Chesapeake Community Research Symposium 2024

Session 6: Understanding the Landscape to Better Manage and Protect Aquatic Ecosystems

Peter Claggett, Sarah McDonald

Mapping high-resolution land use/land cover in the Chesapeake Bay watershed

High spatial and categorical resolution land use/land cover (LULC) data that are consistent over space and time are helpful for assessing the relationship between watershed conditions and estuarine health and essential for planning and targeting restoration and conservation actions. The Chesapeake Bay Program funded the development of 1-meter resolution, 62-class LULC data for all counties intersecting and adjacent to the Chesapeake Bay watershed, a 256,000 km2 region for the years 2013-14, 2017-18, and 2021/22. This presentation will focus on the importance of land use compared to land cover and the methodology and data needed to translate land cover to land use. The 2021/22 vintage high-resolution LULC data are compared with national-scale LULC data (e.g., the National Land Cover Database) produced at coarser spatial and categorical resolutions to demonstrate the information gained from high-resolution data.

Sarah McDonald

Understanding Land Use Change in the Chesapeake Bay Watershed

The Chesapeake Bay Program's (CBP) 1-meter Land Use/Land Cover (LULC) database encapsulates the 64,000 square mile region of the Chesapeake Bay watershed at fine spatial and categorical scales for two dates (2013/14 and 2017/18). In summer 2024, a third date will be added to the time series (2021/22), and all dates will be reprocessed to ensure consistency in change over time. In 2023, the U.S. Geological Survey (USGS) in collaboration with the Multi-Resolution Land Characteristics (MRLC) Consortium released an update of the National Land Cover Database (NLCD) at 30-meter resolution, including LULC for 2013 and 2021. As part of the NLCD release, USGS produced a time series of fractional impervious cover, representing the percent impervious cover within each 30-meter resolution cell. The NLCD release also includes annual fractional tree canopy layers from 2011-2021 developed by the U.S. Forest Service (USFS) representing the percent tree canopy within each 30-meter resolution cell. Research to compare LULC, impervious, and tree canopy change from 2013/14-2021/22 between the 1-meter CBP data and the 30-meter NLCD data will be presented. This presentation will explore how these data compare spatially, categorically, and temporally, and the implications of these differences for targeting restoration and conservation activities to improve water quality and living resources.

Katie Walker

Supporting Data-Driven Conservation Management

With the advent of higher resolution data layers and innovative geospatial analysis techniques, there are more avenues than ever to support precision conservation and restoration. Through the application of data such as 1-meter land use/land cover data, the Conservancy has been providing parcel-scale insights for topics such as tree canopy change, opportunities for Best Management Practice implementation, and conservation planning in partnership with regional non-profits, state agencies, and federal agencies.

Michelle Katoski, Matthew Baker

Characterizing woodland structure using high-resolution spatial datasets

Knowledge of forest stand structure, age, and succession has become increasingly important for conservation planning and monitoring. Forests are known to provide ecological and hydrological functions. Mature and intact forest cover intercepts and stores rainwater and encourages infiltration through soil macropores, providing greater storage capacity for resilience to intense stormflows. Mature forests near streams also shade channels, regulating water temperature and stabilize stream banks. Chesapeake Bay-wide availability of remote-sensed data products such as 1-m resolution Land-Use/Land-Cover (LULC) and Light Detection and Ranging (LiDAR) data, offers a new opportunity for characterizing forested landscapes at high-resolution and multiple time steps. High-resolution LULC maps alone provide measures of tree canopy cover and change at high precision, but do not distinguish woodland patches with distinct interior habitat from fragmented tree canopy. Neither do the maps offer context into forest structural characteristics like gap closure, understory growth, mature closed canopy, or stressors like vine invasion and deer browsing. Quantifying forest vertical structure can give context for these characteristics of forest condition. By interpreting these metrics at the scale of a forest patch, we can identify resilient, improving, or degrading forested areas. Characterizing woodland patches and their structural characteristics will be vital for guiding protection and maintaining integrity of forested landscapes in the Chesapeake Bay watershed under changing climate and other ecological stressors. In addition, understanding and monitoring forested landscapes in the Chesapeake Bay watershed will ensure that we maintain their natural hydrologic function. We present an analysis of woodland internal vertical structure produced using high-resolution canopy cover and hierarchical clustering of LiDAR-based metrics of vertical structure.

Andrew Sekellick, Matthew Cashman, Gina Lee, Kelly Maloney, Leah Staub, Michelle Katoski

An assessment of stream physical habitat conditions in unmonitored locations of the Chesapeake Bay Watershed

Sedimentation and degrading physical habitat are common stressors affecting river ecosystems in the Chesapeake Bay Watershed and a primary focus of stream restoration activities. As part of larger efforts aimed at improving instream ecosystems, it is important to identify and conduct regional assessments of stressor(s) might be affecting local stream health to help prioritize management areas of concern.

In this study, we analyzed existing field-based habitat monitoring data collected by multiple jurisdictions to train a machine-learning model to predict twelve standard physical habitat metrics for nearly 120,000 km of nontidal rivers and streams across the Chesapeake Bay Watershed, USA. We also produced two summary metrics capturing the major components of variation across the watershed: 1) a combined in-channel bed character and hydromorphic heterogeneity and 2) bank and riparian condition. We evaluated changes in these metrics from 2001-2019 and predicted several areas of improving and degrading condition. Lastly, we compared our results against metrics of commonly used surrogate drivers for habitat condition (i.e., sediment supply and hydrologic alteration) to examine their relationships to our modeled habitat scores.

Our results capture a broad range of habitat condition across the Chesapeake Bay watershed driven by both natural and anthropogenic conditions. Despite localized changes over the 18-year period, there was little overall average change across the watershed, as areas of deterioration are roughly balanced by improvements. Local habitat scores were generally variable and did not tightly correspond to local sediment supply, indicating the unique information conveyed by a direct assessment of habitat. Habitat did show some differences with altered hydrologic metrics, most notably with changes to low-flow magnitude, seasonality, and altered hydrograph skew, and indicate the important role of hydrologic forcings on these conditions.

By providing direct estimates and trends of the multiple factors in physical habitat, this model can help support both regional and local watershed managers understand the distribution of stream habitat conditions across the region, identify high-quality stream condition for conservation, and target potential management actions tailored to localized streams.

Hannah Nisonson

Pilot Framework for Fish Habitat Assessments Across Tidal and Non Tidal Waters in the Patuxent River Basin

Prior national and regional fish habitat assessments that included the Chesapeake Bay have treated inland and estuarine habitat conditions separately at relatively coarse spatial scales. A seamless habitat assessment integrating the two could be of value, as many fish species use habitats across both inland and estuarine waters. This project explored and tested methods necessary for a fine scale, seamless assessment across both tidal and nontidal waters, taking into account recently developed high resolution landscape metrics and in-water variables.

At the beginning of this study, a decision matrix was used to select the Patuxent River basin as the area of focus based on factors such as data availability and tributary size. Several spatial frameworks were considered before designating a raster framework that was able to represent inland landscape influences as well as estuarine bathymetry. A suite of fine scale landscape and in-water stressor variables were summarized into the gridded raster framework. Tessellated darter, American eel, and white perch were chosen as illustrative fish species based on data availability, and differences in life history and habitat use.

We conducted species distribution modeling to predict habitat use of non-tidal resident, estuarine resident, and migratory species. A nested modeling approach, which involved successive model runs at multiple scales (1000m, 100m, and 10m raster grids), was developed to examine differences in variable importance at different spatial scales and to enhance modeling efficiency. For white perch, a complementary modeling analysis was performed to accommodate for variables available only in estuarine waters. For all testing, ensemble modeling was conducted, using a suite of potential statistical techniques driven by model strength and variable predictive power. We found the raster framework useful for integrating the influence of landscape stressors with local in-water factors and seamlessly predicting fish habitat distribution across freshwater and tidal environments.