

Bolin Creek Natural Area Conservation Planning Guide (Draft)

Abridged Version

November, 2018

Friends of Bolin Creek



Friends of Bolin Creek

Protecting our Bolin Creek Watershed

Table of Contents

Part 1. Introduction and Goals	4
1.1 A Unique Greenspace- The Value of Bolin Forest	4
1.1.1 Recreation	4
1.1.2 Economy	5
1.1.3 Education	5
1.1.4 Environmental Health	6
1.1.5 Ecology	6
1.2 Vision of Bolin Forest Conservation	7
1.2.1 Friends of Bolin Creek	7
1.2.2 Vision of Bolin Forest	7
1.2.3 Purpose and Intended Use of this Document	7
1.3 Introduction	8
1.3.1 Bolin Forest Definition	8
1.3.2 Reasons Bolin Forest is a Good Candidate for Conservation	8
a) Wealth of botanical and animal assets	8
b) Level of stream impairment	9
c) Value of forest to the community	9
d) High community involvement	9
1.3.3 Committee name and members	9
1.3.4 Conservation Goals	10
Part II. Status of Bolin Forest- Abridged	11
2.1 Project Area History and Description	11
2.1.1 The Adams Tract	11
2.1.2 The Craig Tract	12
2.1.3 Carolina North Forest	12
2.2 Current Condition	14
2.2.1 Terrestrial habitat quality assessment	14
a.) Forest Cover	14
b.) Terrestrial Wildlife	15
2.2.2 Aquatic habitat quality assessment	15
a.) Status	15
c.) Hydrology and Fluvial Geomorphology	16
d.) Water chemistry	17
Part IV. Strategies	18
1. Strategies to Attain Conservation Goal 1	18

2. Strategies to Attain Conservation Goal 2	20
3. Strategies to Attain Conservation Goal 3	21
4. Strategies to Attain Conservation Goal 4	21

References	23
-------------------	-----------

Part 1

Introduction and Goals

1.1 A Unique Greenspace- The Value of Bolin Forest

The towns of Chapel Hill and Carrboro, frequently referred to as “Chapelboro,” make up more than half the population of Orange County with approximately 80,000 people between them, according to NC Department of Commerce 2016 estimation. These adjacent but intertwined cities share a large community of both permanent residents and students from The University of North Carolina. This area boasts a deep-rooted arts and cultural community, established local school systems, active and engaged residents, and a community that values outdoor recreation and environmental protection. Nestled in between the towns, surrounded by schools and residential neighborhoods, is a unique green space that managed to escape encroaching urban development. Locals call this space Bolin Forest; it is also referred to as the Bolin Creek Natural Area interchangeably throughout this document.

If you spend any time on the 429 acres of land that makes up Bolin Forest, you will find the striking view of beautiful exposed roots of mature hardwood trees on the banks of Bolin Creek. You will find an undeveloped, uneven aged forest with trees up to 100 years old that are still healthy and growing. If you stay long enough, you may see a box turtle crossing the trail, a great blue heron wading in the creek, or hear a downy woodpecker tapping in the tall trees, foraging for its meal.

Identified as a natural heritage site, a priority area for protection in the Bolin Creek watershed, and key wildlife habitat, it is evident that this resource must be protected from the environmental threats it faces **[1,2,4,6]**. This large urban forest provides recreational, educational, economical, and ecological benefits to our community, as well as the natural communities that live there.

1.1.1 Recreation

Bolin Forest is filled with recreational trails that allow opportunities for hiking, biking, running, bird watching, and various other activities. The trails in the forest serve as training grounds for Chapel Hill High School’s cross country team as well as a

communal meeting place for running groups, walking groups, and nature enthusiasts [8].

Outdoor recreation provides valuable experiences for visitors and residents alike. Wooded trails support active lifestyles for the community which in turn provides an increase in physical health and mental wellbeing [15,34]. The cities of Chapel Hill and Carrboro are vastly expanding and the forest acts as a sanctuary for residents that live here. It provides a place for solace, solitude, interacting with wildlife, and a place for people of all ages to learn and explore the wonders of the forest. This greenspace gives community members the opportunity to connect with each other and with nature in a personal and often spiritual way.

1.1.2 Economy

Numerous studies have been conducted to determine the value of Greenspaces in urban settings. Evidence suggests that forests and greenspace have potential to add economic value to the community and help to make for a more desirable place to live, work, and raise a family. Greenspaces like Bolin Creek Natural Area attract new residents to the area, increase nearby property values, and increase tourism potential all of which positively impact the local economy [15, 17].

1.1.3 Education

The potential for utilizing Bolin Forest as an educational tool is immense. With three schools surrounding the forest (Chapel Hill High School, The Seawell School, and Smith Middle School) and many more schools and daycares nearby, this forest provides a perfect opportunity to take students out of the classroom for active learning experiences.

Bolin Forest and Bolin Creek both offer an exceptional resource for K-12 teachers, students, homeschoolers, and other community members to develop field trips, educational programs, and short-term and long-term research projects. There is also a great potential for university students and instructors to utilize the forest for environmental, ecological, and urban forestry studies.

Site visits to natural areas provide students an opportunity to experience subject matter in-person with all of their senses. It provides teachers with a resource they don't have in a classroom and an opportunity to use the natural area in conjunction with classroom lessons. These active and experiential learning experiences provide tangible,

kinesthetic, hands-on learning opportunities, in which students are typically more attentive, have higher energy levels, and are more physical active than in a classroom **[22,31]**.

Educational programs and forest field trips are not only beneficial for the students and the local community, but provide a greater benefit to the ecosystem and the environment. When students have positive experiences at the park and learn valuable environmental lessons, they often share that information or experience with their family members and other members of the community. This can lead to increase visitation, greater awareness of the value of nature, and community support for protection of urban greenspace **[22,31]**.

1.1.4 Environmental Health

The environmental health services offered by Bolin Forest are numerous. The importance of forests as carbon sinks in this period of global climate change is well agreed upon within the scientific community. Forests absorb and store carbon dioxide, filter pollutants, and absorb heat and provide shade, cooling the air. This is especially important in urban areas where forests are uncommon and much of the landscape is impervious surfaces. These urban zones act as heat sinks and are typically hotter in air temperature and surface temperature than the surrounding rural areas **[10,11,15,17]**.

The benefits of the forest is not limited to improving air quality, the forest also increases water quality for a drinking water. Bolin Creek feeds into Jordan Lake, a drinking water supply for almost half a million people in the triangle area. A section of Bolin Forest, is in the Bolin Creek riparian zone. The forest filters pollutants and sedimentation of water entering the creek, thereby potentially increasing drinking water quality and taste **[10,15,22,33]**

1.1.5 Ecology

The ecological benefits of urban forests are vast. This isolated forest is located in a rapidly urbanizing residential area and is one of the few suitable habitats left for terrestrial plant and animal communities. Bolin Forest also acts as riparian forests for Bolin Creek and directly and contains “critical habitat” in the Bolin Creek Watershed. Riparian forests filter pollutants and sediment that may enter the stream, increases stream bank stability, mitigating floods and storm water runoff, and provide shade and debris which improves wildlife habitat for aquatic organisms. Terrestrial and aquatic systems are highly connected and greatly influence one another. For example,

residential and commercial development leads to increased erosion and sedimentation in the creek. Sedimentation results in decreased habitat for benthic invertebrates which serve as the primary food source to terrestrial wildlife. [1, 10,15,21,22,33].

1.2 Vision of Bolin Forest Conservation

1.2.1 Friends of Bolin Creek

Friends of Bolin Creek is a local 501-3(c) environmental organization which strives to protect Bolin Creek Watershed and its surrounding natural areas through community education and action. Our work enhances life for all people of Chapel Hill and Carrboro by addressing water quality issues, encouraging environmental stewardship and nurturing appreciation of our natural heritage.

1.2.2 Vision of Bolin Forest

Friends of Bolin Creek envisions Bolin Forest as a healthy living forest that supports natural aquatic and terrestrial communities in coexistence with the growing urban population of Carrboro and Chapel Hill. In this vision, the 400+ acres of undeveloped land remain protected and are managed holistically to promote water quality, environmental integrity, recreation, education, and environmental research.

1.2.3 Purpose and Intended Use of this Document

The purpose of this Conservation Planning Guide is to set out steps necessary to conserve and enhance the ecological, recreational, and educational value of Bolin Creek Natural Area. This document summarizes the current status of Bolin Forest, identifies threats of degradation, and provides general strategies to address those threats and conserve the land's natural integrity. This comprehensive conservation plan is meant to be used as a tool for citizens in the community, local governments, and public and private landowners to assist in conservation planning.

Our goal is for this document to form the basis for coordinated action among government and conservation leaders toward comprehensive management practices. In addition, this plan by considering the resources of the entire 425 acres, will stimulate

and inspire those same leaders to acquire that last piece of private property, the PH Craig tract.

1.3 Introduction

1.3.1 Bolin Forest Definition

Bolin Creek Natural Area is defined as the contiguous forest that runs along Bolin Creek in Chapel Hill and Carrboro east of Seawell School road and south of Homestead Rd. The forest consists of the 3 adjacent parcels of undeveloped land that includes the 27-acre 'Adams Tract', owned by the city of Carrboro since 2004, the 77-acre privately owned 'PH Craig Tract', and the 325-acre 'Carolina North Forest' east of Seawell School road owned by the University of North Carolina. Additionally, it includes common land held by the residential neighborhoods of Ironwoods, Spring Valley, Bolin Forest, Cates Farm, Pacifica, and Claremont.

1.3.2 Reasons Bolin Forest is a Good Candidate for Conservation

a) Wealth of botanical and animal assets –Bolin Forest was declared a Natural Heritage Site in 2004 by the state operated Natural Heritage Program which identifies sites of special significance that are worth preserving [6]. Additionally, much of the Bolin Creek riparian corridor was identified as priority wildlife habitat by NC Wildlife Commissions GAP Analysis Project [30]. The riparian corridor acts to preserve water quality for the Bolin Creek watershed and provides movement corridors for wildlife. The variety of ecosystems throughout the forest result in ecologically diverse plant and animal communities. Mature hardwoods that are rare in developed areas provide ideal sites for migratory birds and other locally rare species in addition to improving air quality [6].

b) Level of stream impairment- Bolin Creek is listed on the [North Carolina's 303\(d\) list](#) as biologically impaired due to an inability to sustain an acceptable community of aquatic organisms. Bolin Creek feeds into Jordan Lake, a vital municipal water source for over 500,000 people in the triangle. The point of impairment has been moving upstream, and currently begins where the creek passes Pathway Drive, which is situated within Bolin Forest. Restoration and protection of critical riparian natural areas within the watershed are necessary for halting this trend and restoring the creek to a healthier status.

c) Value of forest to the community- Public meetings and public opinion surveys indicate residents have strong affections for the forest to be left in a natural state and desire its protection for the future. Although recreational uses and personal interests vary, general opinion is that a greater management effort should exist and the forest should be preserved. The recreational trails within the forest are heavily used, indicated by trail conditions and [Strava global heat maps](#). This outdoor recreation provides immense physical and mental benefits for the community [15, 34].

d) High community involvement - Carrboro and Chapel Hill both have an extremely engaged community that actively support the conservation of Bolin Forest. This engagement is demonstrated in such activities as high public attendance to a meeting for “Protecting Bolin Forest”. Community participation in past outreach programs as well as attendance to related Bolin Creek events shows a willingness to participate in restoration projects which may alleviate funding issues with restoration projects.

1.3.3 Committee name and members

In June of 2018, FOBC Convened a Bolin Forest Advisory Committee to discuss the purpose of a conservation planning document, and provide insight into proposed recommendations for Bolin Forest.

Committee members include:

- i. Michael Paul, FOBC, Stream Ecologist
- ii. Robert Crook, FOBC, Forester
- iii. John Morris, FOBC, Former NC Water Resources Director
- iv. Linda Haac, FOBC, Writer and Editor
- v. Betsy Kempster, FOBC, Education and Outreach Specialist
- vi. Julie McClintock, FOBC, President

1.3.4 Conservation Goals

1. Coordinated conservation management across all 400+ acres of land that comprise Bolin Creek Natural Area.
2. Restoration and preservation of habitat for natural communities, wildlife, water quality and future resources
3. Promote recreation that maintains the natural integrity of Bolin Forest and fosters a strong connection with nature.
4. Promote environmental stewardship to landowners and the wider community through education and outreach.

Part II

Status of Bolin Forest- Abridged

2.1 Project Area History and Description

Bolin Forest lies in Orange County, NC on the border between the towns of Carrboro and Chapel Hill. All three contiguous parcels of wooded land that make up Bolin Forest are west of Seawell School road and under Carrboro planning jurisdiction, excluding a small portion of Mr. Craig's property that is in Chapel Hill's jurisdiction [27]. Bolin Creek is a stream of the Cape Fear River basin and runs north-south throughout the forest. About 11 miles in length, Bolin Creek starts in rural Orange County and flows southeast into the cities of Carrboro and Chapel Hill. In Chapel Hill, it joins Booker Creek east of South Estes Dr. to form Little Creek, which eventually leads to Jordan Lake, a drinking water reservoir for the towns of Cary, Apex, Morrisville, Holly Springs, Chatham County, parts of Durham, Orange, and Wake County. The Orange County Water and Sewage Authority (OWASA) also has rights to Jordan Lake for drinking water if needed [22]. A sewer corridor, about 30 ft. in width, doubles as a multi-use trail and runs parallel to the creek to the east, in all 3 properties. The corridor is maintained by OWASA and has numerous sewer access points throughout [1,6]. The corridor trail connects with various other trails in Carolina North, the PH Craig property, the Adams tract, as well as the neighboring subdivisions, and is the most used trail throughout the forest. A map of the natural area can be found in **Fig. 2.1**. The individual parcels and surrounding areas that make up Bolin Creek Natural Area are described below.

2.1.1 The Adams Tract

In 2004, the City of Carrboro and Orange County obtained funding from the state's Clean Water Management Trust Fund with help from the Orange County Land Legacy Program to purchase the 27.3 acre Adams Tract as a Conservation Easement [18,19]. Prior to 2004, the property was owned by a UNC Botany Professor, J. Edison Adams, and his family. Prior to 1950, when the Adams family bought the property, the land was partially cleared and used for pasture and farmland. It is the southernmost parcel of Bolin Forest, connecting Wilson Park to the south, Bolin Creek to the North, Estes Drive Ext. and the Norfolk Southern rail line to the East, and Pacifica, a residential

neighborhood to the West. The property connects to the PH Craig Tract via the OWASA corridor. The corridor connecting the two properties is surrounded by two open spaces owned by adjacent residential neighborhoods, Ironwoods to the East and Bolin Forest to the west. A major tributary of Bolin Creek, Dry Gulch, runs along the northern edge of the property from Pacifica and Bolin Forest. Wilson Park is a recreational area owned by the City of Carrboro that provides an access point to the Bolin Forest trails through the Adams Tract [27]. A more detailed history of the Adams Tract can be found on the [Friends of Bolin Creek Official Website](#).

2.1.2 The Craig Tract

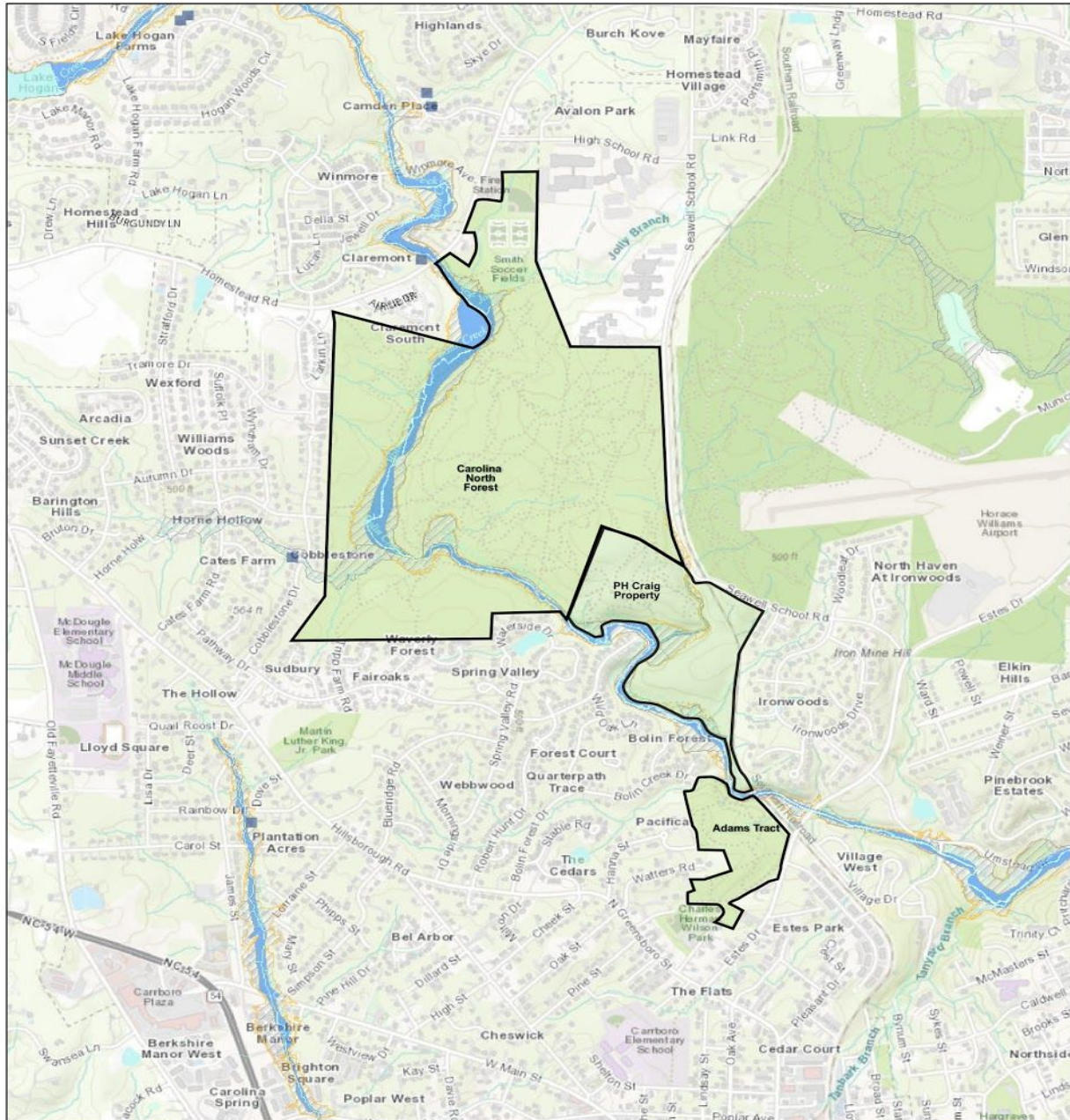
The privately owned 77 acres of wooded land north of the Adams Tract has been owned by P.H. Craig Jr. since 1965. The Craig Tract lies west of residential neighborhood, Ironwoods, south of Carolina North Forest, and residential neighborhoods Bolin Forest and Spring Valley are on the western border. Bolin Creek runs along the western edge of the property. Two significant tributaries of Bolin Creek runs transverse through this property. The northern most of which is named Craig's Branch after the landowner, while the other is unnamed. There is also approximately one other perennial, one intermittent, and 9 ephemeral streams that can be found on the property according to [Chapel Hill GIS Interactive Maps](#). There is a recorded wetland in the [Carolina North Proposed Conservation Area Description, 2011](#) within the property that lies on the border of Carolina North Forest. Other wetlands may be found on the property but inconsistent surveying of this area has resulted in incomplete data. The Norfolk Southern rail line runs through this property on the east side. This rail line separates portions of the land in Carrboro and Chapel Hill [3,27,19,28].

2.1.3 Carolina North Forest

About 325 acres of the Carolina North Forest west of Seawell School Road makes up the majority of Bolin Forest. In this document we will refer to this site as Carolina North-west (CN-west). A portion of the property was willed to the University of North Carolina by Henry Horace Williams, a UNC professor of philosophy, in 1940 [20]. Residential developments and three separate schools surround the property, with Seawell School road to the East and the PH Craig Tract to the south. Bolin Creek runs through the western side of the property, with extensive riparian forest on either side of the creek. Hogan's Creek, a major tributary of Bolin Creek as well as one other unnamed perennial, approximately, 8 intermittent streams, and 10 ephemeral lie within the CN-west property. There are three small palustrine forested wetlands as well as one that borders the Craig tract. In addition to the OWASA corridor, there is a Duke Energy

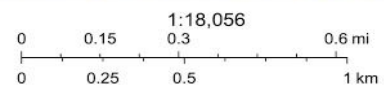
Corridor that runs north-south through the middle of the property and a service road that runs east-west [2,3,27].

Fig 2.1. Bolin Creek Natural Area- General Project Area Map



November 24, 2018

- Elevation Certificates
- Base Flood Elevation
- Streams
- Wetlands
- Lakes, Ponds, and Creeks
- Floodplain**
- 0.2 pct annual chance (500-yr)
- 1 pct annual chance (100-yr)
- Floodway
- 1 pct annual chance future conditions
- Jurisdictions



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User

2.2 Current Condition

In order to support recommended strategies for restoration and conservation of Bolin Forest, past studies that evaluate the condition of the various ecosystems, both within the forest and creek, have been reviewed and summarized. This section summarizes the current health of Bolin Forest and Bolin Creek.

2.2.1 Terrestrial habitat quality assessment

a.) Forest Cover

Forest cover is largely composed of dry mesic mixed oak-hickory/pine forest and mesic mixed hardwood forests in upland regions, and piedmont bottomland forests in the Bolin Creek floodplain according to the 2004 NHP survey [6]. *The 2009 Bolin Creek Conceptual Master Plan* also notes the presence of basic mesic forest along slopes, ravines, and well drained stream bottoms [8]. These forest types are based on the [NHP Plant Communities Classification](#) [16]. This diversity of soil types and moisture levels allow for an abundance of trees and plants throughout the various forest canopy layers.

The canopy of the lowland regions includes hardwoods like sweetgum (*Liquidambar styraciflua*), tulip poplar (*Liriodendron tulipifera*), beech (*Fagus grandifolius*), and some American Sycamore (*Platanus occidentalis*). A few small natural depressions have been recorded that are able to support willow oak (*Quercus phellos*), although a more recent survey is needed to verify these still exist. The herb layer is dense near Bolin Creek. Japanese stiltgrass (*Microstegium vimineum*) and Chinese privet (*Ligustrum sinense*), both invasive, exotic competitors of native plants, are abundant near the OWASA corridor and in the floodplain [2,6,8].

The OWASA corridor and recreational use has altered the vegetation that once existed along the floodplain. Where trees are still present, they are smaller in age and diameter. There are locations throughout the forest where bank erosion and creek incision is apparent [1,8]. This altered hydrology can greatly reduce connectivity between the creek and floodplain which wildlife rely on. Trails throughout the forest are heavily used resulting in lack of vegetation and compacted soils. Trail braiding also occurs throughout the forest. Trail proximity to the creek in several locations has resulted in soil erosion into Bolin Creek or its tributaries. [1,6]

Along high sections of the outer floodplain and lower slopes are mixed mesic hardwood sites. The canopy in these sites includes shagbark hickory (*Carya ovata*), white oak

(*Quercus alba*), red maple (*Acer rebrum*), and southern red oak (*Q. falcata*). Understory trees include Umbrella magnolia (*Magnolia tripetala*), a regionally rare species, and sourwood (*Oxydendrum arboretum*). Painted buckeye (*Aesculus sylvatica*) and spicebush (*Lindera benzoin*) are common in the shrub layer [2,6,8].

Drier upland sites support species such as loblolly pine (*Pinus taeda*), post oak (*Quercus stellate*), blackjack oak (*Quercus marilandica*), pignut hickories (*Carya glabra*), and shortleaf pine (*Pinus echinata*). The understory includes redbud (*Cercis canadensis*), dogwood (*Cornus florida*), sourwood (*Oxydendrum arboretum*), and red cedar (*Juniperus virginiana*). The herb layer is sparse in the upland regions [2,6,8].

In August 2018, An official [Harvest Plan](#) was provided by N.C.Forest Service for the PH Craig Property. This plan recommended clear-cutting approximately 35 acres of pine dominated hardwood stands on the property and replanting with a monoculture stand of loblolly pines for future timber production. Clearing for this process began in October, 2018 and will end in December..

b.) Terrestrial Wildlife

The NC Wildlife Commissions GAP analysis project identified multiple high priority habitats for wildlife along the riparian corridor of Bolin Forest. Piedmont floodplain forests are critical habitats for wildlife and act as movement corridors for birds, mammals, reptiles, and amphibians. North Carolina Wildlife Commission identified priority species within designated NC Piedmont ecoregions in [Ch. 5 of the 2015 NC Wildlife Action Plan](#). [4,16]

Priority wildlife species currently inhabiting Bolin Forest include but are not limited to: Wood Thrush (*Hylocichla mustelina*), Brown-headed Nuthatch (*Sitta pusilla*), Yellow-Billed Cuckoo (*Coccyzus americanus*), and the Cooper's Hawk (*Accipiter cooperii*), Four-toed salamander (*Hemidactylium scutatum*), marbled salamanders (*Ambystoma opacum*), spotted salamanders (*Ambystoma maculatum*), Silver-haired Bat (*Lasionycteris noctivagans*), Long-tailed Weasel (*Mustela frenata*), spotted turtle (*Clemmys guttata*), and the broadhead skink (*Eumeces laticeps*) [6,8,16]

2.2.2 Aquatic habitat quality assessment

a.) Status

[The 2005 NC Division of Water Quality \(DWQ\) Cape Fear Basinwide Plan](#) categorized Bolin Creek as an “impaired” stream and it is still currently on the [North Carolina 303\(d\) list](#) of impaired waterbodies. As of 2016, the 303(d) list has Bolin Creek listed from Pathway Drive within Bolin Forest Neighborhood (adjacent to PH Craig property) downstream as being impaired. NCDWQ uses presence and abundance of diverse aquatic organisms as an indicator of stream health. Impairment status suggests an inability to support biological species expected in a comparable, fully functional stream. This classification was based on benthic macroinvertebrate surveys done from 1993-2003 by DWQ as well as more frequent annual monitoring from the towns of Carrboro and Chapel Hill since 2000. The results of these studies indicated that the creek was biologically impaired with a progressive decline in watershed health as you move downstream. Over time, stream impairment, though once seen only downstream near areas of high development, is now evident upstream as far north as the Pathway Drive in residential neighborhood Bolin Forest. Fish communities in Bolin Creek do not yet seem to show impairment though presence and abundance of rare and significant species are not currently known and sufficient surveys are needed [1,7,26]. .

c.) Hydrology and Fluvial Geomorphology

Bolin Creek has been studied extensively since biological impairment became evident. In 2003, as part of the NC Ecosystem Enhancement Program, DWQ completed a watershed assessment of the Little Creek Watershed, including Bolin Creek, results were published in the [“Assessment Report: Biological Impairment in the Little Creek Watershed.”](#) In 2004, as part of the Morgan Creek and Little Creek Watershed Plan, a [Morgan Creek Detailed Assessment Report](#) and subsequent [Targeting of Management Report](#) was published. The latter report identifies management strategies to address the targeted areas for restoration, protection, and preservation of the watersheds.

In 2003, the upper portion of the watershed remained nearly 50 percent forested with relatively low levels of riparian buffer disturbance. Percentage of Impervious surfaces was also lower in these regions and benthic community and water quality ratings were relatively good compared to the lower reaches of the watershed [7]. But as several studies note, this portion of the Bolin Creek is likely the most susceptible to future development [1,3,7].

Due to the geological features of the Carolina Terrane, bedrock substrate can be found throughout the watershed. At these locations, the stream banks are relatively stable and incision is not common, though where bedrock is absent, incision, and consequential widening, have occurred. The lower portion of the watershed, downstream of Bolin

Forest sits on the Triassic basin, where incision, erosion, and sedimentation are commonly found. This portion has lower quality aquatic habitat due to various problems such as reduced riparian tree canopy and channel instability. Impairment of Bolin Creek downstream of Bolin Forest further emphasizes the need for preservation of Bolin Forest [1,4,7,9].

In 2011, *Carolina North Proposed Conservation Area Descriptions Report* noted within Carolina North-West, Bolin Creek is highly incised in the upper reaches and less incised farther downstream. The intermittent tributaries have lower levels of incision and their channels are generally stable [1,3]. There are two points of direct stormwater runoff from Seawell School Road into two different tributaries. Recent construction at the high school entrance will also result in another source of direct stormwater runoff into Jolly Branch (a tributary of Bolin Creek).

d.) Water chemistry

In 2012, the Bolin Creek Watershed Restoration Plan (BCWRP) was completed, which reviewed all existing studies of the watershed and provided recommendations for preservation and restoration of the watershed.

According to the BCWRP, “analysis for status and trends in water quality conditions showed no clear trend for any constituent except for expected seasonal variations in temperature and dissolved oxygen. No clear pattern of exceedance of state standards was apparent from the available data, either.” The study notes that they were monitoring for these specific constituents as they are known to be associated with urbanization, but that does not necessarily mean that they are the most important constituents to evaluate when determining stream health [1,2].

Part IV Strategies

Strategies to Attain Conservation Goals

In this document we have provided a review of natural resources, we have reviewed the health of the forest and the creek as it relates to the forest, and we have identified stressors both general and specific that impact Bolin Creek Natural Area. Here we will describe strategies to fulfill our overarching conservation goals and address the threats laid out above. Strategies will be categorized within the four conservation goals defined in Part I. Introduction and Goals. Within these more general objectives, examples of specific action plans, such as those that can be implemented by Friends of Bolin Creek or other willing individuals and organizations, are also presented.

1. Coordinated conservation management across all 400+ acres of land that comprise Bolin Creek Natural Area.
 - Bolin Creek Natural Area Committee- Form a work group which formally establishes the existence of valuable contiguous forest, guides decisions, and leads implementation. This committee should include both private and public landowners, local stakeholders, such as FOBC, and relevant experts.
 - Management Plan- Develop a collaborative long-term adaptable management plan for the entire Bolin Forest which provides specific implementation steps with the purpose of sustaining and managing natural resources, protecting biodiversity, restoring areas of impairment, restoring areas that have been timbered and manage those areas as early successional forests, and responding to both generic and specific threats.
 - Future Funding- A multi agency effort to seek out future funding opportunities; coordinated efforts are needed to pursue and develop innovative long-term and short-term funding possibilities for maintenance, monitoring, restoration, and land acquisition; research into urban forestry and riparian forest grants, government grants, as well as actively seeking out private donors.

- Land acquisition- By providing this inventory and the basis for coordinated action for the entire 425 acres, continue to urge and inspire our government leaders to acquire the last piece of private property, the PH Craig tract.
- Seek professional advice- About how to establish a better relationship with the one private landowner; addressing both external and internal motivations to sell; obtain necessary funds; and develop the funding and strategies to acquire the last piece private land within the forest boundaries.

“I believe the [private] property is best protected under a long-term conservation easement, where the tract can become part of the publicly protected land in the County to be enjoyed by the public and used for teaching, research and the long-term benefit of the community”

- *Doug J. Frederick, Professor, Department of Forestry and Environmental Resources, NC State University*

- Monitoring Plan- Establish a comprehensive Monitoring Plan and develop a sufficient natural resource inventory; conduct extensive surveys to establish a more current natural resource inventory to fill the knowledge gaps that pertain to priority native plant and animal communities, riparian health, invasive species, aquatic health, etc. Qualified experts should be utilized for surveying and monitoring assessments as well as guiding decisions such as frequency of surveys.
- Natural Resource Inventory Database- Develop database of natural resources and spatial data for public use potentially using coordinated effort with UNC-CH or NCSU. This effort will help guide management strategies, expose significant temporal and spatial patterns, and promote educational use of the forest and its natural resources for students.
- Strategic Partnerships- Establishing partnerships with similar organizations to build collaborations that will support and facilitate management efforts, i.e. Haw River Assembly, ECWA, NC Botanical Garden, etc. Conferences, symposiums, and other events can help bolster collaborations. One example, to be carried out by FOBC, might include an Urban Riparian Forest Symposium to reach out to similar local organizations and stakeholders with the purpose of building partnerships,

promoting project collaboration, advancing research, and evaluating existing conditions.

- Seek Recognition- Work to obtain urban forest and riparian forest awards and certificates in order to demonstrate and draw attention to restoration and management efforts. Obtaining recognition can assist in receiving funding as well as getting attention from the community. One example of such certificates is the NC Urban Forest Council's state-wide Urban Forestry Awards which recognize communities, organizations, and individuals for outstanding work in protecting and enhancing urban forests.

2. Restoration and preservation of habitat for natural communities, water quality and future resources

- Forest Restoration Projects- The most notable degradation is within or near the riparian zone. Improving ecological functions in this ecosystem will involve investigations into appropriate riparian restoration techniques (including invasive species removal, native species planting, stream bank restoration techniques that promote connectivity, etc.); establish long-term and short-term plans to implement projects; determine responsible parties.

Significant degradation can also be found on the PH Craig Tract. Concurrent timber projects beginning in October of 2018, detailed in Part III. Threats, are underway and will result in approximately 35 acres of PH Craig's property within Bolin Creek Natural Area to be clear cut and replanted with a monoculture of Loblolly Pine saplings. Research into proper management techniques of early successional forest will need to be investigated to determine proper management and restorative techniques to address degradation to this area.

- Investigate wildlife management and restoration strategies with the purpose of maintaining aquatic and terrestrial animal biodiversity within Bolin Forest and Bolin Creek. Such projects may include native plantings, providing habitat, increasing connectivity, etc.

- Minimize Utility Impacts- Minimize or prevent further fragmentation and degradation caused by utility easement and other infrastructure developments e.g. OWASA sewer line, Duke power line; Include developing policies and requirements to mitigate impairment caused by future projects or alterations of existing utility easements; Promote restoration projects from utility companies to mitigate issues such as bank erosion at creek crossings.
- Monitor long-term effectiveness of restoration projects- Measuring effectiveness of restoration projects over time will help guide and prioritize future projects and ensure that restoration projects fulfill objectives.
- Watershed Restoration- Review Bolin Creek watershed restoration projects that have previously been developed for Bolin Forest in pre-existing reports. Such studies include the *Bolin Creek Watershed Restoration Plan*, *Bolin Creek Watershed Geomorphic Analysis and Potential Site Identification for Stormwater Structures and Retrofit*, and *Morgan Creek and Little Creek Targeted Management Report*. Re-evaluate relevant projects to re-prioritize efforts based on available funding and feasibility.

3. Promote recreation that maintains the natural integrity of Bolin Forest and fosters a strong connection with nature.

- Trail Survey- Extensive survey of recreational trails and easements to determine impact of heavy traffic on ecosystem.
- Minimize and prevent further negative impacts from heavy recreation use- Rerouting or permanently closing trails where ecological impact is visible such as where trails are very near to the creek; Engage and educate visitors with trail signs, education pamphlets, etc.; Installation and maintenance of pet waste receptacles to minimize nutrient loading and littering.
- Establish Alternative Greenway Plan- Develop alternative plan to the Town of Carrboro's *Bolin Creek Greenway Master Plan* that avoids

impervious surfaces along the riparian corridor but still addresses recreational needs of the community.

4. Promote environmental stewardship to landowners and the wider community through education and outreach.

- Outreach and education- Community stewardship, Continue existing and create new Education and Outreach programs; Establish educational curricula and programs for local schools; Promote stewardship of landowners
- Promote and teach low-impact development techniques to students, local community members, and developers
- Community Workshops- Bolin Creek Neighborhood Workshops- volunteer recruiting, community involvement, Continuation and improvement of Raingarden Workshops
- Facilitate educational uses of the forest in both nearby k-12 public schools, day-schools and nature schools, and universities.
- Maintain a database of website links and summaries of relevant scientific studies and publications for public access.
- Utilizing Volunteers- Developing a network of community volunteers to assist with restoration projects, invasive species removal, trail maintenance, and monitoring; Reach out to students, local list-serves, community events, other organizations etc. to actively recruit volunteers.

References

1. Chapel Hill and Carrboro, N.C. "Bolin Creek Watershed Restoration Plan." 2012.
2. Biohabitats Inc., University of North Carolina at Chapel Hill Facilities Planning Department, "Carolina North Ecological Assessments Report", 2007.
3. Biohabitats Inc., University of North Carolina at Chapel Hill Facilities Planning Department, "Carolina North Proposed Conservation Area Descriptions", 2011.
4. N.C. Dept. of Natural Resources, Ecosystem Enhancement Program, September 2004. "Morgan and Little Creeks Local Watershed Plan, Upper Cape Fear River Basin," 2004.
5. Tetra Tech. Inc., N.C. Dept. of Natural Resources, Ecosystem Enhancement Program, "Morgan Creek Local Watershed Plan Targeting of Management Report," Upper Cape Fear River Basin, 2004.
6. Orange County Environment and Resource Conservation Department and N.C. Natural Heritage Program, Inventory of Natural Areas and Wildlife Habitats for Orange County, North Carolina, 2003.
7. N.C. Dept. of Natural Resources, Divisions of Water Quality (DWQ), Planning Branch. Assessment Report: Biological Impairment in the Little Creek Watershed, Cape Fear River Basin, Orange County, N.C, 2003.
8. Greenways, Inc., Town of Carrboro, N.C., Bolin Creek Conceptual Master Plan, 2009.
9. EarthTech Inc., Carrboro, N.C., Bolin Creek Watershed Geomorphic Analysis and Potential Site Identification for Stormwater Structures and Retrofit, 2007.
10. Bellassen, Valentin, and Sebastiaan Luyssaert. "Carbon sequestration: Managing forests in uncertain times." *Nature* 506.7487 (2014): 153-155.
11. Stephenson, Nathan L., et al. "Rate of tree carbon accumulation increases continuously with tree size." *Nature* 507.7490 (2014): 90.
13. The Catena Group Inc., Orange County, N.C., Bolin Creek Greenway Conceptual Master Plan Goals Consistency Review, 2010
14. North Carolina Natural Heritage Program N.C. Department of Natural and Cultural Resources, List of Rare Animal Species of North Carolina, 2016, revised 4 April 2017.

15. Tyrväinen, Liisa, et al. "Benefits and uses of urban forests and trees." Urban forests and trees. Springer, Berlin, Heidelberg, 2005. 81-114.
16. North Carolina Wildlife Resource Commission, North Carolina Wildlife Action Plan, 2015.
17. The Economic Benefits of Greenspace, Ohio Land Bank Conference, September 11, 2014, James Kastelic, Trust for Public Land
https://www.wrlandconservancy.org/documents/conference2014/Economic_Benefits_of_Greenspace.pdf
18. Town of Carrboro, 3 Year Management Plan, Adams Preserve, N.C.
19. Chilton, M., and Longnecker M., History of Bolin Creek
<http://bolincreek.org/blog/education/history/>
20. Ridgon, D., History of the Adams Preserve, <http://bolincreek.org/blog/education/history/>
21. Strava Global Heat Map Data
<https://www.strava.com/heatmap#8.95/-77.57562/35.43916/hot/all>
22. Benefits of Nature Field Trips, Learning Through Nature, Nature Academy
<https://www.naturesacademy.org/educator-resources/5-benefits-outdoor-education/>
23. North Carolina DEQ, Jordan Lake Nutrient Strategy
<https://deq.nc.gov/about/divisions/water-resources/water-planning/nonpoint-source-planning/jordan-lake-nutrient#Background>
24. North Carolina Ecosystem Response to Climate Change: DENR Assessment of Effects and Adaptation Measures- DRAFT, 2010.
25. Hession, W. C., et al. "Ecological benefits of riparian reforestation in urban watersheds: study design and preliminary results." Environmental Monitoring and Assessment 63.1 (2000): 211-222.
26. NC Department of Water Quality, "Final 2016 Category 5 Assessments -303(d) List," 2016, updated March 2018
27. Town of Chapel Hill Interactive Map, created 2016, updated 2018
<https://www.arcgis.com/home/item.html?id=80349906ba244c9395b5555e7faaba1c>
28. Orange County GIS Data
<https://gis.orangecountync.gov:8443/orangeNCGIS/default.htm>

29. The University of North Carolina at Chapel Hill Facilities Planning Department, Carolina North Development Agreement Annual Report 2012-2013.
30. North Carolina Wildlife Commission GAP Analysis Project
<http://www.basic.ncsu.edu/ncgap/>
31. Benefits of on-site Educational Field Trips, National Park Services
<https://www.nps.gov/wicr/learn/education/upload/Benefits-of-an-On-Site-Education-Program-2.pdf>
32. Gundersen, Per, et al. "Environmental services provided from riparian forests in the Nordic countries." *Ambio* 39.8 (2010): 555-566.
33. Calder, Ian, et al. "Towards a new understanding of forests and water." *Unasylva* 58.229 (2007): 3-10.
34. J. Barton, R. Hine & J. Pretty (2009) The health benefits of walking in greenspaces of high natural and heritage value, *Journal of Integrative Environmental Sciences*, 6:4, 261-278
35. PH Craig Harvest Plan
http://bolincreek.org/blog/wp-content/uploads/2018/06/PH_Craig_Harvest_Plan_CB.pdf