical parts of North Carolina's dark sky resource. Figure is modified from Riggs et al. (2011)

The night skies of the OAP are among the darkest on the entire US east coastal system (Figure 2). The Peninsula is surrounded by four very large estuarine water bodies: Albemarle Sound on the north, Croatan and Pamlico sounds on the east, and the Pamlico River Estuary on the south. This outer land region consists of Tyrrell, Washington, and mainland Dare and Hyde counties. Plymouth, Roper, Creswell, Columbia, Manns Harbor, Stumpy Point, Engelhard, Swan Quarter, Pantego, and Belhaven are the largest towns on the Peninsula and located on the National Wildlife Refuges occur within the region (Alligator River, Pocosin Lakes, Mattamuskeet, and Swanquarter) as well as vast acreages of NC game lands and private conservation lands. Thus, the >5,000 square miles of public ecosystems within the Outer Albemarle Peninsula (OAP) preserve a unique complex of nocturnal environments and associated night skies.

All of the small towns are located along the highway 64-264-45 corridor around the four sides of the OAP perimeter (Figure 3). However, much of the regions' population is rural and lives in very small crossroad communities scattered throughout the peninsula (e.g., Goat Neck, Cherry, Fairfield, Kilkenny, East Lake, Alligator, Mackeys, Gum Neck, New Holland, etc.). The largest industry is agriculture with vast areas of farms and timber lands, along with a small, but growing tourist industry. Four large National Wildlife Refuges occur within the region (Alligator River, Pocosin Lakes, Mattamuskeet, and Swanquarter), vast acreages of NC Wildlife Resources Commission game lands; a state park, historic site, and coastal preserve; and private conservation lands. Thus, over 485,134 acres (758 mi²) of public ecosystems occur within the OAP and contain a unique, complex system of nocturnal environments and associated night skies.

The OAP night-scape resource results from the vast area of public wetlands surrounded by expansive estuarine water bodies, both with minimal human activity. The 360° horizon vistas provide a never ending parade of sky magic. Every month the night skies rotate from the brilliant, big full moon to inky black new moon with dazzling starry displays. Big seasonal variations range between extremes from the hot, humid drone of summer nocturnal sound-scape of insects and amphibians to the frigid winter nights with their dramatic cacophony of waterfowl, owls, and wolves. Thunderheads illuminate the stage with dramatic lightning as spectacular cloud displays at days end introduce the main feature, a zenith of planets, constellations, and the magical milky-way. The "Big Night Sky" presents an ideal astronomical wonderland that is becoming an endangered environment along the US Atlantic coast due to ever increasing development and resulting light pollution.

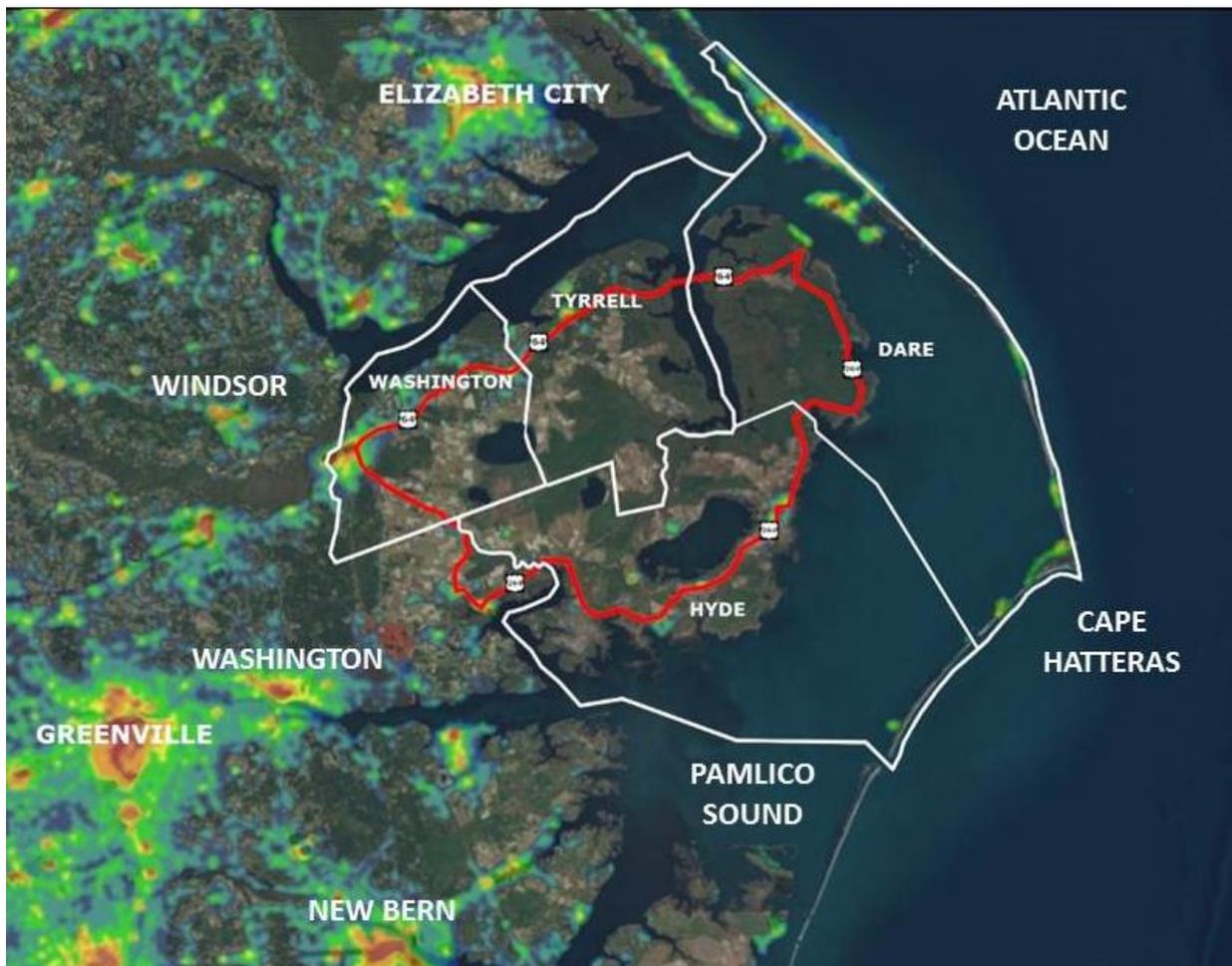


FIGURE 53. A light pollution map shows the four counties of the OAP along with the trace of Highways 64, 264, and 45 (in red) that form a ring around the heart of the dark sky landscape and harbor most of the small villages on the OAP. Seaward of the highway is a coastal rim that also has very dark skies overlooking the estuarine water bodies to the north, east, south, along with vast agricultural fields to the west. The brightest spot of high light pollution is Greenville in the southwest corner with decreasing magnitudes eastward to Washington and Aurora phosphate mine on south side of the Pamlico River estuary. The high light pollution spot to the north is Elizabeth City. Map is modified from Falchi, Fabio, et al. 2016.

NIGHT-SCAPE SITE SUMMARY

North Carolina Land of Water (NC LOW) & A Time for Science (ATFS), two NGO nonprofit 501 c 3 organizations (www.nclandofwater.org and www.atimeforscience.org) carried out a one year study of the “Dark Sky Resources” within the Outer Albemarle Peninsula of NC. The study team included

Dr. Stanley Riggs: Director and Regional Geologist, NC LOW

Mr. Brian Baker: Astronomy Educator, ATFS

Ms. Emily Jarvis: Executive Director, ATFS.

Ms. Karen Clough: Community Outreach Coordinator, NC LOW

Additional team members included Dr. Reide Corbett and Mr. John McCloud, East Carolina University, Coastal Studies Institute.

To understand the nocturnal environment and dark skies of the OAP four additional night-scape survey teams were recruited, one each for mainland Dare and Hyde, Tyrrell, and Washington counties. The teams included the following personnel.

Mainland Dare County: David Sybert, Hayley Grabner, Ian Conery, & Lindsey Dobbs (Coastal Studies Institute)

Tyrrell County: Ms. Kim Wheeler & George Haislip (Citizens)

Mainland Hyde & Washington Counties: Marah Dahn (ECU Technician), Samantha Eubanks (ATFS), & Erik Evanger (Citizen)

A preliminary county trip itinerary with specific sites was prepared by the PI’s for each team, along with data sheets and equipment for both the nocturnal environment and night sky. Each team was equipped with a GPS, SQM-L sky quality light meter, as well as sound and weather meters to collect night-scape data for each site throughout the seasons. In addition the teams provided a general description of the land-scape, view-scape, and sound-scape, as well as the weather conditions, surrounding eco-system environment and recognizable sounds, and visitation capabilities (access, parking, light pollution, hunting, etc.) and the amount and source of light pollution. The Appendix contains the Night-Scape Survey Procedures and example Data Sheets.

The survey teams provided a general description of the night-scape including the dark sky quality, ambient sound, meteorological conditions, surrounding eco-systems, and visitation capabilities (access, parking, light and sound pollution, etc.). Based on these data parameters a night-scape grade was applied to each site (Table 1). The survey teams made 22 data collecting trips on or near the new and full moon nights from July 2018 to May 2019 for a total of 250 visits to 83 sites (Figure 54):

- 1) Mainland Dare: 97 visits to 22 sites (Table 2 and Figure 55)
- 2) Mainland Hyde: 67 visits to 27 sites (Table 3 and Figure 56)
- 3) Tyrrell: 54 visits to 22 sites (Table 4 and Figure 57)
- 4) Washington: 32 visits to 12 sites (Table 5 and Figure 58).

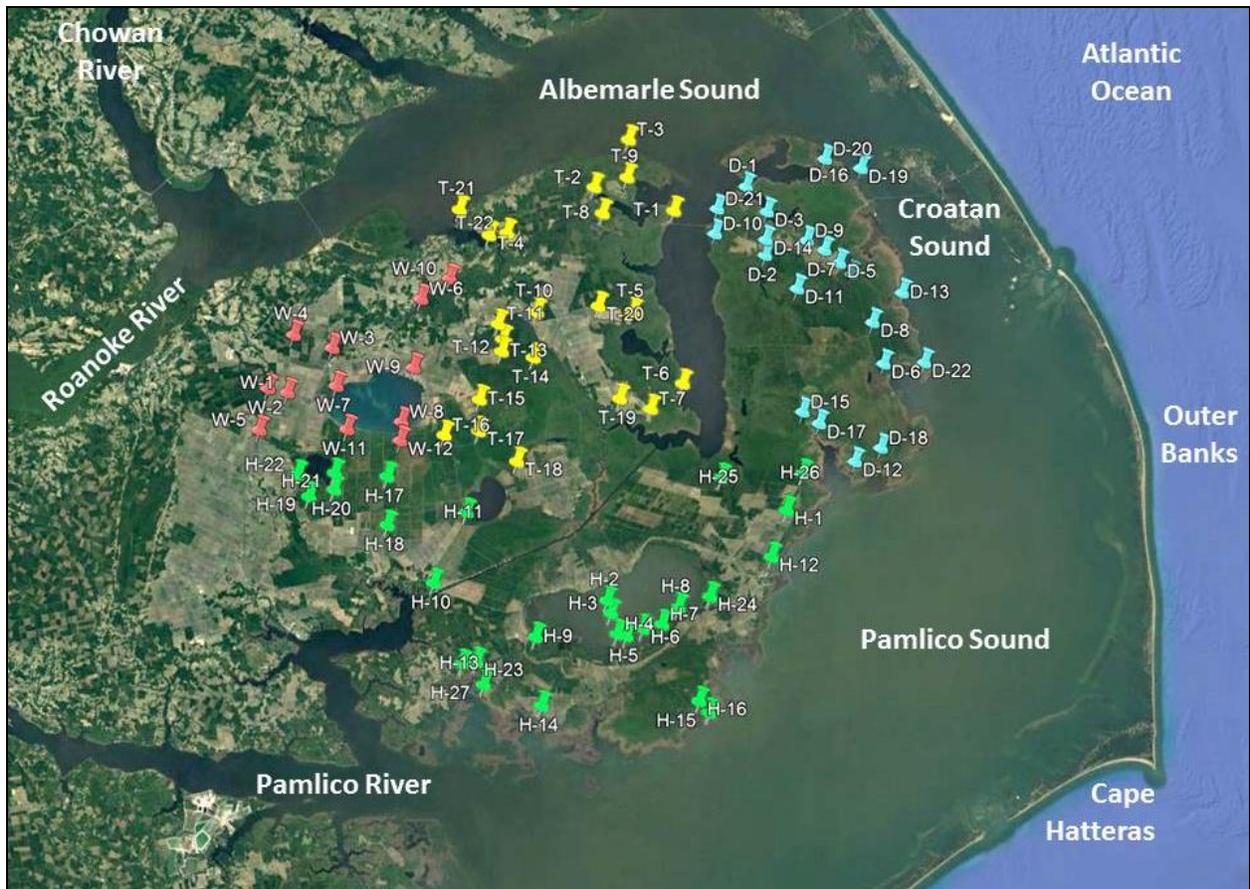


FIGURE 54. A Google Earth satellite image shows the location of 83 sites surveyed during the OAP study: blue pins = Mainland Dare Co. sites, green pins = Mainland Hyde Co. sites; yellow pins = Tyrrell Co. sites, and red pins = Washington Co. sites. See the following county tables and maps for site names, locations, and ownerships.

TABLE 1. NIGHT-SCAPE GRADING SYSTEM

3. HIGHEST QUALITY NIGHT-SCAPE

EXCELLENT NIGHT SKY
EXCELLENT NOCTURNAL ENVIRONMENT
GOOD ROAD ACCESS WITH ADEQUATE PARKING AND NO LIGHT OR
SOUND POLLUTION.

2. MODERATE QUALITY NIGHT-SCAPE

EXCELLENT NIGHT SKY OR NOCTURNAL ENVIRONMENT
GOOD PUBLIC ACCESSABILITY BUT MINIMAL PARKING, AND/OR MINOR
LIGHT OR SOUND POLLUTION

1. POOR QUALITY NIGHT-SCAPE

POOR NIGHT SKY AND/OR NOCTURNAL ENVIRONMENT DUE TO LIGHT
OR SOUND POLLUTION
LIMITED PUBLIC ACCESS DUE TO QUALITY OF ROAD CONDITIONS
AND/OR NO PARKING.

X. SITE USED ONLY FOR ACQUIRING DATA



FIGURE 55. Sunset in Pocsin Lakes NWR. Photograph is by P. Gemperline.

MAINLAND DARE COUNTY SITES

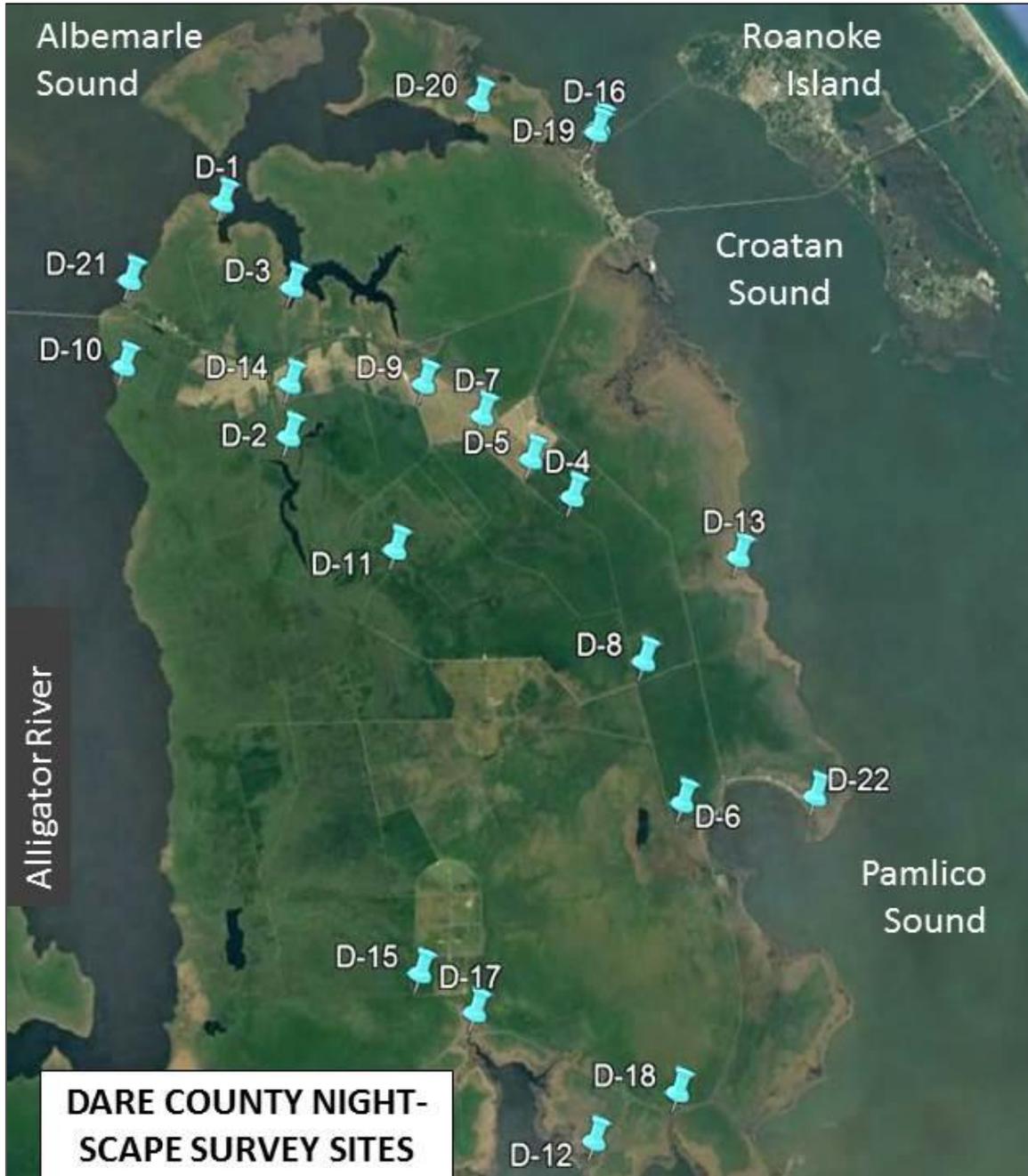


FIGURE 56. A Google Earth satellite image shows the location of 22 sites surveyed during the OAP study: blue pins = Mainland Dare Co. sites, green pins = Mainland Hyde Co. sites, and yellow pins = Tyrrell Co. sites. See the following Table 2 for site names, locations, and ownerships.

SUMMARY: MAINLAND DARE CO. SURVEY SITES--GOOGLE EARTH BLUE PINS					
MAP SITE	SITE NAME	PROPERTY OWNER	GPS LATITUDE	GPS LONGITUDE	NO. SURVEYS
D-1	BRIAR HALL ROAD-SOUTH LAKE	ALLIGATOR RIVER NWR	35°54'54.61"N	75°55'36.48"W	4
D-2	BUFFALO CITY	ALLIGATOR RIVER NWR	35°50'16.23"N	75°55'9.04"W	6
D-3	DEEP BAY ROAD-SOUTH LAKE	ALLIGATOR RIVER NWR	35°53'2.02"N	75°54'20.16"W	6
D-4	JCT LONG CURVE ROAD-BORROW PIT ROAD	ALLIGATOR RIVER NWR	35°47'57.48"N	75°48'35.88"W	6
D-5	JCT LONG CURVE ROAD-GROUSE ROAD	ALLIGATOR RIVER NWR	35°48'50.06"N	75°49'24.48"W	1
D-6	JCT LONG CURVE ROAD-LAKE WORTH ROAD	ALLIGATOR RIVER NWR & US AIR FORCE	35°41'48.29"N	75°47'27.18"W	3
D-7	JCT LONG CURVE ROAD-LINK ROAD	ALLIGATOR RIVER NWR	35°49'50.77"N	75°50'22.63"W	4
D-8	JCT LONG CURVE ROAD-NAVY SHELL ROAD	ALLIGATOR RIVER NWR & US AIR FORCE	35°44'35.96"N	75°47'41.12"W	3
D-9	JCT MILLTALE ROAD-SAWYER LAKE ROAD	ALLIGATOR RIVER NWR	35°50'41.13"N	75°51'37.95"W	6
D-10	LAUREL BAY ROAD-ALLIGATOR RIVER	ALLIGATOR RIVER NWR	35°52'16.29"N	75°58'47.88"W	1
D-11	MILLTAIL CREEK BRIDGE PARKING	ALLIGATOR RIVER NWR	35°47'43.06"N	75°53'8.52"W	4
D-12	PAMLICO ROAD-LONG SHOAL RIVER	ALLIGATOR RIVER NWR	35°35'52.51"N	75°51'14.53"W	3
D-13	POINT PETER ROAD	ALLIGATOR RIVER NWR	35°46'8.18"N	75°44'53.09"W	5
D-14	SAWYER LAKE ROAD	ALLIGATOR RIVER NWR	35° 51'15"N	75°54'52"W	1
D-15	WHIPPING CREEK ROAD	ALLIGATOR RIVER NWR	35°39'43.58"N	75°54'37.34"W	1
D-16	MANN'S HARBOR NORTH PIER	NC DEPT. ENVIRONMENT & NATURAL RESOURCES	35°54'44.03"N	75°46'7.48"W	8
D-17	LONG SHOAL RIVER HWY 264 BRIDGE	NC DEPT. OF TRANSPORTATION	35°38'46.34"N	75°53'29.32"W	3
D-18	PAINS CREEK HWY 264 BRIDGE	NC DEPT. OF TRANSPORTATION	35°36'26.03"N	75°48'59.38"W	3
D-19	MANN'S HARBOR HWY 64 BRIDGE BOAT RAMP	NC WILDLIFE RESOURCES COMM	35°54'39.01"N	75°46'13.10"W	7
D-20	MASHOES EAST LAKE BOAT RAMP	NC WILDLIFE RESOURCES COMM	35°55'42.17"N	75°48'54.68"W	8
D-21	OLD FERRY LDG BOAT RAMP-ALLIGATOR RIVER	NC WILDLIFE RESOURCES COMM	35°53'50.85"N	75°58'13.77"W	6
D-22	STUMPY POINT BOAT RAMP	NC WILDLIFE RESOURCES COMM	35°41'21.88"N	75°44'13.38"W	8

TABLE 2. Mainland Dare County Survey Sites.

SURVEY SITES IN THE ALLIGATOR RIVER NWR

Refuge Information: The sand roads are usable during dry weather, but can be bad during wet weather. Some areas and roads within the ALNWR have restrictions and may be seasonally closed to access. Visitors **PLEASE** check with the refuge personnel in Roanoke Island for details.

DARE 1 Brier Hall Road-South Lake

Alligator River National Wildlife Refuge

GPS Coordinates: 35° 54' 54.61"N; 75° 55' 36.48" W

Access: Excellent access on a long gravel road N off Hwy 64 on Briar Hall Road with good parking area for small groups and a primitive boat ramp.

Night-Scape Quality: Highest quality night sky with low horizons and no light pollution.

Nocturnal Environment: Site is surrounded by open water of South Lake to the E and NE with vast marsh and scattered swamp forest to the W and S. There are great views of storms, clouds, moon and sun rises and sets.

GRADE: 3



DARE 1 Photographs. Left Panel looks SW at the parking area and swamp forest in the background; Right Panel looks E at a primitive boat ramp and vast marsh ecosystem.

DARE 2 Buffalo City:

Alligator River National Wildlife Refuge

GPS coordinates: 35° 50' 16.23" N; 75° 55' 9.04" W

ACCESS: Excellent access on Buffalo City gravel road S off Hwy 64 with a large parking area, port-a-potty, kayak launch pier, and walking and kayak trails.

Nocturnal Environment: Excellent within a vast swamp forest with a natural Milltail Creek and associated ditches.

Night Sky: Moderate due to the woods and high horizon, but no light pollution.

GRADE: 2



DARE 2 Photographs. Left Panel looks E where the N-S and E-W ditches flow into the natural black waters of Milltail Creek. Right Panel looks N at the drainage ditch, kayak launch platform, and Buffalo City Road.

DARE 3 Deep Bay Road-South Lake

Alligator River National Wildlife Refuge

GPS Coordinates: 35° 53' 2.02"N; 75° 54'20.16W

Access: A good gravel road N off Hwy 64 on Deep Bay Road with a very small parking area.

Night Sky: Excellent with broad vistas and no light pollution

Nocturnal Environment: Excellent with vast marshes around the fresh-water estuarine shorelines of South Lake. There are great views of storms, clouds, moon and sun rises and sets.

GRADE: 3



DARE 3 Photographs. Left Panel looks N across the Phragmites dominated marshes around the shores of East Lake. Right Panel looks E across an arm of East Lake at the end of Deep Bay Road.

DARE 4 **Junction Long Curve Road-Borrow Pit Road**

Alligator River National Wildlife Refuge

GPS Coordinates: 35° 47' 57.48" N; 75° 48' 35.88" W

Access: Good gravel roads 1.3 mile SW off Hwy 264 on Borrow Pit Road at the junction with Long Curve Road; limited parking is on the shoulder of the road at the junction.

Night Sky: Poor due to the high horizon of swamp forest trees in all directions.

Nocturnal Environment: Good due to vast pocosin swamp forests totally surrounding the site along with water filled ditches, but high horizons.

Grade: 2



DARE 4 Photographs. Left panel is looking NW along Long Curve Road with ditch and associated mixed scrub shrub and swamp forest. Right panel looks S at a small stand of Atlantic white cedar.

DARE 5 **Junction Long Curve Road-Grouse Road**

Alligator River National Wildlife Refuge

GPS coordinates: 35°48'50.06"N; 75°49'24.48"W

Access: Good gravel roads 1.3 miles SW off Hwy 264 on Grouse Road at the junction with Long Curve Road; limited parking is on the shoulder of the road next to the pumping station.

See Dare 7 for detailed location on the Google Earth map

Night Sky: Good with low horizon to the N across agricultural fields and some light pollution from the Dare Co. landfill. There is a high horizon from the NE to S and the NW due to vast swamp forest.

Nocturnal Environment: Excellent due to vast pocosin swamp forests from the NE to S and NW along with water filled ditches. Great views of storms, clouds, moon and sun rises. There is some noise pollution from the adjacent pumping station during the wet season.

GRADE: 3



DARE 5 Photographs. Left panel shows the pump station at the junction of Long Curve and Grouse Roads. Right panel looks NW at Long Curve Road with scrub-shrub pocosin vegetation on the left and open agricultural fields on the right.

DARE 6 Junction Long Curve Road-Lake Worth Road

Junction of Alligator River National Wildlife Refuge and Dare County Bombing Range (U.S. Air Force) property.

GPS coordinates: 35° 41' 48.29" N; 75° 47' 27.18" W

Access: Good gravel road 1 mile W on Lake Worth Road from Hwy 264 at Stumpy Point to the junction with Long Curve Road. This junction is actually on the U.S. Air Force property. Limited parking is on road shoulder at the junction.

Night Sky: A good low, but irregular horizon to the NW, W, S, and SE due to fire; horizon is high from the E to N due to heavy swamp forest vegetation. Moderate light pollution occurs from Stumpy Point to the E.

Nocturnal Environment: Site has a mixture of ecosystems that include a burned and unburned swamp forest and a broad swamp shrub-scrub segment. Moderate due to proximity of development on Hwy 264, village of Stumpy Point, and common road traffic.

GRADE: 2



DARE 6 Photographs. Left panel looks NNW at Long Curve Road and ditch that separates the burned area to the W from the swamp forest on the E. Right panel looks E at the Lake Worth Road separating the swamp forest on the N from swamp shrub-scrub on the S.

DARE 7 Junction Long Curve Road-Link Road

Alligator River National Wildlife Refuge

GPS coordinates: 35° 49' 50.77" N; 75° 50' 22.63" W

Access: Site is 2.3 miles S of Hwy 64 along Milltail Road and 1 mile E along Long Curve Road the junction with Link Road. These are good gravel roads with a small shoulder for parking. Facilities are available at Creef Cut Wildlife Trail located on Hwy 64 at the junction with Milltail Road.

Night Sky: A low horizon occurs over agricultural fields from the NE to the E and SE, The Dare Co. landfill occurs about 1 mile to the E with some light and noise pollution.

Nocturnal Environment: Swamp forest occurs from the N to the W and S with flooded ditches adjacent to all roads. Great views of storms, clouds, moon and sun rises.

GRADE: 2



DARE 7 Google Earth 2017 Image. The image shows the junction of Long-Curve Road and Link Road with agricultural fields to the NE, E, and SE and swamp forest from the N to W and SE of Long-Curve Road.

DARE 8 Junction Long Curve Road-Navy Shell Road

Road junction of Alligator River National Wildlife Refuge and Dare County Bombing Range (U.S. Air Force) property.

GPS Coordinates: 35° 44' 35.96"N; 75° 47' 41.12"W

Access: Navy Shell Road is a good gravel road that runs 1.5 WSW off Hwy 264 where it junctions with Long Curve Road. There is a moderate size parking area at the junction, but no facilities. The Navy Shell Road has a gated entrance to the Dare County Bombing Range and Long Curve Road to the S is often gated.

Night Sky: Poor due to the high horizon with dense swamp forest to the E side of Long Curve Road and shrub-scrub swamp on the W side.

Nocturnal Environment: Good due to 360 degrees of swamp forest and shrub-scrub with flooded ditches along the road to the N of this site.

GRADE: 2



DARE 8 Photographs. Left panel is looking NNW along Long Curve Road with the shrub-scrub and flooded ditch. Right panel looks WSW along the gated Navy Shell Road that leads into the Dare County Bombing Range with Atlantic white cedar and shrub-scrub ecosystems.

DARE 9 Junction Milltail Road-Sawyer Lake Road

Alligator River National Wildlife Refuge

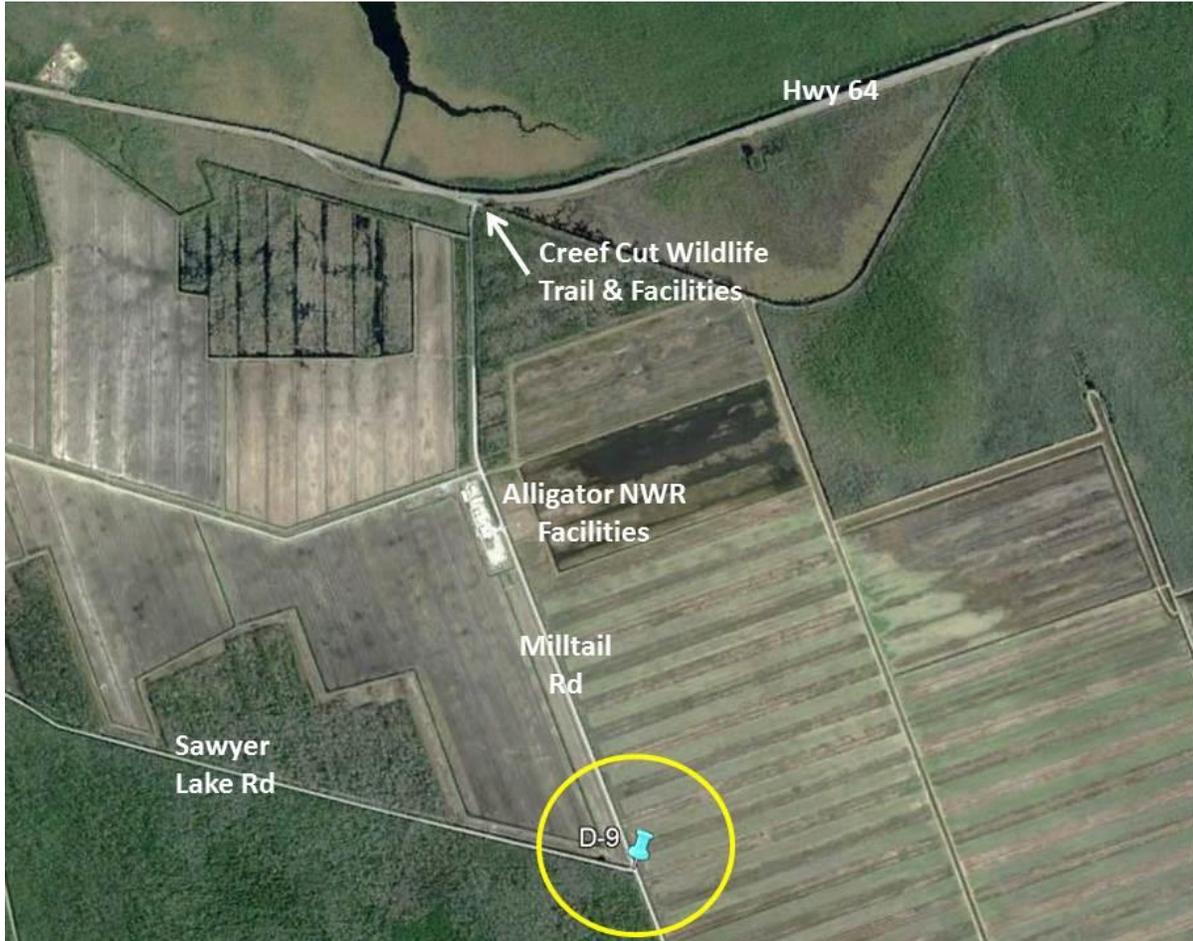
GPS Coordinates: 35° 50' 41.13" N; 75° 51' 37.95" W

Access: Milltail Road is a good gravel road that runs 1.3 miles SSE off Hwy 64 to the junction with Sawyer Lake Road which is 0.8 miles past the Alligator River NWR Maintenance Operations Center. Due to the flooded ditches there is poor parking along the shoulder. Facilities and a boardwalk trail are located at Creef's Cut at the junction of Hwy 64 and Milltail Road.

Night Sky: Low horizon with good night sky views across the open fields extending from the NW, N, E, and SE. Some light pollution occurs at the maintenance facility to the NNW.

Nocturnal Environment: Vast swamp forest occurs to the W and extends to the S and SE with flooded ditches along the roads. The red wolf can frequently be heard in this area. Great views of storms, clouds, moon and sun rises.

GRADE: 2



DARE 9. Google Earth Image. The image shows the junction of Milltail Road and Sawyer Lake Road with vast wildlife agricultural fields from the NW to the N, E, and SE and swamp forest from the NW, W, and SE.

DARE 10 Laurel Bay Road-Alligator River

Alligator River National Wildlife Refuge

GPS Coordinates: 35° 52' 16.29"N; 75° 58' 47.88"W

Access: Poor on frequently flooded, muddy, and pot-holed roads off Hwy 64 with no parking or place to turn around.

Night Sky: Excellent due to open western horizon across the Alligator River and low shrub-scrub to the E and no light pollution.

Nocturnal Environment: Excellent due to the vast area of low shrub-scrub and marsh adjacent to the vast open water of Alligator River. Great views of storms, clouds, moon and sun sets.

GRADE: X. Data Point Only



DARE 10 Photographs. Left panel looks E along the unimproved dirt access road through the shrub-scrub wetlands. Right Panel looks S along the eastern swamp forest shoreline of the Alligator River.

DARE 11 Milltail Creek Bridge Parking

Alligator River National Wildlife Refuge

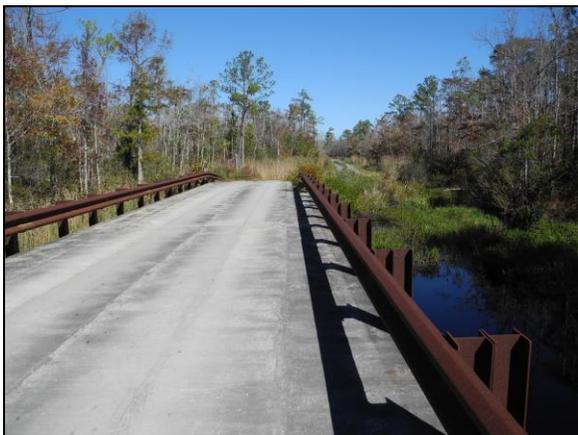
GPS coordinates: 35° 47' 43.06" N; 75° 53' 8.52" W

Access: Milltail Road is generally an OK gravel road that takes you deep into the interior of the Alligator River NWR. During high water and wet weather the low portions of the road are muddy in places and will be under water where the road crosses the Milltail Creek floodplain preventing access to the bridge over Milltail Creek. If the road is dry there is a moderately large and good parking area on the S side of the bridge. There is a small kayak launch platform at this site.

Night Sky: This area is far from everything with no night traffic and one of the darkest areas on the OAP; however, the limitation is the high horizon of the swamp forest for all 360° around the parking area.

Nocturnal Environment: Excellent wildlife and enough open sky so that the night sky is great.

GRADE: 2



DARE 11 Photographs. Left panel looks N across the Milltail Creek bridge. Right panel shows a portion of the parking area on the S side of the black-water creek.



DARE 11 Photographs. Left panel looks W (downstream) from the Milltail Creek bridge with the kayak launch platform. Right panel is the view E looking upstream from the bridge.

DARE 12 Pamlico Road-Long Shoal River

Alligator River National Wildlife Refuge

GPS coordinates: 35° 35' 52.51"N; 75° 51' 14.53"W

Access: 1 mile NW of Pains Creek Bridge on Hwy 264 is Pamlico Road, a good gravel road that goes 1.75 miles SSW off Hwy 264 to Long Shoal River. There is a small turn around and parking area at roads end. See Google Earth map at Dare 15 site for the relative location of Dare 12 site.

Night Sky: Excellent with a low 360° horizon with open water to the W and S, and no light pollution.

Nocturnal Environment: Excellent mixed ecosystems; site is surrounded by vast marshes with open bay and scattered swamp forest in the distance. Great views of storms, clouds, moon and sun rises.

GRADE: 3



DARE 12 Photographs. Left panel looks E at the burned over swamp forest area and salt marsh ecosystems along the Pamlico Road to Long Shoal Bay. Right panel is looking NE along Pamlico Road with the associated ditch and marsh eco-system.

DARE 13 **Point Peter Road**

Alligator River National Wildlife Refuge

GPS coordinates: 35° 46' 8.18" N; 75° 44' 53.09" W

Access: Turn E off Hwy 64 onto Point Peter Road and go 1.2 miles on a good gravel road to the junction with a unnamed road intersection. Don't go to the end of the Point Peter Road because of very limited space for turning and parking.

Night Sky: Excellent night sky with low horizons for 360° and no light pollution.

Nocturnal Environment: Good marsh habitat, except there is an extensive growth of *Phragmites*, and a flowing black-water ditch. Great views of storms, clouds, moon and sun rises.

GRADE: 2



DARE 13 Photographs. Left panel looks E along the Point Peter Road with the vast marsh ecosystem and black-water ditch. Right panel is looking S at the dense growth of Phragmites within the ecosystem.

DARE 14 **Sawyer Lake Road**

Alligator National Wildlife Refuge

GPS coordinates: 35° 51' 15" N; 75° 54' 52" W

Access: Turn S off Hwy 64 on the Buffalo City good gravel road and go 1 mile to the junction with Sawyer Lake Road, also a good gravel road, turn E and go 0.24 miles to a small dirt bridge over the ditch. There is only room for one car to pull off the road when the cable gate is closed.

Night Sky: Excellent viewing to the N and NE with low horizons over the agricultural wildlife fields. There are moderate horizons to the W, S, and E over the swamp forest. There is no light pollution.

Nocturnal Environment: Excellent due to the diverse mix of eco-systems. In the winter the wildlife agricultural fields are flooded for winter water fowl. Great views of storms, clouds, moon and sun rises.

GRADE: 2



DARE 13 Photographs. Upper left panel looks N at the pull off area that crosses a black-water ditch with open wildlife agricultural field and swamp forest in the background. Upper right panel looks NE along Sawyer Lake Road. Lower left panel looks NE at Sawyer Lake Road and drowned “ghost” swamp forest to the SE of the road. Lower right panel is looking SW along Sawyer Lake Road and associated black-water ditch.

DARE 15 Whipping Creek Road

Alligator River National Wildlife Refuge

GPS Coordinates: 35° 39' 43.89" N; 75° 54' 36.97" W

Access: On the east side of the Long Shoal River Bridge, turn north on Stomper

Road, a good gravel road and go about 0.9 miles to the entrance to the Dare Bombing Range and the junction with Whipping Creek dirt road. Turn W on Whipping Creek Road and go about 1.25 miles to first dirt road junction to the N. Whipping Creek Road is unimproved and becomes impassable in wet weather. There is a small parking area on S side of the road at the latter junction for limited parking.

Night Sky: Poor sky gazing due to high swamp forest horizons, poor road, and lack of parking.

Nocturnal Environment: Good due to the vast and remote swamp forest with associated black-water ditches.

GRADE: X. Data Point Only



DARE 15 Google Earth 2018 image shows the location of four Dare County sites (blue pins) including D17 (Long Shoal River Bridge), D18 (Pain Creek Bridge), D12 (Pamlico Road-Long Shoal Bay), and the D15 (Whipping Creek Road) sites. One Hyde County site (green pin) is H2 (junction Hwy 264-5th Ave. E).

DARE 16 Mann’s Harbor North Pier

NC Dept. of Environment and Natural Resources

GPS Coordinates: 35° 54’ 44.03” N; 75° 46’ 7.48” W

Access: NW side of the old Hwy 64 bridge in northern Mann’s Harbor at the BEBOPS memorial and purple martin migration site. Good access with a small gravel parking area and a short pier that extends NE into Croatan Sound with a covered gazebo at the end.

Night Sky: Moderate with broad open sky on the shore and pier; adjacent to bidge and highway with minor night traffic; but moderate light domes to the E over the Outer Banks and S over Roanoke Island and Mann’s Harbor.

Nocturnal Environment: Moderate; broad open water to the E and N, often windy, open marsh environment only to the NW with lots of invasive *Phragmites*, and adjacent to highway. Great views of storms, clouds, moon and sun rises. In August-September it is excellent for the purple martin gatherings by the thousands for their migration party.

GRADE: 2



DARE 16 Photographs. Left panel looks NW at the BEBOPS pier into Croatan Sound. Right panel looks NW at the small beach and extensive brackish water marsh along the NW shoreline of Croatan Sound.

DARE 17 Long Shoal River Hwy 264 Bridge

NC Dept. of Transportation

GPS Coordinates: 35° 38' 46.34"N; 75° 53' 29.32"W

Access: This bridge has a very narrow and steep pull off area that might hold a couple of vehicles, but is frequented by small commercial fishing boats and trucks and consequently is often not available. See the Google Earth map at D 14 site for the location of D 16.

GRADE: X. Data Point Only



DARE 17 Google Earth 2017. Image shows the Hwy 264 old bridge across the Long Shoal River which shows the county line (white) between Hyde (left) and Dare (right) on the river. Notice the blue pin on the pull off with two commercial boats in the ditch.

DARE 18 Pains Creek Hwy 264 Bridge

NC Dept. of Transportation

GPS Coordinates: 35° 36' 26.03" N; 76° 48' 59.38" W

Access: Hwy 264 bridge across Pains Creek has a pull off area on the SE side of the bridge that could hold a few cars. See Google Earth map at DARE 15 for the location of this DARE 18 site.

Night Sky: Moderate site for star gazing due to minor space for telescopes, some night traffic, and moderate horizons.

Nocturnal Environment: Moderate view-scapes and location on the Hwy 264 right of way make this a poor site.

GRADE: 1



DARE 18 Photographs. Left panel looks W along Hwy 264 towards the Pains Creek bridge. The right panel is looking N at the vast shrub-scrub ecosystem taking over and a former burned swamp forest with the remnant ghost forest.

DARE 19 Mann's Harbor Hwy 64 Bridge Boat Ramp

NC Wildlife Resources Commission.

GPS Coordinates: 35° 54' 40" N; 75° 46' 12" W

Access: Excellent access for this site located on the SW side of the old Hwy 64 bridge in N Mann's Harbor. It is a public boat ramp immediately adjacent to and on the S side of the old highway with large gravel parking area.

Night Sky: Poor site adjacent to highway with some night traffic; several small night light posts (with caps) are located along the pier with boat slips and 2 large light posts (with caps) at boat ramp; major light domes occur to the E and S over the Outer Banks, Roanoke Island, and Mann's Harbor.

Nocturnal Environment: Poor due to lack of natural ecosystems; the area is located on a deep, dredged water pond surrounded by *Phragmites* marsh and minor scrub-shrub.

GRADE: 1



DARE 19 Photographs. Left panel looks E along the boat ramps and dock. Right panel looks S across the NC WRC boat ramps and dug boat basin on the SW side of the old Highway 64 bridge. Notice the light poles.

DARE 20 Mashoes East Lake Boat Ramp

NC Wildlife Resources Commission

GPS Coordinates: 35° 55' 42.17"N; 75° 48' 54.68"W

Access: Driving NW from Mann's Harbor on Mashoes Road, go 2.7 miles from old Hwy 64 to a gravel road, turn SW and go 0.33 miles to the East Lake boat ramp with a large gravel parking area.

Night Sky: Excellent view-scape in all directions with minimal light pollution; there is one small solar paneled night light at the boat ramp and a small light dome to the E from the Outer Banks.

Nocturnal Environment: Excellent view-scapes and mixed eco-systems that include the fresh waters of East Lake, marsh, shrub-scrub, and swamp forest on the banks of the remote East Lake estuary. Great area for viewing the clouds, sun and moon rises and sets, storms, and wildlife.

GRADE: 3



DARE 20 Photographs. Left Panel looks SE at the NC WRC boat ramp in the SE corner of parking lot with a directional night light. Right panel is looking NW along fresh water marsh and swamp forest along the East Lake shoreline.

DARE 21 Old Ferry Landing Boat Ramp-Alligator River

NC Wildlife Resources Commission

GPS Coordinates: 35° 53' 50.85"N; 75° 58' 13.77"W

Access: Take the Old Ferry Landing Road off Hwy 64, about 0.75 miles E of the Alligator River bridge in East Lake Village, go about 0.3 miles NW to the NC WRC boat ramp on the E bank of the Alligator River. Large parking area that often contains construction supplies for the bridge or highway.

Night Sky: It is very dark with large trees to the S and E; the sky is moderately open to the N over marsh and NW over the Alligator River due to increasing shoreline erosion and loss of the trees. There are no night lights at this site.

Nocturnal Environment: Moderate with good wetlands to the N with open water of Alligator River to the W, and minor wind and highway noise.

GRADE: 2



DARE 21 Photographs. Left panel looks N at the boat ramp and the Alligator River on the left. Right panel is looking SW along the Alligator River shoreline.

DARE 22 Stumpy Point Boat Ramp

NC Wildlife Resources Commission

GPS Coordinates: 35° 41' 21.88" N; 75° 44' 13.38" W

Access: Turn E off of Hwy 264 into the town of Stumpy Point and go 2.5 miles through the village to the end of the road at the NC WRC boat ramp. Good access to Stumpy Point Bay and Pamlico Sound, There is a large paved parking lot surrounded by 3 foot high rock bulkhead along Stumpy Point bay shoreline and a ditch and dike covered with *Phragmites* on the N side.

Night Sky; Good open sky to the E, S, and SW with 1 major night light at the boat ramp. There is a small area of light pollution from the village to the N and W.

Nocturnal Environment: Moderate due to lack of natural ecosystems; prevalent wind and waves from the open water to the S and E; mostly cut off from the marsh to the N by the ditch and dike with a vast *Phragmite* jungle and the village to the W. Great viewing of clouds, storms, and sun and moon rises and sets.

GRADE: 2



DARE 22 Photographs. Left panel shows the bulkheaded NC WRC boat ramp which is heavily used during good weather. Right panel is looking SE at the rock revetment, Stumpy Point Bay, and Pamlico Sound in the distance.

MAINLAND HYDE COUNTY SITES

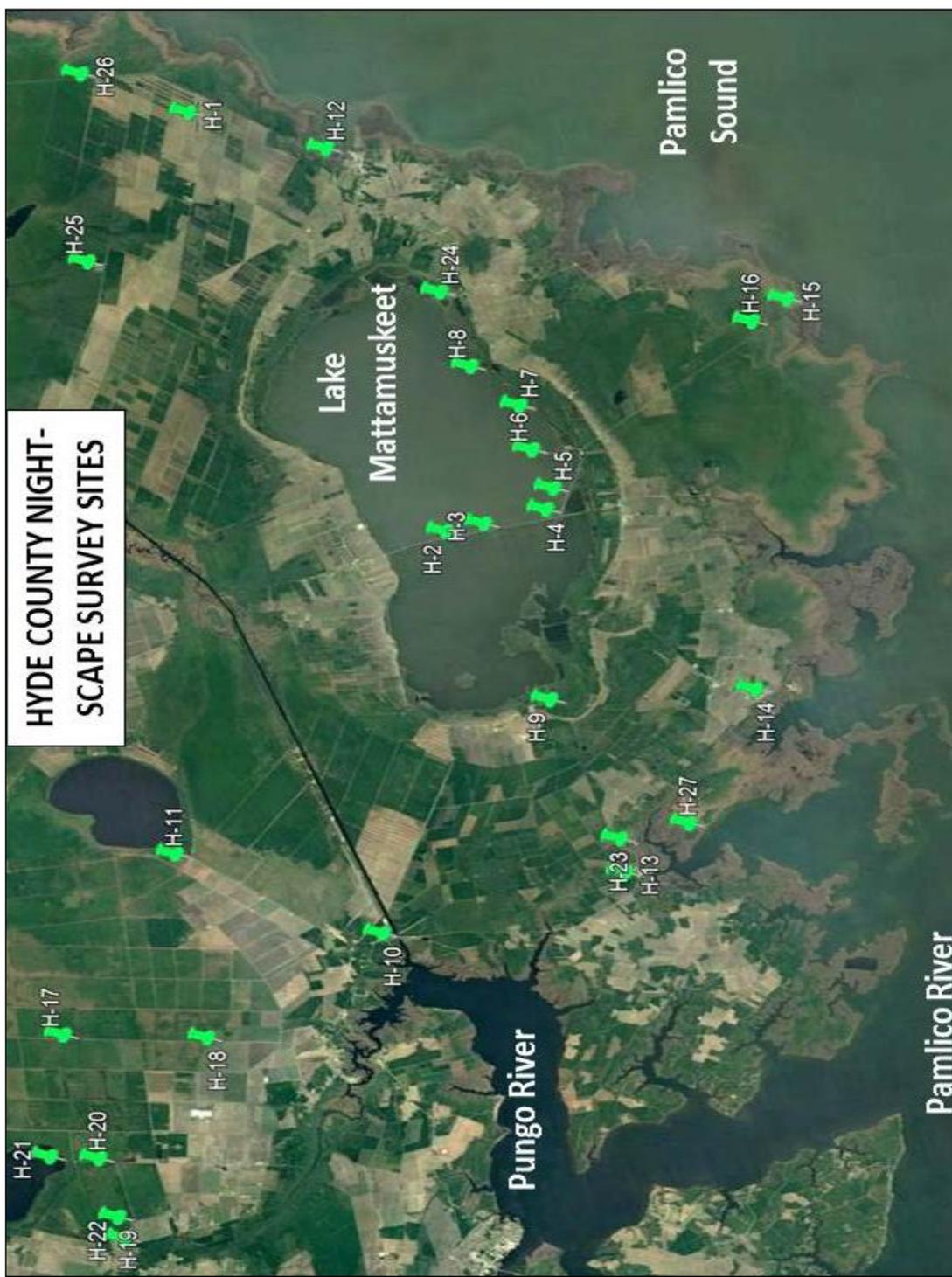


FIGURE 56. A Google Earth satellite image shows the location of 27 sites surveyed during the OAP study: green pins = Mainland Hyde Co. sites. See the Hyde County Table 3 for site names, locations, and ownerships.

SUMMARY: MAINLAND HYDE COUNTY SURVEY SITES--GOOGLE EARTH GREEN PINS						
MAP SITE	SITE NAME	PROPERTY OWNER	GPS LATITUDE	GPS LONGITUDE	NO. SURVEYS	
H-1	COUNTY AIRPORT	HYDE COUNTY	35°33'37.10"N	75°57'23.32"W	3	
H-2	LAKE MATTA HWY 94-THIRD CULVERT	MATTAMUSKEET NWR & NC DEPT OF TRANSPORTATION	35°30'2.63"N	76°12'54.83"W	4	
H-3	LAKE MATTA HWY 94-SOUTH OBSERVATION PIER	MATTAMUSKEET NWR & NC DEPT OF TRANSPORTATION	35°29'10.75"N	76°12'49.47"W	3	
H-4	JCT LAKE MATTA HWY 94-VISITORS ROAD	MATTAMUSKEET NWR	35°27'46.31"N	76°12'37.34"W	1	
H-5	LAKE MATTA VISTORS ROAD-PLATFORM	MATTAMUSKEET NWR	35°27'30.83"N	76°11'56.14"W	4	
H-6	LAKE MATTA PUMP STATION-POINT	MATTAMUSKEET NWR	35°27'47.51"N	76°10'31.29"W	3	
H-7	LAKE MATTA PUMP STATION-SE SHORE	MATTAMUSKEET NWR	35°27'51.06"N	76° 8'57.57"W	1	
H-8	LAKE MATTA PUMP STATION-SE POND	MATTAMUSKEET NWR	35°28'43.57"N	76° 7'24.21"W	3	
H-9	LAKE MATTA ROSE BAY CANAL ROAD	MATTAMUSKEET NWR	35°28'34.74"N	76°19'6.41"W	4	
H-10	HWY 264-INTRA COASTAL WATER WAY BRIDGE	NC DEPT. OF TRANSPORTATION	35°33'17.87"N	76°26'19.97"W	2	
H-11	NEW LAKE ROAD-BIG CURVE (ALLIGATOR LAKE)	NC DEPT. OF TRANSPORTATION	35°37'25.38"N	76°22'41.71"W	1	
H-12	ENGLEHARD BOAT RAMP--PAMLICO SOUND	NC WILDLIFE RESOURCES COMM	35°30'48.79"N	75°59'17.05"W	4	
H-13	ROSE BAY BOAT RAMP	NC WILDLIFE RESOURCES COMM	35°27'45.50"N	76°25'18.98"W	3	
H-14	SWAN QUARTER BOAT RAMP	NC WILDLIFE RESOURCES COMM	35°24'5.86"N	76°19'40.15"W	4	
H-15	OUTFALL CANAL ROAD-PAMLICO SOUND	NC WILDLIFE RESOURCES COMM	35°21'35.23"N	76° 6'34.13"W	2	
H-16	OUTFALL CANAL ROAD-WOOD BRIDGE	NC WILDLIFE RESOURCES COMM	35°22'26.73"N	76° 7'10.11"W	1	
H-17	DEHOOG ROAD- 4 MILE SOUTH	POCOSIN LAKES NWR	35°40'42.58"N	76°28'24.32"W	2	
H-18	DEHOOG ROAD- SOUTH ENTRANCE	POCOSIN LAKES NWR	35°37'35.49"N	76°29'7.74"W	1	
H-19	JCT SOUTH PUNGO ROAD-VAN STRAD ROAD #1	POCOSIN LAKES NWR	35°40'22.33"N	76°34'53.54"W	2	
H-20	JCT SOUTH PUNGO ROAD-HYDE PARK ROAD #2	POCOSIN LAKES NWR	35°40'30.73"N	76°32'47.92"W	3	
H-21	PUNGO LAKE-SOUTH OBSERVA PLATFORM #3	POCOSIN LAKES NWR	35°41'34.43"N	76°32'31.44"W	2	
H-22	CANAL D ROAD	POCOSIN LAKES NWR	35°40'19.26"N	76°35'38.68"W	3	
H-23	OYSTER HOUSE-ROSE BAY	PRIVATE	35°27'42.71"N	76°24'9.08"W	3	
H-24	LAKE LANDING-GREAT DITCH ROAD	PRIVATE	35°29'1.65"N	76° 4'43.50"W	2	
H-25	JCT 4TH AVENUE-GRANNERY	PRIVATE	35°36'31.91"N	76° 2'2.05"W	1	
H-26	JCT HWY 264-5TH AVENUE EAST	PRIVATE	35°35'46.75"N	75°55'32.91"W	1	
H-27	BELLE ISLE-ROSE BAY	SWANQUARTER NWR	35°26'8.81"N	76°23'55.86"W	4	

TABLE 3. Mainland Hyde County Survey Sites.

HYDE 1. County Airport

Hyde County

GPS Coordinates: 35° 33' 36.49" N; 75° 57' 23.11" W

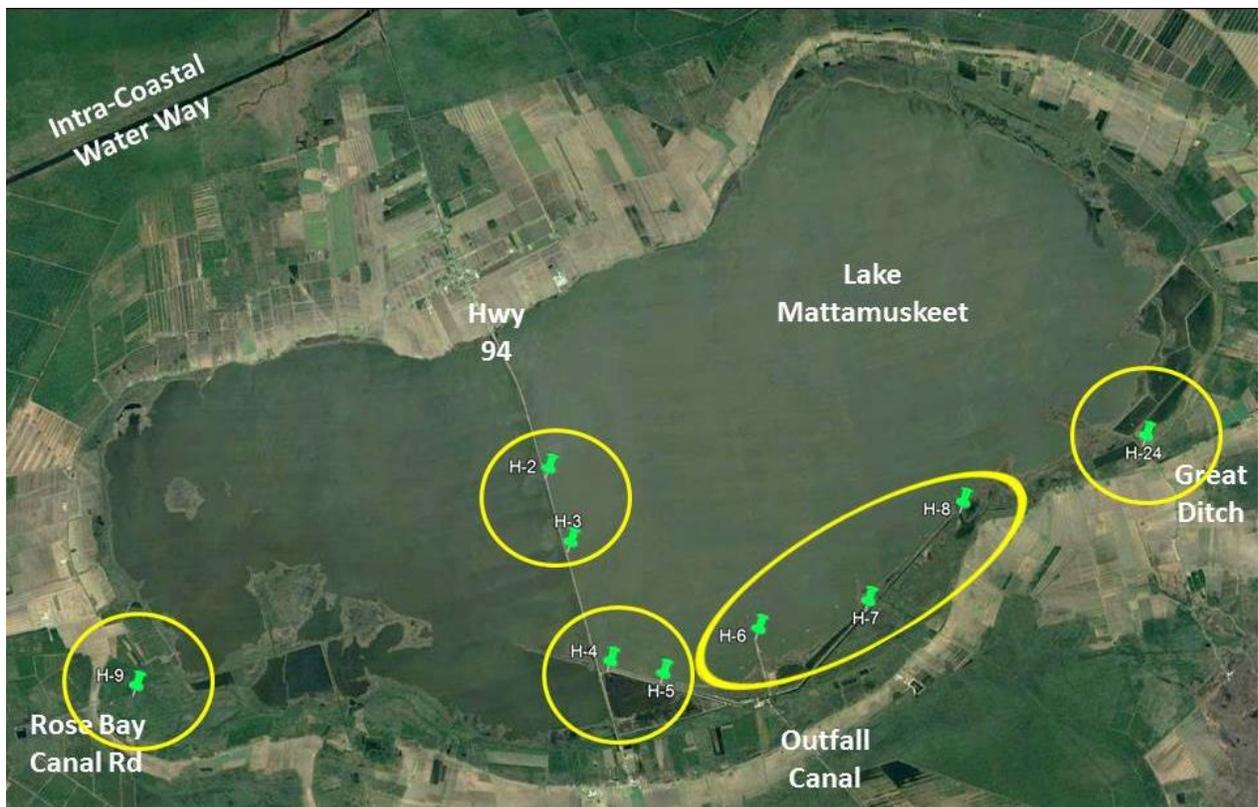
Access: Airport site is 0.5 miles W off Hwy 264 on 2nd Avenue East with plenty of parking in the airport lot. Dirt road is good with parking in airport lot and airport light pollution.

Night Sky: Great open agricultural fields provide low horizons for 360° night viewing. However, the airport light pollution is a negative.

Nocturnal Environment: The broad low horizon provides great view-scapes of the clouds, storms, and sun and moon rises and sets. However, the surrounding is dominated by agricultural fields.

GRADE: 1

NIGHT-SCAPE SITES IN MATTAMUSKEET NWR



Sites Hyde 2 to Hyde 9 are in Mattamuskeet National Wildlife Refuge as located on this Google Earth satellite image.

SURVEY SITES IN MATTAMUSKEET AND SWANQUARTER NWR

Refuge Information: The sand roads are usable during dry weather, but can be bad during wet weather. Some areas and roads within the MNWR and SNWR have restrictions and may be seasonally closed to access. Visitors **PLEASE** check with the refuge personnel at Lake Mattamuskeet Visitor's Center for details.

HYDE 2. Lake Mattamuskeet Hwy 94-3rd Culvert

Mattamuskeet National Wildlife Refuge and NC Department of Transportation

GPS Coordinates: 35° 30' 2.63" N; 76° 12' 54.83" W

Access: Hwy 94 crosses over the middle of the lake. Site 2 is located on the shoulder of Hwy 94 2.5 miles N of gravel entrance road to MNWR visitors center with good graveled pull-off and parking areas for multiple cars. Water culverts connect the E and W lake segments with a small platform on the W side and benches on the E side of the road. Take care in crossing the highway and be sure cars are off the road. See Google Earth image of Lake Mattamuskeet at HYDE 2 description to see location of this site.

Night Sky: Excellent star gazing for 360° with no light pollution except for occasional traffic. Because of the open view-scape this is the preferred site within the lake for night sky viewing.

Nocturnal Environment: Excellent moon and sun rise and sets, wind and waves, clouds and storms, and seasonal waterfowl with minimal night traffic on Hwy 94.

GRADE: 3



HYDE 3 Photographs. Left panel is the small pier and the W portion of Lake Mattamuskeet. Right panel is looking NE to show the water culvert and the E portion of the lake.

HYDE 3. Lake Mattamuskeet Hwy 94-South Observation Pier

Mattamuskeet National Wildlife Refuge and NC Department of Transportation

GPS Coordinates: 35° 29' 10.75" N; 76° 12' 49.47" W

Access: Hwy 94 crosses over the middle of the lake. Site 3 is located 1.5 miles N of gravel entrance road to MNWR visitors center with good grassed pull-off and parking areas for multiple cars on the E side of Hwy 94. A small wooden pier with a covered platform looks E over a small island of drowned cypress trees and this site has a porta-potty. See Google Earth Image of Lake Mattamuskeet at HYDE 2 description to see location of this site.

Night Sky: The western view-scape is perfect, but the site is wooded along the E shoreline and is clogged with a thick growth of *Phragmites* grass limiting a good easterly view-scape.

Nocturnal Environment: Great view scapes for clouds-storms and sun-moon rises and sets.

Because of the large vegetative cover and the offshore drowned cypress island, this is a good site for winter waterfowl.

GRADE: 2



HYDE 3 Photograph. Image is looking E along pier, drowned island of cypress trees, and the eastern portion of Lake Mattamuskeet.

HYDE 4. Junction Lake Mattamuskeet Visitor's Road-Hwy 94

Lake Mattamuskeet National Wildlife Refuge

GPS Coordinates: 35°27'46.31"N; 76°12'37.34"W

Access: Site is about 100 yards E of the junction of Hwy 94 with LM NRW Visitor's Center gravel road. A small wooden platform is located in the NW corner of the wildlife pond.

See Google Earth Image of Lake Mattamuskeet at HYDE 2 for location of this site.

Night Sky: Excellent with wide open vistas to the S, SE, and E.

Nocturnal Environment: The observation platform on S side of the road overlooks a large, shallow pond area that is generally full of wildfowl and small animals, particularly in the winter.

GRADE: 3

HYDE 5 **Lake Mattamuskeet Visitor's Center Road-Platform**

Mattamuskeet National Wildlife Refuge

GPS Coordinates: 35° 27' 30.83" N; 76° 11' 56.14" W

Access: Site is located on Visitors Center gravel road 0.8 miles E of the junction with Hwy 94. A large parking area and a raised wooden observation platform on the S side of the road overlooks a large, shallow pond. See Google Earth Image of Lake Mattamuskeet at HYDE 2 description to see location of this site.

Night Sky: Low horizons to the S and no light pollution are good for star gazing. The canal to the N has large trees with a high horizon that limits viewing to the N.

Nocturnal Environment: The managed shallow pond is generally full of wildfowl and small animals, particularly in the winter when the pond contains large numbers of swan, geese, ducks, and otters.

GRADE: 3



HYDE 5 Photographs. Left panel is looking SW at the raised observation platform. Right panel is a view looking S across the pond that contains scattered areas of fresh-water marsh.

HYDE 6 **Lake Mattamuskeet Pump Station-Point**

Mattamuskeet National Wildlife Refuge

GPS Coordinates: 35° 27' 47.51" N; 76° 10' 31.29" W

Access: At MNWR Visitors Center, turn N and cross over the canal bridge, turn immediately to the ENE and go about 400 feet. Turn N on a dike with a dirt road, opposite the Lake Mattamuskeet pumping station, and drive 0.75 miles out into the lake, past the boat ramp to a small fishing platform and small parking area at the northern end of the dirt road. See Google Earth Image of Lake Mattamuskeet at HYDE 2 description for site location.

Night Sky: Excellent 360° view-scape across water with very low horizons and no light pollution.

Nocturnal Environment: Due to the vast expanse of water this site is great for viewing clouds and storms and sun-moon rises and sets. The night sounds are dominated by wind and water.

GRADE: 3



HYDE 6 Photographs. Left panel is looking S from the fishing pier at the Lake Mattamuskeet pumping station in the distance. Right panel is looking NNW at the small fishing pier-hunting blind at the end dike's end and offshore cypress tree island.

HYDE 7 Lake Mattamuskeet Pump Station-SE Shore

Mattamuskeet National Wildlife Refuge

GPS Coordinates: 35°27'51.06"N; 76° 8'57.57"W

Access: At MNWR Visitors Center, turn N and cross over the canal bridge, turn immediately to the ENE to NE and go 1.8 miles along the dike to a small bridge over another ditch.

There is an elongated pond to the NW of the road and a high dike and associated ditch to the SE of the road and no light or sound pollution. See Google Earth Image of Lake Mattamuskeet at HYDE 2 description to see location of this site.

Night Sky: Due to the vegetation, this is not a good site for star gazing.

Nocturnal Environment: This protected area with three different types of water bodies, high dike, and adjacent swamp forest eco-systems provides a good site for diverse fauna and flora.

GRADE: X Data Point Only

HYDE 8 Lake Mattamuskeet Pump Station-SE Pond

Mattamuskeet National Wildlife Refuge

GPS Coordinates: 35° 28' 43.57" N; 76° 7' 24.21" W

Access: At MNWR Visitors Center, turn N and cross over the canal bridge, turn immediately to the ENE to NE and go 3.6 miles along the dike and adjacent ditch, past sites HYDE 6 and HYDE 7 within a forested area to a moderate sized parking area. The last 2 miles of this dirt road can be very muddy during the wet season. A walking trail goes SE with a wooden bridge across the ditch to a pier and observation platform that extends SE across a fresh-water marsh to a pond. See Google Earth Image of Lake Mattamuskeet at HYDE 2 description to see location of this site.

Night Sky: This inland area has no light pollution, but due to the vegetation and high horizon, this is not a good site for star gazing.

Nocturnal Environment: Because of the multiple wetland eco-systems within this site it has great diversity of fauna and flora and tremendous summer night sounds.

GRADE: 2



HYDE 8 Photographs. Upper left panel is looking SW down the ditch from the walking bridge. Upper right panel is looking NE up the ditch from the walking bridge. Lower left panel is looking SE down the pier across the the fresh water marsh. Lower right panel is looking S across the marsh and the pond from the outer observation platform.

HYDE 9 Lake Mattamuskeet-Rose Bay Canal Road

Lake Mattamuskeet National Wildlife Refuge.

GPS Coordinates: 35° 28' 34.74" N; 76° 19' 6.41" W

Access: At Swindell Fork turn NNW off Hwy 264 onto Turnpike Road and go about 4.7 miles to the junction with Piney Woods Road, turn ENE onto Rose Bay Canal dirt road and go 0.5 miles to the boat ramp. You can walk or bike past the boat ramp till the road ends at the water's edge or one can kayak from the boat ramp past the road's end and islands into Lake Mattamuskeet. See Google Earth Image of Lake Mattamuskeet at HYDE 2 description to see location of this site.

Night Sky: Even though there is no light pollution, this is not a good site for star gazing due to the forest vegetation.

Nocturnal Environment: This site is located on one of the older and higher Lake Mattamuskeet shorelines resulting in well-developed upland forest eco-systems.

GRADE: 2



HYDE 9 Photographs. Left panel is looking WSW at the Rose Canal Road, and kayak launch platform. Right panel looks ENE at Rose Canal and walking-biking trail to Lake Mattamuskeet marshes, ponds, and shoreline.

HYDE 10 Hwy 264 Intra-Coastal Water Way Bridge

NC Department of Transportation

GPS coordinates: 35° 33' 17.87" N; 76° 26' 19.97" W

Access: On the S side of the ICWW Bridge, turn W off Hwy 264 and follow the paved road to the SE side under the bridge.

GRADE: X Data Point Only



HYDE 10 Photographs. Left panel looks N across the ICWW. Right panel looks NE across the ICWW at the piney woods ecosystem on the dredge spoil.

HYDE 11 New Lake Road-Big Curve (Alligator Lake)

NC Department of Transportation

GPS Coordinates: 35° 37' 25.38" N; 76° 22' 41.71" W

(at road junction and big curve south of Alligator Lake).

Access: Turn N off hwy 264 onto New Lake Loop/Higginport Roads, go about 5.4 miles on New on New Lake Road to a major bend in the road. There is a wide area to the N of the curve where several dirt roads come into the paved road with graveled parking alongside the paved road for a few cars. This is not on, nor is there access to New/Alligator Lake; do not drive down any of the private dirt roads.

Night Sky: Good viewing with low horizon over the agricultural fields to the SW, W, and NW. Remainder of the area is surrounded by a moderate horizon due to forest cover. There is no obvious light pollution.

Nocturnal Environment: Good with mixed habitats from open agricultural fields to low forest shrub-scrub should have good winter waterfowl in the vicinity of the lake and agricultural fields. A large drainage ditch with a high water table and lined with low growth grasses and shrubs should have good summer sounds with minimal traffic.

GRADE: 3



HYDE 11 Photographs. Left panel is looking SW along New Lake Road and associated ditch with vast agricultural fields to the SW. Right panel looks N towards New/Alligator Lake along a private dirt road with parking.

HYDE 12 Englehard Boat Ramp

NC Wildlife Resources Commission

GPS Coordinates: 35° 30' 48.79" N; 75° 59' 17.05 W

Access: On the N side of Englehard turn E off Hwy 264 and go 0.25 miles on the graveled Swamp Road to the NC WRC boat ramp on Fat Creek. The site has a large gravel parking area with a walkway E through the grassed and treed area to the open water shoreline.

Night Sky: To the E Fat Creek opens to the vast area of Pamlico Sound with great low horizon view-scapes in the NE, E, and SE directions with minimal light pollution from the town to the S, SW, and W.

Nocturnal Environment: The wide open vista across Pamlico Sound will supply great viewing of clouds-storms and sun-moon rises and sets, as well as the sound of wind and waves.

GRADE: 3



HYDE 12 Google Earth Image and Photograph. Left panel is a 2017 image of the Englehard region showing the location of the Englehard Boat Ramp. Right panel is looking N across the boat ramp and Fat Creek to a marsh and ghost swamp forest.

HYDE 13 Rose Bay Boat Ramp

NC Wildlife Resources Commission

GPS Coordinates: 35° 27' 45.50" N; 76° 25' 18.98" W

Access: Turn S off Hwy 264 directly into the NC WRC Rose Bay boat ramp. A very large gravel parking area is adjacent to a canal that flows S into Rose Bay.

Night Sky: Poor with piney woods to the N, W and S. There is 1 night light pole in the lot, a cluster of trailers with light pollution to the E, and moderate night traffic noise and lights from the adjacent Hwy 264.

Nocturnal Environment: Poor with piney woods to the W and S, developed area to E, and abundant traffic on adjacent Hwy 264. Lots of crabs, shrimp, and small fish occur in the canal and breaking the surface.

GRADE: 1



HYDE 13 Photographs. Upper left panel is the NC WRC Rose Bay boat ramp information board. Upper right panel looks S across the boat ramp and the canal to Rose Bay. Lower panel looks N across the large parking lot towards Hwy 264.

HYDE 14 Swan Quarter Boat Ramp

NC Wildlife Resources Commission

GPS Coordinates: 35° 24' 5.86" N; 76° 19' 40.15" W

Access: Go SE through the village of Swan Quarter on Hwy 45 or Oyster Creek Road and turn SSW into the Swan Quarter boat ramp on the SE side of town. The ditch flows SSW into Swan Quarter Bay. The large gravel parking area usually has lots of trucks and boat trailers of night fishermen. The site has significant light pollution coming from the village to the N, from the NC DOT Swan Quarter-Ocracoke ferry docks 0.5 miles to the SE, and the commercial fishing docks that are 0.5 miles to the W.

Night Sky: Moderate to poor with the light pollution and trees.

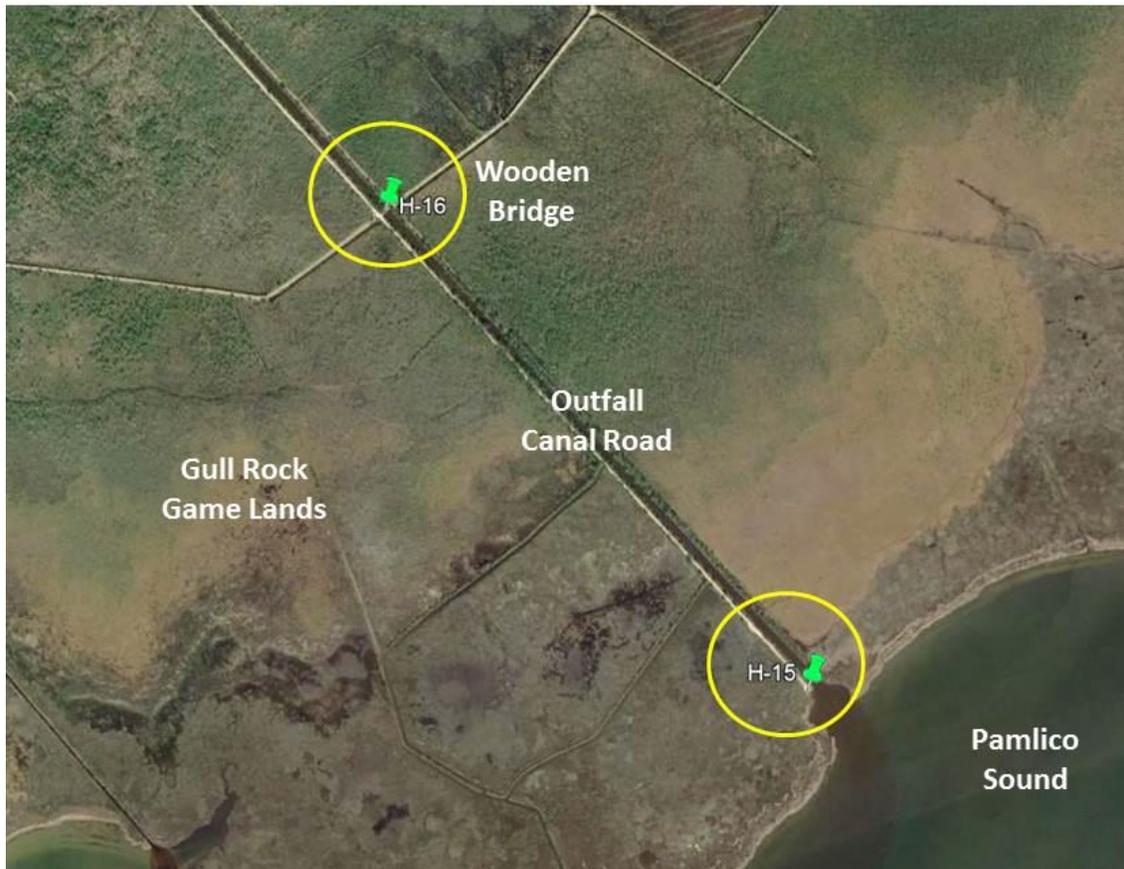
Nocturnal Environment: Moderate with surrounding marsh summer sounds.

GRADE: 2



HYDE 14 Photographs. Left panel is looking NNE along the ditch and Swan Quarter boat ramp parking area. Right panel looks S across the ditch at the vast juncus marsh and Swan Quarter Bay.

SURVEY SITES ON NC WRC GULL ROCK GAME LANDS H-15 & H-16



Sites Hyde 15 to Hyde16 are in The Gull Rock Game Lands as located on this Google Earth satellite image.

HYDE 15 Outfall Canal-Pamlico Sound

NC Wildlife Resources Commission:

GPS Coordinates: 35° 21' 35.23" N; 76° 6' 34.13" W

Access: Turn SE off Hwy 264 onto a good gravel road and go 7.4 miles down the Lake Mattemuskeet Outfall Canal Road to North Bluff Point in the Gull Rock Game Land on Sage Bay of the Pamlico Sound. Use caution as this site is far from anything and there is minimal parking or turning area at roads end. Parking is firm along the side of the road. See Hyde 16 Google Earth image for location in the Gull Rock Game Lands.

Night Sky: Excellent as North Bluff Point is surrounded by marsh and overlooks Pamlico Sound with a 360° horizon and no light pollution.

Nocturnal Environment: Great for seeing clouds-storms, wind-water sounds, and sun-moon rises and sets, along with vast marshes and their wildlife including bears and snakes.

GRADE: 2



HYDE 15 Photographs. Upper left panel is looking down the Outfall Canal with its shrub-scrub vegetation along the higher spoil banks along the canal. Upper right panel looks SE at roads end and vastness of Pamlico Sound. Lower left is looking NE from towards the end of both the road and canal. Lower right panel is looking S from roads end at the eroding marsh edges and resulting organic detritus deposits on the end of the road bed.

HYDE 16 Outfall Canal Road-Wooden Bridge

NC Wildlife Resources Commission: Gull Rock Game Land at North Bluff Point on wooden
 Access: Turn SE off Hwy 264 onto a good gravel road and go 6.2 miles down the Lake
 Mattemuskeet Outfall Canal Road to the wooden bridge across the Outfall Canal in the
 Gull Rock Game Land. Use caution as this site is far from anything and parking is firm
 along the road side as long as you are on the gravel.

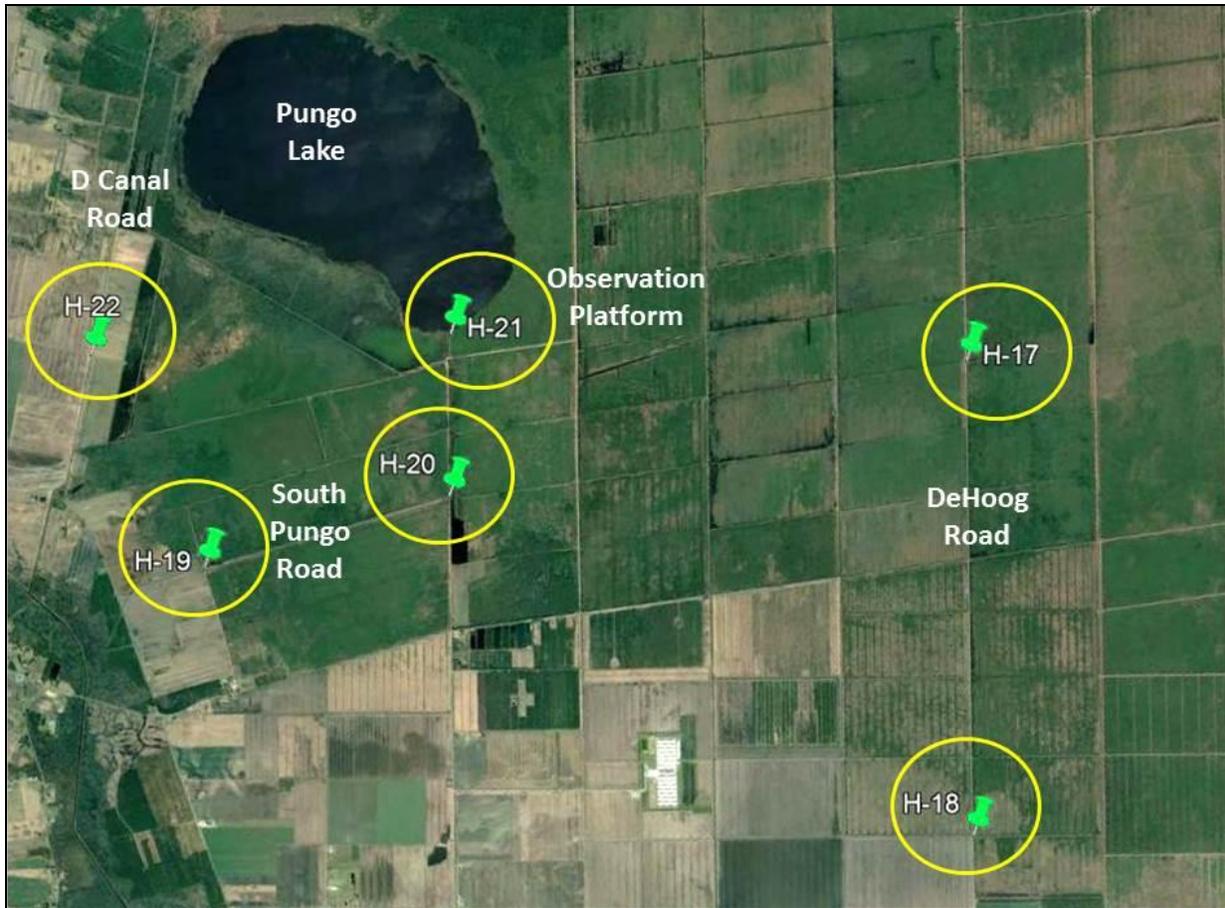
Night Sky: Poor due to high to moderate horizons of swamp forest trees and extensive shrub-
 scrub. However, there is no light pollution.

Nocturnal Environment: Great for seeing different wetland eco-systems and their rich flora and
 fauna including bears and snakes.

GRADE: X Data Point Only

SURVEY SITES IN THE PUNGO LAKE AREA-POCOSIN LAKES NWR

Refuge Information: The sand roads are usable during dry weather, but can be bad during wet weather. Some areas and roads within the PLNWR have restrictions and may be seasonally closed to access. Visitors **PLEASE** check with the refuge personnel in Columbia for details.



Sites Hyde 17 to Hyde 22 are in Pocosin Lakes National Wildlife Refuge as located on this Google Earth satellite image.

HYDE 17 DeHoog Road-4 Miles South

Pocosin Lakes National Wildlife Refuge

GPS Coordinates: 35° 40' 42.58" N; 76° 28' 24.32" W

Access: From Shore Drive around the S shore of Phelps Lake, turn S onto Canal D (DeHoog Road) good gravel road and go 4 miles. Canal D Road site is at the Washington-Hyde County border. There is ample parking on the shoulders at road junctions.

Night Sky: Excellent with low to moderate horizons and vast views, and no light pollution.

Nocturnal Environment: Excellent view-scapes for watching clouds-storms and sun-moon rises and sets, as well as diverse eco-systems that have varied and diverse fauna and flora.

GRADE: 3



HYDE 17 Photographs. Left panel is looking N towards Lake Phelps with vast areas of pocosin swamp shrub-scrub. Right panel looks S with the ditch on the left with moderate horizon up to the edge of the ditch and a broad fire break on the right side of the road.

HYDE 18 Dehoog Road-South Entrance

Pocosin Lakes National Wildlife Refuge

GPS Coordinates: 35° 37' 35.49" N; 76° 29' 7.74" W

Access: From Shore Drive around the S shore of Phelps Lake, turn S onto Canal D (DeHoog) Road good gravel road and go 7.6 miles until the road reaches the S refuge boundary with agricultural fields in the SW corner. There is ample parking on the shoulders at road junctions.

Night Sky: Excellent with low horizons and vast views to the W and S over the agricultural fields. There is minimal light pollution locally from farms in the distance.

Nocturnal Environment: Excellent view-scapes for watching clouds-storms and sun-moon rises and sets. During specific seasons there is good bear watching in the fields.

GRADE: 3



HYDE 18 Photographs. Left panel is looking W along the boundary between the PLNWR on the right and agricultural land on the left. Right panel looks E into the PLNWR shrub-scrub pocosin swamp with a water control structure for the ditches on the lower right side of the photo.

HYDE 19 Junction South Pungo Road-Van Staaldulnen Road #1

Pocosin Lakes National Wildlife Refuge

GPS Coordinates: 35° 40' 22.33" N; 76° 34' 53.54" W

Access: Turn E off Hwy 45 and go 0.7 mile on Refuge Road, turn N at PLNWR

Maintenance Facility and go 1 mile to junction of Van Staaldulnen Road with South Pungo Road. Driving and parking is good along the sand road in dry weather. No night time driving is allowed during the wintering waterfowl season.

Refuge Information: The sand roads are usable during dry weather, but can be bad during wet weather. The PLNWR has restrictions and closures on some roads during specific times of the year. PLEASE check with the refuge personnel in Columbia for details.

Night Sky: Excellent with vast open wildlife agricultural fields with low horizons to the W and S and high horizons to the N, E, and SE with scattered shrub-scrub pocosin vegetation.

Nocturnal Environment: Excellent view-scape to W and S for observing weather and sun-moon sets. Often during the winter wildfowl months these fields and night sky will be filled with thousands of swan and geese.

GRADE: 3



HYDE 19 Photographs. Left panel is looking W along South Pungo Road from the junction of Van Staaldulnen and South Pungo Roads. Right panel looks S along Van Staaldulnen Road towards the PLNWR maintenance shed with wildlife agricultural field on the right and pocosin shrub-scrub eco-system on the left.

HYDE 20 Junction South Pungo Road-Hyde Park Road #2

Pocosin Lakes National Wildlife Refuge

GPS Coordinates: 35° 40' 30.73" N; 76° 32' 47.92" W

Access: Turn E off Hwy 45 and go 0.7 mile on Refuge Road, turn N at PLNWR Maintenance Facility and go 1 mile to junction of Van Staaldulnen Road and South Pungo Road, turn E and go 2 miles on South Pungo Road to the intersection with Hyde Park Road. Driving and parking is good along the sand road in dry weather. No night time driving is allowed during the wintering waterfowl season.

Refuge Information: The sand roads are usable during dry weather, but can be bad during wet weather. The PLNWR has restrictions and closures on some roads during specific times of the year. PLEASE check with the refuge personnel in Columbia for details.

Night Sky: Poor due to moderate to high horizons in all directions that ranges from pocosin shrub-scrub to swamp forest.

Nocturnal Environment: Good with various types of eco-systems with black-water filled ditches to the pocosin wetlands. The night winter sky is often filled with the magic cacophony of flights of swan and geese flying between Pungo Lake and the corn fields.

GRADE: 2



HYDE 20 Photographs. Left panel looks N along Hyde Park Road towards Pungo Lake. Right panel is looking W along South Pungo Road from the same junction.

HYDE 21 Pungo Lake-South Observation Platform #3

Pocosin Lakes National Wildlife Refuge-Charles Kuralt Trail Site.

GPS Coordinates: 35° 41' 34.43" N; 76° 32' 31.44" W

Access: Turn E off Hwy 45 and go 0.7 mile on Refuge Road, turn N at PLNWR Maintenance Facility and go 1 mile to junction of Van Staaldulnen Road and South Pungo Road, turn E and go 2 miles on South Pungo Road to the intersection with Hyde Park Road, and turn N on Hyde Park Road for 1.25 miles to the Pungo Lake S observation platform. Driving and parking is good along the sand road in dry weather, but there is no night time driving allowed during the wintering waterfowl season.

Refuge Information: The sand roads are usable during dry weather, but can be bad during wet weather. The PLNWR has restrictions and closures on some roads during specific times of the year. PLEASE check with the refuge personnel in Columbia for details.

Night Sky: The raised observation platform gets you above the surrounding pocosin shrub-scrub and marsh vegetation, as well as Pungo Lake. Consequently, there is a broad view-scape of the entire sky with no light pollution.

Nocturnal Environment: Excellent view-scape to observe the regional clouds-storms, sun-moon rises and sets, and the incredible waterfowl displays on Pungo Lake during the winter. The diversity of outstanding sounds through the winter, spring, summer, fall seasons result from the evolving cycle of resident birds, amphibians, and insects within this awesome pocosin setting.

GRADE: 3



HYDE 21 Photographs. Left panel shows the south observation platform adjacent to Pungo Lake. Right panel is a view of the thousands of tundra swans that inhabit Pungo Lake and surrounding fields during the winter season.

HYDE 22 Canal D Road #4

Pocosin Lakes National Wildlife Refuge

GPS coordinates: 35°41'55.01"N; 76°35'27.85"W

Access: Turn E off Hwy 45 and go 1.8 miles NNW on Pat's Road. The paved Pat's Road curves to NW, turns to the N where it continues into the refuge as the Canal D sand road, and goes 1 mile to the H-22 site on the SW side of Pungo Lake. No night time driving is allowed during the wintering waterfowl season.

Refuge Information: The sand roads are usable during dry weather, but can be bad during wet weather. The PLNWR has restrictions and closures on some roads during specific times of the year. PLEASE check with the refuge personnel in Columbia for details.

Night Sky: The site is surrounded by vast agricultural fields providing a 360° view-scape with low to moderate horizons. There are local pinpoints of light pollution from individual farm facilities to the NW, W, and SW.

Nocturnal Environment: Because of vast view-scape, presence of Pungo Lake and refuge wetlands, and diversity of eco-systems this is a great area to view the clouds-storms and sun-moon sets, as well as the winter waterfowl and bears.

GRADE: 3



HYDE 22 Photographs. Left panel is looking N along Canal D Road with the vast area of agricultural fields on the W, the flooded Canal D, and a small wildlife agricultural field and forested strip on the right. Right panel is a moon rise on a foggy winter day on Pungo Lake in the Pocosin Lakes NWR. Photograph is by P. Gemperline.

HYDE 23 Oyster House-Rose Bay

Private Boat Docks and Oyster House

GPS Coordinates: 35° 27' 42.71" N; 76° 24' 9.08" W

Access: This site is directly off of Hwy 264 on the SE side of the bridge over a small tributary estuary that opens southward to Rose Bay. There is a large shell gravel parking area.

Site Information: Because this is a private oyster house and small boat marina permission must be obtained to use this site.

Night Sky: Moderate with low horizon obstructions so the sky opens in all directions over the marsh and water.

Nocturnal Environment: Good surrounding estuarine marsh with 360o of view-scape providing good views and the weather systems and wildlife sounds of the vast marshes and surrounding water bodies. There is some light and noise pollution from traffic on the adjacent Hwy 264.

GRADE: 2



HYDE 23 Photographs. Left panel is a view looking N over the marina and parking area. Right panel looks E across a flooded ditch to the vast Juncas marsh.

HYDE 24 Lake Landing-Great Ditch Road

Private Property

GPS Coordinates: 35°29'2.33"N; 76° 4'43.99"W

Access: Turn NW off Hwy 264 on E side of Great Ditch Bridge and go 0.3 miles NW on Great Ditch gravel road to the pumping station and bridge to the pond on the W side of the ditch. There is a wide graveled area for some parking.

Night Sky: This site has a mixture of horizons from low to high resulting in a poor location for star gazing.

Nocturnal Environment: This site has a mixture of agriculture, forest, wetland, ditch, and pond eco-systems.

GRADE: X Data Point Only



HYDE 24 Google Earth image shows the Great Ditch Road that goes NW from the Hwy 264 junction at Lake Landing in Hyde County.

HYDE 25 Junction 4th Avenue-Grannery

Private Property

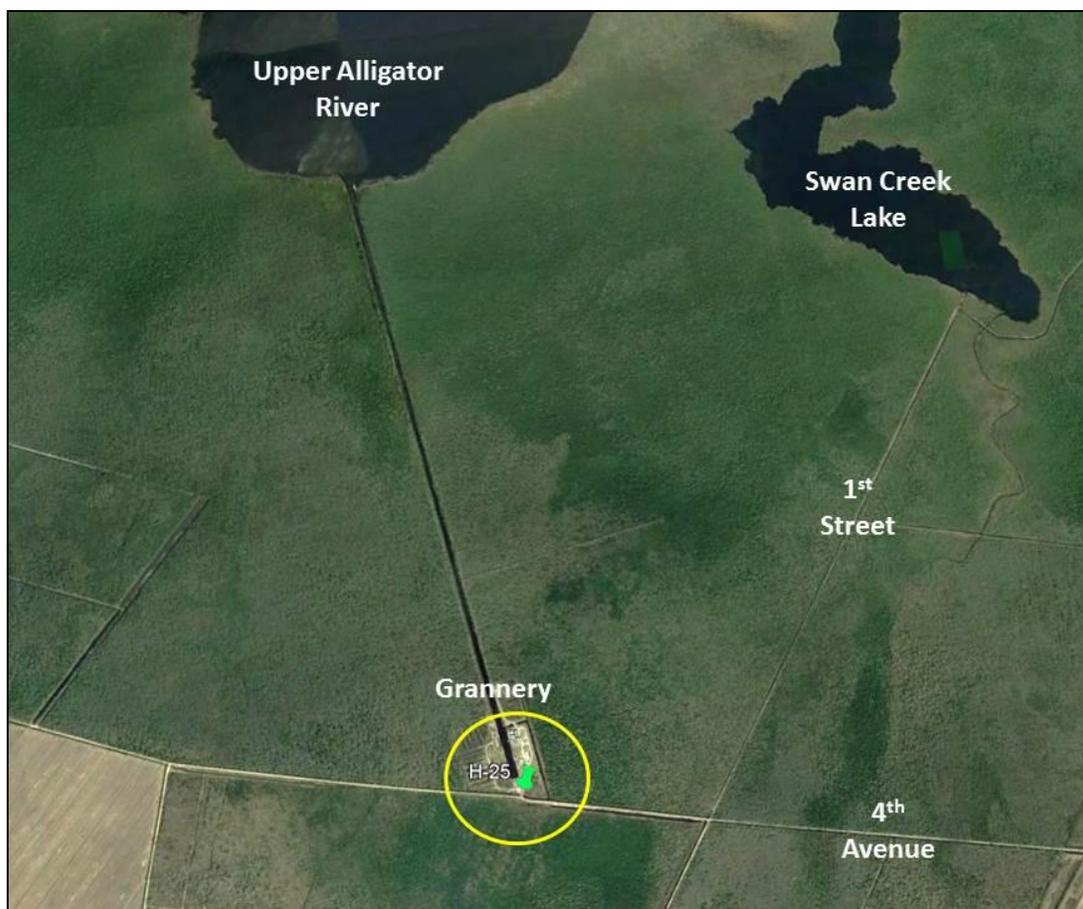
GPS Coordinates: 35° 36' 31.91" N; 76° 2' 2.05" W

Access: Turn W off Hwy 264 on 4th Avenue East and go W for xx miles, turn west on 4th Avenue and go 6.3 miles to the Grannery (see Google Earth image). The dirt road may have some bad spots when it is wet.

Night Sky: This site is heavily forested except for the commercial activity at the grannery and is not good for star gazing.

Nocturnal Environment: The surrounding swamp forest eco-system will have good night sounds.

GRADE: X Data Point Only



HYDE 25 Google Earth image shows the Grannery commercial area on 4th Avenue East at the site of the green pin in Hyde County. The barge canal goes north to the southern end of the Alligator River.

HYDE 26 Junction Highway 264-5th Avenue East

Private

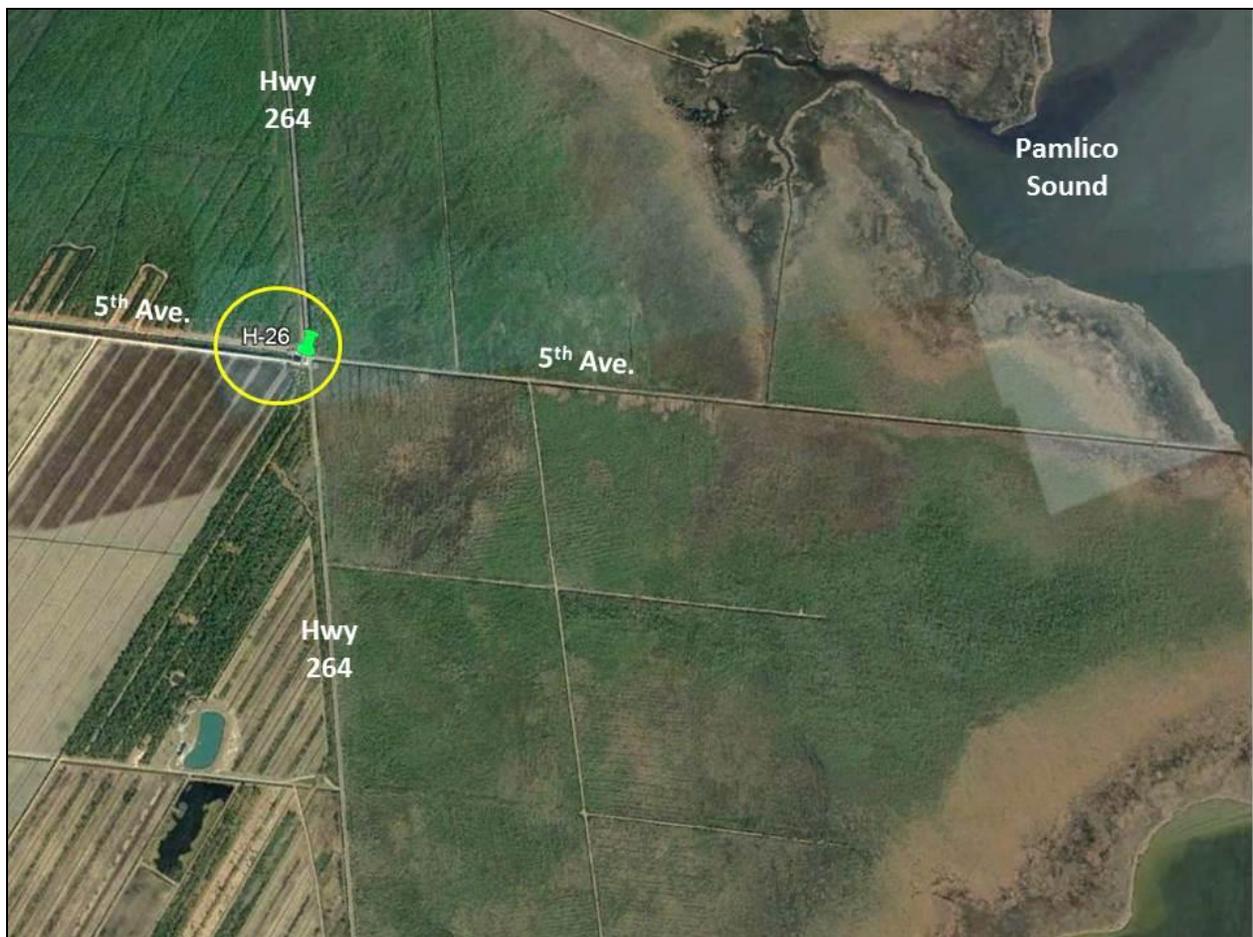
GPS Coordinates: 35°35'46.53"N; 75°55'32.69"W

Access: Turn W off Hwy 264 on 5th Avenue East on the S side of the ditch and go W for 50 feet to a wider portion of the dirt road. There is a pumping station on the ditch just W of the Hwy 264. (see previous Google Earth image).

Night Sky: Poor due to surrounding natural swamp forest wetlands, commercial pine plantations, and some agricultural fields to the SW,

Nocturnal Environment: Marginal due to poor view-scape and lack of natural wetlands.

Grade: X Data Point Only



HYDE 26 Google Earth image shows the site at the junction of Hwy 264 and 5th Ave. east. There is a pumping station on this drainage ditch that goes into the Gull Rock Game Lands to the east.

HYDE 27 Bell Island-Rose Bay

Pier in the Swanquarter National Wildlife Refuge

GPS Coordinates: 35° 26' 8.81" N; 76° 23' 55.86" W

Access: Turn SW off Hwy 264 on a good gravel road and go straight for 2.0 miles to the fishing pier (with railings) that extends ~1000 feet into Rose Bay off of the Pamlico River Estuary. There is a large gravel parking area with a port-a-potty.

Night Sky: Excellent horizon to E, S, and W at the end of the fishing pier with a platform. Also night sky viewing is good in the parking area except for the piney woods to the E. There is no light pollution.

Nocturnal Environment: Night sounds are excellent for both the vast wind-water and surrounding marsh with piney woods to the E, and particularly excellent for observing clouds-storms on the pier.

GRADE: 3



HYDE 27 Photographs. Upper left panel is looking SW down the gravel road at the Hwy 264 turn off. Upper right panel looks NE from the parking area NE across the vast marshes and the piney woods on the right. Lower left panel is the very long fishing pier that extends 1,000 feet SW into Rose Bay. Lower right panel shows a group of locals fishing in Rose Bay from the platform at the outer end of the pier.

TYRRELL COUNTY SITES

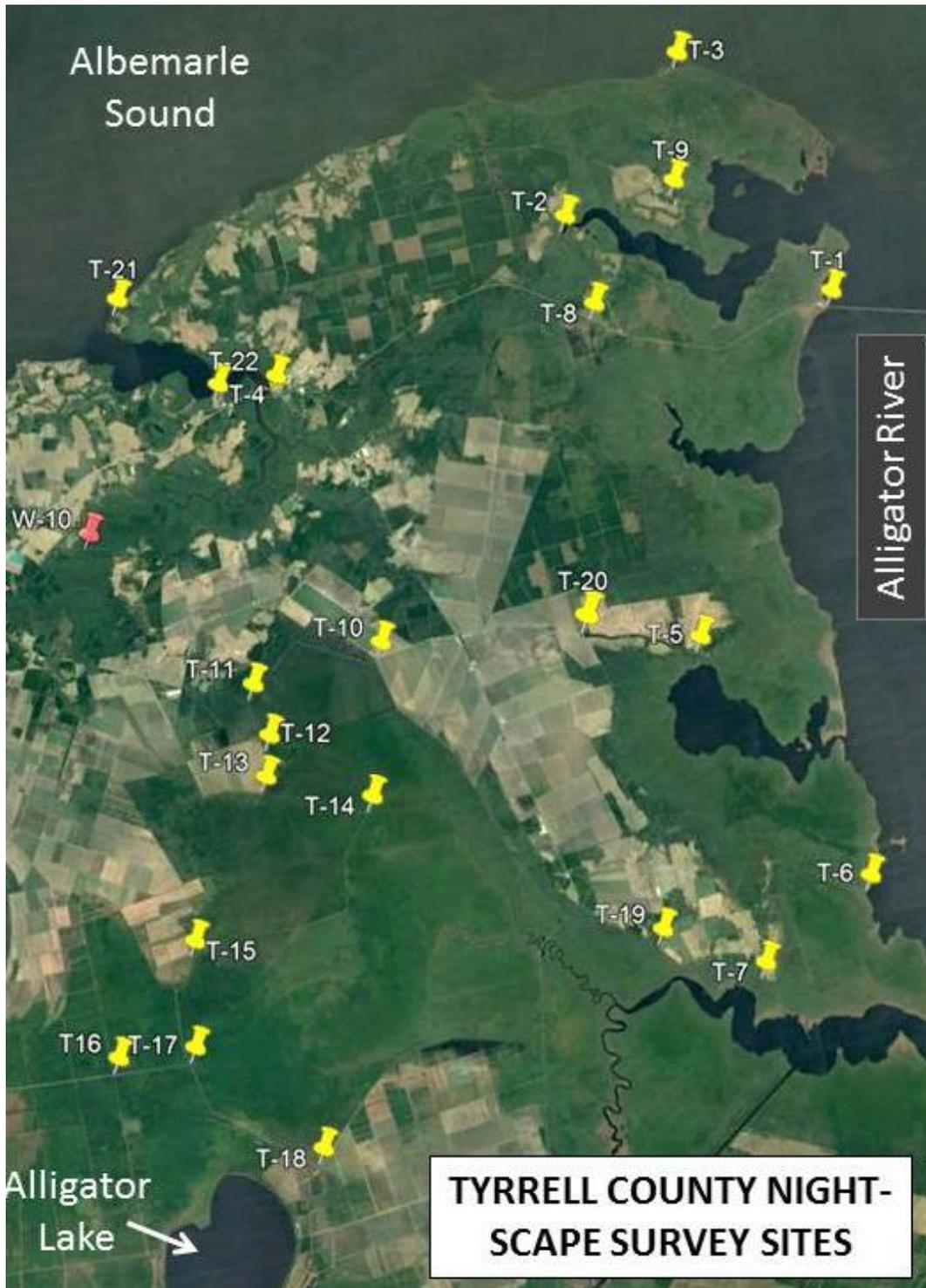


FIGURE 57. A Google Earth satellite image shows the location of 22 sites surveyed during the OAP study: yellow pins = Tyrrell Co. sites. See the following Tyrrell County Table 4 for site names, locations, and ownerships.

SUMMARY: TYRRELL COUNTY SURVEY SITES--GOOGLE EARTH YELLOW PINS						
MAP SITE	SITE NAME	PROPERTY OWNER	GPS LATITUDE	GPS LONGITUDE	NO. SURVEYS	
T-1	ALLIGATOR RIVER BRIDGE SOUTHWEST	NC DOT	35°54'29.87"N	76° 2'16.69"W	3	
T-2	NEWFOUNDLAND BOAT RAMP	NC DOT	35°56'46.05"N	76° 7'38.39"W	4	
T-3	PHLEDGER LANDING-ALBEMARLE SOUND	NC DOT	35°59'24.52"N	76° 4'10.48"W	1	
T-4	COLUMBIA BOAT RAMP-SCUPPERNONG RIVER	NC WILDLIFE RESOURCES COMM	35°54'58.87"N	76°16'41.56"W	3	
T-5	FRYING PAN BOAT RAMP-ALLIGATOR RIVER	NC WILDLIFE RESOURCES COMM & POCOSIN LAKES NWR	35°48'15.53"N	76° 6'30.28"W	6	
T-6	GRAPEVINE LANDING-ALLIGATOR RIVER	BUCKRIDGE COASTAL RESERVE	35°43'3.10"N	76° 3'39.22"W	2	
T-7	GUM NECK BOAT RAMP-ALLIGATOR RIVER	NC WILDLIFE RESOURCES COMM	35°41'49.57"N	76° 6'33.75"W	6	
T-8	JCT HWY 64-FUTCH GAME LANDS	NC WILDLIFE RESOURCES COMM	35°54'59.60"N	76° 7'22.67"W	6	
T-9	TEXAS PLANTATION	NC WILDLIFE RESOURCES COMM	35°57'0.23"N	76° 4'52.94"W	1	
T-10	NORTHERN ROAD-2 MILES WEST HWY 94	POCOSIN LAKES NWR	35°49'26.72"N	76°14'6.23"W	7	
T-11	JCT NORTHERN ROAD-NODWILL ROAD	POCOSIN LAKES NWR	35°49'9.90"N	76°17'19.62"W	1	
T-12	JCT MIDDLE ROAD-PARRISHER ROAD	POCOSIN LAKES NWR	35°48'7.32"N	76°17'11.67"W	1	
T-13	JCT NODWELL ROAD-MIDDLE ROAD	POCOSIN LAKES NWR	35°47'21.46"N	76°17'28.8"W	1	
T-14	JCT MIDDLE ROAD-SEAGOING ROAD	POCOSIN LAKES NWR	35°46'33.96"N	76°15'3.20"W	1	
T-15	JCT SEAGOING ROAD-WESTERN ROAD	POCOSIN LAKES NWR	35°44'32.32"N	76°19'57.68"W	1	
T-16	JCT HARVESTER ROAD-ICHABOD ROAD	POCOSIN LAKES NWR	35°42'37.32"N	76°22'20.25"W	1	
T-17	JCT WESTERN ROAD-HARVESTER ROAD	POCOSIN LAKES NWR	35°42'31.12"N	76°20'28.13"W	1	
T-18	JCT S END WESTERN ROAD-SE AG FIELDS	POCOSIN LAKES NWR	35°40'5.27"N	76°17'55.79"W	1	
T-19	GUM NECK PUMP STATION	PRIVATE	35°42'52.30"N	76° 8'50.26"W	2	
T-20	FRYING PAN ROAD-3 MILE EAST HWY 94	PRIVATE	35°49'4.34"N	76° 9'7.46"W	3	
T-21	LEGION BUILDING-ALBEMARLE SOUND	PRIVATE	35°56'59.78"N	76°18'40.31"W	1	
T-22	COLUMBIA SCUPPERNONG KAYAK PLATFORM	TOWN OF COLUMBIA	35°54'54.25"N	76°15'16.22"W	1	

TABLE 4. Tyrrell County Survey Sites.

TYRRELL 1 Alligator River Bridge-South West

NC Department of Transportation

GPS coordinates: 35° 54' 17" N; 76° 01' 44" W

Access: Commercial fishing dock at SW end of Hwy 64 Alligator River Bridge with direct access off Hwy 64. This small parking area is often filled with trucks and crab pots.

Night Sky: Moderate due to major light pollution from the marina on the N side of Hwy 64 and sometimes heavy highway traffic.

Nocturnal Environment: Moderate view-scape for watching clouds-storms, wind-water, and sun-moon rises due to vast exposure from the N, E, and S across Alligator River. Poor flora and fauna due to development and light and noise pollution from night traffic and marina-gas station complex on N side of highway.

GRADE: 1



TYRRELL 1 Photographs. Left panel shows numerous crab boats docked in the ditch beside Hwy 64. Right panel is looking SE at a stack of crab pots and the western swamp forest shoreline of the Alligator River in the background.

TYRRELL 2 Newfoundland Boat Ramp

NC Department of Transportation Barge Area

GPS coordinates: 35° 56.77' N; 76° 7.64' W

Access: Old Hwy 64 turns NW off new Hwy 64 at the village of Alligator, go about 3 miles to the village of Newfoundland, and cross of the Alligator Creek Bridge. The old DOT barge site (now fenced in), boat ramp, short pier, good parking area (for up to 10 cars) is on the NW side of the Alligator Creek Bridge.

Night Sky: Good with a moderate to low horizon in most directions because of the open water and broad areas of surrounding marsh and shrub-scrub. There is minimal traffic on Old Hwy 64 and only local and minor points of light pollution.

Nocturnal Environment: N of the bridge Alligator Creek is a drowned tributary estuary surrounded by swamp forest, while S of the bridge Alligator Creek narrows to a stream surrounded by a floodplain dominated by marsh and a few ghost trees. Excellent for night sounds due to the high diversity of wetland eco-systems. Good for observing clouds, small water bodies, associated wetlands.

GRADE: 3



TYRRELL 2 Photographs. Left panel is looking SE across the Alligator Creek and Old Hwy 64 Bridge. Right panel looks NE across Alligator Creek with a shrub-scrub eco-system on the left and a swamp forest eco-system on the right.

TYRRELL 3 Pledger Landing-Albemarle Sound

NC Department of Transportation

GPS Coordinates: 35°59'24.52"N; 76° 4'10.48"W

Access: Turn NE off Fort Landing Road onto Pledger Landing Road and go 1.2 miles to Goats Neck, and stay left on Pledger Harbor Road and go N 1.3 miles to Albemarle Sound. All roads are paved. Park and turn on the pavement; be careful not drive into the beach sand at roads end.

Night Sky: The vast open sky to the NW, N, and NE across Albemarle Sound is excellent for stargazing. The areas to the W, S, and E are heavily forested with no view-scape. There are occasional domes of light pollution associated with cities on the N side of the Sound.

Nocturnal Environment: The view-scape across Albemarle Sound is excellent for observing the wind-water and clouds-storms happening up and down the E-W oriented Sound. The dense swamp forest wetlands adjacent to Pledger Harbor Road will provide interesting night sounds.

GRADE: 2



TYRRELL 3 Photographs. Left panel looks NW across Albemarle Sound and shows the outfall for the ditch that is adjacent to Pledger Harbor Road. Right panel is looking N along the S shore of Albemarle Sound with the narrow sand beach and drowned pine trees and stumps standing in the water due to storm erosion and rising sea level.

TYRRELL 6 Grapevine Landing-Alligator River

Buckridge Coastal Reserve

GPS coordinates: 35°43'3.10"N; 76° 3'39.22"W

Access: Turn off Hwy 94 on Gum Neck Road and go SE for 4.4 miles, turn NW on Gum Neck Post Office Road for 1.1 miles, turn onto Grapevine Landing Road and go about 4.1 miles first to the E, then N, then ESE to the landing on the western shores of the Alligator River. The total distance is about 9.6 miles with about 6.2 miles of paved road and the last about 3.4 miles a sand road that is good only in dry weather. There is a small turning area at roads end and a narrow road edge for parking a couple of cars only. The ditch has a few small wooden docks for local crab boats to tie up to.

Night Sky: A beautiful NE to E and SE view-scape across the broad Alligator River with no light pollution for star gazing. A high horizon dominates right up to the N, W, and S shores.

Nocturnal Environment: Excellent view-scape for watching clouds-wind and storms-water. The extensive swamp forest and shrub-scrub eco-systems provide diverse fauna and flora with great night sounds.

GRADE: 2



TYRRELL 6 Photographs. Left panel looks due N across the organic detritus beach, fresh-water marsh, turning circle, and swamp forest wetlands in the background. Right panel is looking NE along the same shoreline with pocosin shrub-scrub into the black, organic-rich waters of the Alligator River on the right side of the photograph.

TYRRELL 4 Columbia Boat Ramp

NC Wildlife Resources Commission

GPS Coordinates: 35°54'58.87"N; 76°16'41.56"W

Access: Old Hwy 64 turns W off new Hwy 64 about 1 mile W of the town of Columbia, go about 0.4 miles and turn N for about 800 feet and turn W for about 300 feet to the NC WRC boat ramp and large gravel parking area with no lights. However, this semi-urban area is adjacent to a marina to N, houses to E, and a motel to the S, all with some night lights.

Night Sky: Poor star gazing due to minor light pollution, as well as a very high horizon to S and W due to tall pine trees and a moderate horizon to N and E.

Nocturnal Environment: Moderate to poor for the above reasons. It is on a ditch that flows into Bull Bay.

GRADE: 1



TYRRELL 4. Google Earth Image shows the location of the Columbia NC Wildlife Resources Commission Boat Ramp site.

TYRRELL 5 Frying Pan Boat Ramp

NC Wildlife Resources Commission and Pocosin Lakes National Wildlife Refuge

GPS coordinates: 35° 48' 17" N; 76° 06' 29" W

Access: Turn E off of Hwy 94 onto the paved Frying Pan Road and go E for 5.6 miles to the NC WRC boat ramp with a good gravel parking area on the S side of the road. The site is at the end of a long ditch that flows 0.3 miles S into the Frying Pan on the W side of the Alligator River.

Night Sky: There is no star gazing due to the tall pine trees that totally surround the boat ramp.

Nocturnal Environment: There is no view-scape, only an upland forest eco-system, and a black-water ditch; but there are woodland night sounds.

GRADE: 2



TYRRELL 5 Photographs. Left panel shows commercial crabbers coming using the Frying Pan boat ramp with the swamp forest in the background. Right panel is looking N from the Frying Pan up the ditch with a shrub-scrub ecosystem filled with ghost trees drowned by rising sea level. To the right of the ditch is the upland pine forest.

TYRRELL 7 Gum Neck Boat Ramp

NC Wildlife Resources Commission

GPS coordinates: 35° 41' 44.9" N; 76° 06' 30.7" W

Access: Turn off Hwy 94 on Gum Neck Road and go SE for 4.4 miles, turn S on Gum Neck Landing Road for 0.65 miles, continue to the end of the paved road over the dike that surrounds the Gum Neck farms and into the NC WRC boat ramp on a dirt road. The boat ramp is on a small canal that flows into the Upper Alligator River. The facility is a very old boat access area with a small parking area, broken ramp, and little wooden dock with no light pollution.

Night Sky: No view-scape due to tall forest over story that totally surrounds the boat ramp and upper ditch.

Nocturnal Environment: To the SW along the ditch the swamp forest changes to a vast area of shrub-scrub pocosin swamp on both sides of the canal. These two environments should have good night sounds, but prevent any larger scale environmental observations.

GRADE: 1



TYRRELL 7 Photographs. Left panel looks W at the boat ramp, dock, and black-water ditch. Right panel is looking SW down the black waters of the ditch where the shrub-scrub eco-system forms the drowning floodplain of the upper Alligator River.

TYRRELL 8 Junction Hwy 64-Futch Game Lands

NC Wildlife Resources Commission

GPS coordinates: 35° 54.9' N; 76° 7.38' W

Access: Turn S off Hwy 64 into the Futch Game Lands with the pumping station located 0.8 miles W of the Town of Alligator at the junction with Old Hwy 64. A good parking area is located just inside the pipe gate; if the pipe gate is not open there is only room for 1 car to get off Hwy 64. Do not go down any of the sand roads on the dikes between ponds.

Night Sky: Good with broad fields for SE to W exposure and slightly protected tree buffer from Hwy 64 night traffic and no light pollution

Nocturnal Environment: Good open fields with shallow duck ponds bordered by dense swamp forest in the distance.

GRADE: 2



TYRRELL 8 Photographs. Left panel looks S over the wildlife agricultural fields and shows the information boards just inside the gate. Right panel looks S at the water pumping station that controls water level in the ditch and associated fields for waterfowl.

TYRRELL 9 **Texas Plantation**

NC Wildlife Resources Commission Game Lands.

GPS Coordinates: 35°57'0.23"N; 76° 4'52.94"W

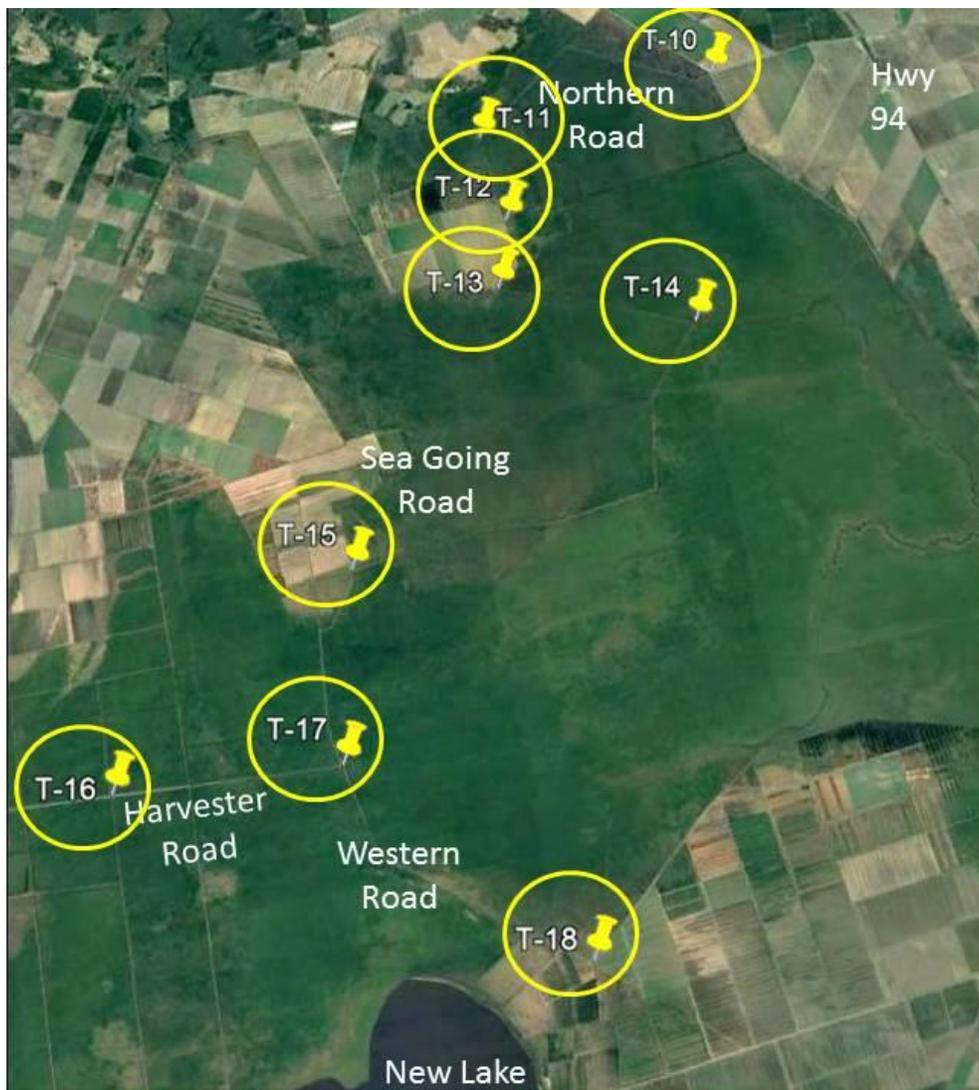
Access: Directly S off Fort Landing Road until you reach the signs for the Texas Plantation on the S side of Road St. Gate is generally closed with foot traffic encouraged, but there is no parking outside the gate.

Night Sky: Walk S on dirt road to good open fields to W and S with no light pollution.

Nocturnal Environment: Patches of forest land at Fort Landing Road with good open fields to the S on the dirt road.

GRADE X Data Point Only

POCOSIN LAKES NWR INTERNAL SITES T-10 TO T-18



Sites Tyrrell 10 through Tyrrell 18 are in Pocosin Lakes National Wildlife Refuge as located on this Google Earth satellite image.

SURVEY SITES IN THE POCOSIN LAKES NWR

Refuge Information: The sand roads are usable during dry weather, but can be bad during wet weather. Some areas and roads within the PLNWR have restrictions and may be seasonally closed to access. Visitors **PLEASE** check with the refuge personnel in Columbia for details.

TYRRELL 10 Northern Road-2 Miles West Hwy 94

Eastern entrance to Pocosin Lakes National Wildlife Refuge

GPS coordinates: 35° 49' 27" N; 76° 14' 06" W

Access: Northern Rd at E boundary of PLNWR; drive 6.9 mi S from the Columbia stoplight, turn W off Hwy 94 onto gravel/sand road (opposite Frying Pan Rd. & just N of large red barn) and go 1.8 mi across private property and big ditch to just inside PLNWR property. This access road is not improved and is only usable under dry weather conditions. The NWR personnel and permitted public have right of access to the refuge across this private land. The refuge is only accessible by special permit from ½ hour after sunset to ½ hour before sunrise. Park in the broad intersection of gravel/sand roads that have rare traffic and minimal light pollution.

Night Sky: Excellent with low horizons to the NW, N, E, and SSE with vast open agricultural fields and moderate horizons to the W dominated by shrub-scrub swamp forest.

Nocturnal Environment: Excellent due to good swamp forest wetlands and water-filled ditches to the W and open agricultural fields to the E.

GRADE: 3





TYRRELL 10 Photographs. Upper left panel shows the SW corner inside the NWR, Northern Road, and the shrub-scrub pocosin swamp eco-system. Upper right panel shows NW corner inside the NWR, Northern Road, and the flooded shrub-scrub wetlands. Lower left panel looks E along Northern Road to Hwy 94 and the barns in the distance. Lower right panel looks SSE along the boundary dike and ditch separating private agricultural land from the Pocosin Lakes NWR.

TYRRELL 11 Junction Northern Road-Nodwell Road

Pocosin Lakes National Wildlife Refuge

GPS Coordinates: 35°49'9.90"N 76°17'19.62"W

Access: Drive 4.6 miles into the PLNWR on Northern Road, a good gravel road, to the junction with Nodwell Road, also a good gravel road. Small parking area is located on the outside of curve.

Night Sky: Star gazing is poor due to the entire 360° area is dominated by moderate to high horizons pocosin swamp forest.

Nocturnal Environment: Due to the dominate swamp forest and presence of two flooded ditches, this is a good site for listening to night sounds, but poor for observing clouds-storms and sun-moon rises and sets.

GRADE: 2



TYRRELL 11. Photograph. Panel shows the swamp forest on the NE side of the road.

TYRRELL 12 **Junction Middle Road-Parrisher Road**

Pocosin Lakes National Wildlife Refuge

GPS Coordinates: 35°48'7.77"N; 76°17'11.71"W

Access: Drive another 1.2 miles along Nodwell Road to S side an E-W ditch, where there is a small private walking bridge across the NNW-SSE ditch. There is a small parking area for a few cars on the E-W dike across from the walking bridge.

Night Sky: The high horizon, to the W and S are open for observing the night sky without any light pollution.

Nocturnal Environment: Excellent with diverse eco-systems including flooded ditches, agricultural fields, and swamp forest for great night sounds and limited regional observations.

GRADE: 3



TYRRELL 12 Photographs. Left panel looks NNW along Nodwell Road with the private agricultural fields to the SW and swamp forest to the N and W. Right panel looks WSW across the private agricultural fields. Notice the eroding bank and sediment-rich muddy ditch water.

TYRRELL 13 Junction Nodwell Road-Middle Road

Pocosin Lakes National Wildlife Refuge

GPS Coordinates: 35°47'21.46"N 76°17'28.8"W

Access: Drive 1 mile S from T-12 to T-13 at the junction between Nodwell and Middle Roads.

There is minimal parking along the road shoulder with no light pollution.

Night Sky: Poor due to no direct access to views across the private agricultural fields.

Nocturnal Environment: Excellent due to diversity of eco-systems with no sound or light pollution.

GRADE: 2



TYRRELL 13 Photographs. Left panel show the corner of the private agricultural fields to the NW. Right panel looks ESE along the swamp forest on both sides of Middle Road. Notice how muddy the ditch is as a direct result of drainage off the agricultural fields.

TYRRELL 14 **Junction Middle Road-Seagoing Road**

Pocosin Lakes National Wildlife Refuge

GPS Coordinates: 35°46'33.96"N 76°15'3.20"W

Access: Drive 2.5 miles from T-13 to T-14. Good parking for a few vehicles on the outside of curve where the unimproved Middle Road continues to the E. This site is located on a extra wide ditch and dike complex and is surrounded by 360° of swamp forest with a major flooded drainage ditch, minimal traffic, and no light or sound pollution.

Night Sky: Moderate due to the presence of a medium swamp forest horizon that completely surrounds this site.

Nocturnal Environment: Good for night sounds due to diversity of eco-systems and regional clouds-storms with no sound or light pollution, but is poor for observing sun-moon rises and sets.

GRADE: 2



TYRRELL 14 Photographs. Left panel looks N across a very wide flowing black-water ditch to the Swamp forest ecosystem. Right panel is looking W down the unimproved dirt segment of Middle Road which provides a good parking area. Notice the abundant growth of Alligator weed.

TYRRELL 15 **Junction Seagoing Road-Western Road**

Pocosin Lales National Wildlife Refuge

GPS Coordinates: 35°44'32.32"N 76°19'57.68"W

Access: Drive 6.2 miles from T-14 to T-15 at the corner of private agricultural fields to the NW.

Night Sky: This site is good for star gazing from the N to W and SW due to low horizon over the agricultural fields and moderate horizon over the shrub-scrub eco-systems to the NE and SW.

Nocturnal Environment: Good for night sounds due to diversity of eco-systems with no sound or light pollution. It is also good for observing clouds-storms, but poor for observing sun-moon rises and sets.

GRADE: 3

TYRRELL 16 Junction Harvester Road-Ichabod Road

Pocosin Lakes National Wildlife Refuge

GPS Coordinates: 35°42'37.32"N 76°22'20.25"W

Access: Drive W for 1.75 miles from T-17 to T-16. This good gravel portion of Harvester Road is extra wide due to large ditches to the S, a wide fire zone along the N side of the road, and large N-S ditch-dike intersections that provide good parking for some vehicles.

Night Sky: Moderate in the E-W directions due to medium horizon, but no light pollution.

Nocturnal Environment: Moderate in the E-W directions due to medium horizon, flowing black-water ditch, and no sound pollution.

GRADE: 2



TYRRELL 16 Photographs. Left panel is looking N up the unimproved road and wide ditch surrounded by swamp forest eco-system. Right panel looks E along Harvester Road with wide shoulders and major ditch water control structure surrounded by swamp forest eco-system.

TYRRELL 17 Junction Western Rd-Harvester Rd

Pocosin Lakes National Wildlife Refuge

GPS Coordinates: 35°42'31.12"N 76°20'28.13"W

Access: Drive 2.6 miles S from T-15 to T-17 on the short Kitts Road. turn S on Western Road, and go along a very wide ditch and dike complex with a good parking area for a few cars on the inside of the curve from the Western Road to Harvester Road.

Night Sky: Moderate due to a medium horizon for 360° of swamp forest eco-system, but extra wide ditch-dike complex.

Nocturnal Environment: Excellent for night sounds due to the black-water and flowing ditches, but moderate for regional sky observations of clouds-storms.

GRADE: 2



TYRRELL 17 Photograph. Panel shows a ditch outflow to control water level in the swamp forest wetland habitat on the opposite side of the ditch.

TYRRELL 18 Junction S End Western Road- SE Ag Fields

Pocosin Lakes National Wildlife Refuge to Private Agricultural Fields

GPS Coordinates: 35°40'5.27"N 76°17'55.79"W

Access: Drive 3.9 miles SE and SSE from T-17 to T-18 which ends at the boundary of the PLNWR and private farmland. The road is good gravel and parking is not a problem at the end of the road.

Night Sky: The night sky is only good if you walk to the edge of the private agricultural fields so there is a very low horizon across a vast open area from NE to E to SE.

Nocturnal Environment: Observing the regional sky is good to the NE to E to SE across the agricultural fields, and the night sounds are moderate with minimal sound and light pollution.

GRADE: 2



TYRRELL 18 Photographs. Left panel is looking NW up the good gravel Western Road that has upland forest growing on the shoulders of the dike. Right panel is looking E from the end of Western Road across private agricultural fields.

TYRRELL 19 Gum Neck Pumping Station

Private

GPS Coordinates: 35°42'52.30"N 76° 8'50.26"W

Access: Drive SE off Hwy 94 for 2.25 miles on Gum Neck Road. The pump station is located adjacent to Gum Neck Road with a small parking area on the SE side of the station. There is minor traffic on Gum Neck Road.

Night Sky: Star gazing is excellent over the vast agricultural fields that extend to the NE and E with low horizons, but there are some scattered and local light pollution sources from small farms and homes.

Nocturnal Environment: Observing the clouds-storms and sun-moon rises and sets is good to the NE and E, but the rest of the surrounding land consists of upland forest to the NW, W, S on the dike. Everywhere S of the dike is swamp forest that is basically at sea level.

Grade: 2



TYRRELL 19 Photographs. Left panel is looking NE across Gum Neck Road at the Gum Neck pumping station with parking on the far side. Right panel looks N with the upland forest on the left and vast open agriculture fields on the right.

TYRRELL 20

Frying Pan Road-3 Mile East Hwy 94

Private Property

GPS coordinates: 35° 49' 04" N; 76° 09' 07" W

Access: Drive 2.85 miles E off Hwy 94 on Frying Pan Road to Junction with a private road on the N side where the agricultural fields change to pine forest. There is a small pull off to the N before the private road crosses the drainage ditch.

Night Sky: An excellent night sky occurs over the vast agricultural lands and extends from the NE to the N, W, and SE with small and local points of light pollution from individual farms and homes.

Nocturnal Environment: Good for observing the clouds-storms and sun-moon sets, but poor for wildlife due to lack of ecosystem diversity, except bears during the summer fall corn and soybean season.

GRADE: 2



Tyrrell 20 Google Earth image shows the location of the three sites along the Frying Pan Road. The agricultural area is known as the Gum Neck Farms.

TYRRELL 21

Legion Beach Veterans Club

Private property

GPS Coordinates: 35°56'59.78"N 76°18'40.31"W

Access: Take the River Neck Road W and drive 1.6 miles from the junction of Sound Side Road to the entrance to Legion Beach Road, turn NW for 0.33 miles through the village to the Veteran's Beach facility (bright red roof) on the S banks of Albemarle Sound and NE corner of Bull Bay. This is private property, but if you stay on the circle road adjacent to the rock revetment you will be on public right of way.

Night Sky: Excellent over the W to N and NE sky over the vast waters of Bull Bay and Albemarle Sound, respectively. There is minor light glow pollution from several towns on the N side of Albemarle Sound and some light pollution from surrounding houses.

Nocturnal Environment: Poor night sounds due to the urban development of this small village, but excellent observations of clouds-storms, wind-water, and sun-moon rises and sets.

GRADE: 2



TYRRELL 21 Photographs. Left panel is looking SW into Bull Bay with a shoreline of swamp forest. Right panel looks ENE along the developed shoreline of Albemarle Sound.

TYRRELL 22

Columbia Scuppernong Kayak Platform

Town of Columbia

GPS Coordinates: 35°54'54.25"N 76°15'16.22"W

Access: Turn S off Hwy 64 into the Tourist Bureau Rest Area and the PLNWR Visitor's Center located at the W edge of town just before the Scuppernong River Bridge. This is a public parking area with access to the Scuppernong River boardwalk and kayak launch platform.

Night Sky: The night sky to the NW and W over the black waters of the Scuppernong River have some, but minimal light pollution from the town, for star gazing.

Nocturnal Environment: The area is surrounded by floodplain swamp forest with great night sounds and the sky observations are moderately good to the NW and W with moderately low horizons over the Scuppernong River.

GRADE: 2



TYRRELL 22 Photograph. Photo is looking W across the Scuppernong River from the kayak launch ramp on the Columbia boardwalk in front of the Pocosin Lakes National Wildlife Refuge Visitor's Center.

WASHINGTON COUNTY SITES

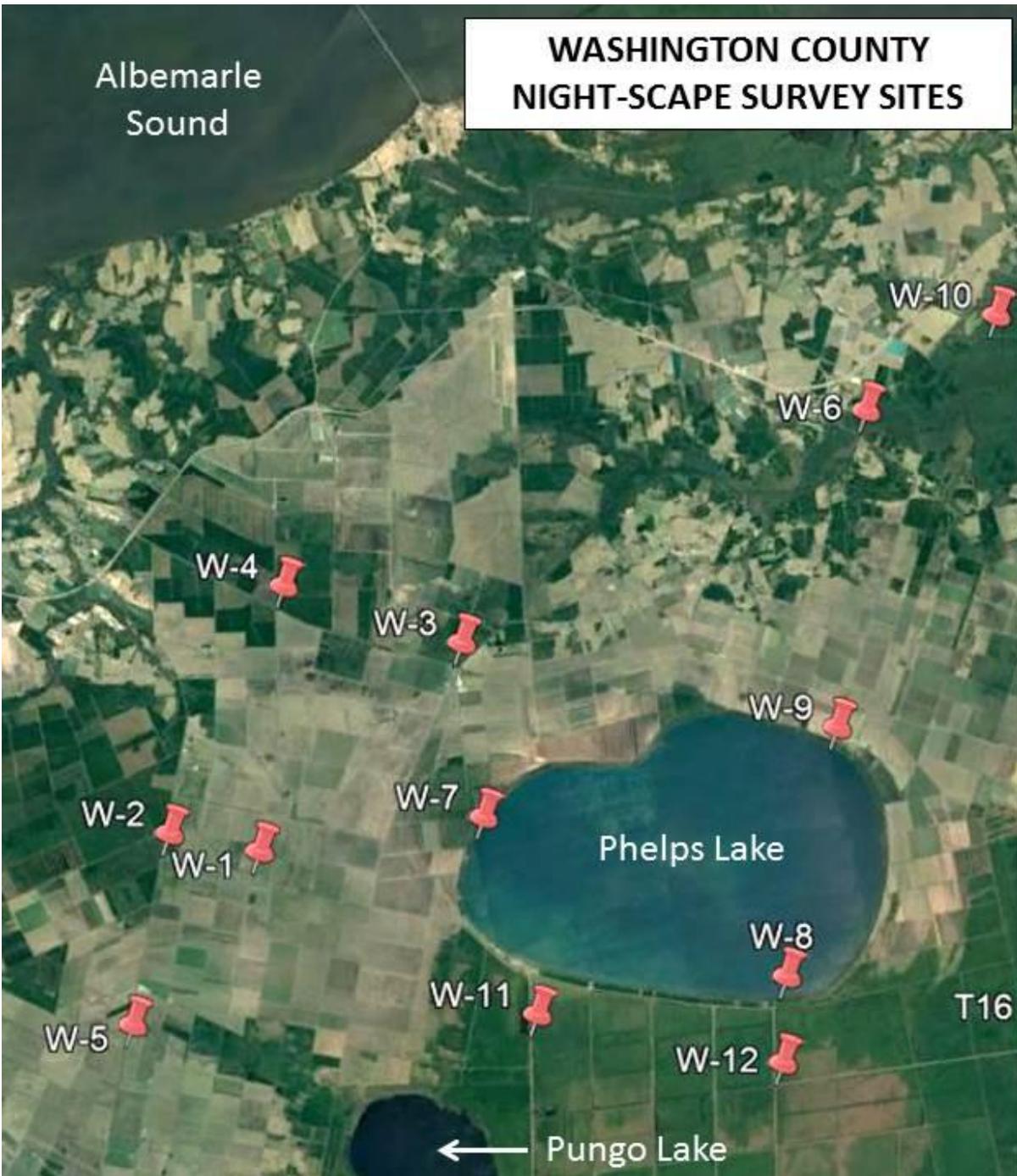


FIGURE 57. A Google Earth satellite image shows the location of 12 sites surveyed during the OAP study: red pins = Washington Co. sites and yellow pins = Tyrrell Co. sites. See the Washington County Table 5 for site names, locations, and ownerships.

SUMMARY: WASHINGTON COUNTY SURVEY SITES--GOOGLE EARTH RED PINS					
MAP SITE	SITE NAME	PROPERTY OWNER	GPS LATITUDE	GPS LONGITUDE	NO. SURVEYS
W-1	JCT B CANAL ROAD-NORTH SLOPE ROAD	NC DEPT OF TRANSPORTATION	35°47'18.65"N	76°35'2.50"W	2
W-2	JCT NORTH SLOPE ROAD-B CANAL ROAD	NC DEPT OF TRANSPORTATION	35°47'49.08"N	76°36'31.73"W	2
W-3	JCT NEWLAND ROAD-SHORE DRIVE	NC DEPT OF TRANSPORTATION	35°49'38.47"N	76°30'49.67"W	2
W-4	JCT NEWLAND ROAD-B CANAL ROAD	NC DEPT OF TRANSPORTATION	35°50'56.91"N	76°33'41.06"W	2
W-5	JCT RAILROAD BED ROAD-SOUTH HOPE ROAD	NC DEPT OF TRANSPORTATION	35°45'14.84"N	76°37'50.56"W	2
W-6	SCUPPERNONG RIVER-SPRUILLS BRIDGE BOAT RAM	NC WILDLIFE RESOURCES COMM	35°51'43.31"N	76°23'3.73"W	4
W-7	PHELPS LAKE-CYPRESS LANDING- WEST PIER	PETTIGREW STATE PARK	35°47'8.60"N	76°31'4.50"W	6
W-8	PHELPS LAKE-POCOSIN SOUTHEAST PLATFORM	PETTIGREW STATE PARK	35°44'2.72"N	76°26'26.89"W	3
W-9	PHELPS LAKE-VISITORS CENTER NORTHEAST PIER	PETTIGREW STATE PARK	35°47'22.64"N	76°24'41.33"W	4
W-10	SCUPPERNONG RIVER-TERCYAK PROPERTY	PETTIGREW STATE PARK	35°52'39.95"N	76°20'28.72"W	1
W-11	ALLEN ROAD-LOOKOUT TOWER	POCOSIN LAKES NWR	35°44'14.03"N	76°30'51.58"W	3
W-12	JCT HARVESTER ROAD-EVANS ROAD	POCOSIN LAKES NWR	35°42'51.03"N	76°26'49.45"W	1
W-13	NEWLAND ROAD-SCUPPERNONG CANAL	PRIVATE	35° 49' 39.36" N	76° 29' 27.60" W	1

TABLE 5. Washington County Survey Sites.

WASHINGTON 1 **Junction B Canal Road-North Slope Road**

NC Department of Transportation

GPS Coordinates: 35° 47' 18.65" N; 76° 35' 2.5" W

Access: Drive 4.3 miles S from Newland Road along B Canal Road to the junction with North Slope Road. Only parking is along the narrow road shoulder, but there is minimal traffic within this area of vast agricultural fields.

Night Sky: Vast 360° of low horizon with only local point sources of light pollution from an occasional farm or house.

Nocturnal Environment: Excellent for night sky viewing of clouds-storms and sun-moon rises and sets, but not so good for wildlife viewing or night sounds.

GRADE: 1



WASHINGTON 1 Photographs. Left panel is looking N along B Canal Road from the junction with North Slope cross-road.

WASHINGTON 2 **Junction N Slope Road-Railroad Bed Road**

NC Department of Transportation

GPS coordinates: 35° 47' 49.08" N; 76° 36' 31.73" W

Access: Drive 1.5 miles W from W-1 to W-2 along North Slope Road to the junction with Railroad Bed Road. Only parking is along the narrow road shoulder, but there is minimal traffic within this area of vast agricultural fields.

Night Sky: The entire area to the E of Railroad Bed Road is agricultural field with a low horizon. The area to the W of W-2 is upland forest with a high horizon. There are only local point sources of light pollution associated with an occasional farm or house and local traffic.

Nocturnal Environment: Excellent for night sky viewing of clouds-storms and sun-moon rises to the E with some wildlife viewing and night sounds associated with the upland forest ecosystem to the W.

GRADE: 1

WASHINGTON 3

Junction Newland Road-Shore Drive

NC Department of Transportation

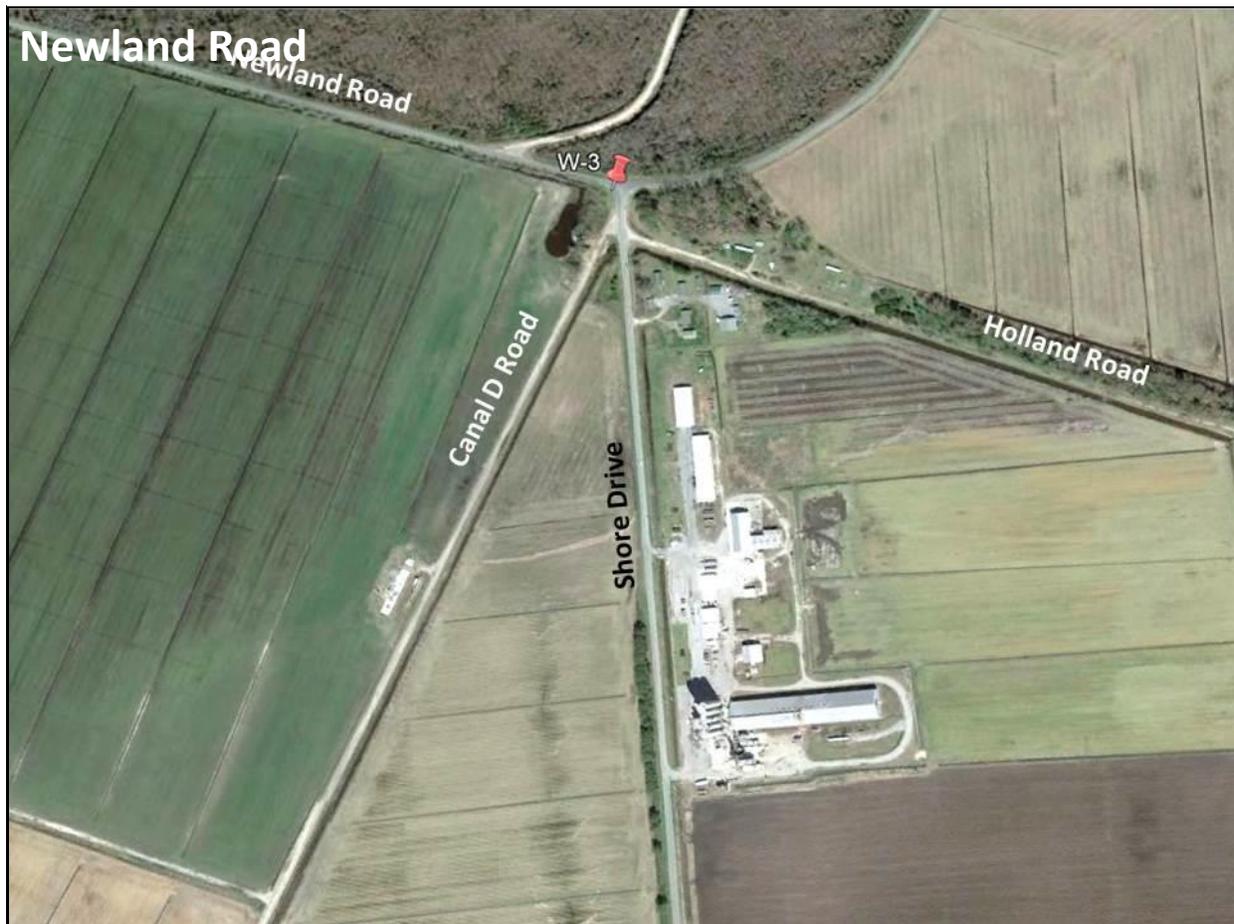
GPS coordinates: 35° 49' 38.47" N; 76° 30' 49.67" W

Access: At the junction of Newland Road and Shore Drive there is a small pulloff area on the SW corner overlooking the vast agricultural fields that extend in all directions except to the N, which is heavily vegetated. Local light pollution comes from the farm located immediately to the S.

Night Sky: The vast agricultural fields cover all the 180° area from the W to the S and E with a low horizon. The area to the N has mixed woodlands and upland forests with high horizons. There are only local point sources of light pollution associated with an occasional farm or house and local traffic.

Nocturnal Environment: Excellent for night sky viewing of clouds-storms and sun-moon rises and sets to with some wildlife viewing and night sounds associated with the upland forest eco-system to the N.

GRADE: 1



WASHINGTON 3 Google Earth image shows the farm at the junction of Newland Road and Shore Drive.

WASHINGTON 4 Junction Newland Road-B Canal Road

NC Department of Transportation

GPS coordinates: 35° 50' 56.91" N; 76° 33' 41.06" W

Access: Drive 3.1 miles WNW from W-3 to W-4 along Newland Road to the junction with B Canal Road. There is a road memorial on the SE corner at the junction where a couple cars can park. There is minimal traffic within this area of vast agricultural fields with only local point sources of light pollution from an occasional farm or house.

Night Sky: The area of low horizon over extensive agricultural fields is limited to the S and E. with much of the remaining area around this site is growing pine trees producing marginal view-scapes.

Nocturnal Environment: Good for night sky viewing of clouds-storms and sun-moon rises, but is not so good for wildlife viewing or night sounds.

GRADE: 1



WASHINGTON 4 Photographs. Left panel is looking SE along Newland Road with tree farms to the N and agricultural fields to the S. Right panel looks S along B Canal Road with a farm in the distance presenting a point source of minor light pollution.

WASHINGTON 5

Railroad Bed Road-Drainage Ditch

NC Department of Transportation

GPS Coordinates: 35° 45' 14.84" N; 76° 37' 50.56" W

Access: Drive 3.2 miles SSW from W-2 to W-5 along the Railroad Bed Road to the junction with a major drainage ditch from the W or drive 2.7 miles N off of Hwy 45-99 on Railroad Bed Road to the junction with a major drainage ditch. There is a broad firm park like area on the W side of the Railroad Bed Road for parking a larger group of cars. There are a minimal number of small point sources of light pollution associated with scattered farms and homes, and Railroad Bed Road has minimal traffic.

Night Sky: A vast 360° night sky view with low horizons provides the best opportunity for viewing in this portion of the Albemarle Peninsula.

Nocturnal Environment: This site has great all around visibility for observing clouds-storms and sun-moon rises and sets. Because the area is almost due W of Pungo Lake the winter waterfowl may be heard and seen flying at night into adjacent fields. During the summer and fall seasons bear may be seen feeding in the fields.

Grade: 3



WASHINGTON 5 Photograph. Panel is looking NNE along Railroad Bed Road and shows a small park like area for parking on the west side of Railroad Bed Road.

WASHINGTON 6 Scuppernong River-Spruills Bridge Boat Ramp

NC Wildlife Resources Commission

GPS Coordinates: 35°51'42.89"N; 76°23'3.37"W

Access: Turn SW off Hwy 64 into Creswell, take Main St. SE 0.85 miles to Spruill's bridge over the Scuppernong River. The boat ramp is on the NE side of the road with good gravel parking lot with no lights. The road does not have much traffic at night, but cars crossing the Scuppernong River Bridge make loud raucous noises.

Night Sky: Poor due to very high horizon of swamp forest in all directions around.

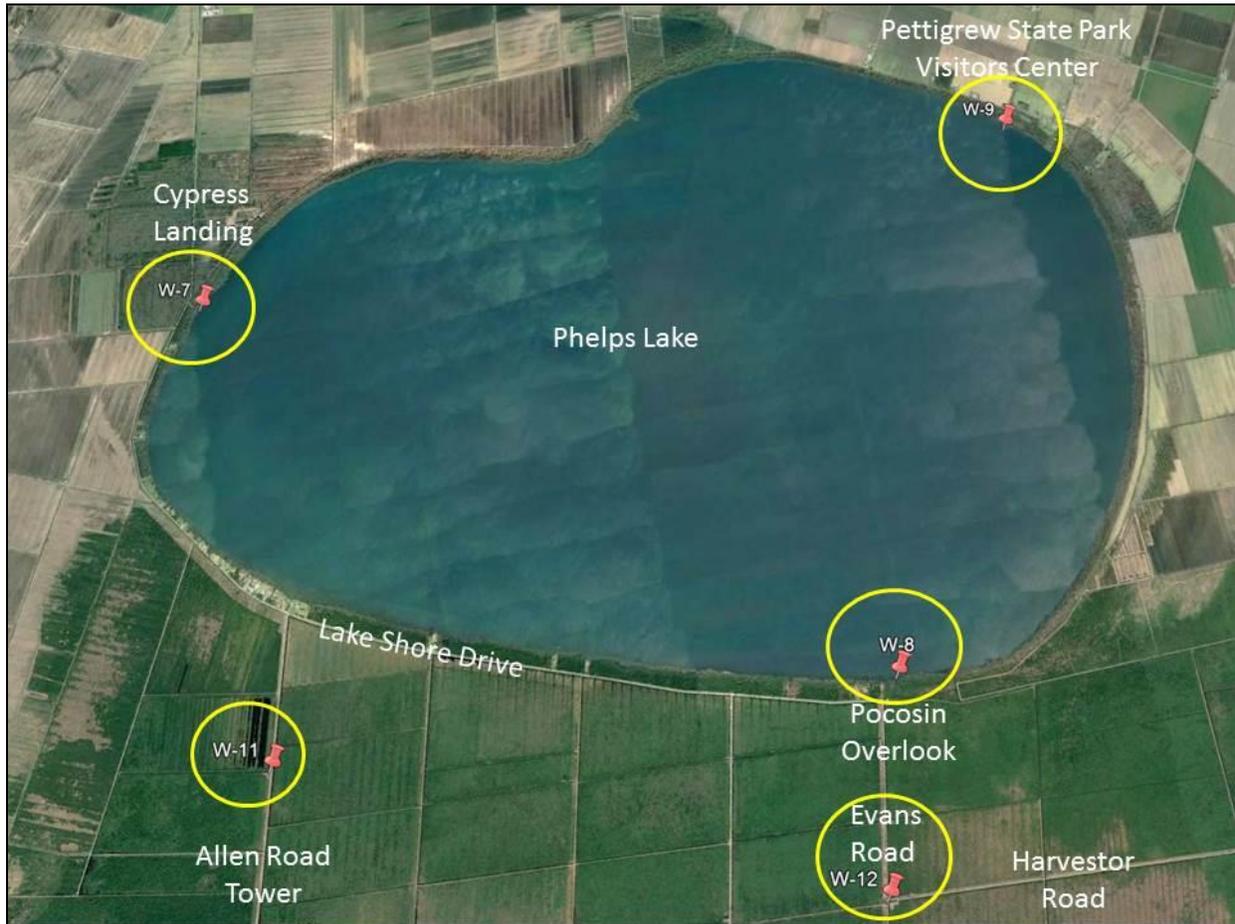
Nocturnal Environment: Excellent night sounds of birds, amphibians, small mammals, and fish due to the broad area of swamp forest and a small dock going into the main stem of the Scuppernong River.

GRADE: 2



WASHINGTON 6 Photographs. Left panel is a picture of the NC Wildlife Resources Commission's boat ramp and parking area from the Scuppernong River at Spruill's Bridge near Creswell. Right panel is looking S from the boat ramp across the Scuppernong River and its floodplain swamp forest.

PHELPS LAKE & PETTIGREW STATE PARK SITES



Phelps Lake area sites that are located in Pettigrew State Park (W-7, W-8, and W-9) and Pocosin Lakes NWR (W-11 and W-12) as shown on this Google Earth satellite image.

SURVEY SITES IN PETTIGREW STATE PARK AND THE POCOSIN LAKES NWR

Park and Refuge Information: The sand roads are usable during dry weather, but can be bad during wet weather. Some areas and roads within the PLNWR have restrictions and may be seasonally closed to access. Visitors PLEASE check with the refuge personnel at Site W-9 and in Columbia, respectively, for details.

WASHINGTON 7

Phelps Lake Cypress Landing-West Pier

Pettigrew State Park on W side of Lake Phelps

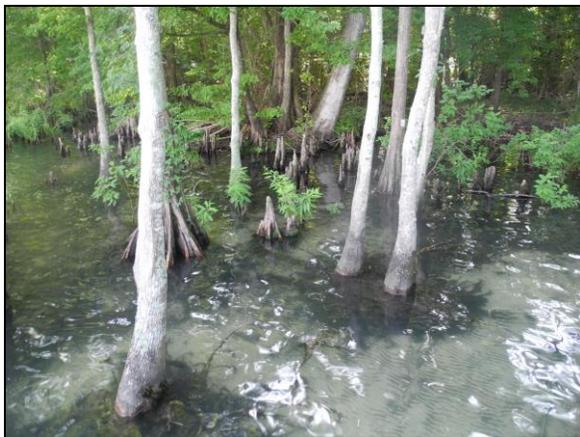
GPS Coordinates: 35° 47' 8.6" N; 76° 31' 4.5" W

Access: Turn off Newland Road and drive S from W-3 to W-7 on Lake Shore Dr. for 2.75 miles to the Pettigrew State Park Cypress Landing on the E side of Lake Shore Drive. This site has good parking, toilet facilities, and hiking trails. There are excellent camping facilities at the Pettigrew State Park Visitor's Center on the NE side of Phelps Lake.

Night Sky: A dock and fishing platform provide excellent star gazing to the NE, E, and SE. Occasionally there is extensive lighting that rims the trail and pier, but there is no light pollution from outside of the immediate area. Arrangements can be made with the Pettigrew staff to have the dock lights turned off ahead of time.

Nocturnal Environment: Excellent night sounds from the lake and shoreline, as well as the fringing swamp forest that grade into upland forest in the parking area. The vast vista across the lake allows awesome views of the clouds-storms and sun-moon rises.

GRADE: 3



WASHINGTON 7 Photographs. Upper left panel is looking E along the dock to the fishing platform in Phelps Lake. Upper right panel is looking NE along the lake shore from the fishing platform. Lower right panel shows the clarity of the shallow water in the fringing swamp forest. Lower right panel is looking E at the clouds over Phelps Lake.

WASHINGTON 8 Phelps Lake Pocosin Overlook-SE Platform

Pettigrew State Park on the SE side of Phelps Lake

GPS Coordinates: 35° 44' 2.72" N; 76° 26' 26.89" W

Access: Turn off Newland Road and drive S from W-3 to W-7 on Lake Shore Dr. for 2.75 miles to the Pettigrew State Park Cypress Landing on the E side of Lake Shore Drive. Continue driving S and E on Shore Drive for 7 miles from W-7 to W-8 at the Pettigrew State Park Pocosin Overlook. This site has good parking and toilet facilities. A short 250 yard hike along a groomed path takes you from the parking lot to the short pier and observation tower on the SE portion of Phelps Lake. There are excellent camping facilities at the Pettigrew State Park Visitor's Center on the NE side of Phelps Lake.

Night Sky: A small dock and raised observation platform provide excellent star gazing to the N, NW, and W. There is no light pollution

Nocturnal Environment: Excellent night sounds from the lake and shoreline, as well as the fringing swamp forest that grade into upland forest in the parking area. The vast vista across the lake allows awesome views of the clouds-storms and sun-moon sets.

GRADE: 3



WASHINGTON 8 Photographs. Left panel is a summer view looking E along the shoreline transition vegetation zone. Right panel is looking N along the short pier and across Phelps Lake.

WASHINGTON 9

Phelps Lake-Visitor's Center-NE Pier

Pettigrew State Park Headquarters and Visitor's Center

GPS Coordinates: 35° 47' 22.64" N; 76° 24' 41.33" W

Access: Turn off Hwy 64 and drive SE for 1.25 miles down Main Street in Creswell to Spruill's Bridge W-6 and continue straight for 1.6 miles to the Thirty Foot Canal Road, turn SSW and go about 4.75 miles to Lake Shore Drive, enter W-8 at Pettigrew State Park main office in about 100 feet. Drive S past the office towards the lake to a small grassed parking area or the paved boat ramp adjacent to a small dock. This site has good parking, toilet facilities, hiking trails, and excellent camping facilities. Occasionally there is extensive lighting in the parking area and at the pier, but there is no light pollution from outside of the immediate area. Arrangements can be made ahead of time with the Pettigrew staff to have the dock lights turned off ahead of time.

Night Sky: Excellent star gazing on the dock to W and S with vast vistas and no outside light pollution.

Nocturnal Environment: Excellent night sounds from the lake and shoreline, as well as the fringing swamp forest that grade into upland forest in the parking area. The vast vista across the lake allows awesome views of the clouds-storms and sun-moon sets.

GRADE: 3



WASHINGTON 9 Photographs. Left panel is looking SW at the Pettigrew State Park pier and across Phelps Lake. Right panel looks W at the vegetated forest shoreline of Phelps Lake.

WASHINGTON 10

Scuppernong River-Pettigrew Tercyak Prop.

Pettigrew State Park

GPS Coordinates: 35°52'39.95"N; 76°20'28.72"W

Access: Take Columbia Road exit off of Hwy 64 and turn S onto Chapel Hill Road and go S and SW for 2.8 miles, turn E onto Cross Landing Bridge Road, go 0.7 miles to (~0.2 miles W of the Scuppernong River bridge) and turn S into the property. Be careful of the narrow road across the steep ditch and if the ground is wet, do not leave the driveway to the little house. Since the site is located within the Scuppernong River floodplain, parking is limited to the old raised driveway.

Night Sky: Large 1+ acre grassed field has a moderately high horizon all around due to a thick riverine lowland forest resulting in a poor site for star gazing.

Nocturnal Environment: The site is excellent for wildlife and night sounds due to extensive lowland swamp forest and a ditch that flows into the Scuppernong River. However, it is not good for night sky observations even though it is dark with no light pollution and only minor road traffic.

GRADE: 1



WASHINGTON 10 Photograph. Image shows NC Division of State Parks personnel and planners standing in the open area of Pettigrew State Park's Tercyak property surrounded by floodplain swamp forest of the Scuppernong River.

WASHINGTON 11 Allen Canal Road-Lookout Tower

Pocosin Lakes National Wildlife Refuge

GPS Coordinates: 35° 44' 14.03 N; 76° 30' 51.58" W

Access: Turn off Newland Road and drive S from W-3 to W-7 on Lake Shore Dr. for 2.75 miles to the Pettigrew State Park Cypress Landing. Continue on Lake Shore Drive for 2.9 miles, turn S on Allen (A) Canal Road and go 1 mile to the Lookout Tower on the SW side of the junction. There is good parking area to the N of the tower. Do not climb the tower without a permit from the Pocosin Lakes NWR personnel.

Night Sky: Excellent star gazing with vast low to moderate horizons due to the extensive area of pocosin shrub-scrub swamp forest vegetation in almost all directions.

Nocturnal Environment: Excellent wildlife and night sounds and night sky observation of clouds-storms and sun-moon rises and sets.

GRADE: 3



WASHINGTON 11 Photographs. Left panel is a view N along Allen Road from the top of the tower. Notice the elongate lake on the left side of the photo, as well as the tower, are remnants of efforts of First Colony Farms to mine the pocosin swamp forest peat in the early 1980s. Right panel is looking E along a dike road and associated flooded drainage ditch.

WASHINGTON 12 Junction Harvester Road-Evans Road

Pocosin Lakes National Wildlife Refuge

GPS Coordinates: 35°42'51.03"N 76°26'49.45"W

Access: Turn off Newland Road and drive S from W-3 to W-7 on Lake Shore Dr. for 2.75 miles to the Pettigrew State Park Cypress Landing on the E side of Lake Shore Drive. Continue driving S and E on Shore Drive for 7 miles from W-7 to W-8 at the Pettigrew State Park Pocosin Overlook. Turn S on Evans Canal Road and go 1.25 miles to site W-12.

Alternatively, if you are traveling W on Harvester Road it is 3.35 miles from site T-16 to site W-12. At the intersection of Evans gravel road and Harvester gravel road is a broad parking area that is used as a helicopter pad during fire season. Site W-8 on the Phelps Lake shore has good parking and toilet facilities.

Night Sky: Good for star gazing with high to low horizons of pocosin shrub-scrub all around with no light pollution or night traffic.

Nocturnal Environment: Excellent pocosin ecosystems and large flooded canals within the heart of the high pocosin is great for wildlife and night sounds, as well as vast vistas for observation of clouds-storms and sun and moon scapes.

GRADE: 3



WASHINGTON 12 Photographs. Left panel is looking E along Harvester Road on an enlarged segment of the dike. Right panel looks N along the Evans Road ditch with the dense and moderately high pocosin swamp forest vegetation.



The winter night sky photograph looks east at the Milky Way from Cypress Landing-West Pier on Phelps Lake (W-7), Pettigrew State Park. Photograph is by Allen Phelps Photography.



The summer nocturnal environment features the American alligator in Alligator National Wildlife Refuge. Photograph is by T. Earnhardt.

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Reserve: <http://www.darksky.org/idsp/become-a-dark-sky-place/>
- Night Skies Network Observatory: Clear Sky Chart
www.cleardarksky.com/c/AuHIIObNCkey.html?1
- Visible Infrared Imaging Radiometer Suite (VIIRS) <https://jointmission.gsfc.nasa.gov/viirs.html>

APPENDIX A: SURVEY TEAM PROCEDURES

To understand the nocturnal environment and dark skies of the OAP, survey teams were established to map the regions night-scape. The survey consisted of four teams, one each for Tyrrell, Washington, mainland Hyde, and mainland Dare counties. The teams were composed of a leader (e.g., science teacher, regional manager, or trained citizen, etc.) along with one or two key assistants or upper-level students. A preliminary county trip itinerary with specific sites was prepared by the PI for each team, along with data sheets and equipment for both the nocturnal environment and night sky. Each team was equipped with a GPS, SQM-L sky quality light meter, as well as sound and weather meters to collect night-scape data for each site throughout the seasons. In addition, the team provided a general description of the land-scape, view-scape, and sound-scape, as well as the weather conditions, surrounding eco-system environment and recognizable sounds, and visitation capabilities (access, parking, light pollution, hunting, etc.) for each site. Each survey described the amount and sources of urban light pollution and identified the darkest sites.

After the first summer survey, the PI's re-evaluated and modified the trip itineraries and sites for the subsequent monthly surveys (on or near the new and/or full moons). The completed surveys were utilized to map the general night-scape resource and light pollution in the OAP. This will form the basis for determining the best way to protect this unique night-scape of the OAP, to incorporate the night-scape resource into ongoing eco-tourism programs, and to develop a plan for the region obtaining a possible designation as an "International Night-Sky Reserve".

1. Each survey team will be responsible for mapping the general characteristics of the a) night sky and b) nocturnal environment at each of 4 to 5 sites within their respective mapping region. The mapping will be carried out two times a month on/or near the new and full moons during a 2 to 3 hour period (4 hour max) starting about ½ hour after full sunset. Thus, on the winter solstice the mapping period will be from about 6 to 9 pm, whereas on the summer solstice it will be about 9 to 12 pm. It is recommended that each team do the farthest site from the home base first in order to get the darkest skies possible.
2. Since you are a sub-contractor, you are responsible for your insurance, vehicle, all your personal effects, as are your assistants. NC LOW/ATFS will a) pay upfront travel expenses on a quarterly basis at the rate of \$100/trip/mapping team; b) supply each team with a set of simple analytical meters; c) general box of supplies such as flashlight, spare batteries, paper and pencils, first-aid kit, insect repellent, etc.; d) set of appropriate maps, site descriptions and directions, mapping instructions, and data sheets; and e) list of pertinent personnel within the mapping region. All meters and unused supplies will be returned at the end of the project.

3. All survey team members must sign a basic waiver form before the first survey takes place. Safety is King—we do not want you out mapping during any kind of extreme weather.
4. The mapping of the night sky sites should, if possible, be done each month on the night of the new and full moons. If the weather is bad or you have serious conflicts, then select either the night or two before or night or two after the peak moon, whichever works best. Each team leader should be in communication with the scientific leader if you are going to change dates.
5. Most of this land is low, wet, and wild. Consequently, do not drive off of any paved, graveled, or sand roadway—YOU WILL GET STUCK; if necessary do 5 or 10 point turns on small roadways when turning your vehicle around. This entire OAP region abounds with wildlife which can pose serious conflicts—do NOT feed, harm, collect, or disturb any plants or animals; but you do need to be aware and conscious about the presence of abundant bears, snakes, alligators, etc. You will need to use insect repellent or netting for the mosquitos, greenheads, and ticks; however, the good news is you won't need sunglasses or sunscreen.
6. Each team leader and/or assistant must have a smart phone available for two purposes. First and foremost is for safety purposes. Second is to be able to obtain GPS coordinates and utilize night sky apps that ATFS and NC LOW will recommend and supply.
7. Almost all sites that you will be visiting are on public lands. Most of the land will belong either to the NC Wildlife Resources Commission, NC State Parks (Pettigrew), NC Dept. of Transportation, or one of four National Wildlife Refuges (Alligator River, Pocosin Lakes, Mattamuskeet, or Swanquarter). It is imperative that your team is totally respectful of the property and all interactions with officials or the public must be courteous. You must carry with you copies of the permits to demonstrate you have permission to be carrying out this survey.
8. In addition to the four program leaders, the following individuals and organizations are also key players within the four county region of OAP that NC LOW and ATFS will be interacting with to develop the regional basis for implementing this proposed program. NC LOW has been working with most of these individuals and their organizations during the past three years with an ongoing science teacher education program and development of a sustainable, eco-tourism trail system. Having these individuals and their organizations totally on board with the proposed project is important to our success and getting them involved will be a major task of this proposal. In addition, they will play critical roles as the OAP begins to incorporate the night-scape into their educational and sustainable eco-tourism programs as an important natural resource component of this uniquely dark-sky coastal region of NC.

Mr. Pete Campbell: Refuge Manager of Mattamuskeet, Swanquarter, and Cedar Island National Wildlife Refuges, 85 Mattamuskeet Rd., Swan Quarter, NC 27885. (252-926-4021) pete_campbell@fws.gov

Mr. Scott Lanier: Refuge Manager of Alligator River National Wildlife Refuge, PO Box 1969, 100 Conservation Way, Manteo, NC 27954. (252-473-1131) scott_lanier@fws.gov

Ms. Rebekah Martin: Project Leader North Carolina Coastal Refuges Complex, PO Box 1969, 100 Conservation Way, Manteo, NC 27954. (252-473-1131) rebekah_p_martin@fws.gov

Mr. Howard Phillips: Refuge Manager of Pocosin Lakes National Wildlife Refuge, 205 S. Ludington Dr., Columbia, NC 27925. (252-796-3004) howard_phillips@fws.gov

Mr. Tom Stroud: Partnership for the Sounds, 223 E. Water St., Washington, NC 27889. (252-948-0000) tmstroud@embarqmail.com

Mr. Jim Trostle: Manager of Pettigrew State Park, 2252 Lake Shore Dr., Creswell, NC 27928. (252-797-4475) ken.trostle@ncparks.gov

APPENDIX B. FIELD SURVEY PERSONNEL

SCIENTIFIC LEADS:

Dr. Stanley Riggs (North Carolina Land Of Water)
Mr. Brian Baker (A Time For Science)

MAINLAND DARE COUNTY:

Dr. Reide Corbett (Coastal Studies Institute)
Mr. David Sybert (Coastal Studies Institute)
Ms. Hayley Grabner (Coastal Studies Institute)
Mr. Ian Conery (Coastal Studies Institute)
Ms. Lindsey Dobbs (Coastal Studies Institute)

TYRRELL COUNTY:

Ms. Karen Clough (North Carolina Land Of Water)
Ms. Kim Wheeler (Citizen)
Mr. George Haislip (Citizen)

MAINLAND HYDE AND WASHINGTON COUNTIES:

Ms. Marah Dahn (ECU Technician)
Ms. Samantha Eubanks (A Time For Science)
Mr. Erik Evanger (Citizen)

APPENDIX C: DATA SHEETS

GENERAL INFORMATION

DATE: _____ TIME: _____ COUNTY: _____ TEAM LEADER: _____

ASSISTANT : _____

SITE NAME: _____ LATITUDE: _____ LONGITUDE: _____

GENERAL DESCRIPTION OF SITE:

NOCTURNAL CONDITIONS

SUNSET: _____ MOONRISE: _____ LUNAR PHASE: _____

WEATHER INFORMATION (Equipment needed: Kressel 3000)

CLOUD COVER (oktas): _____

PRECIPITATION : RAIN / SLEET / SNOW / HAIL / NONE

PRECIPITATION AMOUNT: DRIZZLE / LIGHT / HEAVY / NONE

WINDS (select one): GUSTS / SQUALLS / BREEZE / GALE / NONE

WIND DIRECTION: _____ WIND SPEED MAX (mph): _____

WIND SPEED AVERAGE (mph): _____ TEMPERATURE (°F): _____

DESCRIPTION OF THE NIGHT SKY, THUNDERSTORMS, CLOUD TYPES, ETC.:

GENERAL COMMENTS:

NOCTURNAL ENVIRONMENT (Equipment needed: HT-80A)

SOUND LEVEL (dB):

Reading	North	East	South	West
Max (dB)				
Min (dB)				

GENERAL DESCRIPTION OF SOUND-SCAPE AND WILDLIFE:

NIGHT SKY QUALITY (Equipment needed: SQM-L, Kressel 3000)

ANGLE OF HORIZON (Deg): NORTH: _____ EAST: _____

WEST: _____ SOUTH: _____

IS THE MOON VISIBLE? YES / NODESCRIPTION:

SEEING: _____ TRANPARENCY: _____ HUMIDITY (%): _____

SKY GLOW MEASUREMENT:

$\frac{mag}{arcsec^2}$	$\frac{mag}{arcsec^2}$	$\frac{mag}{arcsec^2}$	$\frac{mag}{arcsec^2}$
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DESRPTION OF OBVIOUS LIGHT POLLUTION:

COMMENTS ON SITE FOR ASTRONOMY GROUPS:



*The winter nocturnal environment features the tundra swans in Pocosin Lakes National Wildlife Refuge.
Photograph is by P. Gemperline.*