Applications of Conservation Technology for Assessing Broad Meadow Brook Wetlands

Clark Graduate School of Geography – GEOG 381: Emerging Technology in Conservation

Authors listed in credits.

INTRODUCTION

Urban streams and wetlands offer numerous environmental and social benefits to city residents, including flood control, enhanced water quality, wildlife habitats, landscape connectivity, and recreation. Collaborative efforts involving Mass Audubon, the Massachusetts Division of Ecological Restoration, and other partners aim to restore a wetland within New England's largest urban wildlife sanctuary, Broad Meadow Brook. The City of Worcester secured a $10M grant in 2016 for sewer system upgrades, initiating discussions about watershed restoration at Broad Meadow Brook. The envisioned restoration seeks to establish a self-sustaining native riparian and wetland ecosystem. Key goals include the restoration of the Broad Meadow Brook wetland complex, bolstering climate resilience, and optimizing water quality and quantity in the upper watershed. Specifically, this project involves decommissioning an obsolete municipal sewer line to connect wetlands, and daylight the stream by removing culverts. In this project, the team investigated the spatial and temporal characteristics of Broad Meadow Brook, focusing on wetland areas. We used earth observations and emerging conservation technology to delineate wetlands, analyze nighttime lights and land surface temperature, and examine bird biodiversity.

This work was conducted under Dr. Florencia Sangermano as the final course requirement for GEOG 381: Emerging Technology in Conservation.

OBJECTIVES

1. To examine human-induced and climate variables that possibly affect biodiversity in Broad Meadow Brook.
2. Using emerging technologies, to determine the possible extent of wetlands in Broad Meadow Brook and comparing them to present day defined wetlands in the sanctuary.
3. To find the amount of bird calls and which species they were over one year using the BirdNET analyzer, an AI software that identifies the species of bird calls.
4. To determine the differences between call activity during the morning (3am-3pm) and the night (3pm-3am).
5. To find the correlation between our species findings and the Acoustic Diversity Index.

DATA

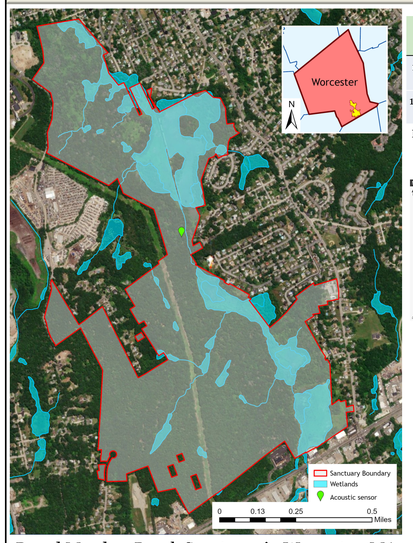
Biodiversity

- Wildlife recorder planted in the center of Broad Meadow Brook (see context map), with daily recordings from July 2022 to June 2023.
- Recordings: 5-minute recordings every 30 minutes from 3-7am and 6-10pm.

Context & Environment

- MassGIS (Building footprints, roads, sanctuary boundary)
- NASA (Nighttime Light Radiance)
- MODIS (Land Surface Temperature, Normalized Difference Vegetation Index)
- USDA (National Agriculture Imagery Program, 2021)
- USGS 2021 LIDAR Dataset (October, Massachusetts)
- Earth Explorer (Land Surface Temperature)

CONTEXT

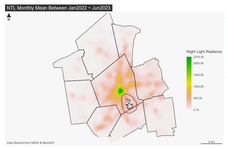


Broad Meadow Brook Sanctuary in Worcester, MA.

Area of Interest	Total Area (sq.ft)	Population (2020)	2020 Density (people per sq.ft)	Population (2010)	2010 Density (people per sq.ft)	Total Number of Buildings	Total Length of Roads (mi)
100-ft outside park boundary	2,165,260	1,020	0.00047	833	0.00039	164	0.6
1 km of surrounding wetlands	67,793,013	76,711	0.00113	101,69	0.00015	23,129	132.7

Broad Meadow Brook Sanctuary and surrounding neighborhoods.

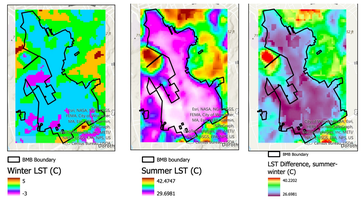
Worcester Area Nighttime Light (NTL) Radiance



	Mean	Median	Min	Max
BMB	133.9	110.30339	53.23595	501.30402
1KM Buffer	305.4791	247.27655	65.85186	1565.02747
Outside Buffer	116.5327	42.58513	0.00000	3625.40161

These result shows that while BMB radiated smaller night light, 1km buffer radiated more lights, as some parts of it is close to the city center of Worcester. (Unit: nWatts·cm−2·sr−1)

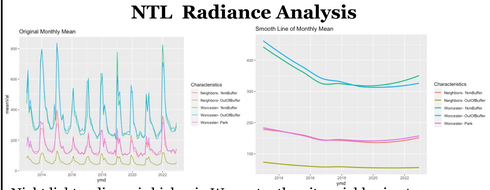
Broad Meadow Brook Land Surface Temperature (LST)



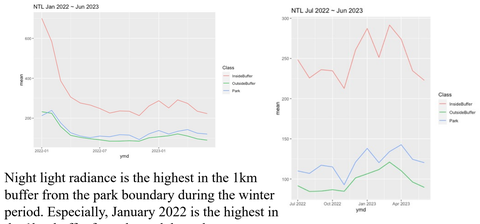
There does not seem to be any substantial difference in LST trends between patches of wetlands and the surrounding forest canopy. The monthly trends for daytime and nighttime LST shows that the difference between daylight and night-time temperatures within the BMB boundary decreases during the winter months.

ENVIRONMENT

NTL Radiance Analysis

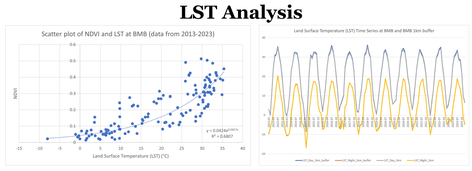


Night light radiance is higher in Worcester than its neighboring towns. However, nighttime radiance in MBM is lower. Also, the radiance is decreasing in these 10 years.



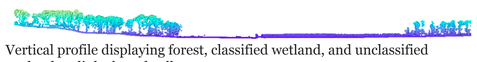
Night light radiance is the highest in the 1km buffer from the park boundary during the winter period. Especially, January 2022 is the highest in the 1km buffer from the park boundary.

LST Analysis

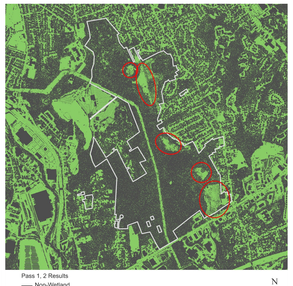


The left graph is a scatter plot of NDVI and MODIS LST and it contains the data within these 10 years. It does not have a very strong linear or exponential relationship, but we can tell that LST and NDVI have positive relationships. The right graph contains MODIS Day time and nighttime LST within the most recent 10 years and both daytime and nighttime LST didn't show much difference when comparing the study area within the park and within 1 km buffer zone.

Lidar Wetland Classification



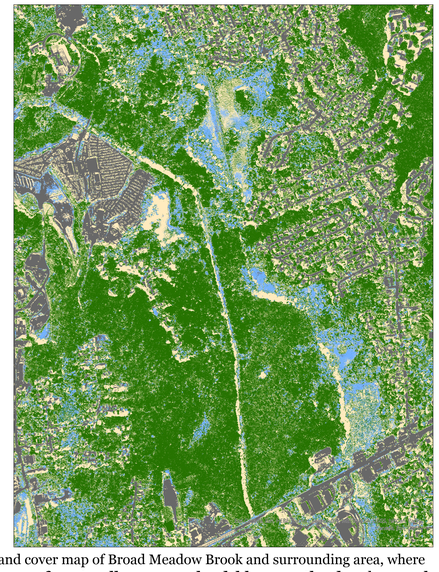
Vertical profile displaying forest, classified wetland, and unclassified wetland- split by boardwalk.



Raw wetland classification results using 2021 Lidar imagery. Red circles denote the wetland class within BMB.

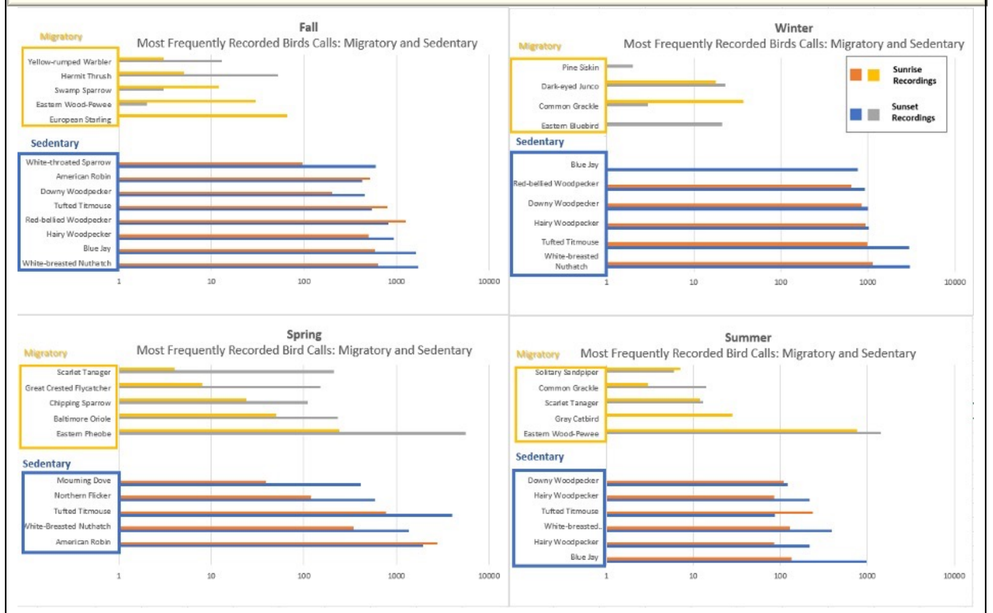
Wetland patch extraction results

Unsupervised Wetland Classification



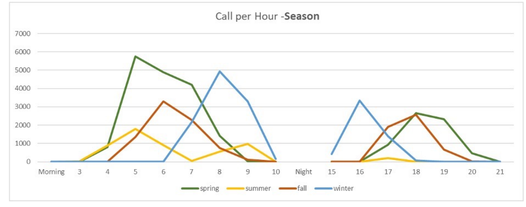
Land cover map of Broad Meadow Brook and surrounding area, where **green = forest**, **yellow = open land**, **blue = wetland**, and **grey = built surface**. This map was created by running an unsupervised land cover module, Cluster, in TerrSet, and manually grouping the resulting 20 clusters into broader classes.

BIODIVERSITY



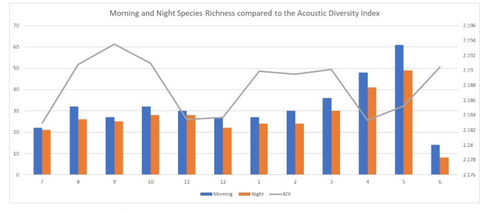
The Chattiest Birds by Season: Broad Meadow Brook's Key Bird Species.

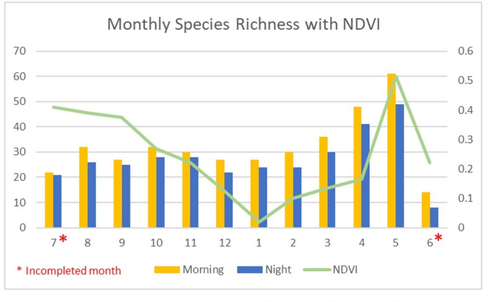
Bird species who overwinter and remain close to their breeding habitat are known as 'sedentary' while birds that fly long distances to take advantage of food abundance and warmer climates are known as 'migratory'. These graphs above display the seasonal trends of calling in species that remain local all year and those who are just passing through.



When do birds Call?: Peak Hour of Activity with Each Season

Our bioacoustic recording device was set to capture the two points of the day when birds are most vocal: sunrise and sunset. An analysis of frequency shows that Broad Meadow Brook's birds chatter more in the morning and call less frequently around sunset.





Acoustic Indices: Useful Tools

Species Richness shows the variety of bird species caught on recording for each month for sunrise and sunset, while the Acoustic Diversity Index increases with sounds covering a wider range of frequencies. These graphs show how more species enter Broad Meadow Brook as the deciduous vegetation returns, and how Acoustic Diversity covaries with Species Richness. Please note that our acoustic recorders only partially collected data in June and July.

Want to learn more? Scan the QR code for our StoryMap.

CREDITS

Fall 2023 Cohort: Ken Baird[1], Claudia Buszta[2], Apple Gould-Schultz[1*], Sarah Hughes[1], Lara Jordan[3^], Vanchy Li[2], Naoya Morishita[2], Andrew Niehaus[1], Yu-Yun Ruan[3], Finnegan Wertz[3]

[1]Environmental analysis via Earth observation methods
[2]Environmental analysis via human-environment relationships
[3]Biodiversity analysis via Ecoacoustics and R
[*]Poster Lead, [^]StoryMap Lead