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Committee Members:
To be determined

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How does disturbance shape avian community composition and diversity in ephemeral wetlands?

Abstract

Wetlands provide humans with critical ecosystem services and serve as important repositories of biodiversity; however, little is known about the importance of small isolated ephemeral wetlands which are largely ignored by managers and policy makers. Ephemeral wetlands in the south eastern coastal plain support a host of specialist plant and herpetological species, but it is unknown if they support unique bird communities. The purpose of our study is to examine how disturbances--prescribed fire and tree thinning treatments--will alter ephemeral wetlands and their constituent avifauna. We will collect avian point count, vegetation, and wetland attribute data at 2 field sites, with one receiving thinning treatments. We expect to find that thinning treatments will reduce bird species richness but may result in larger wetlands with longer hydroperiods. Our study will provide critical information on what bird assemblages are supported by ephemeral wetlands and how these communities are influenced by management disturbances.

Statement of Interest

I have been compelled since the final year of my undergraduate career to study the ecology of our changing planet, with particular emphasis on biodiversity, community ecology, and conservation. My fascination with birds has led me to a project that largely harnesses the aforementioned themes of restoration, forest and wetland management, and bird biodiversity. The primary objective this project fulfills for my graduate career is that it is novel research with broad applications for a diverse audience of conservation practitioners. Oftentimes science lacks adequate communication and distribution to the parties it aims to engage. For example Lab X studies how Hooded Warblers disperse post-breeding in Georgia, it gets published in *The Condor*, and a private landowner in central Georgia managing his land for wildlife conservation never hears about how a certain habitat matrix is important post-fledging for Hooded Warblers. Habitats are managed for birds across our region, and yet academics who study birds--as well as other taxa--rarely interact with the people who manage for them on the vast tracts of private property across the Southeast. That disconnect is addressed by our project incorporating multiple academic institutions with a private landowner, local NGOs, and private land management company to generate actionable science on the ground. Our project utilizes bird biodiversity as the window into this system which has a complex management apparatus including national NGOs like the *National Audubon Society*, local state agencies like SCDNR, and private landowners.

The other objective that this project fulfills is engagement in the scientific process from start to finish. The process of question formulation, methodological design, troubleshooting, restarting, analyzing data, and discussing results is necessary to be a thoughtful scientist in my future academic and professional endeavours. This objective will potentially provide a career path into conservation, whether that be through private land management, graduate school as a PhD student, or further field technician work with a government or non-governmental organization. By engaging in scientific research I can hone the necessary skills for a career in conservation including: study design, grant writing, data analysis, bird monitoring techniques, vegetation sampling techniques, and manuscript writing. This thesis project will give me the tools I need to both complete ecological scientific research and communicate that research to the diverse set of stakeholders that need better access to inform their conservation management practices.

We hope to target our research for publication in *Wetlands*, *Conservation Biology*, or the *Journal of Applied Ecology*. Our current goal is to produce at least one publishable unit, and potentially a second publishable white paper targeted for distribution through Bird-friendly Forestry at *Audubon South Carolina* or through the *Longleaf Alliance*. Once more, the publishing of this research is two-pronged in it's aim to inform the literature in journals, as well as the white literature utilized by many private landowners and non-government organizations that do a vast majority of bird conservation locally, nationally, and globally.

Project Proposal

Introduction

Globally biodiversity is in decline due to the degradation and loss of habitat from changes in land use and climate (Dirzo et al. 2014). Restoration ecology attempts to mitigate these losses by managing ecosystems to benefit species of concern; however, restoration management is not always effective due to the regional and historical context of the site under management (McGlinn and Palmer 2019). This can make developing ecosystem level management plans challenging as a one-size-fits-all approach seldom accomplishes the diverse set of goals of the stakeholders involved in the restoration project.

The coastal plain of South Carolina has been dramatically altered by humans for agriculture, timber production, and suburban development. Ecologists have tried to restore these habitats through management, in an attempt to repair the damage done by human development (Jones and Schmitz 2009). Restoration has been undertaken by a multitude of stakeholders, and in a wide variety of habitats; wetlands represent a significant habitat for ecological restoration (Tiner 2003; Sharitz 2003). Wetlands provide an assortment of ecosystem services including flood management, water filtration, and carbon storage. Restoring wetlands can also offer ecological benefits to various amphibian and invertebrate species (Tiner 2003). Wetlands exist within a variety of habitat community types, and are niche habitat for a host of specialist tree, shrub, and herbaceous species (Moreno-Mateos et al. 2012). We have lost an estimated 31% of wetlands globally (Dixon et al. 2016). However, despite the recognized ecosystem services provided by larger wetlands, ephemeral wetlands have not been a management priority (Semlitsch and Bodie 1998).

Ephemeral wetlands are a subset of seasonally flooded depressions, isolated from other water sources such as streams and creeks that are surrounded by upland habitat (Snodgrass et al. 2000). These wetlands are threatened in South Carolina by salt intrusion, road construction, drainage for residential housing, and particularly for agricultural purposes (Millennium Ecosystem Assessment (Program) 2005). It is estimated that only 10% of the original distribution of ephemeral wetlands remain in the South Carolina Bay ecotone (Bennett and Nelson 1991). Therefore, they represent a critical habitat that needs more research to determine their ecological value, and what response flora and fauna communities have to their disappearance and/or management (Snodgrass et al. 2000; Van Lear et al. 2005a). Ephemeral wetlands exist within all habitat types, but are noted for their ecological importance in the threatened Longleaf Pine habitat matrix, where it is critical to analyze the land use-history.

Land-use history is a critical disturbance regime that alters landscapes and habitats from their natural unaltered state. In South Carolina, for 12,000 years pre-European colonization, native peoples utilized prescribed fire to control Longleaf pine savanna-grassland habitat to produce wildlife habitat for hunting, to favor nut and berry producing plants, and protect themselves from predators and enemy tribes(Whittle. 1984. Van Lear et al. 2005b). Following European settlement, which eradicated native people, fire was largely suppressed and land was slowly converted for agriculture, resulting in wetland drainage for rice paddy construction, and timber production (Rostlund 1957). Today, Longleaf pine (*Pinus palustris*) is a community type particularly targeted by restoration efforts due to its alarming disappearance across it's natural range from fire suppression, land conversion, urbanization, and timber production (Van Lear et al. 2005). Restoration of the wetlands in this habitat focus on ditch plugging to restore hydrology, and woody tree removal to reduce water transpiration in the early summer months, as well as the reintroduction of fire to control mid-story growth (Tiner 2003). The ephemeral wetlands within this habitat complex vary significantly in their size, biotic communities, and hydrology, as well as their land use histories which play a significant role in determining ecological restoration priorities.

Ephemeral wetlands are site specific, varying in their respective hydrology, plant structure, hydroperiod, connectivity, and size. In our region the most common ephemeral wetland types are Coastal Plain Ponds and Carolina Bays, which can vary in size from 50 m in length to 8 km in length (Sharitz 1982). They can vary in connectivity due to agricultural ditching in the past, which can drain these wetlands prematurely in the early summer (Tiner 2003; Sharitz 2003). Lastly, their plant structure can vary greatly from herbaceous cover with little canopy, to many midstory plants with low herbaceous cover, creating unique vegetation structure that can vary greatly from surrounding Longleaf Pine savannah habitat (Sharitz 2003; 1982). Oftentimes ephemeral wetlands in our region have been impacted by the land-use histories mentioned earlier, and the wetland attributes have also changed in response, as they've been slowly encroached by woody tree species that increase water transpiration, resulting in disrupted hydrology during the early summer months (Warren, II. et al. 2007). The bird biodiversity occupying these unique habitats has largely been ignored due to their relatively small size, but due to their numerous appearance across the landscape, they could be an important habitat niche for avifauna communities.

It is known that ephemeral wetlands are utilized by herpetological communities (Snodgrass et al. 2000), and to a lesser extent by avifauna. Wading birds utilize small ephemeral wetlands but due to their large home range, size, and mobility; they easily migrate to other water bodies when ephemeral wetlands dry up in the summer(Herteux, Gawlik, and Smith 2020; Morganti et al. 2019). Ephemeral wetlands in the Southeast may therefore represent a common foraging ground for Wood Stork (*Mycteria americana*), and Great Blue Heron (*Ardea Herodias*) in early summer, especially if they have less canopy cover. Hanowski et al. (2006) found that forest harvest around ephemeral wetlands provided short term habitat for early forest successional species, but in the long-term only provided habitat for forest generalists (Hanowski, Danz, and Lind 2006). There is evidence that this trend is similar in managed longleaf pine in habitats in Georgia (Lee et al. 2020). However, Lee et al. were focused on upland habitat and game species, not ephemeral wetlands and neotropical passerines which are both facing steep declines across the Southeast (Bennett and Nelson 1991).

Birds in forested ephemeral wetlands in the Northeast did not contain any positive correlation with wetland specific, or forest specialist species due to the similar habitat structure of the wetlands and surrounding uplands (Riffell, Burton, and Murphy 2006). However, in our study sites in Longleaf Pine Savannah, vegetation structure varies greatly between the upland dominated by Longleaf Pine (*Pinus palustris*) and Loblolly Pine (*Pinus taeda*) and wetlands which contain many hardwood trees like Black Tupelo (*Nyssa sylvatica*) and Red Maple (*Acer rubrum*). Additionally, the wetland attributes, size, water depth, dominant tree species, and herbaceous species, have not been combined with land management history (timber harvest, rice paddy impoundments) to analyze the community composition or create species distribution models (SDMs) in ephemeral wetlands within our regional context. It is critical to know if threatened bird species such as the Swainson's Warbler, Sedge Wren, or other threatened species are utilizing these habitats, and if so, will the loss of ephemeral wetlands exacerbate rapidly declining bird populations.

Some bird species breeding biology and habitat preferences across the United States are not entirely well understood. Ephemeral wetlands may represent a critical habitat niche, invertebrate foraging space, or nesting habitat above water for forest understory birds, or forest edge specialists. Hooded Warbler (*Setophaga citrina*) nests in the dense understory of swampy mixed hardwood forests of the Southeast, usually with canopy gaps. The size and scale of their preferred wetland habitat has not yet been completely defined, and this species may be utilizing ephemeral wetlands for nesting if there are significant gaps in the canopy (Whittam et al. 2002). Open canopy gaps are an end result of proposed restoration treatments removing woody plants in ephemeral wetlands sites under mitigation (Pasher, King, and Lindsay 2007). This is just one neotropical migrant bird species that may utilize ephemeral wetlands. Birds are already facing increasing pressure from land conversion as well as other anthropogenic land-uses, and who may benefit, or be adversely affected by restoration efforts that prioritize herpetological species, threatened plant species, or other land management priorities.

This project seeks fill in this critical information gap: How do the wetland attributes (area, water depth, vegetation), the disturbance regime (fire, agriculture, coastal flooding), and the restoration targets of land owners/managers determine the avian community composition in ephemeral wetlands within our unique regional context (**Figure 1**, below). We will conduct avian biodiversity monitoring in wetlands targeted for ecological restoration and compare them to unrestored wetlands to what bird communities are utilizing ephemeral wetlands, how are they impacted by restoration activities, and which wetland attributes influence bird community assemblages.

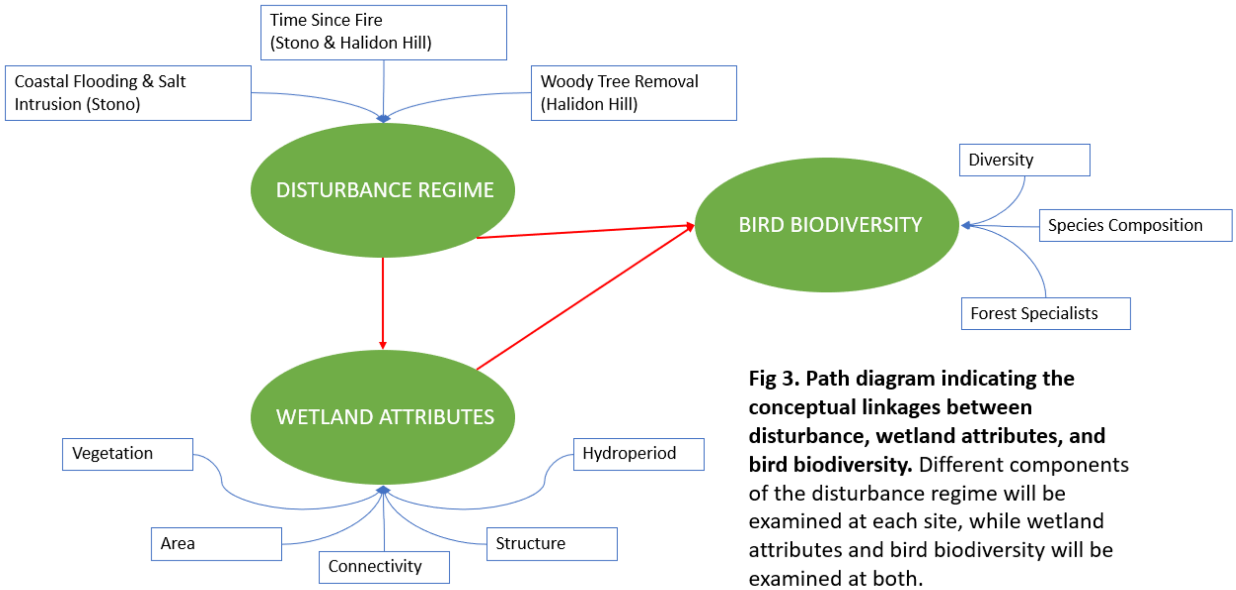

Fig 3. Path diagram indicating the conceptual linkages between disturbance, wetland attributes, and bird biodiversity. Different components of the disturbance regime will be examined at each site, while wetland attributes and bird biodiversity will be examined at both.

Research Question

How does disturbance shape avian community composition and diversity in ephemeral wetlands?

Q_1: What are the impacts of three different wetland management prescriptions (hack and squirt, cut and leave, and cut and remove) on bird biodiversity?

Q_2: At what spatial and temporal scales do birds respond to isolated wetland restoration?

The objective of the proposed study is to understand the drivers of bird community usage of ephemeral wetlands to inform best management practices of this important and threatened habitat.

1. Examine which species of birds are using ephemeral wetlands.

2. Compare how birds respond to different mechanical woody thinning techniques.

3. Examine how birds in ephemeral wetlands change with time since prescribed fire.

4. Setup baseline measurements for long-term monitoring of salt intrusion in ephemeral wetlands that are at greater risk to flooding.

5. Use the information gained in completing previous objectives to develop regional species distribution models.

6. Make management recommendations based upon how birds use this habitat and how these sites respond to disturbance.

Hypotheses

H_1: Forest bird specialists (Least Flycatcher, Wood Thrush, Hooded Warbler) are associated with Cypress, Black Gum, and Water Oak dominated ephemeral wetlands.

H_2: Prothonotary Warbler is associated with longer hydroperiod, greater canopy cover, and larger area in hardwood dominated ephemeral wetlands.

H_3: Thinning treatment sites at Halidon Hill will increase forest generalist species abundance, and decrease forest specialist species abundance.

H_4: Sites with more recent fire will have thinner canopies and potentially different bird species that specialize on them.

H5: Ephemeral wetlands exhibit a 'watering hole effect', where species richness is dramatically higher and more diverse than surrounding upland sites.

Methodologies

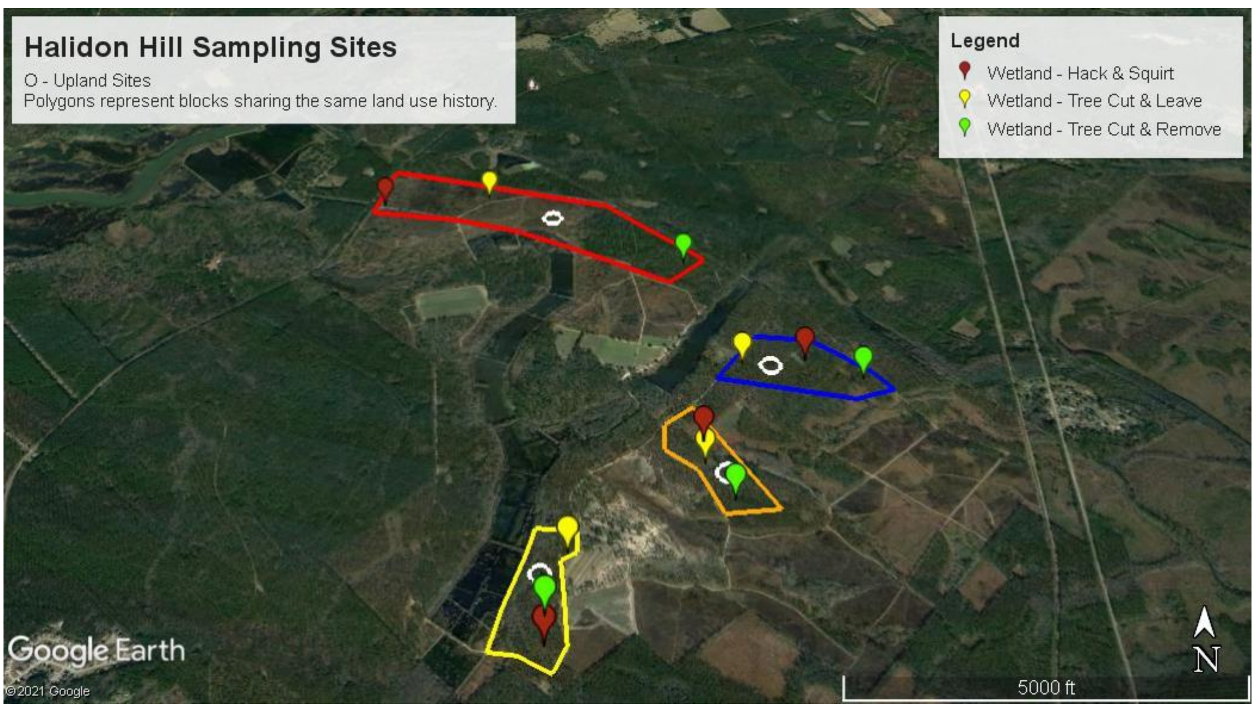

Figure 2. Halidon Hill Sampling Sites.

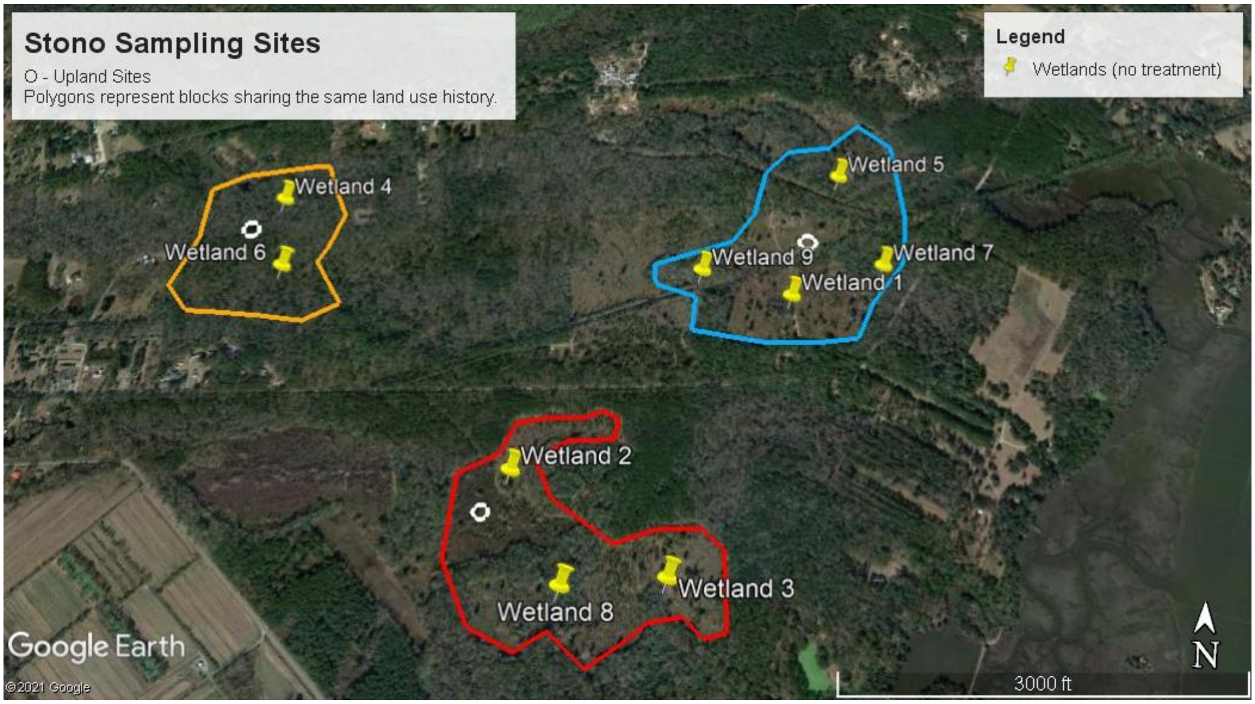

Figure 3. Stono Preserve Sampling Sites

To achieve objective 1, we need to create a block study design where *n*=3 wetland sites and *n*=1 upland site are grouped together that share habitat type, disturbance history, management goal and are in close proximity (>0.5km) (see **Figure 2**). The *n*=3 wetland sites within each block must vary in their wetland attributes (i.e., vegetation structure, hydroperiod, area, and water depth). Within each block, upland sites will act as a control site for the 3 paired wetlands. Upland sites will be in typical open-canopy Longleaf Pine Savannah. Within each block, the *n*=3 wetlands will each receive 1 of 3 different treatments, randomly assigned (represented by bubble colors on Map). The 3 treatments are the following: 1) Hack & Squirt; trees under 15 dBH have bark shaved and herbicide is applied directly into camber layer, 2) Tree Cut & Leave; trees under 15 dBH are cut and left on site to decay, 3) Tree Cut & Removal; trees under 15 dBH are cut and moved >25m from the wetland.

Point counts will be conducted in 5 minute intervals, where the observer will also notate birds flushed upon entry into the wetland, as described by Riffel et al. (Riffell, Burton, and Murphy 2006). Birds will be identified within 25m or 50m distance bands from the center of each wetland from May 1-June 15, 2021 and May 1-June 15, 2022. Birds will be notated as either auditorily, or visually identified. We will notate the number of each species heard or seen in each plot, to get abundance and species richness data. Surveys will be performed at each site twice during the summer of 2021 and summer of 2022. Counts will be performed in random order, and reversed for subsequent visits to combat overestimation or underestimation bias. Counts will be performed at least 30 minutes after sunrise and no later than 3 hours after sunrise. Each wetland block of *n*=3 will be paired with a point count at an upland site <150m away to control for species distributions associated with ephemeral wetlands.

To achieve objective 2, we will survey for each of the desired wetland attributes using the following methods. We will measure the following wetland attributes: area (m^2), water depth (cm), high water mark (cm), surface area covered (%wet). Area will be measured in ArcGIS, using shape file delineations to estimate area when fully inundated with water in early Spring. Each point count will also be accompanied by %wet estimation, which is an estimation of water surface area coverage compared to the high-water mark when wetland delineations are 100% covered in water. We will notate water depth in cm using conduit pipe submerged 2 ft underground in the center of the wetland, with tape marks every centimeter. We will count the number of visible marks from the top to the watermark to obtain the water depth reading.

We will perform vegetation sampling surveys at each site notating: canopy cover (%) using a densiometer, vegetation structure, understory vegetation cover (%),tree species of largest dBH within 15m of wetland described in Bastin et al (Bastin et al. 2015). We will measure vegetation structure using the Roble Pole method (Joubert, Powell, and Schacht 2015). We will use a densiometer to measure canopy cover, notating each ¼ square with visible sky free of canopy obstruction (Jennings, Brown, and Sheil 1999). Lastly, we will utilize a quadrat sampling method to determine understory vegetation cover (Rahman, Khan, and Ali 2017). We will sacrifice defining all plants to species level in favor of general structural elements of the wetland and surrounding vegetation to generate a more robust avian model, as it has been shown vegetation structure is more important in determining avifauna communities than vegetation species(Melin et al. 2019; Riffell, Burton, and Murphy 2006).

To achieve objectives 3 and 4 we will collect the aforementioned data at Stono Preserve which experiences coastal flooding and prescribed fire was recently applied (Spring 2021, see **Figure 3**). We will use a block design design (n = 9) to analyze how time since fire impacts avian community composition in ephemeral wetlands. Halidon Hill is burned 2-3 times annually while Stono receives fire treatment every 2-3 years.

We will perform quantitative analysis using R, to differentiate between treatments and control sites in terms of bird abundance and richness. We will also utilize spatial analysis to determine how isolated wetland size impacts bird biodiversity assemblages. We will perform data analysis to create species distribution models (SDM) for detected species at both Halidon Hill and Stono, which can be tested by future MS students or by local/state agencies.

Timeline

2021	Summer	Fall	Winter	
Objectives	-Collect first year data at Halidon Hill and Stono (*n*=32)	-Input data into database - Begin writing introduction, and methods sections for thesis and publication	- Complete introduction, and methods section of manuscript - Analyze first year data to assess potential data trends	
2022	**Spring**	**Summer**	**Fall**	**Winter**
Objectives	- Complete introduction, methods sections of manuscript - Thinning treatments performed at Halidon Hill	-Collect second year post-treatment data at Halidon Hill and Stono (*n*=32)	- Perform analysis - Write results and discussion sections of manuscript - Submit thesis for review	- Schedule thesis defense - Defend thesis - Prepare manuscript for scientific publication in *Wetlands*

Conclusion

Ephemeral wetlands represent an understudied habitat type within our regional context. The avian communities that utilize these habitats are even less understood, and may be critical for both migratory and resident breeding bird species in South Carolina. The impacts of human development take multiple forms across our landscape including agriculture, timber production, game management, road construction amongst many others. This study through the methodological design aims to gauge how the interactions between wetland attributes and disturbance regime can drive bird biodiversity in ephemeral wetlands. This data will be useful to land managers on a local scale looking to manage their wetlands for bird species. The results could also be useful at the regional scale for organizations like SCDNR who manage tracts of land and could cross-reference our ephemeral wetland bird model with observations to improve habitat modelling for target bird species across the state. Finally, this research aims to improve the linkage between academic science and conservation practice in the lowcountry by engaging private landowners, land management companies, and academic institutions. Ultimately our goal is to perform novel scientific research and make that science communicable and approachable for a multitude of conservation practitioners within our region.

Bibliography

Bastin, J.-F., N. Barbier, M. Réjou-Méchain, A. Fayolle, S. Gourlet-Fleury, D. Maniatis, T. de Haulleville, et al. 2015. "Seeing Central African Forests through Their Largest Trees." *Scientific Reports* 5 (1): 13156. https://doi.org/10.1038/srep13156.

Bennett, Stephen H., and John B. Nelson. 1991. *Distribution and Status of Carolina Bays in South Carolina*. Columbia: South Carolina Wildlife & Marine Resources Dept.

Dirzo, Rodolfo, Hillary S. Young, Mauro Galetti, Gerardo Ceballos, Nick J. B. Isaac, and Ben Collen. 2014. "Defaunation in the Anthropocene." *Science* 345 (6195): 401–6.

Dixon, M. J. R., J. Loh, N. C. Davidson, C. Beltrame, R. Freeman, and M. Walpole. 2016. "Tracking Global Change in Ecosystem Area: The Wetland Extent Trends Index." *Biological Conservation* 193 (January): 27–35. https://doi.org/10.1016/j.biocon.2015.10.023.

Hanowski, JoAnn, Nick Danz, and Jim Lind. 2006. "Response of Breeding Bird Communities to Forest Harvest around Seasonal Ponds in Northern Forests, USA." *Forest Ecology and Management* 229 (1): 63–72. https://doi.org/10.1016/j.foreco.2006.03.011.

Herteux, Camille E., Dale E. Gawlik, and Lora L. Smith. 2020. "Habitat Characteristics Affecting Wading Bird Use of Geographically Isolated Wetlands in the U.S. Southeastern Coastal Plain." *Wetlands* 40 (5): 1149–59. https://doi.org/10.1007/s13157-019-01250-y.

Jennings, SB, ND Brown, and D Sheil. 1999. "Assessing Forest Canopies and Understorey Illumination: Canopy Closure, Canopy Cover and Other Measures." *Forestry: An International Journal of Forest Research* 72 (1): 59–74. https://doi.org/10.1093/forestry/72.1.59.

Jones, Holly P., and Oswald J. Schmitz. 2009. "Rapid Recovery of Damaged Ecosystems." Edited by Geoffrey Clayton Trussell. *PLoS ONE* 4 (5): e5653. https://doi.org/10.1371/journal.pone.0005653.

Joubert, Dave, Larkin A. Powell, and Walter H. Schacht. 2015. "Visual Obstruction as a Method to Quantify Herbaceous Biomass in Southern African Semi-Arid Savannas." *African Journal of Range & Forage Science* 32 (3): 225–30. https://doi.org/10.2989/10220119.2014.919960.

Lee, Myung-Bok, Brian J. Gates, Robert J. Cooper, and John P. Carroll. 2020. "Avian Taxonomic and Functional Diversity in Early Stage of Longleaf Pine (Pinus Palustris) Stands Restored at Agricultural Lands: Variations in Scale Dependency." *Restoration Ecology* 28 (1): 147–55. https://doi.org/10.1111/rec.13053.

McGlinn, Daniel J., and Michael W. Palmer. 2019. "Examining the Assumptions of Heterogeneity-Based Management for Promoting Plant Diversity in a Disturbance-Prone Ecosystem." *PeerJ* 7 (May): e6738. https://doi.org/10.7717/peerj.6738.

Melin, Markus, Ross A. Hill, Paul E. Bellamy, and Shelley A. Hinsley. 2019. "On Bird Species Diversity and Remote Sensing—Utilizing Lidar and Hyperspectral Data to Assess the Role of Vegetation Structure and Foliage Characteristics as Drivers of Avian Diversity." *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* 12 (7): 2270–78. https://doi.org/10.1109/JSTARS.2019.2906940.

Millennium Ecosystem Assessment (Program), ed. 2005. *Ecosystems and Human Well-Being: Synthesis*. Washington, DC: Island Press.

Moreno-Mateos, David, Mary E. Power, Francisco A. Comín, and Roxana Yockteng. 2012. "Structural and Functional Loss in Restored Wetland Ecosystems." Edited by Michel Loreau. *PLoS Biology* 10 (1): e1001247. https://doi.org/10.1371/journal.pbio.1001247.

Morganti, Michelangelo, Milo Manica, Giuseppe Bogliani, Marco Gustin, Federica Luoni, Paolo Trotti, Vincenzo Perin, and Mattia Brambilla. 2019. "Multi-Species Habitat Models Highlight the Key Importance of Flooded Reedbeds for Inland Wetland Birds: Implications for Management and Conservation." *Avian Research* 10 (1): 15. https://doi.org/10.1186/s40657-019-0154-9.

Pasher, Jon, Doug King, and Kathryn Lindsay. 2007. "Modelling and Mapping Potential Hooded Warbler (Wilsonia Citrina) Habitat Using Remotely Sensed Imagery." *Remote Sensing of Environment* 107

(3): 471–83. https://doi.org/10.1016/j.rse.2006.09.022.
"Prehistoric Europe: By T. Champion, C. Gamble, S. Shennan and A. Whittle. 1984. Vii + 359 Pp., Tables, Figures. London: Academic Press. £28·50 (Paperback £14·50). ISBN 0 12 167550 5." 1986. *Journal of Archaeological Science* 13 (1): 92–93. https://doi.org/10.1016/0305-4403(86)90031-2.
Rahman, Inayat Ur, Nasrullah Khan, and Kishwar Ali. 2017. "Classification and Ordination of Understory Vegetation Using Multivariate Techniques in the Pinus Wallichiana Forests of Swat Valley, Northern Pakistan." *Die Naturwissenschaften* 104 (3–4): 24. https://doi.org/10.1007/s00114-017-1431-2.
Riffell, Samuel, Thomas Burton, and Margaret Murphy. 2006. "Birds in Depressional Forested Wetlands: Area and Habitat Requirements and Model Uncertainty." *Wetlands* 26 (1): 107–18. https://doi.org/10.1672/0277-5212(2006)26[107:BIDFWA]2.0.CO;2.
Rostlund, Erhard. 1957. "The Myth of a Natural Prairie Belt in Alabama: An Interpretation of Historical Records." *Annals of the Association of American Geographers* 47 (4): 392–411. https://doi.org/10.1111/j.1467-8306.1957.tb01552.x.
Semlitsch, Raymond D., and J. Russell Bodie. 1998. "Are Small, Isolated Wetlands Expendable?" *Conservation Biology* 12 (5): 1129–33.
Sharitz, Rebecca R. 1982. *The Ecology of Southeastern Shrub Bogs (Pocosins) and Carolina Bays :A Community Profile /*. Washington, DC : http://hdl.handle.net/2027/mdp.39015086454900.
———. 2003. "Carolina Bay Wetlands: Unique Habitats of the Southeastern United States." *Wetlands* 23 (3): 550–62. https://doi.org/10.1672/0277-5212(2003)023[0550:CBWUHO]2.0.CO;2.
Snodgrass, Joel W., Mark J. Komoroski, A. Lawrence Bryan, and Joanna Burger. 2000. "Relationships among Isolated Wetland Size, Hydroperiod, and Amphibian Species Richness: Implications for Wetland Regulations." *Conservation Biology* 14 (2): 414–19.
Tiner, Ralph W. 2003. "Geographically Isolated Wetlands of the United States." *Wetlands* 23 (3): 494–516. https://doi.org/10.1672/0277-5212(2003)023[0494:GIWOTU]2.0.CO;2.
Van Lear, David H., W. D. Carroll, P. R. Kapeluck, and Rhett Johnson. 2005a. "History and Restoration of the Longleaf Pine-Grassland Ecosystem: Implications for Species at Risk." *Forest Ecology and Management*, Relative Risk Assessments for Decision –Making Related To Uncharacteristic Wildfire, 211 (1): 150–65. https://doi.org/10.1016/j.foreco.2005.02.014.
Van Lear, David H., W.D. Carroll, P.R. Kapeluck, and Rhett Johnson. 2005b. "History and Restoration of the Longleaf Pine-Grassland Ecosystem: Implications for Species at Risk." *Forest Ecology and Management* 211 (1–2): 150–65. https://doi.org/10.1016/j.foreco.2005.02.014.
Warren, II., Robert J., Irene M. Rossell, Kevin K. Moorhead, and J. Dan Pittillo. 2007. "The Influence of Woody Encroachment upon Herbaceous Vegetation in a Southern Appalachian Wetland Complex." *The American Midland Naturalist* 157 (1): 39–51.
Whittam, Rebecca M., Jon D. McCracken, Charles M. Francis, and Mary E. Gartshore. 2002. "The Effects of Selective Logging on Nest-Site Selection and Productivity of Hooded Warblers (Wilsonia Citrina) in Canada." *Canadian Journal of Zoology* 80 (4): 644–54.

Faculty Letter & Budget Description

I enthusiastically support Jackson Barratt Heitmann's proposed research project. Jackson has proven himself to be an emerging leader and scholar in the EVSS master's program during the short time he has been on campus. Jackson successfully led a SeaGrant concept letter which has been requested for a full proposal, and although he currently lacks funding Jackson has already begun collecting bird survey point-count data at the wetlands he has identified above (Figure 2, 3). The chief strengths of the proposed work are that:

1. *It will fill an important knowledge gap.* It is well understood that wetlands are extremely important but small ephemeral wetlands are almost completely ignored in protection schemes and management plans. In the coastal plain, ephemeral wetlands are numerous and blanket the landscape. It is largely unknown if management and policy should be targeting these fragile and unique habitats.
2. *There is a clear experimental component to the proposed work.* Jackson will collect one year of data this spring and summer. In the fall of 2021,, tree thinning treatments will be implemented at Halidon Hill. In the spring and summer of 2022, Jackson will be able to collect post treatment response data. Additionally, some wetlands receive prescribed fire annually at Halidon Hill while the wetlands at Stono preserve have received fire treatment at varying intervals in the past. Therefore, there are clear treatments and controls to compare in a data analysis.
3. *We have a strong interdisciplinary team*. Jackson has assembled a strong interdisciplinary group of academics, practitioners, and primate land owners that will ensure strong relevance and transferability of his results into management and conservation decisions. The team includes Lisa Lord of the Longleaf Alliance, an NGO focused on land management of privately held lands, Dr. Stacey Lance, a principal investigator at the Savannah River Lab focused on frog and salamander communities, Dr. Travis Folk of Folk land management, and members of the Coen family who own and help to manage the Halidon Hill property. Dr. Lance is collecting data on frogs and salamanders at the same Halidon hill sites so Jackson has also set himself up to participate in a timely comparative study between how these groups respond to disturbances.
4. *Jackson is an exceptional and emerging scientist*. He developed this project and wrote this proposal himself. I have collaborated closely with him as the project developed but he has taken ownership of this project. Jackson has also proven to have excellent field knowledge of birds, and I consider him to already be a talented writer and a clear thinker.

The primary broader impacts of the proposed work will be:

1. To provide actionable information to our specific partners and to the broader scientific and land management community on how to best consider the conservation benefit and changes in ephemeral wetland communities.

2. To train Jackson Barratt Heitman as a scientist and communicator. Jackson plans to pursue his PhD after completing his master's degree. The proposed work will position Jackson very well to enter a PhD program in ecology and evolutionary biology.
3. Jackson will integrate his work into the outreach he is already participating in at the Stono Preserve student garden. As a member of the garden team, Jackson is helping with outreach to the broader community including K-12. Jackson plans to develop K-12 focused activities that highlight the importance of ephemeral wetlands and ecological research in general.
4. Jackson will also help to mentor an undergraduate researcher that I will recruit from my biology 211 course. Jackson and I will work with the undergraduate student(s) to procure funding for a summer research project from the SSM summer research funding. Jackson and I will then both work to help mentor and develop the undergraduate student's project which will be designed to be integrated with the work proposed here.

The funding listed below would cover items Jackson needs to collect water depth and vegetation structure data, in addition to mileage reimbursement (Table 1). I am not requesting any funding for myself as part of this proposal. Jackson will receive my full attention as he works on this project. He is currently the only graduate student in the lab currently as two other students just recently graduated (Juliane Caughron in GPMB and Sam Norton in EVSS).

In closing, I give the proposed work and Jackson my full endorsement. I am excited about the project and I'm excited about working with Jackson and our collaborators. I think that a lot of interesting science and management guidelines will be developed as a result of this project.

Best,
Dan McGlinn, PhD
Associate Professor
Department of Biology, College of Charleston

Table 1. Budget

Item List	Cost
Roble Poll	$117.99
Mileage Reimbursement for 2022 field season Trip (10) to Stono ($0.575/mile x 19 mi) = $109.25 Trip (10) to Halidon Hill ($0.575/mile x 28 mi) = $161	$270.25
Conduit Pipe (½" x 5') $3.72 x 30	$111.60
Total Cost	$499.84