CBT GIT Scope 10: Updating the Chesapeake Conservation Partnership (CCP) Priority Habitat Dataset

Final Report

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1. Introduction

Scope Purpose and Tasks

As part of the Chesapeake Bay Program (CBP) Goal Implementation Team (GIT) Funding Program, the Chesapeake Bay Trust has received federal funds from the U.S. Environmental Protection Agency (EPA) to advance specific top priority outcomes from the 2014 Chesapeake Bay Watershed Agreement. The Chesapeake Conservation Partnership (CCP) currently hosts a Chesapeake Bay priority habitat map on the Chesapeake Conservation Atlas as a static map, with an interactive version accessible in the Chesapeake Conservation Atlas and the Targeting Tools Portal (also available in raster format). The CCP requested assistance to scope an approach to update the dataset based on new data and methods. Skeo Solutions was selected through a competitive process to complete the project titled "Scope of Work 10: Updating the Chesapeake Conservation Partnership (CCP) Priority Habitat Dataset of the Chesapeake Conservation Atlas: A Scoping Project," referred to as the CCP Priority Habitat Scoping Project.

The overall goal of the CCP Priority Habitat Scoping Project is to produce a report that describes user needs, subject matter expert perspectives, an assessment of similar habitat models, potential approaches, and associated resources. These resources will focus on what is required to update the watershed-wide dataset of important habitat to guide terrestrial and aquatic habitat conservation, restoration and stewardship. This project is the first phase that may lead to a more detailed future project to update the CCP Priority Habitat dataset. Habitat GIS models have traditionally been developed based on landscape ecological principles that seek to maximize core and corridor size and connectivity based on land cover data developed from 30M Landsat imagery. There is now high resolution 1-meter land cover data available for the Chesapeake Bay for multiple timescales. Species models have also become more available and accurate for specific species, which prompts revisiting data and methods of producing high value habitat models. The report will include an assessment of the advantages and disadvantages of using high resolution data (1-meter land use land cover data for the Chesapeake Bay) in a watershed-wide dataset. This report summarizes the project findings, which are organized around the following four main tasks:

- Chapter 2: Conduct stakeholder interviews to identify habitat data user needs, which included CBP GIT leaders and staff, state and federal agencies and conservation organizations.
- Chapter 3: Assess existing large landscape habitat models to identify data and approaches that might be relevant to a CCP high value habitat model dataset update.
- Chapter 4: Conduct subject matter expert interviews to identify state of the art habitat data and methods and recommendations related to scoping, cost, best practices, and other modelling considerations.
- Chapter 5: Develop recommendations for the habitat dataset update including data, methods and approaches.

Relevant Chesapeake Bay Habitat Goals and Initiatives

Discussions with subject matter experts repeatedly emphasized that the approach to building a habitat model must start with the specific goals related to habitat and associated decisions, such as prioritizing and tracking. This section outlines relevant habitat goals, entities and initiatives that could inform the habitat update.

This project has been funded to support the Chesapeake Bay Agreement Goal Implementation Team 6 – Fostering Chesapeake Stewardship, which includes a specific Land Conservation Goal *to conserve*

landscapes treasured by citizens in order to maintain water quality and habitat; sustain working forests, farms and maritime communities; and conserve lands of cultural, indigenous and community value. The current 2025 Protected Lands Outcome is to protect an additional two million acres of lands throughout the watershed—currently identified as high-conservation priorities at the federal, state or local level—including 225,000 acres of wetlands and 695,000 acres of forest land of highest value for maintaining water quality.

The Chesapeake Conservation Partnership has supported this goal through collaboration with over 80 partners throughout the watershed and providing resources such as the Chesapeake Conservation Atlas (developed by the National Park Service Chesapeake Bay Office, NatureServe, Chesapeake watershed states, and U.S. Geological Survey (USGS)) to provide a publicly accessible, watershed-wide land conservation priority system. *The CCP habitat goal is to protect a network of large natural areas and corridors sufficient to allow nature to respond to a changing climate and land development and to support thriving populations of native wildlife, migratory birds, fish and plants and sustain at-risk species.* To support this goal, the Chesapeake Conservation Atlas includes a priority habitat map developed by Nature's Network and customized for the Chesapeake Bay watershed with black duck data by the Conservation Innovation Center (CIC). The map identifies priorities for important habitat, land, water and connectors. To update this priority habitat map to include the most current data, the CCP requested support through the CBP GIT funding program (administered by the Chesapeake Bay Trust) to scope an approach with several options for data selection and methods. In addition, the 2014 Chesapeake Bay Agreement includes a goal for Vital Habitats (guided by Goal Implementation Team 2) to restore, enhance and protect a network of land and water habitats to support fish and wildlife, and to afford other public benefits, including water quality, recreational uses and scenic value across the watershed. This includes specific goals for wetlands, stream health, fish passage, submerged aquatic vegetation, forest buffers, tree canopy, black duck and brook trout. CBP GITs utilize various models to help prioritize and track goals, which have recently been organized under a new Chesapeake Bay targeting website that provides a collection of maps and applications that can be used to evaluate watershed restoration and landscape conservation initiatives relative to multiple goals and outcomes of the Chesapeake Bay Watershed Agreement. The website includes a page specific to habitat conservation goals with links to the following tools:

- Watershed Resources Registry (WRR) for Riparian Restoration and Wetland Restoration
- Cross-GIT Restoration Composite
- Comprehensive Water Resources and Restoration Plan
- Fish Passage Prioritization Tool
- National Fish Habitat Assessment
- Chessie BIBI
- Brook Trout
- Black Ducks
- Climate Resiliency

When the America's Conservation Enhancement Act (Act) became law in 2020, Congress entrusted the U.S. Fish and Wildlife Service (USFWS) to establish the "Chesapeake Watershed Investments for Landscape Defense grants program," or Chesapeake WILD, which responds to a partner-identified need for coordinated action to restore, conserve and protect a resilient and connected landscape of healthy lands and waters. An intact, functioning watershed supports a diversity of wildlife, fish and plants, and

contributes to the social health and economic vitality of all who live, work and recreate in the Chesapeake Bay watershed.

Before launching on a habitat model update, the consultant recommends that key entities such as CCP (funded by the USFWS, the National Park Service), Chesapeake WILD (under the USFWS) and the CBP GIT staff supporting the living resources, habitat and stewardship goals agree specifically on what the updated habitat model needs to accomplish and how it will support and align across the separate but closely related programs.

2. Stakeholder Workshop Summary

The project team led by the project technical leads drafted a stakeholder engagement framework (see Appendix B) to outline the purpose, methods, stakeholders and key questions to be used for collecting feedback. The strategy included holding a series of workshops with CBP staff and external conservation partners with direct knowledge and interest in habitat mapping data to identify habitat data needs. The expertise from these stakeholders includes land conservation organizations, land trusts, land use planners, state wildlife or natural heritage staff, and federal agencies. Participants were engaged to gather current and future habitat mapping needs, data considerations, and end user needs. Two workshops were held for internal CBP stakeholders that have a direct interest in the contents of a Chesapeake-wide habitat dataset or may utilize such a dataset to inform CBP-related goals and outcomes. A third workshop was held with external stakeholder agencies and organizations who have habitat conservation goals along with interest and knowledge in the use and application of high value habitat datasets. The workshop agendas (Appendix C), invitee/RSVP lists (Appendix D) and workshop summaries (Appendix E) are included in the Appendices. The significant themes and considerations from the workshops are summarized below.

Stakeholder Considerations for Priority Habitat Data

Table 1. Significant Themes and Considerations from Workshops

Themes	**Considerations Shared by Participants**
Value of Updating the Habitat Model	Participants agreed there is value in developing a high value habitat model that is science-based and formally adopted to help set, prioritize and track habitat conservation goals at the watershed scale.
Scale	Participants acknowledged that the habitat model cannot be one-size-fits-all, particularly regarding scale. Participants recommended that the high value habitat model would be most valuable as a screening tool at the watershed scale and not for restoration design at the parcel scale.
Use and Audience	Most participants do not use the current CCP Priority Habitat Dataset because they are not aware of it, or they use their own prioritization model related to their agency or organizational habitat goals and mandates. Some suggested CBP could provide more technical assistance/training in how to use the model to inform grant funding requests and conservation priorities. Some suggested that conservation organizations do not want another tool, they just want a map of the priorities.

	Participants noted that a new or updated high value habitat model needs to be tied to achieving purposeful CBP conservation goals and outcomes. Participants noted the need for the model to have the greatest utility possible for conservation users. Participants are concerned that the amount of healthy watersheds is currently being overestimated without considering measured biotic indicators.
Value of 1-Meter Land Cover Data	Participants questioned the additional value relative to the development, maintenance, and of using the high resolution 1-meter land cover dataset. Participants expressed concern that the 1-meter data would not change the outcome significantly, may create false core and corridor fragmentation and introduce computing errors. Participants recognized that 1-meter data can be useful for parcel level, on-the-ground acquisition and restoration design, but not at a watershed tracking scale. The 1-meter data also has three timestamps that could be used to develop a trend model over time highlighting changes in habitat quantity and configurations.
Resiliency Factors	Participants stressed the need to include resiliency factors and strategies in habitat models. Participants noted that connections and corridors are one aspect of resiliency and that species models are more often incorporating resiliency data specific to individual species needs.
Model Indicators	Participants suggested that this scoping effort highlights the opportunity to make a more useful Chesapeake Bay watershed tool that reflects the range of CBP goals beyond habitat, including stream condition, water quality, marshes, ecologic function and biotic health outcomes. Participants noted that remote sensing is limited in what it can capture as an indicator of healthy, high value habitat without considering these other physically measured factors.
Dynamic Interface	The current model is a static black box – there is no understanding of the metrics and methods used to identify high value habitat and the map image does not provide query and layering capability. Participants noted that a dynamic mapping interface would be very useful in the habitat model update, allowing users to toggle different layers on/off or change the weights and work through different scenarios depending on user goals and priorities. No one model can be a one size fits all to meet every person's needs. Some dynamic features are currently offered through the Chesapeake Conservation Atlas. A dynamic interface would allow for new and updated models to be added over time as available. A dynamic interface would also allow users to add

	federal, state, county or other relevant data, or for example combine the tools provided on the CBP targeting page into a single web browser mapping interface, and be included as part of the targeting initiative.
Model Documentation and Maintenance	Participants noted the need to consider data storage, maintenance, updates, and clearly identifying and documenting the methods and metadata used. CCP and CBP are already currently experiencing issues with servers, storage and maintaining their existing tools. This is an issue with many tools that currently exist, as they quickly become outdated or have a lack of documentation. The metadata should provide clear documentation of the data layers and any indices or metrics used.

Use Cases for an Updated High Value Habitat Model

In addition to sharing considerations related to the themes outlined above, workshop participants shared the following potential use-cases for a watershed-wide high value habitat model:

- Funders could use the model to better prioritize grant funding, project proposal review, and conservation investments.
- State agencies and conservation organizations could use the model as a connection tool to overlay with local models and help identify multiple benefits for project selection.
- Local government could use this tool in land use decisions, environmental review, parks planning, habitat stewardship, facilities planning, and master planning efforts.
- Stakeholders could use the model for targeting restoration work to ensure that conservation and restoration is done in places of highest value. This includes providing a rationale for specific projects in a landscape context within conservation or restoration grant applications and proposals.
- Local conservation organizations could use this tool to collaborate with a broad number of partners to identify joint goals, areas of agreement and multi-benefit projects.
- Conservation organizations could also use this tool to identify where interconnected habitat is occupied but other datasets may not show as occupied year-round.
- Stakeholders could use this tool to help identify where high value habitat overlaps with flood prone corridors to target for research or acquisition.

CCP Habitat Model Needs

In addition to the workshops, the new CCP Program Manager Ben Alexandro expressed that CCP's primary need for a high value habitat model is to prioritize habitat investments and track habitat conservation goals. In addition, CCP has a need to run queries related to decision-making questions, for example how much high value habitat is protected, where does high value habitat intersect with recreational access needs, and where is high value habitat threatened by development or climate change, to help strategize, prioritize and tell compelling stories that empower and excite partners toward habitat conservation around a shared visual understanding.

3. Model Assessment Summary

As part of the project scope, the consultant assessed large landscape habitat assessment models, CBP existing decision-support tools, and important overlays potentially useful in evaluating high value. A comprehensive assessment table of these models is included in Appendix G. Table 3 organizes each of

the models according to their relevance to an update of the Chesapeake Bay High Value Habitat Model, which is described in more detail below.

Parallel Efforts. There are three related efforts underway that have direct relevance to a Chesapeake Bay habitat model update: Department of Interior's America the Beautiful/American Conservation and Stewardship Atlas, ESRI's Green Infrastructure Initiative, and the watershed scale Chesapeake WILD collaborative areas of agreement process. The habitat model update will need to consider how to align and potentially overlay these related tools designed to implement federally mandated habitat programs. There are multiple overlapping spatial planning efforts building a slate of decision support tools for different portions of the watershed. Tools are developing and evolving quickly.

Similar Landscape Scale Models. The two most relevant large landscape scale habitat models are the Delaware Conservation Blueprint (under development) and the Southeast Conservation and Adaptation Strategy (SECAS) Conservation Blueprint, both funded by the USFWS. Both models include high value habitat identified at a large landscape scale through a facilitated stakeholder process to select data, priorities and methods.

Potential Base Layers. Potential base layers to be considered for an updated Chesapeake Bay high value habitat model include Nature's Network composite model and individual components, NatureServe's Biodiversity Importance Models and the CBP tools outlined on the Chesapeake Bay targeting website.

1-Meter Land Cover Data. The Chesapeake Bay 1-meter product covers 206 counties within the watershed and over 250,000 km^2, which includes land cover (12 classes) and land use (64 classes) for years spanning 2013/14, 2017/18 and 2021/22. The land use/cover classifications with 64 classes include categories for water and water margins (6), development (18), natural lands (25), and agriculture (15). The 12-class land cover dataset has water, emergent wetlands, tree canopy, scrub/ shrub, low vegetation, barren, impervious structures, other impervious, impervious roads, tree canopy over impervious structures, tree canopy over other impervious, and tree canopy over impervious roads.

Nature's Network. Nature's Network has produced a GIS model and prioritization tool called the Conservation Design, a collection of datasets to identify a network of places that help define the highest conservation priorities in the region to sustain natural resources and benefits for future generations. Conservation Design depicts an interconnected network of lands and waters that will support a diversity of fish, wildlife and natural resources in the Mid-Atlantic region, if protected. Led by partners from nearly 30 organizations, Nature's Network uses innovative modeling approaches developed by the University of Massachusetts Amherst and The Nature Conservancy (TNC). The North Atlantic Landscape Conservation Cooperative (LCC) and the Northeast Association of Fish and Wildlife Agencies (NEAFWA) coordinated a team of partners to build scientific consensus from experts across the 13-state conservation community and create a shared vision for natural resources in the Northeast.

The Nature's Network Conservation Design consists of three primary datasets, including terrestrial core connectors, aquatic core network, and core habitat for imperiled species. Table 2 provides a brief explanation of the three datasets, each of which have undergone or are currently undergoing updates. This model is intended to support identifying the best places for strategic conservation that are intact and resilient, encompass a diversity of lands and waters, and are important habitat for species. The Nature's Network data aim to provide additional scientific guidance to use limited resources more effectively and identify how local conservation efforts work within the larger region to connect priorities. The terrestrial core connector data show how the movement of animals and plants between

core areas and across the landscape can be achieved if they are protected. The core habitat for imperiled species data are intended to complement the aquatic core areas and terrestrial and wetland core areas by highlighting habitat types closely associated with high numbers of imperiled species.

Nature's Network incorporates habitat needs for hundreds of species of fish, wildlife and plants, including those identified as Species of Greatest Conservation Need (SGCN) outlined in state wildlife action plans. In addition to the Conservation Design model, Nature's Network includes individual datasets that reflect specific habitat, species, resilience and probability of development.

Table 2. Current Nature's Network Conservation Design Data

Layer	Description
Terrestrial Core-Connector Network	Made up of two components: terrestrial and wetland core areas, and connectors. Terrestrial and wetland core areas are intact, well-connected places that have the potential to support wildlife and plants that occur in terrestrial settings (such as upland forests) or in wetlands (such as marshes). Core areas contain widespread ecosystems (such as hardwood forests), rare natural communities (such as bogs), and important habitat for a variety of fish, wildlife and plants. Core areas are linked together by a network of connectors.
Aquatic Core Network	Intact, well-connected stream reaches, lakes and ponds in the Northeast and Mid-Atlantic region that, if protected as part of stream networks and watersheds, will support a broad diversity of aquatic species and the ecosystems on which they depend. They feature intact, resilient examples of every major aquatic ecosystem in the region and are designed to incorporate habitat for important species such as brook trout, American shad and Atlantic salmon.
Core Habitat for Imperiled Species	Relatively intact areas that contain habitats likely to support high levels of imperiled terrestrial and aquatic species. This product represents a regional network of habitats critical for sustaining populations of imperiled species, based on over 600 SGCN. Core habitat for imperiled species is intended to complement aquatic core areas and terrestrial and wetland core areas by highlighting ecosystem (habitat) types where they are closely associated with high numbers of imperiled species.

The CBP decision support tools also offer a range of goal-specific or species-specific models and tools to potentially incorporate into an updated habitat model, focusing on items such as water quality, species specific data and prioritization, and regulatory and other environmental planning goals. These datasets can be incorporated into an updated model as determined by user needs or viewed alongside a base model to provide additional context.

Overlays. Lastly, the important overlays identified offer additional context for habitat vulnerability and resiliency based on underrepresented (human) populations[1], climate change, population growth and development, and protected lands. The datasets highlighted are authoritative, updated frequently, and

[1] Underserved communities, organizations and individuals collectively encompass the terms and concepts characterized by our definitions of underprivileged, underrepresented and under-resourced. Generally, these include minority-majority communities, organizations and individuals with respect to race, ethnicity, sexual orientation and gender identity, and those with lower median income, greater rates of poverty, and less economic status and opportunity than others in the watershed.

can be viewed with a habitat model in a dynamic map interface to inform areas of priority for different social and climate risk factors.

- Risk Overlays. Once the base habitat dataset has been determined, overlays can be added to identify intersections with climate or development risk such as the Chesapeake Bay Land Change Model or the TNC Resilient and Connected Landscapes.
- Demographic Overlays. Other overlays could help identify intersections with community goals or concerns to identify recreational access priorities and disadvantaged communities such as CDC/ ATDSR Social Vulnerability Index and EPA EJScreen.

In addition to large landscape scale models, Table 4 references the habitat models used by each state in the Chesapeake Bay watershed and describes the general approach. Most of the state models use 30-meter land cover data, except for Pennsylvania that uses only field observations and no land cover data.

Table 3. Relevant Models and Data Layers

Applicability	Model/ Tool	Use for this Project
Parallel Efforts Underway	Chesapeake WILD	This may be a parallel effort and could potentially be joined into the habitat model update project when the scoping is finished. A 30-meter resolution dataset is more useful for this work, so that it aligns with other regional conservation blueprints. However, partners and prospective grantees may have a need for 1-meter resolution for project planning and implementation.
	Department of Interior's America the Beautiful/American Conservation and Stewardship Atlas	Future effort that may inform goals and implementation of model update, with which data layers are prioritized and built into the model or used as overlays.
	ESRI's Green Infrastructure Initiative	Provides a perspective on defining priority habitats based on green infrastructure/ planning development, as well as depicting every intact natural area greater than 100 acres. Local data can be added to refine the model and to set local priorities and goals. The methodology was designed to be supplemented with additional data.
Similar Landscape Scale Models	Delaware Nature's Network	Future effort involving the creation of a regionally specific Nature's Network model for Delaware, that can inform how a Chesapeake Bay-specific model may be created and the level of effort.
	SECAS Conservation Blueprint	This serves as an example of a regionally focused model that identifies priority areas based on natural and cultural resource indicators, and how to have a cohesive vision across states.
Potential Base Layers	Nature's Network composite model and individual components	Source dataset to current model. Will be used to compare methodologies between other models/tools on how the 1-meter data may change outcomes.
	NatureServe's Biodiversity Importance Models	Provides priority habitat mapping with the emphasis on various species types. Can serve as

		an example on how to incorporate species considerations.
	National Fish Habitat Assessment	Can serve as a key example/guide on how to incorporate sources of habitat threats/ degradation into the overall priority dataset.
	Stream Health Assessment (Chessie BIBI)	May be very useful dataset/analysis for defining and understanding aquatic priority areas specifically.
	The Nature Conservancy's Resilient Land	Offers important climate-related factors to be viewed alongside an updated habitat model for additional context.
	Watershed Resources Registry	This tool can serve as an example of state-specific, preservation and restoration models, and includes suitability analyses for multiple states.
Risk Overlays	Center for Conservation Innovation	May use as a reference tool for determining data to use to show habitat changes over time.
	Chesapeake Bay Land Change Model	Shows how land use changes over time, and can view alongside high value habitat to see potential changes
	TNC Resilient and Connected Landscapes	Emphasis placed on resilience in the context of climate change. May be very useful to understand how to weigh various factors to determine resiliency of a site.
Demographic Overlays	CDC/ATDSR Social Vulnerability Index	Understand current level of social vulnerability around high value habitat and their relation to those areas. The demographic data come from the U.S. Census American Community Survey.
	EPA EJScreen	Understand current environmental risk factors related to demographics around high value habitat and how future change may impact these communities. The demographic data come from the U.S. Census American Community Survey.
	FEMA National Risk Index	Understand current overall risk from factors like social vulnerability, community resilience and expected annual loss of communities near high value habitat and how climate change may impact them and the land.

Table 4. State Models in Chesapeake Bay Watershed [2]

State	Tool	Description
Delaware	Delaware Statewide Vegetation Community And Land Cover Mapping Project	Maps all vegetation communities and land covers in the state of Delaware. Data compiled from aerial imagery analysis, field observations, and data obtained from others. Approximately 10-20% of the state has been field checked. Drawn to the finest extent possible (no defined minimum mapping unit).
Virginia	Virginia Natural Heritage Data Explorer	Interactive maps and data representing Natural Heritage resources and other conservation values in Virginia identified through land cover analysis.
West Virginia	West Virginia Terrestrial Habitat Map	Dataset that represents terrestrial habitats used for the 2015 revision of West Virginia's State Wildlife Action Plan (West Virginia Division of Natural Resources 2015).
Pennsylvania	Pennsylvania Conservation Explorer	Core Habitat of Biological Diversity Areas identified through the County Natural Heritage Inventory program of the Pennsylvania Natural Heritage Program. All areas identified through field observations (not land cover analysis).
Maryland	Maryland GreenPrint	Maryland Department of Natural Resources Parcel Evaluation Tool. The GreenPrint map displays Targeted Ecological Areas, lands and watersheds of high ecological value that have been identified as conservation priorities by the Maryland Department of Natural Resources.
New York	Environmental Resource Mapper	Interactive mapping application that can be used to identify some of New York State's natural resources and environmental features that are state or federally protected, or of conservation concern. Significant natural communities, such as

[2] Other state tools include:

- Virginia Department of Conservation and Recreation Conserve Virginia
- Virginia Department of Wildlife Resources Be Wild, Virginia! Link to Wildlife Action Plan interactive web tool
- Maryland forest planning tools and resources for designating areas to protect
- New York Parks, Recreation, and Historic Preservation Biodiversity Tool
- New York Statewide Riparian Opportunity Assessment tools
- Pennsylvania Conservation Opportunity Area Tool

		rare or high quality forests, wetlands and other habitat types.
District of Columbia	Sustainable DC 2.0 Nature	The District's 2015 State Wildlife Action Plan is a 10-year roadmap for sustaining, conserving, and protecting Washington, DC's wildlife and habitats. The 'Nature' goals directly connect to goals in Health, Climate, and Water. The goals are to protect, restore, and expand aquatic ecosystems, land ecosystems, and improve human access to and stewardship of nature.

4. Subject Matter Expert Interview Findings

As part of the project scope, the project team and Skeo conducted subject matter expert interviews to capture the perspectives of national experts in habitat modeling regarding recommended approaches for a Chesapeake Bay watershed habitat model update. The project team led by the project technical leads identified a set of subject matter experts (outlined in the Stakeholder Engagement Framework, Appendix B) and prioritized a subset for interviews. Full summaries of each interview are included in Appendix F, and highlights of each interview are summarized below.

BJ Richardson, USFWS

BJ provided important background information on the development of the current model as well as insights to consider for an update process. BJ was involved from the beginning in the development of the Nature's Network Conservation Design. The base map for the project was the Northeast Terrestrial Habitat Map from TNC. The Conservation Design is a 30-meter dataset with over 100 classes that supplement the Conservation Design. USFWS contracted with University of Massachusetts Amherst (UMASS) to develop the terrestrial and aquatic cores and NatureServe to develop the imperiled species dataset. UMASS developed a National Land Cover Dataset (NLCD) based on LANDSAT data to depict urban and agricultural areas in what they call the Designing Sustainable Landscapes version of the data that is still based on the original TNC layer. A full Nature's Network 2.0 is a multi-year effort. Now the model is coded and can be more easily updated and replicated. The terrestrial cores and connectors models are already completed. Nature's Network expects to integrate the imperiled species model in the summer of 2023.

Nature's Network does have a desktop toolbox that can be downloaded and customized. The toolbox runs on the Nature's Network website and can create a custom model, change weights, change metrics, etc. The tool coarsens the datasets from 30 meters up to HUC 12 catchment scale, so the spatial resolution is not as high as people want.

The differences in the Conservation Design and the current CCP Priority Habitat Map is the tier classifications (which were an early iteration and no longer exist in the Nature's Network model) and the black duck habitat model, which was added by CIC. Andrew Milliken with USFWS is currently leading updates to Nature's Network to incorporate better data and methods. To consider developing a Chesapeake Bay model, BJ recommended bringing the CBP, the CCP and other decision-making partners together with the technical entities to have a conversation about what can be done versus what the partners want. The partners need to define the specific goals, objectives and outcomes and then work

with the technical entities to identify what is possible and what is not. For Nature's Network, decisions about what was not going to be done were as important as what could be done.

Michael Schwartz, The Conservation Fund

Michael was involved in the Nature's Network work since 2014 as the representative for West Virginia and has been working on this kind of work for years as a GIS modeler in habitat connectivity modelling. Michael offered perspectives on including better species data, as there are always new species models being developed. He noted that having tiers and categorizing the data is very important, and dynamic capabilities such as the ability to turn the layers on and off and being able to change the weighting. He suggests considering how to focus the model on water quality for the Chesapeake Bay. The TNC resiliency tool looks at biodiversity and climate resilience. He also suggests considering the inclusion of species models that are done on different climate change scenarios. Michael used to make suitability models that used economic, social and environmental data together that could be weighted, but that process of creating an integrated model has been less popular recently. The more flexibility users have to make their own map is helpful, but it is also good to have a pre-made habitat priority model as a starting point and not overwhelm people with starting from scratch.

Michael suggested that a bay-wide habitat model may not be that much improved by looking at 1-meter data at the bay-wide scale, but it would be useful at the parcel scale. Individual states (for example West Virginia) can feel differently on how this kind of data are categorized due to politics of prioritizing so much land for conservation. There is an "Ecoscore" that identifies unfragmented forest that could be useful at the Chesapeake Bay scale. Matching up the model with the bay restoration goals will help with other efforts such as aligning with National Fish and Wildlife Foundation grant selection criteria. Ecosystem services would be useful to land trusts and local conservation organizations, especially if there are dollar values associated with it.

Peter Claggett, CBP

Peter Claggett developed CBP's high resolution 1-meter land cover dataset. He noted that this dataset can be useful, but it depends on what a user is looking for. For example, if the goal is to find large unfragmented forest areas, 1-meter data may not be needed. He noted that things such as small subdivisions may not be captured by a 30-meter dataset, which can be an issue for some species that are sensitive to disturbance, but not to others that may thrive near residential development. The 1-meter-high resolution dataset integrates other ancillary datasets and has 64 classes; there is also a simplified 12 class version, and dataset from 2013/14 and 2017/18. Species-based models may be a preferred method to follow as they are more focused and science-backed rather than using only a land cover-based hub and corridor network. Hub and corridor networks can be helpful for comprehensive planning as long as the model scoring can change according to scale.

There is also a recreation aspect that may need to be considered as CCP and CBP have agreed to preserve 30-50% of the watershed. A more generic habitat model with hubs, corridors, parks and trails would be more relevant to the public if recreation is included. Peter mentioned that using a 1-meter dataset will need parameters on what will fragment areas in the model, as the 1-meter dataset has different classes for forest. Peter noted that 1-meter data may be more relevant to underserved communities in urban areas to identify smaller green spaces that may be relevant to recreational access and species that do not rely on large hubs. The 1-meter data can be helpful for transparency and usefulness for communities in terms of locating priorities according to CCP for decision making. He recognized that the 1-meter data will be useful for parcel level scale, and potentially at the watershed

scale if it is picking up things the 30-meter data is not that are relevant for habitat. He notes that there are computational challenges in using 1-meter data and considerations in using GIS or code-based methods. If a pre-made model is to be maintained by CBP, Peter and his team would need the python code, rather than GIS Model Builder files, as having the code is the best way for them to manipulate the data.

Rua Mordecai, Southeast Conservation Blueprint

Rua noted that balancing a species-based versus generic model is a communication challenge with users of the tools. Having species thresholds is helpful when understanding how much of a species may be lost if an area is reduced to under a certain size. However, not having data for all species and making a model only based on a few species is not truly representative. Rua recommended testing any habitat model on certain individual species data to see to what degree the general habitat model captures the species areas as well. The SECAS Blueprint uses NatureServe to run the model across all of the species models and identifies where less than 90% of a species is captured. Rua characterized the Blueprint as both a habitat-based model that is informed by species data that is habitat driven. The SECAS Blueprint uses 30-meter land cover data. They would not consider going to finer resolution until all the indicators are available at that scale. One-meter datasets are large making them difficult to store and take longer run times than 30-meter datasets. Rua noted that highly developed urban areas are where 1-meter data is the most useful. He suggested testing parcel maps with 30-meter pixels to see how much area is covered and if a 1-meter dataset would add much more information. Most of the SECAS Blueprint tool uses are at the parcel level.

The Blueprint has an annual update process. They found that people mostly used tools that are regularly updated, not those that are on longer schedules. The Blueprint has core staff who work on the updates; they do not contract out the work. Each year the model undergoes incremental improvements, not a complete rebuild. In terms of the level of effort, the Southeast Blueprint has three GIS staff, five user support staff, and a full team of 16 people, though more GIS staff is needed. User support is spread out across the area of the southeast states. He noted that building off of existing data makes the work more feasible. It is also critical for them to have communications/user support staff to track who is using the tool, which is helpful for lessons learned during yearly updates. As they develop each update, they pair GIS and user support staff to integrate user needs into the update. The core staff members are funded by USFWS. They found it more efficient to work with one funding source, rather than use time and resources to seek and track multiple sources.

Jim Wickham, EPA Office of Research and Development

Jim noted that one of the considerations with using 1-meter data is the increased funding and resources needed to develop, run and store the significantly larger data files. Cloud computing could be utilized to handle 1-meter data, which would require staff who can operate in that environment and expensive computers and software. For example, Jim's high-performance computer is continually updated and uses ArcPy. One-meter data will show forest in places not shown with 30-meter data, which may be useful and will help give better definition of the edges of habitat. Most 1-meter data only have very generic land cover designations, while 30-meter datasets have very detailed classifications with over 100 vegetation classes. The National Oceanic and Atmospheric Administration SEACAT program received funding through the Bipartisan Infrastructure Law and are now mapping 1-meter data for the contiguous United States and Alaska. They are working with Peter Claggett and his team to ensure they are not duplicating work done for the Chesapeake Bay.

Jim suggested that the Chesapeake Bay scale may not require cloud computing resources, and that there is a need to determine if there is a slightly coarser resolution that would be useful, such as 5-meter data to help reduce data processing. Jim works on accuracy with the NLCD and noted that there is not a good way to look at the accuracy of 1-meter data because it would need to reference a higher resolution data source to be quality assured, and there is a lack of any higher resolution data to use. The literature on 1-meter data is very new and the Chesapeake Bay was the first to put out land cover change data. Jim said that there are errors in NLCD at 30 meters that are visible. From the land cover perspective, Jim noted that if a 1-meter dataset is used, it most likely would not be updated on a yearly basis, and that there must be consideration for the cost/benefit of time and resources to update regularly if much of the Chesapeake Bay does not change over a year. He would suggest a 5-year update interval bay wide and potentially yearly updates/maps that only focus on the urban and urbanizing areas.

Donovan Drummey, USFWS, Regional Species of Greatest Conservation Need

Donovan works with the USFWS on a set of contracts to identify RSGCN (Regional Species of Greatest Conservation Need). Donovan indicated that each state has their own priority listing and ranking of these species and her group wants to look at the regional level. She noted that Chesapeake WILD will adopt the RSGCN list as their primary source to help prioritize and target funding in a way that is helpful and supportive of state goals and priorities. They overlay species with habitat priority areas to help make a general checklist of species within a certain geography but will not provide specific maps due to concerns of exposing species at risk to the public.

State Wildlife Action Plans (SWAPs) are required to identify species, habitats, threats and actions, and there have been inconsistencies in the past in how states created the SWAPs. This led to the Northeast Association of Fish and Wildlife Agencies (NAFWA) developing a SWAP database or lexicon to find the common items like habitat classification and species across all states to have a standard categorization but still leaving flexibility for the states. Each detailed habitat type per state is categorized under a broader category and rolled up to the regional scale. They are currently working to translate 2015 SWAP descriptions to match the new categories. There is no relation of these SWAP habitat categories with the categories in the NLCD. The lexicon starts very coarse with 10 total categories, then breaks into 24 habitat types for both terrestrial and aquatic to allow states the flexibility to add more relevant detail. The TNC terrestrial dataset of the Northeast is a base map starting place for many states to layer on classifications from their state natural heritage programs. The NAFWA tracks and measures degraded habitat quality and status spatially, and summarizes conservation status, which can be found on this webpage. Donovan indicated that having data at 30 meters is very useful at a small scale and the RSGCN process is very intensive in terms of coordination across state technical experts; the most recent update went from November to May.

Greg Podniesinski, Pennsylvania Department of Conservation and Natural Resources

The Pennsylvania state heritage program has been conducting an ongoing survey to develop and maintain a natural heritage inventory since the 1980s. Each natural heritage area has been field identified, rather than modelled, and covers about 3,500 areas. Staff use aerial imagery, remote sensing and other overlays like geology and historical photos to identify areas to field test, working closely with the county planning commissions. The state natural heritage areas capture endangered species and natural habitats and are shown on the state natural heritage inventory website and conservation explorer. NatureServe did the species distribution modeling for Pennsylvania and created and maintains their state map viewer that is used for environmental review screening for development permit

applications. The map viewer tool allows a user to draw polygons for a project area and show any potential natural heritage conflicts. The tool can also run conservation planning reports and has layers for modelling climate change for landscapes and migration corridors. Around 200 to 250 development projects are screened in the tool annually, and 400 to 500 conservation planning reports are run annually.

Greg suggests that higher resolution data are better to use. NatureServe has a relationship with ESRI and helped them put together a library of GIS datasets of 80-90 layers to use for modelling. The Pennsylvania conservation explorer tool services four different state agencies. There is one staff person who dedicates most of their time to the tool and takes questions from the public. One full-time employee may be needed for an annual update for needed layers. Pennsylvania charges $40 for users to run environmental screening reports.

NatureServe performs the hosting and maintenance of the tool. Amazon Web Services (AWS) is used and the revenue generated covers that cost. Greg found that it was more cost efficient to use NatureServe rather than to hire new people internally. NatureServe is under contract to immediately work on any issues that arise and using NatureServe costs $184,000 a year. NatureServe does similar services for about 11 to 13 other states. They have a template/basic version of the web tool that is customized for each state's needs and requirements. Pennsylvania provides all data and NatureServe creates the platform and functionality. Pennsylvania is by far the biggest, most expensive state version of the tool that NatureServe has developed. NatureServe's only role is to make sure the tool is up and running, and they do logistics with AWS and pass that cost on to the state. Pennsylvania also pays for the costs associated with having an ESRI license, paying for an SQL server, and development and ongoing maintenance by using NatureServe. If there is less web traffic, a similar tool could be done on an internal server. There is also a rental fee for using AWS servers. For Pennsylvania, it cost $250,000 for the initial development by NatureServe, which they found was less when compared to other quotes in the $500,000 to $1 million range. There is no political influence on how the Natural Heritage Areas are drawn or placed in Pennsylvania. They are not regulatory, but rather strictly informational guidance. If Natural Heritage Areas are on state or private land it does not require that any action be taken.

Lin Perez, Academy of Natural Sciences, Technical Lead for Delaware Conservation Blueprint

Regarding data resolution, Lin identified 30 meters as the most common for landscape-level decisions, but not ideal for parcel scale. Ten-meter data provide a rich scale that allows for identifying landscape-level dynamics and are also useful for the parcel scale. One-meter data can be beneficial in looking at green stormwater infrastructure needs at the parcel scale, but it is a lot of information and presents many issues with data processing speeds and generating statistics if a landscape-level tool is needed that produces parcel-level stats. Lin develops decision support tools that require interactive statistics, and thinks many people have an expectation of live analysis.

Lin is using Nature's Network as a foundation for the Delaware Blueprint effort, so they are not reinventing model workflow. The Delaware Blueprint effort will result in four bins of data typologies for the conservation blueprint, one of which is habitat and is the most complex typology. Their tool may include functionality that allows a user to click on a parcel and generate statistics for things like number of wetlands, active river area, acres of headwater in forest, stream reaches, etc. One of the objectives of the Blueprint is to provide statistics to help with grant applications. Using a weighted composite score would not be as helpful, unless it is at a regional scale, and the stakeholders prefer the use of statistics on individual metrics. Lin noted that they know of very few applications where 1-meter resolution was appropriate.

Lin emphasized the value of the facilitated stakeholder process to both make a tool and build a network of people who will use the tool; that relationship building drives the need for the technology. The Delaware Conservation Blueprint is being made to serve the Delaware Conservation Fund, which is funded directly from USFWS. They will have the first rollout of the tool from September 2023 to January 2024; they will host webinars and flexible office hour sessions. The cost of developing the tool is $875,000 for the first year of development and the cumulative costs for 5 years of maintaining servers, hosting and updates. This cost is inclusive of development, server maintenance, and staff time for all four bins, not just habitat. This cost does not include the Landscape Conservation Institute which has a separate contract with USFWS for around $75,000 to $100,000 to facilitate the stakeholder process.

5. Recommendations

Based on the research conducted on existing models and feedback gathered from stakeholder workshops and subject matter experts, the following recommendations should be considered for updating the CCP Habitat Model.

General Recommendations

Model Update. Invest in developing a new CBP Habitat Model. The current model is static, lacks a transparent method, is not widely used and is out of date relative to other data sources.

Purpose. The purpose of the new model would be to serve as the CBP-approved high value habitat layer to guide conservation investments and track conservation goals at the watershed scale. The model could be a reference for parcel-specific conservation and restoration, but the priority is to create a watershed-wide baseline screening and tracking tool.

Approach. Adopt the new Conservation Design Nature's Network datasets as the foundation layers for the CBP Habitat Model. Similar to the Delaware Conservation Blueprint effort, clip the datasets to the intersecting counties of the Chesapeake Bay watershed and layer in Chesapeake Bay-specific data such as those listed in Table 3, either baked in or as optional layers. Optional layers will allow users to explore habitat goals in relation to climate resilience, underserved populations, and vulnerability to development. Recommend utilizing the 10-meter scale of the Chesapeake Bay land cover data to capture the bay-specific classifications. The follow section outlines options that consider a range in resources and level of effort.

Interface. Create a dynamic web-based interface to house the new CBP Habitat Model that will provide flexibility in viewing individual data layers, changing scales, and adding data relevant to specific geography and programs (such as 1-meter land cover data set, state habitat models, diversity, equity and inclusion data, climate resilience and other priorities to evaluate multiple benefits as appropriate). This dynamic interface, for example using ArcGIS Online or similar software, could include tools that allow the user to create maps, reports, add other data, etc. Integrate the new dynamic web interface into a landing page such as the CCP Conservation Atlas and the CBP Targeting website to contain metadata, instructions, resources, and scenarios for utilizing the CBP Habitat Model for conservation funding and priorities.

Education/Outreach. Invest in funding for outreach, education and technical assistance to integrate the new CCP Habitat Model into relevant conservation programs, priorities and funding throughout the Chesapeake Bay.

Potential Development Scenarios

Table 5. Range in Resources for Potential Scenarios

Scenario	Cost	Annual Maintenance Staffing, Cost, Computing Needs	Development Timeframe	Updates
A. Adopt Nature's Network 2.0	$30,000 of staff or contractor cost to integrate layers into an interactive web viewer along with other CBP layers, including 10-meter land cover overlay	Minimal Ensure layer updates occur as available; could integrate into current staffing with ArcGIS Online or similar expertise Minimal GIS computing hardware, software, server and storage	Available now	Update data layers as available
B. Tailor Nature's Network 2.0 with Chesapeake Bay data, including 10-meter land cover (similar to Delaware Conservation Blueprint funded by USFWS)	GIS Model: $150,000 to $200,000[3] 12- to 18-month facilitation process over 12 to 18 months: $50,000[4]	$20,000 to $30,000 Includes server costs Assumes contracted or 3-5 dedicated staff with significant in-house GIS expertise	24 months	Small updates could be integrated into maintenance costs
C. Similar to B with Chesapeake Bay 1-meter land cover Assumes static analysis (pre-run lookup tables) summarized at preset units (i.e., county, state) [5]	GIS Model: $250,000 to $450,000 Additional costs for staff run time and storage	$30,000 to $50,000 Includes staff, high performance computers, software licenses, servers and storage Minimal if web browser provided; significant if	36 months	Could be updated with each new 1-meter land cover update

[3] Cost references: USFWS contract with Academy of Sciences for Delaware Conservation Blueprint is $875,000, which includes development of four models (habitat plus three others) and maintenance for 5 years. Nature Serve developed the Pennsylvania state natural heritage model that includes complex report functions for $280,000 and $180,000 annual maintenance.

[4] USFWS has a contract with Landscape Conservation Institute for approximately $75,000 to 100,000 to facilitate a 12- to 18-month process to agree on a method and criteria for the four models.

[5] The analysis would draw from data tables that summarizes metrics (such as habitat acreage, amount of wetlands, active river area, acres of headwater in forest, etc.) related to high priority habitat at various scales, such as county, city, state, for the user to access, rather than having a model run a live analysis.

		model will be maintained and updated in-house Significant increase of ~40 to 50% for increased storage, CPU and RAM needs		
D. Similar to B with Chesapeake Bay 1-meter land cover integrated for select areas (such as urban or urbanizing areas)	GIS Model: $200,000 to $300,000	$30,000 to $40,000 Includes server costs Moderate increase of ~20 to 30% for increased storage, CPU and RAM needs	30 months	Could be updated with each new 1-meter land cover update

Potential Data Sources

The recommendations and defined scenario options for the future of the CCP Priority Habitat model will require additional data to be utilized, whether within a new iteration of the model or through a dynamic web application environment. The data sources in Table 3 show the primary datasets to consider in an updated model or in the creation of a dynamic interface or web tool. These data sources feed many of the models listed in Table 4 and are a few of the high-level sources that may be most applicable to understanding habitat priority areas bay wide. These datasets have a range of resolutions that can be utilized at different scales, with the Nature's Network Conservation Design serving as the primary data and scale at 30 meters.

Considerations for 1-Meter versus 30-Meter Land Cover Data

There must also be considerations for the resolution of the land cover data that drive the habitat model. The Nature's Network dataset utilizes 30-meter data and the consensus feedback received from the workshops and subject matter experts is that 30-meter data offer the most beneficial resolution for a bay-wide landscape scale, while still offering enough granularity to be used at smaller scales. There are however both benefits and potential drawbacks for using either 30-meter data or higher resolution 10-meter or 1-meter datasets. Using 1-meter land cover data will demand large datasets that require significant storage and computing power to utilize, and this resolution is not as relevant at the bay-wide scale.

One-meter data offers more detailed land cover data information that is useful at the parcel level scale, along with land cover change data available over different timescales. CBP also has an aggregated 10-meter fractional dataset created from the 1-meter high resolution data. However, the 1-meter resolution data may fragment areas that were previously thought to be contiguous and will require thresholds to be set regarding interpreting fragmented areas. Thirty-meter data requires less computing power and storage capacity in comparison, though the data inherently offer less fine grain detail than 1-meter or 10-meter data. Data storage and computing power must be considered when integrating the larger CBP 1-meter High Resolution Land Cover dataset. This dataset may serve best as an overlay/reference layer to view parcel scale areas to find more detail than in the 30-meter Nature's Network. Incorporating the 1-meter dataset into a new model may not be insightful at the bay-wide

level and will require a large amount of computing power, storage space, and additional capacity to quality assure on the ground. However, the 10-meter land cover dataset may be worth considering as an overlay to identify more detailed analysis at a finer scale.

Going forward, the ecological processes captured at different scales and resolutions must also be considered when utilizing 1-meter data. Challenges related to spatial resolution and ecological processes pose questions related to the science behind the data and models that should be explored further for both 1-meter land cover data, as well as other high-resolution datasets such as hydrography. These considerations include:

- What do these high-resolution datasets add in terms of ecosystem function and habitat value?
- What are the full range of implications of hydrography and riparian habitat high-resolution data?
- Is further discussion needed on the suitability of various stream network density data, or detail needed for landscape or parcel level applications? Would high-resolution hydrography data (NHD, NHD high res, or others) be useful?

Table 6. 1-Meter Land Cover Data Resolution Considerations

Considerations	Pros of 1-Meter Data	Cons of 1-Meter Data
Data storage and processing	• Possible to move toward cloud-based computing or code based	• Requires more storage, which adds an ongoing cost • Slower speeds to process plus additional time cost • Need to transition from using desktop GIS software
Utility compared to 30-meter data	• More detailed information at finer scale • Bay-specific classifications • May show fragmentation otherwise undetected by 30-meter data that could be relevant	• Such fine detail may not translate to differences at the bay or regional scale • May show fragmentation where habitat is still viable • May introduce errors that are difficult to correct
Update intervals	• Able to see changes in land cover over more frequent intervals	• Requires more level of effort and staff time (up to 10 times greater) to integrate updates given the larger files sizes
Aggregating to 5 meters, or using the 10-meter resolution	• Less computing power and storage needed • Still very granular level detail	• Not using full detail of 1-meter data • More difficult for end users to interpret 10-meter fractional dataset. The 1-meter data are rolled up into 10-meter data.
Recalculate model according to scale	• Provides more detail in urban or urbanizing areas where finer resolution is more relevant	• Larger computing effort • Slower speeds and more processing time and cost • May not be appropriate for CCP if statistics are only needed at bay-wide level
Ground truthing/ verifying accuracy	• Can see changes over time	• Ground-truthing would be larger effort

Development Process Considerations

Existing Regional Models.

Extensive resources and expertise have been invested in developing and updating regional landscape-scale habitat models funded by the USFWS. Replicating a similar process for the Chesapeake Bay could require a significant investment in funds and staffing and would take years to complete, resulting in potentially very similar outcomes at the landscape scale. The consultant recommends building from the Nature's Network Conservation Design datasets and either integrating and layering these datasets into a bay-specific model or web-based map viewer.

Model Ownership and Goals.

The CCP has traditionally relied on the Chesapeake Conservancy's CIC for GIS services as well as USFWS and USGS federal partners. More research is needed to determine which entity would host and maintain an updated active GIS priority habitat model and to what degree the model will serve or align with CBP vital habitat goals and the Chesapeake WILD program in addition to the CBP stewardship goal outcomes. The consultant recommends further coordination among these entities to determine the specific purpose of the updated habitat model and to what degree it will serve or align habitat metrics across conservation programs.

Stakeholder Coordination.

Many of the subject matter experts emphasized the significance of a facilitated stakeholder process in developing a landscape scale habitat model. The stakeholders not only establish the model data, criteria and methods, but by participating in the development process, they become users and champions of the model. This process also builds alignment in methods across different scales as well as different state and federal habitat and conservation programs. Based on information gathered from this project, the consultant recommends crafting a thoughtful stakeholder process to determine the data, criteria and methods and seek alignment across conservation programs with similar goals.

Ongoing Program and Maintenance Considerations

The capacity and responsibilities of the owner/host of the model or web tool should be considered when determining the format of the next habitat model update. Staff must have the capacity to work within the type of environment that will be needed to house and update the tool or model, as well as the proper storage space, computing power, and/or access to server space. With this organizationally owned and hosted environment, a GIS administrator or senior GIS analyst is best suited to address the necessary requirements for licensing and infrastructure in conjunction with existing IT staff based on the specific model update path pursued.

A web-based tool may utilize ESRI's ArcGIS Online platform, and knowledge of how to use this platform and its web applications would be necessary. The appropriate licensing and storage space is also necessary to house a tool and maintain updates within a web environment. With this Software-as-a-Service (SaaS) environment, a GIS administrator is often used for environment management but not required for this model update. A mid to senior GIS analyst could address the environment needs aspects in conjunction with existing IT staff.

Specific to creation or modification of the model, the specific model update path pursued with regards to data processing complexities will determine the range of GIS analyst needed. Potentially, some efforts could be done by a junior to mid GIS analyst, but some may require a senior GIS analyst.

Staff may be required to understand both the technical details of the tool and convey that effectively to users through outreach, education and technical assistance for users. Depending on staff capacity, staff can also track who uses the tool/model, gather feedback to inform future updates, and field any questions. GIS staff capacity and knowledge must also be considered with handling various forms of data, whether code based or GIS models, as well as workload in maintaining an additional tool.

Lastly, the frequency with which the model or tool is updated is key for understanding the level of effort and staff capacity needed. Frequent updates will require more staff solely dedicated to this model who are able to collect and incorporate feedback, as well as develop outreach materials to accompany each update. A new model will require more intensive workflows for updates, longer timeframes, and more staff time and support. Conversely, a web tool or dynamic interface would be less intensive, and have a shorter timeframe and level of effort, with fewer staff needed. Utilizing a dynamic tool also gives staff the ability to create functionality that could collect user feedback, rather than needing additional staff or specified. A dynamic tool would allow for real-time updates and more flexibility for GIS staff to incorporate changes.

Table 7. Tool Development Considerations

Tool Options	Technical Knowledge	Software, Storage	Timing, Level of Effort
Creating an online viewer/application	• Data Preparation • ArcGIS Online Experience Builder application and widgets configuration • User workflow requirements	• ArcGIS Online, or Portal for ArcGIS • Experience builder and widgets • Raw data storage capacity • Processed data output capacity	• Reference table 5 • To create a viewer/app is part of the final phase and may range from 1 to 4 months based on model update from table 4 and iterations of testing
Building a new model	• Data preparation • Data variances from existing model • Desired changes to model	• ArcGIS Pro/Desktop • ArcGIS Model Builder and/or Python • Raw data storage capacity • Processed data output capacity	• Reference table 5

Potential Additional Research

Beyond this scoping effort, there are opportunities for additional research on what model or tool will best serve CCP and the Chesapeake Bay conservation goals. Further literature review can be conducted to stay up to date on the latest trends in habitat modelling, conservation tools, state natural heritage program goals, and on the Nature's Network model update. Additional subject matter experts may be identified who can provide insights, as well as tying in experts working on known parallel efforts such as Chesapeake WILD, conservation blueprints, and Nature's Network to incorporate overlapping goals and

learn best practices. Finally, additional research into the cost proposals related to other models and tools should be conducted, and discussion with entities like NatureServe on the services they provide. Key questions that can be answered with additional research or by a formally convened stakeholder group include:

- Determine what data layers to incorporate.
- Determine how to integrate bay-specific data into the Nature's Network Conservation Design.
- Determine how best to integrate the 1-meter CBP land use land cover data (for example using just in urban and urbanizing areas or using it to create a 10-meter dataset, or recalculating as the user zooms into smaller geographic units such as states or counties).
- Determine whether to vary the model based on scale or eco-geography, for example using 1-meter data in urban and urbanizing areas or integrating species data in geographic areas of relevance. Determine whether multiple models are warranted to represent the different habitat outcome goals or could this be represented with overlays versus baking into a single model.
- Determine more detailed cost estimates for model development and maintenance, including staff levels and expertise, and infrastructure such as hardware, servers, storage and software. For example, considerations and research into matching available funding with the scenario and what impact that scenario would have.

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