Virginia's 2025 Wildlife Action Plan

Prepared by the Virginia Department of Wildlife Resources

7870 Villa Park Drive, Suite 400
Henrico, VA 23228

September 1, 2025

This effort was funded in part by the U.S. Fish and Wildlife Service's State Wildlife Grants Program, Grant No. VA-T-5-P.

Suggested Citation:

Virginia Department of Wildlife Resources. 2025. Virginia Wildlife Action Plan. Virginia Department of Wildlife Resources, Henrico, Virginia, USA.

LIST OF FIGURES

LIST OF TABLES

FOREWORD BY RYAN BROWN

The best first step in achieving a goal is to make a plan. Without a thorough plan for action, a goal can prove to be elusive. And with a big goal, such as to conserve Virginia's diverse fish wildlife species, you need a proactive, comprehensive, and thoughtful plan. That's why we at the Virginia Department of Wildlife Resources (DWR) take the lead on and work with partners to create and implement the Wildlife Action Plan. This plan guides our mission to keep the Commonwealth's fish and wildlife species healthy and sustainable as part of the Commonwealth's landscape.

Decades ago, Congress, the White House, the U.S. Fish and Wildlife Service (USFWS), and thousands of stakeholders developed a funding path for keeping fish and wildlife species from declining, with the goal of keeping common species common. The resultant State Wildlife Grants (SWG) program requires that each state and territory develop an Action Plan. The 2005 Wildlife Action Plan, the first iteration, represented a strategy to conserve Virginia's wildlife resources by developing a framework of coordination and cooperation between agencies, communities, and private conservation groups. These partners and the DWR have worked together to identify certain species, identified as Species of Greatest Conservation Need (SGCN), and habitats in need of conservation, and also to implement meaningful, on-the-ground projects and research to address those needs. Working to support and restore wildlife and habitat before they decline is a proactive approach that's more feasible and less expensive than trying to restore imperiled species.

In the 20 years since the Wildlife Action Plan's first writing, the DWR and partners have used the plan's guidance in identifying and implementing research and projects to benefit a wide variety of species across Virginia. The Wildlife Action Plan identifies species in decline, prioritizes them based on their need and the feasibility of work identified to address those needs, and maps out strategies that would help stabilize or grow those SGCN populations. It's a great way to break a big problem down into manageable, specific steps and actions. Many of the projects and actions taken to address the needs of SGCN have improved habitat for other, more common species that use the same resources.

Like most plans, the Wildlife Action Plan should evolve as needs and capabilities change. For 2025, the DWR has worked with partners, including federally and state-recognized Native American tribes, to update the Wildlife Action Plan to guide our work for the next 10 years. We've included many new SGCN, updated the status of others, examined our successes, and charted paths forward for areas in need of improvement. The 2025 Wildlife Action Plan has a strong focus on more specific, place-based efforts to conserve SGCN and includes new conservation education, enforcement, recreation, and engagement actions.

Together, the DWR, partners, and Virginians can have an impact on the wildlife species that make our natural world so interesting, diverse, and colorful. With a renewed, updated Wildlife Action Plan, we have a guidebook to do so.

Ryan J. Brown
Executive Director
Virginia Department of Wildlife Resources

PREFACE

As I started this, my third Virginia Wildlife Action Plan, I began to reflect on how far we've come and what progress we have made since our first plan 20 years ago. Obviously, we have come along way from massive three ring notebooks holding a thousand pages of narrative and maps, and the GIS technology has also progressed. But how far have we come in making progress on implementing the conservation issues outlined in each of the Plans? As I reviewed the two previous plans, the thing that stood out most was how much better we are getting at describing specific conservation actions that we, our partners and others can take to make a positive impact on the landscape. We still need to do more, but this iteration of the Plan will hopefully improve on the previous two.

There are many changes in the 2025 Plan update. The three biggest changes come in (1) separating out some species that we previously included in the Plan because we don't really have enough information to inform the tier ranking; (2) providing occurrence of Species of Greatest Conservation Need (SGCN) and habitat information on a smaller spatial or geographic scale than in the previous plan; and (3) coordinating with the tribes recognized by the Commonwealth and those who gained federal recognition since 2015. This last point being the most significant part of my learning process throughout this revision. With the help of our partners at the Virginia Department of Conservation and Recreation's (DCR) Division of Natural Heritage (DNH), we have included plants this time. We could not have done this without their expertise and support. In addition, we have included a more complete list of marine species and larger emphasis on climate vulnerability, working lands and outreach and education.

These changes and the complete review of all of our SGCN lists has required significant work on the parts of many people and partners. Most importantly, this revision would not have been completed if it were not for the two Commonwealth Coastal and Marine Policy Fellows, supported by Virginia Sea Grant and the DWR, that worked on this project: Clay Ferguson and Cliff Jenkins. Clay was instrumental in pulling the preliminary SGCN lists together for review by the Taxa teams and then keeping the teams on schedule to complete the reviews. Cliff stepped in as Clay was finishing his fellowship and shepherded our GIS work and defining habitats, threats and conservation actions. I could not have maintained the schedule or handled all of the coordination if it had not been for these two exceptional individuals, and I know they are both headed for great things in the future. In addition, Becky Gwynn kept us all on task and provided guidance to better consider how we wanted to approach different parts of this revision. In addition, she enhanced the Plan with her years of wisdom and unmatched writing skills to expand on many parts of the Plan.

Beyond the core team, many others contributed greatly to the 2025 Wildlife Action Plan. They include:

- The staff and administrators from the Virginia Department of Wildlife Resources: Scores of you contributed your time and expertise to help us identify and prioritize the Species of Greatest Conservation Need, understand the habitats those species require, describe the threats impacting those species and habitats, and articulate the actions that can be taken to address those threats and help keep species from declining. Many of you reviewed draft materials, corrected our mistakes, and helped arrange outreach opportunities. Without your efforts and expertise, the updated plan would not exist as a viable conservation tool.

- Scott Klopfer and the staff at Virginia Tech's Conservation Management Institute: You have been invaluable members of this planning team . Your work on developing the GIS tools and online dashboard for future use set the DWR up well for the work ahead.

- Jason Bulluck, Anne Chazal and many other great staff and experts at the Virginia DCR-DNH: Your assistance and collaborative nature have been greatly appreciated. The data, tools, and analyses you provided were critical in identifying and describing conservation priorities and opportunities, and critically, provided the expertise to include the plants and many of the invertebrates in this version of the plan.

- Dee Blanton and others from the U.S. Fish and Wildlife Service's Office of Conservation Investment: Your efforts to help the northeastern states communicate with each other and to coordinate with the Northeast SWAP Coordinators have advanced our planning efforts and will enhance our collective ability to address our regional conservation needs.

- The tribal environmental staffs who provided input and guidance on how best to incorporate the tribal perspectives, culturally important information and generally just helping the Agency navigate a new set of relationships: Dana Adkins (Chickahominy Indian Tribe), Jack Ryan (Rappahannock Indian Tribe), and Joe Capella (Pamunkey Indian Tribe) were particularly helpful in answering many of my very uninformed questions. I'd also like to thank Mike LaVoie and Caleb Hickman with the Eastern Band of the Cherokee for taking the time to educate us on tribal issues and relationships.

- Lastly, the authors would like to thank everyone that reviewed the draft Wildlife Action Plan and provided comments. We appreciated the words of encouragement as well as the constructive criticisms.

This plan is truly the work of many hands and great minds. My part was simply to "herd the cats" and keep us headed in the right direction. I could never have accomplished this without so many taking their time to provide comments, answer questions, and carry the load to bring this to completion. It was well worth sticking around for a couple more years to shepherd the process. I continue to be amazed at the passion of so many great folks working together to achieve the important conservation goals. Keep up the good work and thank you for carrying on the legacy of so many others who came before us!

Sincerely,

Jeffrey B. Trollinger
Wildlife Action Plan Coordinator
Virginia Department of Wildlife Resources
August 31, 2025

EXECUTIVE SUMMARY

Virginia is an incredibly diverse state. While supporting nearly 9 million people, Virginia's landscape provides hundreds of habitat types that support tens of thousands of wildlife species. Throughout Virginia's history, these wildlife and habitat resources have provided sustenance, economic benefits, icons, and recreational opportunities that contribute to community wellbeing, individual quality of life, and cultural identity.

Over the last century, Virginia's habitats have become increasingly impaired, impacting both wildlife and people. While Virginia's conservation community has successfully restored many imperiled species, including white-tailed deer, Canada geese, and bald eagles, many habitats and the species they support continue to decline. At the time of this writing, over 130 species have been classified as being either threatened or endangered in Virginia. Efforts to restore critically imperiled species are often expensive, contentious, and biologically challenging. Limited budgets, habitat loss and change, and an increasingly diverse suite of interests require Virginia's conservation community to reconsider its work; to become more collaborative and proactive. It is no longer sufficient to ask, "How do we restore endangered species?" Rather, the conservation community must ask, "How do we keep species from becoming endangered?" Virginia's Wildlife Action Plan presents a strategy to help restore imperiled and declining species and to keep more common species common, while also providing benefits to Virginia's human communities.

The updated Wildlife Action Plan identifies 1920 Species of Greatest Conservation Need (SGCN) that are ranked by their relative degree of imperilment and an additional 523 Assessment Priority species for which there is not enough information at this time to determine an accurate tier ranking. Habitat loss is the single greatest challenge impacting many of these species. This Plan, through the online tool, presents habitats by twelfth-order watersheds and the SGCN that occur in those watersheds. In addition, threats to species and habitats, including ones of anthropogenic origin (e.g., poaching, illegal trade, light pollution) are identified. Conservation actions are outlined for each watershed, and others that may be applicable to species or habitats regardless of geography have also been included. The Wildlife Action Plan documents existing programs that address threats or define best management practices, as well as data that could be used to document and evaluate the success of conservation actions. Finally, the updated Wildlife Action Plan describes climatic trends that have been projected for Virginia and identifies actions that can be taken to conserve wildlife and habitats under those changing conditions.

Virginia's Wildlife Action Plan was updated with significant input from Virginia's conservation community. Substantial efforts were also made to obtain feedback from the sovereign tribal nations, state-recognized tribes, and the general public.

It is hoped that this updated Action Plan will help Virginians, in all areas, to expand and enhance existing partnerships, develop new partnerships, direct the use of existing conservation resources toward priority areas and problems, bring new resources to bear, and help the Commonwealth acquire or develop new human and financial resources to address these important conservation issues.

1. CONTENTS

2. INTRODUCTION

BACKGROUND

Congress created the State Wildlife Grants Program (SWG) in 2000 and the Tribal Wildlife Grant Program in 2001 to provide critical funding to state, territorial, commonwealth, District of Columbia (D.C.), and tribal fish and wildlife agencies to conserve at-risk fish and wildlife. These programs, administered by the U.S. Fish and Wildlife Service's (USFWS) Wildlife and Sport Fish Restoration Program (now the Office of Conservation Investment), filled a significant void in conservation funding and opened the door to a new era of partnership between governmental and non-government agencies and organizations, communities, businesses and industry. The primary purpose of the State and Tribal Wildlife Grant Program is to help states proactively invest in fish and wildlife conservation strategies to prevent species from becoming endangered and accelerate efforts to restore those already endangered or threatened (USFWS 2020).

As an initial condition for receiving SWG funding, Congress mandated that each state and territory develop a Wildlife Actions Plan (Action Plan; Plan) by October 2005. The Wildlife Action Plans were conceived as an effort to guide states in identifying and addressing the needs of a wide array of wildlife and habitats of greatest conservation need. These Wildlife Action Plans were also used to ensure the effective use of SWG funding. To guide development of these Wildlife Action Plans, Congress established eight essential elements that had to be addressed before a Wildlife Action Plan could be approved by the Director of the USFWS (Public Law 106-291). These eight essential elements include:

> *1. Information on the distribution and abundance of species of wildlife, including low and declining populations as the state fish and wildlife agency deems appropriate, that are indicative of the diversity and health of the state's wildlife; and*
>
> *2. Descriptions of locations and relative condition of key habitats and community types essential to conservation of species identified in (1); and*
>
> *3. Descriptions of problems which may adversely affect species identified in (1) or their habitats, and priority research and survey efforts needed to identify factors which may assist in restoration and improved conservation of these species and habitats; and*
>
> *4. Descriptions of conservation actions determined to be necessary to conserve the identified species and habitats and priorities for implementing such actions; and*
>
> *5. Proposed plans for monitoring species identified in (1) and their habitats, for monitoring the effectiveness of the conservation actions proposed in (4), and for adapting these conservation actions to respond appropriately to new information or changing conditions; and*
>
> *6. Descriptions of procedures to review the Plan-Strategy at intervals not to exceed ten years; and*

7. Plans for coordinating, to the extent feasible, the development, implementation, review, and revision of the Plan-Strategy with federal, state, and local agencies and Indian tribes that manage significant land and water areas within the state or administer programs that significantly affect the conservation of identified species and habitats; and

8. Congress has affirmed through the Wildlife Conservation and Restoration Program and SWG that broad public participation is an essential element of developing and implementing these Plans-Strategies, the projects that are carried out while these Plans-Strategies are developed, and the Species in Greatest Need of Conservation (SGCN) that Congress has indicated such programs and projects are intended to emphasize.

All states and territories submitted their initial Wildlife Action Plans to the USFWS by October 1, 2005. Since being approved, these Wildlife Action Plans have been a guiding force in wildlife conservation. Virginia's 2005 Wildlife Action Plan represented a strategy to conserve Virginia's wildlife resources. Although the Virginia Department of Wildlife Resources (DWR) was the lead agency in developing the Wildlife Action Plan, and its subsequent revision in 2015, it was intended to be a strategy for statewide wildlife and habitat conservation and a framework for coordination and cooperation between governmental agencies, academic institutions, communities, businesses, industry, and non-governmental organizations. The DWR and partners have used the Wildlife Action Plan to prioritize key species and habitats in need of conservation and to implement needed projects and research on behalf of all Virginians.

Virginia's Wildlife Action Plan was updated in 2015 and, with this 2025 document, is now in its third iteration. The DWR and partners view this update process as an important opportunity to reevaluate the status of Species of Greatest Conservation Need (SGCN) and their habitats, review conservation priorities, and reprioritize conservation actions. Furthermore, this update provides a process to review the conservation efforts, research, and projects implemented during the past decade. It also allows the DWR and partners to consider how the Wildlife Action Plan and project prioritization might be improved to enhance efforts that keep species from becoming imperiled.

Based upon discussions with DWR staff and conservation partners, and review of how conservation actions were described in the 2015 Plan, Virginia's 2025 Wildlife Action Plan has been modified to be more dynamic and applicable to smaller landscapes. The updated Wildlife Action Plan adopts greater emphasis on habitat conservation and, with the associated online tool, provides better guidance on how to implement conservation actions in a meaningful way. While single species efforts may be necessary to conserve the most critically imperiled species, scores of other species can be effectively and efficiently conserved via actions that protect and restore the quality of their habitats. While the 2015 Wildlife Action Plan adopted the format used by the Virginia Outdoors Plan that communicates priority actions and needs at the Planning District scale, the new Action Plan provides an overview of the habitats, impacts from changing environmental conditions and working landscapes, but goes further with the online tool to apply habitat conservation actions at a more local scale. The scope of the printed portion of the Plan addresses those aspects of Virginia's habitats and current knowledge that are less likely to change, while providing flexibility in the online tool to nimbly adjust on-the-ground

conservation efforts needed to address quickly changing stressors and current scientific knowledge of those threats. By enhancing its availability, it is hoped the Wildlife Action Plan will be used by a greater diversity of existing and potential new partners throughout the Commonwealth.

The 2025 Plan includes several important additions. Plants were included this time, with extensive review and work conducted by Virginia's Department of Conservation's Division of Natural Heritage (VDNH). In addition, marine species were included to a greater extent and reviewed by a team of marine taxonomic experts from the Virginia Department of Wildlife Resources, Virginia Marine Resources Commission and the Virginia Institute of Marine Science. A more significant emphasis is placed on conservation education and wildlife-related recreation in this Plan, and the DWR's Watchable Wildlife and Outreach staffs ensured that the Action Plan interfaces with the agency's Wildlife Viewing Plan and outreach efforts. Finally, a significant effort was made to incorporate comments from Virginia's Native American tribes who have been federally recognized since the last Plan revision. Virginia is home to seven federally-recognized and four state-recognized tribes. Many of these tribes are signatories to the Treaty of Middle Plantation, which specifically mentions tribal rights to oystering, fishing, and gathering a series of plants including edible roots, wild oats, rushes, and other species. Several tribes participate in natural resources stewardship through cooperative monitoring of fisheries resources, oyster reef restoration activities, and monitoring water quality on tribal lands. Many of these changes resulted in an increase in SGCN, but also provided a much more comprehensive perspective of the current state of Virginia's wildlife and natural resource communities.

2025 Wildlife Action Plan Implementation

Over the past two decades, Virginia's Wildlife Action Plan has become an important conservation resource, and significant effort has been expended to address issues identified within its pages. Successful implementation of the Wildlife Action Plan can be categorized into four main areas of work: species research, active resource management, land acquisition, and support and planning.

Species-specific research efforts were emphasized between the initial 2005 Plan and the 2015 revision. This work provided more focus for Virginia's conservation community to better understand the distribution, taxonomy, habitat requirements, and life history of a diverse set of SGCN. These data have been critical in helping biologists develop or improve species management efforts. The 2025 Plan builds these efforts; since 2015, State Wildlife Grant resources were used to develop statewide conservation plans for wood and bog turtles, eastern hellbender, Tennessee dace, black-banded sunfish, and eastern tiger salamander. Other notable conservation efforts included building boxes for hellbenders in the Upper Tennessee River watershed in southwest Virginia to provide additional nesting habitat. These efforts were implemented in conjunction with partners from the Smithsonian National Zoological Park, Virginia Tech, the University of Virginia at Wise, Virginia Master Naturalist volunteers and Southwest Virginia Community College. DWR provided start-up funding to a partnership including the Town of Elkton, VA Department of Environmental Quality and the USFWS, to restore the shoreline of the South Fork Shenandoah River at the Elkton Landfill, which prevented additional runoff of effluent and debris from the landfill. Several dam removal projects provided access for shad and river herring, sea lamprey and American eel and a host of freshwater mussel host species to upstream habitats that have been

inaccessible for centuries. Finally, Virginia is a national leader in the propagation of imperiled freshwater mollusks in the Tennessee River and the Atlantic slope watersheds at two mussel propagation facilities. During the past decade, more than 13.6 million mussels, including 23 federal and state listed species, have been propagated at these two facilities, and nearly 400,000 mussels have been released at strategic restoration sites. Of note, these accomplishments included restoring the Appalachian monkeyface and the James spinymussel to their original watersheds for the first time in decades, as well as reintroducing brook floater mussel to three watersheds, including the South Fork Shenandoah, and green floater and yellow lampmussel to the South River. The practices perfected at these propagation and culture facilities have charted new and exciting paths forward for the restoration and conservation of these imperiled aquatic resources.

Important lands were acquired to conserve SGCN and their habitats. The 7,912 acre Coastal Forest Wildlife Management Area (WMA) was acquired through a partnership of the USFWS, The Nature Conservancy, the Conservation Fund, Ducks Unlimited, the National Fish and Wildlife Foundation, Walmart's Acres for America Program, the Wildlife Foundation of Virginia, the American Bird Conservancy and the Virginia Outdoors Foundation and provides a variety of forested and open habitats utilized by SGCN as hemispherically important migratory bird habitat. Active pine-savannah habitat management of the Big Woods WMA resulted in the first pair of nesting red-cockaded woodpeckers at the WMA. This management also provided extensive habitat for other SGCN like northern bobwhite. Likewise, active management of the Highland WMA was successful in providing additional breeding habitat that brought golden-winged warblers onto the property. While these efforts require considerable effort to deliver, they represent a permanent conservation achievement.

The last category of activities involves a range of support and planning services. The original Wildlife Action Plan frequently described how devastating the loss or degradation of habitats can be to species. Often these impacts are caused by human activities. The DWR's Environmental Services Section has incorporated the Wildlife Action Plan into its review and commenting process for construction or development projects. Likewise, the Virginia Fish and Wildlife Information Service, Virginia's comprehensive wildlife database, has integrated the Wildlife Action Plan into its framework and provides a variety of distribution, habitat, and conservation information about the SGCN. Finally, changing environmental conditions was identified as a significant threat to several SGCN. Since 2008, Virginia has been a leader in working to develop strategies that address the changing environment within the updated Wildlife Action Plan, including land acquisitions that allow for marsh migration and developing living shorelines that can withstand increased storm impacts.

Undoubtedly, the original Wildlife Action Plan and the 2015 revision have helped Virginia conserve SGCN. However, it is obvious that more work is needed to make the Plan more useable and focused for specific conservation actions on the ground. This updated Wildlife Action Plan will address these issues while facilitating opportunities to evaluate this conservation tool and adapt efforts to meet new needs and challenges.

GOALS FOR THE UPDATED WILDLIFE ACTION PLAN

The primary purpose of this updated Wildlife Action Plan is to identify conservation actions that will benefit a diversity of species and habitats and describe where those conservation actions should be implemented. Based on the extensive work to implement the first Wildlife Action Plan, several key lessons and concerns emerged to inform the update process. First, the original Wildlife Action Plan was organized by ecoregions. Each ecoregion chapter included background information on the ecoregion and more specific details for a selection of SGCN found within the ecoregion (e.g., species life history, habitat description and status, threats, conservation actions, and research and monitoring needs). The ecoregion sections were informative and included relevant information for some species. Unfortunately, none of Virginia's conservation partners manage resources based upon ecoregion boundaries, making the original 2005 Wildlife Action Plan less "actionable" than was desired. The 2015 Wildlife Action Plan, while more focused on Planning Districts, still did not provide specific enough conservation actions that could be easily implemented. Spatial scale and representation of needed actions must be presented in a context that is meaningful and useful to conservation practitioners, communities and businesses, and, in fact, all Virginians.

A second concern involved the prioritization of projects implemented under the auspices of the Wildlife Action Plan and how those efforts related to conservation partners. Much of the initial implementation has focused on single species survey and research efforts. The majority of these efforts focused on species that were already critically imperiled, and this prioritization prevented many DWR programs from aligning work with the Wildlife Action Plan. Likewise, partners that were not specifically focused on threatened and endangered species were less able to identify actions applicable to their work. The 2015 Plan attempted to address some of these issues by directing efforts at the Planning District Commission (PDC) level (groups of counties/cities) but still lacked the degree of specificity needed for local implementation and direction of activities to specific conservation actions. In addition, the online tool, which was unique for 2015, did not have an effective search engine and often gave results, while accurate for the PDC, were not accurate for specific smaller areas within the PDC.

Finally, there were identified concerns over the breadth and depth of the conservation actions identified in the 2015 Wildlife Action Plan. The specific actions included were ones that could be funded largely by the federal State Wildlife Grants program and excluded ones that could be funded by other means (grants, partnerships, etc.). The DWR recognizes the importance of developing a more robust set of priorities. In the first Wildlife Action Plan, important and necessary actions were outlined but without any specific prioritization. The 2015 Wildlife Action Plan took a much more localized view of conservation actions, but it still lacked enough specific actions. The 2025 Wildlife Action Plan revision provides several improvements to address these concerns:

- *Increased participation by taxonomic experts and other informed partners* – The 2025 Wildlife Action Plan consulted extensively with taxonomic experts, not only in the **complete review of all SGCN species, but also in defining the habitats and threats associated with those species and specific conservation actions that will benefit those species.**

- *Relevance at a more local geographic scale* – The updated Wildlife Action Plan is written to provide resource managers with information about priority species, habitats, threats, and conservation actions in their area of focus and influence at the HUC12 level. A secondary effort, planned for a future addition, will include potential partners and additional funding sources for complementary conservation efforts.
- *Habitat approach and focus to address threats and conservation* opportunities – The revised Wildlife Action Plan focuses conservation efforts by habitats to address threats and conservation actions for a broader array of SGCN.
- *Prioritization of species and actions* – This version of the Wildlife Action Plan continues a focus on prioritizing both SGCN and some of the conservation actions at a local level. In this way, conservation within Virginia can be carried out in areas in the most need of action or areas where efforts are most likely be successful and beneficial. In addition, the addition of Assessment Priority species provides for the inclusion of a host of species that may need conservation efforts, but for which there is little or no information concerning what those efforts might look like.
- *Representation of an array of partners* – The contents of this Wildlife Action Plan focus on SGCN and habitats that are managed by a diversity of federal, state, and local agencies as well as private organizations, tribal nations and individuals that implement conservation efforts throughout Virginia. Whenever possible, relevant tools and priorities developed by these partners have been incorporated into the Wildlife Action Plan.
- *Emphasis on effectiveness* – The Wildlife Action Plan includes specific procedures that will allow the DWR and others to measure the effectiveness of conservation actions implemented from the Wildlife Action Plan.
- *Online dashboard for conservation actions* – This revision is primarily delivered in an electronic online format that allows interested entities to search at a finer geospatial scale and determine SGCN presence in the area, what habitats occur in the area and what conservation actions are associated with those SGCN and their associated habitats.

VALUE OF AN UPDATED WILDLIFE ACTION PLAN

Virginia has a vast array of species and habitats from the coast to the mountains. Natural resource conservation in Virginia, as in most states, is a collaborative effort by government agencies, non-governmental organizations, businesses, communities, private institutions, and citizens. In addition, each of the Sovereign Nations have conservation goals of their own. This broad community partners across the Commonwealth to maximize the opportunities for conserving wildlife and habitats. Virginia's Wildlife Action Plan provides a statewide and local blueprint for conservation actions needed to keep species from becoming endangered. Information regarding these resources is provided at multiple levels, ranging from single species needs to habitats and watersheds. The Wildlife Action Plan is designed to help all conservation sectors understand species and habitats priorities at a state and local levels and the types of actions needed within their area of responsibility or even backyard. The Wildlife Action Plan includes 1920 SGCN and 523 Assessment Priority species; it covers 11 major habitat types representing 32 sub-habitats; and is searchable at the HUC12 level for priority SGCN and threats and conservation actions by habitat. Some species locations are buffered due to the ease of identification,

sensitive nature of very specific habitat associations, size of some hydrologic units, and the risk of collection or poaching. In addition, there is a specific section on Working Lands and how lands specifically managed for human activities still provide habitat for many SGCN.

In addition to these changes, the 2025 Plan has been organized and described according to the Northeast Lexicon (Crisfield, NEFWDTC 2022) to facilitate multi-jurisdiction and regional coordination among the northeast state fish and wildlife agencies. Described habitats, threats and conservation actions are described according to the definitions and coding scheme developed by the Northeast Association of Fish and Wildlife Agencies' Fish and Wildlife Diversity Technical Committee (NEFWDTC) and its partners. Ultimately, data from the Virginia Wildlife Action Plan will be added to the Northeast State Wildlife Action Plan Database so that regional projects will be easier to develop.

The process of updating this Wildlife Action Plan allowed federal, state, and local agencies, as well as nonprofit organizations, academic institutions, state and federally recognized tribes, tribes with a cultural presence in Virginia, and other entities, to identify common goals and actions that will help all entities work more efficiently at achieving conservation success. This Wildlife Action Plan is meant to build upon existing partnerships, foster new partnerships, enhance and prioritize programs, build support for the identified priorities, and lay the foundation for effectively and efficiently implementing conservation actions throughout the Commonwealth.

UPDATED PLAN STRUCTURE

The updated Wildlife Action Plan is organized primarily by the "Eight Essential Elements" required by Congress. Most of the actionable and specific information has been loaded into an online database and is searchable through an online dashboard. This approach provides an easier-to-use format and allows for more accurate species distribution information and associated habitat information. The Plan, while only required to be updated every 10 years, should be dynamic and be updated as new information becomes available. While this tactic may require additional coordination with the U.S. Fish and Wildlife Service, utilizing the defined processes for major and minor changes, it should provide for a more readily useable Plan until the next revision is due.

- *Introduction* provides background information and an overview of the Wildlife Action Plan.
    - Purpose of Wildlife Action Plan
    - Implementation of 2025 Wildlife Action Plan
    - 2025 Wildlife Action Plan Goals
    - Wildlife Action Plan Value
    - Plan Structure
- Overview
    - Description of the online dashboard and database
    - Summary of Species of Greatest Conservation Need
    - Criteria for SGCN species (Element 1)
- Habitats, Threats, Conservation Actions, Monitoring (Elements 2, 3, 4, 5)
    - Habitat descriptions and status (Element 2)

    - Statewide threats to species and habitats, including changing environmental conditions (Element 3)
    - Research needs (Element 3)
    - Conservation actions (Element 4)
    - Monitoring and research needs (Element 5)
    - Effectiveness measures (Element 5)
- Revision Process and Timeline (Element 6)
- Stakeholder and Public Participation (Elements 7 & 8)
- *Appendices*
    - Wildlife Health Issues
    - Conservation Education & Outreach Efforts to Implement the WAP

3. WILDLIFE ACTION PLAN OVERVIEW

Virginia's revised Wildlife Action Plan utilizes a habitat approach to address threats and conservation actions for the state's fish and wildlife resources where feasible. In addition, anthropogenic impacts (e.g., poaching, illegal trade) have been included, along with relevant conservation actions to address these threats. This approach helps ensure that conservation actions benefit a diversity of species within the Commonwealth. A habitat approach also allows for more species potentially to benefit by any single conservation action and for the more efficient use of limited resources. Additionally, this Wildlife Action Plan is designed to facilitate implementation at a scale where conservation most often occurs – the local level.

Throughout the process, DWR administrators and the Wildlife Action Plan's authors worked with the understanding that an effective Wildlife Action Plan could only be created with input and guidance from DWR staff, partner agencies and organizations, tribal nations, communities, businesses, and the public.

ONLINE WEBSITE & TOOL

This revision of the Plan will include delivery of a significant portion of the information through an online website and tool {temporary link}. To make the Plan more executable at a local scale, users will be able to click on a 12th-order watershed, or a place on a map, and be able to look at habitats that exist within that watershed. Users will be able to view a list of SGCN that occur in that area, along with associated habitats, stressors, and conservation actions likely to help conserve those species. In the future, the DWR hopes to include links to resources and partners able to assist with implementing those conservation actions.

The online portion will supplement the information required for submission to the U.S. Fish and Wildlife Service in a printed document and will facilitate making onsite conservation decisions. The text portion will provide the overview of how the Plan was developed, descriptions of the habitats and threats to SGCN and their associated habitats, and a description of some ongoing monitoring occurring between 2025 and the next revision in 2035. In addition, there will be appendices, online links, and information

providing additional information on the Plan, such as conservation education and wildlife-related recreation efforts, and links to a variety of associated documents, especially in the Northeast region.

SPECIES SUMMARY

Virginia's 2025 Wildlife Action Plan includes a list of 1920 SGCN. *Rather than simply revise the 2015 WAP, staff chose to refresh the entire review of potential species.* All criteria for inclusion and ranking of SGCN have been incorporated into this document for reference. While most habitat associations, threats, and conservation actions were known, taxa teams reestablished these linkages according to the NE Lexicon as developed by the NEFWDTC.

The 2025 Wildlife Action Plan includes a more extensive suite of plants (some were amended into the 2015 Plan in 2024) and more extensive inclusion of marine species. The number of species within each taxonomic group and tier are identified within Table 2.1.

Table 3.1. Number of SGCN by Taxonomic Group by Tier.

Taxonomic Group	TIER I	TIER II	TIER III	TIER IV	TOTAL
Amphibians	9	5	12	9	35
Reptiles	8	3	12	7	30
Freshwater Fishes	17	18	22	29	86
Marine Fishes	1	1	15	8	25
Birds	21	14	26	28	89
Mammals	8	3	6	14	31
Aquatic mollusks	28	15	9	9	61
Aquatic crustaceans	3	4	5	4	16
Aquatic insects	16	63	44	32	155
Other aquatic invertebrates	15	18	7	8	48
Terrestrial insects	33	35	64	34	166
Other terrestrial invertebrates	45	78	44	40	207
Plants	623	145	69	134	971
Total	**829**	**403**	**338**	**359**	**1920**

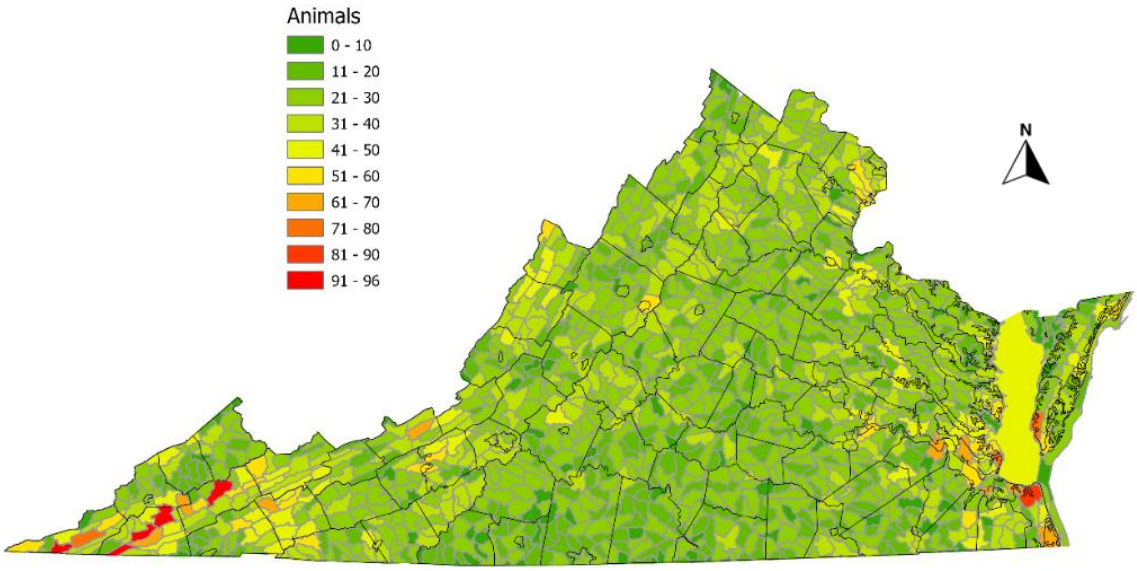


Figure 2.1 - Density of SGCN Animals across Virginia

In addition to updating the Tier rankings to describe level of imperilment, each species was assigned a Conservation Opportunity Rank of A, B, or C (see page 15). This prioritization scheme helps managers focus attention on species with specific management needs and opportunities. Of the 1920 SGCN identified within the 2025 Wildlife Action Plan, 21 percent are classified as Category A, indicating that managers have identified on-the-ground strategies to address the needs of the species or its habitat. Another 45 percent of the 2025 list of SGCN are classified as Category B, indicating that specific research is needed to facilitate on-the-ground action or that identified actions cannot be implemented at this time due to a lack of resources. The remaining SGCN (34 percent) are classified as Category C or not given a Conservation Opportunity Rank at all, indicating that managers have not identified on-the-ground strategies or specific research needs that will facilitate those actions or that there is not enough information to determine a specific ranking or tier. Species also were assigned to Category C when available conservation opportunities have been exhausted. It should be noted that life history and distribution data are lacking for many of the SGCN.

Density of SGCN Animals (top) and Plants (bottom) across Virginia

Species of Greatest Conservation Need List Revision

Due to the inclusion of additional taxa (plants, marine species) and the extensive updating of bird and freshwater mussel distribution data, the DWR chose to re-evaluate the status of all SGCN in this revision rather than just amend the 2015 list. The complete list of SGCN can be found here. {TEMPORARY LINK} The assessment of all SGCN was begun by creating a list of all possible species that could be considered, based on their inclusion on one or more of the following established assessment lists:

the 2015 Virginia list of SGCN, Federally-listed Virginia species, Northeast and Southeast Regional SGCN, NatureServe-ranked species, Virginia listed species, and IUCN-ranked species.

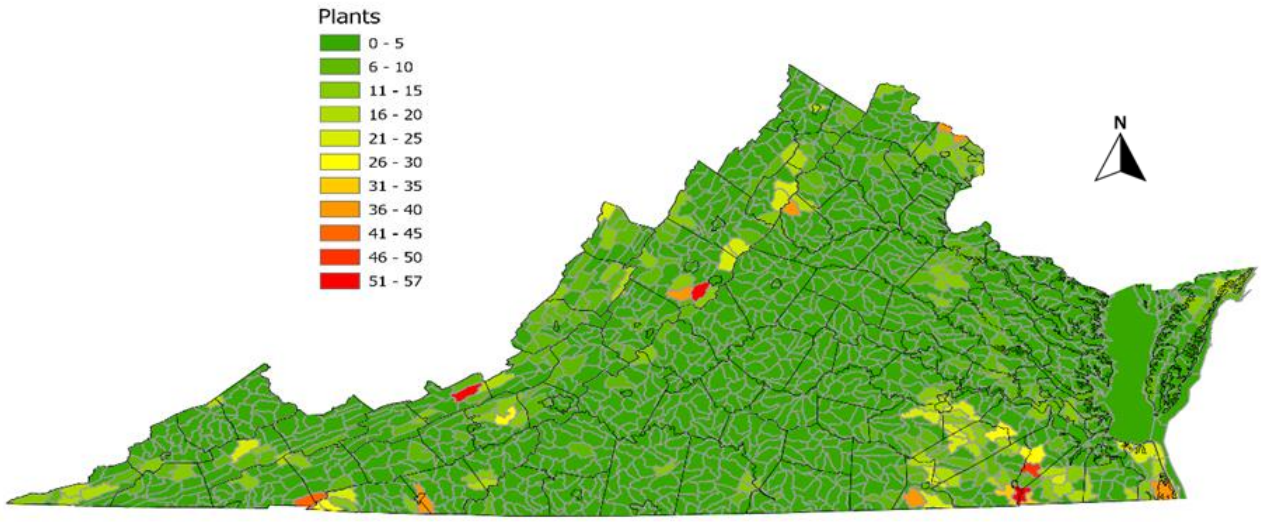


Figure 2.2 - Density of SGCN Plants across Virginia

The DWR identified categories of potential SGCNs to assist in the prioritization of them:

a. *Leaning in:* a species not included in the 2015 SGCN list that qualified for consideration in the 2025 SGCN review process, as it was found on at least one of the established assessment lists. "Leaning-in" species were recommended for inclusion in the 2025 SGCN list and included if their respective TAC supported inclusion or if no justification could be provided for removal.
b. *Low- qualifying:* a species that barely qualified for inclusion on the potential SGCN list. Species received the "low qualifying" label if they were only included on the potential SGCN list because they met one or more of the following intertaxa criteria ranks:

    - ESA, At-Risk Species, petition withdrawn (PW) or not listed (NL)
    - RSGCN watchlist (WL), proposed watchlist (pWL), or proposed moderate concern (pMC)
    - NatureServe G5 or S5, G4-S3, G3-S4, SNR, SU, SH, SNA, or equivalent ranks
      Although "low-qualifying" species received heightened scrutiny for inclusion, they were by default included on the proposed SGCN list if TAC teams could not justify removal.

c. *Leaning-out*: a species recommended for removal because it did not meet at least one of the criteria above and removed if the respective TAC concurred or if no justification could be provided for inclusion.

An important new component added to this Wildlife Action Plan was an assessment priority (AP) category. Synonymous to a "data-deficient" category, the AP category was created to flag "species for which more information is needed to fully understand status and trends to determine the level of conservation concern or SGCN status" (2022 Northeast Lexicon for State Wildlife Action Plans, Crisfield, NEFWDTC 2022). The intended outcome of the new AP list was three-fold: 1) refine the SGCN list down to that which accurately reflects the reality of what is known or can safely be inferred about Virginia's

biota; 2) ensure that Virginia species most in need of basic life history, population size and distribution, and threat assessments are identified in a discrete category ; and 3) catalyze the pursuit, acquisition, and allocation of funding to address taxa- or species-specific knowledge gaps. The definition adopted for AP species in this Wildlife Action Plan was:

> AP species are species for which more contextual information is needed to justify assignment of a conservation status, population trend, and subsequent SGCN ranking, if warranted. Contextual information may include both direct data and indirect inferences concerning, for example, the condition of the species habitat(s), likely ecology and habitat preferences , and trends in known threats or stressors . The list of AP species can be found here {TEMPORARY LINK}.

While AP species are categorically not considered SGCN in this Wildlife Action Plan, they remain eligible for State Wildlife Grant funds (D. Blanton, USFWS, personal communication) or other grant funds. In this way, proper assessments could be adequately funded for many poorly studied species, with the strategic goal of shrinking the AP list over time.

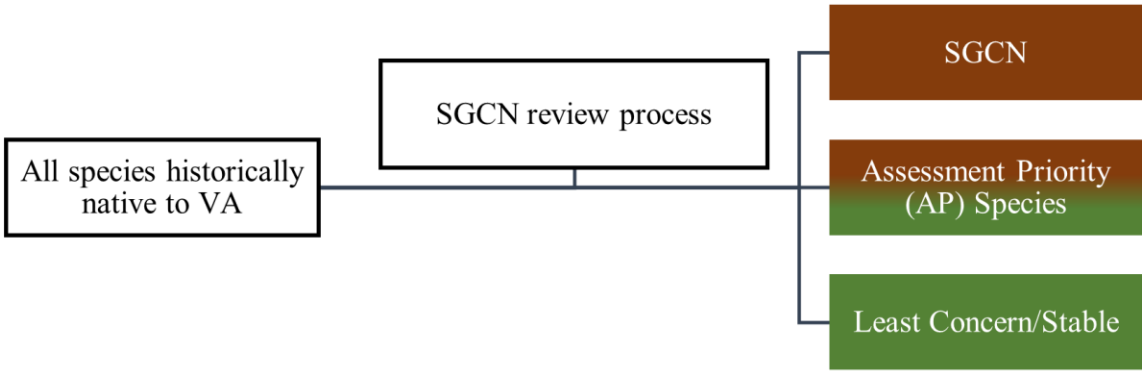


Figure 2.3. Conceptual representation of the assessment priority (AP) category, new to the second revision of the Virginia Wildlife Action Plan. The split-color gradient of the AP box acknowledges that SGCN, perhaps even some of VA's most imperiled species, will fall into this category along with species that do not presently need conservation attention (i.e. least concern/stable).

Species were added to the AP list in a few ways (Figure 2). Undescribed species were first flagged as likely candidates for listing as an AP; TAC teams then either confirmed or denied AP assignment. Similarly, each species suggested for removal from the potential SGCN was considered for goodness-of-fit on the AP list (i.e. is it being recommended for removal as an SGCN because of insufficient information). Species with NatureServe ranks of GU/GNR or SU/SNR were recommended to the TAC for AP assignment. Ultimately, each TAC reserved the authority to migrate any potential SGCN over to the AP list if it could justify that more research and assessment was needed to establish an actual conservation status.

Guidelines were prepared and shared with the TACs to better direct application of the newly-formed AP category. This document was crafted following a literature review of relevant peer-reviewed journal articles. Best practices were identified, as were model examples of what type of information gaps might qualify a species for inclusion on the AP list. One exception was made to the AP process. The Invertebrate TAC asked to add 30 species of isopods as SGCN after that list had been finalized and put out for stakeholder review. Most of these species are not well understood, so rather than drop them completely, or try to rush defining their habitats and conservation actions and then put them out for SAC review a second time, these animals were added to the AP list.

Potential SGCN not categorized as leaning in, leaning out, low-qualifying, or AP were considered likely SGCN. As such, these species received a less rigorous, but nonetheless complete review for inclusion/exclusion. Indeed, a handful of "likely SGCN" were recommended for removal by TAC. Subsequently, all species that made the initial list of SGCN were subjected to a more extensive review to determine their relative imperilment status, and to what degree, if any, viable conservation opportunities exist for slowing or reversing observed population declines.

Each species recommended for SGCN inclusion by a TAC was subjected to a robust status assessment, resulting in the assignment of imperilment tier ranks and conservation opportunity ranks.
As the name implies, SGCN imperilment tier ranks (Tiers) help indicate the relative status of species, and the level of conservation effort needed to slow and reverse the decline. A primary aim of Tiers is to help inform the use of resources and funding for specific species. The tiers and included species and habitats in the Wildlife Action Plan provide guidance on where to direct limited resources and ensure efforts inspired by the Wildlife Action Plan are applied somewhat proportionately to species needs.

> **Tier I.** Critical Conservation Need. Faces an extremely high risk of extinction or extirpation. Populations of these species are at critically low levels, face immediate threat(s), or occur within an extremely limited range. Intense and immediate management action is needed.
>
> **Tier II.** Very High Conservation Need. Has a high risk of extinction or extirpation. Populations of these species are at very low levels, face real threat(s), or occur within a very limited distribution. Immediate management is needed for stabilization and recovery.
>
> **Tier III.** High Conservation Need. Extinction or extirpation is possible. Populations of these species are in decline, have declined to low levels, or are restricted in range. Management action is needed to stabilize or increase populations.
>
> **Tier IV.** Moderate Conservation Need. The species may be rare in parts of its range, particularly on the periphery. Populations of these species have demonstrated a declining trend, or a declining trend is suspected which, if continued, is likely to qualify this species for a higher tier in the foreseeable future. Long-term planning is necessary to stabilize or increase populations.

Conservation opportunity ranks (COR) were retained from the first revision, accompanied with minor clarifications to better distinguish them from the AP category. The goal of the COR is to help managers focus attention on species with already - identified management needs and viable opportunities for delivering those needs. In other words, COR help distinguish the species for which fundable, ready conservation actions have been identified from the species for which knowledge gaps or resources preclude abatement of population and/or habitat declines. The COR also indicates viability of recovery under current resource constraints. Species and/or habitats flagged relatively early in their declines (as indicated by lower Tier assignments) tend to be viewed as more cost-effective opportunities for conservation. While these ranks help guide more fiscally responsible expenditures, they also help in the identification of species-specific knowledge gaps in need of filling. By focusing research efforts on "B" and "C" species, the proportion of SGCN classified as "A" should increase with every revision.

> **A –** Managers have identified "on the ground" or immediately implementable species or habitat management strategies expected to benefit the species; at least some of which can be implemented with existing resources and are expected to have a reasonable chance of improving the species' conservation status.
>
> **B –** Managers have only identified research needs for the species or have only identified conservation actions that cannot be implemented due to lack of personnel, funding, or other circumstance.
>
> **C –** Managers have yet to identify actions or specific research needs beyond additional surveys that could benefit this species or its habitat or all identified conservation opportunities have been exhausted. However, there is enough known about this species to determine a tiered conservation status.

Beyond the definitions provided for each ranking category, the TAC considered species and habitat status, existing and projected threats, adaptive capacity to threats, and other pertinent factors when assigning ranks. This process is inevitably a subjective one, but fittingly reflective of experts' informed opinions. Since an AP category was not used previously, species that should not have been designated SGCN often received a low-Tier rank (III or IV). The process used for the 2025 revision is more reflective of actual status, trend, and related information.

To support the work of the TAC, a tool was developed to predict Tiers for all proposed SGCN (TABLE 2.2). This tool leveraged the intertaxa criteria already collated for the potential SGCN. The tool was developed by associating the ranking categories of all six intertaxa criteria previously noted to the four SGCN Tiers, as best they could be aligned. In all cases, the highest-ranking intertaxa criteria for a given species served as the automatic Tier predictor. For example, the following intertaxa criteria species profile would have resulted in a predicted Tier I only because of the NatureServe G2-S1 and the State Threatened + S1 ranks:

> IUCN vulnerable (VU), ESA candidate, RSGCN moderate concern (MC), State Threatened, and NatureServe G2-S1

If the NatureServe and State listing ranks were removed from the example intertaxa-criteria profile, the ESA candidate rank would become the next highest Tier-qualifying predictor, at Tier II. Remove that ESA rank, and the remaining intertaxa criteria ranks would have resulted in lower-predicted SGCN Tier ranks.

Table 2.2. Reference guide tool used to generate SGCN Tier predictions.

Priority Tier	Definition	Reference Criteria Qualification
Tier I	Critical Conservation Need. Faces an extremely high risk of extinction or extirpation. Populations of these species are at critically low levels, face immediate threat(s), or occur within an extremely limited range. Intense and immediate management action is needed.	IUCN critically endangered (CE) or endangered (EN) ESA federally endangered (FE) ESA federally threatened (FT) or candidate **and** S1 RSGCN very high concern (VHC) State endangered (SE) State threatened (ST) **and** S1 NatureServe G1 NatureServe G2-G3 **and** S1
Tier II	Very High Conservation Need. Has a high risk of extinction or extirpation. Populations of these species are at very low levels, face real threat(s), or occur within a very limited distribution. Immediate management is needed for stabilization and recovery.	IUCN vulnerable (VU) **and** S1 ESA federally threatened (FT) or candidate (CD) ESA discretionary review (DR) or under review (UR) RSGCN high concern (HC) **and** S1 RSGCN proposed very high concern (pVHC) State threatened (ST) NatureServe G2 NatureServe G3 **and** S2-S3
Tier III	High Conservation Need. Extinction or extirpation is possible. Populations of these species are in decline, have declined to low levels, or are restricted in range. Management action is needed to stabilize or increase populations.	IUCN vulnerable (VU) IUCN near threatened (NT) **and** S1 ESA petition withdrawn (PW) or not listed (NL) RSGCN moderate concern (MC) **and** S1 RSGCN high concern (HC) NatureServe G3 NatureServe G4-G5 **and** S1
Tier IV	Moderate Conservation Need. The species may be rare in parts of its range, particularly on the periphery. Populations of these species have demonstrated a declining trend, or a declining trend is suspected which, if continued, is likely to qualify this species for a higher tier in the	IUCN near threatened (NT) RSGCN proposed high concern (HC) RSGCN moderate concern (MC) RSGCN watch list (WL) NatureServe G4-G5 **and** S2-S3 or SX/SH

	foreseeable future. Long-term planning is necessary to stabilize or increase populations.	
Assessment Priority (AP)	Species for which more information is needed to justify assignment of a conservation status or population trend, thus SGCN ranking.	Typically, will not meet any of the above intertaxa criteria. However, exceptions are possible and should be briefly justified. SU/SNR rank qualifies.

Note that not every possible NatureServe ranking (e.g., T ranks, GNR, GNA, etc.) was accounted for in Table 2.2. Omitting these rarer ranks helped reduce clutter. Generally, these ranks were considered comparable to their most closely related rank listed in Table 2.1. For example, a species labelled T5, S3 would have been considered comparable to G5, S3 – and predicted as a Tier IV if that was the highest scoring rank for the species under review. GNA species were typically predicted as "R" (removed). GNR species were predicted as AP/R.

With guidance from regional wildlife diversity working groups, the tool was iteratively tailored until intertaxa criteria rankings aligned reasonably well with Tiers across taxa groups. The tool appeared especially helpful to those TAC charged with assigning first-time Tiers to hundreds of relatively data-poor species (e.g., plants, invertebrates). Although the predicted Tiers served as default Tier assignments when the TAC had no other data from which to base a Tier assignment, this tool merely served as a guide to Tier ranking. In all cases, the TAC reserved the authority to override the predicted Tier, citing expert opinion and data that is more localized to Virginia than that which fed into the various intertaxa criteria ranking processes.

In addition to assisting the TAC with Tier assignments, the predicted Tiers helped reviewers keep close tabs on species with comparable intertaxa criteria profiles that might have otherwise been assigned disparate Tier ranks. If, for example, an ESA endangered (FE) species and a RSGCN very high concern (VHC) species were proposed as Tier I and Tier IV species, respectively, with both being predicted as Tier I, the tool would flag the Tier IV species as a three-step discrepancy from the predicted tier, triggering a second review to ensure all relevant data were considered and that the discrepancy was defensible. In all cases, discrepancies of two or more steps prompted a second review to ensure the proposed Tier was more appropriate for Virginia conditions than the predicted Tier, accompanied by a brief justification. Justifications were also provided if a species Tier rank differed between the first and second Plan revisions. All such justifications were made available to the SAC throughout the formal feedback process.

Criteria for Avian SGCN

It should be noted that the Bird TAC used slightly different criteria for including species in the SGCN list. Based on the immense datasets available for this taxon, and the addition of data from the Second Virginia Breeding Bird Atlas (VABBA2) and associated population models, this TAC felt it necessary to use a different set of selection criteria.

Birds are a well-studied taxonomic group that have benefitted from extensive research, surveys and population monitoring at various geographic scales. Although these efforts have not been implemented evenly across all species, they have produced information that allow for a data-driven approach to selection of SGCN. In 2024, the Bird TAC followed the SGCN selection and Tier-assignment process for birds that has been in place since the first Wildlife Action Plan in 2005, although some modifications were made to the process. Both the process and the modifications are outlined below.

In addition, data displayed for bird SGCN in the new online dashboard are from actual occurrence data, primarily from the Second Breeding Bird Atlas for breeding birds and from the Virginia Fish and Wildlife Information System for wintering species. When the Second Breeding Bird Atlas is published in the fall of 2025, distribution data will be based on modeling developed to provide occurrence data that more comprehensively displays where some of these species may occur based on survey effort and available habitat. To maintain consistency across taxa groups, only actual occurrence data was used for the Plan online dashboard.

Breeding Species

Selection of breeding SGCN for the first two Plans was based on three criteria: population trends, population size, and Virginia Area of Importance. The first two variables were retained for SGCN selection in 2024, while the TAC took a more organic approach to the last variable. The TAC considered all species known to breed in Virginia.

Population Trends:
Data sources include the North American Breeding Bird Survey (BBS) for 1966-2021, Virginia waterfowl surveys conducted as part of the Atlantic Flyway Breeding Waterfowl Survey, Virginia upland game bird surveys, Virginia Colonial Waterbird survey (conducted every five years in coastal Virginia), Virginia Shorebird surveys (plovers and American oystercatcher), Saltmarsh Habitat and Avian Research Program (SHARP, for marsh birds), other Virginia marsh bird surveys, and Virginia-based surveys for individual species (eastern black rail, peregrine falcon, red-cockaded woodpecker).

The credibility of Virginia BBS trends was evaluated based on sample size (number of routes where detected), relative abundance, and precision (ability to detect 3-5% annual change in the long-term). Trends with credibility issues (low sample size, low relative abundance, and/or inability to detected 3-5% annual change) were not used. The TAC decided to retain Virginia BBS trends where relative abundance at the mid-point of the span of survey years was > 0.1 birds/route but < 1.0 birds/route, if the trend was statistically significant. If this condition was not met, or if the trend had credibility issues related to any of the other listed variables, then regional trends were considered as a proxy for the Virginia trend. Regional trends were based on Bird Conservation Regions (BCRs). Virginia falls within four such regions: Southeast Coastal Plain, New England/Mid-Atlantic Coastal Plain, Piedmont, and Appalachian Mountains. The TAC considered regional trends based on a species' distribution within the state (e.g., for a species breeding west of the Blue Ridge Mountains, the Appalachian Mountains BCR trend was considered). If a BCR trend also had credibility issues, the trend for the Atlantic Flyway, the Eastern BBS region or the United States was considered instead. These broader-scale trends were also evaluated by

the TAC for credibility, as well as for applicability to Virginia (i.e. whether the TAC thought that the trends were representative of the status of the species in Virginia); data from the VABBA2 were used when needed in order to help with this assessment. In cases where trends for a species had credibility issues or were not representative of Virginia at any geographic scale, the TAC attempted to assign a qualitative value to the trend (increasing, stable, decreasing) based on professional opinion.

Following the above process, numerical trends were translated to the following trend categories:

- significant decrease (< -50 % over time period for which data are available [1966-2021 for BBS, variable for other surveys],
- moderate decrease (-49 % to -15 %), population stable (> -15 to < +15%),
- moderate increase (+15 to +49 %),
- significant increase (> +50 %), or uncertain trend (not statistically significant).

Virginia Population Estimates:
Data sources include the Partners in Flight (PIF) Population Estimate database, Atlantic Flyway Breeding Waterfowl Survey, Virginia upland game bird surveys, Virginia Colonial Waterbird survey (conducted every five years in coastal Virginia), Virginia Shorebird surveys (plovers and American Oystercatcher), Virginia-based surveys for individual species (eastern black rail, peregrine falcon, red-cockaded woodpecker), VABBA2 population estimates, published literature, and expert opinion.

Population estimates were translated into the following breeding pair categories: < 100, < 500, < 5,000, > 5,000 and > 100,000. As there are measures of error around many population estimates, the assigned categories were reviewed for all species and modified if the TAC felt that the category did not reflect the species' population size in Virginia.

Virginia Area of Importance:
The avian SGCN selection process for the 2005 and 2015 Plans considered Virginia Area of Importance (AI). This metric is based on the proportion of the global or US/Canada population of a species that occurs in Virginia. Species with low AI scores were eliminated from consideration. While this was an imperfect system, some species with low AI scores were still included as SGCN if they were historically well-established in Virginia (e.g., red-cockaded woodpecker) or if the current Virginia population was small relative to the global population as a result of population declines (e.g., golden-winged warbler). In addition, calculation of AI scores relied on population estimates from different sources in cases where both a Virginia and a global population estimate derived from the same source was unavailable; mixing estimates from different sources can be problematic as those estimates can be based on different methods of calculation.

Rather than calculating and using AI scores in 2023-2024, the TAC instead opted to omit from consideration as SGCN those species that fell into one or more of the following categories: introduced non-native species, species with recent range expansions into Virginia, occasional/casual/not established breeders, and species that never bred in abundance/were never significant breeders in Virginia.

Combining Factors into Tiered SGCN:
Following omission of particular species in the last step above, species were assigned to SGCN tiers based on the following criteria:

- Tier I: extremely small populations (<100) and small populations (<500) with significant decreases.
- Tier II: small populations (<500) with moderate decreases and medium populations (<5,000) with significant decreases.
- Tier III: all remaining small populations (<500); medium populations (<5000) with moderate decreases; large populations (>5000) with significant decreases.
- Tier IV: large populations (>5,000) with moderate decreases; very large populations (>100,000) with significant decreases.

Once a draft list was assembled, it was reviewed by the TAC and changes to Tier assignments made if it was felt that the Tier that a species was placed in through the above formulas did not properly reflect the level of conservation concern for that species.

Assessment Priority Species:
The TAC categorized as Assessment Priority those species for which a population trend could not be determined and which were not omitted from consideration as SGCN based on their breeding status in Virginia (see "Virginia Area of Importance"). The former include species whose population trends had credibility issues or were not representative of Virginia at any geographic scale and for which the TAC could not assign a qualitative value to the trend (increasing, stable, decreasing) based on professional opinion.

Nonbreeding Species

As in past iterations of the Wildlife Action Plan, the TAC considered nonbreeding (wintering, transient) species for inclusion in the SGCN list. Because fewer/less reliable data are available for many species outside of their breeding season, the selection process for these species was less data-driven than it was for breeders.

The TAC considered nonbreeding species from two different sources: those that had been included in the 2005 or 2015 Virginia SGCN lists, as well as those on current Regional SGCN lists for the northeastern or southeastern United States. In addition, the TAC consulted with the DWR's Waterfowl Biologist regarding all wintering waterfowl species. Generally, species selected by the TAC from these lists were identified as regional conservation targets and occur in high enough abundance in Virginia that conservation in the Commonwealth could contribute to conservation of the species at a broader scale. Species that were not selected tend to be rare and irregular in their occurrence in Virginia. The Tiers assigned to nonbreeding SGCN were not based on quantitative metrics as they were for breeding species; rather, they reflected the level of conservation concern that the TAC felt was appropriate for the species. Species were also selected for inclusion on the AP list if the TAC felt that they might qualify as SGCN, but there were questions about their status in Virginia.

4. HABITATS

Throughout Virginia's original Wildlife Action Plan, habitat loss and degradation were identified as the most critical issues hindering SGCN conservation (DGIF 2005). Over the past two decades, water quality degradation, habitat fragmentation, and habitat loss have become more acute and widespread. Since the 2015 Plan revision, the NEFWDTC developed an extensive lexicon to define Regional SGCN (RSGCN), their habitats, threats to those habitats and species, and conservation actions that could be taken. Virginia, as part of this team, used the Northeast Regional Conservation Synthesis to define the habitats for the 2025 revision.

Northeast Regional Conservation Synthesis (Terwilliger Consulting, Inc. 2023) – This 2023 Northeast Regional Conservation Synthesis updates the original 2013 synthesis for State Wildlife Action Plans (Terwilliger Consulting Inc. [TCI] and the Northeast Fish and Wildlife Diversity Technical Committee [NEFWDTC] 2013). Its purpose was to support the 2025 State Wildlife Action Plan revisions. Further information about the Northeast Synthesis can be found at www.northeastwildlifediversity.org.

This Regional Conservation Synthesis provides a summary of available information on habitats for RSGCN and Watchlist species and the condition of those habitats at the regional and national scale.

The Regional Overview describes habitat classification systems and tools, spatial datasets of habitat, and habitat prioritization resources available for the Northeast region. In addition, it provides the best available information describing each of 24 regional habitat types, known distribution and level of protection, condition, management tools and resources, and monitoring programs and projects. Conservation partners protecting, managing, or restoring each habitat are listed. Citizen science projects and programs that engage the public in conservation of each habitat are described. Information, research, and monitoring needs for each habitat are identified.

After significant review of the habitat types outlined in the Northeast Regional Synthesis, the DWR decided to simplify the listing to better fit what could most accurately be defined for Virginia SGCN. These will be discussed in-depth later in the chapter, but they do align with the Northeast Lexicon.

Virginia Tech, Conservation Management Institute (CMI) data - The 2021 version of the National Land Cover Dataset (NLCD) was used as a base layer for the habitat map. Several of the base NLCD classes translate directly to the target classes in the Northeast Lexicon. Forests were defined as "[t]errestrial habitats characterized by woody vegetation at least 5 m tall with > 25% tree canopy cover." The coarse classification divides forests into two major classes: Boreal Forests, and Forest and Woodland. The primary factor differentiating these types is the dominant species comprising their canopies, with cold-tolerant deciduous and coniferous species comprising the Boral Forest class. Elevation is the proximate driver for distribution of these types in Virginia. Deciduous, coniferous, and mixed forest types were separated in the NLCD by elevation (map class):

Deciduous

Northern Hardwood Forest – deciduous forests above 900 m elevation (411)
Boreal Hardwood Forest – deciduous forests above 1070 m (412, 413)

Coniferous

Spruce – coniferous forests between 1070 and 1300 m (422)
Spruce – Fir – coniferous forests above 1300 m (423)

Mixed

Boreal Hardwood-Spruce – mixed forests above 900 m (432, 433)

Any of the three NLCD forest types lower than 900m in elevation were classified as Forests and Woodlands, but were maintained as separate codes for deciduous, coniferous, and mixed stands.

Water and Wetlands were represented in two ways. Large water bodies, such as big rivers, lakes, and estuaries, are included in the Plan's landcover map and are based on the NLCD "water" class. National Wetlands Inventory (NWI) data were used to identify lakes, ponds, and rivers and to assign them separate classifications in the Plan's habitat map. The NWI data were used to identify herbaceous, wooded (i.e. shrub and forested) and open water wetlands and to classify those as either estuarine or palustrine, or tidal/non-tidal. The attribute information from the NWI was used to identify tidal water regimes, then coded to those wetlands in the Plan's habitat map.

The Steep Slopes/Cliff habitat feature was developed from a slope layer from the same elevation dataset used to classify forests. Slope values were investigated at various locations to determine what the threshold slope should be for steep slopes and cliffs. Slopes greater than 35% were classified as "steep/cliff."

SGCN Watershed Distribution Maps – Within Virginia's 2005 Wildlife Action Plan, authors provided distribution maps for the most critically imperiled SGCN. These maps include buffered point locations where individual animals had been documented as well as areas designated as potential habitat. While these maps were informative, they were limited in their ability to inform multi-species conservation actions. In 2009, DWR staff developed new distribution maps for each SGCN identified within the

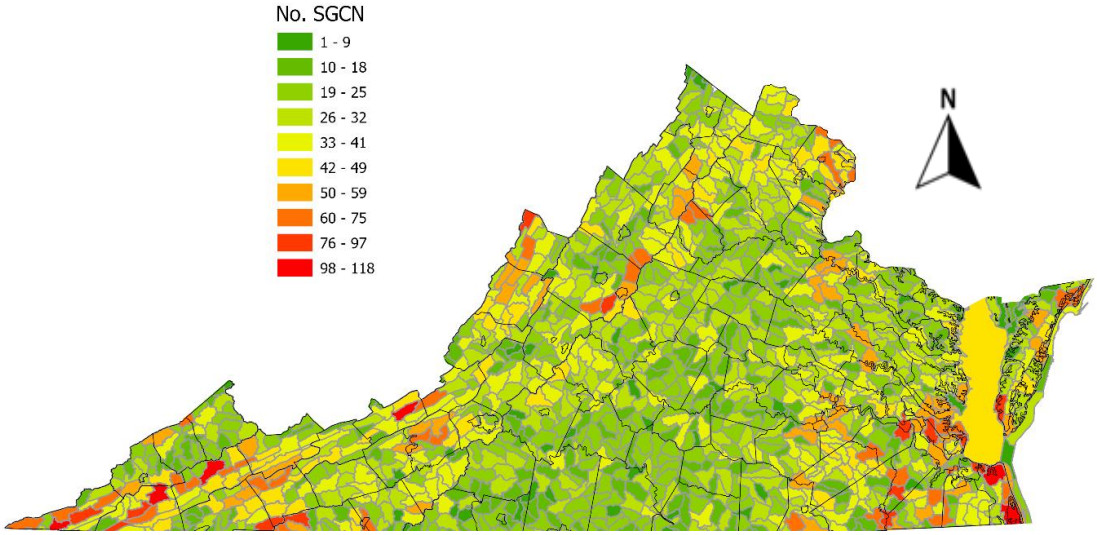


Figure 3.1 - Density of SGCN across Virginia

original Wildlife Action Plan for which distribution information was known. These new maps were based on fine-scale watersheds referred to as HUC12 watersheds (Weary and Doctor 2014). Virginia's HUC12 watersheds range in size from approximately 15 square miles to 70 square miles. Each of Virginia's counties typically encompasses 10 to 15 HUC12 watersheds. Species with known distributions were included and were demonstrated in each HUC12 chosen during a search. The majority of these were vertebrates, freshwater mollusks, terrestrial and aquatic invertebrates, crayfish and plants. By mapping SGCN distributions within HUC12 watersheds, the 2025 Wildlife Action Plan is able to identify areas that support multiple SGCN (Figure 3.1). Likewise, HUC12 maps provide information at a spatial scale with enough detail to identify priority areas within a county or planning region, but at the same time are coarse enough to hinder illegal collections or identifying private landowners. Marine species, in general, were shown for the Chesapeake Bay and off-shore marine environments, in total, because there are no defined HUC12 units in this part of Virginia's geography.

Land conservation in Virginia is affected by many governmental and non-governmental organizations and entities. The DWR owns and manages more than 250,000 acres of lands and waters for fish, wildlife, and the habitats that support them. In total over 4.7 million acres are under some type of conservation status in Virginia.

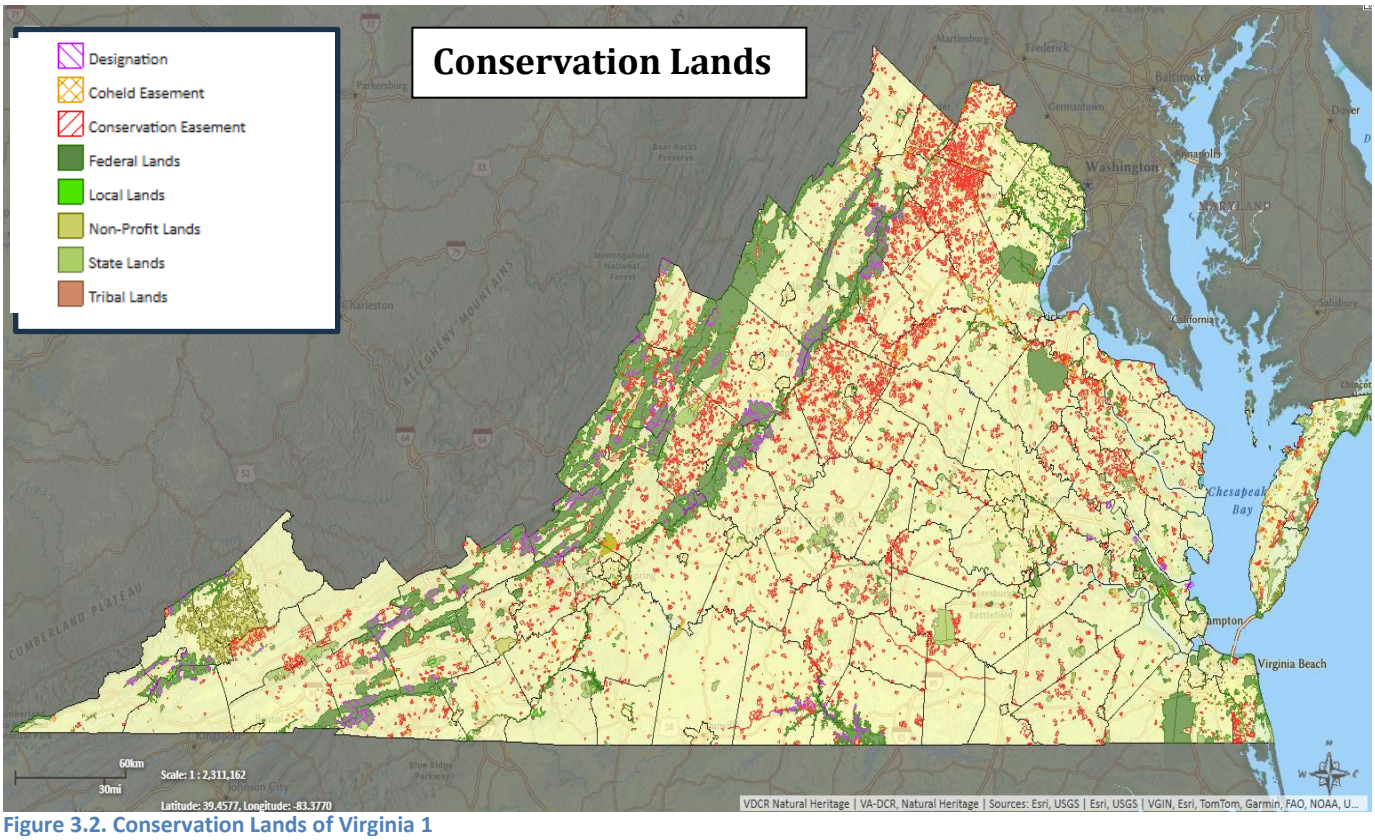


Figure 3.2. Conservation Lands of Virginia 1

Terrestrial

1. Forested Upland – Terrestrial habitats characterized by woody vegetation at least 5m tall with ≥25% tree canopy cover

a. Forests and Woodlands - forested upland with structurally and compositionally diverse ecological community groups (oak, pine, hickory, maple, beech, birch, poplar). Includes woods that have been thinned or logged (working forest). May include tree farms and plantations.
b. Boreal Forests – forested upland (generally above 3000 ft in elevation) whose structure is influenced by shallow soils, increased precipitation, and severe weather and is rich in northern boreal species. Includes forests and woodlands that have been thinned or logged (working forest). May include tree farms and plantations.

2. Open Upland – Terrestrial habitats characterized by <25% tree cover
    a. Grasslands - habitat dominated by herbaceous vegetation with few, if any, trees. May include perennial pastures, hayfields, yards, or crop fields (corn, rye).
    b. Shrublands – habitat composed of shrubs (many stemmed woody plants generally less than 5m tall). May include brushy pastures or crop fields (cotton, peanuts).
    c. Glades, Barrens, Savannas – Habitat composed of sparse, low, and open vegetation with some tree cover. May include silvopastures.
    d. Alpine – Barren substrate or herbaceous and low shrubby vegetation above mountain timberline
    e. Cliff & Talus – Expanses of bedrock or broken rock generally lacking vascular plants, including vertical or nearly vertical rock outcrops

3. Subterranean – Habitats below the soil surface
    a. Caves and Karst – naturally occurring air-filled spaces, ranging in size
    b. Other Subterranean – all other habitats below the soil surface

4. Land-Water Interface – The zone where terrestrial and aquatic habitats meet and interact, with a boundary that shifts in space, over time, and under different weather conditions
    a. Riparian and Floodplains – A zone of habitats directly associated with stream sides that may be periodically flooded
    b. Shorelines – Non-beach and dune habitat bordering large waterbodies where vegetation is limited by fluctuating water levels, waves, and/or tides
    c. Beaches & Dunes – Habitat dominated by sand deposits where wind, tides, and/or waves (current or historical) shape substrate; vegetation is often sparse or absent

Freshwater

5. Riverine –
    a. Headwater Streams – Small order (I or II) tributaries to larger creeks and rivers that may be ephemeral, intermittent, or perennial, depending on precipitation patterns
    b. Creeks and Rivers – Perennial tributaries to big rivers
    c. Big Rivers – The largest channels, characterized by large perennial flows, large quantities of nutrient and organic matter, high turbidity, and fine sediments

d. Tidal Rivers and Streams – Lower reaches of flowing water with tidal influence that expand in size when precipitation is high and retract during periods of drought, due to salt-wedge intrusion.

6. Lacustrine – Perennial bodies of water
    a. Lakes – Large (depth, acreage, turbidity) naturally occurring bodies of fresh water
    b. Ponds – Small (depth, acreage, turbidity) naturally occurring bodies of fresh water, including vernal pools, beaver dams, and surface springs.

7. Palustrine – Areas where water either covers the soil or is present at or near the surface of the soil for at least some portion of the year
    a. Non-tidal Wetlands – Ecological community groups of alluvial habitats with overland, non-tidal flooding regimes. Structurally and compositionally diverse vegetation is represented. Includes seeps, bogs, fens, and pond margins. Also includes forested and scrub wetlands (cypress, tupelo, buttonbush, etc.).
    b. Tidal Wetlands – Ecological community groups of regularly or irregularly flooded lunar tidal wetlands and irregularly flooded wind-tidal wetlands. Structurally and compositionally diverse vegetation is represented. Within the defined community types, the terms “high” and “low” marsh refer to the relative elevation of stands within the intertidal zone.

Marine

8. Estuarine –
    a. Tidal Rivers and Streams – Lowest reaches of flowing, tidally influenced water beginning where brackish water starts and ending where the river mouth dumps into an estuary
    b. Tidal Wetlands – Ecological community groups of regularly or irregularly flooded lunar tidal wetlands and irregularly flooded wind-tidal wetlands. Structurally and compositions diverse vegetation is represented. Within the defined community types, the terms “high” and “low” marsh refer to the relative elevation of stands within the intertidal zone.
    c. Estuaries – Subtidal (continuously submerged) open brackish water, excluding river mouths. Includes open-water aquaculture leases.

9. Marine – Chesapeake Bay; Atlantic Ocean
    a. Marine Nearshore – coastal subtidal marine habitats, extending outward as far as wave action and light penetration to the bottom.
    b. Marine Offshore & Oceanic – pelagic and abyssal zones of open ocean waters

Novel

10. Novel Ecosystems – Areas that have been developed, modified, converted, or otherwise manipulated by people into conditions mostly or entirely different from the original state and that now operate under human management.
    a. Urban Lands - Impervious buildings, structures, and their immediately adjacent semi-impervious surfaces (yards, lawns). May include, but not limited to:
        - Residential
        - Commercial
        - Industrial
        - Military
        - Other institutions
    b. Transportation Networks – Impervious or semi-impervious pathways that exist either in a constant or frequent state of ecologically incompatible disturbance, with the primary goal of provisioning societal needs and activities. May include, but not limited to:
        - Roads/roadsides
        - Railroads
        - Airports
        - Powerlines
        - Shipping lanes
        - Canals, dredged channels
    c. Artificial Impoundments – Human impounded creeks, rivers, or wetlands
        - Reservoirs
        - Ponds
    d. Mines – Human created air-filled spaces below the natural land surface, whether open to daylight or not

Working Lands

11. Working Lands – Lands that are managed or manipulated for agricultural or industrial uses or human development purposes.
    a. Working Forests and Woodlands – Forests and woodlands managed and manipulated for a variety of purposes, many of which support fire-dependent species
    b. Working Grasslands, Savannas and Early Successional Shrublands - Agricultural pastures and hayfields, both of which are directly or indirectly managed to produce livestock.
    c. Working Estuaries and Marine Nearshore Habitats – Marine habitats that support extractive activities as well as bay and offshore aquaculture

HABITAT SUMMARY: DESCRIPTIONS, STATUS, THREATS, AND CONSERVATION ACTIONS

Virginia is home to an incredibly rich abundance of habitats. From the shorelines of the Atlantic Coast and mouth of the Chesapeake Bay to the high alpine forests of its western mountain ranges, the Commonwealth enjoys a physiography supportive of abundant and varied wildlife. Though the separation of a necessarily interconnected, holistic landscape into discrete types will always involve

some degree of simplification and abstraction, the 2025 Wildlife Action Plan team has constructed a habitat Lexicon which integrates both state and regional-level concerns.

Previous versions of the Plan have relied upon several models which successfully identified habitat types and their conditions, albeit differently than our current approach. The 2015 Plan relied on a combination of resources pulled together internally by DWR (then DGIF) staff and their conservation partners, including USEPA ecoregional descriptions (Griffeth *et at.* 1999), Natural Communities of Virginia: Classification of Ecological Community Groups (Fleming *et al.* 2013), National Land Cover Dataset (Fry *et al.* 2011), and The Nature Conservancy's Northeast Terrestrial Habitat Map (Anderson *et al.* 2013). This approach successfully modeled Virginia's major habitat types by utilizing a combination of national- and state-level conservation tools to accurately reflect the Commonwealth's ecological conditions. Some of these major habitat types have, in fact, been transferrable to our current approach, and their 2015 definitions have served as the basis for the 2025 update. However, in an effort to align the 2025 Plan with regional conservation efforts, and to take advantage of an accessible and available series of sophisticated habitat models, the 2025 Plan habitat types have been primarily based on definitions provided by Terwilliger Consulting's Northeast Regional Conservation Synthesis.

This habitat synthesis serves to "identify the extent and condition of wildlife habitats and community types essential to conservation of species identified" (Element 2) on a regional scale and provide a framework for interstate consistency to support regional conservation efforts. As such, landscapes and seascapes of the Northeast U.S. were determined by using the NatureServe Biotics 5 habitat classifications and tailoring them to regional physiography. This work was undertaken by Terwilliger Consulting Inc. and the NEFWDTC, which ensured that certain ephemeral and subterranean habitat types would be captured in the main classification system. Habitat modifiers, also developed by Terwilliger Consulting Inc. and the NEFWDTC, supplement the broader habitat types by communicating specific species requirements for land managers. These include, but are not limited to, habitat niches ("features"), vegetative species composition ("type"), and land management practices ("no-till" or "till agriculture").

The basic structure laid out in the Northeast Lexicon was retained in this version of the Plan. The three-level hierarchy was left unchanged, with a Habitat Type (the SGCN pairing-unit) nested within a Habitat Category (the broad ecosystem category) nested within a Habitat Class (Terrestrial, Freshwater, Marine, or Novel). However, in employing this classification tool for Virginia, modifications were made to tailor habitat types to the Commonwealth's physiography and to simplify the pairing process for the TAC. Habitat types were added, deleted, and edited from the Biotics 5 definitions. "Headwater Streams" and "Savannas" were added; "Open Alpine Upland," "Great Lakes," and "Vernal Pools" were deleted; and changes were made to the definitions and hierarchical classification of several others. All habitat types considered "working lands" (see page 90) were pulled out of Natural Habitat Categories and considered in a parallel definition process. This effort will be articulated later in this Plan. Additionally, habitat modifiers were altered to provide details on life-stage usage of habitat types by SGCN. The SGCN were paired with habitat types if they bred, developed their young, fed, wintered or hibernated, or stopped over (during migration) in them. This excludes using habitat types that wildlife used simply as corridors, or just to navigate between preferred habitats.

These habitat type definitions serve as the basis for the Virginia online tool habitat layer and the habitat summaries included later in this Plan. They have also been used to provide aggregate statistics on critical SGCN habitats which inform broader conservation efforts. It was our intent to create a system which is usable at multiple landscape scales.

Habitat Advisory Committees (HACs), modeled after the TAC, were formed to supply robust summaries for each habitat type listed above. Like the TACs, the HACs were composed of both internal and external experts. Beyond engaging DWR staff, who provided substantial authorship, individuals from the Virginia Department of Conservation & Recreation's Division of Natural Heritage, Virginia Department of Forestry, and The Nature Conservancy developed summaries. In some cases, a single individual was responsible for one or more habitat type summaries with which they had a deep knowledge. However, the development of descriptions of some habitat groups, such as "Riverine," required more intensive coordination among an array of several authors due to less clearly defined boundaries of the included habitat types.

Each of these habitat summaries includes a general description, current extent, historic extent, habitat threats, and potential conservation actions. Additional requirements were introduced, where appropriate, including (but not limited to) sections detailing species relationships to urban or agricultural development, age class descriptions, hydrologic regimes, and use as a working land. The information gleaned from these summaries, particularly that which explicitly concerns conservation threats and actions, does not serve as the basis for their SGCN analogues, which were supplied by the TACs and are required elements of every Wildlife Action Plan. Instead, these habitat threats and actions focus on landscape-scale challenges which may be the most pressing issues for SGCN, but which are potentially managed by different individuals or entities. Any Wildlife Action Plan would be remiss to exclude a landscape perspective from its conservation recommendations, both in the immediate implications of carrying out that conservation work and for the broader purpose of conceptualizing the current status of Virginia’s wildlife.

Twenty-seven habitat summaries are listed below, along with CMI-produced maps which roughly display their distribution throughout the commonwealth. Every summary lists its primary author or group of authors, whose work has been invaluable to the 2025 Wildlife Action Plan.

Habitat Descriptions

Forests & Woodlands

Jean Lorber, The Nature Conservancy

Forested uplands represent a large majority of natural cover across the state. Upland forest cover steadily expanded during the first half of the 20th century, as abandoned farmland turned into successional forestland. However, this expansion soon peaked, with forest loss from urban/suburban expansion beginning to outpace the aforementioned forest gain. Total forest acreage in Virginia has stabilized in the last several decades at around 16 million acres.

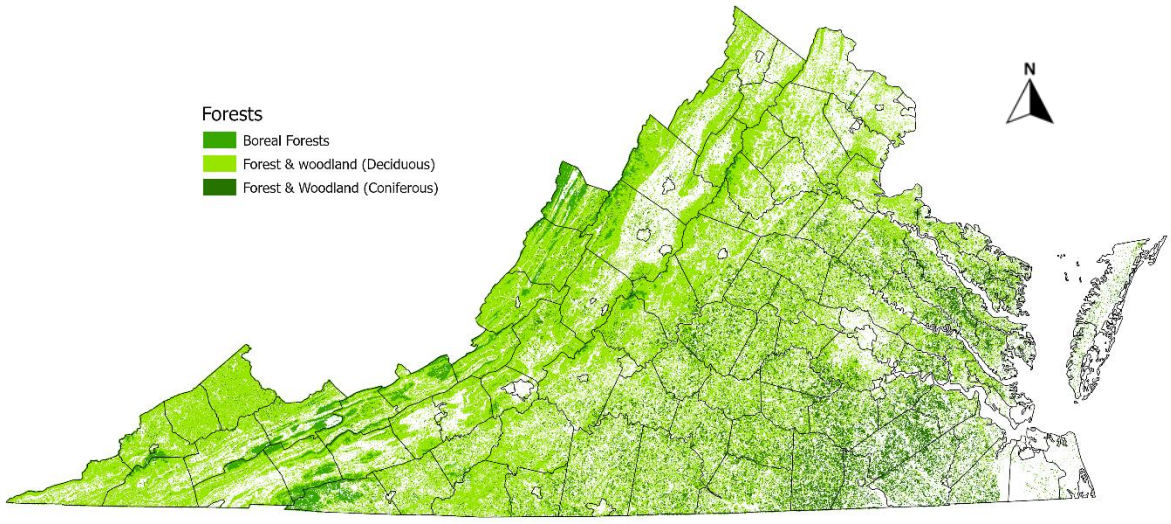


Figure 3.3. Forest Lands in Virginia

There is a great diversity of upland forest communities in Virginia. Broadly speaking, the easternmost Coastal Plain contains significant managed and natural loblolly pine stands, while the westernmost Appalachian Mountains are dominated by natural mixed oak stands, with the central Piedmont representing a transition between the two. While 118 species of trees have been found on forested uplands in Virginia, only 15 species represent the great majority of the forest canopy.

The Coastal Plain's uplands contain significant amounts of loblolly pine plantations, typically managed on a 30–40-year rotation. However, natural pine/hardwood stands represent over half of upland acreage and are fairly evenly distributed in age, ranging from 0-100 years old. In the plantations,

Rapidan WMA - North Central Virginia

loblolly-focused management results in little room for other species; it is over 80% of forest volume. In

the natural stands, tulip poplar is numerous, followed closely by oaks, then sweetgum. There is still a sizeable component of loblolly pine, with numerous other hardwood species like red maple, American beech, swamp tupelo filling out the remaining growing space.

The Piedmont's uplands contain an overall lower percentage of loblolly pine plantations, with the Southside subregion home to much of it. The pine plantations here are dominated by loblolly, managed on the same 30–40-year rotation. The natural stands the Piedmont's uplands are fairly evenly distributed in age, with more acreage in the 20–100-year range, and lesser amounts either older or younger. In the natural stands, oaks and yellow poplar are equally dominant, each representing ~30% of forest volume. The remaining growing space is occupied by loblolly and Virginia pine, with smaller amounts of hardwoods, like red maple, hickories, and sweetgum.

The Mountain region's uplands are almost exclusively dominated by natural, mixed-oak and hardwood stands, with yellow pines relegated to drier and otherwise marginal sites. Virginia's single largest land ownership is found here: the George Washington and Jefferson National Forest, representing about a third of the region's forests at 1.8 million acres. Upland forest in the Mountains is weighted heavily towards older age classes (80-120 years), especially on public lands; young forest makes up just 3% of acreage on public lands and 10% of private lands. True old-growth forest is relatively rare, but much of the public lands are approaching the age threshold for old-growth. Oaks represent close to 50% of forest volume, with other hardwoods like tulip poplar and red maple, as well as white pine, occupying smaller (but increasing) amounts of growing space, especially on more productive sites. Pitch, Virginia, shortleaf and table-mountain pines are found on less productive sites, while subcanopy tree species like blackgum and sourwood persist throughout.

The design of timber harvesting in Virginia's uplands is dictated more by forest type than by geographic region. In both the Coastal Plain and Piedmont, pine plantations are typically managed with a regular series of thinnings, culminating with a final clearcut around age 30. That said, more recent changes in markets have caused landowners to shorten their rotations due to increasing pulpwood prices, and stagnant sawtimber prices make shorter rotations attractive. This trend has slowed during the past year. In all three regions, natural oak and hardwood stands are typically harvested using diameter-limit or selection methods, a practice that is believed to be harmful to the long-term viability of the forest resource.

Many of today's conservation challenges in the forested uplands stem from management, or lack thereof, that leaves out dynamics which shaped these forest ecosystems. For millennia, fire was an ever-present force across Virginia, curating the assemblage of species that could thrive and persist in the forest. Indigenous burning and natural ignition were regular occurrences, giving rise to a mosaic of forests, woodlands and savannas, each providing a distinct habitat type. Fire also favored oaks and longleaf pine, which have been proven to serve a foundational role in their respective ecosystems. These foundational species harbor and enable higher levels of biodiversity by their presence, creating richer and more resilient ecosystems. After a century of fire suppression, the structural mosaic and foundational species described above are declining, along with the animal species that thrive with them.

The specifics of this conservation challenge vary by region. In the Coastal Plain, young forest is still abundant due to actively managed pine plantations. However, a shift to more chemical-intensive site preparation practices has reduced the ecological value of that young forest habitat. The lack of old pine stands represents its own challenge to high conservation value species like the Red-cockaded Woodpecker. That said, loblolly pine is fire-adapted, and compatible with many of the fire-related conservation practices common to longleaf pine savanna management. In the Mountains, young forest is relatively rare. Even more pressing is the lack of open woodland conditions; woodlands are believed to have been several times more common than early successional forest. Additionally, red oak species are rapidly approaching an age where natural mortality increases. Furthermore, the next generation of oak seedlings is not present, outcompeted by maples and poplars in the absence of fire. The same is true for yellow pine species, albeit for slightly different reasons. In the Piedmont's mix of oak and pine forests, all the challenges described in the Coastal Plain and Mountains are relevant.

The likelihood of rapidly changing climatic conditions also represents a threat to the uplands of all three regions. Future projections show a hotter climate with more drought. While overall annual precipitation will remain steady, rainfall will be concentrated in fewer, larger events, leading to more runoff and less water available to vegetation. All regions will therefore experience more heat and drought stress, leading to decreased productivity and higher tree mortality. In the hardwood-dominated regions, the trajectory of the current forest is misaligned with the future climate. Mesic species like red maple and tulip poplar are on the rise, enabled by the previous century of fire suppression and moist climate. Over the next few decades, these species will continue to gain dominance at the expense of oaks. However, they will eventually begin to suffer under the future climate and recede. Unfortunately, a generation of oak seedlings will have been lost during that time, and the remaining, aging oak canopy will be ill-equipped to produce a new generation. What species fill the vacuum is up for debate.

While the conservation challenges vary by region, two types of actions would address many of them: **protecting priority blocks** of high-functioning forestland and **enhancing forest management** within those blocks. There are existing prioritization exercises that could be utilized, based on ecology (e.g., TNC's Resilient and Connected Network) or ecology paired with socio-economic factors (e.g., VaNLA). The resourcing of voluntary land protection tools like conservation easements would secure the continued existence of the working forest landscape. To improve the condition of that protected forest landscape, a comprehensive advocacy and landowner assistance campaign could be established (e.g., DOF's Hardwood Initiative). Many of the challenges listed above can be addressed with practices found in existing cost-share programs. Ideally, both of these steps would be conducted in collaboration with forest industry and localities and informed by strategic planning and visioning to create maximum awareness and engagement by all parties.

Boreal Forests

Greg Estoll, Virginia Department of Forestry

Evidence suggests red spruce grew over a larger range before widespread logging and wildfires in the early 1900s. Northern hardwood species, and associates, claimed many areas – including those below 3500'. Boreal forest comprises approximately 136,000 acres (~56% of forest above 3500'). Two large

areas (Mt. Rogers/Whitetop and northwest Highland County) contain most of the two primary subtypes, spruce/fir (~12,000 acres total) and northern hardwoods (~40,000 acres total). Multiple associate subtypes, such as eastern white pine, northern red oak, and mixed hardwoods, are found nearby and scattered along ridgetops from Wise County to Shenandoah National Park in the Appalachian Plateau, Blue Ridge, and Ridge and Valley provinces.

Boreal Forest - Mt. Rogers NRA

Boreal forests, defined as forested high-elevation (>3500') uplands with structure influenced by shallower soils, increased precipitation, and severe weather that are rich in northern latitude species, vary in structure, age, size, species composition and productivity. Cool, moist sites with organic rich soils differentiate from other high elevation forests. Red spruce dominates highest elevation areas with nearly pure stands (occasionally mixed with balsam or Fraser fir). Most larger trees are ≥100 years old, yet younger trees exist, including seedlings and saplings. Both gradations and hard edges exist between spruce and hardwood trees. Virginia northern hardwoods contain sugar maple, American beech, and yellow birch, along with black cherry, black birch, red maple, American mountain-ash, striped maple and mountain maple.

Associate boreal species include eastern white pine, eastern hemlock, northern red oak, white oak, yellow buckeye, serviceberry, pin cherry, mountain magnolia, and basswood. Predominant species are shade tolerant, with a fringe of other species that regenerate solely in gaps. Productivity varies from good to poor based on soil, primarily depth, and exposure to wind, with short trees indicative of harsh growing conditions.

Structure is often uneven-aged, or uneven-sized, from small-scale disturbances and tree mortality often induced by extreme cold temperatures, wind, snow and/or ice. Most species include trees within each appropriate size class; oaks, black cherry, and basswood are exceptions with insufficient replacement trees – without greater canopy modification, these portions of the boreal forest will shift toward shade tolerant species. Eastern hemlock also has inadequate small trees due, in part, to impacts of hemlock

woolly adelgid. Understory vegetation is usually lush, except in the shadiest areas, and includes species uncommon elsewhere. Forbs, sedges, grasses, brambles, and mosses are common, along with deciduous shrubs and patches (sometimes very large) of evergreen rhododendron and/or mountain laurel shrubs.

Springs, seeps, small streams, and occasionally bogs are commonplace. Boreal forests provide valuable ecosystem water service with infiltration and filtration. In addition to fully forested areas along slopes and ridges, boreal forests also include boulderfield areas usually dominated by yellow birch, and shrub or open balds (mostly small acreage openings) often with hawthorn on the edges. For further descriptions, the Virginia Department of Conservation and Recreation's Natural Communities of Virginia Classification of Ecological Groups and Community Types includes five forest types and two balds or barrens.

Invasive plants, invasive pests, native pests, competitors, and potential climate shifts each pose a risk for boreal forests. Invasive plants are minimal due to limited human use and disturbances and unsuitable climatic conditions. However, some invasive plant species will push into the boreal forest especially where disturbances occur. The invasive pest emerald ash borer will continue to eliminate white ash as a component; hemlock woolly adelgid continues to weaken or kill eastern hemlock; balsam woolly adelgid has caused massive declines of native firs in other areas; spongy moth creates periodic widespread disturbance and mortality; beech leaf and bark diseases may cause declines in a primary species. The native southern pine beetle occasionally causes mortality in red spruce, hemlock, and white pine. New York, hayscented, and bracken ferns are present in some areas, and evergreen wood fern is common. These species are aggressive competitors that can impede tree regeneration especially when coupled with high white-tailed deer density.

There is limited evidence that higher elevations may be more resistant to warming temperatures; nevertheless, under the scenario of warmer summer temperatures and similar precipitation, the boreal forest will likely shrink as summer temperature and moisture stress push suitable conditions to higher elevations; for example, red spruce maximum mean monthly temperature is ≤68°F. Red spruce and firs may be prone to increased winter damage from periods of intense cold especially if mean fall, winter and spring temperatures are higher (which will otherwise aid growth). Genetic diversity is also low, indicating low phenological variation possible. As spruce and fir are only present at high elevation sites (a few at ~2700'), this already rare resource may be diminished. Most other boreal forest species have greater plasticity and occur at lower elevations; however, their geographic and elevation range will likely decrease. Oaks, as a component, face a challenge as there is little advance regeneration present to allow for movement. Warming temperatures may also lead to increased pest issues and susceptibility to wildfire.

The majority of boreal forest is government-owned or is protected by a conservation easement; however, there are unprotected private lands,including some Fraser fir Christmas tree farms. Grazing of balds and clearing for additional pasture are potential threats as are new homes fragmenting and reducing (albeit small) sections of forest. Invasive plant species spread increases with grazing and home building.

Many animals are associated with boreal forests and a number are dependent upon the habitat provided, especially the spruce/fir component. These include northern flying squirrel, snowshoe hare, northern saw-whet owl, hermit thrush, magnolia warbler, golden-crowned kinglet, red-breasted nuthatch, winter wren, pigmy salamander, and Weller's salamander. In addition, brown creeper, mourning warbler, and yellow-bellied sapsucker breed only in the northern hardwood subtype. Proper forest management can improve forest and/or wildlife habitat conditions. Generally, total harvesting is unsuitable. Planting red spruce seedlings to increase range, and genetic diversity, is possible and has occurred recently. Prime locations are cool, moist, fog-shrouded, snow-laden sites with some shade. Road or trail construction and maintenance should utilize best management practices to minimize erosion, water quality impacts, and invasive plant species introductions. Additional acres could also be protected with conservation easements.

Grasslands

Ron Hughes, Virginia Department of Wildlife Resources

Maintained Grassland - C.F. Phelps WMA

Grasslands are plant communities dominated by grasses, sedges, and non-woody forbs that, through various factors (such as soils, grazing, fire, weather) remain in an open condition. Grasslands can vary tremendously in size, structure, function, and species assemblages, from natural prairies and high-elevation grassy balds to human-influenced old fields, pastures, and hay fields. They can range in size from a few acres to hundreds. Grasslands provide important ecosystem services beyond wildlife habitat. World-wide, grasslands sequester approximately 34% of the global terrestrial carbon stock, help mitigate soil erosion, and minimize run off and improve water quality (Colvig 2024).

Grasslands are one of the most imperiled ecosystems in North America. Natural grasslands in the East were open, grass-dominated areas interspersed with trees (Hanberry and Noss 2022). The historical extent and distribution of natural grasslands in Virginia is unclear. During early colonial settlement (ca. 1630), it was purported that Virginia was 96% forested (Weakly et al. 2012). The remaining 4% (~2,000,000 acres) was in other cover types. How much of the 4% was grasslands is unknown. Historical

records, local demographics, and the fossil record suggest natural grassland ecosystems in the East may have been more extensive than once thought. Fossils of specialized grassland birds, such as the greater prairie-chicken, Henslow's sparrow, and savannah sparrow found in the East indicated grasslands were important components of eastern North America.

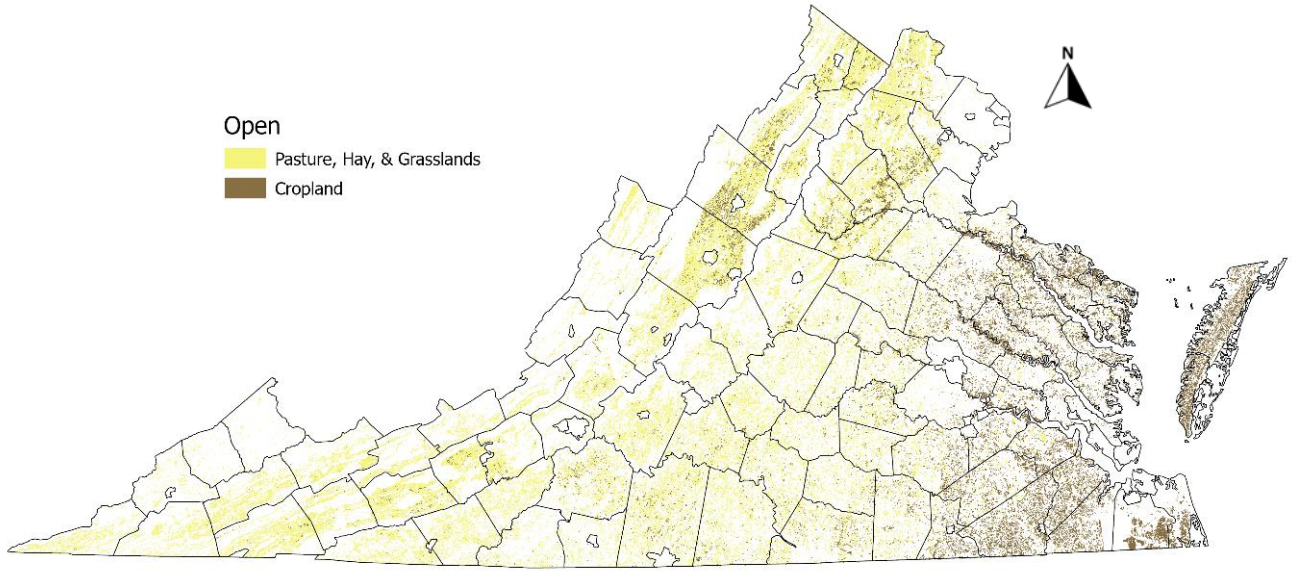


Figure 3.4. Open Lands in Virginia

The post-settlement period (1630-1860) is considered the most far-reaching period of human influence effecting changes in the distribution and abundance of Virginia's native flora and fauna (Weakly *et at.* 2012). Further, land use changes over the sixty years following the Civil War caused major ecosystem changes that includes loss of more than 90% of the grasslands in the United States (Colvig 2024). In the East, natural grasslands were often converted to agriculture and other uses, causing significant loss of this habitat and associated wildlife. Non-native plants were established for grain and hay, and development expanded. By the 1920s, most of the natural grasslands were lost, and populations of associated wildlife species were at all-time lows. During this period, though, modern conservation values emerged concurrent with a period of farm abandonment. Fallow pastures and fields became old field habitat that functioned as "artificial" grasslands. However, over time, major developments in agriculture resulted in a shift toward habitat loss again as fallow fields and open lands were converted to agricultural use. These uses emphasized maximum use of space, highly mechanized machinery, genetic engineering of crop plants, and the advent of chemical pesticides and fertilizers. By the 1980s, land managers realized the plight of grassland habitat and wildlife loss and targeted open land for conservation across Virginia. Consequently, grassland conservation on both public and private lands began, slowing the decline of this imperiled habitat and associated wildlife species. Grasslands serve as vital wildlife habitat for 274 Species of Greatest Conservation Need (SGCN) identified in the Virginia Wildlife Action Plan.

Natural grasslands are rare in Virginia. The DNH lists the few known natural grasslands found in Virginia. Not only grasslands (prairies), but Piedmont woodlands and savannas — open forest communities dominated by grasses and forbs —are included in this listing. Most of the natural grasslands listed are human-influenced and found only within Virginia's Piedmont military base training grounds (e.g., Marine Corps Base Quantico, Fort Barfoot, and Fort A. P. Hill) (Weakly et al. 2012). These habitats are disturbed by random incendiary round fires that are of the size, intensity, and frequency comparable to pre-settlement fire regimes; thus, perpetuating healthy ecosystems (Fleming et al. 2013). Only one natural high-elevation grassy bald, spanning roughly 200 acres, exists in Virginia on Whitetop Mountain in Grayson County (Weakly et al. 2012). More information regarding Virginia's natural grassland ecosystems can be found in the VDCRNH Natural Communities Classification of Ecological Groups and Community Types for Piedmont Oak-Hickory Woodlands, Savannas, and Grasslands as well as Southern Appalachian Shrub and Grass Balds.

Approximately 30% of Virginia's land base is in agricultural use. Of that, a much smaller portion (not known) is in agricultural use that functions as grassland (some hay and pasture) yet are not managed directly to benefit wildlife (e.g., haying fields during the breeding and nesting season). An even smaller portion of Virginia's functional grasslands are protected and managed on public lands (e.g., parks, battlefields, natural area preserves, military installations). Some private landowners manage their lands as grasslands, mainly with the help of Federal cost share programs. These habitats are important to a variety of Virginia's SGCN, such as the eastern meadowlark, grasshopper sparrow, and northern bobwhite as well as seven SGCN bumble bees, monarch butterfly, and other native pollinators. In addition, these habitats are important to a variety of transient and wintering bird species, such as the short-eared owl and dickcissel.

Two primary issues threaten the existence and quality of Virginia's grassland habitats: development and lack of disturbance factors and regimes. Open land is attractive to humans for development and agriculture and is easily converted to those uses. The lack of disturbance factors and regimes hinder ecological succession and natural processes that keep grasslands in an open and functional state. Given the Commonwealth's climate, latitude, and soils, Virginia's landscape can support a diversity of open habitats including grasslands. During pre-settlement, influences such as natural and anthropogenic fires, floods, hurricanes, thunderstorms, tornados, ice storms, large herbivores (e.g. elk, bison) and insect outbreaks created and maintained large areas of open habitat within the larger forested landscape (Oehler et al. 2006). However, in modern times, several disturbance factors are controlled (e.g., fire suppression). Grasslands must be kept in open state and managed using fire or other tools that control establishment and encroachment of woody species. Further, the scale to which grasslands are established and managed is challenging yet is important to consider in management decisions.

Shrublands

Marc Puckett, Virginia Department of Wildlife Resources

As Virginia transitioned from a rudimentary farming economy in the early 1900s to an industrial economy after World War II, open lands acres began to be reforested or developed. Though it is difficult to assess, shrublands likely peaked in Virginia in the late 1800s to early 1900s. In 1900, it is estimated

Shrubland, Virginia Piedmont

that 80% of Virginia was in open farmland of some kind. And many of the remaining forests were in early successional stages due to excessive logging. At that time, methods of maintaining fence lines, field edges and uncropped openings were crude. Common equipment like large rotary mowers and modern herbicides did not exist. Therefore, shrubby fence lines and shrubby areas around crop fields were common. It is hard to estimate the acres of shrubland then, but it would have likely dwarfed the acres of modern times. Using a rough estimation of 80% of Virginia's total land area yields 20,400,000 acres. If only 10% of that farmed land was in shrub habitat, there would have been over 2,000,000 acres of shrub habitat surrounding farmed lands alone, not including young forests in regeneration. Virginia at that time was an early-successional species wonderland. However, it was also at a time when soil erosion and stream sedimentation likely were at an all-time high.

Loss of shrubland continued with large scale reforestation after World War II. The development of more intense farming methods, feeding more people on far fewer acres, modernization of forestry and conversion of many farmed acres to pine plantations, coupled with human population growth and development, greatly reduced early successional acres. Today, about 34% of Virginia's land mass is in farmed land, consisting largely of row crops and pasture and hay land. These modern farmed acres are managed with effective herbicides and brush control techniques, making shrubland less common now than a century ago. The question remains, though, what did Virginia's pre-European settlement landscape consist of? Are today's shrublands substantially different from those of pre-colonization times? Considering that aboriginal people practiced rudimentary farming for centuries, often relying on prescribed fire to set back plant succession, it is likely that a significant component of shrubland existed during pre-colonial times. Historical accounts of large expanses of switch cane dominated lowlands and hunting grounds written about by eastern bison hunters, and valleys described as consisting of native grasses and forbs suggests that shrublands may have been common. Since Virginia's climate is largely a

mesic one, and soils are fair to good in many areas, the natural tendency here is for open lands to revert to older forests over time. It is hard to assess what a purely natural landscape in Virginia would look like. Shrublands would exist due to natural occurrences like hurricanes, tornadoes, and wildfires, along with some grazing by large ruminants, but to what extent is speculation.

A better analysis is to look at the last twenty years, recognizing that the shrublands category includes clearcuts, or young forests in regeneration. Whether they are naturally regenerating hardwoods or pine plantations of some type, these lands still provide the majority of shrublands in Virginia. Depending on location, soil type and site index, clearcuts may exist in a shrubland structure from two to ten or more years post-harvest (transitioning from forb- and brier thicket-dominated areas to those dominated by low growing saplings and shrubs and pines in many cases). National Land Classification Data from the last twenty years show an increase in shrubland in Virginia from approximately 760,000 acres in 2001 to 992,000 acres in 2021. There was a substantial dip in the acreages following the 2008 economic crisis, but a recovery of timber harvesting followed over the last fifteen years. The NLCD does not break down these acres by those attributed to timber harvest versus those occurring from other activities. Current data suggest shrubland comprises about 4% of Virginia's landscape. If new methods for making paper, cardboard or building construction materials are not developed that outpace the use of wood, the amount of timber harvest and, thus, shrubland in Virginia should stay consistent into the foreseeable future.

The DOF tracks timber harvests annually. On average between 200,000 and 250,000 acres of timber harvest occurs in Virginia each year. This effort consists of clear-cuts, and timber thinning cuts of various intensities. Clear-cutting creates the best opportunity for shrublands, but thinning also increases shrub levels in the forested understory. Conducting annual surveys for northern bobwhite and songbirds provides some insights into species that rely on shrubs for at least some component of their life cycles. When observing near clear-cuts in their early years, shrubland bird species such as bobwhite , yellow-breasted chat, white-eyed vireo, indigo bunting, rufous-sided towhee, field sparrow, and prairie warbler are commonly heard. It could be argued that these clear-cut derived shrublands do not have the quality or plant diversity of more naturally occurring shrublands, or field borders and hedgerows developed specifically with planted shrubs, and this is likely true. But the sheer volume of the shrublands provided by timber harvest dwarfs all other types. It appears that some of these shrubland species are adapting quite well to modern forestry practices that, while they are not perfect in their provision of habitat, prove adequate for many species.

While timber harvests will likely maintain substantial acres of shrublands into the foreseeable future, it remains critical that those managing state, federal, or private lands recognize the value of and create or maintain shrublands where it makes sense to do so. In addition to clearcuts, shrublands can occur on rights-of-way, in old pastures and fields, around wetlands, on restored mined lands, and in other odd areas. It takes active management to maintain shrublands through time. Some sort of disturbance or selective management must occur or many of these shrublands will transition to mature forest. Multiple federal incentives programs exist that financially support establishing shrublands such as field borders and hedgerows, heavy thinning and burning of thinned pine stands, patch clearcuts and others. The key

is to increase the awareness of the value of shrublands and other early-successional plant communities in the eyes of landowners and the public.

Savannas
From Virignia's 2015 Wildlife Action Plan

Savannas are unique communities dominated by large mature trees, open canopies, low densities of

Pine Savanna - Big Woods WMA

young trees, and abundant grass and forb ground covers. A few examples of hardwood savannas occur on military installations in northern and eastern Virginia, and small acreages of longleaf pine savanna occur on conserved lands in southeast Virginia. Historically, savannas would have been maintained by wildfires or anthropogenic fires that would have removed shrubs and young trees while leaving mature trees intact. Today, savannas are maintained by prescribed fire. While existing savanna habitats can be maintained with management, new savannas are not likely to be created through natural processes.

While savannas offer unique habitat conditions that can support an assortment of species, they have limited economic value. As such, few private landowners can afford to manage their properties to include savanna habitat. Historic fire suppression on conserved lands has allowed diverse mixed forest communities to exist in areas that were once savanna communities. The only viable means of creating and maintaining savannas involves working with public and private landowners to conserve areas through acquisition, easement, or agreement and managing those areas with fire to preserve mature trees while eliminating younger-aged trees and shrubs. To maximize the benefit of these efforts, Virginia's conservation community should focus such efforts on areas either adjacent, or in close proximity to, existing savanna habitats.

Savannas historically were related to fire-maintained longleaf pine (LLP) ecosystems in Virginia which is at the northern extent of the LLP ecosystem range that stretches from Texas to Virginia. Eighteen Longleaf Implementation Teams (LIT) are organized through the Longleaf Alliance, including the Longleaf Cooperators of Virginia (LCOV). LCOV is a collaboration of public and private land managers that plans and implement conservation actions to benefit longleaf and its species components. Throughout the

range, connectivity, and conversation of corridors of species movement is important. Species are increasingly moving north and west in response to changing environmental conditions. According to The Nature Conservancy (TNC). Species are moving 11 miles north per decade. Wildlife corridors identified in the Virginia Wildlife Corridor Action Plan identify these natural pathways that will be used in conservation action. Six conservation lands comprised of longleaf pine savanna habitat owned by DWR, the Virginia Department of Forestry (DOF) and the Virginia Department of Conservation and Recreation (DCR) and private landowners fall within the identified corridor that runs along the Nottoway River (Chub Sandhill, Big Woods WMA, Flippo Gentry, Piney Grove, Racoon Creek, and Nottoway Arch). Corridors identified in Conserve Virginia along the Blackwater and James River contain four other LLP conservation areas owned by state and federal managers (Old Dominion University's Blackwater Ecological Preserve, DCR's Antioch Swamp and South Quay NAPs and the James River National Wildlife Refuge). These conservation lands will benefit from conservation actions that provides connectivity to ensure resiliency of preserved lands over time as well as allowing pathways for species movement.

Glades & Barrens

From Virginia's 2015 Wildlife Action Plan

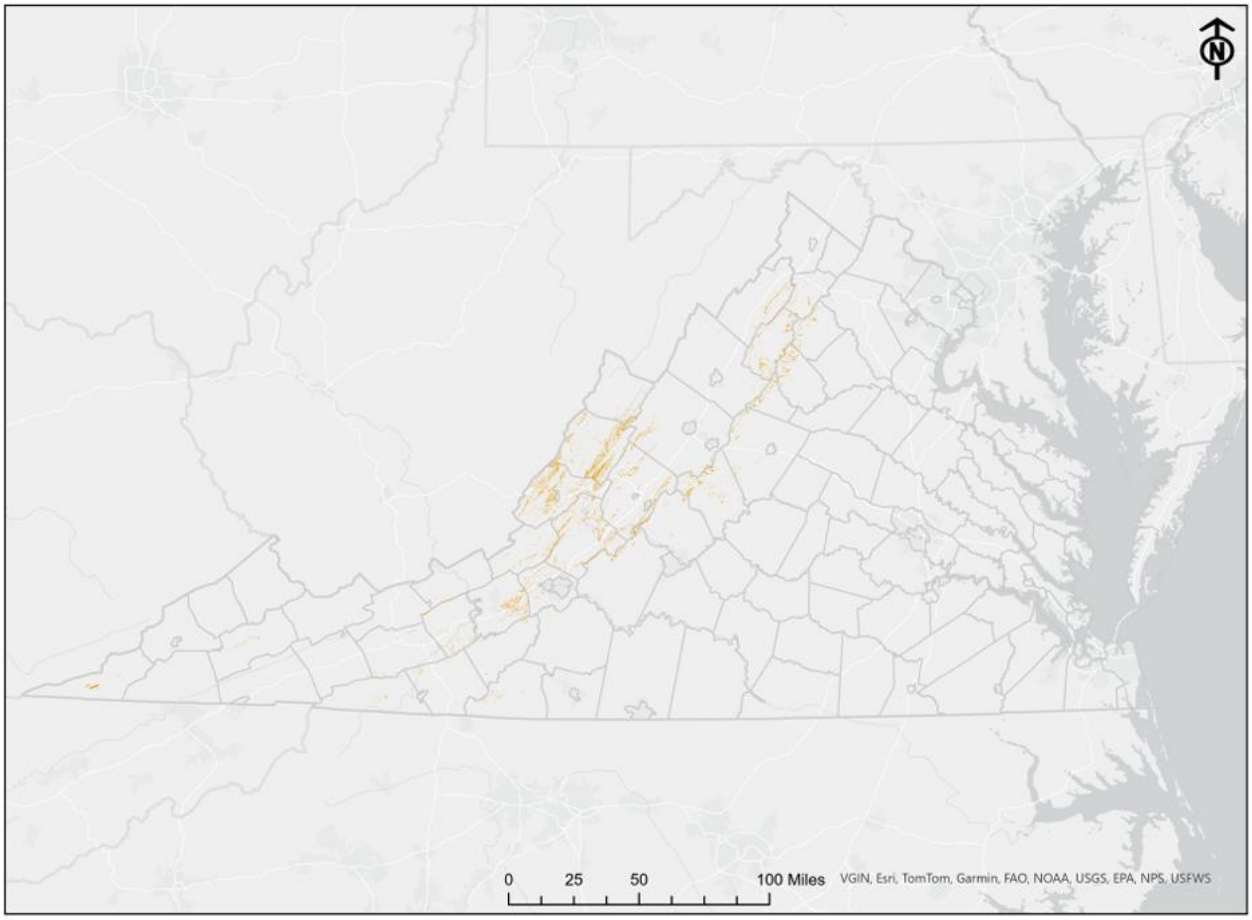


Figure 3.5. Glades and Barrens

Glades and barrens are naturally occurring open habitats that are characterized by shallow soils and rocky substrates. These habitats generally have a grassy layer with some low shrubs and herbs and

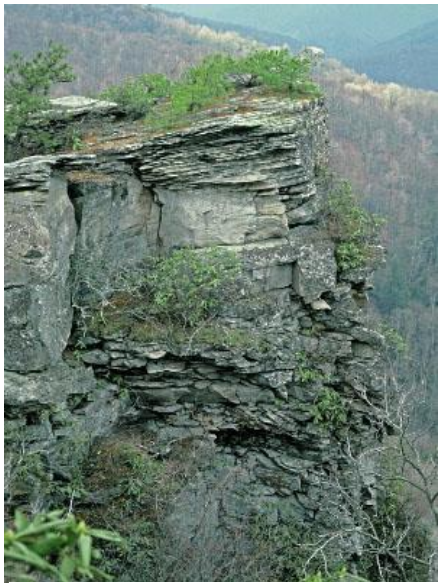
scattered trees (often less that 40% of tree cover) as well as patches of moss and lichen (Anderson *et al.* 2013; Fleming *et al.* 2013; Comer *et al.* 2003). Open rocky areas can also be predominant (Comer 2003). Glade and barren habitats are found in the central and western portions of the state.

Glades and barrens represent distinct botanical communities (C. Ludwig, VA Dept. Of Conservation and Recreation, Natural Heritage Program, personal communication 2015). Because of their small size, prolonged disturbances of glades and barrens can eliminate these botanical communities. Because these habitats tend to be geographically isolated, once a community is eliminated, it may be impossible for many species to reoccupy without human intervention. Historic threats to these systems have included intense quarrying, which has resulted in loss of many habitat patches and the fragmentation of surrounding areas (Anderson *et al*. 2013). Some glades and barrens occur within agricultural lands, which also can lead to fragmentation and degradation of the habitat from overgrazing. The introduction of non-native and invasive species threatens native species endemic to these habitats, and recreational activities within these habitats often results in trampled vegetation (USFS 2014).

Public and private land conservation is vital, through easement, acquisition, or agreement. As agencies and organizations consider land acquisitions, they should consider giving greater priority to conserving this unique habitat. Important management actions include prescribed burns and managing wildfires, monitoring and controlling non-native species, and managing the recreational use of areas to prevent the trampling of rare plant communities (USFS 2014).

Cliff & Talus

From DCR's Natural Communities of Virginia Classification of Ecological Groups and Community Types - Mountain/Piedmont Cliffs



Cliffs - Photo credit: DCR-DNH, Thomas J. Rawinski

Cliff and talus plant communities consist of woodlands, shrub, herbaceous communities and/or nonvascular vegetation, such as lichen and bryophytes. Vegetation is often sparse and occurring on very steep or precipitous bedrock faces. Many habitats are the result of periglacial phenomena. Both calcareous and acidic cliff habitats may be formed by incision of high-order streams. Acidic bedrock communities can also occur on erosion-resistant mountain ridges or domes. Communities where vegetation is entirely dominated by lichens and bryophytes generally occupy exposed, minimally weathered, massive cliffs and boulder fields in the mountains of western Virginia. Habitats vary with aspect and other environmental conditions. Local zones or ephemeral seepage may be present.

On south- and west-facing cliffs of carbonate formations, the surficial bedrock, hot microclimates, and associated chemical and physical stresses limit overall vegetation cover, woody growth, and species richness. Scattered scrub growth is typical. On north-facing limestone or dolostone cliffs, habitats are open but sheltered, with limited direct solar exposure. Local zones of ephemeral seepage are frequent. Woody vegetation of these more mesic calcareous cliffs in comparatively diverse and often achieves larger size than on similar xeric sites. Cliffs on metamorphic and non-carbonate sedimentary rocks are poorly documented and known from relatively few siltstone, metasiltstone, and metabasaltic cliffs in the western Piedmont and Blue Ridge. Ordovician red mudstone/shale cliffs of the Ridge and Valley Province also support communities of this group. All require additional investigation. Habitats probably vary with aspect and other microhabitat conditions. Vegetation is generally dominated by umbilicate, foliose, and/or crustose lichens, with relatively sparse representation of vascular plants.

The vegetation of acidic cliffs is generally dominated by lichens, with the umbilicate “rock tripe” species especially prominent. Vascular plants are confined to crevices and humus-covered shelves. On drier, south- to west-facing cliffs, vascular species may be very sparse and consist of stunted pines, heathery shrubs, and occasionally herbaceous lithophytes. Sheltered, north- to east-facing cliffs often support more diverse shrub and herbaceous flora.

Cliff communities are generally considered state-rare, but their conservation status needs further investigation. Because of inaccessible locations, stands seem immune from many types of anthropogenic disturbance. Scattered individuals of non-native weeds sometimes find footholds on xeric cliffs, but are largely excluded by the hot, rocky substrates.

Caves & Karst

Will Orndorff, Division of Natural Heritage, Virginia Department of Conservation and Recreation

As of the spring of 2023, the Virginia Speleological Survey has documented 2,953 caves over 10 meters in length in Virginia. Ten meters is the international convention for minimum length of passages needed to qualify as a cave. Nearly 600 miles of passages have been surveyed within these caves. All but a small handful of these caves occur in the Ridge and Valley physiographic province west of the Blue Ridge. Biological sampling has been performed in approximately 800 of these caves, resulting in identification of over two hundred cave-limited invertebrate species, mostly endemic to Virginia and new to science when initially discovered. Two-thirds of these species are considered globally imperiled or critically imperiled with primarily to extremely restricted ranges (G2 or G1 Natureserve Conservation Status

Rank), with many known from only a single cave or karst system. These accessible and documented caves underlie a small portion of a much more vast landscape developed across western Virginia by the dissolution over geological time of limestone and dolostone, resulting in a largely internally drained landscape called karst. Karst is characterized by sinkholes, disappearing streams, relatively few surface streams, large springs, and caves. Over four thousand square miles (> 2.6 million acres) of western Virginia is underlain by karst topography, according to mapping by the Virginia Department of Energy.

The vast majority of Virginia's karst and caves lies west of the Blue Ridge, in the Ridge and Valley province either on valley floors or along the lower slopes of mountain ridges. While a systematic land use analysis is beyond the scope of this document, it is clear that the vast majority of Virgina's karst has been subjected, since European colonization, to major land conversion from forests, woodlands, and grasslands to anthropogenic agricultural landscapes characterized dominantly by grazing and row crops, with widespread interspersed and upslope silviculture. In parts of the state, land application of chemical fertilizer, poultry litter, and biosolids is widespread, as is the use of pre-emergent herbicides and pesticides.

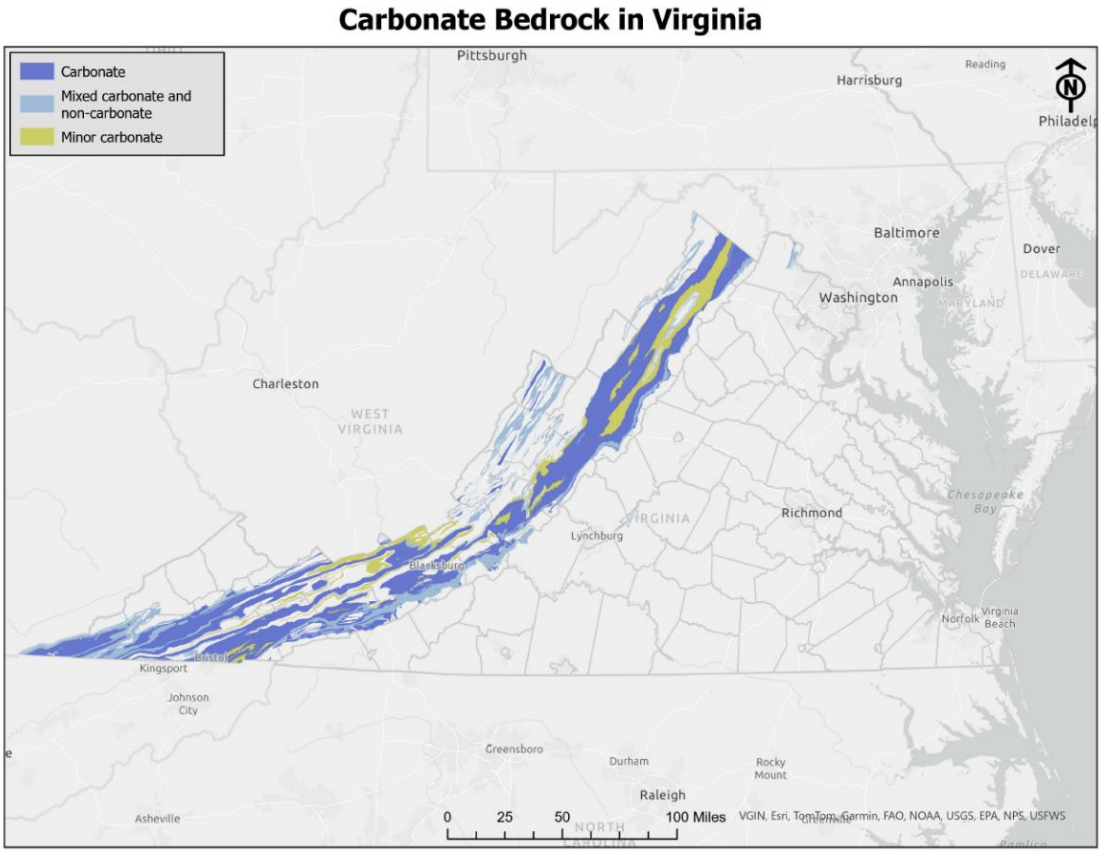


Figure 3.6. Caves and Karst

There are few cave- or karst-specific regulations in Virginia, although general environmental regulations provide varying degrees of protection. The Virginia Cave Protection Act of 1979 established the Virginia Cave Board, which provides guidance as requested to citizen and agency stakeholders and maintains a list of caves designated as "significant." Many significant caves are so designated primarily because of the species that live in them. The Cave Protection Act also establishes a research permit system for

scientific studies in caves, prohibits the sale of speleothems (cave formations such as stalactites and stalagmites), and exempts landowners from liability should someone be injured in a cave on or beneath their property, provided no fee is charged for entry. Solid waste management and stormwater management laws regulated by the Department of Environmental Quality contain karst-specific provisions, as do septic system siting standards regulated by the Department of Health. Guidelines for certified nutrient management plans approved by the Department of Conservation and Recreation contain karst specific provisions.

In a broad sense, all subterranean communities share a fundamental dependence on a combination of heterotrophic and chemotrophic/chemoautotrophic sources of energy. Around the world, there are subterranean communities based on both kinds of systems. However, most of the food base for the ecological groups seen in Virginia appears to be derived from material produced in an autotrophic environment and subsequently transported into the subsurface.

The designation and definition of subterranean invertebrate natural communities in Virginia only exists to the ecological group level, performed by Dr. David Culver (American University biology professor and long-term member of the Virginia Cave Board) under contract to The Nature Conservancy in 1991. While Culver (1991) describes these as six "cave community types," the level of detail is clearly more consistent with their designations as ecological groups, and his descriptions lack characteristic taxonomic associations necessary for delineation to the community level. Slightly updated and simplified descriptions of these habitats appear in "The Invertebrate Cave Fauna of West Virginia, second Edition" by Fong *et al*. 2007 and include lists of species associated with each habitat based on sampling. "The Invertebrate Cave Fauna of Virginia," (Holsinger *et al*. 2013) is an annotated list of cave-limited species known from Virginia, but does not provide any habitat pairing.

Aquatic versus terrestrial habitats, combined with the physical habitat and associate sources of food, form the basis of Culver's six cave habitats common in the Appalachians, all of which occur in Virginia. These habitat types, with names slightly modified from Culver's, are:

- Aquatic Cave Stream
- Aquatic Cave Drip Pool/Epikarstic
- Aquatic Karst Phreatic Zone
- Terrestrial Riparian Cave
- Terrestrial Edaphobitic/Epikarstic Cave
- Terrestrial Dung/Transitory Organic Matter Cave

Aquatic Cave Stream Habitat

Cave streams are streams that flow through cave systems. They may have a variety of physical structures (e.g., pool/riffle) and substrate (gravel, cobbles, bedrock, hardpan or cemented gravel and clay). In general, they are dominantly vadose in nature (above the water table) and commonly exhibit turbulent flow. Some cave streams are very dynamic in response to precipitation events, while others

remain more constant. Cave streams in Virginia are, in many cases, parts of integrated subterranean basins that may, in some cases, exceed 100 square miles in area.

There are three sources of water for cave streams. **Allogenic** water is derived from precipitation that landed in nonkarst areas and typically enters the cave as channelized flow captured into the subsurface after flowing onto carbonate bedrock. **Autogenic** waters are derived from precipitation falling on carbonate bedrock and may reach the stream through flow into sinkholes, channelized surface flow captured by the subsurface, or quite often by slow, mostly vertical movement through the soil and epikarst (the upper portion of the bedrock between cave passages and the overlying soil/bedrock interface). A third source is **phreatic** water, where water upwells or spills over from the deeper aquifer, forming an underground spring that feeds a cave stream. Any particular cave stream represents a combination of one or more of these three sources.

Water in cave streams can vary in terms of "hardness" based on its source, but most cave stream water qualifies as alkaline (bicarbonate water), with dissolved calcium, magnesium, bicarbonate, and carbonate ions. Cave streams fed by mostly autogenic sources are commonly saturated and deposit calcite in the stream bed, while allogenic-dominated streams are generally unsaturated and do not deposit minerals in their beds.

Nutrients in these systems generally flow into cave streams with the water, although nutrients may be introduced within the cave (e.g., bats roosting over water). Culver (1985) considered particulate organic matter as the main source of organic carbon in caves, but substantial carbon may also enter as dissolved organic carbon. In both cases, microbial communities may play a role in converting this carbon into forms more usable by higher taxa. In many cave streams, feeding trails can be observed across microbial deposits on the stream substrate.

Cave stream habitats are sensitive to degradation of water quality through introduction of chemical contaminants, excess nutrients (Holsinger, 1966), and/or sediment. Cave stream habitats can be resilient, especially in case where there are underground tributaries that serve as refugia hydrologically connected to impacted portions of the stream. Cave stream habitats can also be degraded by changes in stream flow, both in terms of rate and volume. Human activities likely to negatively impact cave stream habitats include land development, agriculture, water withdrawals, and logging activities. In all of these cases, there are best management practices that may be followed to avoid or reduce impacts to cave streams. However, the implementation of such practices in inconsistent at best and should be encouraged.

Fong *et al.* (2007) list the following faunal orders that, in West Virginia, contain cave-limited taxa associated with cave stream communities: amphipods (Amphipoda), asellid isopods (Isopoda), crayfish (Decapoda), hydrobiid snails (Mesogastropoda), and flatworms (Tricladida, Lecithoepetheliata). All but cave-limited crayfish are known from cave stream communities in Virginia. Troglophilic fauna may include crayfish, salamanders, and small fish, none of which have cave-limited species documented in Virginia. Larvae of epigean insects are locally common.

Terrestrial Riparian Cave

Terrestrial Riparian Cave habitats form adjacent to cave streams, within and immediately adjacent to the volume of the cave impacted by frequent flooding of the cave streams. The particulate organic matter introduced into the habitat during flood events is the major source of food in these systems (Holsinger and Culver, 1988). These habitats occur along flood prone perennial cave streams and also along intermittent cave streams that flood after storm events. The habitat is commonly (but not always) characterized by significant deposits of fine-grained sediment, rich in organic matter, much of it coarse and particulate in nature. In some cases, coarse organic matter may be deposited in the riparian zone with a relative dearth of fine, inorganic sediment.

Terrestrial Riparian Cave habitats in Virginia are in many cases parts of integrated subterranean basins that may, in some cases, exceed 100 square miles in surface recharge area.

There are three sources of water for the cave streams that support terrestrial riparian cave habitats. **Allogenic** water is derived from precipitation that fell on nonkarst areas and typically enters the cave as channelized flow captured into the subsurface after flowing onto carbonate bedrock. **Autogenic** waters are derived from precipitation falling on carbonate bedrock, and may reach the stream through flow into sinkholes, channelized surface flow captured by the subsurface, or quite often by slow, mostly vertical movement through the soil and epikarst (the upper portion of the bedrock between cave passages and the overlying soil/bedrock interface). A third source is **phreatic** water, where water upwells or spills over from the deeper aquifer, forming an underground spring that feeds a cave stream. Any cave stream represents a combination of one or more of these three sources. Allogenically dominated cave stream systems are typically more flood prone and introduce more and coarser particulate carbon into the riparian cave terrestrial habitat than do other stream types.

Microbial communities almost certainly play a role in converting the coarse particulate carbon into forms more usable by higher taxa. Extensive bioturbation of fine-grained sediments in the riparian habitat is common, and the presence of oligochaetes is nearly ubiquitous. Taxa occupy the surface and interior of and areas adjacent to these riparian surface deposits.

Terrestrial riparian cave habitats are sensitive to degradation of water quality through introduction of chemical contaminants, excess nutrients, and/or sediment, but less so than cave streams themselves. Terrestrial riparian cave habitats can also be degraded by changes in stream flow, both in terms of rate and volume, especially when these changes impact flood frequency and severity. Terrestrial riparian cave habitats can be resilient, especially in case where there are underground tributaries that serve as refugia hydrologically connected to impacted portions of the stream. Human activities likely to negatively impact terrestrial riparian cave habitats include land development, agriculture, and logging activities. In all of these cases, there are best management practices that may be followed to avoid or reduce impacts to cave streams and associated riparian terrestrial habitats. However, the implementation of such practices is inconsistent at best and should be encouraged.

Fong *et al.* (2007) list the following faunal orders that, in West Virginia, contain cave-limited taxa associated with terrestrial riparian cave habitats: mites (Acari), spiders (Araneae), springtails (Collembola), pseudoscorpions (Pseudoscorpionida), bristletails (Diplura), millipedes (Chordeumida), and beetles (Coleoptera). These are also the faunal groups represented that occur as cave-limited species in Virginia's terrestrial riparian cave habitats. Harvestmen (Opiliones) may also include cave-limited species associated with terrestrial riparian cave habitats in Virginia.

Other Subterranean

Will Orndorff, Division of Natural Heritage, Virginia Department of Conservation and Recreation

Aquatic Cave Drip Pool/Epikarstic Habitat

The cave drip pool/epikarstic habitat is characterized by water moving vertically (or subvertically) into the cave (Culver, 1991), following multiple pathways and at various rates. The majority of epikarstic habitat may not be directly accessible from the cave, consisting of water stored in and flowing through inaccessible cracks, fissures, and solution pockets between the cave and the bedrock-soil interface or land surface. Animals observed in or collected from drip pools likely in many cases represent "wash-outs" from the primary, overlying habitat.

Cave drip pool/epikarstic waters are typically bicarbonate (alkaline) waters rich in dissolved calcium, magnesium, bicarbonate, and carbonate. In most cases and at most times, they are saturated with respect to the mineral calcite and deposit speleothems near the bottom of the epikarst and at the interface with underlying cave passages. Dissolved oxygen levels are generally neither saturated nor anoxic.

In the case of the epikarst and cave drip pools, there is less energy input from particulate matter and more from dissolved organic carbon and organisms. This habitat is characterized by much lower resource levels than cave streams, and the associated fauna has adapted to this low energy environment. Introduction of excessive carbon and/or nutrients into this system can be very damaging and lead to invasion of the habitat by organisms accustomed to higher nutrient levels (Culver, 1986; Holsinger, 1966).

Drip pool/epikarstic habitats are sensitive to degradation of water quality through introduction of chemical contaminants, excess nutrients, and/or sediment, which can clog flow paths in the epikarst. Epikarstic habitats can be resilient, especially in cases where impacts are localized and not extensive across the overlying land surface. The key is ability for fauna to move laterally to and from unimpacted refugia within the epikarst. Epikarstic habitats are easily degraded by changes in recharge volume and patterns. Any activity that increases surface runoff and reduces or focuses recharge is likely detrimental to this habitat. Human activities taking place above or nearly above the epikarstic habitat and likely to cause negative impacts include land development, agriculture, septic systems, water withdrawals, and logging activities. In all of these cases, there are best management practices that may be followed to avoid or reduce impacts to cave streams. However, as in the case of cave streams the implementation of such practices is inconsistent at best and should be encouraged.

It should also be pointed out that epikarstic habitat may extend laterally well beyond the area overlying humanly accessible cave passages. Delineation of habitat extent in such cases is difficult and must be inferred from the distribution of bedrock and geomorphology/surface topography. Continuous areas of similar bedrock and surface morphology between caves likely are underlain by contiguous epikarstic habitat, and extensive epikarstic habitat most likely exists even in karst areas that are not near known caves. Protection of the land surface overlying epikarstic habitat is the overriding strategy for protection of epikarst habitat.

Fong (2007) state that this habitat is dominated by copepods and also lists several associated amphipod species. In Virginia, the characteristic fauna of aquatic epikarstic/drip pool habitats include amphipods (Amphipoda), asellid isopods (Isopoda), and planaria (Triclada), as well as numerous copepods (Cyclopoida and Harpacticoida) and a variety of other microcrustacea.

Aquatic Karst Phreatic Zone Habitat

Karst phreatic zone habitat occurs below the water table (zone of saturation) and consists of waterfilled solution conduits (caves), chambers, fissures, and fractures. It is accessible to sample and monitor at the intersection of the phreatic and vadose (unsaturated) zones in cave lakes (Culver, 1991) and cenotes, through groundwater wells, and indirectly through discharge of phreatic water through springs. The habitat extends to unknown depth, and crustaceans have been observed to occupy the habitat to depths in excess of thirty meters in the Shenandoah Valley.

Phreatic waters are comparable to drip waters in that they are generally bicarbonate (alkaline) waters rich in dissolved calcium, magnesium, bicarbonate, and carbonate. In many cases they are saturated with respect to the mineral calcite. Dissolved oxygen levels are low compared to cave streams, but not anoxic.

Energy input and distribution in the karst phreatic zone is highly irregular. While the bulk of the water in the phreatic zone is typically low in dissolved organic carbon, both dissolved organic carbon and carbon from particulate matter are high near intersections with the vadose zone or the land surface (e.g., beneath sinkholes or sinking streams). Much of the phreatic zone fauna is free-swimming and can migrate laterally and vertically through the aquifer to feed or to escape impairments.

Water in the phreatic zone comes from a variety of sources and has a much longer residence time in the system than in cave streams or cave/pool epikarstic habitats. The recharge areas for the karst phreatic zone are large, complex, and not easily delineated. A simple description of the karst phreatic zone is a vast network of interconnected underground “lakes” occupying caves, chambers, fissures, and fractures below the water table. Water quality in the phreatic zone can change quickly on a local scale in response to contamination events, and slowly on a more regional scale because of land use practices over decades and centuries. Protection of groundwater quality and groundwater levels is critical to the protection of karst phreatic zone communities (Culver, 1991). Promotion of practices at the land surface

that encourage dispersed infiltration of clean water to recharge the karst aquifer are essential and must be widespread to be effective.

Fong *et al.* (2007) only specified a single Cirolanid isopod (*Antrolana lira)* as characteristic of phreatic karst habits in West Virginia. However, Virginia taxa commonly collected from the phreatic karst habitat include amphipods (Amphipoda), planaria (Triclada), copepods (Cyclopoida and Harpacticoida), and isopods (Isopoda). While nonmarine representatives of the isopod family Cirolanidae are restricted to cave-limited karst phreatic habitats in Virginia, they are not the only taxa present in or common to this habitat.

Terrestrial Edaphobitic/Epikarstic Cave Habitat

This habitat consists of a network of small, air-filled cavities in the epikarst, between the cave and the surface. It is the terrestrial equivalent of the STK2 described above. Because this habitat is difficult to directly sample, much of what is known about the animals that live there is from specimens that fall or are flushed into an underlying cave from above, particularly during storm events.

As the case of the epikarst/cave drip pool habitat (STK2), there is less energy input from coarse particulate matter and more from dissolved organic carbon and organisms, including plant roots and associate microbial communities. This habitat is characterized by lower resource levels than cave streams, and the associated fauna has adapted to this low energy environment. Introduction of excessive carbon and/or nutrients into this system can be very damaging and lead to invasion of the habitat by organisms accustomed to higher nutrient levels (Culver, 1986).

The environmental sensitivity, resilience, and potential sources of impacts to aquatic epikarstic/cave crip pool habitat also apply to terrestrial edaphobitic/epikarstic cave habitat. Terrestrial edaphobitic/epikarstic cave habitat may extend laterally well beyond the area overlying humanly accessible cave passages. Delineation of habitat extent in such cases is difficult and must be inferred from the distribution of bedrock and geomorphology/surface topography. Continuous areas of similar bedrock and surface morphology between caves likely are underlain by contiguous terrestrial edaphobitic/epikarstic cave habitat, and extensive terrestrial edaphobitic/epikarstic cave habitat most likely exists even in karst areas that are not near known caves. Protection of the land surface overlying and adjacent to terrestrial edaphobitic/epikarstic habitat is the overriding strategy for protection of terrestrial edaphobitic/epikarst habitat.

Fong *et al.* (2007) does not identify a characteristic fauna associated with this community in West Virginia, but does cite two Coleoptera as examples. In Virginia, samples from cave formations and drip pools, and in drip collectors, suggest that the terrestrial edaphobitic/epikarstic habitat likely may include representatives from many of the same faunal orders as the terrestrial riparian cave habitat, in some cases even to the species level.

Terrestrial Dung/Transitory Organic Matter Cave Habitat

Fong *et al.* (2007) describes this habitat as being within a few hundred meters of a cave entrance (though not necessarily large enough for a human to fit). The resource (food) base is derived primarily from the activities of animals (e.g., bats, raccoons, cave rates, crickets, salamanders), such as troglophiles and trogloxenes that migrate in and out of caves regularly. Organic matter, such as leaves and woody debris falling into the entrance, may also contribute. Bodies of animals that fall into the cave but cannot escape, or that fall in dead, comprise significant sources of food as well. Note that habitat associated with extensive accumulations of bat guano are rare (and poorly documented) or absent in Virginia, though they are well-documented in several southern states and Texas (Culver, 1991).

Culver (1991) points out that the protection of this habitat requires protection of the foraging areas of the associated species outside of the cave entrance. Taylor *et al.* (2005) showed that cave crickets regularly forage at distances up to 100 meters from a cave entrance. Protection of this habitat requires maintenance or restoration of a natural buffer of at least 100 meters radius from any entrance associated with a cave. In addition, if cave gates are installed for security or conservation purposes, only designs that do not adversely impact foraging behavior and access to foraging animals should be used (Culver, 1991). In general, bat-friendly cave gates are also friendly to the foragers associated with the terrestrial dung/transitory organic matter cave habitat.

Note that in cases where terrestrial dung/transitory organic matter cave habitat is adjacent to cave streams, it may well contribute food to both the aquatic cave stream and terrestrial riparian cave community habitats.

Fong *et al.* (2007) list the following faunal orders that, in West Virginia, contain cave-limited taxa associated with terrestrial dung/transitory organic matter cave habitat: mites (Acari), spiders (Araneae), springtails (Collembola), pseudoscorpions (Pseudoscorpionida), millipedes (Chordeumida), beetles (Coleoptera), and flies (Diptera). These are also the faunal groups represented that occur as cave-limited species in Virginia's terrestrial riparian cave habitats. Harvestmen (Opiliones) may also include cave-limited species associated with terrestrial dung/transitory organic matter cave habitat in Virginia.

Of the six cave-associated habitat types, the terrestrial dung/transitory organic matter cave habitat is the one with the highest concentration and diversity of troglophilic species, those commonly found in but not limited to caves. Many of these troglophiles do depend on the cave for parts of their life cycle but move freely in and out as part of their ordinary behavior. Common troglophiles include Alleghany woodrats, bats (eight species in Virginia are known to use caves), racoons, eastern phoebes, owls, salamanders, crickets, fungus gnats, millipedes, spiders, and harvestmen.

Ecological Zonation

One traditional way of looking at cave habitats was ecological zonation (Fong *et al*. 2007) based on proximity to light and/or a cave entrance. The "threshold zone" consists of the entrance to the extent of light penetration. The "transition zone" is completely dark, but where the microclimate changes rapidly in response to surface changes. The "deep zone" is, ideally, a part of the cave characterized by extreme climatic stability and where climatic fluctuations on the surface have little influence. Several of the six

habitat types occur in more than one of these ecological zones, introducing yet another element of complexity to understanding or generalizing cave habitats. Over time, the fauna have evolved to occupy a wide array of habitats, many of them occurring in geologically isolated karst areas making migration between them difficult. The net result is a high number (over two hundred) of cave-limited invertebrate species documented in Virginia.

Riparian & Floodplain

Ben Sagara, Virginia Department of Wildlife Resources

Riverine floodplains are all the low-lying areas adjacent to any size stream that can be inundated with non-tidal floodwaters. When a watershed receives enough water to top a stream channel bank, the water begins to flow into the adjacent floodplain. Flooding can be caused by precipitation, snowmelt, storm surge, opening of dam gates, or dam breech/failure. Bottomland and floodplain forests, swamps, riverside prairies, impoundments, beaver ponds, and adjacent floodable forest, agricultural, and developed lands are all located within riverine floodplain ecosystems. Lower elevation areas are inundated more frequently, whereas higher elevation areas require greater hydrologic inputs and flood less frequently. Unaltered floodplains account for the dynamic inundation regime of riverine ecosystems and serve as critical natural infrastructure by attenuating floodwaters and allowing natural sediment transport. In doing so, they protect human communities and improve water quality and groundwater recharge. However, these flat and fertile floodplains, particularly those adjacent to large navigable waterbodies, were some of the first areas to be developed and farmed in Virginia. Many floodplain areas are still often considered prime real estate. Berms, levees, dams, and other infrastructure have been created to help protect developed areas from catastrophic flooding disasters. Development along river corridors has significantly altered floodplain functions, leading to more frequent and severe floods, extensive loss of fish and wildlife habitat, and a greater risk to water supplies.

Floodplain habitats are distributed across the landscape along nearly every stream channel. Virginia has about 2.3 million acres of mapped Special Flood Hazard Areas which represents 9% of Virginia's land. Natural floodplains often contain valuable fish and wildlife habitat and support 248 SGCN identified in the Virginia Wildlife Action Plan. Vegetative composition is driven by differences in frequency of flooding, groundwater hydrology, watershed size, landscape position, geomorphology, soil composition, underlying geology, climate, and historic disturbance regime. Low elevation floodplains that are near permanently inundated generally maintain herbaceous and shrub dominated communities, while seasonally flooded and temporarily flooded areas are largely forested habitats. Shorelines and other depositional bars maintain bare or herbaceous-dominated habitats. Historic fire regimes in floodplains are highly dependent on the surrounding forestland community and could have a nearly annual return interval to an over 1,000-year return interval (LANDFIRE 2007). More information on Virginia's alluvial floodplain communities can be found here in the Virginia Department of Conservation and Recreation (DCR) Natural Communities of Virginia Classification of Ecological Groups and Community Types in Palustrine Systems.

Riparian-Floodplain - Hardware River WMA

Conversion to developed lands and associated habitat fragmentation remain the greatest threat to riverine floodplain habitats. Levees separate rivers from their floodplains and inhibit their ability to attenuate water during floods, which reduces the health and function of floodplain ecosystem. Dams block the natural flow of sediment and nutrients to downstream areas and impede natural fish and wildlife movement. Other threats include changes in flood frequency and intensity in rapidly developing watersheds, stormwater, agricultural, and industrial pollutants, intensive silvicultural practices, conversion to open water through damming, and the colonization of aggressive invasive species. Changing environmental conditions are expected to cause more frequent and severe storms and droughts, which will increase the risk of severe flooding. The average 100-year floodplain is projected to increase by 45% by the year 2100. Changes in the timing and extent of hydrologic inputs affects biogeochemical processes and negatively impacts habitat and water quality services.

Floods are the most common and costly natural disaster. Development within floodplains is now federally regulated by the Federal Emergency Management Agency (FEMA). The DCR Virginia Floodplain Management Program and local jurisdictions pose further regulation and oversite over development in floodplains. Although these regulations do protect some floodplain habitats, many were created to establish guidelines to enable development within floodplains. The federal government does encourage states and local governments to establish more restrictive floodplain regulations [44 CFR 10.1(d)] and rewards these "higher standards" through premium discounts for locality participation in the voluntary Community Rating System Program (CRS). The CRS incentivizes smart floodplain management, preservation of open space, and retention or restoration of natural floodplain functions. Twenty-six communities in Virginia participate in the CRS. Other conservation actions include reconnecting streams to floodplains through stream restoration or enhancement, maintaining and planting forested buffer

zones around streams, removing unnecessary dams, and limiting upstream point and non-point source pollution through regulation and incentive programs.

Riparian buffers are critical for the conservation of many aquatic species. In general, it is recommended that a buffer of at least 100 feet on both sides of all intermittent or perennial streams, a buffer of at least 200 feet on both sides of all perennial tributaries to waters known to support listed aquatic species, and a buffer of at least 300 feet on both sides of waters known to support listed aquatic species be maintained to sustain water quality, provide wildlife habitat, and ensure the stability of the stream structure and function. (Hawes, et. al, 2005)

Shorelines

Ruth Boettcher, Virginia Department of Wildlife Resources

The Shorelines habitat for the Northeast includes shorelines on lakes and ponds, estuaries and the

Shoreline - Ragged Island WMA

marine nearshore but excludes Beaches and Dunes, Non-Tidal Wetlands, Tidal Wetlands and Flats. These Shorelines tend to be rocky throughout most of the Northeast United States but also include intertidal bedrock or rocky shores of estuaries or the Atlantic Ocean, maritime bluffs and headlands, peat outcrops in tidal zones or lakeshores without beaches. These habitats are often utilized by wading birds and small sandpipers and can often suffer from wind-driven and wake created erosion.

Beaches & Dunes

Ruth Boettcher, Virginia Department of Wildlife Resources

Virginia has 8,916 miles of tidal shorelines that abut sandy beaches and marshes, of which 7,858 miles are natural or unmodified and 1,058 miles are artificially defended by bulkheads, revetments, breakwaters or living shorelines (VACoastalResourcesTool). Beaches are comprised of unconsolidated sandy material that is exposed to the forces of erosion, sediment transport and deposition that extends from the low water line landward to a physiographic feature such as a dune, bluff, or marsh, or to the effective limit of storm waves, or the nearest impermeable human structure, such as a bulkhead, revetment, or paved road (CCRM, VIMS 2009).

Beaches and Dunes - First Landing SP Photo Credit: Virginia Tourism Corp.

Virginia's coastal beaches are found primarily along ocean shorelines (hereafter referred to as offshore beaches) and within the Chesapeake Bay estuary (hereafter referred to as inshore beaches). They perform a host of ecological services that benefit wildlife, adjacent ecosystems and human interests. Virginia's southeastern offshore beaches adjoin the mainland and extend from the North Carolina/Virgina border to the Joint Expeditionary Base-Fort Story. The beaches under the ownership and management of the City of Virginia Beach support extensive commercial and residential development whereas the beaches on Back Bay National Wildlife Refuge and False Cape State Park are under conservation ownership. A small portion (< 5 miles) of the southeastern offshore beaches is under state and US military ownership. The Commonwealth's remaining offshore beaches are on 14 transgressive barrier islands located on the seaward fringe of the lower Delmarva Peninsula. These islands are largely owned and managed by The Nature Conservancy – Volgenau Virginia Coast Reserve, the USFWS, the Commonwealth of Virginia, and the National Atmospheric and Space Administration (NASA). Only NASA-owned Wallops Island has significant infrastructure on the beach; the remaining islands are undeveloped and maintained as naturally functioning ecosystems. Virginia's inshore beaches are found throughout the Chesapeake Bay Estuary and are under the ownership of the USFWS, the Commonwealth of Virginia, non-governmental conservation organizations, municipalities, the US

military, private citizens and commercial businesses. Within the Chesapeake Bay, concentrated beaches occur around isolated Bay islands, along barriers within the lower Western Shore, around the mouths of large tributaries where the long-shore transport of sand is disrupted, and along the outer edges of extensive marshes. Although not as extensive as along the outer Atlantic Coast, dune systems do occur within the Chesapeake where historic or current wave and wind energies are high (Watts 2013).

Virgina is the northern extent of the US Atlantic Coast loggerhead sea turtle nesting range, and the southeastern offshore beaches continue to support the majority the species' nesting activity in the Commonwealth. A few Kemp's ridley and green turtle nests have also been documented on these beaches (see the Virginia Sea Turtle Conservation Plan) {ADD LINK}. The southeastern offshore beaches also provide nesting habitat for a small portion of the state's northern diamondback terrapin breeding population. While these beaches do not support any breeding shorebirds or seabirds, the intertidal and supratidal habitats do provide foraging and roosting habitats for several SGCN during the non-breeding season, including common terns, least terns, laughing gulls, herring gulls, red knots, dunlin, piping plovers, sanderlings, black-bellied plovers and willets.

Virginia's barrier island offshore beaches provide important breeding habitat for many shorebirds and seabirds, several of which are SGCN. They include piping plovers, Wilson's plovers, American oystercatchers, gull-billed terns, common terns, least terns and black skimmers. These beach-nesting species rely on natural coastal processes to form and maintain expansive sand/shell flats on which to successfully breed. One hundred percent of the state's piping plover and Wilson's plover breeding populations occur on these dynamic barrier beaches. They typically select nesting areas with unimpeded access to backside mudflats where young broods can forage on a variety of invertebrates. Low sparsely vegetated dunes provide additional breeding habitat for American oystercatchers, common terns, gull-billed terns and an occasional piping plover. Low densely vegetated dunes provide breeding habitat for two additional SGCN; herring gulls and laughing gulls. While laughing gulls are generally considered a marsh-nesting species, subsidence and frequent flooding of saltmarshes have forced them to seek higher-elevation nesting areas on the barrier beaches. Lastly, all barrier island beaches provide important nesting habitat for diamondback terrapins and a few islands have documented an occasional loggerhead sea turtle nest. Assateague is the only island where loggerheads nest almost every year.

Barrier island supratidal habitats (areas above mean high-water) are important non-breeding roosting sites for the following SGCN: black skimmers, common terns, red knots, dunlin, piping plovers, American oystercatchers, sanderlings, black-bellied plovers, willets (western race) and marbled godwits. Finally, barrier island shorelines and intertidal zones provide critical foraging habitat for breeding, migrating and wintering SGCN, including the red knot, dunlin, piping plover, American oystercatcher, sanderling, black-bellied plover, willet (western race) and marbled godwit.

Virgina's inshore beaches also support a variety of SGCN throughout the year but not to the same extent as the barrier island offshore beaches. Beach-nesting American oystercatchers, common terns, least terns, black skimmers, and herring gulls are known to breed on inshore beaches along with diamondback terrapins and, on very rare occasions, loggerhead sea turtles. Inshore intertidal shorelines, supratidal beach habitats and artificial structures (*e.g.,* groins and seawalls) are important foraging and

roosting sites for several SGCN during the non-breeding season, including purple sandpipers, sanderlings, red knots, dunlin, willets (western race), black-bellied plovers, Forster's terns, herring gulls and laughing gulls.

Riverine Overview

Louise Finger; John Odenkirk; Tim Owen; Margi Whitmore; Jason Hallacher; Brad Fink; and Kristen Chestnut-Faull, Virginia Department of Wildlife Resources

The Commonwealth of Virginia includes a range of physiographic regions from the Appalachian Plateau in the far southwest, through the Valley and Ridge, over the Blue Ridge Mountains, across the Piedmont, and into the Coastal Plain that meets the Chesapeake Bay and the Atlantic Ocean. These physiographic regions contain freshwater systems that range from narrow, steep, mountain streams to more sinuous, moderate-size channels with flatter valleys to larger rivers with expansive floodplains. The habitat conditions that occur in these various stream types are driven by the elevation, topography, geology, surrounding land use, vegetative cover, and point and non-point inputs to the water body from a variety of sources. For example, habitat characteristics associated with geomorphology, chemistry, and physical conditions that may be present in a headwater stream in the Allegheny Plateau of westernmost Virginia will likely differ significantly from the characteristics of a headwater stream in the Piedmont region. Though these streams may fall into the same stream-order category as delineated in this planning document and have multiple overlapping habitat characteristics, recognizing their inherent differences is crucial to understanding the ecological systems and species that they support, and the actions that are necessary to conserve, protect, or restore them.

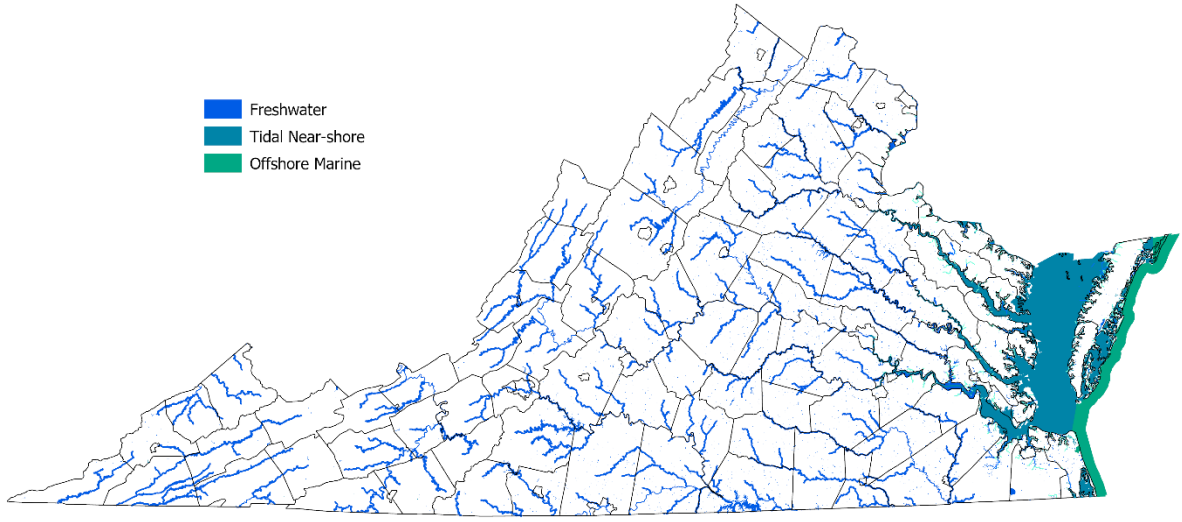


Figure 3.7. Fresh and Saltwater in Virginia

While recognizing this extensive variability across the Commonwealth, this portion of the Wildlife Action Plan describes in very general terms the habitat conditions likely to be present within the waterbodies as broken out by stream order and tidal versus non-tidal influence. Although this categorization can be useful for planning purposes on a general scale, it is important, if not critical, to recognize that an overly

generalized description of aquatic resources has drawbacks and limitations. The following categorical descriptions of freshwater habitat should be viewed in this context as such. When making decisions about protection, enhancement, or restoration of freshwater systems, the specifics of any given waterway need to be fully examined and considered. Habitat variability in nature is extensive, and it is valuable to recognize this when considering management objectives and associated actions.

Programs that offer assistance in implementation of conservation practices for freshwater systems overlap in many cases for the below habitat types, whereas others have very site-specific focus. The qualification requirements of such programs tend to be based on either past or current land-use (e.g., mining, agriculture, or urban development), the presence or absence of a particular species or aquatic community (e.g., eastern brook trout (*Salvelinus fontinalis*), candy darter (*Etheostoma osburni*), or James spinymussel (*Parvaspina collina*), or the receiving stream or waterbody (e.g., the Chesapeake Bay or an impaired stream with a Total Maximum Daily Load plan. Non-governmental agencies and local, state, and federal government agencies provide a range of funding opportunities and technical-assistance programs to facilitate conservation actions across Virginia. For example, the Chesapeake Bay Foundation supports BMP implementation in the Bay watershed; local governments assist with implementation of urban-stormwater BMPs; Virginia DOF supports a riparian-buffer easement program; Virginia DEQ coordinates the Coastal Zone Management Program; NRCS has a multitude of programs that address agricultural practices to protect water quality; Virginia DWR, the Chesapeake Bay Program, USFWS, and NOAA all have programs that support fish passage and other aquatic-connectivity efforts, including barrier removal, aquatic-organism passage construction, and road-crossing retrofits. Additionally, many of the rivers in Virginia have very active "Friends of . . ." groups that promote and facilitate conservation in their respective watersheds. Depending on the particular watershed, land use, species present, and a variety of other factors, there are likely to be opportunities available for technical assistance and/or funding to implement conservation practices on any given waterway. The best initial step to obtaining such information is to seek contact information online for these non-governmental, local, state, or federal government organizations, based on proximity to the site, species present, or on the nature of the issue or the land use.

Headwater Streams

Headwater Stream - Rapidan WMA

Headwater streams in Virginia are diverse in both physical and chemical attributes depending on the geographic region (mountain, valley, or Piedmont) from which they originate. These diverse habitat features lead to various communities of aquatic species that inhabit Virginia's headwaters.
Virginia's geographic mountain ranges (Blue Ridge, Ridge and Valley, and Appalachian Plateau) are home to headwater streams often inhabited by coldwater to coolwater species. These streams originate at higher elevations as freestone streams with highly erosion-resistant geologies (including granite, quartz, and greenstones) in the Blue Ridge and sedimentary sandstone for the Appalachian Plateau and ridges of the Ridge and Valley. Streams are confined laterally by steep, narrow valleys and dissipate energy longitudinally resulting in stair-step plunge pools intermixed with short rapids and runs. Large, course substrates of boulder, cobble, gravel, bedrock are dominant with some finer sediments in low-velocity areas. Gradient is typically steeper than most other lotic systems in Virginia ranging from 2% to 5% but can exceed 10% in some instances. Summertime water temperatures range from cold (<20°C) to moderate (>20°C to <24°C). The lack of carbonate rocks results in nutrient-poor, low-conductivity water (i.e. soft water), low buffering ability, and a pH that is slightly acidic. Because sunlight is limited due to the heavily forested canopy, the base of the food web in headwater streams is allochthonous input from plant material (i.e. leaves and woody debris). Many of the headwaters in the mountains of Virginia are located on federal and state lands where conservation practices are likely to be implemented; therefore, most have healthy canopy cover and riparian areas. However, some headwater stream reaches on private lands may be exposed to practices that could be detrimental to stream processes and aquatic organisms.

Headwater mountain streams contain species that are specifically adapted to this type of environment. Because headwaters are highly dynamic systems prone to catastrophic disturbances, species inhabiting them are excellent at recolonizing habitats compared to many lowland species. For instance, the fusiform shape and behavior of the eastern brook trout (*Salvelinus fontinalis*) allows it to negotiate upstream over small cascades and falls to reach unoccupied stream reaches. The winged adult stage of many aquatic insects can fly to new upstream reaches regardless of barriers. Because headwaters are low-productivity systems, species are especially adapted to survive on low-quality and low-quantity food items, which is accomplished by having slower metabolisms and smaller sizes than lowland species. Colder water conditions throughout the year contribute to this metabolic state.

Two main sources of pollution, point and nonpoint, occur in Virginia. Point-source pollution originates at a known, specific location, such as an outlet pipe entering a stream. In contrast, non-point source pollution can originate from disperse locations across the landscape, including stormwater from roads, sediment from logging or development, and nutrients from livestock farming. While headwater streams can be altered by both of these, non-point source pollution is more common and can usually be attributed to land use practices. Without the effective implementation of BMPs , logging and road development can significantly alter stream habitat and, in turn, impact aquatic organism populations. Although recent research has indicated a potential slight improvement, acid deposition from industrial sources of SO_2 and NOX emissions on mountain headwaters streams continues to be a concern. Mining occurs around headwater streams in southwest Virginia, which may cause elevated selenium levels in some fish species. High selenium levels can lead to spine, fin, and skeletal deformities during early life stages of fish.

Many valley headwater streams originate from groundwater sources such as springs and seeps. In contrast to montane streams, valley streams have high levels of carbonate from sedimentary limestone and dolomite geologies. Coldwater species can only occur for short distances in these streams before conditions transition to suit warmwater species. By not being confined to steep valley walls, these streams are able to meander laterally and can overflow into their adjoining floodplains. The result allows for a variety of habitats, including deep, wide pools; long riffles; and shallow runs. Gradient is usually lower (0.5% to 2%) and velocities slower than mountain headwater streams. Summertime water temperatures range from coldwater (10°C) at the spring mouth to warmer (25°C) downstream. The increased concentration of anions from carbonate rocks results in water chemistry consisting of high pH, high conductivity (i.e. hard water), and high buffering ability. These conditions lead to streams with high productivity and nutrient levels, which support abundant population of aquatic species. Compared to mountain streams, finer substrates of sand, gravel and cobble can be dominant in valley streams. Composition of these substrates are dependent upon the surrounding geologies and sources washed down from nearby streams. In areas with land-use disturbance, fines of silt and clay may cover courser substrate.

The geographic range known as the Piedmont is the largest physiographic province in Virginia and contains headwater streams and smaller tributaries that feed larger rivers. These streams are mainly moderate to low gradient, slow velocity with cobble, gravel, and sand-dominated substrate. Summertime temperatures in Piedmont streams usually range from 25°C to 35°C. Due to the geology, Piedmont headwater streams are typically neutral to slightly basic.

Valley and Piedmont streams face potential impacts from both point-source and nonpoint-source pollution including impervious-surface and agricultural runoff and industrial- or municipal-wastewater discharges. These sources of pollution drive changes in the chemistry, hydrology, sediment, and biota in the receiving stream. Additional habitat impacts include land-use practices such as removal of riparian vegetation and canopy cover that can result in increased channel-bed sedimentation, increased turbidity, and warmer stream temperatures. All headwater streams are vulnerable to non-native floral and faunal invasive species, riparian habitat degradation, and loss of connectivity due to dams and road crossings.

Potential conservation actions to benefit headwater streams include protection of springs; establishment and enhancement of riparian buffers; implementation of BMPs for logging, agriculture, and other land-disturbance activities; mitigation of acid-mine drainage or acidification from atmospheric deposition through liming; and replacement of road-crossing barriers with structures that provide full aquatic organism passage.

Creeks & Rivers

The Valley and Piedmont creeks and smaller rivers serve as an important transitional zone connecting the forested headwaters of the Commonwealth to the larger rivers flowing towards the coast. These often-overlooked resources are far from inconsequential as they are the capillaries that carry the

lifeblood for the larger rivers, coastal areas, and the Chesapeake Bay. These waterways are used for recreational and commercial angling, paddle sports and boating, and water withdrawal, and are home to a myriad of flora and fauna.

Virginia's warmwater creeks and small rivers meander their way throughout much of the Commonwealth, flowing through urban, suburban, rural, and wilderness areas. These gently sloped, lotic systems mainly consist of slow-moving, deep pool sections coupled with faster-flowing, shallow riffles and runs. Adjacent terrestrial habitats range from heavily forested, to tree-lined, to none. Substrate can include sand, silt, clay, gravel, cobble, boulder, and bedrock, and the amount of siltation over the substrate can be heavily influenced by surrounding land use. Creeks typically exhibit average levels of dissolved oxygen that rise and fall with habitat changes such as turbulence in shallow riffles or at varying water depths within pools. Turbidity can range from very clear to very turbid depending on land use and substrate type. Temperatures range from 20-30° C in the summer months. Submerged aquatic vegetation growth also increases within these resources in comparison to the headwater streams. Native species like water stargrass (*Heteranthera dubia),* wild celery (*Vallisneria americana*), and American water-willow (*Justicia americana*), among others, are common across the Commonwealth.

As water temperature increases, so too does the diversity of aquatic fauna. Unlike the headwater streams, which typically harbor only a small number of fish species, the creeks and smaller rivers harbor a variety of minnow, sucker, sunfish, and catfish species. Unfortunately, anthropogenic threats to these waterways increase within these reaches as well. Stream-channel and riparian-zone manipulations such as straightening, tile draining, and or livestock grazing/access often cause unnatural flow regimes, thermal stress, sedimentation, increased nutrient loading, and poor water quality. These changes can affect the habitat and the biota in a range of ways including shifts in aquatic-vegetation type and abundance, increased intensity of algal blooms, reduced spawning habitat due to embedded gravels, altered macroinvertebrate-community composition, and increased levels of disease and/or mortality in fish communities.

Warmwater streams are heavily impacted by both point- and nonpoint-pollution sources. Point-source pollution include industrial- and municipal-wastewater discharge. Nonpoint-source pollution examples include runoff from urban development, certain agriculture, and mining practices. Common impacts on Virginia's warmwater streams from these pollutant sources and land use activities include sedimentation, changes in aquatic vegetation, algal blooms, increased nutrient loads and contaminant levels, as well as increased levels of disease in fish communities.

Within the more rural areas of the state, efforts to improve the health of Virginia's low-order streams should include constructing fences to exclude livestock from accessing streams and installing offsite water sources; riparian area restoration through maintaining buffer zones and planting native grasses, forbs, shrubs, and trees; utilizing streambank- and channel-restoration practices to return impacted streams to a more natural state; managing and treating stormwater runoff appropriately; minimizing fertilizer and pesticide use and application, utilizing erosion control barriers; removing aquatic organism barriers such as dams and culverts; and limiting and properly mitigating point-source discharges.

Conserving established riparian areas from degradation is paramount for the future health of Virginia's small rivers and streams.

Similar efforts should be implemented for more developed, urban areas of the state; however, these areas have the additional stressor that results from an increase in impervious surfaces which adds to the intensity of runoff events. These events result in increases in sediment, chemicals from roadways and parking lots, pesticides and nutrients from lawns and gardens, heavy metals, and thermal pollution impacting the waterway. Localities should focus on curbing the use of pesticides and fertilizers used on yards, golf courses, and parks. Efforts should be made to increase water infiltration by reducing the amount of impervious surface within the watershed. Additional remediation efforts to be considered include converting to permeable-pavement options, creating stormwater-retention areas, utilizing green roofs and rain gardens, and reducing the use of road salt. Developers should focus on controlling construction site runoff from entering waterways through the use of silt barriers and retention ponds, and existing developments should seek out innovative ways to protect, improve and/or restore their local terrestrial and aquatic habitats.

Big Rivers

Virginia boasts numerous large, non-tidal riverine ecosystems supporting diverse mosaics of lotic habitats throughout several physiographic provinces, each resulting from a unique blend of watershed attributes, flow regimes, and physical habitat features influencing species assemblages. Chesapeake Bay drainage rivers (Shenandoah, Rappahannock, James, and Appomattox) share many attributes and function largely on a regional scale with respect to climactic conditions, flow, and fisheries recruitment

James River - James River WMA

mechanisms. Historically, many of these rivers were used extensively for navigation above the fall line, and various canal and lock systems were constructed to facilitate that use. Currently, recreational use is

high for motorized and non-motorized watercraft alike, and some rivers have excellent options for river trips or "floats" with a plethora of access sites; while others, such as the Rappahannock, have limited ingress. Recent, significant hydrograph changes, including increased prevalence of record-breaking high- and low-flow events, have resulted in highly variable recruitment of recreationally and commercially important fish species. Declines in certain Centrarchid populations (e.g., Rock Bass, Smallmouth Bass) may be linked to gradual warming temperature trends as well as this flow variability.

Efforts aimed at mitigating previous anthropogenic actions have resulted in the removal of a number of some the most dramatic habitat-altering features – impoundments – as efforts are made to restore riverine connectivity (e.g., Boshers Fishway, James River 1999; Embrey Dam removal, Rappahannock River 2004). However, flows of many reaches are still controlled by numerous power plant operations and their associated in-river structures. Much of the impetus for dam removals has centered on restoration of spawning habitat for anadromous fish, but most populations have failed to respond thus far. The benefits of dam removal extend beyond the passage of anadromous fish, though, and include the restoration of riverine hydrology, sediment transport, and hydraulics, all of which directly impact the aquatic habitat upon which resident fish and freshwater mussels rely.

Typical substrates west of the Piedmont include bedrock, large boulder, and cobble amidst Class II and III rapids, while many reaches within the Piedmont transition to wider, shallower, and sandy-bottomed channels. Aquatic vegetation, both native and non-native, is common and provides habitat for aquatic species as well as semi-aquatic and terrestrial organisms using rivers for various life-stage functions (e.g., waterfowl feeding). Nuisance aquatic vegetation blooms, including harmful algal blooms (HABs), many of which are fueled by cyanobacteria, have become more prevalent in recent years. These blooms can impact human and animal health and often lead to public health warnings to limit contact with water. Precursor nutrient enrichment fueling HABs and other deleterious aquatic effects have resulted in establishment of Total Maximum Daily Load (TMDL) designations by Virginia Department of Environmental Quality (DEQ) in an attempt to reduce negative impacts. Fish consumption advisories for mercury and polychlorinated biphenyls (PCBs) are common. Emerging contaminants, such as perflourooctane sulfonic acid (PFOS) and perflourinated alkylated substances (PFAS) that are commonly used in non-stick and stain-resistant consumer products, food packaging, fire-fighting foam, and industrial processes, are causes for concern in large rivers, as bioaccumulation, toxicity, and environmental effects of these and other, similar substances are poorly understood.

Western mainstem rivers in the Appalachian Plateau and Valley and Ridge Provinces draining the Tennessee River tributaries of the Clinch, Powell and Holston rivers support many rare and listed endemic species. Current impacts and historical legacies of coal mining and natural gas extraction operations in these watersheds have often left the fauna in peril. In the North Fork Holston River, industrial pollution from the first half of the 20th century decimated the aquatic species and resulted in mercury contamination and fish consumption advisories. In some reaches of the Virginia's Tennessee drainage, water quality conditions have sufficiently improved to conduct restoration efforts, including species augmentation and reintroduction.

Most mainstem rivers in Virginia flow predominantly through farmland but also receive stormwater runoff and municipal and industrial effluents from towns and cities along the river valleys. Non-tertiary treated discharges pose a threat to the aquatic system primarily due to their nutrient content, but "emerging contaminants" such as endocrine disruptors, other pharmaceuticals, and PFOS/PFAS are also a significant concern and warrant further research. Threats from streamflow alteration due to water withdrawals or dam releases can also significantly impact water resources.

Though direct conservation actions (e.g., stream restoration, bank stabilization) on mainstem rivers can be difficult given the magnitude of the system, conservation actions taken throughout a river's entire watershed will likely benefit the mainstem. These actions include implementation of agricultural and urban BMPs intended to minimize nutrient loading and moderate hydrograph response to storm events. Similarly, riparian buffer establishment, protection, and enhancement throughout the watershed will filter nutrients and reduce sedimentation. Removal of dams should be pursued whenever feasible to address impacts that these structures present to aquatic-organism passage, hydrology, water temperature, and habitat. The Virginia Department of Environmental Quality (with support of DWR staff) aims to prevent alteration of the instantaneous flow in all rivers, regardless of size, by more than ten percent. These on-going efforts are critical to ensure that streamflow alterations result in minimal impacts to aquatic life.

Tidal Headwater Streams

Interposed on the west by Virginia's Piedmont and to the east by the Atlantic Ocean and the Chesapeake Bay, streams within the Coastal Plain of Virginia often have transitional areas known as the fall zone. It is within this fall zone that gravity-fed systems lose elevation and become undulating bodies of water that

Dragon Run Photo Credit: Connie Lapallo

ebb and flow in conjunction with the tide cycles of the Atlantic Ocean. This natural feature commonly results in tidal headwater streams that contain distinctive sections, which can be generally classified as slow backwater swamps; low-gradient streams; and tidal estuarine waters. While these habitats are

complex individually, and occasionally exist in homogeneity as a singular system, most tidal headwater streams are comprised of a longitudinally dynamic network of each of these habitats, resulting in aquatic ecosystems that are the most ecologically diverse in Virginia.

Swamps and wetland sections of Virginia's tidal headwater streams occur in areas with minimal slope and are often found in locations that have been dammed by beaver or impounded by anthropogenic activities. These locations are predominantly stagnant, can be characterized by varying levels of tree cover, and contain several species of submerged aquatic plants. Many of these habitats are found in locations with silicious geology, resulting in substrates comprised of silt, mud, and detritus with tannic waters that are often uniformly shallow in depth, high in acidity, low in conductivity, and very low in dissolved oxygen. While lethal to most species of fish, maintaining such parameters within tidal headwater streams is essential to protecting the endemic fishes that have adapted the feeding strategies, habitat needs, and reproductive processes to thrive in this environment.

Within the low-gradient, flowing sections of Virginia's tidal headwater streams, areas with higher discharge velocities have substrates comprised of cobble and gravel. As these systems meander and lose energy, finer suspended particles fall from the water column, and features such as runs and pools become dominated by sandy substrates. As the stream moves through these areas, it tumbles over rock formations, root structures, downed logs, and other important features that elevate dissolved oxygen levels. While stream temperatures and acidity are often comparable to swampy sections, the elevated oxygen levels and interstitial spaces in the substrates allows for an entirely different community of benthic macroinvertebrates to thrive. In response, the fish assemblage endemic to such environments possesses trophic, habitat, and reproductive niches that are dependent on the viability of these physical and chemical parameters.

Estuarine areas of Virginia's tidal headwater streams are under the constant natural pattern of receding and advancing tidal waters. Water chemistry at these locations varies immensely based on the strength of the tide, the size of the watershed, and recent precipitation trends occurring upstream. Substrates in estuarine areas are most often sand, silt, or mud. Because the habitats in this environment can alternate from optimal to lethal for a given species multiple times per day, aquatic life within this environment is often nomadic. Fish assemblages within estuarine areas may have needs associated with saltwater, brackish, or freshwater requirements, and each may be present at different times of the year.

Virginia's tidal headwater streams provide an environment for an impressive diversity of ecological roles, allowing thousands of species of aquatic animals and plants to survive. Although important distinctions between microhabitats in this environment exist, many factors are collectively influenced by anthropogenic activities – both beneficial and detrimental. Major threats to tidal headwater streams include deforestation and anthropogenic development. Even if not occurring in close proximity to the stream, it is possible for such activities to alter the natural hydrologic function of an area, exacerbate sedimentation, increase thermal pollution, and increase point-source pollutants. An increasingly common threat to tidal headwater streams is the volume of water utilized in agricultural and municipal water intake systems, which alters flow patterns and has been documented as entrapping and entraining significant numbers of at-risk fish species. Not unique to tidal headwater streams, ubiquitous impacts

from changing environmental conditions, invasive species, and land subsidence also exist. Promoted activities that may increase the resilience of habitats within tidal headwater streams include conserving contiguous tracts of undeveloped area, expanding riparian buffers, reducing existing development within floodplains, and preserving the natural heterogeneity of these dynamic habitats. Mitigation activities are largely unsuccessful in recreating the natural processes of this environment once they are disturbed, and therefore the conservation of what currently exists should be paramount to other alternatives.

Tidal Creeks & Rivers

Meandering throughout the low-elevation Coastal Plain of Virginia is a network of tidal creeks and rivers that serve as an intermediate link between smaller headwater environments and the expansive tidal ecosystems at their confluence. These dynamic estuarine systems act as a conduit for rhythmically fluctuating tidal flows which are characterized by an interplay of fresh and saltwater conditions. Aquatic habitats in tidal creeks and rivers can vary tremendously, as low-tide conditions often result in the active channel being at least partially dewatered, while incoming tides regularly produce water levels that spill out across expansive floodplains, creating diverse aquatic habitats throughout the inundated mosaic of grasslands, marshes, and forests that surround them. In these ever-changing conditions, aquatic biodiversity thrives, and the complexity of tidal creeks and rivers provide unique habitats for an array of plant and animal species which have adapted to persist along with the fluctuating water chemistry, substrates, and cover types of the environ.

The water chemistry of tidal creeks in Virginia is influenced by natural processes and anthropogenic sources. As with big tidal rivers, precipitation and tidal cycles are important drivers of water chemistry in tidal creeks and small rivers. Salinity levels fluctuate daily with tide cycle and over longer periods, with precipitation and freshwater inputs from upstream. Salinity also varies spatially, with creeks lower in the watershed undergoing higher magnitude fluctuations than those located further upstream.

Land use and habitat distribution within tidal creek sub-watersheds influence water chemistry on finer scales. Urban and agricultural runoff alter nutrient loads and may have bottom-up influences on creek productivity. Groundwater seepage and inputs from tidal headwaters naturally influence nutrient loads and may alter pH, depending on regional differences in geology. Freshwater inputs from precipitation and runoff increase turbidity, by increasing suspended solids and sediment loads. These inputs are driven in turn by precipitation within the watershed and vary inter- and intra-annually. Spatial and temporal variability in water chemistry plays a significant role in shaping aquatic communities and the overall ecological functioning of tidal creeks.

Tidal creeks in Virginia face similar threats as tidal headwaters and large rivers, including development, pollution, and fish passage barriers. Urbanization is primarily a threat to larger creeks and those proximate to population centers. Runoff from non-porous surfaces and discharge from municipal wastewater treatment plants causes nutrient loading, sedimentation, and temperature increases, all of which can decrease habitat quality or suitability for aquatic species. Similarly, agricultural development increases inputs of fertilizers and pesticides, which directly impact nutrient cycles and productivity. Placement of riprap, seawalls, and bulkheads to protect industry and private property lead to loss of

habitat, habitat fragmentation, and ultimately a decrease in resilience to disturbance. Water diversions for irrigation and industry alter natural hydrology, floodplain dynamics, and temperature regimes.

Barriers to fish passage, such as dams and culverts, are common in tidal creeks. These barriers restrict migration, limiting spawning habitat availability and thereby hindering recovery efforts for anadromous species, such as shad and herring. Collaborative efforts of federal and state partners have been successful in removing dams and replacing culverts, increasing habitat connectivity and opening miles of potential spawning habitat.

Saltwater intrusion from rising sea levels, increased water temperatures, and altered precipitation patterns caused by changing environmental conditions pose a significant, long-term threat to Virginia's tidal creeks. Salinity levels may increase in some creeks to the extent that they become unsuitable for freshwater or estuarine species, regardless of tidal cycle. Water temperature is an important reproductive cue for many species, including SGCN such as Atlantic sturgeon and American shad. Changing water temperatures have already altered migration timing for both of these species; further increases are likely to continue impacting migratory cues and river residence, to unknown effect. Similarly, changes in the frequency and magnitude of rain events will impact erosion, water quality, and water chemistry, impacting habitat suitability for aquatic species.

Threats to tidal systems will be compounded by the recent change in the definition of "waters of the United States" in the Clean Water Act. Wetlands had previously been subject to federal regulation under the Clean Water Act based on connectivity to navigable waters. The U.S. Supreme Court revised this definition in 2023, removing waterbodies lacking perennial flows. Tidal systems are dynamic by nature and include countless ephemeral and intermittent creeks and wetlands. Changes in precipitation patterns predicted by climate models may further impact flows and connectivity. Unregulated development of these areas will compound existing threats, alter hydrology, and greatly reduce resilience.

Recommended conservation actions for tidal creeks and rivers are similar to those of tidal headwater streams, though these habitats are typically less developed than tidal river mainstems. Conserving undeveloped tracts of land, expanding riparian buffers, and preserving wetlands are among the highest priorities to improve water quality and maintain resilience. New or replacement infrastructure should incorporate design elements that minimize in-stream footprints and bare hardscape. Riparian buffers and livestock exclusion on agricultural lands would limit nutrient and pesticide inputs, reduce the erosion that necessitates bank stabilization, and create higher quality shoreline habitat for aquatic fauna. Similarly, increasing riparian buffers on non-agricultural lands would reduce erosion and sedimentation and increase habitat quality. Efforts to remove dams and replace road-crossing barriers should be a priority. Water-intake and diversion permits should take long-term flow and climate trends into consideration.

Chickahominy River - Chickahominy WMA

Big Tidal Rivers

Virginia's tidal rivers are delineated by the Fall Line, the boundary between the Piedmont and Coastal Plain physiographic regions along much of the East Coast. The transition is characterized by a sharp increase in gradient, caused by differential erosion between the bedrock-dominated Piedmont and the softer sediments of the Coastal Plain. In Virginia, the Fall Line is marked by series of rapids in the James River at Richmond and in the Rappahannock River at Fredericksburg, where elevation drops 100 feet or more over several miles to reach sea level. The York River watershed is relatively small and the mainstem extends only 50 km inland before branching into the Pamunkey and Mattaponi Rivers. Small tributaries to the Mattaponi and Pamunkey Rivers cross the Fall Line further inland and generally lack the rapids and steep gradients characteristic of other systems.

Tidal rivers are dynamic systems characterized by wide channels, perennial flows, and a semidiurnal tidal cycle. Below the Fall Line, tidal rivers cut deeper channels through soft sediments along a low gradient before widening out. Habitat distribution along the tidal river gradient is defined by the interaction between freshwater inputs from precipitation and upstream sources and saltwater intrusion from the Chesapeake Bay. A salt front forms where freshwater and saltwater meet, and less dense freshwater flows on top of a layer of saltwater. Mixing occurs along the salt front and creates a gradient of salinity zones, transitioning from mesohaline to oligohaline and ultimately to tidal fresh water. The location of salinity zones differs among rivers, depending on position within the Bay watershed, bathymetry, and channel features. Within each river, salinity zones shift with tidal cycle, precipitation, flow rate, and wind.

The substrate consists of a complex mix of sediments, rocks, and organic matter. In the lower reaches where tidal influence is stronger, fine sediments such as silt and clay dominate in the river channel while sand is found along the shoreline. Coarser materials like sand and gravel are more prevalent in the tidal fresh reaches below the Fall Line. Natural and artificial structures provide essential cover for aquatic organisms. Downed trees and root wads from riparian forests and large, woody debris flushed downstream during high flow events create complex habitats along river margins. Underwater structures such as piers, sunken barges, docks, and channel markers provide structure in a range of depths and distance from shore. Both natural and artificial structure offers flow refugia, cover, and breeding areas for diverse aquatic communities.

Tidewater habitats are predominantly a mix of emergent and forested wetlands, where they have not been developed. In tidal fresh and oligohaline reaches, wetlands are common along inside river bends in shallow coves and sloughs. Arrow arum (*Peltandra virginica*), spatterdock (*Nuphar advena*), wild rice (*Zizania aquatica*), and pickerel weed (*Pontederia cordata*) dominate these areas and provide high quality nursery habitat to aquatic species. In mesohaline zones, wetlands are dominated by a few species of salt-tolerant grasses, including saltmarsh cordgrass (*Sporobolus alterniflorus*), black needle rush (*Juncus gerardii*), and saltmarsh bulrush (*Bolboschoenus maritimus*). Wide mudflats border the channel in downstream reaches providing foraging for benthivores and detritivores during high tides and birds during low tides.

Tidal river habitats in Virginia face a myriad of threats, including conversion or outright loss, invasive species, pollution, changing environmental conditions, and sea-level rise. The mainstem reaches of the James, York, and Rappahannock rivers are heavily impacted by industry and commerce, altering the historic floodplain and flow regimes. Regular dredging operations, river bend cutoffs, and water diversions to support mining operations and ports have permanently altered the floodplain. Bank stabilization protecting homes, factories, energy infrastructure, and parks further restrict natural hydrological processes. Industrial discharge, water intakes, agricultural runoff, urban stormwater runoff, and sewage effluents contribute to nutrient enrichment, sedimentation, and contaminant accumulation, compromising water quality and habitat suitability. Shoreline development, urbanization, and agricultural lands have reduced floodplain connectivity and encroached on wetland habitats, limiting resilience to storms and flood events. Invasive species, such as northern snakehead, blue catfish, and flathead catfish, along with introduced sportfish, such as largemouth bass, have disrupted tidal systems by outcompeting and predating on native species.

Recommended conservation actions for large tidal rivers include land conservation, infrastructure upgrades, and riparian buffers. Land adjacent to the mainstem James, York, and Rappahannock rivers is heavily developed by industry and agriculture but undeveloped tracts have been conserved by tribal, federal, state, and local government entities. Supporting tribal landback efforts, direct land purchases, and conservation easements are supported mechanisms for limiting encroaching development. Wetland conservation and restoration are especially high priorities, given their role in increasing resilience. In urbanized areas, upgrades to sewer infrastructure to reduce effluent inputs is a high priority. Incorporating porous surfaces and living shorelines into hardscape features would offer habitat improvements where bank stabilization can not be avoided. Riparian buffers and livestock exclusion on

agricultural lands would limit nutrient and pesticide inputs, reduce the erosion that necessitates bank stabilization, and create higher quality shoreline habitat for aquatic fauna. Similarly, increasing riparian buffers on non-agricultural lands would reduce erosion and sedimentation and increase habitat quality. Water intake and diversion permits should take long-term flow and climate trends into consideration. Virginia is a hub for developing data centers, which require high energy inputs to maintain servers and water intakes for cooling purposes. Data centers are currently considered one of the top water-consuming industries, and development within tidal watersheds is slated to increase over the next several years. Invasive-species control efforts, including commercial fishery development and angler outreach, should continue with the goal of reducing impacts to native species.

Lakes

Clint Morgeson and Jeff Williams, Virginia Department of Wildlife Resources

Virginia has only two natural lakes, Lake Drummond in the cities of Suffolk and Chesapeake and Mountain Lake in Giles County, with the rest of the impoundments within the Commonwealth originating from anthropogenic activities. The two lakes share very few geophysical similarities and are located on opposing ends of the Commonwealth.

Located within the 113,000-acre Great Dismal Swamp National Wildlife Refuge, Lake Drummond is a large open body of water (3,142 acres) and is relatively shallow, at maximum six feet in depth. Roughly circular in shape, Lake Drummond is fed by surrounding marshes and swamps and is acidic; the leaching processes from organic matter give its waters a characteristic stained (blackwater) appearance. Historically, the forested wetland covered more than a million acres in southeastern Virginia and northeastern North Carolina. The area was drained and cleared after European colonization for agricultural land and timber production. Attempts to drain Lake Drummond and turn it into agricultural land by the George Washington-backed Dismal Swamp Company were abandoned in the early 1800s, but timbering operations continued into the 1950s. Drainage canals connect Lake Drummond to the Elizabeth River to the north and the Pasquotank River to the south. The Great Dismal Swamp National Wildlife Refuge was established in 1974 from purchased lands and a nearly 50,000-acre land donation from The Nature Conservancy.

Currently, the water level is controlled by the U.S. Army Corps of Engineers via a lock and system of water control structures in the draining canals/ditches. The lake and surrounding swamp are intensively and cooperatively managed by the U.S. Fish and Wildlife Service along with the Army Corps of Engineers. Much of the substrate is characterized by thick peat deposits, which are vulnerable to fire if not kept saturated. Since Lake Drummond supplies the water levels for the Dismal Swamp Canal, excessive dewatering of the lake must be prevented to maintain stable ecological conditions. No streams directly supply the lake as it is sustained by precipitation inputs from the surrounding swamp.

The ecology of Lake Drummond and the surrounding Great Dismal Swamp has been significantly altered due to the construction of drainage canals, the Great Dismal Swamp Canal connecting the Chesapeake Bay to the Albemarle Sound, and extensive deforestation of historic Bald Cypress and Atlantic White Cedar stands. Further, unmanaged fires have depleted the peat bank and hastened the conversion of

surrounding forests to gum/maple-dominated canopies. This succession alters surface water patterns and creates more dry-land habitats within the ecosystem.

Lake Drummond, Great Dismal Swamp NWR

Future threats to Lake Drummond include increasing stochastic climatic events that impact water levels, invasive species infiltration, and watershed development. The lake is largely protected from watershed development, being surrounded by the Great Dismal Swamp National Wildlife Refuge, which also largely comprises the lake's limited watershed. However, water levels must be controlled to maintain lake levels and watershed sediment saturation to preserve the unique geophysical characteristics of the area.

Within the watershed, advanced rates of succession have been established due to the extensive logging of the Great Dismal Swamp. Future conservation actions to correct or mitigate these impacts might include water level manipulation, mechanical removal of late-stage species, and restoration of the historic timber stands, particularly with Atlantic White Cedar and Bald Cypress.

Located near the Town of Pembroke, Mountain Lake is the other of only two natural lakes found in Virginia and is the only natural lake located in the unglaciated southern Appalachian Highlands. The lake rests near the summit of Salt Pond Mountain at an elevation of almost 1,800 meters. Estimated to be around 6,000 years old, Mountain Lake has a history of severe lake level fluctuations, and the origin of the lake has been the subject of much investigation. The earliest hypothesis of the lake's origin came in the 1930s and pointed to damming of the valley by a lateral landslide. This hypothesis was later modified in the mid-1970s to suggest that a vertical collapse of a canyon feature in one of the underlying geologic formations was more likely the cause. The presence of a crevice, likely a fault, located in the deepest part of the lake has also been pointed to as a potential area of seepage and water loss. Most recently, during a period when the lake was almost completely drained, four sinkhole-like

Mountain Lake, Giles County, VA

depressions were observed. These areas had piping holes at their bottoms and sides and subsequent investigations suggested that the piping of lake sediment was the primary mechanism responsible for lake level fluctuations.

Mountain Lake was full for much of the twentieth century but had completely dried up by the fall of 2008. From 2008 to 2020, the lake was only partially filled with water. Since 2020, the lake has refilled to about one-third of its normal volume. The last such period of drastic fluctuations is believed to have occurred between 1751 and 1804, based on historical accounts of widely varying lake size. Researchers now believe that the there is a natural cycle to the lake levels in Mountain Lake with extreme lows occurring about every 400 years.

When full, the small, narrow lake covers only about 50 acres and has a maximum depth of approximately 33 meters at the north end of the lake. This deepest point consists mainly of the aforementioned crevice. The remainder of the northern end of lake measures about 24 meters in depth. The Mountain Lake watershed is relatively small, measuring just 321 acres. The lake is fed by cold, underground springs causing the water temperature to typically stay below 21°C at the surface and 8° C at a depth of 15 meters.

The forest surrounding Mountain Lake consists primarily of a mix of upland hardwoods, such as oak and maple, and shows little evidence of harvest in the past seven decades. The only development that has occurred within the Mountain Lake watershed is the privately-owned Mountain Lake Lodge. The hotel was initially built in 1856 to provide lodging for visitors to the lake. The original wooden structure was replaced in 1938 by the current stone structure, which utilized stone native to the area. Since 1989, the Mountain Lake Conservancy has worked to manage and protect the 2,600 acres of property around the lake.

Ponds

Susan Watson, Virginia Department of Wildlife Resources

Virginia's ponds and seasonally flooded depressional wetlands, the latter commonly referred to as *vernal pools*, are habitat to many obligate and facultative wetland SGCN . Ponds are dynamic habitats with fluctutations of water level depending upon weather conditions and changing climate. There may also be extreme fluctuations influenced by either natural events or human actions.

Vernal pools are isolated depressions on the landscape that fill with water during fall and winter months and dry or significantly decrease in water level during warmer months due to changes in the seasonal rates of precipitation, evaporation, and transpiration. They may be influenced by natural or human activities. In Virginia, vernal pools usually occur within or in the edge of a forested habitat, and they can range in size from just several inches across to a few acres. More detailed descriptions may be found Virginia Vernal Pools and in the Field Guide to the Animals of Vernal Pools.

The importance of vernal pools to many species that use them to breed, such as Ambystoma salamanders, is that the fluctuations in water annually and the usual lack of connection to flowing water systems prevent predatory fish from inhabiting these ephemeral habitats. Ambystoma salamanders (e.g., mole salamanders) are not adapted to coexist with predatory fish that would feed upon their eggs and larvae. Another important characteristic needed for Ambystoma salamanders is a surrounding upland forest habitat that adults use the rest of the year. Most of Virginia's vernal pools can be defined as isolated wetlands above minimal ecological value, according to the Virginia Department of Environmental Quality's regulation of definitions. Most of Virginia's pools are forested, which is one of the conditions in the definition, and some pools also meet some of the other conditions listed.

Vernal pools exist throughout the Commonwealth, with variations in landscape and associated species. Since most vernal pools are quite small (many less than 0.1 acres), they often do not show on wetland inventory maps, and information on historic presence is lacking. Virginia Commonwealth University studied a sample of vernal pools recorded in the greater Richmond area during the 1980s that showed approximately half of them were found to still exist during a rediscovery effort in 2010 to 2012. Among the other half of the pools recorded in the 1980s, about half of those were found to be lost to development or other land use, while the other half simply could not be determined by the past data provided.

Some variations of vernal pools that are used by SGCN species, such as Eastern tiger salamanders and Eastern chicken turtles, include sinkhole and interdunal pool/pond complexes. There are just a few examples of these known in Virginia, in parts of the Valley and Ridge, the Blue Ridge Mountains, and the Coastal Plain. These are usually relatively deeper and larger than most vernal pools.

All vernal pools may be threatened with destruction/degradation due to development, land use (such as logging), depending on the methods and management of the activity, and changing environmental conditions. Best management practices that include certain buffers to the pool site and select cut timbering of the surrounding forest may help conserve this habitat and its associated species. A good summary about vernal pools, threats, and conservation has been developed by the Appalachian Trail

Conservancy. Additionally, Partners in Amphibian and Reptile Conservation (PARC) has a working group to address vernal pool conservation.

Ponds created by damming flowing waterways, with dams constructed by beavers (*Castor canadensis*) or by humans, are another aquatic habitat type in Virginia. Fish species, such as black-banded sunfish, redfin pickerel, and swampfish, are adapted to very low flowing, dark-stained water found in eastern Virginia. These ponds may be forested or open but are often partially forested and partially open. The pond itself often provides a more open area in the long run, as those trees not adapted to surviving in standing water will die off. These wetland meadows that are comprised of emergent and submergent vegetation are beneficial to many SGCN species, including smooth greensnake, wood turtle, and spotted turtle. Beaver ponds occur throughout Virginia and support a variety of SGCN that either permanently or seasonally use these habitats. Human-created ponds, such as dams for mill ponds and farm ponds, can act as a surrogate for natural habitats. However, it is not uncommon for these waters to be stocked with predatory gamefish and only managed for angling, which can be incompatible for many SGCN .

Threats to beaver ponds and similar habitat types include removal of dams and of beavers inhabiting the area. There are also threats to the water quality and associated habitats due to development and incompatible land use practices. While many ponds are in rural areas, there are sites close to expanding roadways and related development. Unfortunately, roads and highways constructed adjacent to these habitats become death traps for wildlife transitioning or migrating between wetlands and upland areas. Introduction of grass carp is another threat to the emergent and submergent vegetation in these habitats, which are needed for the native fish species to thrive. Nonnative plants (i.e. hydrilla) can cause negative impacts by outcompeting native aquatic vegetation.

Maintaining beaver ponds is beneficial to many other species. Ponds decrease the amounts of nutrients and reduce sedimentation thereby helping to improve water quality for aquatic species inhabiting downstream reaches (Kroes & Bason, 2015) and (Bason *et al*., 2017). Additionally, beaver dams have shown to increase groundwater levels (Feiner & Lowry 2015) and aid in the formation and persistence of wetlands during low and high flow periods (Westbrook et al. 2006).

Non-Tidal Wetlands

Ben Sagara, Virginia Department of Wildlife Resources

Historically, Virginia is estimated to have had just under 1.9 million acres of wetland habitats spread across the state. Following colonial settlement, approximately 42% of Virginia's wetland habitats were drained or filled in to support agriculture, silviculture, and development. This widespread landscape

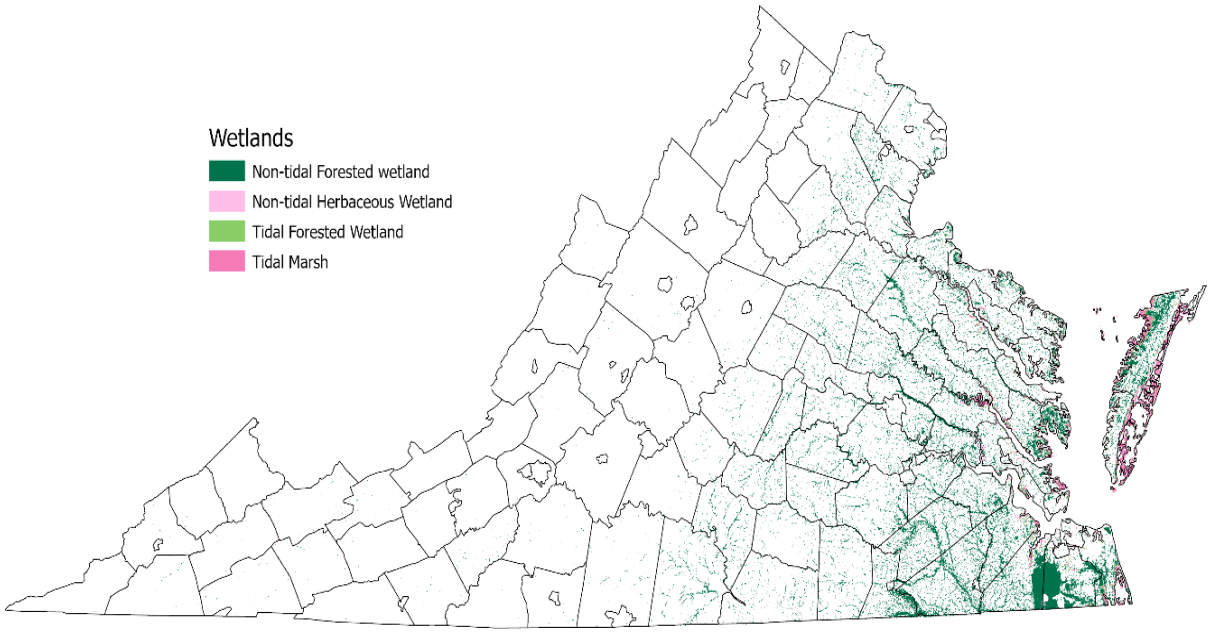


Figure 3.8. Wetland Habitats in Virginia

alteration led to severe flooding and poor water quality in many Virginia rivers and bays. Several federal and state policies were enacted beginning in the 1970s, including the Clean Water Act and the Virginia Tidal and Non-tidal Wetland Acts, which now protect most wetlands from detrimental impacts. Virginia is now estimated to support only 1.07 million acres of wetland habitats, with approximately 71% located in the Coastal Plain, 20% in the Piedmont, and 9% in the mountainous physiographic provinces. Nearly 75% of Virginia's wetlands are defined as non-tidal freshwater wetlands (Dahl 1990, Tiner and Finn 1986).

Tuckahoe Creek Swamp, Henrico, VA

Non-tidal wetlands cover a diverse array of habitat types including swamps, bottomland forests, wet meadows, marshes, bogs, fens, pocosin, seepages, springs, scrub-shrub thickets, impoundments, vernal pools, and much more. These wetlands are inundated or saturated with freshwater during the growing season long enough to influence soil characteristics and develop distinct vegetative communities. Wetland hydrology is received from either surface water (precipitation, snowmelt, riverine floodwaters) or groundwater (seeps, springs, high groundwater table) inputs, and wetlands can be inundated with water all year (e.g., portions of Coastal Plain Depression Swamps and Ponds) or may only have saturated soils for several weeks in the early growing season (e.g., some Non-Riverine Flatwoods and Swamps). Non-tidal wetlands provide vital fish and wildlife habitat for a great quantity of species, including 488 of Virginia's SGCN . These wetlands trap and store excess sediments and nutrients which is critical to the health of Virginia streams and waterways, including the Chesapeake Bay. Wetlands can also attenuate floodwaters, provide erosion control, stabilize local water tables, serve as an important storage component in the global carbon cycle, and provide endless educational and recreational opportunities.

Inland non-tidal freshwater wetlands, also referred to as palustrine wetlands, are distributed all across the landscape, and vary widely in structure, function, and vegetative composition with changes in hydrology, landscape position, geomorphology, soil composition, underlying geology, climate, and historic disturbance regime. Palustrine wetlands are often broadly defined by their canopy cover as either forested, scrub-shrub, or emergent. Although they are generally found along riverine bottoms and in other low-lying areas, some flat and concave landscape features at higher elevation can perch water and maintain wetland habitats like Appalachian Bogs and Piedmont Upland Depression Swamps. More information on Virginia's natural palustrine wetland communities can be found in the Virginia Department of Conservation and Recreation's Natural Communities of Virginia Classification of Ecological Groups and Community Types for Non-tidal Wetlands in Palustrine Ecosystems. Based on U. S. Forest Service LANDFIRE Vegetation Models, the historic fire regime for non-tidal wetlands has a very broad range depending on the larger vegetative community they are encompassed within. Historic fire regimes could occur as often as a nearly annual return interval in eastern woodland mosaic forests to an over 1000-year return interval for southern floodplain (rare fire) vegetative communities (LANDFIRE 2007).

Common threats to non-tidal wetlands include conversion to developed lands through drainage and/or fill, habitat fragmentation, changes in water level associated with a large increase in impervious services and stormwater infrastructure in rapidly developing watersheds, pollution impacts from stormwater and agricultural runoff, poor silvicultural practices, mowing, conversion to open water through damming, and colonization of aggressive invasive species. Some coastal inland wetlands are being converted to tidal wetlands due to rising sea levels, and increases in intense weather events, including severe storms and droughts, are also impacting wetland hydrology. There are several existing cost share programs, easement programs, and competitive grant programs offered by nonprofit, local, state, and federal organizations that support wetland conservation opportunities for both private and public landowners. Wetland conservation actions include enhanced legal protection through easement or acquisition; restoration on historically drained or otherwise impacted wetlands by plugging ditches, removing drain tiles, removing dams and berms, removing legacy sediments, reconnecting streams to floodplains, and/or regrading of the landscape where wetlands have been filled in or topographically altered;

enhancing existing wetlands through cattle exclusion, erosion protection, supplemental native plantings, maintaining effectively managed impoundments, and invasive species removal; and wetland creation where new wetlands are constructed from non-wetland areas such as impoundments created in uplands or island creation on subaqueous lands.

Nutria are an increasing threat to Virginia's tidal and non-tidal wetlands. This species is non-native and known to cause widespread damage to important coastal marsh systems through feeding and excavating activities. Nutria are endemic to South America but have been translocated throughout the world including the eastern United States. Nutria appear to be expanding their range further north and west, posing a potential threat to valuable wetland systems north of the James River and in river habitats west of the Great Dismal Swamp.

Tidal Wetlands

Ben Sagara, Virginia Department of Wildlife Resources

Historically, Virginia is estimated to have had just under 1.9 million acres of wetland habitats spread across the state. Following colonial settlement, approximately 42% of Virginia's wetland habitats were drained or filled in to support agriculture, silviculture, and development. This widespread landscape alteration led to severe flooding and poor water quality in many of Virginia's rivers and bays. Several federal and state policies were enacted beginning in the 1970s, including the Clean Water Act and the Virginia Tidal and Non-tidal Wetland Acts, which now protect most wetlands from detrimental impacts. Virginia is now estimated to support only 1.07 million acres of wetland habitats, with approximately 71% located in the Coastal Plain, 20% in the Piedmont, and 9% in the mountainous physiographic provinces. Nearly 25% of Virginia's wetlands are defined as tidal estuarine wetlands (Dahl 1990, Tiner and Finn 1986).

Virginia has vast estuarine ecosystems that support a complex network of tidal wetland habitats throughout the coastal plain physiographic province, including seaside bays, Back Bay, and the Chesapeake Bay and its major tributaries. This network of tidal wetlands serves as critical natural infrastructure, protecting adjacent uplands from storm surge, flash flooding, and erosion, trapping and storing excess sediment and nutrient, and serving as an important storage component in the global carbon cycle. Tidal wetlands also provide vital fish and wildlife habitat for 580 of Virginia's SGCN .

Tidal wetland habitats vary in structure, function, and vegetative composition with changes in landscape position, geomorphology, soil composition, underlying geology, salinity, tidal influence, climate, and historic disturbance regime. Tidal wetland communities can broadly be defined by regular (lunar tidal) or irregular (wind-tidal) flooding. These systems are further defined by salinity levels (polyhaline to freshwater). The terms "high marsh" and "low marsh" are used to define distinct habitat types restricted to high or low elevation areas within the intertidal zone (Figure 3.9). The historic fire regime for tidal marshes in the southeast is estimated to range from nearly annual, to up to a 300-year fire-return interval (Frost 1995). Although most tidal wetlands are represented as coastal marshes dominated by herbaceous vegetation with a scrub-shrub fringe along the high elevation edge, tidal wetland habitats can be represented by a range of forested, shrub, and herbaceous dominated communities. More

information on Virginia's natural tidal wetland communities can be found in the Virginia Department of Conservation and Recreation's Natural Communities of Virginia Classification of Ecological Groups and Community Types for Tidal Wetlands in Estuarine Ecosystems.

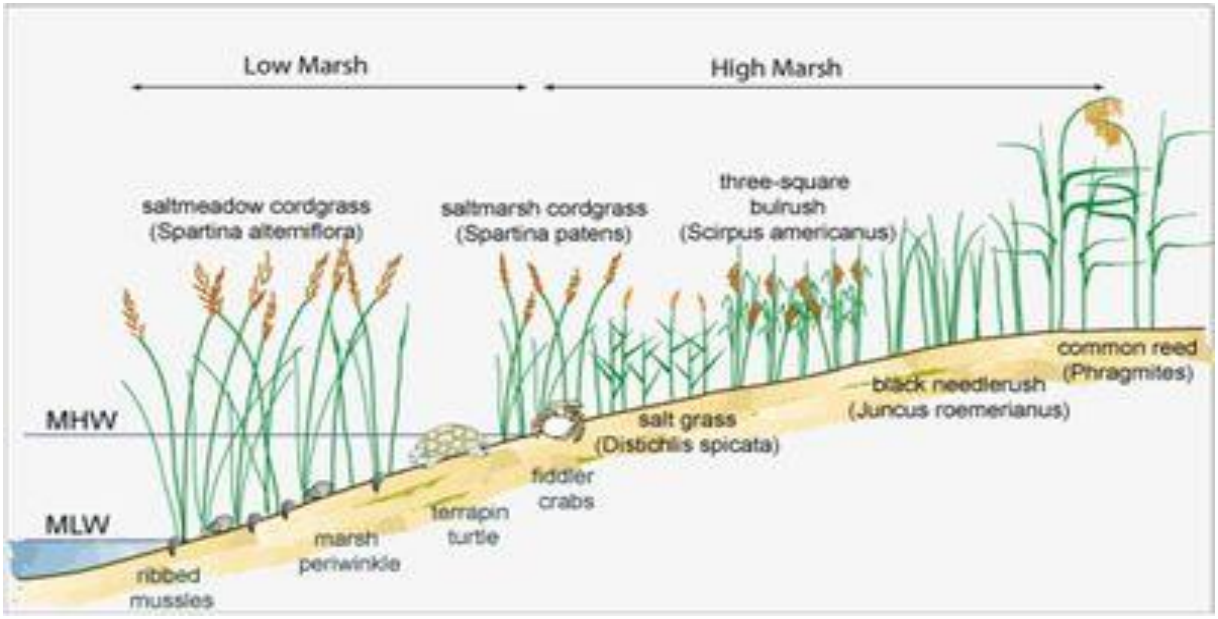


Figure 3.9. Tidal Marsh Structure (Saltmarsh Ecology, Cambridge University Press)

Common threats to tidal wetlands include development-related fill impacts, conversion of native habitat to invasive species (e.g., *Phragmites*), and pollutant impacts from stormwater and agricultural runoff. Many tidal marsh systems within Virginia are also experiencing significant change alongside rising sea levels and more frequent and intense storms. Furthermore, the southern portion of the Chesapeake Bay is experiencing substantial land subsidence, which has caused areas in Virginia to have the highest rates of observed relative sea level rise along the Atlantic Coast. There is a very thin range of elevations able to support tidal marsh vegetation establishment. Many existing low marshes are under substantial threat of drowning in the next few decades from rising sea levels, more frequent storm surges, and prolonged high tides. Natural marsh migration processes can ensure marsh habitats are not completely lost as the landscape changes. Marsh migration occurs when "low marshes" drown, higher elevation "high marsh" vegetative communities convert to "low marsh" vegetative communities, and adjacent even higher elevation uplands begin to regularly flood and transition to "high marsh" vegetative communities. However, much of Virginia's coastal areas are densely populated and developed, so natural processes like marsh migration will come into conflict with many existing human uses and activities (Figure 3.9). This puts Virginia's tidal wetland habitats at an increased risk of experiencing widespread flooding and loss. There is a need to protect existing low marsh to ensure existing quality habitat remains long enough for new quality marsh to establish. There is also a need to identify and protect areas with future marsh migration potential to ensure Virginia maintains vital marsh habitat through time.

Three SGCN , saltmarsh sparrow, eastern black rail, and American black duck, are also flagship species for the Atlantic Coast Joint Venture (ACJV). Where practical, tidal wetland conservation efforts should

seek to enhance habitat for these species, as they occupy a range of coastal marsh habitats that are highly threatened by sea-level rise and urbanization. Efforts aimed at enhancing habitat for these species would also benefit a host of other marsh-dependent fish and wildlife species. Tidal wetland restoration, enhancement, and protection techniques include living shorelines, dune restoration, berm removal, runnels, marsh terracing, thin/thick layer placement, back barrier marsh creation, island creation, and more. There are several existing cost share programs, easement programs, and competitive grant programs offered by nonprofit, local, state, and federal organizations that support tidal wetland conservation opportunities for both private and public landowners.

Estuaries

Margi Whitmore, Virginia Department of Wildlife Resources

Estuaries are dynamic environments, formed over geologic time scales, where saltwater from the ocean mixes with freshwater from rivers. This mixing creates a range of salinity zones that are further influenced by precipitation, wind, and tides. Aquatic and riparian habitats shift with these environmental factors along the continuum from the ocean to head of tide, supporting high biodiversity. Virginia's estuarine habitat is comprised of the northern waters of Currituck Sound and the southern portion of the Chesapeake Bay and its tributaries.

Currituck Sound is part of the Mid-Atlantic Embayed Region stretching from southeast Virginia to North Carolina's Neuse River. This Region consists of a complex of sounds and embayments, including Albemarle and Pamlico sounds, separated from the Atlantic Ocean by a narrow, nearly continuous strip of barrier islands. Formation began within the past 11,700 years with retreating glaciers raising sea level and flooding coastal valleys. Simultaneously, the interaction between high-energy ocean storms and the sediments of the low-sloping Coastal Plain began forming barrier islands. The ocean-facing sides of barrier islands absorb energy from waves, currents, tides, and storms, protecting inland habitats. As a result, the waters of the Embayed Region are uniformly shallow, supporting abundant wetlands and high biodiversity.

The waters of Currituck Sound cross the border from northeast North Carolina into southeast Virginia as two tributaries, the Northwest and North Landing rivers, and Back Bay. The Northwest River stretches northwest towards the Great Dismal Swamp, gradually turning to wetlands. The North Landing River stretches north, connecting to the Elizabeth River via the Intracoastal Waterway and Great Bridge Lock. Back Bay is a large embayment dominated by wetlands along its shoreline and numerous islands. All three waters were formerly influenced by diurnal lunar tides but are now upstream of tidal influence due to the closure of barrier island inlets over time. However, the shallow depths and low-velocity flows characteristic of these systems form unique wind-tidal marsh habitats. Strong winds from the south and southeast blow along the length of Currituck Sound, pushing water northward into Back Bay and the two rivers. Wind-driven currents cause water level variations of up to three feet and irregular salinity regimes that fluctuate from freshwater to brackish. As a result, Back Bay's marshes are a mixture of freshwater and brackish species, supporting diverse wildlife communities and providing critical habitat for migrating waterfowl, shorebirds and wading birds.

Westmoreland SP Photo Credit: VDCR/VSP

The Chesapeake Bay is the largest estuary in the United States and lies within the borders of Virginia and Maryland. The Bay first began to form 35 million years ago when a bolide collided with the continental shelf, near present day Cape Charles, creating a crater over 50 miles wide. Sea level was much higher during this period, pushing Virginia's coastline further inland to the west of Richmond and Washington D.C. While the bolide did not create the Chesapeake Bay, it determined where it would ultimately form as sea levels changed. Approximately 18,000 years ago, massive ice sheets covered the continent, reaching as far south as Pennsylvania. With so much water trapped in glaciers, sea level dropped 600 feet lower than it is today, exposing the continental shelf and what would become the Chesapeake Bay. As temperatures warmed, glacier melt formed streams and rivers that cut channels into the landscape, flowing towards the ocean. What is now the Chesapeake Bay began as the Susquehanna River Valley. The Susquehanna River is one of the oldest rivers in the world and the longest river on the East Coast, draining 27,500 square miles. Its headwaters in present-day Pennsylvania and New York created a network of streams and rivers funneling glacial meltwater through Maryland and towards the low-lying crater before draining into the ocean.

The impact crater filled in with soft sediments and compacted over time but the geological differences between the crater and surrounding rock still impact Virginia residents today. Subsidence is a term used by geologists to describe the gradual sinking of ground due to shifting underground materials. As the soft sediments filled in the crater and compacted, subsidence slowly caused the surrounding land to shift and move towards the crater. Today, this process has been tied to land instability and aquifer disruption and may be responsible for the high rates of sea level rise near the mouth of the Bay. A more visible effect of subsidence can be observed in the unique channels of the James and York rivers. Whereas the Potomac and Rappahannock Rivers flow steadily southeast into the Bay, the James and York Rivers have sharp turns to the northeast near their mouths, reaching towards the impact crater.

This, in turn, affects the hydrology and water chemistry of the estuarine portions of these rivers up to the Fall Line.

The Fall Line is a significant geological feature that marks the boundary between the Piedmont and Coastal Plain physiographic regions along much of the East Coast. In Virginia, the Fall Line runs roughly from Alexandria through Richmond to Petersburg and is characterized by a drop in elevation, leading to the formation of rapids. This transition zone delineates the upper limit of estuarine environments (head of tide) in Bay tributaries and marks a shift from the shallow, bedrock-dominated rivers of the Piedmont and the deep, soft-bottom streams of the Coastal Plain. The geology of the Fall Line influences the hydrology, water chemistry, and sediment distribution in the estuary below.

The Chesapeake Bay is characterized by a semidiurnal tidal cycle and fine sediment substrates. Habitat distribution throughout the Bay and its tributaries is driven by the interaction between freshwater inputs from rivers and saltwater intrusion from the Atlantic Ocean. A salt front forms where freshwater and saltwater meet, and less dense freshwater flows on top of saltwater. Mixing occurs along the salt front and creates a gradient of salinity zones, transitioning from polyhaline ocean water to mesohaline, oligohaline, and ultimately to tidal fresh water in Bay tributaries. The location of salinity zones differs among tributaries, depending on position within the Bay watershed, bathymetry, and channel features. Within the Bay and its tributaries, salinity zones can shift with tidal cycle, precipitation, flow rate, and wind.

Dynamic environmental conditions heavily influence habitat distribution, and the flora and fauna found there. In the lower estuary, beaches and coastal wetlands makeup most of the undeveloped shoreline. In shallow waters, submerged aquatic vegetation provides nursery habitat, refuge, and abundant food for fish, invertebrates, and birds. Eelgrass beds are important habitats for blue crabs, providing protection from predators and ample forage. Open water habitats historically supported vast oyster reefs. Habitat degradation and intense harvest decimated oyster populations but restoration efforts are working to reverse the trend. Oysters are a keystone species, and established reefs not only create habitat for fish and other invertebrates but also contribute to improved water quality through filter-feeding. Upper estuary habitats include emergent wetlands, forested wetlands, and mudflats that provide habitat and forage for abundant and diverse aquatic life.

Virginia's estuaries are complex and dynamic systems shaped by geological features, hydrological processes, and human development. Estuaries support high biodiversity and provide abundant ecosystem services. Understanding the interplay between anthropogenic impacts, environmental dynamics, and aquatic communities is crucial to the conservation and sustainable management of these vital ecosystems. Actions addressing point and nonpoint source pollution, sedimentation, time of year restrictions on dredging are just a few actions that would have positive impacts on Virginia estuaries.

Marine Nearshore

Brendan Runde and Kate Wilke, The Nature Conservancy

Nearshore marine habitats in Virginia represent an extensive and dynamic group of ecosystems. These waters include the surf zone along Virginia's ocean beaches, the coastal bays and inlets on the seaside of Virginia's Eastern Shore, and the lower Chesapeake Bay. In terms of extent, modern coverage of these habitats is not dissimilar to historical coverage. However, anthropogenic influence and human use of these systems is evident throughout.

Submerged aquatic vegetation, particularly eelgrass (*Zostera marina*), once dominated the substrate in Virginia's coastal bays. This species virtually disappeared from these bays in the 1930s, due to a combination of disease and the effects of a hurricane (Orth and McGlathery, 2012), but has since been restored to a total coverage of ~10,000 acres. This habitat serves as an invaluable nursery for myriad species of fish and shellfish (Lefcheck *et al.*, 2017), many of which are SGCN. The extent of eelgrass in the coastal bays continues to grow as a result of restoration efforts and – now – self-propagation from previously restored areas.

Mockhorn Island WMA

The eastern oyster (*Crassostrea virginica*) has long been one of the most important species in Chesapeake Bay and other Virginia waters. The ecosystem services provided by oysters are immense: their ability to filter water, plus the structured habitat they form for fish, crabs, and other marine life, make oysters a keystone species in these ecosystems. Records from the early decades of European contact suggest extensive oyster reefs in many nearshore waters of the Bay (McCormick-Ray, 2005), including the [perhaps embellished] 1608 account from Captain John Smith who wrote that "oysters lay as thick as stones." High levels of exploitation began in the 1800s and accelerated as technology allowed harvesting to become more efficient (Schulte, 2017). By 2011, one study estimated that the abundance of oysters in one section of Chesapeake Bay was 0.3% of its historical levels (Wilberg *et al.*, 2011).

Threats to the marine nearshore habitats in Virginia include those originating from changing environmental conditions. Increasing water temperature has the potential to disrupt spawning cycles and thus survival of numerous organisms, including many SGCN, eelgrass, and oysters. Invasive species, such as blue catfish (*Ictalurus furcatus*) and northern snakehead (*Channa argus*), are more prevalent in the estuarine portions of the Bay but may threaten lower portions as well. These species are known to

outcompete some native species, including striped bass. More informed management of the oyster fishery, paired with restoration efforts for the same species, have been somewhat successful; however, the diseases MSX and dermo have taken a further toll on this population over the last several decades (Ewart and Ford, 1993). Human uses of nearshore marine habitats in Virginia also threaten these ecosystems. These include dredging (e.g., for shipping channel maintenance and port construction), increased shipping activity, shoreline stabilization such as bulkheading, and agricultural and storm runoff which can greatly affect water quality.

There are many conservation actions for marine nearshore habitats in Virginia that could be considered priorities. Addressing nutrient-rich runoff, for instance by amending agricultural fertilizer application or modernizing sewage treatment and outflow, is likely to pay dividends for living habitats (such as eelgrass and oysters) as well as the marine life living in and around them. Continued restoration of eelgrass and oysters should also be prioritized. Finally, monitoring the impacts of human use such as shipping and dredging on SGCN using diverse empirical scientific methods is recommended.

Marine Offshore

Brendan Runde and Kate Wilke, The Nature Conservancy

The open ocean is one of the most extensive ecosystems on the planet. Off the coast of Virginia, pelagic and benthic zones provide habitat for dozens of SGCN. Continental shelf habitat off Virginia consists of approximately 20,000 km^2 of seafloor. Although much of this area is unconsolidated sediment, natural hardbottom habitat and artificial structures provide refuge and forage for many SGCN. Approximately 0.05 km^2 (i.e. 50,000 m^2) of Virginia's seafloor is occupied by state-managed artificial reefs (Paxton *et al.*, 2024), and likely far more is covered by natural reefs (Steward *et al.*, 2022). The extent of artificial reefs is increasing, while changes in extent of natural reefs off Virginia is not known. In addition to purpose-built artificial reefs, man-made structures, such as wind turbine foundations, offer habitat for diverse marine life. Virginia's number of wind turbine foundations has increased from a historical absence to two in 2020 and over 150 additional foundations planned as of this writing. Each of these seafloor habitats are important for marine life, including many or all SGCN that live in the ocean.

At and beyond the continental shelf break off Virginia, deepwater canyons offer high-relief habitat for marine life. Indeed, deepwater corals are present in these canyons (Brooke *et al.*, 2017) that are not found elsewhere on the sedimented shelf and slope of the Mid-Atlantic Bight. Due to the importance of these habitats, the canyons of the Mid-Atlantic are protected from fishing and other extractive use. The oceanic habitat may be far from shore, but it is still subject to anthropogenic threats. Pollution, in the form of macro-plastics (Jambeck *et al.*, 2015), microplastics (Everaert et al., 2020), heavy metals (Mart et al., 1982), and other contaminants threaten the quality of seawater and the biological processes that take place therein. Warming ocean waters are causing increases in sea surface temperature in the global ocean, including off Virginia (Lapointe *et al.*, 2020). While the Gulf Stream has historically driven processes off states south of Virginia, changing environmental conditions are driving major changes in this current that will impact Virginia as well (Gonçalves Neto *et al.*, 2021). Indeed, the effects of these changing conditions on marine life are manifesting as (for example) poleward shifts in distributions (Morley *et al.*, 2018; Nye *et al.*, 2009). These climate-driven distribution shifts may

complement range expansions that are facilitated by the emplacement of artificial structures in the ocean (Paxton *et al.*, 2019).

Humpback Whale off of Virginia Beach

Invasive species in Virginia's ocean waters include lionfish (*Pterois spp.*) and green crab (C*arcinus maenas*). While it is not currently believed that lionfish can overwinter north of North Carolina, increasing seawater temperatures and the increase in rocky habitat (i.e. due to offshore wind foundations) may allow them to do so. Green crabs are generally estuarine or shore-associated; however, they may colonize offshore structured habitats as well. As waters continue to warm and the availability of novel structured habitats increases, these and other invasives should be priorities for monitoring as they may outcompete native species (including some SGCN).

Priority conservation actions in Virginia's marine offshore ecosystem should include continued protection of deepwater coral ecosystems, monitoring for the spread of invasive species, and research on the impacts of new built habitats such as offshore wind on SGCN. Furthermore, empirical research techniques such as acoustic telemetry would further elucidate habitat use by SGCN.

Urban Lands

Steve Living, Virginia Department of Wildlife Resources

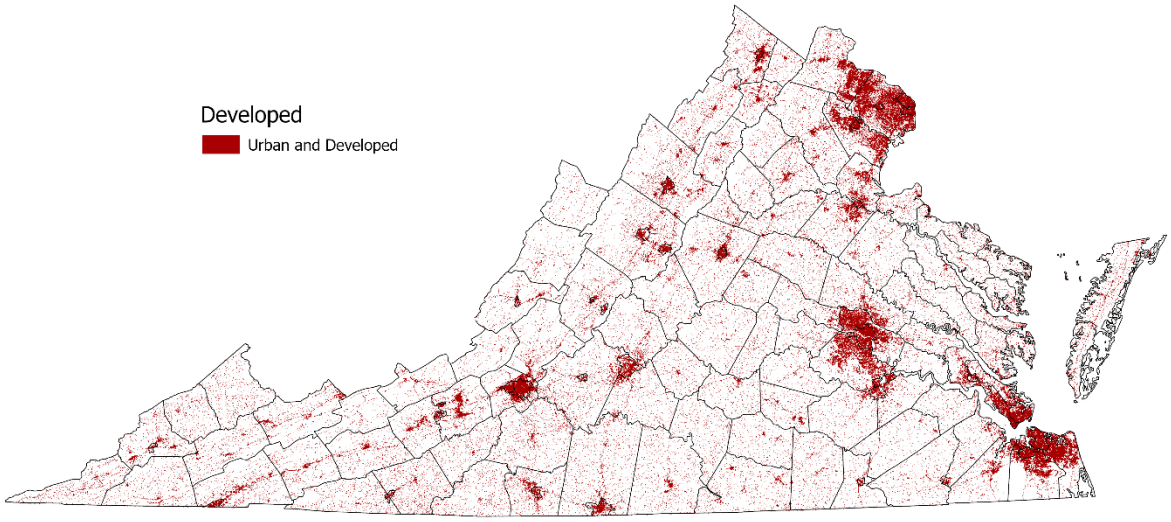


Figure 3.10. Urban/Developed Land across Virginia

Urbanization poses a variety of challenges to wildlife. Development of natural habitat can directly displace species and fundamentally alter habitat characteristics. The fragmentation can isolate populations and increase the impacts of predation and degradation of habitat. Sensitive species and specialists may be more susceptible to these effects. Urbanization can introduce chemical pollutants, litter and debris, as well as light and noise pollution that can significantly impact the life processes of a variety of species. The risk of collision with structures and vehicles poses another risk. Invasive species are often more prevalent in urban areas and can reduce the value of what natural cover may remain. Urban areas are comprised of a complex mixture of structures, undeveloped spaces and aquatic habitats. The relative ratio of each component varies widely across the urban landscape. A variety of wildlife make their home within this urban framework. This includes generalists like racoons, resident Canada geese, and even deer and black bear. A variety of non-native species thrive in the urban context including rock pigeons, house sparrows and black rats.

Goochland/Henrico County Line, 2024

Virginia's largest urban areas are all associated with significant waterbodies. These provide valuable habitat and act as corridors providing connection to other less developed lands and habitats. These aquatic (or marine) habitats also face pressures from urbanization including channelization, thermal impacts from loss of streamside vegetation, erosion, and pollution in the form of chemicals, nutrients, trash and sedimentation.

Despite these challenges, urban areas can still provide valuable habitat for a variety of SGCN . Green spaces with urban settings may be relatively small but can still support wildlife such as pollinators and can provide stopover habitat for neo-tropical migratory birds. For example, Monroe Park in Richmond, Virginia, is 7.65 acres in a highly urbanized setting and has eBird records for 55 bird species including five SGCN.

Several SGCN can thrive in urban habitats. The peregrine falcon (*Falco peregrinus*) is an excellent example of this adaptability. Peregrines were deemed extirpated in Virginia by the 1960s. In conjunction with national efforts, releases took place in coastal Virginia beginning in 1978 and continued through 1985. Although the intent had been for these birds to wander and eventually reestablish historic breeding sites in the mountains of Virginia, the birds instead established breeding sites on bridges and in urban areas of Virginia. A well-known territory in Richmond, Virginia, is the subject a widely viewed live webcam and generates significant public interest in conservation. In downtown Richmond, the peregrines find ample avian prey and the high-rise building provide a constructed analog to the cliffside aeries that the birds nested in historically. This includes urban birds such as rock pigeons but perhaps surprisingly, a number of prey items typically associated with forested habitats like yellow-billed cuckoo or even wetland dependent species like bitterns and rails. This would seem to highlight the importance of riparian buffers and forests both as habitat in and of themselves and as corridors for connectively and dispersal. Understanding that urban areas are potential habitat is important in understanding how wildlife use these areas and how best to manage those species.

Richmond City, James River Photo Credit: VA Tourism Corp.

Programs to enhance habitat within existing public and private greenspace can bolster the habitat value of these habitats in the urban environment. Encouraging the use of native plants and the maintenance of native tree canopy can have direct benefits for wildlife while addressing environmental equity issues such as heat islands and access to quality outdoor nature based recreational opportunities. The monitoring for and removal of invasive species can further enhance habitat value.

The monitoring for and provision/protection of resources for wildlife that take advantage of urban spaces can provide additional benefits. Chimney swifts will utilize large industrial chimney stacks in urban areas as communal roosts during migration and as such these can provide a key habitat resource.

Working with partners to promote Lights Out campaigns and other mitigation strategies to address window strikes where appropriate can help to mitigate a significant threat to bird populations.
Urban habitats present complex challenges for many wildlife species, especially habitat specialists and those sensitive to human disturbance. A select suite of wildlife, including SGCN, are able to successfully make use of urban habitats. Identifying these species, understanding their needs and the opportunities for management within the urban context will be important to maximizing the value of this habitat type. The proximity to significant human populations creates opportunities to make positive connections with wildlife, enhancing the overall understanding of DWR's mission to conserve, connect, and protect wildlife and habitat conservation.

Transportation Networks
Steve Living, Virginia Department of Wildlife Resources

Virginia's transportation network is a landscape feature that is distributed throughout the Commonwealth, intersecting other habitat types and occurring in both rural and urban areas. Within the urban framework, this network is concentrated as road and rail infrastructure corridors intersect in hubs and can be seen as part of the larger matrix of the built environment. In rural environments this network is more dispersed, but its impact on habitat perhaps more immediately noticeable as road and rail infrastructure corridors dissect habitat that may otherwise be relatively contiguous.

Virginia's road network is comprised of 70,066 miles of roads

- Interstate: 1,118 miles of four- to ten-lane highways that connect states and major cities
- Primary: 8,111 miles of two- to six-lane roads that connect cities and towns with each other and with interstates
- Secondary: 49,943 miles of local connector or county roads (1638 miles locality maintained).
- Frontage: 333 miles of frontage roads
- Urban streets: 10,561miles (maintained by locality)

The majority of these roads are comprised of impervious surface and are accompanied by rights-of-way of varying widths that are maintained with a combination of mowing, trimming and herbicides to maintain drainage and line-of-sight as necessary.

Road networks pose a variety of challenges to wildlife and their habitats. Roads create barriers to dispersal and a direct hazard due to the risk of vehicle collisions. The noise and artificial light associated with roadways create additional impacts for wildlife.

Springfield Interchange Photo Credit: VDOT

Virginia's Rail network is comprised of 11 freight lines, eight Amtrak intercity passenger routes, and two Virginia Railway Express (VRE) commuter routes. The passenger rail services operate primarily on rail lines owned by the freight companies under negotiated agreements. Rail lines pose hazards similar to road networks, creating barriers to dispersal and the risk of strikes. The managed rights-of-way adjacent to these networks create potential attractants and habitats for wildlife. The Virginia Department of Transportation participates in the Monarch Butterfly Candidate Conservation Agreement with Assurances program administered by the University of Illinois-Chicago. Under the auspices of this program VDOT has contributed over 8,000 acres of pollinator habitat, including planting 82 acres in 2023 with 135 acres slated to be planted in 2024.

These rights-of-way also create pathways for the spread of a variety of invasive plant species. These can become well-established within these areas and provide sources for continued invasion. Inclusion of invasive species monitoring and control as part of right-of-way vegetation management protocols can help mitigate this issue.

Attractive habitat adjacent to these road and rail infrastructure corridors is not without potential risk to wildlife. Wildlife species may be attracted to browse on vegetation or to hunt. Scavengers may be attracted to roadsides by the carcasses of previously struck wildlife. Carrying out these activities adjacent to roads and railways creates potential risk.

Some transportation infrastructure can offer analogues for key habitat features. Bridges and culverts can act as substitutes for caves, rock and tree crevices and hollow trees and are utilized as roosts and hibernacula by up to half the North American bat species. Notable Virginia bat SGCN that are known to utilize these features include Rafinesque's big-eared bat (*Corynorhinus rafinesquii macrotis)*, Virginia big-eared bat (*Corynorhinus townsendii virginianus)*, Indiana myotis (*Myotis sodalis)* and northern long-

eared bat (*Myotis septentrionalis)*. Opportunities exist to retrofit existing bridges or to incorporate bat-friendly features into new designs.

The continued study and implementation of wildlife passage related to transportation infrastructure corridors has the potential to mitigate habitat isolation and the risk of strikes. Identifying effective designs and locations for such passage efforts will be increasingly important as development pressures continue to fragment wildlife habitats.

Wildlife Habitat Corridors and Connectivity

Virginia is one of the first states in the eastern U.S. to create a Wildlife Corridor Action Plan (Plan) (VDWR et al. 2023) with a clear emphasis on protecting vital wildlife habitat corridors and reducing wildlife-vehicle conflicts, such as collisions, to promote driver safety. Wildlife corridors connect fragmented habitats separated by human activities or infrastructure; this habitat connectivity is vital to the long-term sustainability of wildlife biodiversity. When road infrastructure fragments wildlife habitats, some species of wildlife may need to move across roads to reach suitable habitats for fulfilling their food, water, shelter, and mating requirements. Wildlife-vehicle conflicts can occur, resulting in driver safety risks due to direct collisions with the animals or crashes from avoidance maneuvers, as well as wildlife population impacts such as significant mortality and barriers to dispersal. More than 60,000 (Donaldson and Elliott 2021) known deer-vehicle collisions have occurred annually in Virginia since 2015, costing the Commonwealth and its citizens approximately $533 million each year. One example of creating these corridors are the areas along the Nottoway and Blackwater Rivers in Southeastern Virginia related to the conservation of longleaf pine ecosystems (see page 41.)

One of the key outcomes of the Wildlife Corridor Action Plan is the identification of Wildlife Biodiversity Resilience Corridors (Figure 3.11). These coarse-scale statewide wildlife corridors were identified by leveraging the Commonwealth's ConserveVirginia and Virginia Natural Landscape Assessment conservation planning tools (Virginia Department of Conservation and Recreation), as well as other geospatial data sources. Conservation of these existing large-scale wildlife corridors, and their connectivity, are important for the long-term sustainability of Virginia's native biodiversity and habitats in the face of threats such as land development and climate change. In 2027, the Wildlife Corridor Action Plan will also integrate species-specific habitat corridors for 11 Species of Greatest Conservation Need thought to be vulnerable to road risks (e.g., via direct mortality and/or dispersal disruption through habitat fragmentation). The VDWR is partnering with VDOT-Virginia Transportation Research Council, VDCR, Smithsonian Conservation Biology Institute, and George Mason University to pilot how to identify priority species habitat corridors for SGCN using expert input, available biological data and research outcomes, and geospatial and remote sensing data within a Google Earth Engine modeling workflow. This pilot is focused on the following 11 SGCN: bog turtle (*Clemmys muhlenbergii*), spotted turtle (*C. guttata*), wood turtle (*Glyptemys insculpta*), box turtle (*Terrapene carolina carolina*), Mabee's salamander (*Ambystoma mabeei*), northern diamondback terrapin (*Malaclemys terrapin terrapin*), timber rattlesnake (Crotalus horridus), eastern mud snake (*Farancia abacura abacura*), common rainbow snake (*F. erytrogramma erytrogramma*), eastern spotted skunk (*Spilogale putorius putorius*), and Allegheny woodrat (*Neotoma magister*). Understanding the location of important habitat corridors

for SGCN will inform future conservation actions, such as priority locations for installing wildlife crossing infrastructure on roads, land conservation, and habitat restoration. In addition, the modeling methodology developed for these 11 SGCN will serve as a protocol that can be duplicated for additional SGCN which are also detrimentally impacted by road infrastructure or other land uses causing habitat fragmentation.

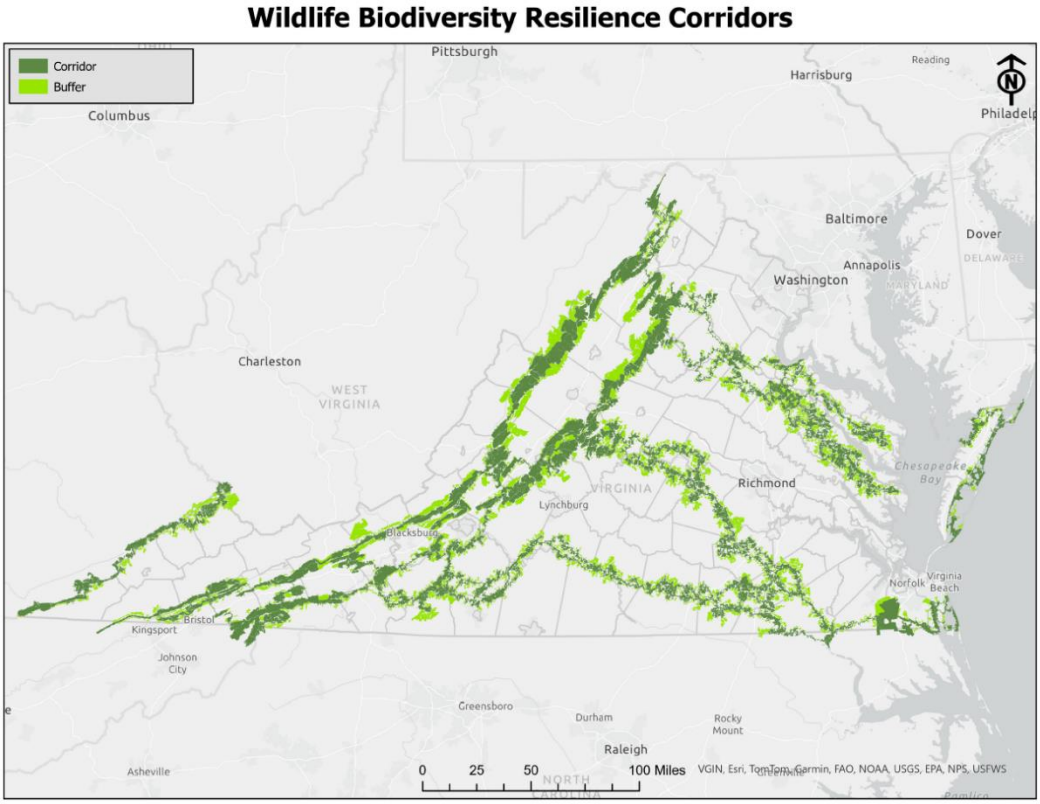


Figure 3.11. Wildlife Biodiversity Resilience Corridors, VA Wildlife Corridor Action Plan, VDWR et al. (2023)

Working Lands

Clay Ferguson, Virginia Department of Wildlife Resources

Lands and waters from which food or fiber are provisioned to support the needs of people are known as working lands and waters (hereafter referred to collectively as working lands). Working lands exist in actively managed areas, are typically privately owned – but can be publicly owned, and include a broad spectrum of agricultural, aquacultural, and silvicultural practices (Placerrcd.org). In Virginia, working lands occupy undeveloped spaces and include timbered forests and tree plantations, pastures, hayfields, crop fields, shellfish farm leases, orchards, nurseries, gardens, and vineyards. Besides furnishing many of the resources that society needs to function, working the land is vital to many landowners' financial solvency. Today, well beyond half of Earth's habitable land is utilized as working land (Ritchie and Roser, 2024), hence the considerable potential for working lands to impact wildlife and their habitats.

Not all modern versions of food and fiber production qualify as working lands. A first requisite of working lands is a direct physical connection between the food production system and local environment. For instance, although confined animal feeding operations (CAFOs) produce lots of food, the human-built, impervious and artificial environment disqualifies them as a type of working land. However, the crop and hay fields that grow inputs for CAFOs are subject to the climate, soil, and biota of a site and qualify as working lands. Another key requisite that distinguishes working lands from other related land uses is the harvest of renewable resources. Industries such as mining or drilling, though capable of producing goods comparable to those derived from working lands (such as synthetic fibers and building materials), are not considered working lands because the operation is non-renewable and merely extractive. Lastly, working lands preserve some level of ecosystem services that were present in the previously natural, unworked landscape. For example, timbering regenerates forests and provides crucial early successional habitats for many SGCN. Although activities commercial fishing, mining, and CAFOs produce important resources for humanity, they cannot provide valuable habitat to Virginia's wildlife like working landscapes.

Nonetheless, working lands can have serious impacts on Virginia's biota. Working lands tip the delicate scale from ecological asset to liability when their operations sever key cycles of nature (White Oaks, 2021). The carbon, nitrogen, mineral, microbial, fungal, light, wind, and water cycle are among a few such key cycles whose disruption can upend the stability of a habitat or greater ecosystem. At the same time, because of their direct connection to the environment, working lands have the potential to align harmoniously with nature's cycles. When harmony is struck between natural habitats and resource provisioning, ecosystem services both critical to our and other species' wellbeing are preserved – services like clean air, abundant water, and healthy soils.

Working farms, ranches, and forest lands are some of Virginia's best examples of intact ecosystems, functioning natural cycles and processes, and resilient wildlife communities. Many of these lands and waters are managed by the Commonwealth's most dedicated stewards and strongest champions for conservation. As such, maintaining the economic viability of working lands is a top priority of Virginia's conservation strategy, as is finding more cost-effective ways to financially reward managers who cannot afford to adopt or sustain wildlife-friendly BMPs, despite a desire to do so. At more than 20% of the state's gross domestic production, working lands are recognized as the foundation of Virginia's economy and receive broad public support for conservation programs that assist farmland sustainability (Rephann, 2022). Collaborating more fully with the working land industry must continue growing as a central tenet to Virginia's wildlife conservation strategy .

Working Lands Pre-Commonwealth

The recorded history of working lands in Virginia began around 4,000 BCE, when native peoples first developed stone axes large enough to clear small patches of forests (VDOE, 2024). Clearing forests provided not only bulk timber for building more substantial tools and structures but also encouraged plants of more direct benefit to people, such as berry bushes, fruit and nut trees (VDOE, 2024). As harsh conditions of the late Pleistocene gave way to the milder Holocene, longer growing seasons and

expanding working lands spurred human population growth across what would later become Virginia's Commonwealth.

Once bands of people came to inhabit all regions of Virginia, they began establishing small, more sedentary settlements and developing unique tribal cultures (VDOE, 2024). The gradual abandonment of nomadic ways necessitated more substantial cultivation of food. Native plants like sunflowers, gourds, tuckahoe and amaranth were cultivated through selective breeding. Fields of beans, corn, and squash, all of which were traded into Virginia from the southwest US or Mexico, eventually provided foodstuffs throughout the seasons. Fire, a tool long used to corral animals for ease in hunting, found greater use in clearing land for more productive grass and shrubland habitats, where wild provisions are more accessible.

As tribal populations surpassed the tens of thousands, larger parts of the natural landscape underwent significant change. Marshes adjacent to settlements were commonly converted to monocrops of wild rice (Nomad Seed Project, 2017). Similarly, floodplain bottom lands were deforested and cultivated for crop production. For many species of wildlife, these anthropogenic conversions from natural to working landscapes would have resulted in a net loss of habitat, or at least a decline in habitat functionality within the acreage impacted. But given the small scale and low intensity of these early food and fiber production systems, the loss was negligible.

From Inconsequential to Highly Consequential Land Use

The geospatial scale and production intensity of Virginia's working lands was radically increased when European colonization imposed a new global economy on the landscape commons. The subsequent privatization of land and establishment of commodity-driven economies all but antiquated the notion of sufficiency in working the land – that was, working the land to feed family and immediate community. Land became a commodity from which individual owners could obtain transferrable wealth (money) via resource extraction. Those who maximized resource extraction could purchase more land or make other investments to advance their social ranking. Prospects for wealth accumulation were high, given the virgin richness of many Virginia soils and relatively stable climate.

Periods of indentured servitude, chattel slavery, and technological advancements of the industrial revolution enabled vast expansion of working lands across the Commonwealth. Eventually, working lands expanded across Virginia so widely that practically every forest was timbered – most have been logged numerous times. Similarly, nearly all tillable land has been plowed and cropped for decades, centuries in some places. Moreover, much of the land has, with few exceptions, been grazed by livestock over similar timeframes. Conversion of natural habitats to working lands accelerated so rapidly during the 19th century that species across all taxonomic groups experienced population declines. The near or complete extirpation of Virginia's big game species (elk, deer, turkey, and bear) provides a reminder not only of the destructive potential of technological advancement within working lands, but also as an indication of the likely losses of more sensitive, endemic species were unknown (Cowie, et. Al, 2022).

This is not to say that before European contact, land was never overworked. However, prior to the development of a global economy, the direct consequences of overworking the land, as is evidenced by erosion of soil fertility and "souring" of previously arable lands, were not readily escapable. Depletion of localized resources would have almost certainly required settlement relocation – a strong disincentive against unsustainable resource extraction and strong incentive for preserving considerable natural habitat for ecosystem resilience. In contrast, the globalized economy has enabled commodity production to steadily intensify in the face of localized overexploitation. Soils depleted of organic matter and key nutrients are renourished by importing nutrients (fertilizers) from off the farm – sometimes from around the world (World Population Review 2024). Likewise, loss in a soil's water-holding capacity is overcome by irrigating crops with nearby ground or surface waters. On the demand side of the equation, once local food or fiber supplies saturate regional markets, export markets are pursued to maintain revenue potential. Increases in food and fiber production have historically resulted in human population growth, which in turn has necessitated additional conversion of natural habitats to working lands to support growing demands.

Moving Past a Conservation Philosophy Crossroads

Anthropogenic manipulation of a natural ecosystem for the benefit of humanity is implicit to working lands. Working the land necessarily displaces some degree of natural ecosystem functionality that co-evolved for millennia prior to human inhabitance. However, some of Virginia's most successful

Timber Management Cut

conservation initiatives of the 21st century have centered on keeping working lands working for the landowner and wildlife. Notable among these initiatives are USDA's Working Lands for Wildlife program

Working Farm

– supported by many state and NGO personnel in the Commonwealth (NRCS, 2024), Virginia land trusts' holdings of conservation easements on working lands that now exceed more than a million acres (Shepherd, 2023), a concerted reorientation of Chesapeake Bay pollution reduction efforts towards working lands (Blankenship, 2023), and unprecedented levels of grant funding awarded to cooperative extension efforts that assist producers and harvesters in adopting best management practices (Taylor, 2023).

This approach tethers working lands and wildlife conservation under the shared mission of economic and ecological resilience. It recognizes that biodiversity and the modern economy are inextricably interlocked – that the longevity of one requires strength and support from the other. It embraces the nuanced concept that working lands of Virginia "cover the full gradient from intensively managed to semi-natural, constitute a vast reservoir of land area, [and] are both part of the problem and also, part of the solution (Coffin, et. al, 2021)."

No Two Working Lands are Exactly Alike

Categorizing Virginia's working lands by their relative compatibility with native wildlife results in a wide spectrum of groupings. On the "highly compatibility" side of the spectrum are versions of farming and forestry that closely emulate the natural ecosystem processes that define the resilient habitats with which native biota coevolved. Highly compatible farming and forestry practices, often referred to as holistic, regenerative, or nature-based systems, preserve most or many of nature's key processes, such as the water, carbon, mineral, fungal, and microbial cycle. These high-functioning systems tend to be managed at low-to-moderate production intensities by managers who value ecosystem services, biodiversity preservation, and thus longevity of their farms, in addition to immediate economic needs.

Some other farm and forestry practices result in novel, anthropogenic ecosystems. Although select species thrive in these human-dominated settings, rarely do SGCN since the novel conditions are mostly unrecognizable from natural habitats. Examples include most commercial crop fields, orchards, vineyards, gardens, and plant nurseries. Unlike highly compatible working lands, these systems necessarily sever many key cycles of nature. For example, cost-effective row crop farming requires the suppression of all but one plant variety (monocrop). Following mechanical harvest, the field lies barren with no physical structure, forage, or live perennial roots to provide wildlife habitat, until a cover crop can be sown and established. These novel working lands are typically managed intensively, often for the sole purpose of provisioning food and fiber. Although best management practices can minimize their ecological impact, improve economic performance, and increase ecosystem services, they do not serve as effective surrogates for Virginia's natural habitats. Working lands that result in novel, anthropogenic-dominated ecosystems are low priorities for wildlife conservation.

The following habitat classes are those which have associated working lands with the greatest potential to support Virginia's SGCN. Discussion of these highly compatible working lands detail the status quo of operation, potential for supporting SGCN, and barriers precluding realization of support potential.

Working Lands and Waters Summaries

Working Forests & Woodlands

Working forests and woodlands include stands of trees that have been timbered and are being considered for a future harvest by the current landowner. They exist on most private and many public lands and include nearly all forest species compositions, barring the less accessible forests at high elevations or in lowland swamps. Much of the diversity in the Commonwealth's forest age-classes results from logging – the timber-harvesting practice that makes a forest a working forest. Though certainly not free of ecological impact, logging benefits many SGCN, particularly birds and mammals, by regenerating young forests as early successional shrubland habitat. Ruffed grouse, golden-winged warblers, bobwhite , woodcock, spotted skunk, and snowshoe hare are just a few SGCN that rely on shrublands for food, cover, nesting, and other key life stages.

Without active logging, young forests would cease to exist across much of the state, along with their co-dependent SGCN. Although early successional forests existed prior to human inhabitance, virtually all the disturbance mechanisms that naturally regenerated forests – old-growth deadfalls, disease, fire, beavers, bison, elk, have been markedly reduced or entirely removed and now, in many cases, would be difficult to restore for scalable reestablishment. Fire, for example, would have naturally opened forest canopies in mosaic-like patchworks when and where flames burned intense enough to girdle or torch trees, creating early successional habitats. Today, the ubiquity of people across the Commonwealth and their financial dependence on private property resources (timber) potentially serve as barriers to returning healthy fire at meaningful scale. Because logging does not deal with the same degree of risk and liability to people and their property, it is a more viable disturbance regime.

Clear cuts – A logging method where all trees are removed from a contiguous block of forest at once, this approach is perhaps the most common harvest method employed in the Commonwealth. The popularity of clear-cut practices is economically driven – they are more cost-effective for loggers (more revenue per time invested) and more immediately lucrative for the landowner (VDOF, 2014). However, some landowners prefer *select cuts* for various economic and environmental reasons, and loggers are typically willing to accommodate if the tract is large enough with a mature stand to select from. Light-to-moderate select cuts, where some mature and many maturing trees are left to grow, are generally considered more supportive to Virginia's wildlife as they create multi-aged canopies with a diverse assemblage of plant species. Moreover, by preserving some canopy coverage, light select cuts continue to shield sometimes highly erodible soil from the elements (wind, precipitation, UV radiation), helping keep watersheds healthy and soils productive. Still, clear cuts can mimic the type of broad forest regeneration that would have historically followed an intense wildfire and are compatible with many SGCN, especially when conducted at flatter topography. If prescribed fire is integrated into the timber rotation, natural habitat conditions are even more achievable.

How a working forest is allowed to regenerate following a timber harvest is also of consequence to SGCN. Ideally, for native wildlife, the native seedbed and stump sprouts are allowed to regenerate naturally. Natural forest regeneration enables a diverse array of species associated with multiple stages

of forest succession to express themselves and support co-dependent species. Rarely thinned between harvests, natural regeneration limits the frequency at which heavy machinery compacts the soil and reduces hydrologic functionality, which is a threat to aquatic SGCN. When markets are up, timber harvests can produce considerable economic windfalls for the landowner, especially stands of mature hardwood. At the very least, timber harvests help cover the cost of landownership from years prior and years to come, disincentivizing deforestation (the conversion of forests to another land use). With harvest frequencies ranging typically somewhere between a half and full century, naturally regenerated forests require patience . Working with a professional forester to develop a forest management plan helps landowners fully consider all economic and ecological factors.

Landowners who desire more frequent infusions of revenue from their working forests often convert a clear-cut stand to a commercial tree plantation. In Virginia, these are typically pine plantations, mostly replantings of fast-growing loblolly, but increasingly native short- and long-leaf pine. Commercial pine plantations are characterized by relatively high density, even-aged, single-species stands planted in rows at regular intervals (FWC, 2019). Site prep and subsequent thinning can be harsh on the environment since intensive use of herbicides and mechanical tillage/compaction is requisite. Except for the first and last few years of a stand's lifespan, most commercial pine habitats consist of monocrop, closed canopy, needle-covered forest floors with little value to SGCN. However, tree plantations that are thinned, burned, and allowed to mature beyond initial market readiness often reestablish an early successional understory with considerable value to the SGCN that can migrate to it (mostly birds).

Regardless of harvest method, when a forestry management plan is developed and BMPs adopted, impacts to SGCN can be minimized and habitats can recover more quickly to a condition that supports wildlife. Importantly, BMPs help keep fertile soils in place throughout the timbering rotation, ensuring a future forest's ecological and economic productivity. Landowners who need not maximize profits from their working forest, who would like to ensure the forests productivity for future generations, and who would like to increase their forest's compatibility with SGCN might consider letting their forests naturally regenerate after harvest, opt for light select cuts (especially on steeper topography), incorporate prescribed fires, and leave behind some mature trees to support wildlife that rely on old-growth habitat.

Prescribed Fire – The importance of prescribed fire is well-documented for many species. The regular rotation of fire to conserve fire-dependent plants and animals is an important part of conservation efforts in Virginia. Without regular logging, application of herbicides or prescribed fire, lands in Virginia naturally progress from grasslands or timbered lands to shrublands to early successional forests to old growth forests. In addition, many species, such as northern bobwhite, red-cockaded woodpecker, frosted elfin, and long-leaf pine require either fire directly to germinate or fire-maintained habitats to thrive. Increasing residential development, urban growth and stricter air quality standards are making prescribed fire harder to plan and carry out. It is crucial for the conservation of fire dependent communities that prescribed fire continue to be an available tool for wildlife and ecological conservation professionals. There are 339 SGCN in the 2025 Wildlife Action Plan that benefit from the occurrence of fire in their habitats.

Working Grasslands, Savannas, & Early Successional Shrublands

Like forests and woodlands, most of Virginia's grassland, savanna, and early successional shrubland habitats are active working lands. Working lands associated with these habitats include agricultural pastures and hayfields, both of which are directly or indirectly managed to produce livestock. Although more prominent on private land, open-land habitats on public lands are occasionally maintained as pastures and hayfields. Unlike slow-growing forests, livestock grazing and hay production afford farmers a more consistent commodity capable of generating substantial annual income off average-sized farms (186 acres in Virginia; Ellison, 2022). Generally, grazing confers better income potential than haymaking because of the high value of livestock and relatively low expenses needed to grow them. This is especially true for ruminant grazers, which require little to no supplemental feeding when pasture forage is diverse and strategically stockpiled for grazing outside the growing season. As the costs of fertilizer, feed, fuel, equipment, and other farming expenses outpace rises in commodity values (Myers, 2022), grazing pastures has become a financial stronghold for rural communities, helping maintain grasslands, savannas, and shrublands.

Pastures have more potential than hayfields to support diverse flora and fauna because grazing-animal impact (hoof tramping, manure, urine, etc.) is a natural disturbance mechanism and the only disturbance necessary for most livestock production. When managed with care, livestock impart a disturbance pattern that closely simulates the herbivory cycles once fulfilled by native elk, bison, and even larger herbivores that are now extirpated or extinct. Biomimicry is the term used to reference working land systems that intentionally simulate natural systems and processes. To achieve biomimicry, livestock farmers adopt a suite of best management practices (BMPs) such as stocking their pastures at a site-appropriate rate (below carrying capacity) and allowing pastures ample rest by rotating the herd. Cattle are well suited for biomimicry in Virginia because their size and herd-like tendencies are close surrogates to bison and elk. Cattle is the predominant livestock animal pastured in the Commonwealth, but sheep, goats, pigs, and poultry are also pastured and have compatible potential with native biota. Most of Virginia's pastures are classified as treeless grasslands. However, savanna-like silvopastures are also common and can establish one of two ways: when heavy thinning of a woodland allows light penetration to the forest floor, advantaging herbaceous grasses and forbs, or when intentional tree plantings or natural tree regeneration occurs within a grassland pasture. Pastures also account for a good percentage of Virginia's bramble-dominated early-successional shrublands, which form when grazing pressure is light and managers choose not to control all woody encroachment in their pastures. Shrubland pastures are therefore considered habitats transitioning from a grassland to a savanna or woodland and require heavy browsing to persist.

In the absence of grazing or fire, most of Virginia's grasslands would cease to exist. This is because Virginia's climate and soil profiles, with few exceptions, support the succession of grasslands into shrublands, woodlands, and eventually forests, the "terminal" terrestrial habitat type. While forests provide critical wildlife habitat and ecosystem services, they do not support SGCN that are dependent upon open-canopy habitats. Grasslands and similar herbaceous-dominated open lands are Virginia's most imperiled habitat (Borowy, 2013). As such, area ecologists often emphasize the need for prescribed grazing and fire across Virginia's landscape to create and maintain a patchwork mosaic of forested and open habitats. Indeed, habitats managed both by grazing animals and fire represent some

of Virginia's most intact ecosystems. Without these regenerative disturbances, SGCN like the loggerhead shrike, bobolink, and bog turtle could well vanish from the Commonwealth.

Poor management practices, such as stocking animals on pastures far above the farm's carrying capacity, continuously overgrazing pasture paddocks, and allowing livestock routine access to streams are among the top threats prompting the inclusion of many SGCN. Invariably, grazing operations become harmful when farmers manage for maximum commodity production. Such operations are never sustainable since soil fertility and hydrologic functionality are eventually lost, imperiling both the farmer and wildlife.

Virginia's hay fields are complementary to grazed pastures in that they serve as the forage base for livestock outside of the growing season. Some hayfields represent Virginia's purest stands of native warm season grasslands, but most are dominated by non-native, naturalized cool-season grasses. Hayfields consist primarily of perennial grasses and are distinguished from monocrop annuals that produce haylage and result in a truly novel, human-altered ecosystem. Active hayfields are harvested every year – up to four times a year, depending on climate conditions, grass composition, and nutrient application.

As Virginia's temperature regime warms and growing seasons expand, Virginia grazers are focusing less on hay production and more on stockpiling cool season grasses for winter grazing. Some grazers have joined Virginia's Graze 300 campaign to limit hay feeding to 65 days or less – impressively, some have been able to stop feeding hay entirely (except during times of severe winter weather or growing season droughts; VCE, 2024). Rising costs in hay production is motivating more farmers to convert hayfields to pastures. Depending on the intensity of a grazer's operation, getting by without hay usually requires a reduction in herd size, even with converting hayfields to pastures. But despite reduced income from selling fewer head of livestock, reductions in haying expenses have reportedly made this alternative business model more profitable, less risky, and enjoyable for many grazers (USDA, 2000;Teutsch, 2008;Williams, 2019).

Because pastures have greater habitat potential than hayfields, converting hayfields to pastures is a boon to grassland SGCN. Unlike hayfields, pastures do not require a replenishment of soil nutrients over time. The resulting reductions in chemical fertilizer application on the watershed improves soil, stream, and bay health and helps make farms more profitable long-term. Moreover, regeneratively grazed pastures – those grazed under appropriate stocking densities and resting rotations - build soil fertility through animal impact (root sloughing, trampling, manure, urine). By sequestering carbon into stable soil reservoirs, regenerative grazing is both a key adaption and mitigation to changing environmental conditions (Wiltshire & Beckage, 2022). Hayfields also tend to be less diverse than pastures in species composition and structure. This is because hay mowing necessarily clips fields immediately prior to seasonal extremes, such as peak summer heat and first fall frosts. These highly stressful events select for a few hardy grasses and forbs that can endure. Over time, most hayfields become quasi-monocrops, dominated by one or two varieties of grass (typically non-native) and have extremely limited habitat value for SGCN, despite being undeveloped green space.

Low-intensity haying is key to achieving compatibility with Virginia's SGCN. The fewer the hay harvests, the less fertilizer is applied to the watershed, the less equipment compacts the soil, the less equipment physically kills wildlife, the more plant diversity can express itself, and the more plant structure and living roots can provide wildlife habitat.

Working Estuaries and Marine Nearshore
John Lewis, VA Institute of Marine Science

In addition to working terrestrial landscapes, Virginia has a deep history of working the marine and estuarine waters in the Chesapeake Bay and outer coast of the state. This key sector of Virginia's economy involves harvesting renewable marine resources via numerous methods of take. A multitude of species are harvested commercially in Virginia waters, with some of the more notable including Atlantic menhaden, striped bass, blue crabs, hard clams, and eastern oysters. According to a report

Tangier Island, Virginia

prepared by the Virginia Seafood Agricultural Research and Extension Center, marine resource harvests contributed $1.1 billion to the Commonwealth's economy in 2019, incorporating multiple facets of the supply chain to include harvests made by watermen, value added through processors, and services provided by distributors (Goncalves *et al.*, 2022). Annually, Virginia ranks among the top seafood producers in the United States, boasting the titles of largest hard clam producer in the nation, the bulk of which are aquacultured products, and largest eastern oyster producer on the East Coast.

Working waterfronts are also a source of pride and cultural significance to the people who take part in or live adjacent to such operations. Symbols of working the water are woven into daily life in these areas, with numerous social events revolving around products harvested from local waters (i.e. oyster roasts, crab feasts). Restaurants, hotels, housing developments, and other social constructs share monikers with terms or symbols directly related to working the water. While such things may seem trivial in the broad view of wildlife conservation, these cultural influences can lead to positive changes in the minds of the average person regarding marine conservation, cultivating a respect for the resources

related to said symbols and, in a best-case-scenario, leading to lifestyle changes that will benefit the local environment. Through this process, generational conservation ethics are developed frequently in the form of 'wise use' of the environment or utilizing natural resources for human benefit while maintaining good stewardship.

While Virginia employs a diversity of techniques for harvesting marine resources, many of these methods of take are solely extractive. While this can be sustainable with adequate management, it does not typically involve a reinvestment to the resource, relying instead on natural productivity. However, an expanding segment of the seafood industry is taking a more intensive approach via shellfish mariculture, commonly referred to as shellfish aquaculture. Shellfish aquaculture is a large, growing part of Virginia's seafood economy and major contributor of ecosystem services to marine ecosystems. Of the $1.1 billion contribution of the seafood industry reported in 2019, $117.2 million was attributed to the shellfish aquaculture sector (Goncalves *et al.*, 2022). Of this sector, the overwhelming majority of landing values are credited to hard clams and oysters, with hard clams being the largest contributor (Hudson, 2019). In 2021, hard clam aquaculture produced the number one seafood item by value for the entire Commonwealth of Virginia (Snyder, 2021).

Containerized culture is a common system for shellfish aquaculture used by growers throughout the state. By placing animals in a container or planting them within a specific area leased from the state (with specific permit requirements), shellfish farmers can return to their nearshore site to work their crop for regular maintenance or harvest. Not only do these containment systems confine the shellfish to prevent product loss, but they are also designed to reduce predation. While these containers are intended to protect the shellfish within, they are also used by a plethora of sea life as artificial reefs. Shellfish leases tend to be in areas that are relatively shallow and protected from wind and waves, similar to nursery grounds for many species found in and around seaside coastal lagoons, the Chesapeake Bay, and its tributaries. Juveniles of many species seek refuge from predation in these nursery areas, where food resources are also abundant. The infrastructure provided by aquaculture gear has the potential to offer excellent protection in such environments while also accumulating biofouling, a term used for unwanted biotic growth on otherwise clean farming gear (i.e. barnacles, hydroids, sea squirts), which may serve as a food source for juvenile fishes and invertebrates.

Bivalve shellfish, especially oysters and clams, are proficient filter feeders, known for their excellent ability to filter large volumes of water to sustain growth of their outer shell and somatic tissue. Aquacultured shellfish are no exception to this rule, providing an ecosystem service similar to those in the wild. This filtration potential is considered one of the greatest benefits of aquaculture to the environment, where shellfish remove particles from the water, selectively consuming microalgae while rejecting inedible particles which results in clearer water for seagrass growth and benthic algae colonization, ultimately lessening the effect of nutrient loading. Nutrients such as nitrogen are then stored within the animal which is directly removed from the system upon harvest. The waste produced through filtration also benefits the surrounding environment by providing nutrients to the benthos, potentially spurring the growth of submerged vegetation such as eelgrass (Peterson and Heck, 1999) and offering additional food sources for bottom-dwelling organisms. This biodeposition can also lessen nitrogen loads in the water column through burial and nitrification-denitrification, or the coupled

process by which microbes convert reactive ammonium into nitrate, which is subsequently converted to nitrogen gas and removed from the system (Ayvazian *et al.*, 2021). In addition to filtration, some farming systems (e.g., floating oyster gear) possess the added potential to decrease wave action which may lessen the impact of shoreline erosion adjacent to the farm site. Shellfish aquaculture operations can even be set up in areas that aren't necessarily suitable for wild shellfish colonization, in turn providing robust ecological benefits in areas that otherwise may not receive them.

The shellfish aquaculture industry can produce negative externalities, however. For example, derelict gear, or equipment dislodged or otherwise lost from an aquaculture operation, can be potentially harmful to marine life. While no shellfish farmer intends to lose gear, some degree of loss is inevitable due to bouts of severe weather and aging equipment. This can lead to debris washing up on marshes, beachfronts, or other habitats adjacent to aquaculture operations, though it is best practice (and most economical) to anticipate impending scenarios that may lead to gear loss and take appropriate measures to reduce such loss. Most aquaculture operations and trade organizations like the Virginia Shellfish Growers Association will readily respond to calls and aid in the retrieval of derelict gear in their area. While aquaculture operations can positively impact submerged vegetation, they also have the capability of harming seagrass beds through shading and bottom disturbance which can lead to significant loss of vegetation directly under aquaculture gear (Howarth *et al.*, 2022). This impact, however, is limited to the given farm site and is often mitigated entirely during the application process for aquaculture leases, where new proposed leases sited near seagrass beds are heavily scrutinized and those that are applied for within seagrass bed boundaries are typically denied. Additional information on potential issues and best management practices regarding bivalve shellfish farming can be found at .

Even with potential negative impacts in mind, shellfish aquaculture in Virginia is one of the most environmentally conscious and net-positive food systems the Commonwealth has to offer. Shellfish farmers tend to be staunch stewards of the environment they work in, as their livelihoods are directly impacted by the health of the waterways from which they draw their sustenance and personal satisfaction. A healthy aquaculture product is just one part of a broader coastal ecosystem, and aquaculture operations throughout Virginia are striving to create a healthier environment to the benefit of all flora and fauna found within.

CLIMATE OF VIRGINIA

Virginia's tremendous biodiversity is enabled by a diverse range of climates. Spatial variability in temperature and precipitation patterns result in six distinct climate regions within the Commonwealth, labelled east-to-west in **Figure 3.12** as: 1) Tidewater, 2) Eastern Piedmont, 3) Western Piedmont, 4) Northern, 5) Central Mountain, 6) Southwestern Mountain. Some of this climatic diversity is explained by Virginia's 3-degreespan in latitude, measured from the North Carolina border to the northernmost piked corners that help shape parts of Maryland and West Virginia. But political boundary lines alone cannot explain the Commonwealth's regionally exceptional climatic differences. For instance, summer middays that rival Florida's heat and humidity across the Eastern Piedmont can simultaneously feel like a pleasantly moderate New England summer day in the high terrain of the Southwestern Mountains. Likewise, winter nights in the Central Mountain region can rival the bitter, blustery cold of a Chicago blizzard, while, at the same time, register calm, well-above-freezing conditions in the Tidewater region. The land and waterscape features that engender substantial regional variation in Virginia's climateinclude Virginia's diverse topography, mainland orientation, and ocean proximity, among other influential physiographic features.

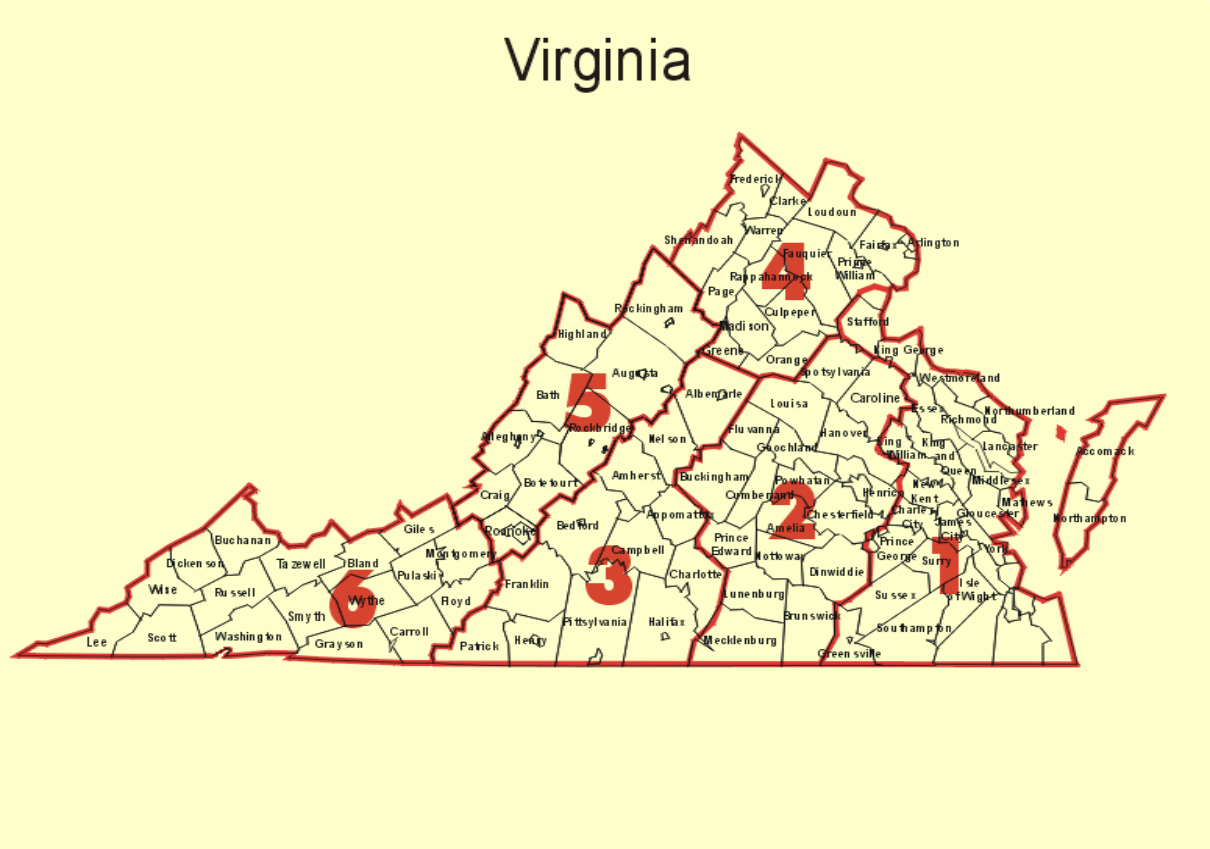


Figure 3.12 – The six distinct climate regions of Virginia, according to the National Weather Service: 1) Tidewater 2) Eastern Piedmont 3) Western Piedmont 4) Northern 5) Central Mountain 6) Southwestern Mountain.

The climate variables described in this chapter pertain to the latest "normal" climatological conditions, as determined through data collected across the state from 1991-2020 and published by the National

Oceanic and Atmospheric Administration's National Center for Environmental Information. Although the shifts and trends that are evident across this mere 30-year period are useful for predicting climate conditions into the future, a later chapter will explore in greater depth how and at what rate environmental change has and is expected to continue shifting Virginia's climatic patterns and subsequent selective pressures on Virginia's flora and fauna. Over the decadal tenure of this second Wildlife Action Plan revision, the climate conditions described below will be considered normal for the state.

Precipitation and Storm Patterns

Precipitation does not hydrate Virginia evenly. Several high-elevation summits and mountain sides average more than 70 inches of liquid-equivalent precipitation each year, at par with much of Africa's tropical Congo Region. On the other hand, some central and western regions of the state, including valleys directly adjacent to the wettest summits, receive only half that volume of precipitation in the average year. In those drier regions of the Commonwealth, moisture profiles more closely match the annual precipitation patterns for the semi-arid state of Nebraska. When averaged statewide, Virginia receives over 45 inches of precipitation every year with no distinct dry season, although monthly precipitation totals are about an inch greater than the annual mean from late spring through early fall (Figure 3.13).

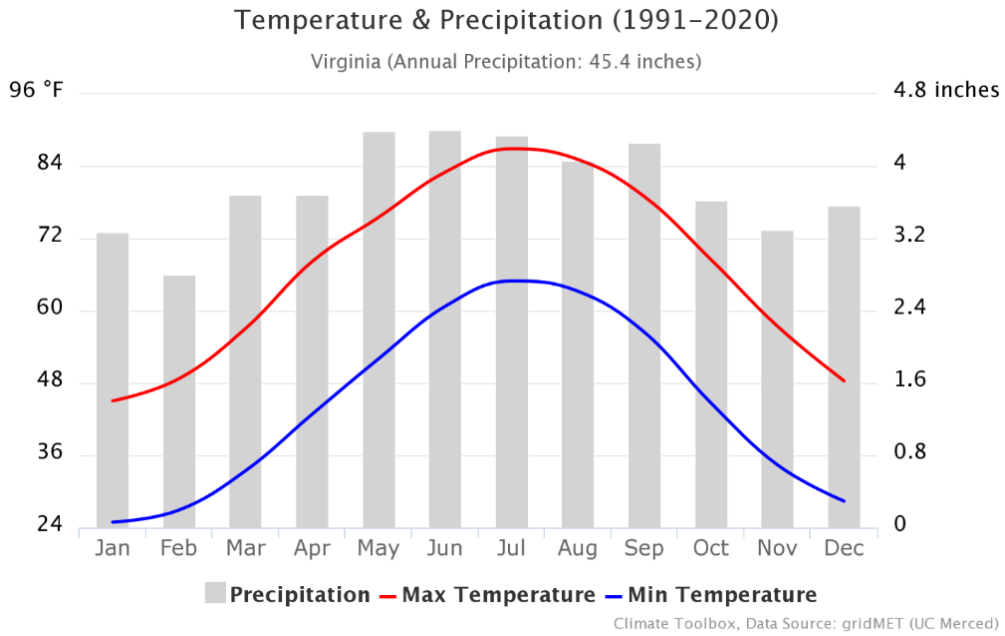


Figure 3.13 – National Oceanic and Atmospheric Administrations calculated normalized, 30-year period climate data for the state of Virginia. Temperature curves, like precipitation bars, reflect monthly averages in maximum and minimum daily temperatures.

As **Figure 3.14** illustrates, some years deviate significantly from the 45-inch average as a result of widespread flooding or droughts. Year-to-year vagaries in precipitation maintain dynamic pressures on Virginia's ecosystems, advantaging species that can tolerate a wide spectrum of moisture conditions.

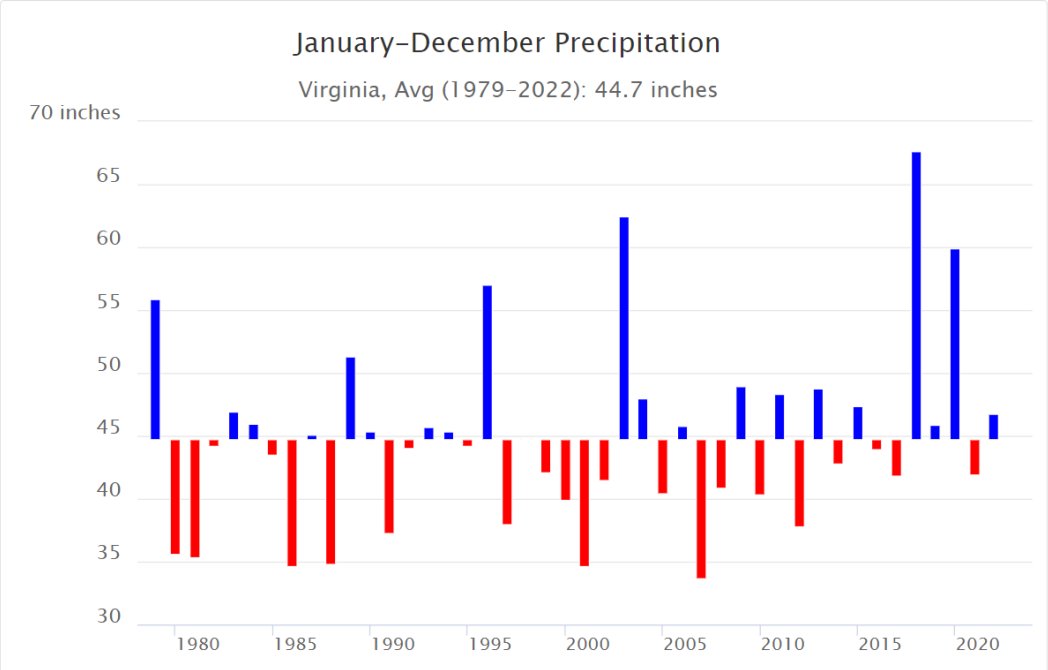


Figure 2.14 – Statewide precipitation averages over the past 43 years. Climate toolbox – University of California.

Regional disparities in precipitation can be attributed largely to the size, location, and orientation of Virginia's mountain ranges, river systems, and coastlines. The Appalachian Mountain range is often first to influence precipitation patterns across the state, since the plurality of storms entering Virginia in the average year move west to east, guided by the Coriolis-driven jet stream. These continental storms grow with the merging of warm, evapotranspiration-filled air from the Gulf of Mexico and Mississippi River Valley, and as they approach the Commonwealth, moist air is deflected upward by the Appalachian's western flank (**Figure 3.15**). Water vapor subsequently cools in the upper atmosphere and condensates in mass, inducing heavy precipitation. This topography-driven phenomenon is referred to as orographic precipitation and explains why far-southwest Virginia is consistently one of the wetter regions of the state. Over the past 30 years, parts of Lee and Wise County have averaged more than 55 inches of precipitation annually, with years of 60 plus inches occurring roughly 25 percent of the time (NOAA NCEI Normals Mapper).

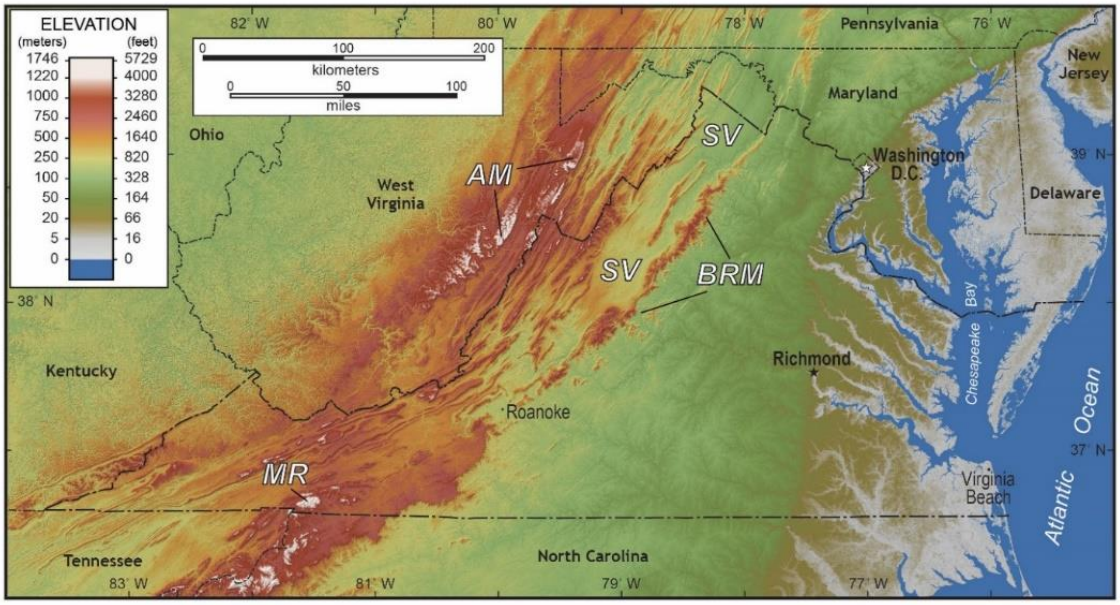


Figure 3.15 – Elevation map of Central Appalachia, with key landmark features centered in Virginia. BRM = Blue Ridge Mountains, SV = Shenandoah Valley, MR = Mount Rogers (Virginia's tallest peak), and AM = Alleghany Mountains of Western and West Virginia. Sourced from Bailey 2016.

Continental storms that make it up and over central Appalachia descend into Virginia's ridge and valley and western Piedmont terrain where they mix with warmer surface air that stifles condensation and resultant precipitation. With these eastern-advancing weather systems, eastern-facing mountain slopes are said to be in the mountain's rain shadow, or on the dry leeward side, and usually receive just a fraction of what fell on the western, windward mountain sides. The typically weakened and fragmented fronts continue their eastward journey across the Piedmont where they slowly regain precipitation potential by warming and rising higher in the troposphere, again where cooler air excites condensation. Fed steadily by an infusion of evapotranspiration coming off Virginia's river and riparian systems, storms tend to follow major rivers like the James and Rappahannock as they meander east towards the Chesapeake Bay and Atlantic Ocean. If this pattern sets in during the summer, when evapotranspiration rates peak, areas of the Piedmont most distant from major river systems can fall into periods of intense drought. These droughts can extend into the Coastal Plain but fronts typically reassemble by then with moisture supplements from the exceptionally humid coast.

Nevertheless, the eastern flank of the Appalachian Mountains, specifically the eastern-facing Blue Ridge mountains, consistently register the greatest annual precipitation totals (**Figure 3.16**). This is because the occasional storms, fronts, and systems tracking north from over the Gulf of Mexico or Atlantic Ocean are responsible for over half the state's precipitation. When precipitation moves into Virginia from the coastal southeast and abuts the eastern Blue Ridge escarpment, heavy orographic precipitation commences. Most of Virginia's highest-record flooding events have occurred when a strong oceanic storm stalled out against the eastern Blue Ridge. Such incidents have resulted in the dramatic reshaping of river channels within their floodplains or the sloughing off of entire hillsides via mud slides. Historic events like these can be particularly perilous for SGCN with confined distributions or heightened vulnerabilities and is why much focus is given here to increasingly extreme precipitation events.

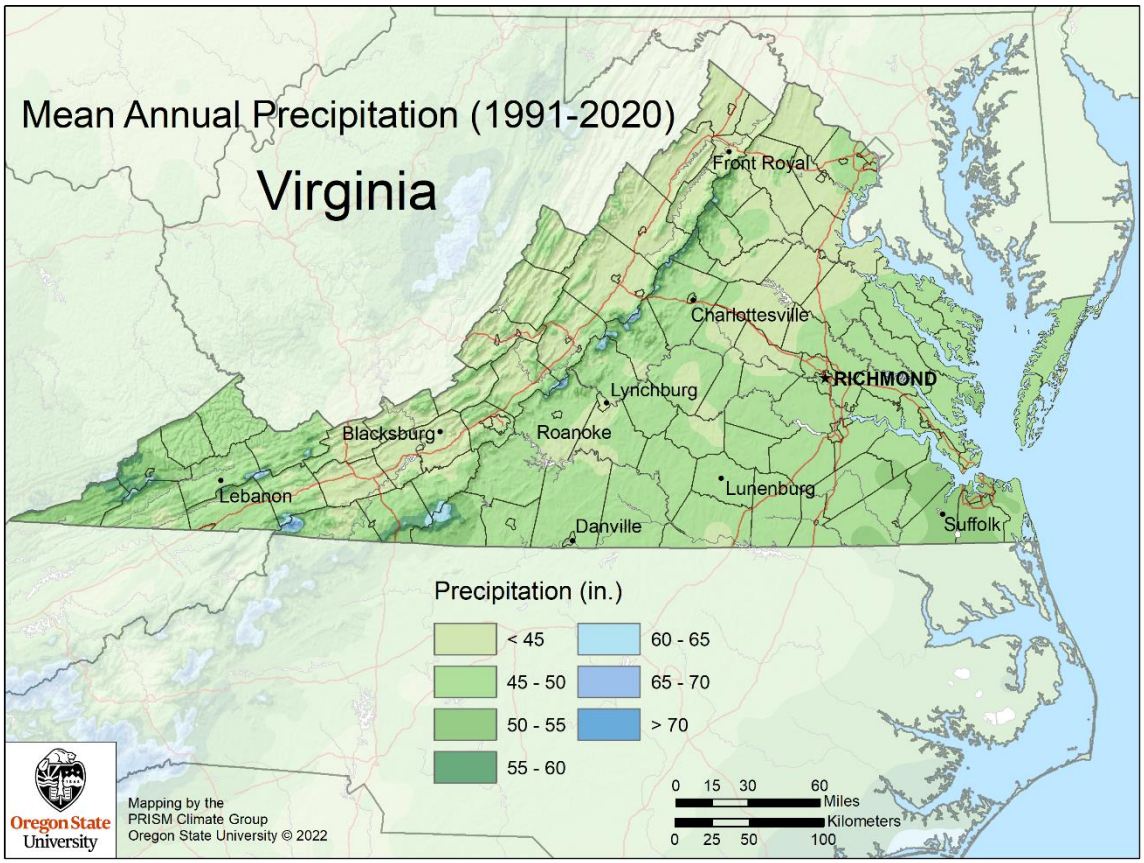


Figure 3.16 – Normalized, statewide precipitation totals map. PRISM climate group.

In the average year, ocean-sourced precipitation more than makes up for the precipitation that the Appalachian Mountains deprive Virginia's eastern terrain, except for the valleys that are bordered by mountains both to their west and east. As was noted by Hayden and Michaels in a previous Virginia climate summary (2011), "[w]hen the [air]flow is from the west, the New River and Shenandoah River valleys are in the rain shadow of the Appalachian Mountains; when the airflow is from the east, they are in the shadow of the Blue Ridge Mountains. As a result, both the New River and the Shenandoah River valleys are the driest portions of the state," averaging under 40 inches in a normal year. Furthermore, because the respective rivers flow north through both valleys, when occasional storms line up with the river's direction and drops into the bowl of the valley, leeward air currents force clouds down where condensation is less conducive. While some degree of drought is expected in these valleys each year, it is also normal for at least some other region of the state to endure a similar drought each year. And while droughts can strike anywhere, historic regional land-use practices, particularly industrial timbering and farming, alter evapotranspiration cycles and have been increasingly linked to drought proneness in-place and downwind (Marengo et al. 2018). Increased adoption of land-stewardship practices aimed at improving the water-holding capacity of soils are helping, but progress is difficult to discern amidst simultaneous growth in industrial land development. Like industrial farming, rapid expansion of

impervious surfaces via urbanization has demonstrated intensification of local drought and flood events (Roy et al. 2022).

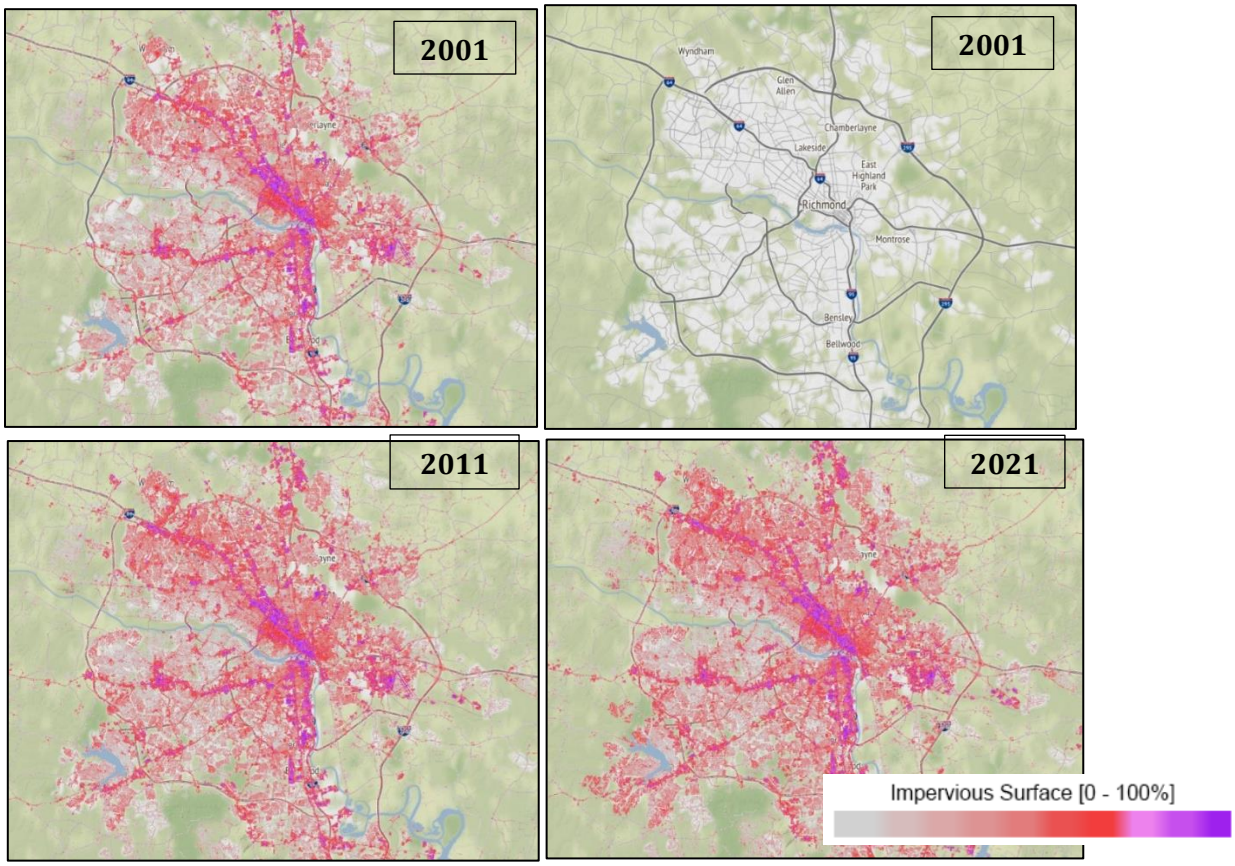


Figure 3.17 - Impervious surface-area coverage of Virginia's greater Richmond area. Images were derived from USGS Multi-Resolution Land Characteristics National Land Coverage Interactive Viewer web application

Storms sourced from the Atlantic and Caribbean oceans, and Gulf of Mexico can manifest in diverse temporal, spatial, and intensity scales of precipitation. Some systems deliver gentle soaking rains over extended periods of time, while others deliver extreme downpours in relatively short spurts. Of the various types of oceanic storms impacting Virginia, hurricanes often garner the most attention because of their acute, high-energy impacts capable of transforming built and natural infrastructure with the violent battering of wind, rain, and waves. The Bermuda High, a dynamic high-pressure system over the Northern Atlantic, is a major determinant of where hurricanes make landfall and subsequently traverse the continent (**Figure 3.18**). A narrow and contracted Bermuda High sends hurricanes north up the Atlantic seaboard, whereas a range extended Bermuda High funnels hurricanes west into the Gulf of Mexico. The former can result in a direct hit to Virginia's Coastal Plain, where damages are most severe Virginia's marine and estuarine ecosystems. However, hurricanes that end up impacting Virginia more commonly make landfall along Gulf shores and recurve northeast towards the Atlantic Ocean.

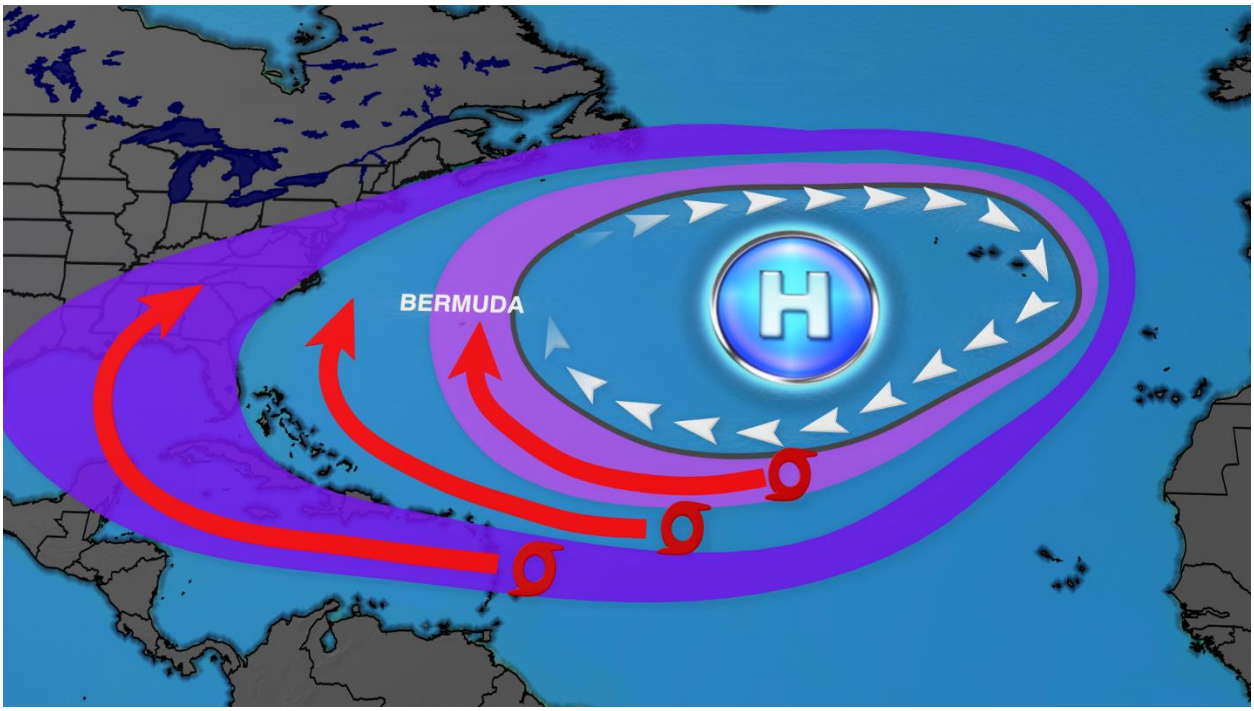


Figure 3.18 – The Bermuda High pressure extension scenarios and resulting pathway influence of tropic storms. Thomas (2021) Action News 5, Memphis Tennessee.

During peak hurricane season, typically September, tropical storms and hurricanes can contribute up to 40 percent of the state's monthly rainfall, rarely less than 10 percent (Hayden and Michaels 2011). Hurricane season for the Atlantic's northern hemisphere typically starts in June and goes through November.

Nor'easters are the other major ocean-originating storm system that impact Virginia. They are aptly named after the strong and persistent winds that blow in from the Northeast Atlantic, often days ahead of the storm. If the foreshadowing winds sustain for days, wind-driven storm surge can dramatically inundate coastal lands. Waves have reached, but are not limited to, 30 feet in height (ACS UVA, 2010). Like hurricanes, severe Nor'easters often result in transformed coastal habitats, saltwater-inundated coastlines, and extreme inland precipitation. However, Nor'easters are massive, slow-moving systems that can span 1,000 miles and unload their disturbance over relatively long durations of time. While hurricanes rarely hit Virginia directly, the Commonwealth lies at the center of the typical latitudinal band where Nor'easters make landfall along the eastern seaboard. Moreover, because Nor'easters tend to develop during the winter and early spring in a more northern reach of the Atlantic, they are "cold-core" systems that are as likely to precipitate snow and ice as they are cold rain. As they move inland, precipitation can intensify, particularly if polar air from the continental jet stream is nearby to force the ascent of warm-moist oceanic air. An oft-cited example of a Nor'easter that intensified upon landfall was the blizzard of December 1989, which resulted in the first-ever recorded white Christmas for the entire Atlantic Coastline. **Figure 3.19** reveals the expansiveness of the most recently memorable Nor'easter to hit New England and the Mid-Atlantic. Coastal forces of these magnitudes exert great pressures on species inhabiting Virginia, and when severe enough, can serve as singular events that restrict which species persist in the state. For species whose northernmost range is expanding into

Virginia as a result of warming temperatures, a single Nor-easter can knock back decades of range expansion. Conversely, the same Nor'easter might offer a high-latitude, cold-loving species a few more years of competitive advantage before their predicted extirpation due to increasing temperatures.

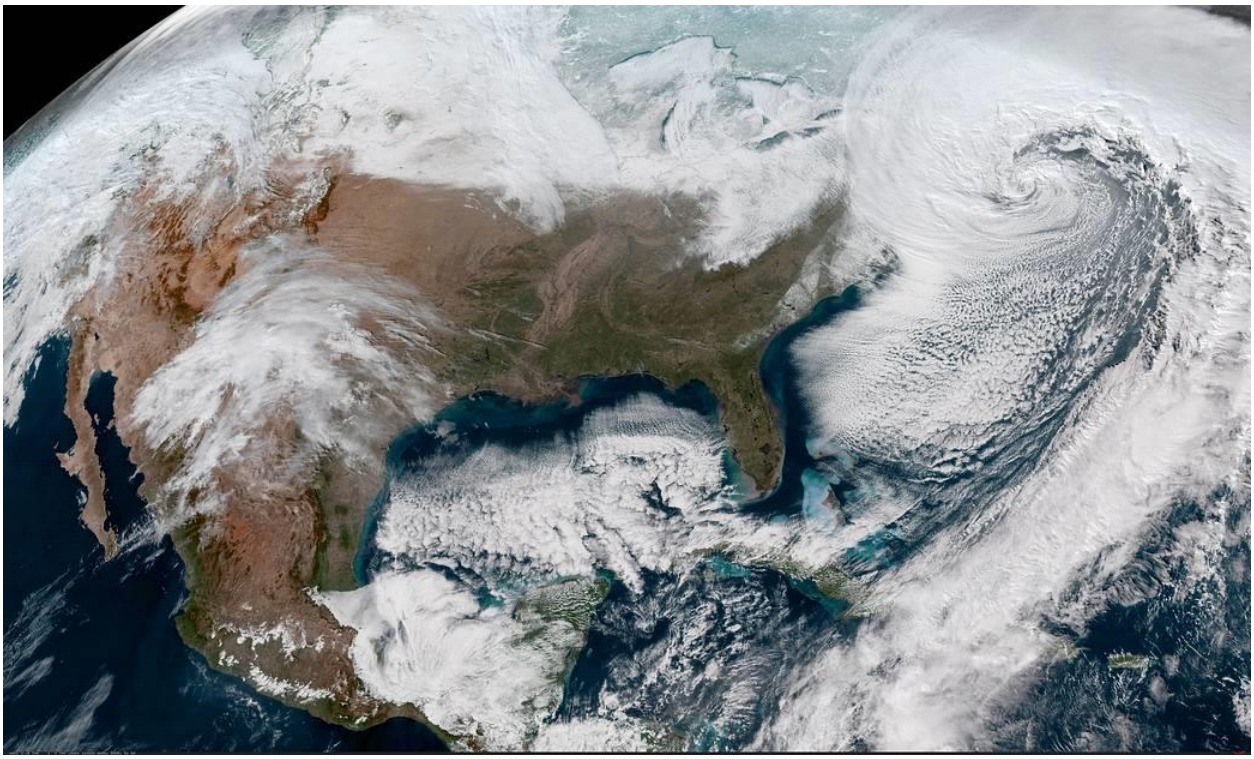


Figure 3.19 – Satellite view of the powerful January 2018 Nor'easter that engulfed much of the Northern U.S. in a harsh blizzard.

Virginia's wintertime temperatures are more likely than moisture availability to be the determining factors as to how much precipitation falls as snow and ice in a given year. It is rare for measurable snow or ice to fall outside of winter, except for select areas of Virginia's highlands. Naturally, mountainous regions of the state receive far greater winter weather than the Piedmont or Coastal Plain. The western sliver of Highland County, Virginia's snowiest area, receives 20 annual snowfall events of one inch or more and well over 40 inches in the average year, all despite being in the snow shadow of West Virginia's Alleghany Mountains, just a few miles away from where some of the highest annual snowfall accumulations in the Eastern U.S. are recorded, at more than 100 inches (Hayden and Michaels 2011). Conversely, because surface waters of the Chesapeake Bay and Atlantic Ocean retain the solar heat of summer well into the first part of winter, snowstorm development along the eastern part of the state is unlikely, though not impossible. But again, and not coincidentally, the eastern flank of the Blue Ridge accounts for the state's heaviest single and multi-day snowfall events. The top five three-day snowfall records in Virginia belong to the northern Blue Ridge range; of which the blizzard of 1996 is the most significant at 49 inches in Madison County (NOAA 2023). As increasing temperatures makes for milder Virginia winters, sleet and freezing rain become more likely outcomes of high-moisture cold fronts. This is an important trend for SGCN and their habitats because freezing rain can damage large enough swaths of vegetation to induce population-level impacts.

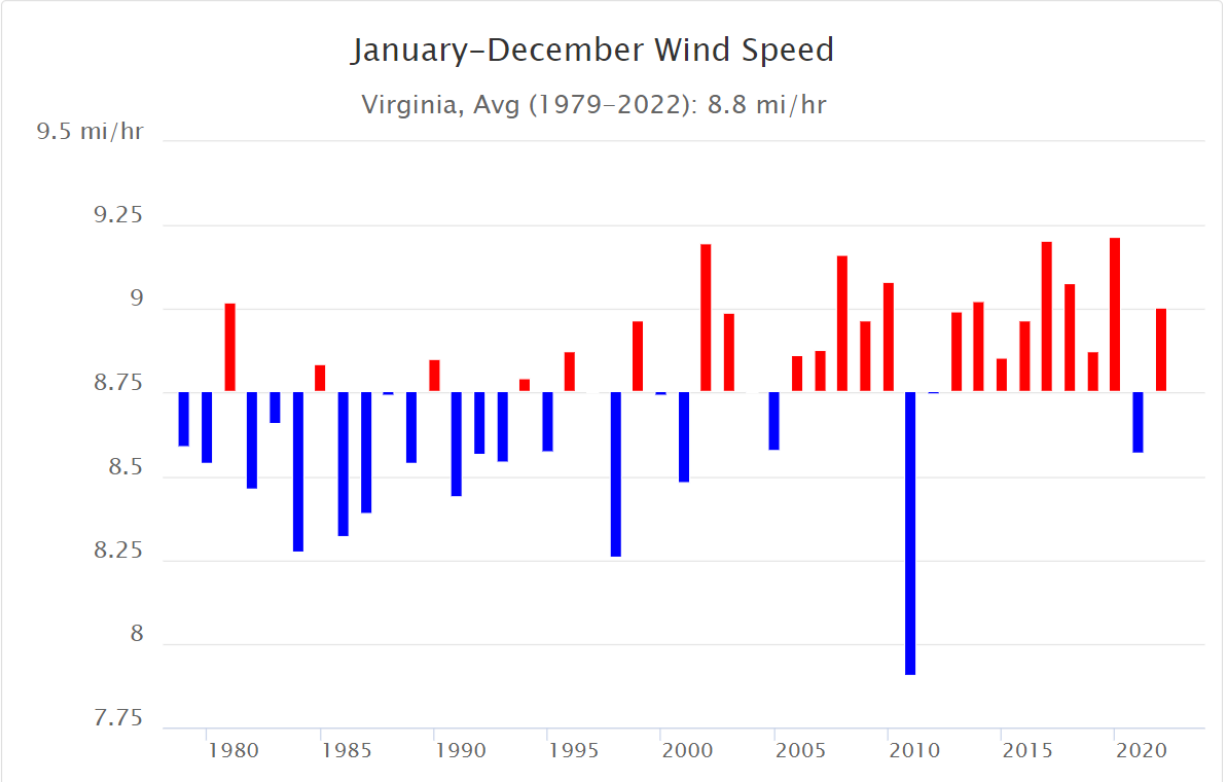


Figure 3.20 - Statewide windspeed averages over the past 43 years. Climate toolbox – University of California.

Tornadoes are not particularly common in Virginia, relative to many other states. Over the past 25 years, Virginia has averaged 20 per year, comprising about 1 percent of the nation's total annual tornadoes (NOAA 2023). April, May, and September account for over half of Virginia's tornadoes, which coincide with the typically windy spring and peak hurricane season – hurricanes routinely spin off tornados as they unload energy inland. With a nine-mile-per-hour average wind speed (**Figure 3.20**), Virginia is not a relatively windy state – likely a result of Virginia's heavily forested landscape and state-spanning mountain ranges. Naturally, wind speeds are greatest where air-fetch is minimally impeded, along the coastline and atop bald Appalachian summits.

Temperature

The average annual temperature in Virginia registers at 55.6°F but can range considerably from year to year. Over the most recent "normalized" 30-year period (1991-2020), average annual temperatures have diverged from the mean low of 53.6 °F (1996) to a mean high of 58.2 °F (2012) (**Figure 3.21**).

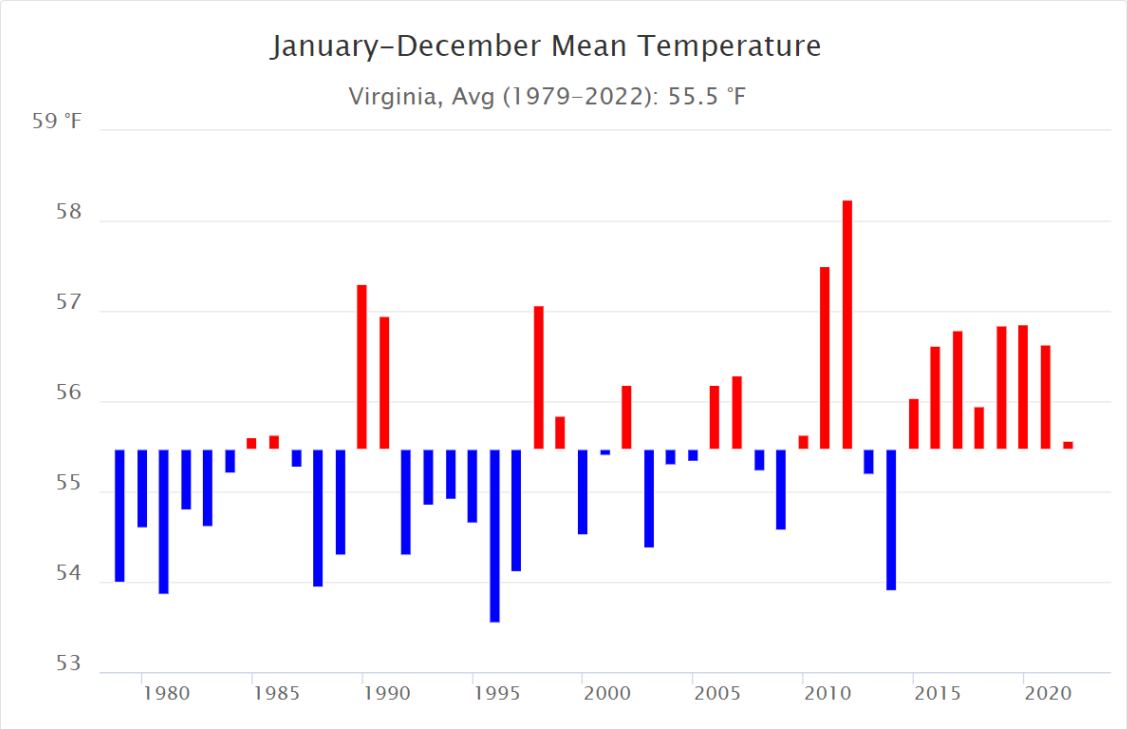


Figure 3.21 - Statewide temperature averages over the past 43 years. Climate toolbox – University of California.

Like precipitation, variance in temperature patterns across the Commonwealth is primarily a function of topography and coastal proximity. Virginia has five mountain peaks that extend beyond 5,000 feet in elevation, the tallest of which is Mount Rogers at 5,729 feet above sea level (**Figure 3.22**). Mount Rogers

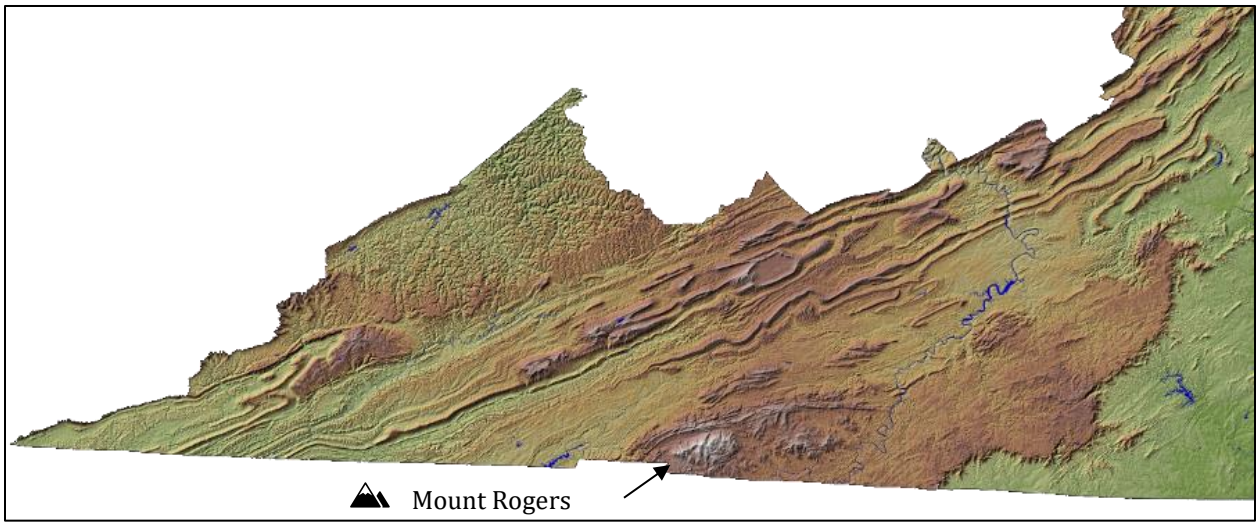


Figure 3.22 – US Geological Survey (USGS) NED Shaded Relief topographical layer of Southwest Virginia, featuring Mount Rogers, VA's tallest peak at 5,729 feet above sea level. Virginia's other four summits above 5,000 feet in elevation are within 7 miles of Mount Rogers.

substantiates the general rule that average temperatures fall 3.5°F for every 1,000 feet ascent in elevation, as it averages approximately 20° F cooler than the Tidewater, year-round. However, because Mount Rogers is near Virginia's southern border, several summits at lower elevations but more northerly reaches of the Commonwealth are comparable in coolness to the state's true pinnacle

(VP.org). Thus, the topography of Virginia "usually masks the 3° latitudinal difference between the state's southern boundary and its northernmost point," noted Terwilliger (1991).

Virginia's generally humid, subtropical climate is the product of a near-middle latitude (upper 30°s Lat) and warm coastal influence. The moist, warm air entering Virginia from the Gulf Stream offshore is effectively illustrated by the orange-to-red colored cells in **Figure 3.23.** Most of that land area is below 2,000-foot elevation and categorically falls under Köppen climate classification code *Cfa*: temperate with no dry season and a hot summer (≥ one month above 71.6°F). While parts of the Western Piedmont, Northern, and Southwestern Mountain regions marginally qualify for this climate class, Tidewater cities

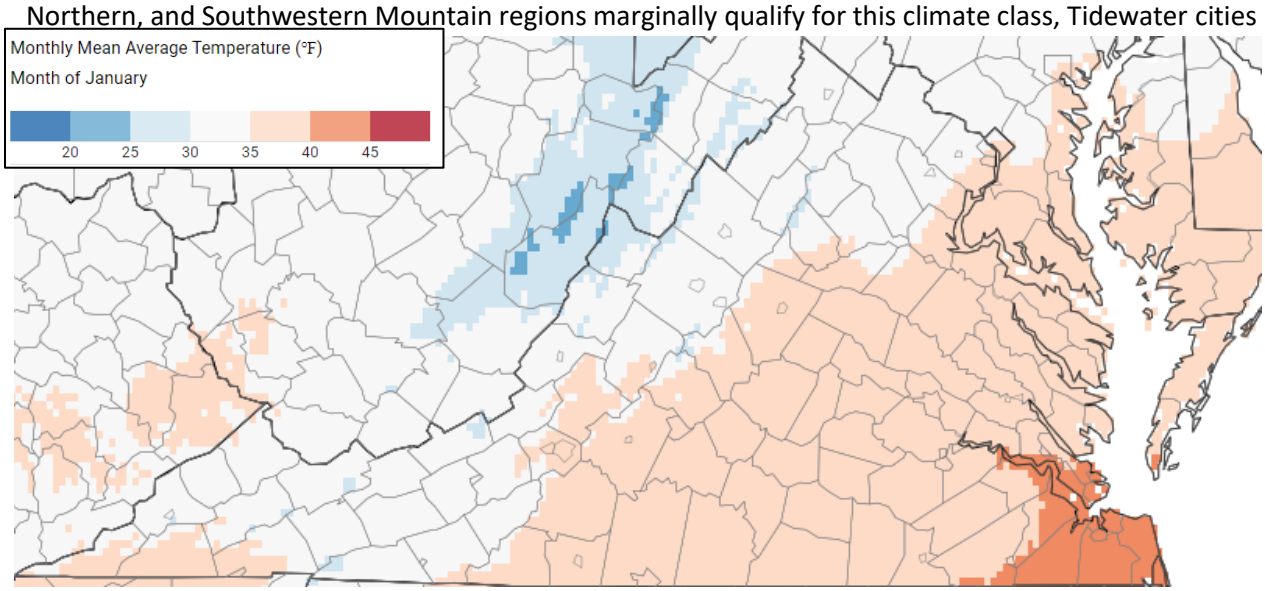
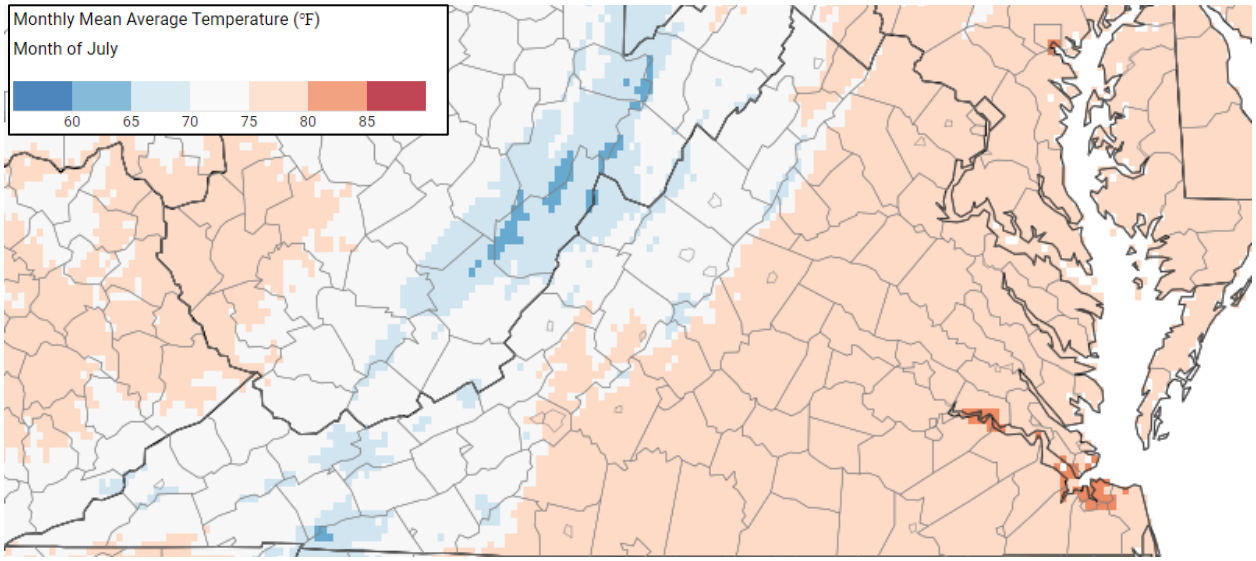


Figure 3.23 – Above, 1991-2020 normal-mean temperature for the month of January (range from 22.86 to 41.75°F). In contrast below is the 1991-2020 normal-mean temperature for the month of July (range from 61.19 to 80.19 °F).



like Chesapeake and Portsmouth fall firmly within the *Cfa* bounds, consistently recording the state's warmest temperatures throughout the year. The mountainous regions qualify Virginia for two other Koppen climate zones, *Dfa* and *Dfb*, the former being associated with white cells and the latter with the select blue cells in **Figure 3.23**. Both zones are associated with milder summer and colder winter

temperatures. These cooler zones, particularly *Dfb*, serve as key thermal refuges for heat-intolerant species. As changing environmental conditions continues to shrink *Dfb* and *Dfa* climate zones to isolated mountain ridges and peaks, so too will the population ranges of remnant cold-obligate species.

Mountainous topography and ocean influence also regulate plant and wildlife phenology. The peak flush of springtime blooms and buds moves northwest across the state, mirroring the heat maps shown in **Figure 3.23**. Virginia's frost-free growing season averaged nearly 194 days from 1991-2020, more than half the year (**Figure 3.24**). But like other climatic variables, the growing season varies considerably across regions of the state. In the average year, southeast Virginia, including the Eastern Shore, experiences three additional months of growing season over the more mountainous parts of western Virginia (STEM), such as Virginia's highest valley, Burkes Garden. Such dramatic differences translate to unique floral and faunal compositions across the state and its four distinct seasons.

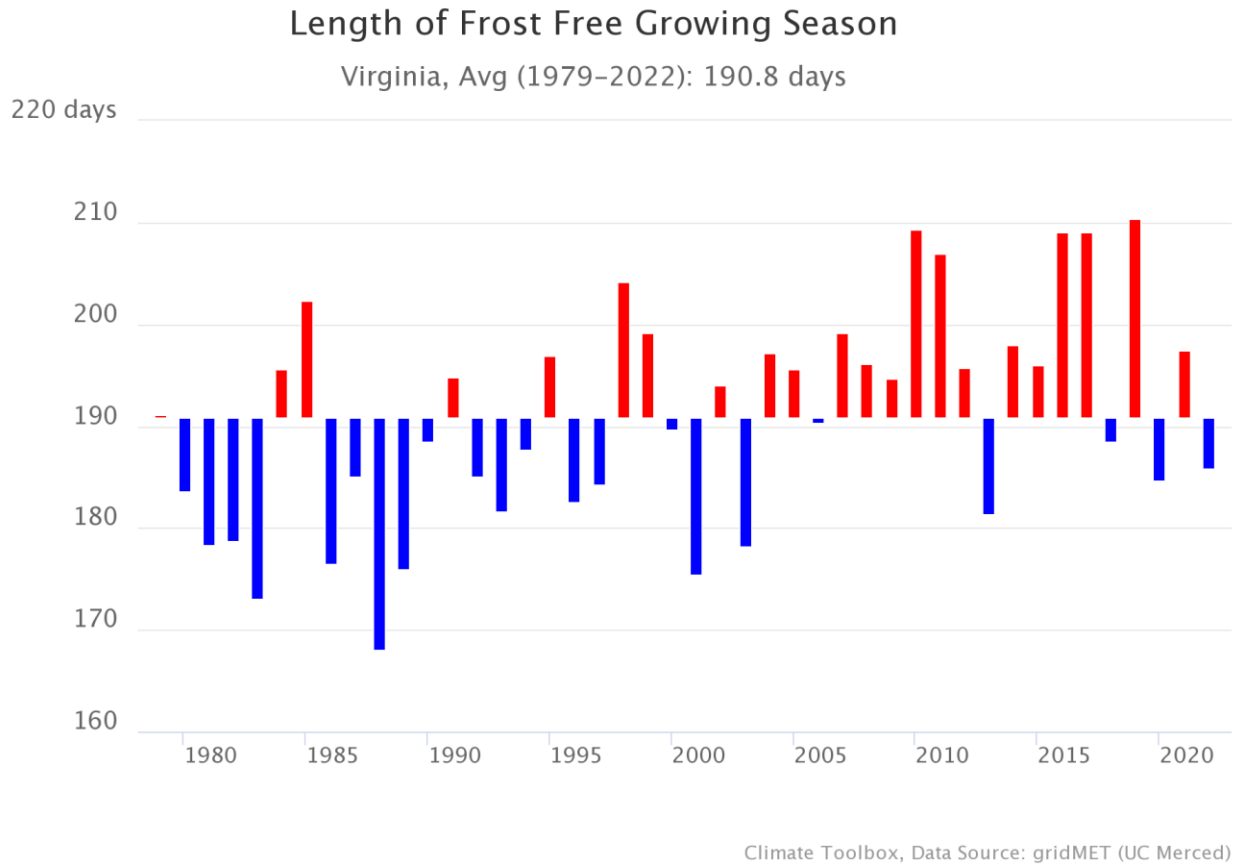


Figure 3.24 – Average length of frost-free growing season in Virginia. When clipped to the normalized data range of 1991-2020, the average climbs to 193.8 days. Climate toolbox – University of California.

Given the emphasis placed here on discerning the state's regional climates, it is worth noting that the lines dividing the six regions (**Figure 3.12**) are fluid and subject to considerable movement year to year. It is, for example, not exactly uncommon for the Central Mountains to experience temperatures and precipitation more normal to the Western Piedmont, and vice versa. The expansion or shrinking of regional climates further complicate climate dynamics experienced by Virginia's biota.

5. THREATS

Overview

Threats and conservation actions are described at the species level, with the DWR's taxonomic teams pairing each SGCN with three high-priority threats and three associated conservation actions. To develop these sections, the authors tasked the TACs with first identifying three threats drawn from the Conservation Management Partnership's (CMP) Direct Threat Classification Lexicon. This approach allows for population impacts to be classified using a standardized definition and coding system. This tactic was recommended by the Northeast Association of Fish and Wildlife Agencies so as to allow for comparable species impact narratives and regional aggregate statistics to support multi-state and regional conservation initiatives. The TACs were then asked to write a short description on the conservation action recommended to address the associated threat; unlike the threats, these action descriptions do not follow standardized definitions, and TACs were encouraged to include whatever narrative information would be most useful to managers in Virginia. By standardizing the threats but not their corresponding actions, the authors intend to build a Plan that is both useable to a wide variety of potential partners and aligned with regional assessments and conservation efforts.

The 2015 update of the Wildlife Action Plan attributed threats at the habitat level and subsequently paired them with the SGCN which lived in those habitats. For the 2025 Update, the authors have departed from this strategy for two reasons. First, some SGCN are most directly impacted by threats which are not habitat related. Examples of such threats include high-impact pathogens, a major threat to several terrestrial mammal SGCN, and poaching/illegal pet trade, a major threat to several marine and reptile SGCN. Additionally, threats which may be habitat-centered are often best addressed with conservation actions which are unique to a particular SGCN and therefore not uniform across a particular habitat type. The habitat type summaries found on page 28 also include expert assessments on the biggest threats affecting each of these areas and the conservation actions which support broader landscape recovery.

The SGCN threats and associated conservation actions included in this section are not ranked by importance, conservation opportunity, or any other metric. All three threats are considered equally as the most paramount concerns for each SGCN. Whenever possible, the authors attempted to capture threats and actions which are manageable at a local or near-local scale. However, many SGCN required threat narratives centered around systemic challenges such as changing environmental conditions or environmental regulatory structures. As with Element 1 and Element 2 of this Plan, all data were first provided by the DWR's taxonomic efforts, then reviewed by the Stakeholder Advisory Committee, then re-verified by the taxonomic experts before final review from the Plan authors.

The NE Regional Conservation Synthesis summarizes the issues and problems identified in the 14 Northeast Wildlife Action Plans that may adversely affect regional SGCN or their habitats. It also describes the priority research and survey efforts needed to support restoration and improved conservation of these species and habitats. Following the development of the 2015 Plans, the Northeast State Wildlife Action Plan Synthesis: Regional Conservation Priorities report synthesized the threats to both species and habitats identified in the 14 individual state Plans (TCI and NEFWDTC 2017). The

Conservation Measures Partnership (CMP) and the International Union for Conservation of Nature (IUCN) have developed several threat classification systems, which were advanced by Lamarre *et al.* (2021) for use in Quebec. This classification system is consistent with the older classification systems and was modified to include relevant threats for the Northeast. The only change the Virginia staff made to the threat codes was to specifically add Data Centers to the Residential & Commerical Development codes under 1.2.1 Commercial & Industrial Areas. This was done in response to a request from the Rappahannock Tribe to specifically call out data centers for their impacts to land and water and their energy requirements.

1. **Residential & Commercial Development** – This threat refers to all human settlements (cities, towns, etc.) or non-agricultural land uses with a substantial ecological footprint. It includes habitat conversion that is associated with early phases of development (deforestation, filling/excavation, drainage, etc.), as well as infrastructure use, maintenance and subsequent impacts that are related to the presence of infrastructure (e.g., birds flying into window) It excludes transportation- and pollution-related issues.

    1.1. Housing & Urban Areas – Anything that is related to or integrated with urban or housing structures. Urban areas (cities), suburbs, villages, cottages, shopping areas, offices, schools, hospitals, and urban parks, among others.

    1.1.1. Dense Housing & Urban Areas – medium- to high-density development for residential use and buildings for related services. Allows very little to no maintenance of ecological functions. E.g., urban areas, suburbs, villages, schools, libraries, seniors' housing, hospitals

    1.1.2. Low-Density Housing Areas – extensive development that is residential (including resorts), where the spacing allows ecological functions to continue to some extent. This type of development is seen particularly in rural and agroforestry areas. E.g., residential buildings in agricultural areas, cottages, vacation homes near water bodies, ecotourism lodges, fishing resorts, backcountry ski lodges.

    1.2. Commercial & Industrial Areas – anything that is related to or integrated with commercial or industrial structures, as well as designated areas for storing waste material. Includes animal deterrence activities, which are needed near certain infrastructures.

        1.2.1. Commercial & Industrial Areas – e.g., industrial parks, manufacturing plants, offices, shopping centers, all military base facilities, power plants, seaports, shipyards, airports, and data centers (includes impacts resulting from development, water withdrawal impacts and energy supply requirements.)

        1.2.2. Open Dump Sites – open-air facilities that are used to dispose of materials or to store them prior to recycling. E.g., automobile junkyards, metal recycling centers

        1.2.3. Landfills

1.2.4. Nuclear Waste Disposal Facilities

1.3. Tourism & Recreation Areas – Tourist sites or recreational facilities with a significant ecological footprint. Excludes residential infrastructures.

1.3.1. Parks and Sports Fields – areas that are intensively managed (e.g., grass-cutting, thinning of woodlands) and are primarily designed for recreational activities, such as walking in urban parks and sports. Also includes outdoor sites that are managed for prayer or mourning (cemeteries)

1.3.2. Campgrounds – sites that are maintained for camping activities, for which the facilities may have some ecological impact. To be distinguished from wildness camping without amenities (Threat 6.1.5). E.g., car or RV camping areas, with or without services, camping with site management and/or facilities.

1.3.3. Ski Resorts – rights-of-way of ski trails (managed areas of the hills) and service facilities (ski lifts, visitor centers, etc.)

1.3.4. Recreational Trails – creation of trails in parks (see Parks and sports fields, Threat 1.3.1) or areas outside the urban environment for walking and recreation. Includes the creation and maintenance of trials in recreational parks as well as private properties. Excludes activities that are related to the use of the trail (e.g., hiking, Threat 6.1.2).

1.3.5. Docks & Marinas – high-impact infrastructures that are associated with recreational boating. To be distinguished from the activity of recreational boating itself (Threats 6.1.4) and includes local dredging. E.g., docks, marinas, boat launches.

2. **Agriculture & Aquaculture** – Threats from agricultural activities, such as the expansion and intensification of agriculture and livestock farming, including silviculture, mariculture, and aquaculture and related infrastructures. This includes the initial conversion of habitat (deforestation, filling/excavation, draining of wetlands, etc.) that is associated with cultivation or infrastructure development, as well as uses and practices (intensification of agricultural practices, use of machinery, etc.), but not the transport of the resources that are produced, crop irrigation, of the resources that are produced.

2.1. Annual & Perennial Non-Timber Crops – Non-timber crops that are planted for food, fodder, fuel or other uses; farms, crop fields, vineyards, mixed agroforestry system, etc. For rotational crops, it is necessary to refer to the most intensive practice that is used. Considered the diversity of agricultural practices and related impacts, some specialty cultures will be pooled into a generic threat category.

2.1.1. Annual Cropping Systems (field crops) – wide-row crops that require the most intensive agricultural practices and which has the most significant impacts. E.g., maize (corn), soybean, barley, vegetable crops, oat, wheat, canola, hemp.

2.1.2. Perennial Cropping Systems – crops that are associated with less intensive agricultural practices that have less of an ecological impact than do annual crops. E.g., pastures, forage crops, hay, alfalfa, clover.

2.1.3. Other Types of Agriculture – specialty crops for which the ecological impacts may vary depending on the practices that are used. E.g., cranberry bogs, vineyards, verry fields, sod production, greenhouse farming.

2.2. Plantations – Wood plantations that produce timber, fiber or other non-timber products that are made from trees and which maintain a certain amount of forest cover year-round. This type of plantation is generally located outside of natural forests and often consists of non-native tree species.

2.2.1. Plantation of Pulpwood – cultivation of hybrid poplars and other species that are used for pulp production.

2.2.2. Ornamental Tree Plantations – e.g., cultivation of ornamental cedars, Christmas tree farms.

2.2.3. Non-Timber Products from Plantation – cultivation of trees outside of natural forests for the production of fruits, nuts, barks or sap. E.g., orchards, walnut production, rubber production

2.3. Livestock and Poultry Farming – Farming of various domestic (cow, pigs, chickens, sheep, goats, turkeys, ducks, etc.) or semi-domesticated animals (llamas, alpacas, etc.); livestock rearing in outdoor pens (farms) or extensive rearing in natural habitat (pastures, ranching). Productivity is measured in terms of animal units.

2.3.1. Outdoor Extensive Livestock Operation (On Pasture)
2.3.2. Outdoor Intensive Livestock Operation (High-Density)
2.3.3. Indoor Livestock Operation

2.4. Marine & Freshwater Aquaculture – Aquaculture that is conducted in different types of facilities (finfish aquaculture in the ocean, in tanks, in pens, along the shoreline, etc.). Farminig fish for the purpose of stocking natural lakes falls under this category. IT also includes the construction, maintenance and use of facilities but not the transport of resources (threat 4) and contaminants (threat 9).

2.4.1. Marine Finfish Aquaculture
2.4.2. Finfish Aquaculture in Outdoor Tanks
2.4.3. Finfish Aquaculture in Indoor Tanks
2.4.4. Algae Cultivation
2.4.5. Marine Shellfish Cultivation – e.g., oyster farming and cultivation of other shellfish (scallops, mussels, softshell clams, etc.)

3. **Energy Production & Mining** – Threats from the production/development of non-biological resources, including the conversion of the original habitat, development of necessary infrastructure, as well as uses and practices (use of machinery, exploration, excavation, drilling

and storage of ore or drill cuttings, tailing ponds, settling ponds, site reclamation after development, etc.). Excludes the transport of resources (threat 4) and contaminants (threat 9). Also includes the impacts of wildlife collisions with the related infrastructure.

3.1. Oil & Drilling – Exploring for (prospecting), developing and producing petroleum or other hydrocarbons.

- 3.1.1. Onshore Oil Development
- 3.1.2. Offshore Oil Development
- 3.1.3. Oil Development in Freshwater
- 3.1.4. Onshore Natural Gas Development
- 3.1.5. Offshore Natural Gas Development
- 3.1.6. Natural Has Development in Freshwater

3.2. Mining & Quarrying – Exploring for, developing and producing minerals, rocks and various other substrates (sand, gravel, etc.). Includes trialing treatment (settling and tailings ponds), site expansion and site reclamation after development. This threat does not include the transportation of resources (threat 4) and acid mine drainage (treat 9.2). Although not a mineral resource, peat harvesting induces impacts on the ecosystem that are similar to quarries and sandpits due to the use of similar excavation machinery. E.g., coal mines, mining of various sources of metals (gold, copper, nickel, magnesium, etc.), quarries, sand pits.

- 3.2.1. Underground Mines
- 3.2.2. Open-Pit Mines
- 3.2.3. Quarries & Sand Pits
- 3.2.4. Peat Harvesting

3.3. Renewable Energy – Exploring and developing infrastructure for and producing renewable energy; excludes its transport (threat 4).

- 3.3.1. Hydroelectric Dams
- 3.3.2. Wind Farms
- 3.3.3. Hydrokinetic Turbines
- 3.3.4. Solar Farms

4. **Transportation & Service Infrastructure Corridors** – Threats from developing, using and maintaining transportation infrastructure corridors (road, pipelines, power lines, etc.) and their rights-of-way. These types of facilities may create obstacles or hinder the natural movement of species in addition to causing disturbances during maintenance (e.g., disturbance of falcon nests during bridge maintenance; widespread avoidance of roads by caribou, etc.). This threat also includes vegetation control during rights-of-way maintenance and collisions with wildlife.

4.1. Roads & Railroads – Development, maintenance, and presence of the surface transportation network. The impact of rights-of-way may vary according to their size.

- 4.1.1. Roads
- 4.1.2. Railroads
- 4.1.3. Bridges – includes road and rail network bridges.

4.1.4. Logging Roads

4.2. Utility & Service Lines – Linear networks for transportation energy and various resources, including their rights-of-way. Possible impacts: electrocution, barrier to dispersal, habitat modification/loss, fatal collisions.

4.2.1. Power and Service Lines – networks of buildings, towers, pylons and poles that are associated with electricity distribution and telecommunications, excluding hydroelectric dams of power plants (Threat 3.3.1). The scope of rights-of-way may vary according to their size.

4.2.2. Oil & Gas Pipelines – infrastructure network for transporting oil and natural has products aboveground or underground, including seismic lines, but excluding extraction sites (Threat 3.1)

4.3. Shipping Lanes – Threats associated with transportation people and goods on water (oceans, estuaries, rivers, etc.), as well as waterway development. This category does not include activities that are related to creational boating (Threat 6.1)

4.3.1. Shipping – ships striking wildlife, damage associated with wake waves, disturbance caused by the presence of vessels transporting people and goods

4.3.2. Dredging of Shipping Lanes – dredging in order to facilitate the transit of boats. Excludes dredging within marinas and docks (Threats 1.3.5) and dredging for looks and canals (Threat 4.3.3)

4.3.3. Locks & Canals – creation, maintenance, and use of locks and canals. Includes the associated dredging.

4.4. Flight Paths – Using air space to transport people and goods, excluding recreational activities such as hang-gliding and drones (Threat 6.1)

4.4.1. Flight Paths – flying airplanes, paragliders, helicopters or ultralight aircraft at low altitudes, which could lead to collisions with birds or disturbance of other wildlife. E.g., disturbance of caribou herds by low-altitude training flights.

5. **Biological Resource Use** – Threats that are due to the use/consumption of wildlife biological resources, including the impacts of legal, illegal and unintentional harvesting. The disturbance and control of certain species falls under this threat category, which includes habitat conversion and degradation, the development of related infrastructure as well as the uses and practices that are associated with the latter (e.g., use of machinery, wood storage, soil management). Excludes the transport of resources (e.g., logging roads (Threat 4.1) and peat harvesting (Threat 6.3))

5.1. Hunting & Collecting Terrestrial Animals – Hunting animal species or collecting animal products for commercial, recreational, subsistence, cultural, research study or control purposes. Including hunting terrestrial species and trapping semi-aquatic species. This

category also covers incidental captures, control and persecution, but excludes harvesting for research purpose (Threat 6.3)

5.1.1. Hunting– harvesting of wild animal species by hunting for recreation or subsistence that is governed by management measures. Including incidental killing, but illegal harvesting or killing should be classified under "Poaching/Persecution of terrestrial animals" (Threat 5.1.4). Excludes contamination of habitats due to solid lead from hunting ammunition (Threat 9.4.2). E.g., hunting with firearms, bows or crossbows, or blunt objects for sport or subsistence, taxidermy, trophies.

5.1.2. Trapping – harvesting of wild terrestrial or semi-aquatic animal species (e.g., beavers_ by trapping that is governed by management measures. Includes incidental killing, but animal control by trapping should be classified under "Management/control for terrestrial animals" (Threat 5.1.5). E.g., trapping of wild terrestrial or semi-aquatic animals for fur, meat, taxidermy, trophies, non-target birds or prey caught in traps.

5.1.3. Non-Lethal Harvesting of Terrestrial Animal Products – harvesting of terrestrial animal products that does not require the killing of individuals and that is governed by management practices. E.g., down collection, guano collection.

5.1.4. Poaching/Persecution of Terrestrial Animals – illegal harvesting of terrestrial animals or animal products (e.g., feathers) for personal, commercial or persecution purposes, or actions that would be interpreted as abuse or harassment of wildlife. E.g., people killing birds of prey, people deliberately harming snakes out of fear, illegal collection of seabirds or shorebird egg collection, illegal wildlife trade for skins, meat or the pet trade.

5.1.5. Management/Control of Terrestrial Animals – deliberately killing individuals of a terrestrial species for human gain that is governed by management measures. E.g., cormorant culling.

5.2. Gathering Terrestrial Plants or Fungi – Harvesting and gathering wild plants, mushrooms or other non-animal/non-timber species for commercial, recreational, subsistence, cultural, research or control purposes, but excludes research (Threat 6.3)

5.2.1. Recreational or Subsistence Harvesting – harvesting or plant or fungi species that has a lethal effect on the individual and is governed by managed measures. Illegal harvesting should be classified as "Poaching/eradication of terrestrial plants or fungi" (Threat 5.2.4) E.g., recreational or subsistence harvesting of wild leeks.

5.2.2. Commercial Harvesting – commercial harvesting of plants or fungi species that has a lethal effect on the individual and is governed by management measures. Excludes peat harvesting (Threat 3.2.4) and products from plantations (Threat 2.2). E.g., commercial harvesting of fiddleheads.

5.2.3. Non-Lethal Harvesting of Terrestrial Plant Products – sub-lethal harvesting of plants or fungi related products, which is governed by management measures. E.g., collecting of cedar bark, tree tapping for sugar maple production.

5.2.4. Poaching/Eradication of Terrestrial Plants or Fungi – deliberate and illegal harvesting of plants or fungi for personal or commercial purposes oreradication due to prejudices against the species. e.g., illegal gathering of American ginseng, eradication of cow parsnip because of its similar appearance of giant hogweed, which is an invasive alien species.

5.2.5. Management/Control of Terrestrial Plants or Fungi – deliberately destroying a plant species or fungi for human gain. Includes indirect or unintended impacts on other species, but excludes cutting or vegetation management due to maintenance activities or early phases of development. E.g., eradication of dandelions from lawns.

5.3. Logging & Wood Harvesting – Harvesting trees/other forest species in natural environments for timber or fiber outside of plantations (Threat 2.2). Includes cutting and the use of machinery, as well as wood storage and debris management, excluding their transport (Threat 4.1) and associated erosion (Threat 9.3)

5.3.1. Complete Removal of the Forest Cover – cutting removing the majority of the forest cover. E.g., clear-cutting and related cuts (CT, CRS, CPRS, CPHRS, CPPTM).

5.3.2. Partial Removal of the Forest Cover – partial cutting of the forest leaving a certain amount of cover. E.g., shelterwood cutting, selection cutting.

5.3.3. Improvement Cutting in Natural Forests – silviculture treatments that alter the composition of the forest to increase the growth of certain plant species. These interventions alter wildlife habitat by affecting the availability of food and shelter. E.g., pre-commercial thinning, tending felling.

5.3.4. Artificial Regeneration of Forest Stands – planting of trees in natural forests (opposed to planting taking place outside of natural forests, threat 2.2.) to promote the regeneration of stands that are composed of species of commercial interest where natural regeneration is absent or insufficient.

5.3.5. Management of Cutting Areas – management of the area and debris during a cutting or afterwards. E.g., scarification, formation of windrows from woody debris.

5.4. Fishing & Harvesting Aquatic Resources – Harvesting aquatic species (wild plants and animals) for commercial, recreational, subsistence, cultural, research or control/scaring purposes. This category also covers incidental capture (bycatch), but excludes research activities (Threat 6.3)

5.4.1. Recreational of Subsistence Fishing – harvesting of aquatic species for recreation or subsistence that is governed by management measures. Illegal harvesting by fishing should be classified under "Poaching/persecution of aquatic species" (Threat 5.4.4). Includes bycatch and damage to released individuals, but excludes contamination of habitats due to solid lead from fishing gear (Threat 9.4.2). e.g., recreational fishing of sturgeon, accidental catching of mudpuppies during ice fishing, sea turtles ingesting hooks, personal collection for aquariums with authorized species.

5.4.2. Commercial Fishing – harvesting of aquatic species for commercial purposes that is governed by management measures for which the environmental impact is primarily on the species (as opposed to habitat damage from sea bottom trawling, Threat 7.3.6). Includes bycatch but excludes ghost fishing gear entangling wildlife (Threat 9.4.4). E.g., commercial fisheries, use of nets and fishing gear for eels, factory ships, marine mammals caught in industrial fishing nets.

5.4.3. Poaching/Persecution of Aquatic Species – deliberate and illegal harvesting of aquatic animals for personal or commercial purposes or persecution, harassment, abuse or to cause deliberate harm due to prejudices against the species. E.g., poaching of glass eels.

5.4.4. Management/Control of Aquatic Species – deliberately killing individuals of an aquatic species for human gain that is governed by management measures. E.g., control of lampreys using lampricides, control of mosquitos in their aquatic larval stage , water weed cutting.

6. **Human Intrusions & Disturbance** – Threats from activities (unrelated to the use of biological resources) that disturb, alter, or destroy habitats and their species.

6.1. Recreational Activities – Activities with generally low ecological impact that are conducted in natural areas for recreational purposes away from road networks (Threat 4). To be distinguished from Threat 1.3, which is a source of pressure primarily on habitats, whereas recreational activities have a more impact on individuals of a species (disturbance, mortality) and, to a lesser extent, habitats.

6.1.1. Motor Vehicles – using recreational motor vehicles. E.g., ATVs, motocross motorcycles, snowmobiles.

6.1.2. Hiking – walking, cycling or horseback riding on or off trails in natural environments. Includes opportunistic observation of nature but excludes disturbance by intensive observation/photography that is oriented towards one of several target species (Threat 6.1.8). e.g., walking, running, dirt biking, geocaching, orienteering, disturbance from users or their domestic animals.

6.1.3. Recreational Use of Cliffs and Rock Faces – e.g., rock climbing, hang-gliding

6.1.4. Recreational Boating – use of recreational boats and watercraft that disturb wildlife, incur collisions with animals, and induce wake damage. Excludes the spread of invasive species (Threat 8.1). E.g., yacht, zodiac boats, watercraft

6.1.5. Wilderness Camping Without Amenities – temporary camping without amenities, away from dedicated networks. Distinguished from Threat 1.3.2 (campgrounds) by the lack of amenities.

6.1.6. Drones

6.1.7. Caving

6.1.8. Wildlife Observation/Photography – wildlife observation activities without any gathering that disturb the target species due to harassment or through the use of attractants and lures. E.g., photographers attracting birds of prey with domestic rodents.

6.1.9. Special Events in Natural Environments – outdoor performances in natural settings, gatherings that cause trampling and disturbance of habitat. Does not include noises pollution (Threat 9.6.3). E.g., outdoor concerts, gatherings on beaches that incur some trampling, outdoor sports competitions in natural habitats.

6.2. War, Civil Unrest & Military Exercises – Military and paramilitary activities that do not have a permanent ecological footprint. To be distinguished from the construction and use of permanent military bases (Threat 1.2)

6.2.1. War – e.g., military intervention in conflicts, transportation using military vehicles, minefields.

6.2.2. Riots

6.2.3. Military Exercises – off-base military training activities with a local footprint. E.g., unexploded ordinance, trampling from military training activities, firing ranges, military equipment testing.

6.3. Work & Other Activities – Activities carried out in natural areas (undeveloped areas) for purposes other than recreational or military activities.

6.3.1. Research Activities – research activities that are governed by management measures that can affect species by causing disturbance, by collecting individual, or by degrading the environment. E.g., research fisheries requiring mortality, trampling by research teams.

6.3.2. Illegal Activities – illegal activities that are unrelated to the harvesting of wild animal or plant species. Also includes habitat or species disturbance during

related law enforcement interventions. E.g., illegal activities or law enforcement intervention, drug trafficking.

6.3.3. Vandalism – deliberate and illegal destruction of structures that are of benefit to animal and plant species. E.g., destruction of gates limiting access to bat caves.

7. **Natural Systems Modifications** – Threats from activities that are generally carried out to improve human welfare but may result in habitat degradation or destruction. This threat category includes the development or redevelopment (management) of natural and semi-natural habitats, as well as certain natural processes that can act as threats. Stopping a conservation action or a practice that is conducive to conservation is not interpreted as a threat, but as a return to the source threat (e.g., vegetation succession affecting pioneer species). Excludes meteorological or threats related to changing environmental conditions that may modify natural systems.

7.1. Fire & Fire Suppression – Suppression or increase in fire frequency, severity or scope, changes in the natural fire regime that are directly related to human activity.

7.1.1. Increase in the Fire Regime – increase in fire frequency/scope/severity due to human activities. E.g., out of control agricultural burning, campfires.

7.1.2. Suppression in the Fire Regime – intervention aimed at preventing and putting out forest fire (fire management). E.g., putting out forest fires, controlled burning, creating firebreaks and trenches, and other measures.

7.2. Dams & Water Management/Use – Facilities or activities that alter the natural water regime (flow or water levels).

7.2.1. Water Level Management Using Dams – construction, operation and water management using non-power dams. Includes the dismantling of man-made dams and excludes dams used for power generation (Threat 3.3.1) and excludes lock system (Threat 4.3.3.)

7.2.2. Beaver Dam Management – structures (dams) built by beavers create habitats for a number of species; however, these dams may be dismantled by humans. Dismantling of dams result in habitat loss by drying out the beaver-created basin and flooding lands downstream. It could also potentially cause loss of accumulated sediments due to increased flow in streams farther downstream.

7.2.3. Water Management using Culverts – the design, installation and management of culverts that are used to permit water flow under roads or railroads can cause discontinuities in streams and promote erosion.

7.2.4. Drainage in Agricultural Environments – construction and maintenance of channels that drain surface waters in agricultural environments. Excludes the

use/management of culverts (Threat 7.2.3). Excludes erosion/sedimentation that are associated with the drainage system (Threat 9.3.2).

7.2.5. Drainage in Forest Environments – construction and maintenance of channels that drain surface waters in forest environments. Excludes erosion/sedimentation that is associated with this drainage system (Threat 9.3.2).

7.2.6. Withdrawal of Surface Water – withdrawal of fresh surface water for human consumption, crop production or other purposes. E.g., withdrawal by municipalities, spring water bottling companies and farmers; reservoirs for firefighting, creation of man-made lakes.

7.2.7. Withdrawal of Groundwater – withdrawal of groundwater for human consumption, crop production or other purposes. E.g., pumping water from the water table.

7.3. Other Ecosystem Modifications – Other activities that contribute to habitat alteration or loss by redeveloping natural systems to improve human welfare. To be distinguished from the development and maintenance of urban parks (Threats 1.3).

7.3.1. Shoreline Alteration – e.g., shoreline hardening, riprap along shorelines, breakwaters, concrete walls, shoreline filling

7.3.2. Vegetation Succession – natural vegetation succession causing habitat loss for species of early successional habitats.

7.3.3. Natural Erosion and Sedimentation – removal, transport and deposition of sediments that is caused by natural erosional processes. To be distinguished from the transport of sediments that is associated with tides (Threat 4.3.1), or by drainage systems in agriculture (Threat 7.2.5) and forestry (Threat 7.2.6).

7.3.4. Beach Development – creation of beaches, their nourishment (substrate replenishment) and maintenance.

7.3.5. Removal of Snags in Watercourses – removal of snags and other structures that are used by wildlife within watercourses to promote water flow, embellish the landscape, or facilitate boating. Excludes the maintenance of road ditches (Threat 4.1.1) and agricultural ditches (7.2.4), as well as shoreline clean-ups that are performed as conservation action. E.g., removal or snags that are used by river turtles for basking .

7.3.6. Sea Bottom Trawling – trawling of the sea bottom that alters marine habitats. Excludes the impact of harvesting on target species (Threat 5.4.2).

8. **Invasive & Other Problematic Species, Genes & Diseases** – Threats posed by non-native and native species (plants, animals, pathogens or genetic materials) that have or are expected to

have harmful effects on biodiversity following their introduction, spread or increase in population (abundance).

8.1. Invasive Non-Native/Alien Plants & Animals – harmful plants and animals that were not originally present within an ecosystem, but were directly or indirectly introduced into or spread in the ecosystem as a result of human activities. The concept of exotic species includes species that are not native to a specific habitat; it can therefore include the introduction of species that are considered native to a different region. Domestic species are also considered non-native, whether they are feral or semi-domesticated (e.g., domestic cats going outside). Also includes introduction of wildlife due to "mercy releases".

    8.1.1. Terrestrial Animals
    8.1.2. Terrestrial Plants
    8.1.3. Aquatic Animals
    8.1.4. Aquatic Plants

8.2. Problematic Native Plants & Animals – Plants and animals that were originally present in ecosystem(s), but whose populations have increased to a level where they are now or overabundant as a direct or indirect result of certain human activities.

8.3. Habitat Alteration by Beavers – flooding/drainage of habitats caused by beavers

    8.3.1. Increased Grazing by Vertebrates – e.g., increased grazing by white-tailed deer and snow geese.

    8.3.2. Localized Increase in Invertebrate Grazing – e.g., increased grazing of American ginseng by native slugs.

    8.3.3. Insect Pest Epidemics – increased in insect pest density, resulting in large-scale impacts on the ecosystem. To distinguished from localized increases in invertebrate grazing (Threat 8.2.3).

    8.3.4. Increased Predation by Mesopredators – e.g., racoons, striped skunks, foxes, coyotes.

8.4. Introduced Genetic Materials – Human modified or altered organisms/genes that pose a threat to biodiversity in natural environments by competing with wild populations or hybridizing with them and altering their gene pool.

    8.4.1. Genetic Material from Agriculture – e.g., pesticide-resistant cereals/forages, use of genetically modified insects for biocontrol.

    8.4.2. Genetic Material from Silviculture – e.g., genetically modified trees.

    8.4.3. Genetical Material from Aquaculture – e.g., genetically modified salmon.

8.5. Pathogens – Diseases caused by various taxa of pathogenic micro-organisms living within hosts.

8.5.1. Bacterial Pathogens

8.5.2. Viral Pathogens – e.g., ranavirus in amphibians, rabies in raccoons.

8.5.3. Fungal Pathogens – e.g., white-nosed syndrome in bats (WNS), snake fungal disease (SFD), salamander chytrid disease (BSal), fungal pathogens affecting the roots of American ginseng.

8.5.4. Worm-Induced Disease – any diseases directly induced by a worm (helminthiases). E.g., flatworms, nematodes, nemertean worms.

8.5.5. Protozoan-Induced Diseases

8.5.6. Prion Disease – e.g., chronic wasting disease of cervids (CWD).

9. **Pollution** – Threats that are associated with the introduction of foreign or excess material/energy from point and non-point sources. Threats that are posed by pollution are typically correlated with other human activities listed in the other sections (e.g., air pollution from cars, water pollution from sewage, agricultural effluents). Although there is a direct correlation between pollution and these other threats, their impact (scope and severity) is often evaluated separately from the source activity.

9.1. Domestic & Urban Wastewater – Point or non-point source wastewater from residential and urban areas; these discharges (may) contain nutrients, sediments, toxic substances, chemicals, etc.

9.1.1. Domestic Wastewater – liquid domestic waste that is produced by urban centers and discharged primarily by the sewage system. E.g., discharges from municipal waste treatment plants, leaks from sewers/septic tanks, untreated discharged, pit toilets, medical components in water (birth control hormones, antidepressants, antibiotics), toxoplasmosis, etc.

9.1.2. Runoff – effluents resulting from urban activities that are separate from the water supply system. For oils and other hydrocarbons, refer to Threat 9.2.1. E.g., salt/sand used to de-ice roads, fertilizers and pesticides used for lawns, parks, golf courses.

9.2. Industrial & Military Effluents – wastewater (pollutants) from industrial and military sectors, including mines, energy production sectors and other resource extraction industries. These effluents may result from deliberate or accidental spills that are legal or illegal and (may) contain various nutrients, sediments, toxic substances and chemicals. Among others. Considering the difficulty in identifying contaminants or contaminant "cocktails" that are responsible for environmental damage, other unknown contaminants from industries will be listed with Threat 9.2. This section excludes natural sources of contaminants that are found in the environment (e.g., mercury found in soils

or in river substrates). Intoxication due to natural sources of these contaminants are likely to result from an indirect threat increasing exposure and to which conservation actions can be matched.

9.2.1. Oil Spills – spills from vehicle fuel tanks or from facilities that are associated with hydrocarbon extraction and transportation. E.g., oil spills from grounded vessels, military vehicles, pipeline failures.
9.2.2. Acid Mine Drainage (AMD)
9.2.3. Flame Retardant
9.2.4. PCB
9.2.5. Mercury
9.2.6. Industrial Lead – lead released into the environment by industrial effluents. Excludes lead contaminants due to hunting ammunition or fishing gear (9.4.2).
9.2.7. Other Industrial Discharges – unidentified or mixed toxic liquid chemicals that are released from industrial plants.

9.3. Agricultural & Forestry Effluents – Wastewater (pollutants) that is generated by agricultural, silvicultural and aquacultural activities. These discharges are transported primarily in drainage systems, runoff and eroded; they (may) contain various nutrients, toxic substances, chemicals, etc. Excludes erosion and sedimentation that is associated with drainage systems in agriculture and forestry (7.2) or oil spills from machinery (9.2)

9.3.1. Nutrient Loads – e.g., manure, compost, chemical fertilizers.

9.3.2. Soil Erosion, Sedimentation – erosion and sedimentation that are due to agricultural or silvicultural activities, regardless of the presence of local drainage systems (threat 7.2.4 and 7.2.5).

9.3.3. Herbicides & Pesticides – includes the use of inputs for controlling crop pests. E.g., herbicides, insecticides, fungicides.

9.4. Garbage & Solid Waste – garbage and solid waste, including materials that can intoxicate or entangle plants and animals (strangulation/asphyxiation from plastic bags, elastic materials, ropes, etc.).

9.4.1. Garbage – garbage and solid waste in the environment. Excludes waste in open dump-sites (Threat 1.2.2), landfills (Threat 1.2.3), and ashore or adrift in the ocean (Threat 9.4.4). E.g., municipal waste, litter discarded on roads from vehicles, floating waste from recreational boats, construction debris/waste, etc.

9.4.2. Solid Lead – lead released into the environment in a solid form (e.g., pellets) from a source other than industrial effluents (Threat 9.2.6). E.g., lead from ammunition or fishing gear contaminating the environment, ammunitions from shooting ranges.

9.4.3. Asbestos

9.4.4. Drifting Plastic and Entanglement Rubbish – plastic garbage adrift or ashore of oceans or large water bodies that intoxicate or entangle wildlife. E.g., floating rubbish, nets, robes, buoys, ghost or derelict fishing gear, plastic bags.

9.5. Airborne Pollutants – Air contaminant emissions from a point or non-point source.

9.5.1. Acid Rain

9.5.2. Smog – smog caused by air pollutant emissions from cars (vehicles in general)

9.5.3. Ozone – atmospheric nitrogen deposition.

9.5.4. Dust & Ashes – fine particles carried by the wind that pollute the environment when deposited or taken in by organisms. Excludes ash from volcanic eruptions (Threat 10.1.1). E.g., radioactive fallout, wind dispersion of pollutants/sediments, smoke from forest fires or wood burning.

9.6. Excess Energy – Inputs of heat, sound or light that disturb wildlife or ecosystems.

9.6.1. Light Pollution – e.g., lamps (light) that attract insects or birds, lights on beaches that disorient turtles.

9.6.2. Thermal Pollution – e.g., heated water discharges from power plants (coal, gas, nuclear, etc.), atmospheric radiation resulting from ozone layer thinning.

9.6.3. Noise Pollution – e.g., noise from highways, air traffic (airplanes), submarine sonar that disturbs whales and other marine mammals, loud music from outdoor events and engine noise from marine traffic.

10. **Geological Events** – Threats from catastrophic geological events.

10.1. Volcanoes – volcanic activities, eruptions, emissions of volcanic gases
- 10.1.1. Eruptions
- 10.1.2. Emissions of Volcanic Gases

10.2. Earthquakes/tsunamis – earthquakes and associated events (tsunamis, etc.).
- 10.2.1. Earthquakes
- 10.2.2. Tsunamis

10.3. Avalanches/Landslides
- 10.3.1. Avalanches
- 10.3.2. Landslides and Mudslides

11. **Changing Environmental Conditions & Severe Weather** – Threats from major changes in ecosystems and severe climate/weather events outside of the natural range of variation that could harm species or habitats. May or may not be related to changing climate.

11.1. Habitat Shifting & Alteration – Major changes in habitat composition or location

11.1.1. Changes in Vegetation Communities – major changes in an ecosystem resulting in changes to vegetation communities distinguished from natural vegetation succession, which may threaten open-country species (Threat 7.3.2). E.g., migration of deciduous trees towards the boreal forest, rising sea levels, desertification, thawing permafrost (in tundra), coral bleaching.

11.1.2. Phenological Mismatch – behaviors that have evolved to adapt to seasonal changes become unsynchronized due to irregularities or delays in the cycle of the seasons.

11.2. Changes in Geochemical Regime – large-scale changes in an ecosystem's physio-chemical makeups

11.2.1. Changes in pH of habitats – e.g., ocean acidification
11.2.2. Changes in salinity

11.3. Changes in Temperature Regimes – periods in which temperatures of the air, water or soil either exceed or fall below the normal range of variation. Events that may or may not be related to changing environmental conditions.

11.3.1. Heat Waves

11.3.2. Extreme Cold Spells

11.3.3. Gradual Temperature Change – e.g., altered sex-ratio in species relying upon a temperature dependent sex determination, reduction of dissolved oxygen that is available to fish species, earlier ice-free dates, thawing of permafrost affecting bird breeding sites.

11.3.4. Increase in Temperature Fluctuations – increase in temperature fluctuations, which disturb the phenological responses of wildlife. E.g., raise in the frequency of freeze-thaw events, rain-on-snow events, etc.

11.4. Changes in Precipitation & Hydrological Regimes – Periods in which the amount and frequency of precipitation either exceeds or falls below the normal range of variation. Events that may or may not be related to changing climate conditions, and exclude periods that are associated with storms and heavy weather (Threat 11.5)

11.4.1. Overabundant Rains
11.4.2. Droughts
11.4.3. Gradual Change in the Precipitation Regime
11.4.4. Increase in Fluctuations in the Precipitation Regime – increase in the fluctuations that are related to the precipitation regime, which have impacts on the hydrology of natural habitats.

11.5. Storms & Severe Weather – Strong winds and extreme weather events or a major change/shift in the storm season.

11.5.1. Storms & Severe Weather – e.g., thunderstorms, tropical storms, hurricanes, cyclones, tornadoes, hailstorms, ice storms, blizzards, dust storms.

11.5.2. Storm Surges – e.g., erosion of shorelines/beaches during storms.

Statewide Threats to Multiple Habitats

Invasive Species

In addition to the previously noted impacts that invasive species have on wetland habitats, the Virginia Invasive Species Management Plan (VISAC 2018) identifies several species that have a profound impact on terrestrial ecosystems. Invasive species such as the gypsy moth, ramorum blight, sirex wood wasp, and emerald ash borer are known to kill large numbers of trees and alter forest health and composition. Invasive plant species, such as tree of heaven, privet, and Japanese stilt grass are aggressive colonizers, taking advantage of degraded natural habitats, outcompeting native species, and significantly altering the character and quality of local habitats. Virginia's Natural Heritage Program has identified over 90 invasive plant species. Additionally, invasive wildlife species such as fire ants and feral hogs are known to degrade the quality of native habitats, damage crops, kill native wildlife, and, in some cases, be dangerous to humans.

Unfortunately, there are insufficient resources in Virginia to eradicate all known invasive species. Virginia's Invasive Species Management Plan identifies seven goals (each with multiple strategies) for addressing invasive species issues in Virginia (VISWG 2012). These goals include:

- *Coordinate state, federal, and stakeholder prevention and management of invasive species infestations;*
- *Prevent known and potential invasive species from entering the state through detecting and interrupting all unauthorized species introductions;*
- *Promote and enhance professional and volunteer invasive species early detection through education and reporting tools;*
- *Enhance rapid response capability to implement eradication or containment procedures for target species through planning;*
- *Provide control of priority invasive species through containment, abatement, and other management strategies—including habitat restoration and use of native species—to minimize environmental and economic impacts;*
- *Support or conduct research, monitoring, and risk assessment necessary to assess, prioritize, and control invasive species; and*
- *Provide current information on invasive species, their negative impacts to environmental and economic resources, and methods of prevention and control to the general public, environmental nongovernmental organization, special interest groups and K-12 science teachers (VISWG 2012).*

Changing Environmental Conditions In Virginia

Changing environmental conditions – precipitation, temperature, sea levels – are expected to have significant effects on Virginia's fish, wildlife, and natural communities. At least six SGCN salamanders, found nowhere else in the world, live in high-elevation habitats in western virginia that are expected to die out over the next 100 years as the result of increased temperatures and changed precipitation regimes impacting the cool-climate vegetation. Without significant intervention to expand their footprints and extend their presence in virginia, remnant spruce-fir forests are also expected to disappear for the same reason. In coastal Virginia, species such as eastern black rail and saltmarsh sparrow, both dependent on high saltmarsh habitats, are expected to be extirpated within the next 30 to 50 years as coastal high marshes succumb to a combination of rising sea levels and land subsidence (Ezer, T. and L. Atkinson, 2016). These changing conditions are undermining the ability of lands and waters to support Virginia's native fish and wildlife and the cultural and economic benefits they provide. Taking proactive measures to prepare for the impacts on the state's native species and habitats will make these challenges more manageable.

In 2021, the Commonwealth published the state's first Coastal Resilience Master Plan (Phase 1) that outlined the imminent threats to communities, businesses, national defense, infrastructure and natural habitats in coastal Virginia. Of particular note relevant to the Wildlife Action Plan was the finding that an estimated 170,000 acres (89 percent) of existing tidal wetlands and 3,800 acres (38%) of existing dunes and beaches may be permanently inundated by 2080, effectively lost to open water. Of the nearly 1,000 adaptation and resilience projects captured presently in the Virginia Coastal Resilience Project Tracker, a super-majority of them relate specifically to the protection of people and property. The Commonwealth anticipates completing the first Virginia Flood Protection Master Plan in 2025, which will be an actionable plan to use in crafting policies and programs to mitigate the impacts of flooding on people, the economy, and the environment. Both of these initiatives have provided significant attention to certain aspects of environmental conditions, but neither is comprehensive with respect to all anticipated changes, and both have an emphasis on people, property and infrastructure.

Warming temperatures are already affecting fish, wildlife and habitats in Virginia. Within the past 30 years, armadillos have naturally expanded their range from southern states northward, observed in southwest Virginia beginning in the mid-2010s. Spotted lanternfly, emerald ash borer, and spongy moth – all insect pests significantly impacting native vegetation – have become more pervasive across Virginia's landscape due in part to more moderate winter conditions. Other impacts, such as the earlier arrival of spring-like conditions and changes in the timing of biological events (such as migration, reproduction and flowering) which potentially lead to mismatches in the life cycles of interdependent species, are also being observed as of this writing.

Across the DWR, and indeed the conservation community more broadly, actions are underway that support the adaptation and resilience of species and habitats to these on-going environmental changes. Specific examples include treatment (or removal) of invasive common reed (Phragmites australis) from wetlands to prevent crowding of native species or alteration of water regimes, the application of prescribed fire to increase the resilience of habitat to wildfires and improve ecosystem health, and

improvement of riparian habitats – most often through vegetative plantings – to moderate water and air temperature changes.

In their assessments of species for possible inclusion as SGCN, the TACs evaluated, where possible, climate change vulnerability assessments (CCVAs) to determine potential impacts of changing environmental conditions to species and habitats and the likely responses of these resources. These CCVAs evaluate exposure (the degree of change likely to be experienced), sensitivity (the degree of susceptibility or responsiveness to the climatic changes), and adaptive capacity (the ability of the resource to cope with or adjust to the changes). Adaptive capacity has three main components: demographic or life-history traits, including dispersal and colonization abilities that support range shifts; genetic diversity and potential for evolutionary adaptation by natural selection; and phenotypic plasticity, including physiological and behavioral acclimation. Conducting the CCVAs helped identify uncertainties in need of further study, many of which are outlined in identified conservation actions or future research needs explained in Chapters 5 and 6.

Ultimately, the outcome of changing climatic and environmental conditions is that a species persists in place, shifts in space, or becomes extirpated. However, the rapid rate of change and the fragmentation of habitat will make it more difficult for many species to move in a timely manner or without assistance to preclude local extirpation or extinction. The implementation of conservation migration (or human-assisted migration for conservation purposes) is in its infancy in the U.S., with few policies or protocols at national or state levels to guide this work. Issues regarding genetic integrity, wildlife disease, and invasion; more importantly, though, no frameworks currently exist to support states in their efforts to authorize translocations of most species for conservation purposes and regulatory mechanisms to support that work are lacking. The DWR is taking a small step in this arena in its proposed translocation of eastern tiger salamanders to a DWR-owned property in southeastern Virginia, outside of the known range of the species in the Commonwealth. This effort will increase the resilience, redundancy and representation of the species in Virginia, as the three populations currently known in eastern Virginia are at great risk of extirpation.

To ensure that the DWR addresses and responds appropriately to these changing conditions, the agency launched the development of its own adaptation and resilience plan in 2025. This effort will help ensure that, across the organization, employees understand the risks and opportunities associated with changing climatic conditions and incorporate appropriate actions into the Department's programs to maximize the conservation, use and enjoyment of fish, wildlife and habitats now and into the future. Keys to success will include maintaining and restoring key ecosystem processes, supporting a statewide network of lands and waters to support fish and wildlife adaptation (i.e. movement), evaluating proposed management actions in the context of changing conditions, and coordinating with governmental and non-governmental partners, stakeholders, businesses, and communities. The project team began by interviewing employees across the organization to develop a baseline of adaptation and resilience actions already being implemented in agency programs. From there, a suite of goals and actions will be developed to augment existing work and begin the integration of relevant actions into other DWR programs and in discussions with partners and stakeholders. This work will also complement new efforts begun in 2025 in the Virginia Secretariat of Natural and Historic Resources with the

establishment of the Office of Commonwealth Resilience and a supporting Interagency Resilience Management Team, recruitment of a Chief Resilience Officer and program staff, and development of a report on the status of resilience in the Commonwealth.

Other Specific Threats

As previously mentioned, several threats are not necessarily habitat-related or specific to one habitat. Illegal poaching, conservation actions on out-of-country avian wintering grounds, need for specific actions and increased regulations impacting these actions (e.g., prescribed fire) and other anthropomorphic impacts (e.g., lights on buildings) are unique and are addressed specifically in this section.

Threats to Avian SGCN - Lighting can attract large numbers of night-migrating birds from as far as 5 kilometers away. Birds can become entrapped in these areas of bright lights, circling endlessly, depleting energy stores needed for migration, and even colliding with buildings and infrastructure. This phenomenon is particularly prevalent on nights with low-cloud ceilings or foggy weather, when birds tend to migrate at lower altitudes where light reflecting on clouds can be disorienting. Multiple mass-mortality events, each involving hundreds of birds, have been documented on foggy nights during migration.

Throughout the year, nighttime lighting can affect birds by illuminating their habitats. This can cause birds to avoid habitats essential for their survival and can alter the relationships between predators and prey, all because these areas have too much light. Birds that migrate or forage offshore are also affected by and disoriented by nighttime lighting from coastal areas and offshore vessels and structures.

In addition to migration issues, every year anywhere from 365 million to one billion birds collide with glass in the U.S. alone. While most fatal collisions happen at homes and buildings shorter than four stories tall, smaller structures like glass walkways and bus stop shelters also pose a threat (USFWS 2024). Bird-building collisions can happen at any time of the day and year but tend to increase during migration and when young birds are fledging. Therefore, migration seasons and spring and early summer it is important to mitigate for window/bird collisions (Audubon 2020).

Bird-building collisions can be reduced by reducing the use of transparent or reflective surfaces on building facades, by making these surfaces visible to birds, and by reducing artificial light at night. For new construction, architects can consult the American Bird Conservancy's Bird Friendly Design Guide. This resource includes information about both building and lighting design and materials that can reduce the probability of bird collisions. Existing buildings can be retrofit to reduce collision risk. The American Bird Conservancy, U.S. Fish and Wildlife Service, and Audubon Lights Out all have resources on how to retrofit existing buildings. Retrofits such decals, films or chords make glass visible and are extremely effective; many have been shown to reduce collisions by 90% or more (Klem Jr. 1990, 2009, Klem Jr. and Saenger 2013, Brown *et al.* 2019, 2021, Sheppard 2019, Swaddle *et al.* 2020, Coolidge *et al.* 2021, Groot *et al.* 2022, Leung 2022, Riggs *et al.* 2023, Marler 2024).

Adjustments to lighting also can reduce collisions. Blue and cooler toned lights tend to be more attractive to birds (Zhao *et al.* 2020), thus using warmer toned lights may reduce collisions. Reducing the overall amount of light, by using shields to direct exterior lights down toward the ground, shades to keep interior lights from illuminating windows, and timers or motion sensors so that lights are off when not in use can help to reduce collisions (Ogden 2002, Lao *et al.* 2020, Van Doren *et al.* 2021, Scott *et al.* 2023). Half of all collisions occur in only 15% of days (Scott *et al.* 2023), because of interactions between migration timing and weather (Van Doren *et al.* 2021, Chen *et al.* 2024). Thus, reducing artificial light at night during these high-collision risk nights can avoid many collisions. Audubon's Lights Out Toolkit is a comprehensive resource with everything needed to implement a Lights Out campaign. DarkSky International certifies outdoor lighting, has guidelines for exterior lighting, and sample codes and statutes. Agencies, organizations, businesses and communities can set an example by implementing policies to ensure any new agency construction is bird-safe, retrofitting existing buildings, and communicating this work to the public to increase the impact of these conservation efforts.

Bird collisions are not limited to buildings. Collisions also occur with communication towers, vehicles and wind turbines (Bullock *et al.* 2024) and other lit structures. Solutions for communication tower and turbine collisions include acoustic deterrents (Boycott *et al.* 2021) and using only flashing (rather than steady-burn) lights (Gehring *et al.* 2009). Tower owners can simultaneously reduce tower costs and reduce bird collisions by as much as 70% by extinguishing their steady-burn lights and using only flashing lights at night. The U.S. Fish and Wildlife Service has guidance to reduce bird collisions with different components of the built environment.

Perhaps the most critical threat to avian SGCN species is protection of their out-of-state and often out-of-country wintering habitats and grounds. Southern Wings encourages states to acknowledge the full annual life cycle needs for birds. This program works to conserve and manage habitat and research on stopover sites and the wintering grounds – migrant breeding birds spend up to eight months of the year outside of the United States. Efforts to conserve these critical habitat areas outside of Virginia and the United States are critical to protecting many avian SGCN species. Virginia has participated in Southern Wings since 2013 and will continue to support the research and conservation efforts for the full annual life cycle of Virginia's breeding birds through this and other initiatives with similar objectives.

Illegal Trade - The poaching or taking of protected or managed species and the illegal trade in wildlife and their related parts and products has escalated into an international crisis. Wildlife trafficking is both a critical conservation concern and a threat to global security, with significant effects on the national interests of the United States and the interests of its partners around the world (USFWS 2024). Turtles, bears and several plant species are under exceptional pressure from illegal collection and international trade. Turtles are highly prized in Asian markets as pets and as food items. Bear gallbladders are prized as aphrodisiacs. In 2018, Virginia and other states helped form the Collaborative to Combat the Illegal Trade in Turtles (CCITT), a coalition to combat the illegal trade of turtles. The intent of this group is to advance efforts to better understand, prevent, and eliminate the illegal collection and trade of North America's native turtles. There is critical need for additional law enforcement and research staff in this realm to prosecute poachers and do the critical health assessments and genetics work to return confiscated turtles to their points of origin (Kleopfer and Sevin, 2024).

Zoonotic diseases and threats - The effects of emerging wildlife diseases are global and profound, often resulting in the loss of human lives, economic and agricultural impacts, declines in wildlife populations, and ecological disturbance. The USGS National Wildlife Health Center (NWHC) is one agency working to safeguard wildlife from diseases by studying the causes and drivers of these threats and by developing strategies to prevent and manage them. Snake fungal diseases, avian influenza, *Batrachochytrium salamandrivorans* ("Bsal") , and white-nose syndrome are just some of the bacterial, fungal and viral threats that impact Virginia's wildlife (USGS 2024). Many of these pathogens are not well understood, and ongoing research is needed to determine causes, possible treatments and how best to protect many SGCN species from their impacts. White-nose syndrome has especially demonstrated how one pathogen can decimate populations of several bat species. Little brown bat (*Myotis lucifugus*) populations in Virginia have declined by over 95% since the disease was detected in the state (Reynolds 2024). **Appendix 1** has a further explanation of fish and wildlife health issues as provided by the Northeast Fish and Wildlife Health Coordinator.

6. Conservation Actions

In reviewing the list of SGCN, DWR staff and partners were asked to assign each species into one of three triage categories related to conservation and management opportunity (see Methods and Approach Section). Category A was reserved for instances when managers have identified "on the ground" strategies expected to benefit species and/or habitats. Category A also requires that at least some of these strategies be able to be implemented with existing resources and have a reasonable chance of improving a species' conservation status.

Of the 1920 SGCN identified for 2025, 406 (21.1%) are classified in Category A. For these species, partners identified 21 overarching management actions that benefited more than just a few species that could be implemented to improve their conservation status. The number following each action listed below represents the number of SGCN to which that action applies. For specific actions identified for each of the 406 species, please see the SGCN Table here. {temporary link}

1. Conserve/ restore wetland habitats (124) Maintain and/or restore natural hydrologic processes within occupied and historic habitats.
2. Restore the natural fire regime within occupied areas. (109) Avoid large scale timber harvests/clear cuts within occupied habitat. (23)
3. Create/ restore/ manage – open habitats (glade, grassland, savanna, shrubland) (86)
4. Address water quality impairments (63)
5. Maintain/restore riparian buffers. (55)
6. Pursue the protection of priority populations and habitats through landowner education. (47)
7. Implement captive propagation/ translocation/ reintroduction (37)
8. Conserve/restore/create beaches, dunes, shoals, sandspits, mudflats and peat banks in a manner that benefits beach-nesting wildlife and migrant and wintering waterbirds. (35)
9. Control invasive plant and animal species (33) and prevent the introduction of species that out-compete SGCN (e.g., variegate darter in candy darter range). Avoid using non-native seed mixes. Plant only locally native species

10. Restore aquatic connectivity (4). Avoid construction of new dams and remove old, non-functioning dams (29). Dams that cannot be removed should be retrofitted to allow fish passage. Coordinate with the Virginia Department of Transportations to replace and install new culverts that allow movement of aquatic species. Reduce standing stocks of Blue Catfish in Chesapeake Bay rivers.
11. Mitigate for the impacts of sea-level rise using both traditional and novel methods (e.g. purchase and protect upland areas for marsh and shoreline migration, placement of dredge materials on islands, restore eroded shell rake habitats in seaside marshes, etc.) (20)
12. Limit the use of pesticides, anticoagulant rodenticides and neonicotinoids. (19)
13. Regulate legal harvest (6). Continue maintaining "no personal possession" regulations (16).
14. Engage in public education/ outreach (14). Educate landowners on the importance of beavers in maintaining fish and wildlife habitat. Provide alternative to dam and beaver removal, such as flow control devices to prevent extreme flooding and damage to property and the improve their understanding of the importance of maintaining submerged vegetation in their ponds and lakes
15. Exclude/ manage human use of habitats or human activities at specific times (19)
16. Engage in predator control (11)
17. Exclude humans from caves occupied by sensitive species (12)
18. Maintain the quality and quantity of water flowing into karst and other groundwater systems (8) Increase partnerships to implement best management practices such as alternate water sources for cattle and protecting/establishing vegetated stream buffers for agriculture and forestry.
19. Continue environmental commenting and engagement with industrial citing for wind energy (12)
20. Continue to maintain a high level of law enforcement presence on key waterbird nesting islands and stopover sites. (10)
21. Protect known fall roosts and swarm areas for bats (7)
22. Conserve/ restore large forest blocks and maintain/restore habitat connectivity between them (5)

PRIORITY RESEARCH NEEDS

Conservation Opportunity Ranking Category B was reserved for those species that met one of two conditions. Either managers have identified specific research needs that must be addressed before more "on the ground" actions can be initiated, or the conservation community has been precluded from implementing "on the ground" actions due to a lack of personnel, funding, or other circumstances. Of the 1920 SGCN, 861 (44.8%) are assigned to Category B. The list of research needs for these species follows, in no priority order. In future budget discussions, it is DWR's intention to use this list to prioritize the research projects funded through State Wildlife Grants and other sources.

- Improve detection methods for hellbenders to better estimate population size and distribution – both to document initial conditions as well as to help evaluate effectiveness of conservation actions.
- Investigate the utility and opportunity of using translocation as a management and recovery tool for hellbenders and other animals.

- Determine American woodcock wintering and breeding abundance to facilitate creation of a management strategy.
- Determine the impacts of avian predators on beach nesting birds on Virginia's barrier islands and develop appropriate management actions to ameliorate these impacts over the long term.
- Research belted kingfisher, black-billed cuckoo, chimney swift, eastern wood peewee, green heron, and northern flicker to determine the circumstances that threaten these species and the impacts of these threats to populations so that appropriate management strategies can be developed.
- Develop conservation plans for the following species:
    - Variegate darter,
    - Tennessee darter,
    - Atlantic sturgeon.
- Determine if the following species would be suitable candidates for reintroduction into suitable habitats:
    - Duskytail darter,
    - Ashy darter,
    - Greenfin darter,
    - Longear sunfish,
    - River redhorse,
    - Sauger,
    - Blackbanded Sunfish
    - Candy Darter
    - Golden Darter
    - Roanoke Bass
    - Sickle Darter
    - Tennessee Dace
    - Yellowfin Madtom
    - Smallmouth redhorse, and
    - Spotfin chub.
- Determine possible reintroduction streams in the Roanoke drainage with suitable habitat for Roanoke bass and absent of rock bass.
- Determine the distribution and habitat associations of roughhead shiner.
- Determine if or how changing climatic conditions or changing groundwater levels are affecting the Allegheny pearl dace.
- Locate maternity colonies of the eastern big eared bat populations.
- Determine the extent and effects of insecticide contamination and bioaccumulation on eastern big eared bat and Indiana bat populations.
- Assess coastal migration patterns for hoary bats, silver-haired bats, red bats, and Virginia big eared bats.
- Evaluate the productivity and survivorship of little brown bats, northern long-eared bats, tricolored bats, southeastern myotis, and eastern small footed myotis at maternity colonies as a means of evaluating the success of conservation actions.
- Identify foraging habitat preferences for Virginia big eared bats.

- Determine if the following freshwater mussel species are suitable candidates for captive propagation and, if so, develop propagation techniques:
    - Crackling pearlymussel,
    - Deer toe,
    - Cumberland monkeyface,
    - Fine-rayed pigtoe,
    - Tennessee clubshell,
    - Rough rabbitsfoot,
    - Shiny pigtoe,
    - Elephant ear,
    - Tennessee heelsplitter,
    - Tennessee pigtoe,
    - Slabside pearlymussel,
    - Northern Lance ,
    - Pimpleback,
    - Pistolgrip,
    - Spectaclecase,
    - Three-ridge, and
    - Pink heelsplitter.
- Resolve taxonomic confusion between the purple bean and the Cumberland bean so that appropriate broodstocks can be identified to support captive propagation efforts.
- Determine the genetic distinctiveness of alewife floater populations in the Rappahannock, Pamunkey, James, Chickahominy, and Chowan basins so propagation and reintroduction strategies can be developed.
- Determine if the Virginia pigtoe is a distinct species or a population of the Atlantic pigtoe.
- Determine if sufficient numbers of slippershell mussels exist to serve as broodstock for a captive propagation program.
- Determine if the two known populations of Bunting's crayfish in Virginia (one in the Big Sandy Basin and the other in the Clinch River) represent one species or two so that appropriate management and conservation strategies can be developed.

SGCN Distribution, Abundance, and Life History Information

Of Virginia's 1920 SGCN 34.3% were included in Conservation Opportunity Ranking C. Species were included in this category for one of two reasons. In many cases, such as the Shenandoah salamander, conservation opportunities have been exhausted. While this species may remain imperiled, no additional actions can be taken on its behalf as the only known population in Virginia is contained within a National Park system.

Category C was also used when managers were unable to identify "on the ground" actions or research needs that could benefit the species or its habitats. The threats and conservation actions identified for these species may be included in the list, but either may not be conclusive or, in many cases, conservation actions identified are either not feasible or have not been researched enough to

conclusively demonstrate an impact the populations. The vast majority of these species lack the basic distribution, abundance, and life history information needed to formulate a management strategy or applied research program. This is an overwhelming issue, affecting many SGCN. However, given current resource limitations, it is a logistical impossibility that the DWR and partners will ever be able to fully address these needs.

It is the DWR's intention to continue to commit some portion of State Wildlife Grant dollars to collect baseline data on Category C species. However, this list of species will be reviewed and prioritized to ensure that resources are used efficiently and that efforts provide the greatest management utility in terms of keeping species from becoming imperiled.

Propagation and Restoration of SGCN

Virginia's aquatic habitats support some of North America's most diverse assemblages of aquatic mollusks, fish, and crayfish. Historic and continuing loss of habitat and habitat fragmentation, water pollution, sedimentation, invasive species introductions, hydrologic modification and impoundments have reduced many of these populations to critical levels and severely restricted many species' distribution.

Virginia has a long history of propagating game fishes in hatcheries to augment existing populations and establish new populations in unoccupied habitats. In 1997, Virginia Tech's Freshwater Mussel Conservation Center began propagating and releasing endangered mussels to augment wild populations. In 1998, the DWR established the Aquatic Wildlife Conservation Center (AWCC) at its Buller Fish Hatchery near Marion, Virginia, to support the restoration of populations of imperiled mussels in the Upper Tennessee River drainage. The AWCC has also propagated the endangered spiny river snail (*Io fluvialis*) and eastern hellbenders (*Cryptobranchus alleganiensis*). In 2007, the DWR and USFWS established the Virginia Fisheries and Aquatic Wildlife Center (VFAWC) at the Harrison Lake National Fish Hatchery in Charles City County to propagate mussels for release into Virginia's Atlantic Slope rivers. Since 2016, the DWR has contracted with Conservation Fisheries, Inc. to propagate and release endangered yellowfin madtom (*Noturus flavipinnis*) into the upper reaches of the North Fork Holston River.

It is the DWR's intention to continue supporting these propagation and restoration activities with State Wildlife Grants and other resources. While current SGCN efforts largely focus on aquatic species, species in other taxonomic groups may also be considered as appropriate. The target species, the use of State Wildlife Grants, and the priority of individual efforts will be determined during the DWR's project planning, annual budget development, and annual work planning efforts.

Translocation – Translocation is utilized to restore species to their previous range, increase genetic diversity of a remnant population and to establish new populations in areas they are likely to persist in to reduce the impact of a catastrophic event in their remaining range. Beyond mussels, Virginia has used translocation in many times to restore populations to the state. In the early 1900s, white-tailed deer and wild turkey populations were extremely low due to extensive logging and habitat degradation

across the state. These species were imported from other states and supplemented. Today these species are incredibly abundant across most of the Commonwealth. In terms of SGCN, red-cockaded woodpeckers were translocated from the Carolinas to Piney Grove Preserve and the Great Dismal Swamp National Wildlife Refuge (GDSNWR.) There has been successful breeding in both areas now for several years that the population has now grown from two breeding pairs in 2002 at Piney Grove to 170 individuals combined at Piney Grove and GDSNWR and a successful breeding pair on the Big Woods Wildlife Management Area in 2017. Additional efforts involving loggerhead shrikes and Bachman sparrows are being investigated now, and future efforts for additional translocation are being researched. State Wildlife Grants funds may be dedicated to these efforts if appropriate species and habitats are identified.

As mentioned above under the description of the Savanna habitat, Savannas historically were related to fire-maintained longleaf pine (LLP) ecosystems in Virginia which is at the northern extent of the LLP ecosystem range that stretches from Texas to Virginia. Eighteen Longleaf Implementation Teams (LIT) are organized through the Longleaf Alliance, including the Longleaf Cooperators of Virginia (LCOV). LCOV is a collaboration of public and private land managers that plans and implement conservation actions to benefit longleaf and its species components. Savanna ecosystems and prescribed fire to maintain them is particularly important to 14 animal and 119 plant SGCN in Virginia.

One issue not addressed directly by the Northeast Lexicon that is critical to many species threatened by habitat loss is the need to complete the identification of important habitat corridors and the identification of high risk road locations for species mortality and/or movement and dispersal barriers (VDWR, VDOT, VDCR, Smithsonian Conservation Biology Institute, and George Mason University). By 2027, integrate these results into the revised Wildlife Corridor Action Plan to inform state priorities for where future wildlife crossing infrastructure and wildlife crash countermeasures along roads are needed (VDWR, VDOT, VDCR). The eleven SGCN mentioned under the Transportation Corridors habitat description are just a few examples that require these corridors and additional research to find solutions for impacts from transportation infrastructure corridors.

7. MONITORING, EFFECTIVENESS MEASURES AND RESEARCH NEEDS

Monitoring

In terms of monitoring, a Wildlife Action Plan must describe how each state will monitor the status of species and habitats that have been included within the Plan. Information on monitoring within the Wildlife Action Plan must also identify the mechanisms that will be used to monitor the effectiveness of implemented conservation actions . Finally, each Wildlife Action Plan must describe the mechanisms that will be used to adapt conservation actions in response to new information or changing conditions. While distinct, these concepts are related. Ideally, over time, conservation actions that are implemented will produce detectable improvements for local wildlife populations and/or their habitats. While the benefits of some projects might not be fully realized for years or even decades, monitoring the changes achieved from conservation efforts will make it possible to evaluate the conservation community's

ability to achieve conservation goals. Additionally, information from monitoring will allow managers to adapt those efforts to be more effective as experience is gained and changes are observed. The DWR staff and partners used the following mechanisms to address monitoring within Virginia's 2015 Wildlife Action Plan and they remain effective tools for this revision.

Monitoring Species Status

Virginia is home to over 30,000 species, including vertebrates, invertebrates, aquatic, terrestrial, marine, karst, and migratory species. With available resources, it is impossible to maintain an accurate census of this many populations. As an alternative, DWR staff work with multiple partners to collect status and trend data that are incorporated into relevant data management systems and the Wildlife Action Plan. These efforts include:

Population Monitoring by DWR Staff – DWR field staff spend many months each year monitoring wildlife populations. The agency may also contract with academic institutions or private entities to collect these data on the agency's behalf. In many cases, data collection efforts are iterative multi-year projects to ensure annual variability is normalized over time.

Much of the data collected are incorporated into the Virginia Fish and Wildlife Information System (VAFWIS), a publicly available database that provides public access to data and information about Virginia's wildlife. Among other uses, these data inform species management efforts and the environmental review process. These data, in conjunction with other information, were used to determine if a species should be included within Virginia's Wildlife Action Plan and how a species should be prioritized within the Tier structure (see Methods – Species of Greatest Conservation Need List Revision). Results of individual data collection and species monitoring efforts are reported in annual reports for State Wildlife Grants and Wildlife Restoration Grants provided to the USFWS. Examples of recent species monitoring efforts funded with State Wildlife Grants and other resources include the black-banded sunfish in southeast Virginia, freshwater mussel populations in Copper Creek and other portions of the Clinch River, the Atlantic sturgeon in the Chesapeake Bay watershed, and beach nesting species on Virginia's beaches and barrier islands.

In addition to DWR field staff, the Virginia Natural Heritage Program within the Virginia Department of Conservation and Recreation conducts a variety of surveys documenting the location and conservation status of rare plant and animal species, unique geological features and outstanding native ecosystems. This ongoing inventory is led by a team of ecologists, botanists, karst scientists, and zoologists who assess the status and condition of these natural heritage resources and prioritize their conservation needs. Field inventories focus on globally rare species, karst features and caves, and natural communities.

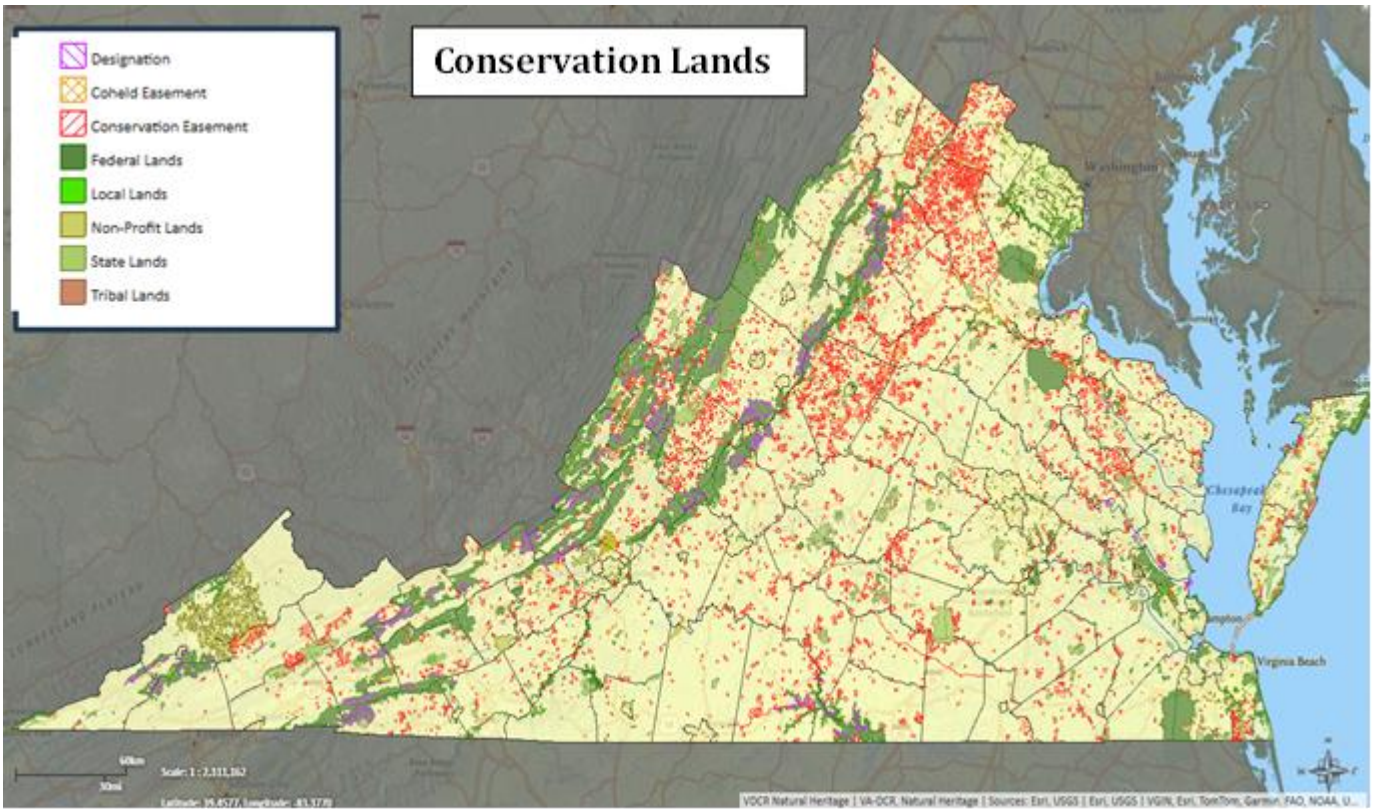


Figure 6.1 - Conservation Lands in Virginia

Natural Heritage scientists collect information on a large number of natural community types, significant caves, rare vertebrates, invertebrates, and plants representing a significant portion of the state's vertebrate and plant species. Over 2200 conservation sites, containing more than 6970 rare species populations, significant caves and natural communities have been found to date.

In addition to inventories for specific plants, animals and communities, inventories are conducted to assist private and public land managers. Inventories have included: all National Park Service lands, the Appalachian Trail, all major Department of Defense facilities, selected National Forest lands, many State Park lands, and others.

Scientific Collection Permits – The DWR is responsible for regulating the collection of wildlife by researchers and partner organizations within the Commonwealth. Species distribution data collected under the auspices of scientific collection permits are submitted annually by permittees to the DWR. These data are reviewed for accuracy and then incorporated into the VAFWIS. These data were also used to determine if species should be included within Virginia's Wildlife Action Plan and how a species should be prioritized within the Tier structure (see Methods – Species of Greatest Conservation Need List Revision).

NatureServe Status Rankings – NatureServe is an international nonprofit organization that works to answer four questions: What species and habitats exist? Where are they found? How are they doing? And which are conservation priorities? NatureServe provides a standardized set of global status rankings for species and habitats. These are commonly referred to as the "G&S" ranks. "G" represents "global"

status, and "S" represents "state" status. Both the global and the state rankings utilize a 5-point ranking system. A score of 5 indicates a species is "Secure", a score of 4 indicates a species is "Apparently Secure", a score of 3 indicates a species is "Vulnerable", a score of 2 indicates a species is "Imperiled", and a score of 1 indicates a species is "Critically Imperiled." The state ranking might also include SH, which indicates a species is "Possibly Extirpated," or a value of SX indicates a species is "Presumed Extirpated" in Virginia. The S ranks are maintained by the DCR Natural Heritage Program, a member of the NatureServe Network. NatureServe rankings are generally consistent with the Wildlife Action Plan's Tier system. NatureServe rankings were also used as one criterion to determine if species should be included with Virginia's Wildlife Action Plan and how a species should be prioritized with the Tier structure (see Methods – Species of Greatest Conservation Need List Revision).

Monitoring Amphibians

Changing water conditions due to droughts, flooding, or extreme weather events will have an effect on amphibian persistence as many species are dependent on water availability and quality to reproduce successfully. Habitat losses are also of significant concern to amphibian species which are often dispersal limited and temperature dependent. Riparian ecosystems, where many species of amphibians reside, are particularly crucial habitats that are likely to be highly impacted by changing environmental conditions (Capon *et al*. 2013). This can lead to cascading effects for amphibians. For example, reduced riparian forest cover impairs the development of young eastern hellbender salamanders (*Cryptobranchus alleganiensis alleganiensis*) (Funkhouser et al 2025). Unfortunately, amphibian declines have been observed worldwide (Adams *et al.* 2013). Ongoing monitoring efforts, such as the USGS Northeast Amphibian Research and Monitoring Initiative (NEARMI), are vital to continue managing and sustaining amphibian populations in Virginia. For example, one active NEARMI project evaluates the Shenandoah salamander (P*lethodon shenandoah*), an IUCN-listed Vulnerable species whose range is expected to decrease. The project studies the Shenandoah salamander and its habitat to understand its changing distribution and help guide future decisions on management, most recently facilitating a National Park Service-led discussion on next steps in 2024. Citizen science programs organized by partners like the Loudoun Wildlife Conservancy are also ongoing efforts to monitor and understand current amphibian biodiversity. These monitoring efforts are useful for managers to anticipate impacts of changing envimental conditions on amphibians and identify the best conservation decisions.

Monitoring Habitat Status

Water Quality

The National Clean Water Act requires each state to monitor the quality of its surface and ground waters to determine if they support six designated uses, including aquatic life, fish consumption, public water supplies (where applicable), recreation (swimming), shell fishing, and wildlife (DEQ 2024). Virginia also has instituted subcategories under most of these designated use categories. The U.S. Environmental Protection Agency (USEPA) requires that DEQ prepare biennial reports (305(b)/303(d) Water Quality Integrated Report) describing the status of water quality within the state (DEQ 2024). During the course

of their water quality monitoring to prepare these reports, DEQ personnel gather data from over a thousand stations located in Virginia's lakes, reservoirs, rivers, and estuaries. The types of data collected include measurements of temperature, pH, dissolved oxygen, nutrients, suspended solids, bacteria, metals, pesticides, herbicides, and toxic organic compounds. These data allow individual waters to be classified into one of five groups:

- Category 1: Water that fully supports all designated uses.
- Category 2: Water that fully supports some designated uses, but there is either insufficient or no information regarding the remaining designated uses.
- Category 3: There is insufficient information to determine if designated uses are being met.
- Category 4: Waters are impaired or threatened but do not need a TMDL.
- Category 5: Waters are impaired and need a TMDL.

The Water Quality Integrated Report is transmitted to Congress and the USEPA. Based on water quality monitoring and the degree of impairment, a watershed may require a Total Maximum Daily Load (TMDL) figure be calculated (see Statewide Overview; Freshwater Aquatic and Riparian Habitats). The most seriously impaired waters require a Water Quality Improvement Plan (see Statewide Overview; Freshwater Aquatic and Riparian Habitats). Virginia's list of impaired waters and the available water quality improvement plans are available online (DEQ 2024).

Virginia's Healthy Waters Initiative

Virginia's Healthy Waters Initiative, a joint effort of the DCR, Virginia Commonwealth University, and DEQ, is an effort to broaden conservation efforts to maintain critical, healthy resources before they are compromised. This Initiative is meant to work in concert with water quality programs that focus on repairing degraded systems to protect living resources. The approach encompasses protecting everything from aquatic insect larvae and bugs hidden in gravelly stream bottoms to forested buffers alongside streams to natural stream flows to the water we drink in an effort to maintain ecological balance. Healthy streams in Virginia have been identified and ranked through a stream ecological integrity assessment known as the Interactive Stream Assessment Resource (INSTAR). Streams may be ranked as "exceptionally healthy," "healthy," or "restoration candidate." Developed by the Center for Environmental Studies at Virginia Commonwealth University, INSTAR is an online interactive database application that identifies healthy streams using stream data that includes information about fish communities and insects, in-stream habitat, and riparian borders. Healthy waters are incorporated into DCR's Natural Heritage Biotics Database and used for land conservation and land planning purposes.

Virginia Wetlands Catalog

The Virginia Department of Conservation and Recreation's Natural Heritage Program, working with the federal Natural Resources Conservation Service, the Virginia Department of Transportation, The Nature Conservancy, and Virginia Commonwealth University's Center for Environmental Studies, has developed the Virginia Wetlands Catalog. This tool considers the condition and status of wetlands and ranks them in terms of restoration or conservation priority. Wetland patches are evaluated on several factors,

including existing plant and animal diversity, presence of significant natural communities, presence of natural lands providing ecosystem services, presence of corridors and stream buffers, proximity to conserved lands, inclusion within or downstream of healthy watersheds, and location of drinking water sources, proximity to degraded watersheds, proximity to impaired waters, location of existing wetland mitigation banks, presence of prior converted and farmed wetlands, and inclusion of stream reaches with lower aquatic biodiversity (Weber and Bulluck 2014). This material provides the most extensive set of habitat quality data available for Virginia's wetlands.

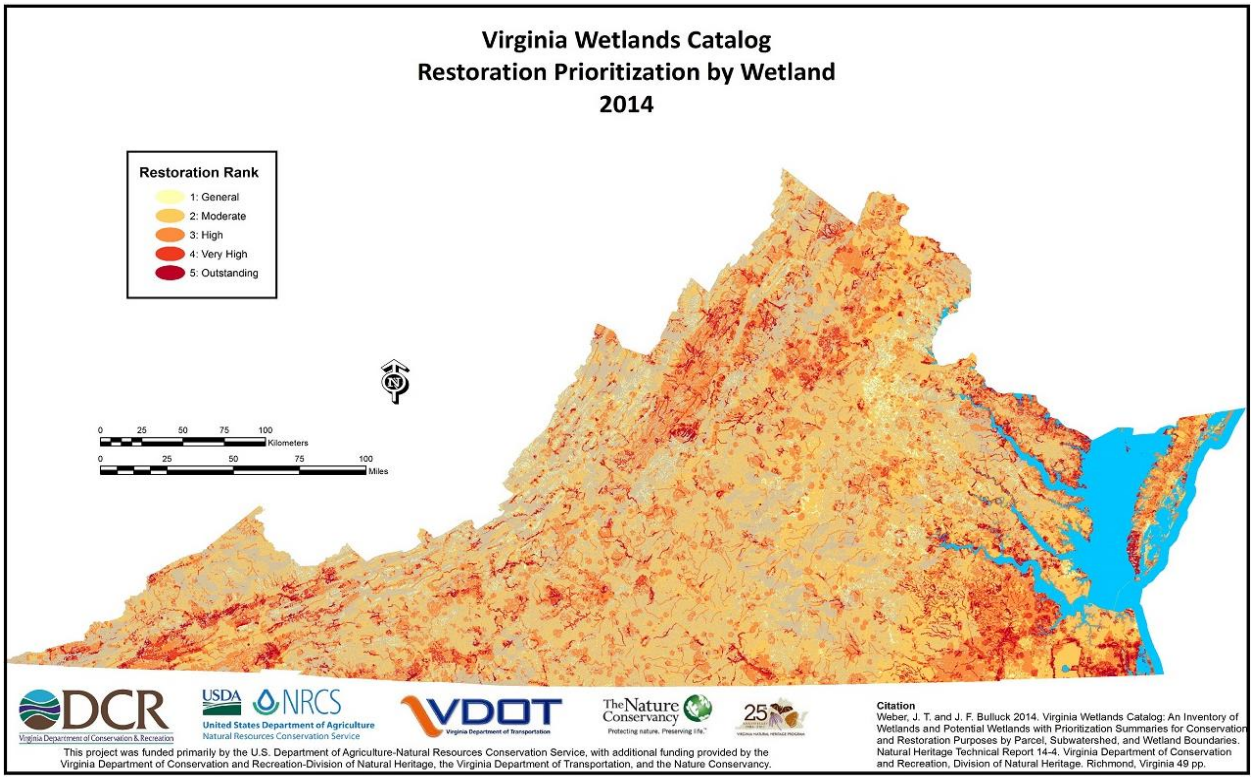


Figure 6.2. Virginia Wetlands Catalog

Chesapeake Bay Fish Passage Prioritization Tool and the Southeast Aquatic Connectivity Assessment Tool

Many of Virginia's rivers are fragmented by dams, culverts, and other impediments that limit the connectivity of these aquatic habitats. This fragmentation can prevent aquatic species from accessing important aquatic habitats crucial to various life stages. Stream restoration and connectivity projects (e.g., removing dams and culverts or modifying them to allow for passage) help improve and provide additional aquatic habitats for fish species within the state; however, there are many dams, and not all can or should be removed. In recent years, two tools have been developed to explore this issue. The Chesapeake Bay Fish Passage Prioritization Tool was designed by The Nature Conservancy in coordination with the NOAA Restoration Center, the U.S. Fish and Wildlife Service's Maryland Fisheries Resource Office, and other partners (Martin and Apse 2013). The Southeast Aquatic Connectivity Assessment Tool was designed by The Nature Conservancy in coordination with the Southeast Aquatic

Resource Partnership, the South Atlantic Landscape Conservation Cooperative, and other partners (Martin *et al.* 2014).

Both tools were created to evaluate the ecological return on investment of restoring connectivity in streams and rivers. Dams were assessed in terms of their ability to provide ecological benefits for one or more species if removed or altered to allow fish to bypass. Contributors to these tools prioritized dams for removal throughout the study areas based on benefits to three target groups of species – diadromous fish, resident fish, and brook trout. A wide range of metrics were developed and assessed for each of the three targets to help identify which dams were of highest priority for each of the three targets. Metrics for diadromous fish included amount of upstream river length available; upstream and downstream barriers, amount of impervious surface, amount of natural landcover, stream health, and number of diadromous species in the stream network, etc. The prioritization tool for diadromous fish was used to identify the top 3 tiers (top 15%) of priority dams for removal or alteration within Virginia. Most of these dams fall within the Coastal Plain region. DWR staff have identified several high priority dams for removal and continue to work with partners on these priority projects. Ashland Mill and Rapidan Mills Dam are just two of the current projects under evaluation.

Forest Inventory and Analysis

The United States Forest Service (USFS) monitors forest and woodland habitats across the country. The federal agency conducts an annual census of forests and woodlands with its Forest Inventory and Analysis (FIA) Program 107. The program assesses forests and woodlands by collecting data on tree species composition, size and health as well as tree growth, mortality and removals by harvest. There are 6,952 sample points in the FIA dataset within the Northeast region. The US Forest Service also monitors forests and woodlands via remote sensing and has developed a field sampling protocol to pair with remote sensing data to monitor carbon in forests and woodlands.

Northeast Terrestrial Habitat Map

In 2013, The Nature Conservancy, working on behalf of the Northeast Association of Fish and Wildlife Agencies and the North Atlantic Landscape Conservation Cooperative completed *Northeast Habitat Guides: A Companion to the Terrestrial and Aquatic Habitat Maps* (Anderson *et al.* 2013). This document and the habitat classification system it describes were developed "…as a comprehensive and standardized representation of habitats for wildlife that would be consistent across states and consistent with other regional classification and mapping efforts" (Anderson *et al.* 2013). As part of each habitat's description, the authors indicate in which states the habitat occurs, how many acres occur within each state, and how many of those habitat acres are managed as some form of conserved land. This report also provides tables indicating patch size, age class distribution, likelihood of loss due to development, and degree of fragmentation. These data provide a snapshot of the status for habitats restricted to Virginia and provide a general overview of status information for habitats that occur more broadly across the Northeast. The status information provided within the Terrestrial habitat map report is supplemented by additional information provided within *Conservation Status of Fish, Wildlife, and Natural Habitats in the Northeast Landscape: Implementation of the Northeast Monitoring Framework* (Anderson *et al.* 2011). This project led to an online tool using innovative mapping methods and

NatureServe's ecological system classification. The Nature Conservancy's Center for Resilient Conservation Science (formerly the Eastern Conservation Science) team produced the online mapping tool.

Natural Communities of Virginia: Classification of Ecological Community Groups

The DCR's Natural Communities of Virginia: Classification of Ecological Community Groups is a classification system that represents assemblages of co-existing, interacting species, considered together with the physical environment and associated ecological processes that usually recurs on the landscape. DCR's natural community inventory and classification represent an important "coarse filter" approach to biological conservation that ensures the protection of intact ecological systems containing diverse organisms. By identifying and protecting excellent examples of all natural community types in Virginia, the majority of our native plant and animal species, including many cryptic and poorly known ones, can be protected without redundant individual attention (Fleming et al. 2013). More information and detailed classification descriptions and images can be found online at the Natural Heritage website.

In addition to these resources, the Northeast Regional Conservation Synthesis For 2025 State Wildlife Action Plans provides many other resources for inventory and monitoring as part of the synthesis at the NE Synthesis website.

Eastern Brook Trout Joint Venture

In response to a need for guidance in setting wild Brook Trout conservation priorities, the Eastern Brook Trout Joint Venture (EBTJV) completed a range-wide assessment of wild Brook Trout distribution and status at the sub-watershed level (HUC 12) in 2006. While this initial assessment provided Brook Trout resource managers, decision-makers, and the public with an essential understanding of the current "state" of wild Brook Trout in the eastern portion of its U.S. range, many EBTJV partners felt that an assessment at a finer scale would yield better assistance by establishing a more workable set of wild Brook Trout conservation strategies. Therefore, the EBTJV conducted a second rangewide assessment of wild Brook Trout at the catchment scale, which was completed in 2015. Building from its wild Brook Trout assessment work, the EBTJV has developed strategies that provide the blueprint for Brook Trout conservation actions at multiple scales across the range. In addition to Brook Trout, this work of the EBTJV monitors the status of coldwater habitats throughout the Northeast and works to set conservation goals that maintain and enhance these sensitive and threatened habitats (EBTJV 2018).

Measuring the Effectiveness of Conservation Actions

Since Virginia's original Wildlife Action Plan was completed, monitoring and reporting the effectiveness of conservation actions has become an increasingly important issue. In late 2005, the U.S. House of Representatives initiated a performance review of the USFWS's Wildlife and Sportfish Restoration Programs, including State Wildlife Grants. This report concluded that results, related to the effectiveness of conservation actions, "are not being demonstrated." In subsequent years, funding for State Wildlife Grants has been scrutinized regarding its value to the American public. The USFWS and state wildlife agencies have worked to develop a mechanism to describe the importance and value of this program

and the Wildlife Action Plans. In September 2009, the Association of Fish and Wildlife Agencies (AFWA) recruited staff from state wildlife agencies and nongovernmental organizations to develop and test a framework of effectiveness measures to support the State Wildlife Grants program and the implementation of Wildlife Action Plans. This framework of effectiveness measures was designed to:

- *Provide a means to evaluate conservation actions so that successful activities/programs can be continued and communicated and less successful ones improved or abandoned;*
- *Establish a standardized and accessible body of project performance data to inform and guide actions by current and future wildlife managers; and*
- *Provide a cost-effective mechanism for reporting data through regional and national summaries that will help meet congressional reporting expectations and articulate the value of state wildlife grants, and potentially the wildlife action plans, to policy makers, conservation partners, and taxpayers (AFWA 2011).*

The final Effectiveness Measures report identifies 11 basic conservation actions that have been implemented by states to support their Wildlife Action Plans (AFWA 2011). These include:

- Direct Management of Natural Resources;
- Species Restoration;
- Creation of New Habitat;
- Acquisition/Easement/Lease of Land;
- Conservation Area Designation;
- Environmental Review;
- Management Planning;
- Land Use Planning;
- Training and Technical Assistance; and
- Data Collection and Analysis.

For each project type, the working group used a planning tool called a Results Chain to identify intermediate output measures that can be used to evaluate the quantity and quality of work completed during a project's implementation (FOS 2007). Each results chain also identified longer-term outcome measures that are used to evaluate how successful a project is in meeting its intended goals.

This working group's final report was completed and approved by the AFWA Executive Committee in April 2011. Subsequently, the USFWS's Office of Conservation Investment adopted this framework and coordinated with AFWA and state agency partners to incorporate these measures into the Tracking and Reporting on Actions for Conservation of Species (Wildlife TRACS) reporting system. Wildlife TRACS serves as the mandatory, central repository for all projects implemented using State Wildlife Grants and other Office of Conservation Investment grant programs. As the Wildlife TRACS framework was developed to specifically support Wildlife Action Plan implementation and has been integrated into the mandatory project reporting system, the DWR will use these resources to track the effectiveness of conservation actions in the Wildlife Action Plan as outlined by Congress.

Looking beyond the Effectiveness Measures and TRACS outlined above, there are a variety of regional and state level monitoring programs that will consider the ongoing success of the WAP.

The Motus Wildlife Tracking System network is an international program that uses nanotag technology to track and monitor migratory wildlife via telemetry receiver stations at the landscape scale, targeting species that are too small for satellite tracking equipment. As of 2022, there were more than 1550 Motus receiver stations located in 34 countries on five continents. More than 300 species (with more than 36,500 individuals) have been tagged as part of 573 projects. Nearly 1700 partners collaborate as part of the international Motus network. In the eastern United States, the network was initially developed to monitor shorebirds, seabirds, and coastally migrating songbirds, with most of the array located in coastal areas and along the Great Lakes shorelines. Since 2017, the Northeast Motus Collaboration has expanded the array throughout the interior Northeast, filling a geographic gap along a key migratory route in the western hemisphere. More than 470 Motus stations exist in the NEAFWA region as of 2022, the densest concentration of receiver stations in the world. Wildlife that is tracked in the Northeast with the Motus network includes songbirds, seabirds, raptors, bats, bumble bees, Monarch butterfly (*Danaus plexippus plexippus*), and migratory dragonflies. A Motus project in Tennessee tracked the movements of the RSGCN Bog Turtle (*Glyptemys muhlenbergii*).

Multiple partners working under the **Chesapeake Bay Partnership Agreement** monitor conservation efforts, species status, and habitat conditions in the estuary and its watershed. Monitoring information is collated and provided to oversight partners and the public through the Chesapeake Bay Program's Chesapeake Progress. More than two dozen indicators track progress on meeting the goals and outcomes of the Agreement among the six states and the District of Columbia:

- Vital Habitats
- Sustainable Fisheries
- Water Quality
- Toxic Contaminants
- Healthy watersheds
- Land conservation
- Public access
- Environmental literacy
- Stewardship
- Climate resiliency

Additional information about efforts in the Chesapeake Bay region can be found at the Chesapeake Bay Program website.

The **Virginia Coastal Zone Management Program** is known, in the national coastal zone management arena, as a "networked program." To manage Virginia's coastal resources, the program relies on a network of state agencies and local governments to administer the enforceable laws and regulations that protect wetlands, dunes, subaqueous lands, fisheries, and air and water quality – within the Virginia "Coastal Zone."

Since 2011, through annual grants (CZMA Section 309) from NOAA, the Virginia CZM Program has supported comprehensive ocean planning to understand current ocean uses and needs, plan for emerging uses such as offshore energy development, and protect the ocean's habitats, wildlife and overall health. This has become an increasingly difficult challenge as coastal populations have grown, ocean uses have diversified and intensified, and overall ocean health has declined.

The current Section 309 Ocean Resources Strategy (October 2021 – September 2026) prioritizes developing a Virginia Ocean Plan that will provide a framework for communication and coordination between agencies, organizations, and interests that make up Virginia's relationship to the ocean, as well as to the public. The Plan will include many recommendations based on input received to-date around topics like marine mammal/sea turtle conservation, addressing ocean acidification, increasing the resilience of Virginia's blue economy, and minimizing use conflicts. The Plan also proposes an ongoing coordinative body that will provide a forum for cross-jurisdictional planning as new circumstances arise.

In addition, Virginia CZM works closely with the Mid-Atlantic Regional Council on the Ocean (MARCO) to engage on regional ocean planning efforts, particularly when it comes to data collection and sharing. The continued development of the Mid-Atlantic Ocean Data Portal has created an incredibly strong foundation for data driven decision making while providing tools and training to resource managers, industry and the general public.

In addition to MARCO, the VA CZM Program is coordinating the development of the Virginia Ocean Plan and working with the DWR to develop the final Virginia Marine Mammal and Sea Turtle Conservation Plans (See Appendices 4 & 5 once complete.)

The **Mid-Atlantic Fishery Management Council** monitors the status of the Mid-Atlantic marine ecosystems, collaborating with NOAA to issue annual State of the Ecosystem Reports on the Mid-Atlantic shelf systems (NOAA 2024). These monitoring reports assess the trends and status of several indicators related to seascape scale fishery management objectives.

The **NEAFWA Regional Conservation Needs (RCN) Grants** program strategically fills critical monitoring gaps and needs highlighted in SWAPs including surveys, assessments, and monitoring protocols on priority species. The Northeast Association of Fish and Wildlife Agencies has supported a strong technical committee structure to further wildlife conservation. Technical committees are species or habitat-focused groups that exchange ideas and develop common approaches to wildlife issues. Typically, these conservation actions are implemented by individual states using their own funds; however, in some cases additional funding has been made available by agreement of the Northeast wildlife agency Directors. In one such case, the Directors established the Regional Conservation Needs (RCN) Program, which is managed by the Northeast Fish and Wildlife Diversity Technical Committee.

The RCN Program utilizes four percent of each state’s annual State Wildlife Grants apportionment to address the needs of SGCN across multiple states. Specifically, the RCN Program is used to coordinate

and implement conservation actions that are regional/sub-regional in scope and build upon the many regional initiatives that already exist. Output measures related to the RCN Program include monitoring the number of conservation actions and research projects selected by the participating agencies, the number of projects completed by the funding recipients, and the number of articles, publications, and technical reports developed each year as a result of funded projects. Example outcome measures include development, adoption and implementation of best management practices and data that drives decisions to not list at-risk species or supports downlisting and delisting. It is the DWR's intent to continue contributing SWG funds and personnel resources to support the RCN Program and the Northeast Fish and Wildlife Diversity Technical Committee.

Directed RCN projects have been developed to address these needs for priority RSGCN species and their habitats. RCN grants have supported a variety of monitoring and assessment projects within the last decade. These include:

- Eastern black rail
- Development of Avian Indicators and Measures for Monitoring Threats and Effectiveness of Conservation Actions in the Northeast
- Identification of Tidal Marsh Bird Focal Areas in BCR 30
- Bats and White-nosed Syndrome
- Allegheny woodrat Recovery
- Hellbender Population Assessment and Protocols
- Ranavirus in Amphibian Populations
- Timber rattlesnake Population Assessment
- Strategic Implementation of Regional Conservation Priorities for Freshwater Turtles at Risk in the Northeast
- Tiger beetle Status Assessment
- Coordinated Assessment of the northeastern diamondback terrapin Populations

A complete list of all RCN projects can be found at the Northeast Regional Conservation Needs website.

International Conservation

Dozens of migratory SGCN songbirds, waterfowl, shorebirds, and the monarch butterfly utilize habitats in Virginia as part of their annual life cycle. Due to threats impacting these species in other states or countries, conservation efforts in Virginia may be insufficient to ensure the long-term conservation of many of these species.

The DWR currently participates in several multi-stakeholder programs (Joint Ventures, Atlantic Flyway Council, Partners in Flight, Southern Wings) that work to monitor and conserve these migratory species. As part of these collaborative efforts, the DWR may consider using a portion of its State Wildlife Grants apportionment to conserve habitats or conduct research in other jurisdictions if those efforts have the potential to improve the status of one or more of Virginia's SGCN. The DWR's participation

with such a project would be considered as part of the agency's annual budgeting process and contingent upon an internal review by appropriate agency staff.

Adapting Conservation Strategies

As conservation projects are implemented and effectiveness data are collected, it is likely that projects will need to be modified, because experience will be gained, circumstances will change, or new information will become available. Through Wildlife TRACS system, the DWR will provide a mechanism to monitor effectiveness and identify issues. If issues or concerns are identified, the DWR and partners will update species specific management plans and develop additional research projects to adapt conservation efforts.

Plans or strategies have been developed for several specific SGCN conservation efforts. Examples of plans include the 2011 Canebrake Rattlesnake Conservation Plan and the 2010 Virginia Freshwater Mussel Restoration Strategy: Upper Tennessee Basin (DWR 2011; DWR 2010). These plans are created in collaboration with appropriate partners and contributors. If it is determined that conservation actions are not meeting expectations, or if circumstances dictate that conservation objectives must be altered outside of the scope of the original plan, the DWR will coordinate efforts with partners and stakeholders to amend plans as necessary. A state mussel recovery plan, a sea turtle conservation plan and a marine mammal conservation plan (See Appendices 4 & 5 once complete) are currently under development, and several nongame conservation plans are complete or in process (wood turtle, bog turtle, eastern hellbender, Tennessee dace, variegate darter, blackbanded sunfish and the tiger salamander). In addition, there are several regional plans that Virginia actively supports for conservation of eastern box turtle, spotted turtle, wood turtle and timber rattlesnake.

Few of these habitat and research efforts are expected to require a more specific or detailed planning document. As these projects are implemented, the Wildlife TRACS system (see above) is expected to provide the necessary effectiveness reporting framework to allow project managers and administrators to track and evaluate project results. Should a program need to be revised to address changing circumstances or new information, the DWR will rely upon its established science teams (see below) to provide program managers with the necessary guidance.

RESEARCH NEEDS

While updating the SGCN list (see Methods), the Technical Advisory Committees, species experts and partners were asked to describe actions that could be taken to conserve each species. Many partners identified research needs that fell into two categories. The vast majority of research needs involved collecting data to determine the distribution, status, and life history of SGCN. In most of these cases, no additional conservation actions were specified, and species were classified as conservation opportunity ranking "C." In other cases, specific research needs were identified that must be addressed before "on the ground" actions can be implemented to benefit a species. Under these circumstances, species were classified in management opportunity category "B." Absent other criteria, State Wildlife Grants funding will be prioritized to address research needs for category "B" species. This is not to indicate that no

baseline research will be implemented for category "C" species, but this type of research is expected to be a lower priority unless a compelling rationale can be articulated to explain how such an effort would likely lead to the removal of a species from the Wildlife Action Plan or contribute to a restoration effort. In addition, in this version of the plan, Assessment Priority Species were included in the Plan. As mentioned above, these species are considered rare, but there is not enough currently known to assign either a Tier or Conservation Opportunity Ranking. They have been included to ensure that they are tracked in future plans and to ensure that if their status changes at some point, then a minor revision will be conducted according to USFWS guidelines.

During the implementation of this Wildlife Action Plan, other research needs are likely to be identified as projects are developed and carried out. New research needs will be evaluated and prioritized during DWR's annual budgeting process. If the research involves a species that is not included within the Wildlife Action Plan, the DWR staff will coordinate with staff from the Office of Conservation Investment to ensure compliance with USFWS guidelines.

8. UPDATE OF VIRGINIA'S WILDLIFE ACTION PLAN

Congress requires that each state describe the procedures that will be used to review and update their Wildlife Action Plan at intervals not to exceed ten years (Public Law 106-291). Virginia will complete a comprehensive and formal revision of Virginia's Wildlife Action Plan by October 2035. The exact process for updating this Plan will be determined closer to that deadline. The process will be developed in close consultation with DWR administrators and staff, the USFWS, other agencies, and partners. As indicated previously, the DWR will continue its annual reporting of projects and accomplishments. When reporting on projects funded via State Wildlife Grants, the DWR will provide data on project outputs and effectiveness measures per the standardized metrics developed by AFWA and the Wildlife TRACS system. If indicated by the effectiveness and project output data, projects and programs may be altered to better address changing conditions. Efforts may also be adjusted as new technologies, data, or conservation strategies become available. If circumstances require the Wildlife Action Plan be revised prior to the 10-year deadline, the DWR staff will coordinate efforts with the appropriate representatives of the USFWS' Office of Conservation Investment .

9. STAKEHOLDER AND PUBLIC PARTICIPATION

Two of the Eight Essential Elements each Wildlife Action Plan must address involve outreach. Element 7 indicates that, "…Federal, State, and local agencies and Indian tribes that manage significant land and water resources within the State or administer programs that significantly affect the conservation of identified species and habitats…" must be afforded the opportunity to participate in the development, implementation, review, and revision of the Wildlife Action Plan (Public Law 106-291). In addition to the Federal, State, and local agencies and Indian Tribes, DWR also worked to involve the many private nongovernmental organizations that own conservation lands and easements in Virginia or implement conservation projects consistent with the Wildlife Action Plan. Collectively, these groups are called

conservation partners. Element 8 indicates that, "…broad public participation is an essential element of developing and implementing…" Wildlife Action Plans. Throughout the development of the Virginia's 2025 Wildlife Action Plan, the authors have made a significant effort to engage and address the needs and interests of both the conservation partners and the general public.

Conservation partner lists from the 2015 Plan were used to initiate development a comprehensive list of potential partners. As partners were contacted to determine their willingness to participate in the 2025 revision, additional groups were added. A very few groups had disbanded and were removed from the list. Two stakeholder meetings were held in May 2023 and one stakeholder meeting was held in September 2024. The first meeting in 2023 was held with all of the state, federal and local government agency partners. The second with all of the non-governmental agency partners. Both groups were combined for the 2024 meeting. In addition, staff reached out to the seven federal recognized tribes, four state recognized tribes and seven additional tribes with a historic presence in Virginia. Staff utilized the Virginia Sovereign Nations Conference, the EPA Virginia Tribal Operations Team, and one-on-one meetings or phone calls with the environmental programs at each tribe to coordinate their comments. Stakeholder comments were solicited through an online web portal at each major step of the process (SGCN lists, habitats, threats and conservation actions and the final draft.) Tribes were contacted individually and were provided a separate website for their comments.

Table 8.1. WAP Stakeholders

Federal	State	Regional/NGO
USFWS, Great Dismal Swamp National Wildlife Refuge	**Virginia Department of Health**	**Virginia Association of Planning District Commissions**
NPS, Shenandoah National Park	**Virginia Department of Conservation and Recreation, Natural Heritage Program**	**American Fisheries Society-VA Chapter**
USFWS, Eastern Virginia Rivers National Wildlife Refuge Complex	**Virginia Department of Forestry**	**Audubon Society of Northern Virginia**
USFWS, Potomac River National Wildlife Refuge Complex	**Virginia Department of Environmental Quality, Coastal Zone Management Program**	**B.A.S.S. Federation Nation of Virginia, Inc.**
USFWS, Ecological Services Staff	**Virginia Department of Environmental Quality, Division of Environmental Enhancement**	**Blue Ridge Land Conservancy of VA**
National Park Service – GW Memorial Parkway	**Virginia Department of Environmental Quality, Division of Water & Biological Monitoring**	**Capital Region Land Conservancy**
USFS, George Washington/Thomas Jefferson National Forests	**Virginia Department of Agriculture and Consumer Services, Plant Protection**	**Chesapeake Bay Foundation-Virginia Office**
USFWS, Back Bay National Wildlife Refuge	**Virginia Department of Energy**	**Coastal Conservation Association**
USFWS, Chincoteague National Wildlife Refuge	**Virginia Tech, Conservation Management Institute**	**Dan River Basin Association**
U.S. Bureau of Land Management	**Virginia Marine Resources Commission**	**Delta Waterfowl Richmond**
USFWS, Eastern Shore National Wildlife Refuge		**Discover the James**
DoD, Marine Corps Base Quantico		**Ducks Unlimited**
DoD, Ft. Walker		**Friends of Dyke Marsh**
DoD, Ft. Barfoot		**Friends of the Rappahannock**
DoD, Readiness and Environmental Protection Integration Program		**Friends of the Rivers of Virginia**

DoD, Ft. Belvoir	**Garden Club of Virginia**
NRCS, Virginia State Office	**Healing Harvest Forest Foundation**
NOAA, Regional Habitat and Ecosystem Services	**Izaak Walton League - Virginia Division**
NOAA, Protected Resources	**James River Association**
	National Wild Turkey Federation, Virginia
	New River Land Trust
	Northern Virginia Conservation Trust
	Piedmont Environmental Council
	Richmond Audubon
	Sierra Club - Virginia Chapter
	The Conservation Fund
	The Wildlife Foundation of Virginia
	The Nature Conservancy-VA Office
	Trust for Public Land -Chesapeake & Central Appalachians Field Office
	Virginia Association of Counties
	Virginia Conservation Network
	Virginia Council of Trout Unlimited
	Virginia Deer Hunters Association, Inc.
	Virginia Farm Bureau
	Virginia Herpetological Society
	Virginia Municipal League
	Virginia Native Plant Society
	Virginia Outdoors Foundation
	Virginia Society of Ornithology
	Wetlands Watch
	Wild Virginia
	Wildlife Center of Virginia
	Virginia Master Naturalist
	Virginias United Land Trusts
	Virginia Associsation of Soil and Water Conservation Districts
	Virginia Forestry Association
	Virginia Working Landscapes (Smithsonian)
	American Farmland Trust
	Cave Conservancy of the Virginias
	Virginia Speleological Survey
	The Wildlife Society of Virginia

Table 8.2. WAP Tribal Contacts

Federally Recognized Tribes
Monacan Nation
Rappahannock Indian Tribe
Upper Mattaponi Indian Tribe
Chickahominy Indian Tribe-Eastern Division
Chickahominy Indian Tribe
Nansemond Indian Tribe
Pamunkey Indian Tribe
State Recognized Tribes
Cheroenhaka Nottoway
Nottaway Indian Tribe
Mattaponi Nation
Patawomeck Indian Tribe
Other Tribes with a Historic/Cultural Presence in Virginia
Piscataway Conoy Tribe
Piscataway Indian Nation
Shawnee Tribe
Eastern Band Cherokee Indians
Occoneechee Band of the Sapponi Tribe
Sappony Tribe
Catawba Nation

{THIS SECTION WILL BE COMPLETED ONCE PUBLIC COMMENT HAS BEEN COMPLETED.} On XXXXX, 2025 the DWR made the draft 2025 Wildlife Action Plan available to conservation partners and the public via the DWR website at: and https://dwr.virginia.gov/wildlife/wildlife-action-plan/wildlife-action-plan-2025/

Following the release of the draft 2025 Wildlife Action Plan for review, and the distribution of the announcement emails, recipients suggested that the DWR notify other potentially interested parties. All the partners listed above were sent notice of the final draft being available for comment. In addition, the DWR published the call for public comment on various social media channels and published it in agency newsletters and on the agency website.

In another attempt to create awareness about and engage stakeholders in the revision of the Wildlife Action Plan to a larger public audience, the authors gave presentations to a variety of groups regarding the purpose of the Wildlife Action Plan. The authors requested that DWR staff and other partners help identify opportunities to give presentations to conservation partners and public audiences. Throughout the revision process, DWR staff presented information on the WAP revision, process and call for comments and partners at a variety of professional meetings. These are listed in Table 8.3 below. These presentations all involved discussions of the Wildlife Action Plan which included describing how changing environmental conditions would be addressed, how the updated Wildlife Action Plan would be

formatted, types of threats to wildlife and habitats that would be included, and types of actions that can be taken to address these issues. Several of these meetings were with individuals or a small group from the Organization and some were larger meetings open to the public where audiences ranged in size from 20 individuals to 120 individuals. During each presentation, the presenter offered to meet with other groups at other events as needed.

Table 8.3. Presentations to Organizations/Groups on the Wildlife Action Plan

Date	Organization/Group
08/08/22	DWR Watchable Wildlife Staff
8/24/2022	VA DCR/Division of Natural Heritage Staff
10/27/2022	DWR Nongame and Endangered Species Staff
11/17/2022	DWR Outreach Staff
12/13/2022	DWR Nongame and Endangered Species Staff
2/8/2023	VA DCR/Division of Natural Heritage Staff
3/21/2023	Dana Adkins, Chickahominy Tribe
4/6/2023	First Stakeholder Group meeting, NonGovernmental Organizations, DWR HQ, Henrico, VA
4/25-27/23	Virginia Land Conservation and Greenways Conference, Harrisonburg, VA
5/11/2023	First Stakeholder Group meeting, Government Agencies, DWR HQ, Henrico, VA
5/9/2023	EPA Regional Tribal Operations Team (virtual)
5/17/2023	Environmental Staff, Eastern Band of the Cherokee, Cherokee, NC
5/14/2023	Virginia Sovereign Nations Conference (attended/met with tribal representatives), Glen Allen, VA
10/31-11/1/23	Marine Mammal Conservation Plan Meeting, Norfolk, VA
3/6/2024	DWR Fish and Wildlife Information System Staff
4/9 -11/24	Environment Virginia Symposium, Lexington, VA
4/21-24/24	Northeast Association of Fish and Wildlife Agencies, Hyannis, MA
5/8/2024	Joe Capella, Pamunkey Tribe, Pamunkey Reservation, King William, VA
6/25-27/24	Northeast State Wildlife Action Plan Coordinators Meeting, Northampton, MA
9/11/2024	Second Stakeholder Advisory Committee Meeting, Richmond Public Library, Richmond, VA
9/19/2024	Virginia Sovereign Nations Conference, (Attended/met with tribal representatives), Glen Allen, VA
9/30-10/15/24	Tribal Office Visits, met with all 7 federally recognized tribes and the Mattaponi Tribe
10/7/2024	The Nature Conservancy Virginia Office (virtual)
10/17/2024	The Wildlife Center of Virginia, Waynesboro, VA
1/13/2025	Southeast Climate Adaptation Center Staff (virtual)
3/4/2025	Atlantic Flyways Council, Bird Collision meeting (virtual)
3/18-19/25	Virginia Chapter, The Wildlife Society, Richmond, VA
4/8-10/25	Environment Virginia Symposium, Lexington, VA
4/28-30/25	Virginia Land Conservation and Greenways Conference, Lynchburg, VA

{THIS SECTION WILL BE COMPLETED ONCE PUBLIC COMMENT HAS BEEN COMPLETED.} The updated Wildlife Action Plan was presented to the Board of the Virginia Department of Wildlife Resources at its public meeting on August 21, 2025. The public was provided an opportunity to comment on the draft Wildlife Action Plan during this event.

DWR Involvement

When Virginia's original Wildlife Action Plan was written, the planning effort was directed by the Wildlife Diversity Division. The Wildlife Diversity Division consisted of programs related to threatened and endangered species, nongame species conservation, environmental commenting, watchable wildlife, geospatial analysis, and data management. During 2010, the DWR executed a significant restructuring of its wildlife resource programs. Per this restructure, the former Wildlife Diversity Division was merged with the former Fisheries Division, which managed sportfish resources, and the former Wildlife Division, which managed terrestrial game species and habitat resources. These three divisions, Wildlife Diversity, Fisheries, and Terrestrial Wildlife, became the Bureau of Wildlife Resources. Functions and procedures within the Bureau were distinctly different from those used during the previous agency structure. These changes were significant in terms of how DWR prioritized projects and allocated State Wildlife Grant dollars.

In 2018, the Bureau was reorganized into 4 divisions and non-game staff were assigned to either the Fisheries or Wildlife Divisions. In 2022, non-game staff were consolidated into a new section within the Executive Office. As part of the 2025 revision, nongame, fisheries and wildlife staff were engaged to lead the taxonomic teams, develop the habitat associations, threats and conservation actions, which were then put out for stakeholder comment at each stage. Staff were also notified when the draft plan went out for public comment.

In updating the Wildlife Action Plan, to develop an effective and comprehensive document, it was imperative to ensure that the diversity of Bureau programs and personnel had the opportunity to participate in this planning effort. DWR staff members are an important conservation partner and, as such, were treated as a target for outreach efforts consistent with the guidance of Element 7.

During development of the WAP, staff met monthly with DWR leadership to discuss the schedule and additional constituent groups that should be contacted. Various parts of plan were presented and revised as needed. Agency leadership provided valuable input to the process and made recommendations to better structure the online tool. When the Nongame Program was reconstituted, the new Nongame Program Manager was added to the team that regularly met to review Plan progress. Ultimately the Nongame Program Manager will be responsible for implementing the approved Plan.

{THIS SECTION WILL BE COMPLETED ONCE PUBLIC COMMENT HAS BEEN COMPLETED.} On May 16, 2025, before the draft Wildlife Action Plan was made available to the general public, the draft Wildlife Action Plan was made available to DWR staff for review and comment. This effort provided an additional opportunity to find typographical errors, identify issues with species distributions, and clarify narratives regarding habitats, conservation threats, and actions.

Summary of Comments and Wildlife Action Plan Adaptations

During the comment period, comments were received during each part of the revision process. After the bulk (excluding the bird, plants and invertebrates) of the SGCN species' lists were published we

received comments from 17 stakeholders, primarily related to changing a tier ranking for a species, including just a subspecies and a few technical fixes related to species status. In addition, the DWR received an official response from the Rappahannock Tribe requesting that river herring and striped bass be moved to the highest tier of SGCN due to their tribal cultural significance and their populations declining. Agency fisheries biologists responded in a letter directly back to the tribe regarding agency concerns for these species, how the existing tiers were selected, and provided open avenues for future collaboration with the agency in managing these species. During the third comment period, which included the birds, plants and invertebrates, the DWR received three comments, most of which were from the Virginia Society of Ornithology members on a variety species requesting a change in tier or for the inclusion of a few species that were not included. In one case there was concern expressed about the conservation opportunity ranking.

During the second major comment period, stakeholders and each of the tribal nations were asked to review the habitats, threats and conservation actions associated with all of the SGCN except the terrestrial snails which had not been completed yet. Habitat descriptions, written by our habitat teams from various stakeholder experts, were also included and the SAC was asked to review those for accuracy and completeness. All threats and conservation actions were coded to correspond to the NE Lexicon. During this period, the DWR received extensive comments from four stakeholder groups, including the Rappahannock Tribe. Comments related to the inclusion of Data Centers as a specific threat. After consultation with the Northeast SWAP Coordinators, it was decided to update the description for the Commercial and Industrial Development to specifically identify Data Centers, including their impacts on water withdrawal, power generation and land development. Other comments identified the omission of Back Bay from the description of estuaries in the Commonwealth; the description was updated. One stakeholder requested information that would be included on Marine Mammals. These are addressed in this plan, but at the time of stakeholder comment, the Marine Mammal Conservation Plan had not been completed yet. Finally, the Wildlife Center of Virginia submitted extensive comments on wildlife diseases and the threats they post to SGCN. A section on wildlife diseases was added and an appendix provided by the NEAFWA and SEAFWA Fish and Wildlife Health Coordinators.

{THIS SECTION WILL BE COMPLETED ONCE PUBLIC COMMENT HAS BEEN COMPLETED.} The final draft of the Wildlife Action Plan, along with the Online Tool, were posted for Stakeholder Advisory Committee review on May 16, 2025. The DWR received XXX comments related to: During this comment period the WAP was also reviewed internally by staff and Agency administrators. All comments were reviewed and addressed as appropriate. Specifically, ...

All comments were addressed on the website to inform the stakeholders about how the Technical Advisory Committees addressed their comments and the reasoning behind the actions taken. All tribal comments were addressed with a formal letter to the specific tribe addressing their concerns and providing opportunities for further coordination.

As the updated Wildlife Action Plan is implemented, DWR staff will continue collaborating with Conservation Partners and working to inform the general public about the wildlife conservation efforts

implemented on their behalf. These efforts will include working with the our conservation partners like the Piedmont Environmental Council, Blue Ridge Prism, The Nature Conservancy and many others. Future work will involve corporate and private partners along the lines of current efforts involving Devil's Backbone Brewery, The Paul G. Allen Foundation, and others through the work of our Agency Community Engagement and External Relations Coordinator. Finally, the Agency has already begun cooperative projects with Virginia's Sovereign Nations and we will continue to engage with them wherever possible to develop cooperative conservation projects that respect their traditional ecological knowledge and advance Wildlife Action Plan conservation actions.

10. CONCLUSION

From a statewide level, reviewing conservation needs in this Wildlife Action Plan may be discouraging as hundreds of species are identified as being of greatest conservation need. Concerns over the loss or degradation of Virginia's aquatic, wetland, terrestrial, subterranean, and coastal habitats are not inconsequential. If we fail to address these issues, more regulatory actions may be needed to further protect and conserve some of these species, which would have profound impacts for people, businesses, and communities, as well as wildlife.

Alternatively, this document can be viewed from the perspective of implementation. The Plan focuses on what the conservation community, as well as communities, businesses, and private citizens, can do to best protect and conserve species and habitats within the Commonwealth. Management actions have already been identified for scores of these species and habitats that, if implemented, are likely to benefit hundreds of additional SGCN. Important research needs have been identified that should allow the DWR and its partners to implement more "on the ground" conservation for dozens of species. Many of the threats affecting Virginia's terrestrial and aquatic habitats can be addressed with known techniques, technologies, and best practices. Finally, and perhaps most importantly, Virginia has a robust and dedicated conservation community, comprised of governmental and non-governmental agencies and organizations, colleges and universities, and talented enthusiasts, who have proven that great things can be accomplished when efforts are focused .

IIt is the DWR's intent that the revised Wildlife Action Plan will define problems based on areas of common interest. This updated version was created to find ways to keep species from becoming imperiled. While this perspective may seem limited, the majority of conservation issues Virginians face are not just "wildlife issues" but are, in fact, Virginia issues for which wildlife are an indicator. Clean and healthy rivers are important for wildlife, people, communities, and industries. Healthy riparian forests, wetlands, and upland habitats provide people with economic and recreational opportunities, while also supporting diverse wildlife species and helping to ensure clean water flowing thru our landscapes. As waters flow from Virginia , these rivers, and their adjacent habitats, support even more species, communities, industries and recreational opportunities. Working to keep species from becoming imperiled benefits our communities, our economy, and our quality of life by addressing the problems that exist within our collective habitats and preventing them from becoming a crisis.

The conservation actions defined at the sub-watershed level are not mandates. Rather, they identify shared problems and describe the types of actions that can be taken to address conservation priorities. Ideally, these actions will inspire collaboration among the conservation community and provide guidance as to how limited time, money, and people can be utilized to best effect. Groups with other focuses, such as clean water, open space, outdoor recreation, commercial fisheries, or civic enhancement, may use this document as a means of forging new collaborations that achieve mutual goals.

The problems outlined within this revised Wildlife Action Plan can be addressed. It will require time, resources, and dedication, and a little luck. It is within our ability to prevent many of these species from becoming imperiled while also doing beneficial things for human communities.

11. REFERENCES

Adams MJ, Miller DAW, Muths E, Corn PS, Grant EHC, Bailey LL, et al. (2013) Trends in Amphibian Occupancy in the United States. PLoS ONE 8(5): e64347. https://doi.org/10.1371/journal.pone.0064347

Anderson, M.G. and A. Olivero Sheldon. 2011. Conservation Status of Fish, Wildlife, and Natural Habitats in the Northeast Landscape: Implementation of the Northeast Monitoring Framework. The Nature Conservancy, Eastern Conservation Science. Boston, Massachusetts. 289 p.

Anderson, M.G. M. Clark, C.E. Ferree, A. J., A. Olivero, S. and K.J. Weaver. 2013. Northeast Habitat Guides: A companion to the terrestrial and aquatic habitat maps. The Nature Conservancy, Eastern Conservation Science, Eastern Regional Office. Boston, MA.

Anderson, M.G., M. Clark, and A. Olivero. 2023. Conservation Status of Natural Habitats in the Northeast. The Nature Conservancy, Eastern Conservation Science. Boston, Massachusetts.

Anthony, A. 10 Feb 2022. "The Meat Industry's Middlemen Are Starving Families and Farmers." The American Prospect. https://prospect.org/economy/meat-industrys-middlemen-starving-families-and-farmers/.

Atlantic States Marine Fisheries Commission. 2009. Terms of reference and advisory report forth eNEAMAP Nearshore Trawl Survey peer review. Report 09-01 of the Atlantic States Marine Fisheries Commission. Alexandria, VA.

Association of Fish and Wildlife Agencies (AFWA). 2011. Measuring the Effectiveness of State Wildlife Grants: Final Report. Washington, D.C. Available at http://www.fishwildlife.org/files/Effectiveness-Measures-Report_2011.pdf.

Audubon. 2020. Reducing Collisions with Glass. https://www.audubon.org/news/reducing-collisions-glass

Ayvazian, S., Mulvaney, K., Zarnoch, C., Palta, M., Reichert-Nguyen, J., McNally, S., Pilaro, M., Jones, A., Terry, C., & Fulweiler, R. W. 2021. Beyond Bioextraction: The Role of Oyster-Mediated Denitrification in Nutrient Management. Environmental Science and Technology, 55(21), 14457–14465. https://doi.org/10.1021/acs.est.1c01901

Basilio, L. G., D. J. Moreno, and A. J. Piratelli. 2020. Main causes of bird-window collisions: a review. Anais da Academia Brasileira de Ciências 92:e20180745.

Bason, Christopher W., Daniel E. Kroes, and Mark M. Brinson. 2017. The effect of beaver ponds on water quality in rural Coastal Plain streams. Southeastern Naturalist, 16(4): 584-602.

Blankenship, K. 1 May 2023. "Chesapeake Bay cleanup faces difficult trade-offs with agriculture." Bay Journal. https://www.bayjournal.com/news/policy/chesapeake-bay-cleanup-faces-difficult-trade-offs-with-agriculture/article_896365bc-e43b-11ed-beac-b396d2795ed7.html.

Blanton, D. 2022. Personal Communication on inclusion of Assessment Priority species in the list of Species of Greatest Conservation Need.

Borowy, D., 2013. Re-Growing Southeastern Grasslands. National Park Service. https://www.nps.gov/articles/000/re-growing-southeastern-grasslands.htm

Boycott, T. J., S. M. Mullis, B. E. Jackson, and J. P. Swaddle. 2021. Field testing an "acoustic lighthouse": Combined acoustic and visual cues provide a multimodal solution that reduces avian collision risk with tall human-made structures. PLOS ONE 16:e0249826.

Brooke, S., Watts, M., Heil, A., Rhode, M., Mienis, F., Duineveld, G., Davies, A., Ross, S., 2017. Distributions and habitat associations of deep-water corals in Norfolk and Baltimore Canyons, Mid-Atlantic Bight, USA. Deep Sea Research Part II: Topical Studies in Oceanography 137, 131–147.

Brown, B. B., E. Kusakabe, A. Antonopoulos, S. Siddoway, and L. Thompson. 2019. Winter bird-window collisions: mitigation success, risk factors, and implementation challenges. PeerJ 7:e7620.

Brown, B. B., S. Santos, and N. Ocampo-Peñuela. 2021. Bird-window collisions: Mitigation efficacy and risk factors across two years. PeerJ 9:e11867.

Bullock, H. E., C. T. Panter, and T. A. Miller. 2024. Conservation Letter: Raptor Collisions in Built Environments. Journal of Raptor Research.

Capon, S.J., Chambers, L.E., Mac Nally, R. *et al.* Riparian Ecosystems in the 21st Century: Hotspots for Climate Change Adaptation?. *Ecosystems* 16, 359–381 (2013). https://doi.org/10.1007/s10021-013-9656-1

Center for Coastal Resources Management, Virginia Institute of Marine Science. (2009) Sand Dune and Beaches in Virginia: Science and Management. Rivers & Coast, Fall 2009 Special issue. Virginia Institute of Marine Science, College of William and Mary. http://dx.doi.org/doi:10.21220/m2-9d3t-6r70

Chen, K., S. M. Kross, K. Parkins, C. Seewagen, A. Farnsworth, and B. M. Van Doren. 2024. Heavy migration traffic and bad weather are a dangerous combination: Bird collisions in New York City. Journal of Applied Ecology 61:784–796.

Coffin, A.W., Sclater, V., Swain, H., Ponce-Campos, G.E., and Seymour, L. 1 Mar 2021. Ecosystem Services in Working Lands of the Southeastern USA. Frontiers in Sustainable Food Systems. Vol 5. https://www.frontiersin.org/journals/sustainable-food-systems/articles/10.3389/fsufs.2021.541590/.

Colling, O. M., C. G. Guglielmo, S. J. Bonner, and Y. E. Morbey. 2022. Migratory songbirds and urban window collision mortality: vulnerability depends on species, diel timing of migration, and age class. Avian Conservation and Ecology 17:22.

Colvig, C. D. "Restoring Essential Grasslands in the East", National Park Service, 2024, https://www.nps.gov/articles/000/essential-eastern-grasslands. Accessed July 10, 2024.

Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological Systems of the United States: A Working Classification of U.S. Terrestrial Systems. NatureServe, Arlington, Virginia.

Coolidge, M., D. Helzer, and J. Ujcic-Ashcroft. 2021, March 2. A Successful Monitoring and Mitigation Project to Address Bird Window Collisions at the City of Portland's Columbia Building, 2015-2019.

Cowie, R. H., Bouchet, P. and Benoit, F. 10 Jan 2022. "The Sixth Mass Extinction: fact, fiction or speculation? Biological Reviews. https://onlinelibrary.wiley.com/doi/full/10.1111/brv.12816.

Crisfield, E and the Northeast Fish and Wildlife Diversity Technical Committee (NEFWDTC). 2022. The 2022 Northeast Lexicon: Terminology Conventions and Data Framework for State Wildlife Action Plans in the Northeast Region. Northeast Association of Fish and Wildlife Agencies, Washington, D.C.

Culver, D. C. 1991. Element stewardship abstracts for six subterranean natural communities common to the karst of Appalachia. Contract deliverable to The Nature Conservancy, submitted to Larry Master, 11 June 1991.

Culver, D.C. 1986. Cave faunas, pp. 427-443. In E.E. Soule, editor, Conservation biology.Sinauer Associates, Sunderland, MA.

Culver, D.C. 1985. Trophic relationships in aquatic cave environments. Stygologia 1:43-53.

Cusa, M., D. A. Jackson, and M. Mesure. 2015. Window collisions by migratory bird species: urban geographical patterns and habitat associations. Urban Ecosystems 18:1427–1446.

Donaldson, B.M. and K.E.M. Elliott. 2021. "Enhancing Existing Isolated Underpasses with Fencing Decreases Wildlife Crashes and Increases Habitat Connectivity." Human-Wildlife Interactions Vol. 15, Issue 1, Article 20. https://digitalcommons.usu.edu/hwi/vol15/iss1/20.

Dahl, T.E. 1990. Wetlands Losses in the United States 1780's to 1980's. U.S. Department of the Interior, Fish and Wildlife Service, Washington. D.C.

Eastern Brook Trout Joint Venture. 2018. Conserving the Eastern Brook Trout: Action Strategies. Eastern Brook Trout Joint Venture. https://easternbrooktrout.org/science-data/reports/eastern-brook-trout-roadmap-to-conservation-2018/view

Eastern Ecological Science Center (2016). U.S. Geological Survey. *Managing the Future Status of the Shenandoah Salamander*. https://www.usgs.gov/news/managing-future-status-shenandoah-salamander

Eastern Ecological Science Center (2023). U.S. Geological Survey. *Northeast Amphibian Research and Monitoring Initiative*. https://www.usgs.gov/centers/northeast-armi

Ellison, H. 2022. "Virginia Agricultural Statistics 2022 Annual Bulletin." USDA National Agricultural Statistics Service, Virginia Field Office.

https://www.nass.usda.gov/Statistics_by_State//Virginia/Publications/Annual_Statistical_Bulletin/2022%20VA%20Annual%20Bulletin.pdf.

Elmore, J. A., S. B. Hager, B. J. Cosentino, T. J. O'Connell, C. S. Riding, M. L. Anderson, M. H. Bakermans, T. J. Boves, D. Brandes, E. M. Butler, M. W. Butler, N. L. Cagle, R. Calderón-Parra, A. P. Capparella, A. Chen, K. Cipollini, A. A. T. Conkey, T. A. Contreras, R. I. Cooper, C. E. Corbin, R. L. Curry, J. J. Dosch, K. L. Dyson, E. E. Fraser, R. A. Furbush, N. D. G. Hagemeyer, K. N. Hopfensperger, D. Klem, E. A. Lago, A. S. Lahey, C. S. Machtans, J. M. Madosky, T. J. Maness, K. J. McKay, S. B. Menke, N. Ocampo-Peñuela, R. Ortega-Álvarez, A. L. Pitt, A. Puga-Caballero, J. E. Quinn, A. M. Roth, R. T. Schmitz, J. L. Schnurr, M. E. Simmons, A. D. Smith, C. W. Varian-Ramos, E. L. Walters, L. A. Walters, J. T. Weir, K. Winnett-Murray, I. Zuria, J. Vigliotti, and S. R. Loss. 2021. Correlates of bird collisions with buildings across three North American countries. Conservation Biology 35:654–665.

Environmental Protection Agency. 4 Oct 2024. "Green Infrastructure: Mitigate Flooding." https://www.epa.gov/green-infrastructure/mitigate-flooding.

Everaert, G., De Rijcke, M., Lonneville, B., Janssen, C., Backhaus, T., Mees, J., van Sebille, E., Koelmans, A., Catarino, A.I., Vandegehuchte, M.B., 2020. Risks of floating microplastic in the global ocean. Environmental Pollution 267, 115499.

Ewart, J.W., Ford, S.E., 1993. History and impact of MSX and Dermo diseases on oyster stocks in the northeast region. Northeastern Regional Aquaculture Center, University of Massachusetts.

Ezer, T. and L.P. Atkinson. 2016. Sea Level Rise in Virginia – Causes, Effects and Response. Center for Coastal Physical Oceanography, Old Dominion University. https://research.fit.edu/media/site-specific/researchfitedu/coast-climate-adaptation-library/united-states/east-coast/virginia/Ezer-et-al.--2016.--Review-of-SLR-in-Virginia.pdf

Feiner, K. & Lowry, C.S. 2015. Simulating the effects of beaver dams on regional groundwater flow through a wetland. Journal of Hydrology 4: 675-685.

Fleming, G.P., K.D. Patterson, K. Taverna, and P.P. Coulling. 2013. The natural communities of Virginia: classification of ecological community groups. Second approximation. Version 2.6. Virginia Department of Conservation and Recreation, Division of Natural Heritage, Richmond, VA.

Florida Fish and Wildlife Conservation Commission (FWC). 2019. Florida's Wildlife Legacy Initiative: Florida's State Wildlife Action Plan. Tallahassee, Florida. https://myfwc.com/media/22767/2019-action-plan.pdf.

Fong, D.W., D.C. Culver, H. H. Hobbs, III, Pipan, T., 2007, The invertebrate cave fauna of West Virginia: second edition. Bulletin #16, West Virginia Speleological Survey, Barrackville, WV. 163 pages

Foundations of Success (FOS). 2007. Using Results Chains to Improve Strategy Effectiveness, An FOS How-To Guide. Foundations of Success. Bethesda, MD., USA.

Frost, Cecil C. 1995. Presettlement fire regimes in southeastern marshes, peatlands, and swamps. Pages 39-60 in Susan I. Cerulean and R. Todd Engstrom, eds. Fire in wetlands: a management perspective.

Proceedings of the Tall Timbers Fire Ecology Conference, No. 19. Tall Timbers Research Station, Tallahassee, Florida.

Fry, J., Xian, G., Jin, S., Dewitz, J., Homer, C., Yang, L., Barnes, C., Herold, N., and Wickham, J., 2011. Completion of the 2006 National Land Cover Database for the Conterminous United States, PE&RS, Vol. 77(9):858-864.

Funkhouser, H.A., Case, B.F., Groffen, J., Holloway, A. and Hopkins, W.A. (2025), Association Between Reduced Upstream Riparian Forest Cover and Impaired Development of Embryos From Eastern Hellbenders (*Cryptobranchus alleganiensis*). Freshw Biol, 70: e14368. https://doi.org/10.1111/fwb.14368

Gartland, J., Gaichas, S.K. and Latour, R. J., 2023. Spatiotemporal patterns in ecological community of the nearshore Mid-Atlantic Bight. Marine Ecology Progress Series, 704, pp. 15-33.

Gehring, J., P. Kerlinger, and A. M. Manville. 2009. Communication towers, lights, and birds: successful methods of reducing the frequency of avian collisions. Ecological Applications 19:505–514.

Gelb, Y., and N. Delacretaz. 2009. Windows and Vegetation: Primary Factors in Manhattan Bird Collisions. Northeastern Naturalist 16:455–470.

Gonçalves Neto, A., Langan, J.A., Palter, J.B., 2021. Changes in the Gulf Stream preceded rapid warming of the Northwest Atlantic Shelf. Communications Earth & Environment 2, 74.

Gonçalves, F. H., Van Senten, J., Schwarz, M. H., & Hegde, S. 2022. Economic Contributions of the Virginia Seafood Industry. www.arec.vaes.vt.edu/arec/virginia-seafood

Griffeth, G.E., J.M. Omernik, and A.J. Woods. 1999. Ecoregions, watersheds, basins, and HUCs: How state and federal agencies frame water quality. Journal of Soil and Water Conservation 54(4):666-677.

Groot, K. L. D., A. G. Wilson, R. McKibbin, S. A. Hudson, K. M. Dohms, A. R. Norris, A. C. Huang, I. B. J. Whitehorne, K. T. Fort, C. Roy, J. Bourque, and S. Wilson. 2022. Bird protection treatments reduce bird-window collision risk at low-rise buildings within a Pacific coastal protected area. PeerJ 10:e13142.

Hager, S. B., B. J. Cosentino, K. J. McKay, C. Monson, W. Zuurdeeg, and B. Blevins. 2013. Window Area and Development Drive Spatial Variation in Bird-Window Collisions in an Urban Landscape. PLoS ONE 8:e53371.

Hanberry, Brice B., and Reed F. Noss. 2022. “Locating Potential Historical Fire-Maintained Grasslands Of the Eastern United States Based on Topography and Wind Speed.” Ecosphere 13(6): e4098. https://doi.org/10.1002/ ecs2.4098

Hawes, Ellen and Markelle Smith. April 2005. Riparian Buffer Zones: Functions and Recommended Widths. Yale School of Forestry and Environmental Studies.

Hayden, Bruce P. and Michaels, Patrick J. 2011. Virginia's Climate. University of Virginia Climatology Office, Department of Environmental Sciences. Retrieved from http://climate.virginia.edu/description.htm.

Hintz, W.D., S.E. Arnott, C.C. Symons, D.A. Greco, A. McClymont, J.A. Brentrup, M. Canedo-Argüelles, A.M. Derry, A.L. Downing, D.K. Gray, S.J. Melles, R.A. Relyea, J.A. Rusak, C.L. Searle, L. Astorg, H.K. Baker, B.E. Beisner, K.L. Cottingham, Z. Ersoy, C. Espinosa, J. Franceschini, A.T. Giorgio, N. Göbeler, E. Hassal, M.P. Hebert, M. Huynh, S. Hylander, K.L. Jonasen, A.E. Kirkwood, S. Langenheder, O. Langvall, H. Laudon, L. Lind, M. Lundgren, L. Proia, M.S. Schuler, J.B. Shurin, C.F. Steiner, M. Striebel, S. Thibodeau, P. Urrutia-Corderou, L. VendrellPuigmitja, and G.A. Weyhenmeyer. 2022. Current water quality guidelines across s North America and Europe do not protect lakes from salinization. PNAS 119(9): e2115033119.

Holsinger, J.H., D.C. Culver, D.A. Hubbard, W.D. Orndorff, C. S. Hobson. 2013. The Invertebrate Cave Fauna of Virginia. Banisteria vol. 42, p. 9-46.

Holsinger, J.H., and D.C. Culver, 1988. The invertebrate cave fauna of Virginia and a part of eastern Tennessee. Brimleyana, no. 14.

Holsinger, J. R., 1966. A preliminary study of the effects of organic pollution of Banners Corner Cave, Virginia. International Journal of Speleology 2:75-79.

Howarth, L. M., Lewis-McCrea, L. M., Kellogg, L. M., Apostolaki, E. T., & Reid, G. K. 2022. Aquaculture and eelgrass Zostera marina interactions in temperate ecosystems. *Aquaculture Environment Interactions*, *14*, 15–34. https://doi.org/10.3354/AEI00426

Hudson, K., & Virginia Sea Grant Marine Advisory Program. 2019. Virginia Shellfish Aquaculture Situation and Outlook Report: Results of the 2018 Virginia Shellfish Aquaculture Crop Reporting Survey. In *W&M ScholarWorks*. https://doi.org/10.25773/jc19-y847

Jambeck, J.R., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A., Narayan, R., Law, K.L., 2015. Plastic waste inputs from land into the ocean. Science 347, 768–771.

Klem Jr., D. 1990. Collisions between birds and windows: mortality and prevention. Journal of Field Ornithology 61:120–128.

Klem Jr., D. 2009. Preventing Bird–Window Collisions. The Wilson Journal of Ornithology 121:314–321.

Klem Jr., D., and P. G. Saenger. 2013. Evaluating the Effectiveness of Select Visual Signals to Prevent Bird-window Collisions. The Wilson Journal of Ornithology 125:406–411.

Kleopfer, J.D. and J. Sevin, Ph.D. Dec. 3, 2024. Shell Game. VA Dept. Of Wildlife Resources website. https://dwr.virginia.gov/blog/shell-game/

Kornreich, A., D. Partridge, M. Youngblood, and K. Parkins. 2024. Rehabilitation outcomes of bird-building collision victims in the Northeastern United States. PLOS ONE 19:e0306362.

Kroes, Daniel E., and Christopher W. Bason. 2015. Sediment-trapping by beaver ponds in streams of the Mid-Atlantic Piedmont and Coastal Plain, USA. Southeastern Naturalist, 14(3): 577-595.

Lamarre, P., J. Samson, and J. Tardif. 2021. Standardized Classification of Threats to Biodiversity – Definitions for Quebec's Conservation Data Centre, version 1.0. Ministere des Forets, de la Faune et des Parcs, Gouvernement du Québec, Québec, Canada. 25 p.

Lamb, B. 2023. Love for the Land: Lessons from Farmers Who Persist in Place. Yale Univ. Press. https://brookslamb.com/.

LANDFIRE Rapid Assessment. 2007. Rapid assessment reference condition models. In: LANDFIRE. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Lab; U.S. Geological Survey; The Nature Conservancy (Producers). Available: http://www.landfire.gov/models_EW.php [66533]

Lao, S., B. A. Robertson, A. W. Anderson, R. B. Blair, J. W. Eckles, R. J. Turner, and S. R. Loss. 2020. The influence of artificial light at night and polarized light on bird-building collisions. Biological Conservation 241:108358.

Lapointe, F., Bradley, R.S., Francus, P., Balascio, N.L., Abbott, M.B., Stoner, J.S., St-Onge, G., De Coninck, A., Labarre, T., 2020. Annually resolved Atlantic sea surface temperature variability over the past 2,900 y. Proceedings of the National Academy of Sciences 117, 27171–27178.

Latour, R.J., Brush, M.J. and Bonzek, C.F. 2003. Toward ecosystem-based fisheries management: strategies for multispecies modeling and associated data requirements. Fishereis, 28(9), pp. 10-22.

Latour, R.J., Gartland, J. and Bonzek, C.F., 2023. Design and redesign of a bottom trawl survey in Chesapeake Bay, USA. Frontiers in Marine Science, 10.

Lefcheck, J.S., Marion, S.R., Orth, R.J., 2017. Restored eelgrass (Zostera marina L.) as a refuge for epifaunal biodiversity in mid-western Atlantic coastal bays. Estuaries and Coasts 40, 200–212.

Legner, K., Andersen, H.K., Cooke, A., and Cohen, W. 2020. A cost-effective field measurement protocol to support lidar-assisted carbon monitoring programs—implementing a prototype design at six different sites in the United States. USDA Forest Service, Pacific Northwest Research Station. https://research.fs.usda.gov/treesearch/59714

Leung, K. 2022, April 13. Invisible to visible : A field study investigating dirty windows and bird-friendly artwork as mitigation strategies against bird-window collisions. University of British Columbia.

Loss, S. R., S. Lao, J. W. Eckles, A. W. Anderson, R. B. Blair, and R. J. Turner. 2019. Factors influencing bird-building collisions in the downtown area of a major North American city. PLOS ONE 14:e0224164.

Loss, S. R., T. Will, S. S. Loss, and P. P. Marra. 2014. Bird–building collisions in the United States: Estimates of annual mortality and species vulnerability. The Condor 116:8–23.

Loudoun Wildlife Conservancy. (n.d.). *Amphibian and Reptile Monitoring*. https://loudounwildlife.org/volunteer/amphibian-reptile-monitoring/

Marengo J.A., Souza C.M. Jr, Thonicke K., Burton C., Halladay K., Betts R.A., Alves L.M. and Soares W.R. 2018. Changes in Climate and Land Use Over the Amazon Region: Current and Future Variability and Trends. *Front. Earth Sci.* 6:228. doi: 10.3389/feart.2018.00228

Marler, S. C. 2024, July 10. Bird-Window Strike Trends and Mitigation. University of Saint Joseph, West Hartford, Connecticut.

Mart, L., Rützel, H., Klahre, P., Sipos, L., Platzek, U., Valenta, P., Nürnberg, H., 1982. Comparative studies on the distribution of heavy metals in the oceans and coastal waters. Science of the Total Environment 26, 1–17.

Martin, E. and C. Apse. 2013. Chesapeake Fish Passage Prioritization: An Assessment of Dams in the Chesapeake Bay Watershed. The Nature Conservancy, Eastern Division Conservation Science. Available at http://maps.tnc.org/erof_ChesapeakeFPP.

Martin, E. H, Hoenke, K., Granstaff, E., Barnett, A., Kauffman, J., Robinson, S. and Apse, C.D. 2014. SEACAP: Southeast Aquatic Connectivity Assessment Project: Assessing the Ecological Impact of Dams on Southeastern Rivers. The Nature Conservancy, Eastern Division Conservation Science, Southeast Aquatic Resources Partnership. Available at http://www.maps.tnc.org/seacap.

Mastini, R., Kallis, G. and Hickel, J. Jan. 2021. "A Green New Deal without growth?" Ecological Economics Vol. 179: 106832. https://www.sciencedirect.com/science/article/abs/pii/S0921800919319615.

Maxwell, S., Fuller, R., Brooks, T. et al. 2016. Biodiversity: The ravages of guns, nets and bulldozers. Nature 536, 143–145 (2016). https://doi.org/10.1038/536143a

McCormick-Ray, J., 2005. Historical oyster reef connections to Chesapeake Bay–a framework for consideration. Estuarine, Coastal and Shelf Science 64, 119–134.

Morley, J.W., Selden, R.L., Latour, R.J., Frölicher, T.L., Seagraves, R.J., Pinsky, M.L., 2018. Projecting shifts in thermal habitat for 686 species on the North American continental shelf. PLoS ONE 13, e0196127. https://doi.org/10.1371/journal.pone.0196127

Musengezi, J., Mehlman, D., Zganjar, C., and Fisher, J.R.B. 29 July 2016. "U.S. Beef Supply Chain: Opportunities in Fresh Water, Wildlife Habitat, and Greenhouse Gas Reduction."

Myers, S. 17 Mar 2022. "Analyzing Farm Inputs: The Cost to Farm Keeps Rising." Market Intel. American Farm Bureau Federation. https://www.fb.org/market-intel/analyzing-farm-inputs-the-cost-to-farm-keeps-rising.

National Oceanic and Atmospheric Administration, National Centers for Environmental Information. 2023. https://www.ncei.noaa.gov/access/monitoring/snowfall-extremes/VA/2

The Nature Conservancy. 2016. U.S. Beef Supply Chain: Opportunities in fresh water, wildlife habitat, and greenhouse gas reduction. Available from https://www.nature.org/en-us/what-we-do/our-insights/perspectives/sustainability-and-the-u-s--beef-supply-chain/

The Nature Conservancy. 2018. Enhancing Coastal Resilience on Virginia's Eastern Shore 2018 Update: Application of the Sea-Level Affecting Marshes Model. *Prepared by* the Warren Pinnacle Consulting, Inc. Nassawadox, VA. 31 p.

Nomad Seed Project. 25 Dec 2017. "Southern Wild Rice or River Rice – Zizania Aquatica." https://www.nomadseed.com/2017/12/southern-wild-rice-or-river-rice-zizania-aquatica/.

Northeast Fisheries Science Center (U.S.) 2024. 2024 State of the Ecosystem : Mid-Atlantic Available at DOI : https://doi.org/10.25923/vz5a-d111

Nye, J., Link, J., Hare, J., Overholtz, W., 2009. Changing spatial distribution of fish stocks in relation to climate and population size on the Northeast United States continental shelf. Mar. Ecol. Prog. Ser. 393, 111–129. https://doi.org/10.3354/meps08220

Oehler, J. D., D. F. Covell, S. Capel, and B. Long. 2006. Managing Grasslands, Shrublands, and Young Forest Habitats for Wildlife A Guide for the Northeast. The Northeast Upland Habitat Technical Committee Massachusetts Division of Fisheries & Wildlife.

Ogden, L. J. E. 2002. Summary Report on the Bird Friendly Building Program: Effect of Light Reduction on Collision of Migratory Birds. Fatal Light Awareness Program (FLAP).

Olivero Sheldon, A. and M.G. Anderson. 2016. Northeast Lake and Pond Classification. The Nature Conservancy, Eastern Conservation Science, Eastern Regional Office. Boston, MA. 116 p.

Orth, R.J., McGlathery, K.J., 2012. Eelgrass recovery in the coastal bays of the Virginia Coast Reserve, USA. Marine Ecology Progress Series 448, 173–176.

Otero, I., Farrell, K.N., et. al. 13 Apr 2020. "Biodiversity policy beyond economic growth." Conservation Letters. https://doi.org/10.1111/conl.12713.

Parkins, K. L., S. B. Elbin, and E. Barnes. 2015. Light, Glass, and Bird—Building Collisions in an Urban Park. Northeastern Naturalist 22:84–94.

Paxton, A.B., Peterson, C.H., Taylor, J.C., Adler, A.M., Pickering, E.A., Silliman, B.R., 2019. Artificial reefs facilitate tropical fish at their range edge. Communications biology 2, 1–7.

Paxton, A.B., Steward, D.N., Mille, K.J., Renchen, J., Harrison, Z.H., Byrum, J.S., Brinton, C., Nelson, A., Simpson, E., Clarke, P.J., LaPorta, C., Barrett, P.D., Rousseau, M., Newton, D.C., Rigby, R.B., Williams, D.T., Shipley, J.B., Murakawa, P., Runde, B.J., Riley, K.L., Bacheler, N.M., Kellison, G.T., Taylor, J.C., 2024. Artificial reef footprint in the United States ocean. Nature Sustainability 7, 140–147. https://doi.org/10.1038/s41893-023-01258-7

Peterson, B. J., & Heck, K. L. 1999. The potential for suspension feeding bivalves to increase seagrass productivity. *Journal of Experimental Marine Biology and Ecology*, *240*, 3752. https://repo.library.stonybrook.edu/xmlui/bitstream/handle/11401/64365/Peterson%20and%20Heck%201w.pdf?sequence=1

Placer Resource Conservation District. March, 2024. "What are Working Lands?." https://placerrcd.org/what-are-working-lands/.

Public Law 106-291. 2000.Department of the Interior and Related Agencies Appropriations Act of 2001. United States Statutes at Large, 114 STAT. 1025. Washington, D.C.

Rebolo-Ifran, N., A. di Virgilio, and S. Lambertucci. 2019. Drivers of bird-window collisions in southern South America: a two-scale assessment applying citizen science. Scientific Reports 9.

Rembert, E. 1 Aug 2023. "Ranchers got tired of Big Beef taking their profits. So they're starting their own processing plant." Harvest Public Media, NPR. https://www.kcur.org/2023-07-28/ranchers-meat-concentration-big-four.

Rephann, Ph.D, Terance J. Nov 2022. The Economic Impact of the Agriculture and Forest Industries of Virginia. University of Virginia, Weldon Cooper Center for Public Service.

Reynolds, R. Dec. 3, 2024. Mixed News for Virginia's Bats After 10 Years of White-nose Syndrome. VA Dept. Of Wildlife Resources website. https://dwr.virginia.gov/blog/mixed-news-for-virginias-bats-after-10-years-of-white-nose-syndrome/

Riding, C. S., T. J. O'Connell, and S. R. Loss. 2020. Building façade-level correlates of bird–window collisions in a small urban area. The Condor 122:duz065.

Riggs, G. J., C. M. Barton, C. S. Riding, T. J. O'Connell, and S. R. Loss. 2023. Field-testing effectiveness of window markers in reducing bird-window collisions. Urban Ecosystems 26:713–723.

Ritchie, H. and Roser, M. "Land Use: How is humanity using the Earth's land? And how can we decrease our land use so that more land is left for wildlife?" Our World in Data. May, 2024. https://ourworldindata.org/land-use.

Rosenberg, K. V., A. M. Dokter, P. J. Blancher, J. R. Sauer, A. C. Smith, P. A. Smith, J. C. Stanton, A. Panjabi, L. Helft, M. Parr, and P. P. Marra. 2019. Decline of the North American avifauna. Science 366:120–124.

Roy, P.S., Ramachandran, R.M., Paul, O. *et al.* Anthropogenic Land Use and Land Cover Changes—A Review on Its Environmental Consequences and Climate Change. *J Indian Soc Remote Sens* **50**, 1615–1640 (2022). https://doi.org/10.1007/s12524-022-01569-w

Sabo, A. M., N. D. G. Hagemeyer, A. S. Lahey, and E. L. Walters. 2016. Local avian density influences risk of mortality from window strikes. PeerJ 4:e2170.

Schulte, D.M., 2017. History of the Virginia oyster fishery, Chesapeake Bay, USA. Frontiers in Marine Science 4, 127.

Scott, K. M., A. Danko, P. Plant, and R. Dakin. 2023. What causes bird-building collision risk? Seasonal dynamics and weather drivers. Ecology and Evolution 13:e9974.

Shepard, E. 27 Apr 2023. "Press Release: Sen. Emmett W. Hanger, Jr. Announces 1 million acres conserved." Virginia's United Land Trusts. https://vaunitedlandtrusts.org/sen-emmett-w-hanger-jr-announces-1-million-acres-conserved/.

Sheppard, C. D. 2019. Evaluating the relative effectiveness of patterns on glass as deterrents of bird collisions with glass. Global Ecology and Conservation 20:e00795.

Snyder, R. A. 2021. Fisheries Landings for the Eastern Shore of Virginia (ESVA) 2021. In *W&M ScholarWorks*. https://doi.org/10.25773/jxkh-b683

Staudinger, M.D., A. Karmalkar, K. Terwilliger, K. Burgio, A. Lubeck, H. Higgens, T. Rice, T. Morelli, and A. D'Amato. 2023. A regional synthesis of climate data to inform the 2025 State Wildlife Action Plans in the Northeast United States. United States Department of Interior Northeast Climate Science Center Cooperator Report, Amherst, Massachusetts. Available from https://necasc.umass.edu/.

Steward, D.N., Paxton, A.B., Bacheler, N.M., Schobernd, C.M., Mille, K., Renchen, J., Harrison, Z., Byrum, J., Martore, R., Brinton, C., 2022. Quantifying spatial extents of artificial versus natural reefs in the seascape. Frontiers in Marine Science 9, 980384.

Swaddle, J. P., L. C. Emerson, R. G. Thady, and T. J. Boycott. 2020. Ultraviolet-reflective film applied to windows reduces the likelihood of collisions for two species of songbird. PeerJ 8:e9926.

Taylor, M. 9 Oct 2023. "Virginia Tech receives record $80 million grant to fund climate-smart farming program." 13News Now. https://www.13newsnow.com/article/tech/science/environment/virginia-tech-80-million-grant-to-fund-climate-smart-farming-program/

Taylor, S.J., J.K. Krejca, and M.L. Denight. 2005. Foraging range and habitat use of Ceuthophilus secretus (Orthoptera: Rhaphidophoridae), a Key Trogloxene in Central Texas Cave Communities). The American Midland Naturalist, 154(1):97-114.

Terwilliger, K. (coord.) 1991. Virginia's Endangered Species: Proceedings from a Symposium. Virginia Department of Game and Inland Fisheries. The McDonald & Woodward Publishing Company. 672 pp.

Terwilliger Consulting, Inc. (TCI) and NEFWDTC. 2017. Northeast State Wildlife Action Plan (SWAP) Synthesis: Regional Conservation Priorities. Summary Report to the Northeast Fish and Wildlife Diversity Technical Committee of the Northeast Association of Fish and Wildlife Agencies. Locustville, Virginia. 74 p.

Terwilliger Consulting, Inc. (TCI) and the Northeast Fish and Wildlife Diversity Technical Committee. 2023. Northeast Regional Conservation Synthesis for 2025 State Wildlife Action Plans. Northeast Association of Fish and Wildlife Agencies, Washington, D.C.

Teutsch, C. Dr. 2008. "Building a Year Round Grazing System." Univ. Of Kentucky Research and Education Center at Princeton. https://uknowledge.uky.edu/cgi/viewcontent.cgi?article=1071&context=forage_kca.

Tiner, R.W., and Finn, J.T. 1986. Status and Recent Trends of Wetlands in Five Mid-Atlantic States: Delaware, Maryland, Pennsylvania, Virginia, and West Virginia. US Fish and Wildlife Service, U.S. Environmental Protection Agency.

U.S. Dept of Agriculture. 2000. “Steps for a Year-Round Grazing Management Plan.” Illinois Grazing Manual Fact Sheet: Grazing Management. file:///C:/Users/odl05101/Downloads/ILGM-GRAZMGT_Steps-Year-Round-Grazing-Mgt-Plan.pdf.

U.S. Clean Water Act of 1972, 33 U.S.C. § 1251 et seq. 2002. Available at http://epw.senate.gove/water.pdf.

U.S. Department of Commerce, Environmental Science Services Administration (ESSA). 1969. The Virginia Floods, August 19-22, 1969: A Report to the Administrator. ESSA/P1690035. https://www.weather.gov/media/publications/assessments/Virginia%20Floods%20August%201969.pdf

U.S. Forest Service, Southern Region (USFS). 2014. Environmental Impact Statement Appendices for the Revised Land and Resource Management Plan, George Washington National Forest, Appendix E - Ecosystem Diversity Report. Roanoke, VA.

USDA Natural Resources Conservation Service (NRCS). March 2024. “Working Lands for Wildlife.” https://www.nrcs.usda.gov/programs-initiatives/working-lands-for-wildlife.

U.S. Fish and Wildlife Service, 2020. The State and Tribal Wildlife Grant Programs: 20 Years of Conservation Success. United States Department of the Interior. Van Ryzin, P.J. (Ed.).

U.S. Fish and Wildlife Service. Dec. 3, 2024. Threats to Birds: Collisions (Nighttime Lighting). Edited by Valerie Fellows. https://www.fws.gov/story/threats-birds-collisions-nighttime-lighting#

U.S. Fish and Wildlife Service. Dec. 3, 2024. Threats to Birds: Collisions (Buildings & Glass). https://www.fws.gov/story/threats-birds-collisions-buildings-glass

U.S. Fish and Wildlife Service. Dec. 3, 2024. Combating Wildlife Trafficking. https://www.fws.gov/program/combating-wildlife-trafficking

U.S. Geological Survey. Dec. 3, 2024. Emerging Wildlife Diseases. https://www.usgs.gov/centers/nwhc/science/emerging-wildlife-diseases

University of Virginia, Department of Environmental Sciences. 2010. Atlantic Coastal Storms. https://acs.evsc.virginia.edu/storm-surge

Valliant, J. and Freedgood, J. 15 May 2020. “Land Access Policy Incentives: Emerging Approaches to Transitioning Farmland to a New Generation.” Farmland Information Center, Journal of Agriculture, Food Systems and Community Development, Ithaca, NY. 8 pp. https://farmlandinfo.org/publications/land-access-policy-incentives/.

Van Doren, B. M., D. E. Willard, M. Hennen, K. G. Horton, E. F. Stuber, D. Sheldon, A. H. Sivakumar, J. Wang, A. Farnsworth, and B. M. Winger. 2021. Drivers of fatal bird collisions in an urban center. Proceedings of the National Academy of Sciences 118:e2101666118.

Virginia Coastal Zone Manager Program (CZM). 2011. Section 309 Needs Assessment and Strategy. NOAA Office of Ocean and Coastal Resource Management. Available at

http://deq.state.va.us/Programs/CoastalZoneManagement/Funds,Initiatives,Progects/CoastalNeedsAssessment/CoastalNeedsAssessmentFY2011-2015.aspx

Virginia Cooperative Extension. 2024. "Graze 300 VA." https://ext.vt.edu/agriculture/graze-300.html.

Virginia Department of Conservation and Recreation (DCR). 2008. Natural Heritage Resources Fact Sheets: Karst Resources in the Upper James and Roanoke River Basins. Available at http://www.dcr.virginia.gov/natural_heritage/documents/UpperJames_Roanoke2008.pdf.

Virginia Department of Conservation and Recreation (DCR). 2015. Virginia Natural Heritage Karst Program Cave and Karst Protection website. http://www.dcr.virginia.gov/natural_heritage/karsthome.shtml

Virginia Department of Conservation and Recreation, Natural Heritage. 2021. "Piedmont Oak - Hickory Woodlands, Savannas, and Grasslands." The Natural Communities of Virginia Classification of Ecological Groups and Community Types, 2021, https://www.dcr.virginia.gov/natural-heritage/natural-communities/nctd9. Accessed 6 July 2024.

Virginia Department of Conservation and Recreation. 2022. Virginia Coastal Resilience Master Plan, Task 3: Coastal Flood Hazard Framework. *Prepared by* Dewberry Engineers Inc., Contract No. E194-89627, Richmond, VA. 57 p.

Virginia Department of Education. March 2024. "Virginia's First People Past and Present History." https://www.doe.virginia.gov/teaching-learning-assessment/k-12-standards-instruction/history-and-social-science/virginia-s-first-people-past-and-present/history.

Virginia Department of Environmental Quality. 2024 Draft. Virginia Water Quality Assessment 305(b)/303(d) Integrated Report 2024 to Congress and the EPA Administrator for the Period January 1, 2017 to December 31, 2022. Available at https://www.deq.virginia.gov/our-programs/water/water-quality/assessments/integrated-report

Virginia Department of Forestry. 2014. "Clearcutting: Facts and Myths." https://dof.virginia.gov/wp-content/uploads/Clearcutting-Facts-and-Myths_pub.pdf.

Virginia Department of Game and Inland Fisheries (DGIF). 2005. Virginia's Comprehensive Wildlife Conservation Strategy. Virginia Department of Game and Inland Fisheries. Richmond, VA.

Virginia Department of Game and Inland Fisheries (DWR). 2010. Virginia Freshwater Mussel Restoration Strategy: Upper Tennessee River Basin. Available at http://www.DWR.virginia.gov/awcc/freshwater-mussel-restoration/virginia-freshwater-mussel-restoration-strategy-UTRB.pdf.

Virginia Department of Game and Inland Fisheries (DWR). 2011. Canebrake Rattlesnake Conservation Plan. Wildlife Diversity Division. Available at http://www.DWR.virginia.gov/wildlife/reptiles/snakes/canebrake-rattlesnake/conservation-plan/canebrake-rattlesnake-conservation-plan.pdf.

Virginia Department of Wildlife Resources (DWR). 2015. Virginia's Wildlife Action Plan. Virginia Department of Wildlife Resources. Henrico, VA.

Virginia Department of Wildlife Resources, Virginia Department of Transportation, Virginia Department of Conservation and Recreation, and Virginia Department of Forestry. 2023. Virginia Wildlife Corridor Action Plan. 100 pages. https://dwr.virginia.gov/wildlife/corridors/

Virginia Institute of Marine Science (VIMS). 2013. Recurrent Flooding Study for Tidewater Virginia. SJ76ER. Gloucester Point, Virginia. Available at http://ccrm.vims.edu/recurrent_flooding/Recurrent_Flooding_Study_web.pdf.

Virginia Invasive Species Advisory Committee. 2018. Virginia Invasive Species Management Plan. Virginia Department of Conservation and Recreation. Natural Heritage Technical Document 18-09. Richmond, VA. 33 pages, plus appendices.

Virginia Places. 2023. http://www.virginiaplaces.org/geology/mountains.html#:~:text=The%20five%20highest%20peaks%20in,Mountain%2C%20are%20in%20Grayson%20County.

Watts, B. D. 2013. Waterbirds of the Chesapeake: A monitoring plan. Version 1.0. Virginia Department of Game and Inland Fisheries, Richmond, VA. 95 p.

Weakley, A. S., J. C. Ludwig, and J. F. Townsend. 2012. Flora of Virginia. Bland Crowder, ed. Foundation of the Flora of Virginia Project Inc., Richmond. Fore Worth: Botanical Research Institute.

Weary, D. J., and Doctor, D.H. 2014. Karst in the United States: A digital map compilation and database: U.S. Geological Survey Open-File Report 2014-1156 Available at http://pubs.usgs.gov/of/2014/1156/.

Weber, J. T. and J. F. Bulluck 2014. Virginia Wetlands Catalog: An Inventory of Wetlands and Potential Wetlands with Prioritization Summaries for Conservation and Restoration Purposes by Parcel, Subwatershed, and Wetland Boundaries. Natural Heritage Technical Report 14-4. Virginia Department of Conservation and Recreation, Division of Natural Heritage. Richmond, Virginia.

Westbrook C.J., Cooper, D.J. & Baker, B.W. 2006. Beaver dams and overflow floods influence groundwater-surface water interactions of a Rocky Mountain riparian area. Water resources research 42 (6): 2006.

The White House. 10 Dec 2021. "Recent Data Show Dominant Meat Processing Companies Are Taking Advantage of Market Power to Raise Prices and Grow Profit Margins." White House Briefing Paper. https://www.whitehouse.gov/briefing-room/blog/2021/12/10/recent-data-show-dominant-meat-processing-companies-are-taking-advantage-of-market-power-to-raise-prices-and-grow-profit-margins/.

White Oak Pastures Team. "The Cycles of Nature: How We Regenerate Land." White Oak Pastures. 4 October 2021. https://blog.whiteoakpastures.com/blog/the-cycles-of-nature-how-we-regenerate-land.

Wilberg, M.J., Livings, M.E., Barkman, J.S., Morris, B.T., Robinson, J.M., 2011. Overfishing, disease, habitat loss, and potential extirpation of oysters in upper Chesapeake Bay. Marine Ecology Progress Series 436, 131–144.

Williams, N. 19 Jan 2019. "Year-round grazing the goal of beef educator." Illinois Farmer Today. https://agupdate.com/illinoisfarmertoday/news/livestock/year-round-grazing-the- goal-of-beef-educator/article_e34c4724-19d8-11e9-a83c-b3bb12e4420c.html.

Wiltshire, S. and Beckage, B. 11 Apr 2022. "Soil carbon sequestration through regenerative agriculture in the U.S. state of Vermont." PLOS Climate. https://journals.plos.org/climate/article?id=10.1371/journal.pclm.0000021.

Winger, B. M., B. C. Weeks, A. Farnsworth, A. W. Jones, M. Hennen, and D. E. Willard. 2019. Nocturnal flight-calling behaviour predicts vulnerability to artificial light in migratory birds. Proceedings of the Royal Society B 286:20190364.

World Population Review. March 2024. "Fertilizer Production by Country 2024" https://worldpopulationreview.com/country-rankings/fertilizer-production-by-country.

Zhao, X., M. Zhang, X. Che, and F. Zou. 2020. Blue light attracts nocturnally migrating birds. The Condor 122:duaa002.

APPENDIX 1: SOUTHEAST CONSERVATION ADAPTATION STRATEGY

As Virginia is part of the Northeast Region, coordination with the Southeast Conservation Adaptation Strategy and the southeastern states information came in too late to fully integrate into the 2025 Revision. In addition, since Virginia was trying to stay in line with the Northeast Lexicon and Northeast regional efforts, it was not possible to fully integrate the Southeastern criteria. The SE RSGCN list was used as one criteria for including SGCN species in the 2025 Virginia WAP and some information in the section on changing environmental conditions in Virginia was incorporated from the SE Climate Adaptation Science Center. This appendix is included for future cooperative efforts among the southeastern states.

Virginia: A Regional Perspective

In 2018, the Association of Fish and Wildlife Agencies (AFWA) adopted a resolution on landscape conservation that recognized "the importance of collaborating at landscape scales to help fish and wildlife agencies meet their statutory and regulatory responsibilities to conserve fish and wildlife and their habitats." In response to the resolution, AFWA established a President's Task Force on Shared Science & Landscape Conservation Priorities in 2020, which recommended that State Wildlife Action Plans (SWAPs) serve as a framework for regional coordination and collaboration.

Within this Plan, Virginia has identified Species of Greatest Conservation Need (SGCN) and outlined strategies to sustain them, including conservation actions to promote species recovery and prevent federal listings under the Endangered Species Act. But to sustain the species that are the State's responsibility to protect and that also reflect the rich biodiversity, culture, and history of the state, Virginia must consider its role and the influences of the larger Southeast landscape.

This chapter examines regional, landscape-scale considerations for Virginia and serves as a means for the State to find potential collaborations to best support the State's SGCN and Southeast Regional SGCN (RSGCN). Additionally, some of the threats that impact SGCN (e.g., shifting climates) have consequences locally, statewide, and regionally. Addressing these threats effectively requires aligning conservation strategies across state boundaries. By using consistent regional information shared by other states to inform their own SWAPs, Virginia can better contribute to regional conservation priorities, identify potential landscape-level threats, and help connect the Southeast region's lands and waters.

VIRGINIA'S CONSERVATION PORTFOLIO: CONNECTING THE REGION'S LANDS AND WATERS

Virginia supports a wide diversity of habitats, culturally and historically significant landscapes, and ecosystems that provide benefits to the state as well as the broader Southeast region. The State also plays an important role in connecting the lands and waters of the Southeast Region, as well as hosting some regionally important ecosystems and habitat types like maritime forests, longleaf pine, and spruce-fir forests. Many regional and local partners and partnerships are working with the Virginia Department of Wildlife Resources (VADWR) to help conserve the state's iconic and

important landscapes. According to the Protected Areas Database of the United States (PAD-US, v4.0 considering fee simple, easements, and designation areas), approximately 4.45 million acres (16%) of the state are considered protected. This includes important landscapes like the George Washington and Jefferson National Forests, the Eastern Shore of Virginia and the Great Dismal Swamp National Wildlife Refuges, and state game lands like Chester F. Phelps Wildlife Management Area.

In addition to contributing to the conservation landscape of the Southeast, Virginia's lands and waters also benefit the state's economy. In 2023, the Bureau of Economic Analysis estimated that the outdoor recreation economy generated $13.4 billion in value for the state's Gross Domestic Product and another $6.5 billion in wages and salaries (U.S. Bureau of Economic Analysis for Outdoor Recreation, 2023). Beyond providing recreational value, natural landscapes also support working lands such as agriculture and timber. As of 2023, Virginia supported more than 7.3 million acres of farmland across 39,000 farms (U.S. Department of Agriculture, 2023).

Virginia and the Southeast Conservation Adaptation Strategy (SECAS)

The Southeast Conservation Adaptation Strategy (SECAS) is a regional conservation initiative that spans the Southeastern United States and Caribbean. SECAS brings together diverse partners around an ambitious goal: a 10% or greater improvement in the health, function, and connectivity of Southeastern ecosystems by 2060. The Southeast Conservation Blueprint is the primary product of SECAS. The Blueprint is a living, spatial plan that identifies priority areas where conservation action would make an impact toward creating a connected networks of lands and waters, based on a suite of natural and cultural resource indicators and a connectivity analysis.

So far, more than 2,500 people from over 650 different organizations have been actively involved in developing the Blueprint. At least 14 staff from VADWR alone and many more from the Virginia Natural Heritage Program have participated in workshops to review and improve the Blueprint, along with many other conservation practitioners from across the State. Since 2014, the Blueprint has been used by a broad suite of partners to inform many different conservation actions across the Southeast region including Virginia. For example, staff from the Southern Appalachian Spruce Restoration Initiative used the Blueprint to support a successful proposal to Department of the Interior's Restoration and Resilience Framework to prioritize restoration and improve coordination and monitoring of spruce-fir restoration in western North Carolina and Virginia. The Blueprint was also used in a successful proposal by the Virginia Department of Conservation and Recreation for $5.6 million to acquire 1,900 acres of forest land for biodiversity conservation and recreation in Suffolk through NOAA's Climate Ready Coasts initiative.

Maps of the Blueprint and other regional data are provided within this chapter. These maps also include a boundary that extends beyond the State and includes surrounding HUC8 watersheds within 1.5 kilometers of the State boundary. By looking beyond the State's boundaries, Virginia can consider how to best align conservation actions and identify cross-jurisdictional opportunities with neighboring states to maximize benefits for SGCN with wider ranges.

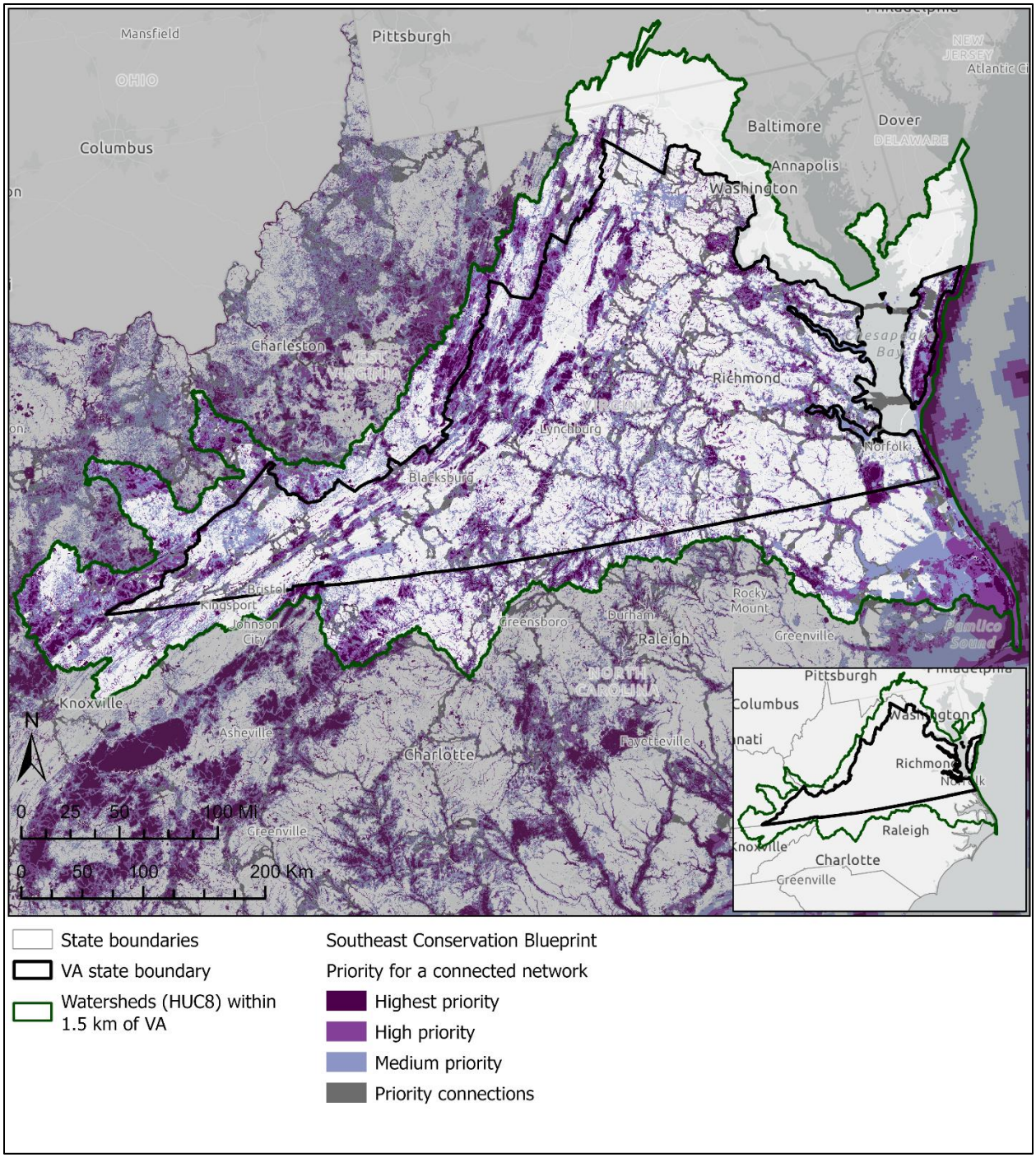


Figure 3. Southeast Blueprint (v2024) priorities within Virginia and surrounding watersheds within 1.5 km of the state line.

The Blueprint recognizes more than 13.1 million acres, or roughly 48 % of the state, as a priority for connecting the region's lands and waters (Table 1, Figure 1). About 5.2 million acres (19.1%) are rated as highest or high priority. An additional 5.3 million acres (19.7%) are rated as medium priority and about 2.5 million acres are considered priority connections, or key linkages between priority areas that can help facilitate the flow of species and ecological processes within the State while also considering

connectivity within the broader region. Together, these classes represent the most important areas for shared conservation action to connect lands and waters and improve ecosystem health. The Blueprint includes more than 60 indicators that represent both natural and cultural resources and collectively represent ecosystem health, function, and connectivity across terrestrial, freshwater, and coastal and marine systems. Examples include imperiled aquatic SGCN, cores of intact natural habitat, natural floodplain landcover, prescribed fire frequency, and more. Indicator data is available on the Blueprint page of the SECAS Atlas.

The Blueprint recognizes the vast majority (77%) of Virginia's protected areas as a priority for connecting the lands and waters of the Southeast (Table 1). This means that while these conserved areas are contributing to the state-wide landscape and represent unique habitats and locally important areas, many of them are also contributing to a wider regional conservation strategy. The State's conservation portfolio exemplifies a complementary landscape-scale approach to conservation that links local actions with conservation outcomes that contribute to a broader geographic scale.

Table 2. Protected areas within VA and how much of those areas that are recognized as priority places within the Southeast Conservation Blueprint 2024. Percentages are provided to show of the total protected lands, what percentage of them fall within Blueprint categories. For example, the Blueprint recognizes about 11% of NC's lands and waters as the highest priority for connecting lands and waters. However, 23% of VA's protected lands and waters are considered highest priority by the Blueprint.

Priority for a connected network	Acres of each Blueprint (v2024) priority category within VA	Acres of conserved lands (PAD-US 4.0) recognized as Blueprint priority and what percentage of the total protected lands are prioritized
Highest	2,054,303 (7.5%)	1,004,145 (23%)
High	3,182,311 (11.6%)	1,171,737 (26%)
Medium	5,394,371 (19.7%)	1,536,606 (34%)
Priority connections	2,480,115 (9.1%)	143,970 (3%)
Lower priority	14,249,179 (52.1%)	599,608 (13%)
Total	27,360,280 **(100%)**	**4,456,067 (100%)**

The Southeast Blueprint also includes a least-cost path connectivity analysis that identifies corridors that link coastal and inland areas and span climate gradients (Figure 3). The corridors connect hubs across the shortest distance possible, while also routing through as much Blueprint priority as possible. The hubs that anchor the connectivity analysis are large patches of highest priority Blueprint areas and/or protected lands. About 9.2 million acres (34%) within Virginia are considered a hub or corridor within this analysis, providing many conservation opportunities to support species movement and migration—an important strategy for helping wildlife adapt to landscape-level changes (Figure 2).

Virginia has also done a lot of great work at the state level to develop corridors that are important for wildlife. The Virginia Wildlife Corridor Action Plan emphasizes protecting important wildlife habitat corridors and reducing wildlife-vehicle conflicts, such as collisions (Virginia Department of Wildlife Resources, 2023). These wildlife corridors also help connect fragmented habitats. Many of

the State's corridors align with the Blueprint connectivity analysis both within and outside the state (Figure 2).

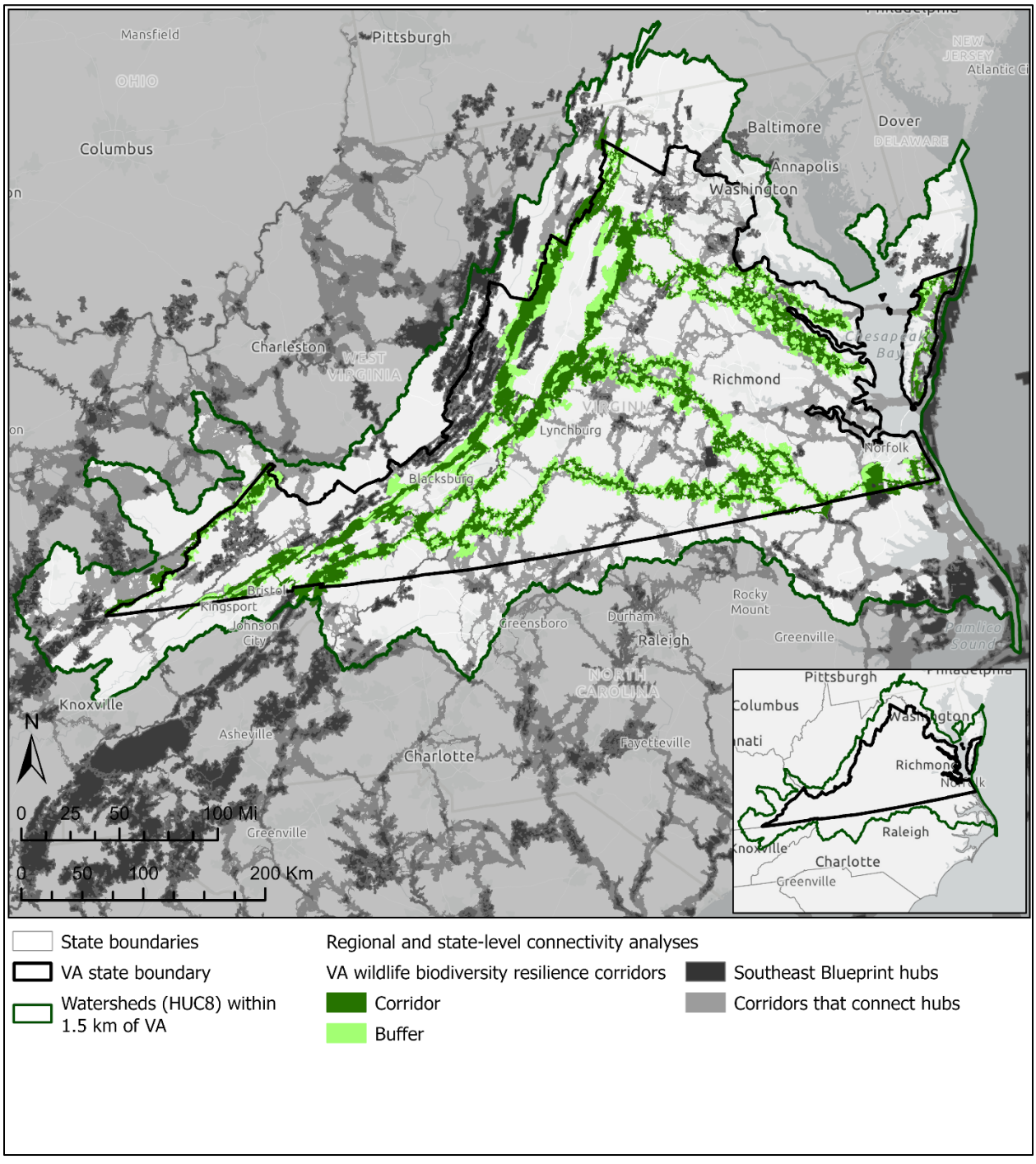


Figure 4. The Virginia Wildlife Corridor Action Plan resilience corridors and the Southeast Blueprint connectivity analysis showing hubs and corridors in Virginia and surrounding watersheds shared with Virginia and West Virginia. The Virginia wildlife corridors connect fragmented habitats separated by human activities or infrastructure and is considered vital to the long-term sustainability of wildlife biodiversity. The Blueprint uses a least-cost path connectivity

analysis to identify corridors that link hubs across the shortest distance possible, while also routing through as much Blueprint priority as possible. In the continental Southeast, hubs are large patches (~5,000+ acres) of highest priority Blueprint areas and/or protected lands.

Ensuring landscape connectivity across jurisdictional boundaries is becoming increasingly important for species management as changes in land use, climate, and weather patterns shift species distributions. Collaborating with the neighboring states of Maryland, West Virginia, Kentucky, Tennessee, and North Carolina to identify cross-boundary species migration and habitat pathways can increase regional connectivity for state SGCN and RSGCN. It is also important to consider potential barriers to connectivity such as existing and future urbanization.

One lens to characterize the landscape of Virginia is by its ecoregions as defined by the Level III ecoregions of the continental US (Omernik 1987, 1995): the Central Appalachians, Ridge and Valley, Blue Ridge, the Piedmont, the Middle Atlantic Coastal Plain, and the Southeastern Plains (Figure 3). Ecoregions are identified by analyzing areas where ecosystems (and the type, quality, and quantity of environmental resources) are generally similar. Evaluating ecoregions that Virginia shares with its neighbors is one way to identify cross-boundary conservation opportunities, as these areas share similar mosaics of biotic, abiotic, terrestrial, and aquatic ecosystems.

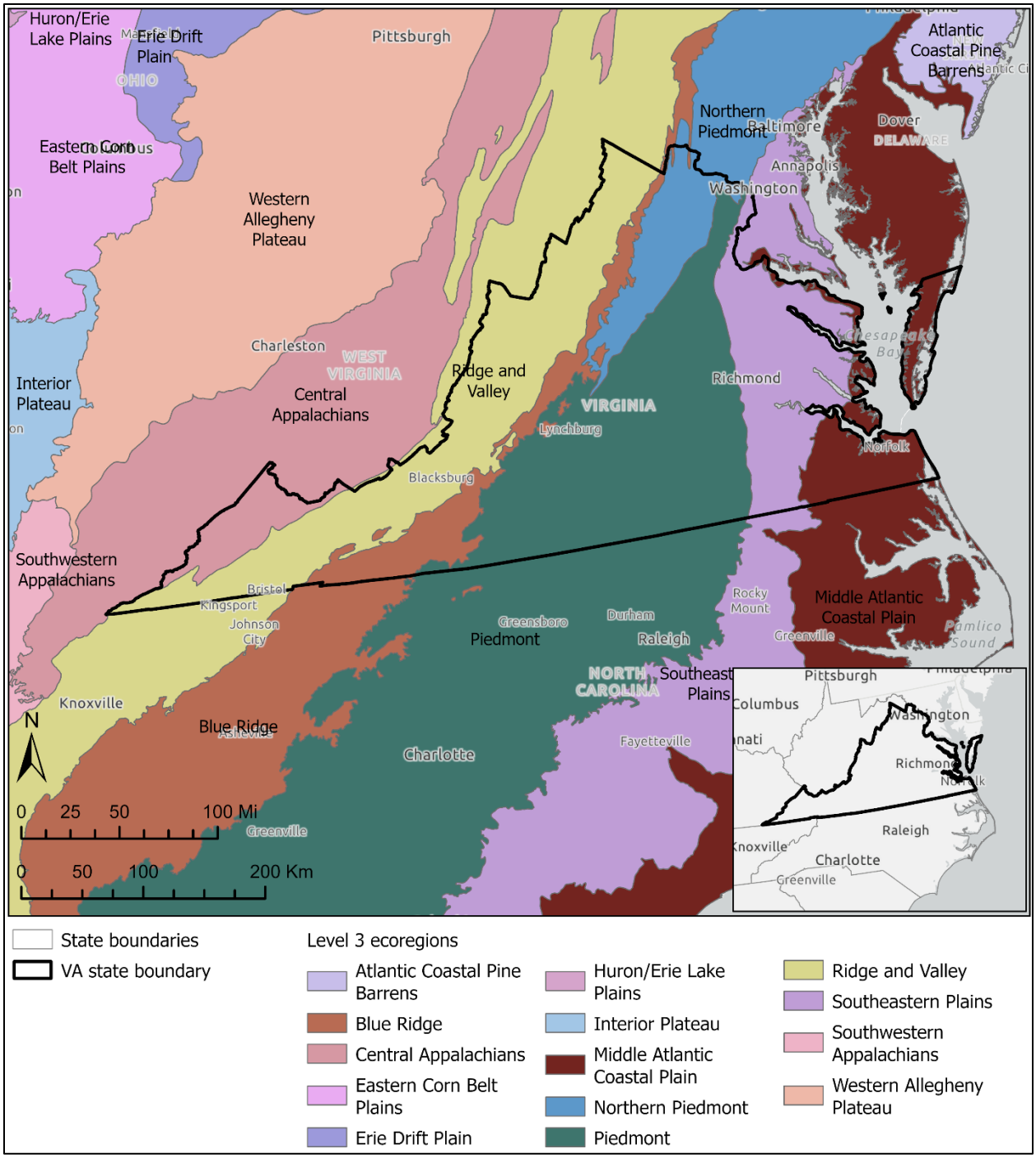


Figure 5. Omernik Level III ecoregions that occur within Virginia.

VIRGINIA AND THE SECAS GOAL

Through SECAS, partners work together to design and achieve a connected network for the benefit of ecosystems, species, and people, and to achieve the SECAS goal: a 10% or greater improvement in the health, function, and connectivity of Southeastern ecosystems by 2060. The work of the VADWR and conservation partners within the State help advance this goal. In addition to the

Southeast Blueprint, SECAS releases an annual report—*Recent Trends in Southeastern Ecosystems*—that assesses progress toward the SECAS goal using the best available data. This report assesses progress toward the SECAS goal using information from existing monitoring programs and is intended to facilitate discussion around conservation actions needed to meet the goal.

Recent Trends in Southeastern Ecosystems (2024) synthesizes 13 different assessments to evaluate indicator trends. Assessments ranged from remotely sensed data like the National Land Cover Database to long-term citizen science monitoring programs like the eBird. States can use this SECAS goal report to assess their own progress and overall trends for the broader Southeast Region.

Recent trends in ecosystem indicators in Virginia compared to the Southeast US

Table 3. *Overview of recent trends in ecosystem indicators comparing Virginia and the Southeast US. Indicators shown in green are on track to meet the goal (≥1% increase every 4 years); indicators shown in yellow (<1% increase) and red (declines) are not.*

Ecosystem	Type	Indicator	Virginia yearly % change	Southeast yearly % change
Terrestrial				
	Health	Areas without invasive plants	0.84% decline	0.33% decline
		Beach birds	1.16% decline	1.42% decline
		Forested wetland area	0.1% increase	0.08% increase
		Forested wetland birds	1.27% increase	2.85% increase
		Grassland & savanna area	0.65% decline	0.31% decline
		Grassland & savanna birds	0.4% decline	2.2% decline
		Salt marsh area	0.12% decline	0.03% decline
		Upland forest birds	0.43% decline	0.98% increase
	Function	Working lands conservation	9.7% increase	11% increase
	Connectivity	Landscape condition	0.01% decline	0.02% decline
		Undeveloped land in corridors	0.02% decline	0.02% decline
Freshwater				
	Health	Natural landcover in floodplains	0.005% decline	0.008% decline
	Function	Water quality	0.01% decline	0.003% increase

Like other states in the Southeast, Virginia has:

- Increases in forested wetland area, forested wetland birds, and working lands conservation
- Declines in areas without invasive plants, beach birds, grassland & savanna area, grassland & savanna birds, salt marsh area, landscape condition, undeveloped land in corridors, and natural landcover in the floodplain

Unlike other states in the Southeast, Virginia has:

- Declines instead of increases in upland forest birds and water quality
- Steeper declines in areas without invasive plants, grassland & savanna area, and salt marsh
- Shallower declines in grassland & savanna birds (primarily due to increases in red-cockaded woodpeckers)

Beach birds

Table 4. Goal status by state for each beach bird species from 2012-2022, abbreviated for space. "Increase/off track" indicates a small increase insufficient to meet the goal, while "increase/on track" indicates a larger increase. "High" indicates higher confidence and "low" indicates lower confidence in the trend. Selected bird species are Southeast Regional Species of Greatest Conservation Need (SGCN) associated with this habitat and with sufficient data for eBird trend analysis.

	American oystercatcher	**Black skimmer**	**Gull-billed tern**	**Least tern**	**Piping plover**	**Royal tern**	**Willet**
AL	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High		Decline | Off track | Low	Decline | Off track | High
AR				Decline | Off track | High			
FL	Decline | Off track | High	Decline | Off track | High	Decline | Off track | Low	Decline | Off track | High	Decline | Off track | Low	Decline | Off track | Low	Decline | Off track | High
GA	Decline | Off track | Low	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High		Decline | Off track | High	Decline | Off track | High
KY				Decline | Off track | Low			
LA	Increase | On track | Low	Decline | Off track | High	Increase | On track | High	Decline | Off track | High		Increase | On track | High	Decline | Off track | High

MO				Decline | Off track | High			
MS	Decline | Off track | High	Decline | Off track | High	Decline | Off track | Low	Decline | Off track | High		Decline | Off track | High	Decline | Off track | High
NC	Increase | On track | Low	Decline | Off track | High	Increase | On track | Low	Increase | Off track | Low	Decline | Off track | High	Increase | On track | High	Decline | Off track | High
OK				Decline | Off track | High			Decline | Off track | High
SC	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High		Decline | Off track | High	Decline | Off track | High
TN				Decline | Off track | High			
TX	Decline | Off track | Low	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High		Increase | On track | High	Decline | Off track | High
VA	Decline | Off track | Low	Decline | Off track | Low	Decline | Off track | Low	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High
PR	Increase | On track | High		Increase | On track | Low	Increase | On track | High		Increase | On track | High	Decline | Off track | High
VI	Increase | On track | High			Increase | On track | High		Increase | On track | Low	

Forested wetland birds

Table 5. Goal status by state for each forested wetland bird species from 2012-2022, abbreviated for space. "Increase/off track" indicates a small increase insufficient to meet the goal, while "increase/on track" indicates a larger increase. "High" indicates higher confidence and "low" indicates lower confidence in the trend. Selected bird species are Southeast Regional Species of

Greatest Conservation Need (SGCN) associated with this habitat and with sufficient data eBird trend analysis.

	Prothonotary warbler	Swainson's warbler	Swallow-tailed kite	Yellow-throated warbler
AL	Increase | On track | Low	Increase | On track | High	Increase | On track | High	Increase | On track | High
AR	Increase | On track | High	Increase | On track | High		Increase | On track | High
FL	Decline | Off track | High	Decline | Off track | Low	Increase | On track | High	Increase | On track | Low
GA	Increase | Off track | Low	Increase | On track | High	Increase | On track | High	Increase | On track | High
KY	Increase | On track | High	Increase | On track | High		Increase | On track | High
LA	Decline | Off track | Low	Increase | On track | High	Increase | On track | High	Increase | On track | High
MO	Increase | On track | High	Increase | On track | High		Increase | On track | High
MS	Increase | On track | High	Increase | On track | High	Increase | On track | High	Increase | On track | High
NC	Decline | Off track | Low	Increase | On track | High	Increase | On track | High	Increase | On track | High
OK	Increase | On track | High	Increase | On track | High		Increase | On track | High
SC	Decline | Off track | Low	Increase | On track | High	Increase | On track | High	Increase | On track | High
TN	Increase | On track | High	Increase | On track | High		Increase | On track | High
TX	Increase | On track | High	Increase | On track | High	Increase | On track | High	Increase | On track | High
VA	Decline | Off track | Low	Increase | On track | High		Increase | On track | High
WV	Increase | On track | High	Increase | On track | High		Increase | On track | Low

Grassland & savanna birds

Table 6. Goal status by state for each grassland and savanna bird species from 2012-2022, abbreviated for space. "Increase/off track" indicates a small increase insufficient to meet the goal, while "increase/on track" indicates a larger increase. "High" indicates higher confidence and "low" indicates lower confidence in the trend. Selected bird species are Southeast Regional Species of Greatest Conservation Need (SGCN) associated with this habitat and with sufficient data eBird trend analysis.

	American kestrel	Eastern meadowlark	Grasshopper sparrow	Loggerhead shrike	Northern bobwhite	Prairie warbler	Red-cockaded woodpecker	Scissor-tailed flycatcher
AL	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | Low	Decline | Off track | Low	Decline | Off track | High
AR	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | Low	Increase | On track | High	Decline | Off track | High
FL	Decline | Off track | Low	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	
GA	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | Low	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High
KY	Decline | Off track | Low	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High		Decline | Off track | High
LA	Decline | Off track | High	Decline | Off track | High		Decline | Off track | High	Decline | Off track | High	Decline | Off track | Low	Decline | Off track | High	Decline | Off track | High
MO	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High		Decline | Off track | High
MS	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | Low	Decline | Off track | Low	Decline | Off track | High
NC	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Increase | On track | Low	Increase | On track | Low
OK	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Increase | On track | High	Increase | On track | High	Decline | Off track | High
SC	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | Low	Decline | Off track | Low
TN	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High		Decline | Off track | High
TX	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Increase | Off	Increase | On track | Low	Decline | Off track | High

						track | Low		
VA	Decline | Off track | Low	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Increase | On track | High	Decline | Off track | High
WV	Decline | Off track | Low	Decline | Off track | High	Decline | Off track | High	Decline | Off track | High	Decline | Off track | Low	Decline | Off track | High		Decline | Off track | High
PR	Decline | Off track | Low		Decline | Off track | High					
VI	Decline | Off track | Low							

Upland forest birds

Table 7. Goal status by state for each upland forest bird species from 2012-2022, abbreviated for space. "Increase/off track" indicates a small increase insufficient to meet the goal, while "increase/on track" indicates a larger increase. "High" indicates higher confidence and "low" indicates lower confidence in the trend. Selected bird species are Southeast Regional Species of Greatest Conservation Need (SGCN) associated with this habitat and with sufficient data eBird trend analysis.

	Cerulean warbler	**Louisiana waterthrush**	**Wood thrush**	**Worm-eating warbler**
AL	Decline | Off track | High	Increase | On track | High	Increase | On track | High	Decline | Off track | High
AR	Increase | On track | High	Increase | On track | High	Increase | On track | High	Decline | Off track | Low
FL		Decline | Off track | Low	Increase | On track | High	
GA	Decline | Off track | High	Increase | On track | High	Increase | On track | High	Decline | Off track | High
KY	Decline | Off track | High	Increase | On track | Low	Increase | On track | High	Decline | Off track | High
LA		Increase | On track | Low	Increase | On track | High	Increase | On track | Low
MO	Decline | Off track | High	Decline | Off track | Low	Increase | On track | High	Decline | Off track | High
MS	Decline | Off track | Low	Increase | On track | High	Increase | On track | High	Decline | Off track | High

NC	Decline | Off track | High	Increase | On track | Low	Increase | On track | High	Decline | Off track | High
OK	Increase | On track | Low	Increase | On track | High	Increase | On track | High	Decline | Off track | High
SC	Decline | Off track | High	Increase | On track | High	Increase | On track | High	Decline | Off track | High
TN	Decline | Off track | High	Increase | Off track | Low	Increase | On track | High	Decline | Off track | High
TX		Increase | On track | High	Increase | On track | High	Increase | On track | High
VA	Decline | Off track | High	Increase | On track | Low	Increase | On track | High	Decline | Off track | High
WV	Decline | Off track | Low	Increase | On track | High	Increase | On track | High	Decline | Off track | High

Virginia Regional Species of Greatest Conservation Need

Each state's wildlife action plan identifies SGCN, or the species most in need of proactive conservation attention (see Chapter XX and Appendix XX for a list of Virginia's SGCN identified for this SWAP revision). After the 2015 SWAP revision cycle, the combined lists of SGCN for the 15 states that fall within the SEAFWA geography included more than 7,000 species. However, many SGCN occur across multiple states. Effectively managing and conserving these species requires actions and management strategies that will best allow for species movement and ensure the availability of key ecological attributes provided by different habitats across the landscape at different times. To help support long-term conservation goals for imperiled plant and animal species conservation partners have developed a Southeast Regional Species of Greatest Conservation Need (RSGCN) list.

Southeast Animal RSGCN

In 2019, the National Wildlife Federation, as part of the Vital Futures project funded by the U.S. Geological Survey, prioritized the large number of SGCN collectively identified in the previous iteration of 15 Southeastern SWAPs. Across the 15 southeastern states, the combined lists of SGCNs totals nearly 6,700 species (National Wildlife Federation 2023). The Southeastern Association of Fish and Wildlife Agencies (SEAFWA) Wildlife Diversity Committee collaborated with the National Wildlife Federation and other partners to evaluate these species and produce a list of 960 regional priority species (1,034 including subspecies), or animal RSGCN. A report, "Regional Species of Greatest Conservation Need in the Southeastern United States," was written to detail the methodology used to develop the RSGCN list (Rice et al. 2019) and this is list is hosted on the Georgia biodiversity portal available at georgiabiodiversity.org/portal/regional_conservation_info (GADNR 2024). This effort aligns with the

Northeast Association of Fish and Wildlife Agencies' similar project to develop a RSGCN list for the Northeast Region.

Identifying Southeast animal RSGCN drew upon a collaborative process among state fish and wildlife agencies and partners that involved more than 100 experts and used a set of consistent criteria to review current scientific information and evaluate state-identified SGCN. Species were evaluated based on several primary factors, including: 1) the level of conservation concern (i.e. extinction risk), 2) regional stewardship responsibility (i.e. importance of the Southeast in conservation of the species), and 3) biological or ecological significance (e.g., unique evolutionary lineages). The regional assessment focused on species in key taxonomic groups, including vertebrates (mammals, birds, reptiles, amphibians, and fishes) as well as several better-known groups of invertebrate animals (freshwater mussels, crayfish, and bumblebees). Scientific experts in each of these groups convened to evaluate and identify those species that warranted identification as a regional priority. Additionally, the science teams characterized the level of conservation concern for each regional priority, ranging from moderate to high and very high concern. Through this established process, the RSGCN list can be updated as the States' SGCN lists change over time.

Table 8. List of RSGCN by taxa and their level of concern (very high, high, or moderate). Fish taxa have the most species categorized as "very high concern" and comprise 30% of all RSGCN within the Southeast region. This list totals 1,034 (versus 960) because it includes subspecies.

RSGCN taxonomic group	Very high concern	High concern	Moderate concern	Total
Amphibians	26	52	34	116 (11%)
Birds	10	56	18	84 (8%)
Bumblebees	2	1	2	5 (.4%)
Crayfish	53	86	34	173 (17%)
Fishes	101	120	96	317 (30%)
Mammals	18	37	30	85 (8%)
Mussels	69	55	13	139 (13%)
Reptiles	18	58	39	115 (11%)
Total	302	466	266	1,034 (100%)

Out of the total animal RSGCN list, two-thirds are freshwater fish, crayfish, and freshwater mussels. The number of RSCGN that are considered the stewardship responsibilities of each state varies widely. These patterns can reflect the underlying diversity of species in each state–particularly the number of imperiled and/or limited range species–which is also influenced by a state's size and diversity of habitats. These patterns are also influenced by the "regional stewardship responsibility" criterion in the assessment of priority species.

Nearly 70% of regional priority species are endemic to the 15-state SEAFWA region. Overall, more than half (55%) of Southeast RSGCN are shared by three or more states, presenting opportunities for cross-state conservation collaboration. The remaining 45% of RSGCN have narrow ranges and are found in just one or two states. By taxa, fish and crayfish represent 47% of all RSGCN within the region. Many aquatic habitats and ecosystems within the Southeast are highly fragmented, resulting in severe limitations to ecosystem integrity and species persistence regionwide. Habitat fragmentation in rivers and streams is a

determining factor in the decline in abundance of numerous species such as Eastern brook trout, freshwater mussels, and fully aquatic amphibians such as Eastern hellbender.

Several regional datasets can help Virginia identify lands and waters that support animal RSGCN and find opportunities to collaborate with other states. For example, habitat maps at the species level from the USGS Gap Analysis Project (GAP) are available for approximately 290 animal species, and 90 sub-species, on the RSGCN list. While GAP does not include species habitat maps for invertebrates or plants, it does include a high percentage of vertebrate RSGCN (93% of amphibians, 92% of birds, 76% of mammals, and 77% of reptiles). Figures 4 through 7 show Southeast RSGCN richness using GAP species habitat models. This data, in combination with other tools like the Southeast Blueprint or with data representing the Northeast RSGCN, can help identify areas where conservation actions are likely to yield co-benefits for RSGCN as well as other species, habitats, and ecosystem services. As recommended by AFWA, cross jurisdictional or regional strategies can enhance ecosystem resiliency, function, and connectivity– especially in the face of climate change. All data, including model inputs, are available from the USGS Gap Analysis Project Species Habitat Maps on their website: https://www.usgs.gov/programs/gap-analysis-project.

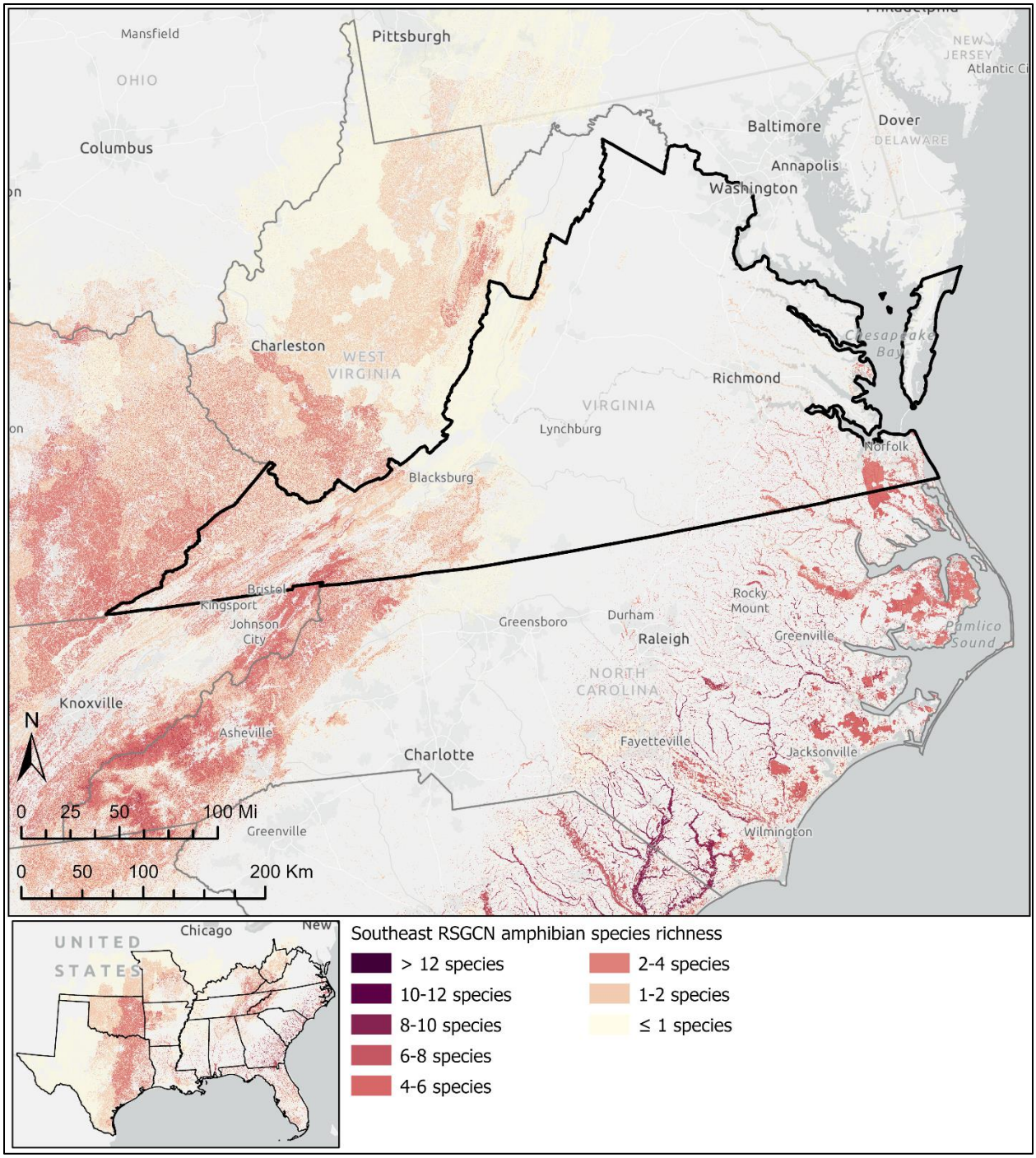


Figure 6. Species richness for amphibian RSGCN that are considered very high or high concern. Species richness is represented using available GAP species-habitat models (using 2016 NLCD).

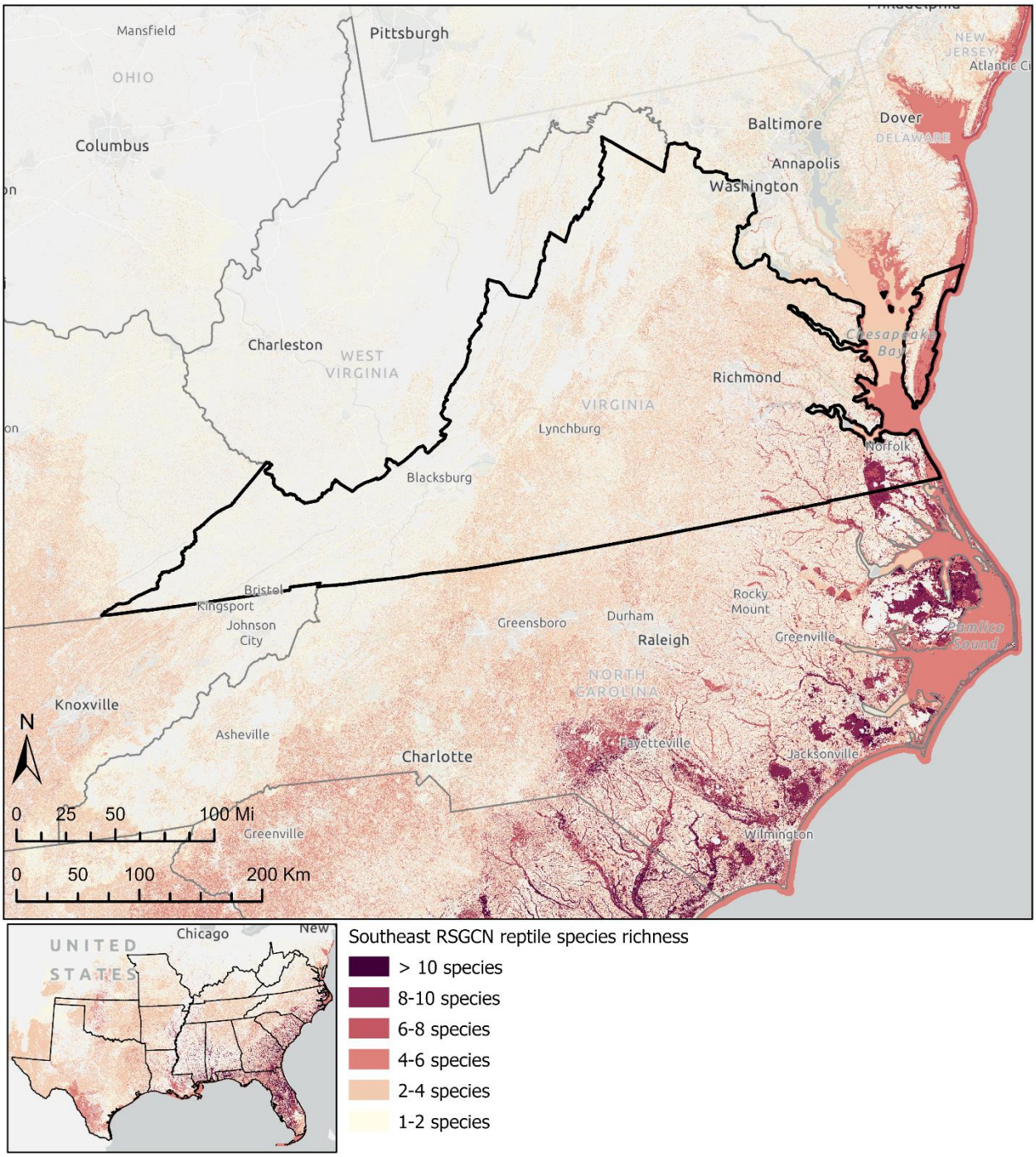


Figure 7. Species richness of reptile RSGCN that are considered very high or high concern. Species richness is represented using available GAP species-habitat models (using 2016 NLCD).

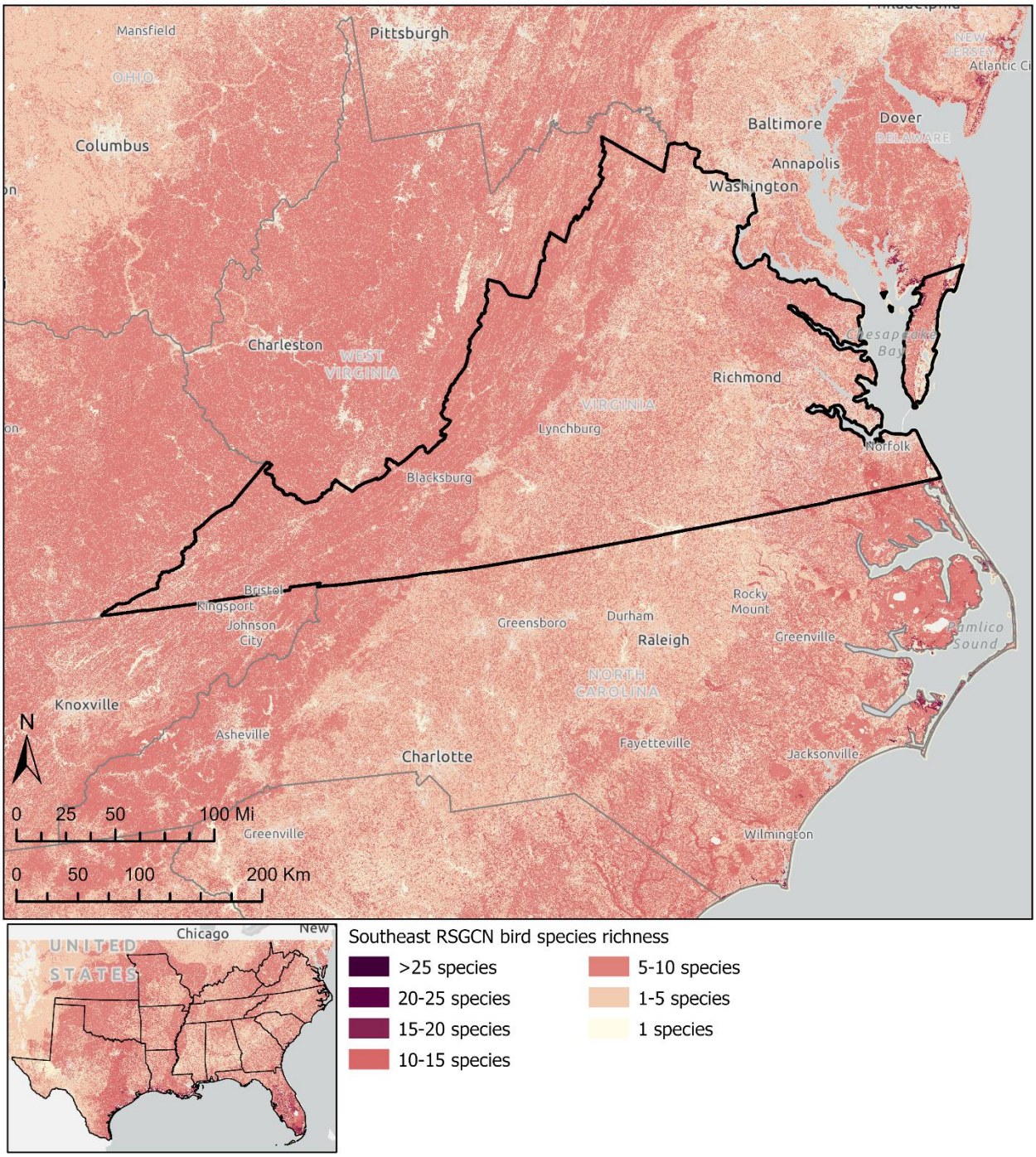


Figure 8. Species richness of bird RSGCN that are considered very high or high concern. Species richness is represented using available GAP species-habitat models (using 2016 NLCD).

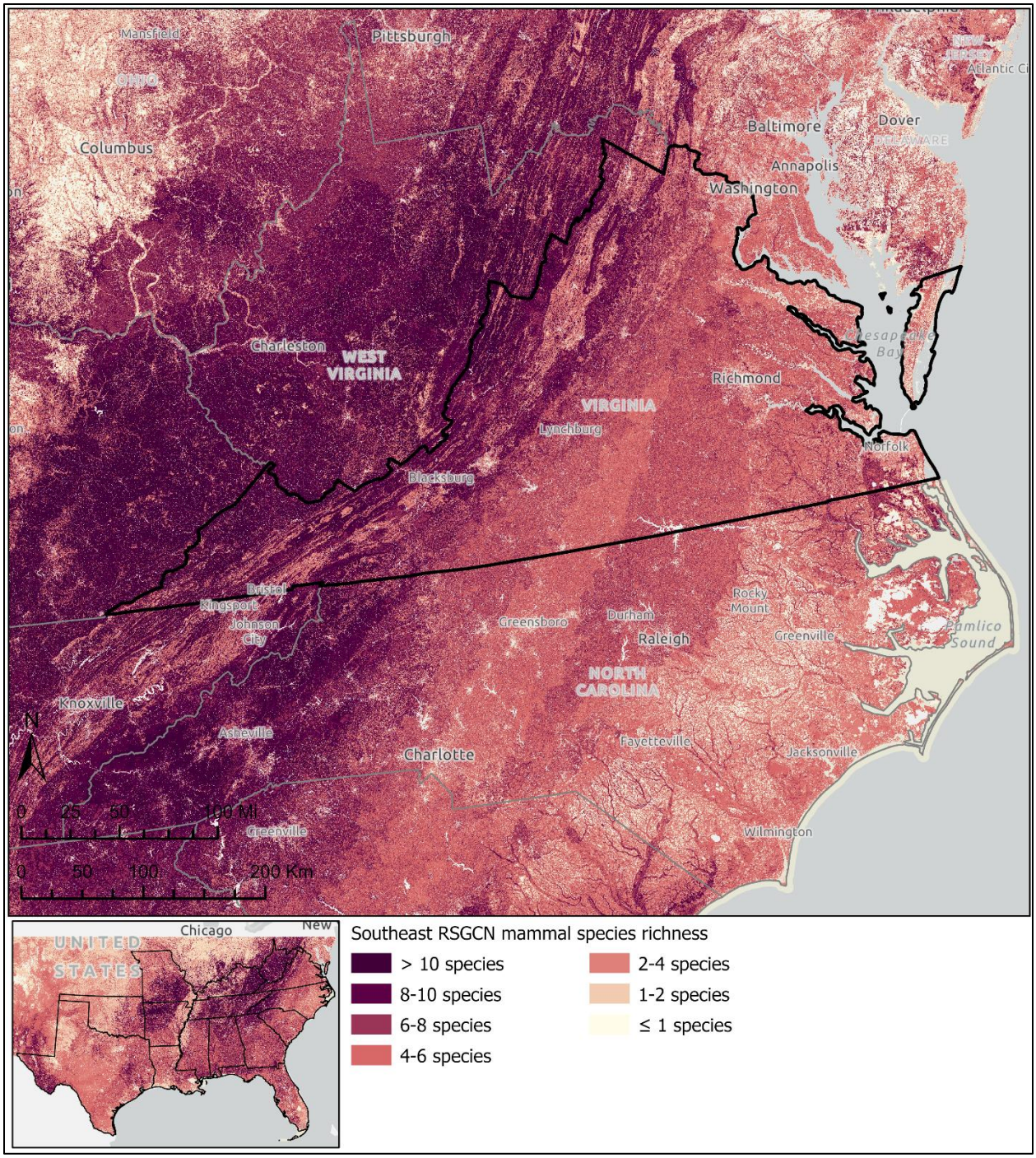


Figure 9. Species richness of mammal RSGCN that are considered very high or high concern. Species richness is represented using available GAP species-habitat models (using 2016 NLCD).

SOUTHEAST PLANT RSGCN

The Southeast is home to more than 11,000 native plant species, 30% of which are regional endemics (i.e., found only in the Southeast). In 2023 the Southeast Plant Conservation Alliance (PCA) released the first plant RSGCN list in the nation. The PCA worked with a broad coalition of

partners including the Atlanta Botanical Garden, NatureServe, and Terwilliger Consulting, and received funding from the U.S. Fish and Wildlife Service. This list narrows down the vast number of plants native to the Southeast to 1,824 species that are a regional conservation priority based on criteria such as rarity, threats, and needed conservation actions. The plant RSGCN list complements the Southeastern animals RSGCN list developed in 2019 to create a more complete picture of the region's exceptional biodiversity. The report, "Southeastern Plants Regional Species of Greatest Conservation Need (Radcliffe et al. 2023)," and the dataset of plant RSGCN are available online at https://www.se-pca.org/southeastern-plants-rsgcn/.

To develop a pool of potential species to draw from, the PCA worked with NatureServe to compile a list of more than 10,000 vascular plants native to any of the SEAFWA considering each species' G-Rank (global rarity), S-Rank (state rarity) and endemism. Unfortunately, due to data limitations, plants native to Puerto Rico and the U.S. Virgin Islands could not be included.

The full list received extensive review from botany experts, a technical team composed of representatives from each state, and NatureServe. Based on partner feedback, the technical team assigned each species a level of conservation concern rating ranging from low to very high or "manual review needed". Any plant scoring moderate or above was ultimately considered an RSGCN. After cleaning the data to remove redundancies, the complete Southeastern plant list evaluated 9,271 species and prioritized 1,824 as RSGCN. Southeast endemic species make up 72% of the plant RSGCN list (Figure 8)

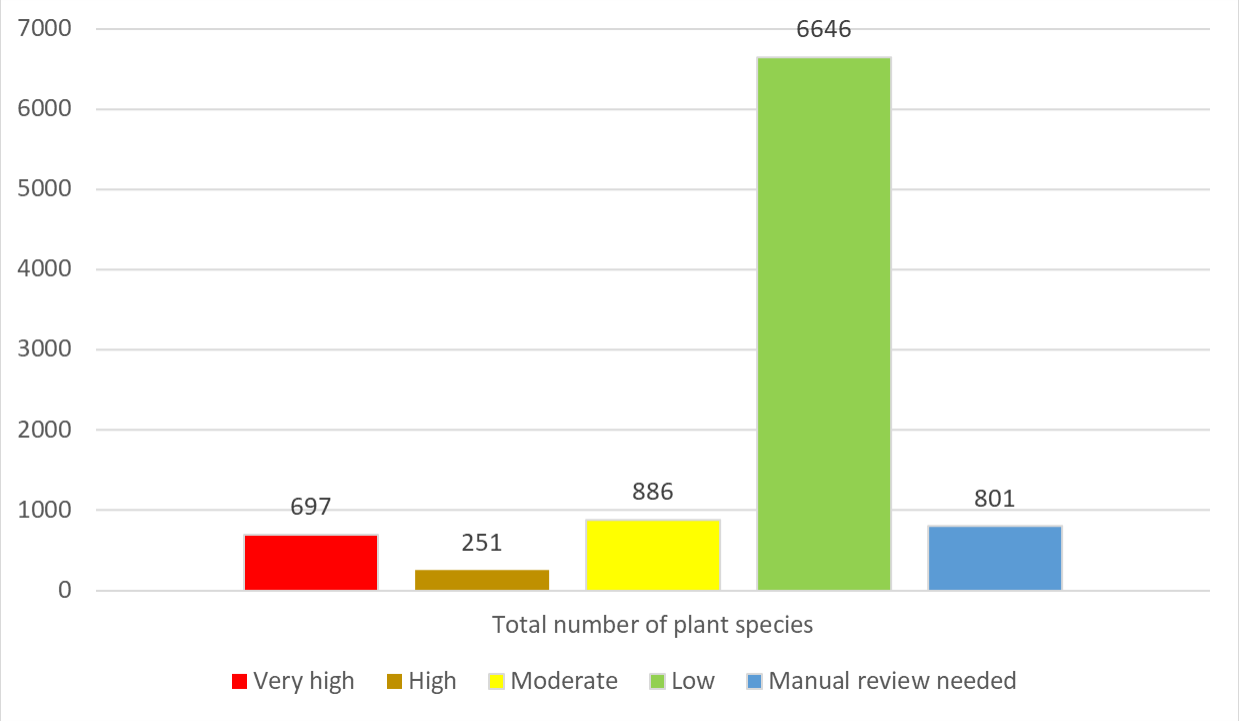


Figure 10. Plants with a very high, high, or moderate level of conservation concern are considered plant RSGCN.

To better understand shared plant needs and threats at the ecosystem level, the PCA crosswalked each plant RSGCN to its primary habitats using U.S. National Vegetation Classification (USNVC) "Groups" (Table 8). The USNVC provides a widely-used, standardized system of classifying vegetation types and habitats. The distribution of RSGCN across ecosystems demonstrates their diversity and broad geographic extent. A total of 31 USNVC Groups contained at least 10 plant RSGCN, indicating that many of the region's ecosystems support plant species of conservation need. As many of these same habitats tend to provide crucial habitat for animal RSGCN as well, conserving these ecosystems can safeguard regional biodiversity more broadly.

Table 9. The top 15 U.S. National Vegetation Group Assignments for all Southeast plant RSGCN, showing longleaf ecosystems supporting this highest number of priority plants.

USNVC groups serving as primary habitat	Number of plant RSGCN
Wet-Mesic Longleaf Pine Open Woodland	80
Xeric Longleaf Pine Woodland	43
South Florida Slash Pine Rockland	29
Central Interior Alkaline Open Glade & Barrens	29
Appalachian - South-central Interior Mesic Forest	28
Tamaulipan Dry Mesquite & Thornscrub	28
South Atlantic & Gulf Coastal Plain Pondshore & Wet Prairie	22
Blackland & Coastal Tallgrass Prairie	21
Florida Xeric Scrub	18
South Atlantic & Gulf Coastal Dune & Grassland	17
Atlantic & Gulf Coastal Plain Seep	16
Southern Coastal Plain Mixed Evergreen Swamp	13
Southern Mesic Beech - Oak - Mixed Deciduous Forest	12
Southern Appalachian Rocky Outcrop	11
Southeastern Coastal Plain Barrens & Glade	9
Central Interior-Appalachian Riverscour Barrens & Prairie	9
Caribbean Hardwood Hammock & Coastal Strand Forest	9
Coastal Live Oak - Hickory - Palmetto Forest	9
Appalachian Mafic Barrens	8
Central & Southern Appalachian Seep	8

Table 9 lists the USNVC groups serving as primary habitat that support the most Southeast plant RSGCN in Virginia. By far the USNVC group that supports the most Southeast plant RSGCN within the State is Appalachian - South-central interior mesic forest. These forest that are composed of a diverse suite of deciduous broad-leaved trees occur within coastal plains and includes wet pine flatwoods and wet pine savannas (NatureServe Explorer, 2024). These habitats are typically dominated by tulip poplar (*Liriodendron tulipifera*, black cherry (*Prunus serotina*), sugar maple (*Acer saccharum*), basswood (*Tilia americana*) and American beech (*Fagus grandifolia*) (NatureServe Explorer, 2024).

Table 10. USNVC groups serving as primary habitat that support the most Southeast plant RSGCN in Virginia.

USNVC groups serving as primary habitat in Virginia	Number of plant RSGCN
Appalachian - South-central Interior Mesic Forest (G020)	13
Wet-Mesic Longleaf Pine Open Woodland (G190)	6
Central Appalachian - Northeast Pine - Oak Rocky Woodland (G906)	6
Southern Mesic Beech - Oak - Mixed Deciduous Forest (G166)	4
North Atlantic Coastal Tidal Freshwater Marsh (G914)	4
Central Interior Alkaline Open Glade & Barrens (G179)	3
Central & Southern Appalachian Seep (G184)	3
Southern Appalachian Rocky Outcrop (G670)	3
Xeric Longleaf Pine Woodland (G154)	2
Southeastern Coastal Pocosin & Shrub Bog (G186)	2

VIRGINIA'S STEWARDSHIP OF RSGCN

Roughly 265 RSGCN occur within Virginia and 226 of those species are also included in the state's list of SGCN. The most common RSGCN taxa type represented in Virginia are fishes (97), birds (49), and mussels (36) (Figure 9). Virginia is also home to multiple species that are not only endemic to the SEAFWA region but are not often found in many other states within the region. Virginia shares the highest amount of RSGCN with North Carolina, Georgia, Tennessee, and Alabama. In particular, Virginia shares RSGCN stewardship responsibility for 18 mussels that are considered very high concern with Tennessee. Identifying these shared RSGCN can help Virginia collaborate with other states on conservation actions that not only provide local benefits but support a regional landscape.

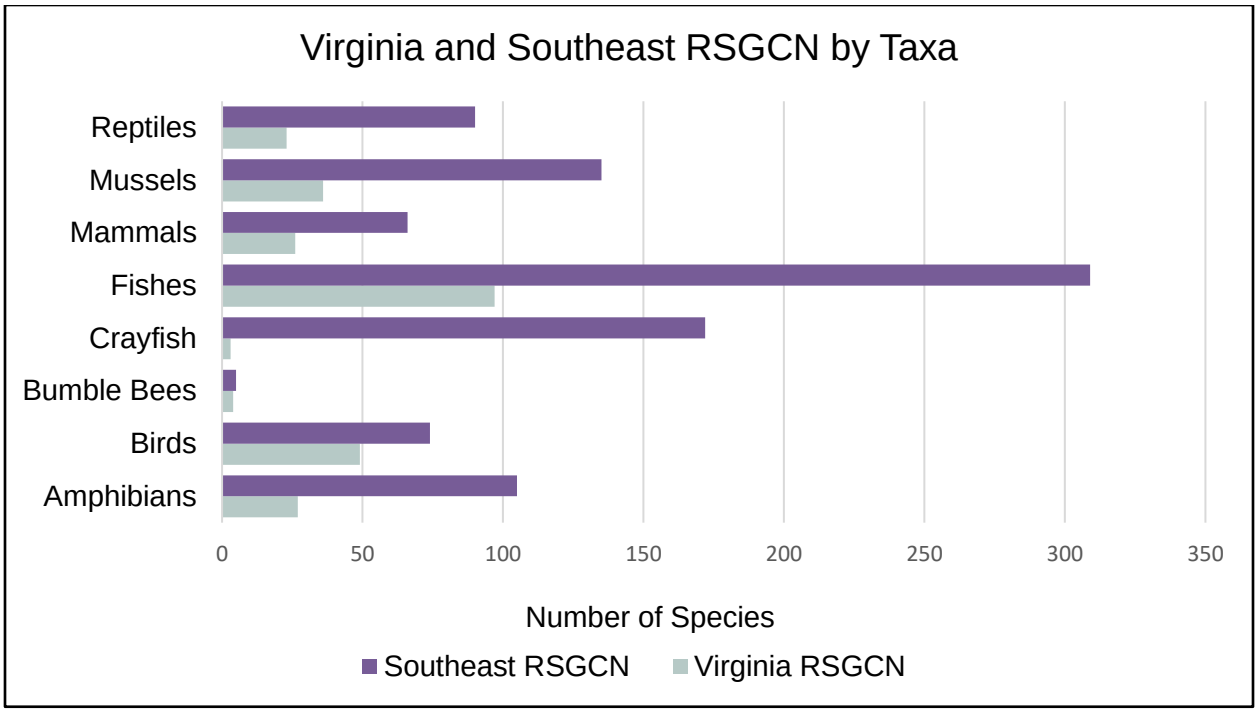


Figure 11. Virginia's Regional Species of Greatest Conservation Need (RSGCN) vs. the Southeast's RSGCN.

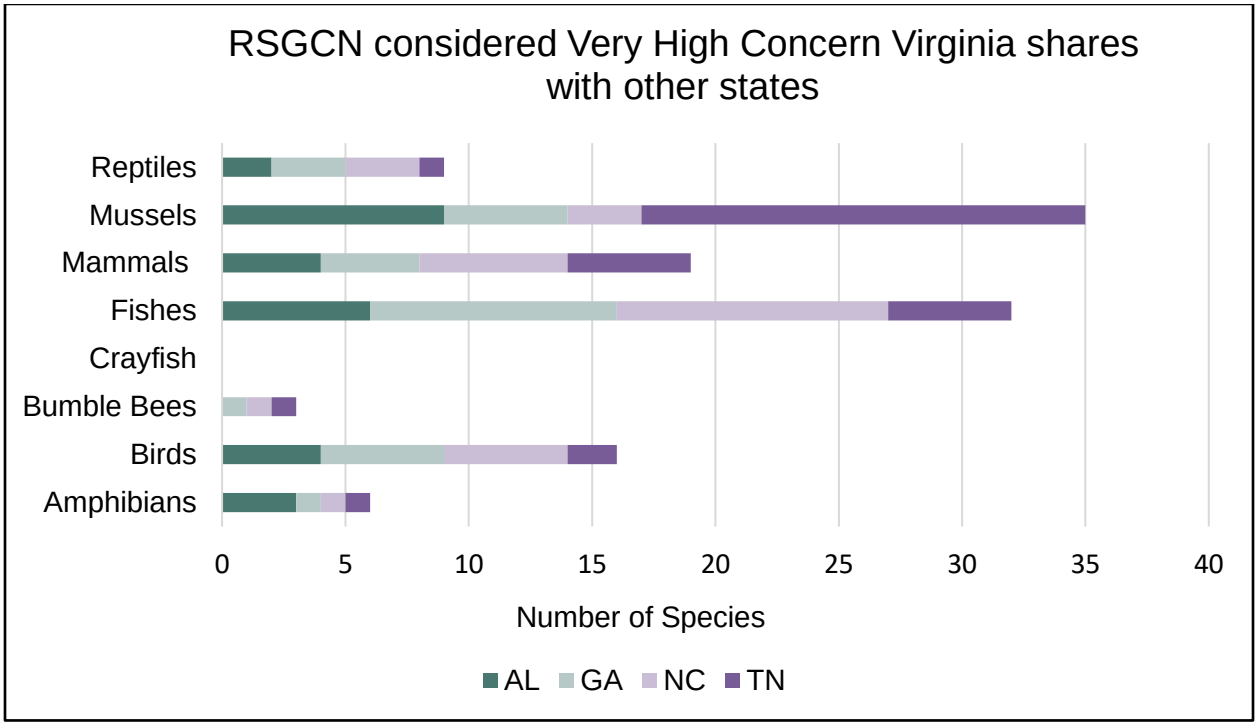


Figure 12. Southeast RSGCN that are considered very high concern and shared by Virginia, Tennessee, North Carolina, and South Carolina.

CITATIONS

Association of Fish and Wildlife Agencies. The Eight Requires Elements to include in Comprehensive Wildlife Action Plans (State Wildlife Action Plans). https://www.fishwildlife.org/application/files/5815/7125/4229/SWAP_Eight_Required_Elements.pdf.

Georgia Department of Natural Resources. 2024. 2025 SWAP Revision Southeastern SGCN Database and Supporting Documents. Georgia Biodiversity Portal. https://georgiabiodiversity.org/portal/regional_conservartion_info.

National Wildlife Federation. 2023. Southeastern Regional Species of Conservation Need (RSGCN). Accessed January, 2024. https://www.nwf.org/Our-Work/Wildlife-Conservation/southeast-regional-priority-species

NatureServe. (2023). NatureServe Network Biodiversity Location Data accessed through NatureServe Explorer [web application]. NatureServe, Arlington, Virginia. Available https://explorer.natureserve.org/. (Accessed: August 21, 2023).

NatureServe. 2024. NatureServe Network Biodiversity Location Data accessed through NatureServe Explorer [web application - Wet-Mesic Longleaf Pine Open Woodland]. NatureServe, Arlington, Virginia. Available https://explorer.natureserve.org/. (Accessed: January 30, 2024).

Omernik, J.M. 1987. Ecoregions of the conterminous United States. Map (scale 1:7,500,000). Annals of the Association of American Geographers 77(1):118-125.

Omernik, J.M. 1995. Ecoregions: A spatial framework for environmental management. In: Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Davis, W.S. and T.P. Simon (eds.), Lewis Publishers, Boca Raton, FL. p. 49-62.

Radcliffe, C., Norris, S., Ambrose, J., Knapp, W., Rice, T., Treher Eberly, A., Weakley, A.., Terwilliger, K., Coffey, E.E.D. (2023). Southeastern Plants Regional Species of Greatest Conservation Need. Atlanta, Georgia: Southeastern Plant Conservation Alliance. https://www.se-pca.org/wp-content/uploads/2023/10/SE-PCA_publication_final_Booklet_23.pdf

Rice, T.M, Crisfield, E., and Terwilliger, K. (2010) Regional Species of Greatest Conservation Need in the Southeastern United States. Available at https://secassoutheast.org/pdf/SEAFWA_RSGCN_Final_Report_20190715.pdf

Southeast Conservation Adaptation Strategy. 2024. Recent Trends in Southeastern Ecosystems (2024): Measuring Progress Toward the SECAS Goal. Available online: http://secassoutheast.org/pdf/SECAS-goal-report-2024.pdf

U.S. Bureau of Economic Analysis for Outdoor Recreation 2023. https://www.bea.gov/data/special-

topics/outdoor-recreation (accessed January 25, 2025).

U.S. Department of Agriculture. 2023. https://www.nass.usda.gov/Quick_Stats/Ag_Overview/stateOverview.php?state=VIRGINIA (accessed January 28, 2025).

USGS. Gap Analysis Project (GAP). 2025. https://www.usgs.gov/programs/gap-analysis-project

Virginia Department of Wildlife Resources, Virginia Department of Transportation, Virginia Department of Conservation and Recreation, and Virginia Department of Forestry. 2023. Virginia's Wildlife Corridor Action Plan. https://dwr.virginia.gov/wp-content/uploads/media/Virginia-Wildlife-Corridor-Action-Plan.pdf (accessed January 25, 2025).

APPENDIX 2: WILDLIFE HEALTH

WHAT IS WILDLIFE HEALTH?

Wildlife health is a complex, dynamic topic that can be difficult to define and measure. Wildlife health encompasses more than simply the presence or absence of disease caused by pathogens, parasites, and toxicants (e.g., contaminants or other poisonous substances produced by animals, plants, or people); rather, wildlife health is defined by a population's ability to withstand stressors and challenges, such as climate change, habitat loss, the emergence of disease-causing agents, and other environmental, climatic and anthropogenic threats. The term "resilience" can be used instead of "health" and, as such, health is the result of interacting biological, social, and environmental determinants (Stephen 2014).

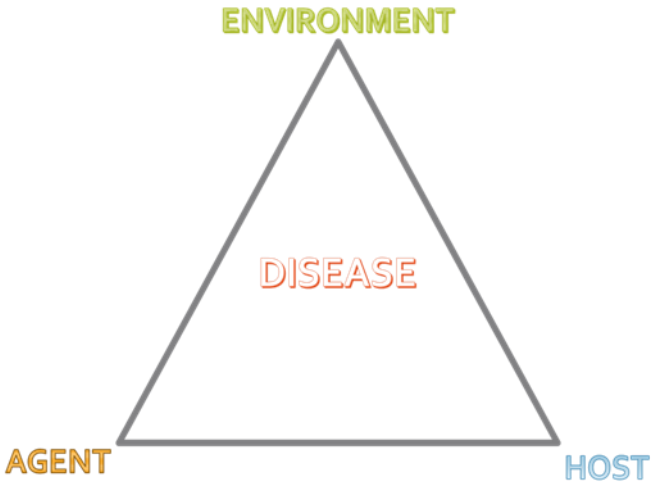
Why is wildlife health important?

The health of wildlife populations determines their ability to persist in the wild at sustainable levels for the long term. Wildlife health is linked to environmental and ecosystem health, as well as the health of humans and domestic animals. Monitoring wildlife health provides important information about population, community, and ecosystem dynamics and can inform measures needed to protect human and domestic animal health, as well as other wildlife populations. Further, wildlife health is linked with ecosystem health, and healthy ecosystems provide a plethora of services, from supporting productive agriculture to facilitating enjoyment of natural areas through recreation to mitigating the effects of severe weather and climate events, among many others. Healthy, resilient wildlife populations contribute to biodiversity, which also supports healthy ecosystems.

How does disease relate to wildlife health?

Disease occurs when a host responds to the presence of a pathogen, parasite, or toxicant and it can be both a determinant of health, as well as a stressor. Disease-causing agents can have significant impacts on wildlife populations. Diseases can have direct (e.g., causing overt morbidity and mortality) and indirect (e.g., decreased fitness) impacts on populations, both of which can result in or exacerbate population declines.

The development of disease depends on factors related to the host organism, the environment and climate, and the disease-causing agent (see epidemiologic triad at right). In healthy wildlife populations, pathogens (e.g., bacteria, fungi, viruses, parasites) and toxicants are present, and disease associated with these pathogens and toxicants typically occurs at low levels that do not have population-level impacts; however, when the host (i.e., wildlife) population experiences additional stressors or threats, the prevalence of disease may increase.



How do emerging diseases and other health threats impact wildlife populations?

An emerging disease is defined as "one that has recently been discovered; has recently increased in incidence, geography, or host range; or is newly evolved" (Rachowicz et al. 2005). Two hypotheses can apply to an emerging disease: the novel pathogen hypothesis states that the disease has recently spread into new geographic areas, whereas the endemic pathogen hypothesis suggests that it has been present in the environment but recently has affected new hosts or increased in its ability to cause disease (Rachowicz et al. 2005).

Diseases pose unique challenges to the conservation of wildlife populations, particularly in many species that are already experiencing other stressors. Disease may be the primary cause of population declines, or it may exacerbate population declines. Although in many instances we lack full comprehension of the impacts of diseases on wildlife populations, the impact of disease is well-documented in certain populations. For example, in North America, chytridiomycosis, caused by the fungus *Batrachochytrium dendrobatidis*, and white-nose syndrome, caused by the fungus *Pseudogymnoascus destructans*, have emerged following pathogen introduction and have had devastating impacts on amphibian and bat populations, respectively.

The role of wildlife health in One Health

There are numerous definitions of One Health, but generally, One Health is considered a collaborative approach that recognizes that the health of humans, domestic and wild animals, and the ecosystems/landscapes they inhabit are interconnected (AFWA 2023). For example, sometimes disease-causing agents/toxicants that impact wildlife health may also threaten human (e.g., zoonotic diseases) or domestic animal health and vice versa. Further, anthropogenic changes to the landscape can also affect wildlife populations. Discussions of wildlife health should consider linkages with humans, domestic animals, and ecosystems through a variety of measures and collaborations.

How do we measure wildlife health?

Many different approaches can be used to measure health and evaluate health outcomes in wildlife. In a population of interest, potential health threats should be evaluated, followed by estimating the possible subsequent health outcomes. The health of wildlife populations (i.e., a population's resilience to stressors) is difficult to measure without the presence of an obvious challenge or threat that causes overt mortality. Evaluating potential threats to the health of wildlife populations will inform and guide the best way(s) to measure, evaluate, and subsequently manage health outcomes, which may vary by individual species, population, threat, and scenario.

Factors that may influence the health of populations include: genetic diversity; population demographics; climate change and weather events; resource availability; habitat continuity/quality; exposure to toxicants, pathogens, or parasites; and other stressors. These factors may directly affect population health or may work in conjunction with other factors to affect populations. For example, climate change may alter the geographic distribution of certain pathogens, leading to exposure of naive wildlife populations to novel pathogens. Additionally, decreased resource availability or poorer quality

and/or quantity of habitat may weaken a population's ability to respond to pathogens, thus resulting in more significant impacts of pathogens in certain populations.
Factors that may be reflective of the health of individuals and populations, and thus the resilience of a population, include: genetic diversity; immune function; reproductive fitness; population parameters; body condition; organ function; active infections; parasite loads; and causes of morbidity and mortality. These lists are not meant to be exhaustive but do provide good examples of various factors to consider when evaluating both potential health threats and measuring/evaluating health outcomes and the health of wildlife populations.

COMPONENTS OF WILDLIFE HEALTH

Morbidity and mortality events

Wildlife morbidity and mortality events often occur unexpectedly and may be highly visible and variable in scale. These events may include a few individuals of one species or a large number of multiple species or any combination of these and occasionally may involve a legal component (e.g., poisoning). Management agencies must be prepared to respond quickly and efficiently to investigate the cause of such events and to address the media and the public, should there be interest. They should also be prepared to communicate their findings and coordinate their response with other state, regional, and federal partners. The overarching goal of wildlife mortality investigations is to identify the cause(s) of such an event and identify any factors that may have contributed. Successfully investigating wildlife mortality events requires planning, preparation, flexibility, and often cooperation among agencies and other organizations (e.g., diagnostic laboratories).

Steps and considerations during investigation of wildlife mortality events should include: obtaining sufficient and relevant history; field evaluations; safe collection of sick and dead wildlife and/or samples; diagnostic laboratory analyses; communication of results to stakeholders; determination if any management actions are necessary; and implementation of such management actions, as appropriate. There are many resources that provide additional details on these steps (e.g., Friend and Franson 1999; Franson et al., 2015).

Emergency disease outbreak preparedness

An agency's ability to appropriately respond to morbidity and mortality events and disease outbreaks largely depends on the agency's emergency disease outbreak preparedness, meaning how well they have planned and prepared for potential future disease outbreak scenarios. Often, disease outbreaks occur rapidly and with minimal to no forewarning. Disease outbreaks may involve endemic or emerging/novel pathogens, parasites, or toxicants and may occur in a variety of scenarios. Emergency disease outbreak preparedness is necessary to respond rapidly and appropriately to these events and can encompass many different elements that are tailored to each specific agency and region's needs. Foundational elements of emergency disease outbreak preparedness and response may include: planned coordination among all involved agencies/organizations, including established contracts with diagnostic laboratories; dedicated funding to enable swift and appropriate responses; predetermined agency response plans and protocols for field investigation of disease outbreaks and morbidity/mortality events; biosecurity protocols; and kits with all necessary field investigation supplies. Agencies may consider conducting regular table-top exercises with staff; developing an Incident Command and

Management System; engaging in long-term planning regarding potential management decisions; developing internal and external communication plans; and evaluating specific needs for prolonged/future surveillance and/or monitoring, depending on the outcome.

Prevention

While many threats to wildlife health cannot be prevented, certain steps can be taken to reduce the risk of them occurring and/or their effects on wildlife populations. For example, avoiding the transport of animals, plants, or environmental substrates (i.e. water and soil) between different areas can help to reduce the risk of moving disease-causing agents or diseased animals to naive areas. Regular inspections of facilities that temporarily house animals may reduce risk. Adhering to biosecurity measures when handling animals or biological material also reduces risk. Such measures may include: disinfection of field equipment; cleaning boots; and wearing personal protective equipment such as gloves, masks, and/or disposable aprons or boot covers. Previous knowledge of the potential disease-causing agents in a particular area can also help managers be prepared for outbreaks and prevent their spread.

Surveillance, monitoring, and management

It's important to understand the differences between surveillance, monitoring, and management when dealing with wildlife health. Surveillance can be active (intentional, planned collection of specific samples) or passive (opportunistic collection of samples as they are available) and involves testing for specific pathogens, toxicants, diseases, or other markers. While surveillance is typically aimed at prevention or early detection of health threats, monitoring aims to measure the threat and its impacts once present in the population. Finally, management is action taken to reduce the risk, spread, or impacts of a health threat. Merely conducting surveillance for the presence of a threat is not management, but monitoring is necessary to evaluate whether management actions are effective. Strategies for pathogen surveillance are described for herpetofauna populations in a paper by Gray et al (2017). While there are limited available published surveillance strategies for other taxa, similar strategies can apply to a broad range of species. Further, fish and wildlife health specialists are an excellent resource to collaborate with to develop species-, state-, and region-specific surveillance and monitoring strategies, as these may vary spatially and by population.

INTEGRATING WILDLIFE HEALTH INTO STATE WILDLIFE ACTION PLANS: ACTION ITEMS FOR CONSIDERATION*

***At the discretion of state fish and wildlife agencies**

Action: Recognize the importance of wildlife health and its role in supporting *resilient* wildlife populations and **i**ncorporate wildlife health into management plans.

Action: Work with academic and other partners to address emerging diseases through surveillance and research, including determining causes of death and/or population declines in species of greatest conservation need.

Action: Develop agency-specific morbidity and mortality event protocols and emergency disease outbreak and response protocols, including appropriate biosecurity measures, to better respond and address morbidity/mortality events and emergency disease outbreaks, as necessary.

Action: Work collaboratively and cooperatively with adjacent state fish and wildlife agencies, regional fish and wildlife associations, national fish and wildlife associations and agencies, agricultural and public health agencies, and others to address wildlife health issues at a regional and national scale.

Action: Provide opportunities for wildlife biologists, managers, agency personnel, and the public to expand their knowledge of wildlife health and improve wildlife health communication, as necessary.

REFERENCES AND SUPPORTING LITERATURE

Association of Fish and Wildlife Agencies (AFWA). 2023. AFWA President's Task Force on One Health-Final Report. AFWA. Washington, D.C. 14 pages.

Gray MJ, Duffus MLJ, Haman KH, Harris RN, Allender MC, Thompson TA, Christman MR, Sacerdote-Velat A, Sprague LA, Williams JM, Millder DL. 2017. Pathogen surveillance in herpetofaunal populations: guidance on study design, sample collection, biosecurity, and intervention strategies. *Herpetological Review* 48(2): 334-351.

FEMA, updated 2024. National Incident Management System. https://www.fema.gov/emergency-managers/nims.

Friend M., and Franson J.C., eds., 1999. Field manual of wildlife diseases: General field procedures and diseases of birds. https://pubs.usgs.gov/itr/1999/field_manual_of_wildlife_diseases.pdf

Franson, J.C., Friend, M., Gibbs, S.E.J., and Wild, M.A., eds., 2015. Field manual of wildlife diseases: U.S. Geological Survey Techniques and Methods 15. http://dx.doi.org/10.3133/tm15.

Rachowicz LJ, Hero J-M, Alford RA, Taylor JW, Morgan JAT, Vredenburg VT, Collins JP, Briggs CJ. 2005. The novel and endemic pathogen hypotheses: Competing explanations for the origin of emerging infectious diseases of wildlife. *Conservation Biology* 19:1441-1448.

Stephen C. 2014. Toward a modernized definition of wildlife health. *Journal of Wildlife Diseases* 50:427-430.

APPENDIX 3: RECOMMENDATIONS FOR ENHANCING CONSERVATION OF SGCN AND THEIR HABITATS THROUGH EDUCATION, OUTREACH, AND WILDLIFE VIEWING

Engaging Virginians in outdoor recreation is critical to the conservation of the state's Species of Greatest Conservation Need (SGCN) and their habitats. Numerous studies have shown that participation in outdoor recreation fosters a sense of responsibility for natural resources in both adults and children. As the population increases, so does the demand for more and better access to outdoor recreational opportunities that allow the public to sustainably engage with nature.

The work of the DWR's Watchable Wildlife Program (WWP) and Outreach Division (OD) is vital to connecting the public to Virginia's SGCN and illustrating the relevancy of DWR's conservation efforts for SGCN and the habitats they depend on. Protecting, enhancing, and increasing recreational opportunities throughout the state plays an important role in the agency's mission and serves to leverage support for SGCN conservation. Through the provision of opportunities that allow the public to contribute to on-the-ground habitat initiatives as well as citizen/community science programming, the WWP and OD are directly connecting constituents to the state's SGCN and tangible actions that anyone can take to conserve imperiled species. Further, this connection to SGCN is fostered more fundamentally through the agency's efforts to increase public knowledge, awareness, and appreciation of Virginia's SGCN and their habitat needs which ultimately inspires the public to conserve them. DWR's programming for both educators and public audiences aims to generate a more informed and connected public perspective that is supportive of conservation measures and the relevancy of DWR in SGCN management.

The following list of actions are intended to preserve SGCN and their habitats while engaging and informing constituents about DWR's conservation actions. This list was comprised by staff within DWR's WWP and OD and is made up of specific recommendations with a tangible education, stewardship, and/or outreach components for SGCN identified within this plan. The recommendations are organized by general category with a list of specific actions applicable to each recommendation.

EDUCATION AND AWARENESS INITIATIVES

Recommendation: Increase the public's general awareness and support for conservation needs and initiatives pertinent to SGCN.

Specific Actions:

- Develop Virginia specific field guides (e.g. butterflies, darters, freshwater mussels) which incorporate 'Call to Action' suggestions for designated SGCN.
- Launch a 'Tern Cam' which would showcase Virginia's largest nesting seabird colony (comprised of five SGCN). In addition to showcasing these species, supplemental materials would be developed which highlight the management techniques applied at this site to conserve the colony.

- Support the development of nature centers (either DWR-owned/maintained/managed or others via provision of additional resources) to foster a greater appreciation of local flora and fauna to communities.
- Produce more materials that educate the public as to what the Wildlife Action Plan is and how it connects to the Agency's mission.

Recommendation: Develop programs and initiatives that will garner more public knowledge and awareness about conservation needs specific to urban localities.

Specific Actions:

- Develop a list of SGCN that commonly occur in urban areas. Especially those for which tangible management actions have been identified and are feasible to implement at a local level.
- Develop workshops to increase awareness about urban conservation actions for municipal governments, Planning District Commissions, city/county planning commissioners, and developers as well as digital media resources/outreach efforts; e.g. lights out and bird-safe buildings, the seven simple actions, etc. which would support the conservation of SGCN bird species
- Regularly host beginner birding workshops and walks across the state to recruit and engage new audiences with birding.
- Identify and build partnerships with urban localities, parks and rec departments, businesses, and schools, etc. to create simple habitat improvements and enhancements that would support SGCN (e.g. pollinators and birds) and help keep common species common.
- Fund a grant/cost-share program that can provide funding for design and implementation of habitat projects benefitting SGCN within these urban areas.
- Provide technical assistance in the implementation and maintenance of these habitat practices.
- Within urban localities, identify opportunities for new VBWT sites to be designated. At these new sites and already existing VBWT sites:
    - Conduct an assessment of habitats; rate each according to condition, suitability for enhancement, SGCN known or likely to occur in the area, and proximity to underserved communities. The highest-ranked projects will provide the greatest benefits to SGCN and opportunities to engage local communities.
    - Leverage local contractors and community organizations (e.g., Master Naturalists, Master Gardeners, school groups, civic associations) to implement projects and provide local engagement in the completion of the identified enhancements.
    - Provide interpretive signs or other educational materials to increase public awareness and knowledge of the SGCN on the enhanced properties.

Recommendation: Develop programs and initiatives geared specifically towards youth and families that promote a more holistic understanding of wildlife/habitat management, SGCN, and the role of state wildlife management agencies.

Specific Actions:

- Expand existing education and outreach programs to inform Virginians about SGCN species, their habitats, and non-consumptive wildlife-related recreational opportunities (e.g. Bird by Bird program).
- Support trainings for the statewide Mater Naturalist Program so they can educate their communities about Virginia's natural resources and the role of wildlife management agencies
- Grow the official environmental education school recognition program of the Commonwealth, Virginia Naturally Schools, which recognizes the wonderful efforts of many Virginia schools to increase the environmental literacy of our youngest citizens.
    - Expand the current number of schools recognized by the program.
    - Develop materials that support schools in their efforts to achieve recognition.
    - Expand on the SGCN collection of Virginia Naturally School's Program awards, which includes education about the SGCN species for recognized schools.
- Develop educational materials focused on SGCN species that correlate to the Virginia Department of Education's Standards of Learning.
- Adapt existing educational materials, such as Project WILD activities and workshops, to focus on SGCN species.
- Conduct additional educational workshops for educators to improve environmental understanding and the role of wildlife management agencies.
- Conduct additional local workshops for youth and adults to improve environmental understanding and the role of wildlife management agencies.

RESEARCH AND STEWARDSHIP OPPORTUNITIES

Recommendation: Offer new or bolster support for existing participatory science opportunities which harness volunteers to augment the DWR's data collection needs related to SGCN and habitat conservation.

Specific Actions:

- Work with DWR biologists and Land Management staff to identify data needs that could be fulfilled through volunteer engagement and determine the best ways to meet these goals.
- Expansion of Diamondback Terrapin Monitoring and Reporting Project; utilizes volunteers to annually conduct standardized headcount surveys as part of a larger multi-state initiative to identify priority areas in Virginia.
- Shrike Force (Loggerhead Shrike survey project); volunteers conduct surveys to locate shrikes and then monitor banded shrikes (a pre-designed project implemented in other states that we would implement with partners here in Virginia)
- Conduct species inventories, targeting SGCN, on DWR properties to inform WMA management plans and SGCN species conservation efforts across Virginia; the opportunities here are numerous and could include volunteers conducting targeted surveys for a specific SGCN species of interest (e.g. Swainson's Warbler at Cavalier WMA) or conducting broad inventories of birds at WMAs to document the more common SGCN and generate a species list for the WMAs, or inventories of butterflies to serve this same purpose as well as to provide data to the larger NABA national database.

- Allegheny Woodrat camera trap monitoring in Virginia's mountains; would utilize volunteers to assist with setting up and monitoring trail cameras to monitor the presence of woodrats. DWR has a number of historic locations where "trapping" is needed. Typically, 6-10 cameras are placed at a site and run for a week. Volunteers could run the cameras, download pictures, ID species, enter in a datasheet, and upload photos to DWR.
- Development of an online portal on the DWR website for the public to report bald eagle nests in the mountains and piedmont.
- Bat box monitoring project; a replication of Vermont's project for big brown bats here in Virginia. This would generate baseline data for the species in Virginia.
- Indiana Bat box monitoring project - a potential future project after other pilot projects and mapping efforts are completed.
- Expansion of acoustic bat monitoring for North American Bats (NA BATS); seeks volunteers to collect acoustic data through road surveys or at stationary points.
- Administer a centralized invasive species reporting system for the agency that can be utilized by the public to report invasive species observations.
- VA Candid Critters Program: A statewide camera trapping program (modeled after the NC program) that utilizes volunteers to deploy trail cameras on public and private properties across the state and review/analyze the collected footage. The program would engage/educate the public and improve our understanding of many understudied species distribution in VA.
- Long term box turtle monitoring program modeled after NC's Box Turtle Connection project, volunteers would be trained to collect data and conduct long-term monitoring of box turtle populations in priority areas. This would generate critical baseline data for the state, monitor population trends, identify threats, and assess the effectiveness of applied conservation management techniques for the species.
- Sea turtle stranding monitoring: volunteers could regularly patrol certain areas for stranded, cold-stunned turtles (would need to partner with the Virginia Aquarium on this project)
- Statewide Reptile and Amphibian Atlas; following the 1999 Mitchell Atlas, substantial need exists to conduct another statewide reptile and amphibian atlas. This project could be developed exclusively by DWR or in conjunction with the Virginia Herpetological Society. Volunteer involvement would be critical to meet the data collection needs associated with this project.
- Virginia Wildlife Mapping Project: a statewide project that utilizes the iNaturalist platform as a database that anyone may submit observations of Virginia wildlife into from any location in Virginia–from the backyard to the backcountry; it provides an educational and recreational opportunity for its participants and provides observations of SGCN to the DWR
- Incorporate volunteer data collection opportunities into livestreaming wildlife camera programming. Examples include:
    - Shad Cam: Utilize volunteers to review footage and collect information on American shad, American eel, and other migratory fish passage in the James River.
    - Falcon Cam: Utilize volunteers to review footage and collect behavioral data on urban-nesting peregrine falcons.

Recommendation: Develop and implement habitat stewardship projects which harness volunteers to supplement the DWR's habitat work at agency-managed properties across the state.

Specific Actions:

- Invasive species removal (utilizing manual, low-risk techniques)
- Supplemental plantings to augment habitat for SGCN on DWR properties.
- Provision of aquatic habitat (e.g. deployment of artificial fish habitat and establishment of aquatic natives)
- Implement citizen science monitoring of DWR habitat treatments to track long term impacts and progress towards identified desired future conditions.

Recommendation: Bolster current and develop new initiatives that work to conserve SGCN and relevant habitats on private land/around the home.

Specific Actions:

- Enhance DWR's Habitat at Home to include data collection regarding applied habitat practices, acreage enrolled and wildlife utilization. Utilize citizen science data collection platforms to track SGCN occurrence Habitat at Home certified properties.
- Offer workshops and trainings that provide information on establishing Habitat at Home for wildlife.
- Fund and develop programs/resources to encourage and help homeowners' associations to mitigate habitat loss and establish green spaces within residential common areas.
- Expand DWR's work to connect constituents to cost share programs (like the Virginia Conservation Assistance Program) that provide assistance to habitat conservation practices on private lands.
- Provide information on bird feeders, bird baths, nest boxes, vernal pools, treefrog hotels, frog ponds, etc. as mechanisms that people can support and view wildlife in their backyards.

COLLABORATION AND PARTNERSHIP BUILDING

Recommendation: Increase collaboration and partnerships with State, Federal and local agencies and organizations that promote conservation of SGCN and their habitats.

- Expand on DWR's efforts to provide training for State and Federal Agencies and Conservation NGOs pertaining to habitat and SGCN. Ensure that SGCN information is included in management plans and public facing materials.
- Support additional requests from partners to provide programming for events such as festivals, bird walks, presentations, and demonstrations.
- Partner with conservation organizations to produce and enhance materials that inform the implementation of habitat practices that benefit SGCN. DWR to provide support and expertise in the development of the materials. Examples include the Plant Virginia Natives Campaign, and the James River Association's buffer planting guide.
- Continue as a project partner for the Pollinator Smart Program, this seeks to create/enhance habitat value related to industrial solar development. This program highlights the potential

value for SGCN species, especially pollinators. Increase the scope of this effort to include brown fields, utility corridors and other lands.
- Bolster sponsorship and agency recognition opportunities to relevant partnership organizations such as VMNs, VSO, VHS, and VBS.
- Continue to fund organizations getting youth outdoors and prioritizing programs that place an emphasis SGCN.
- Prioritize regular communications with partners for awareness of agency initiatives related to SGCN.

PUBLIC ACCESS

Recommendation: Encourage increased use of agency lands and waters by non-consumptive users, participants that don't hunt or fish, through comprehensive habitat management on DWR properties consistent with the DWR Wildlife Action Plan, benefiting SGCN species**.**

Specific Actions:

- Promote management practices that foster diverse habitat assemblages to support native wildlife.
- Incorporate habitat enhancement and relevance to SGCN species during the planning phase for WMA management strategies.
- Develop communications that clarify the purpose of agency properties and the ability of these lands and waters to support multiple forms of wildlife-dependent recreation.
- Create simple, user-friendly communications about wildlife viewing opportunities for SGCN species on various DWR properties.
- Conduct a thorough investigation of wildlife viewing amenities that could support ethical viewing of SGCN species at WMAs on a site-by-site basis.

Recommendation: Encourage increased use of the Virginia Bird and Wildlife Trail (VBWT) and better utilize these sites for potential wildlife/habitat management actions which could positively impact SGCN**.**

Specific Actions:

- Revitalize partnerships and strengthen communications with VBWT site owners/managers to foster more public awareness of the VBWT and site-specific connections to SGCN viewing opportunities.
- Provide workshops for VBWT site owners/surrounding communities to increase their awareness of local SGCN and actions that benefit them.
- Develop and promote a DWR-sponsored grant program which would provide needed funding for site managers to implement restoration work aligned with the needs of SGCN on VBWT properties.
- Improve online information about the VBWT to address widespread lack of understanding about what the VBWT is and what can be expected when visiting a site.
- More formally connect DWR staff to the VBWT and its numerous properties. Identify specific sites where partnerships could be formed to support SGCN on these lands.

- Utilize VAFWIS to better understand historical reports of SGCN species on VBWT sites and use this to guide on the ground partnerships and initiatives.
- Provide more targeted promotion surrounding the VBWT and its relevance to wildlife viewers and outdoor enthusiasts across the state.
- Support development of trails, wildlife viewing structures, interpretive signage, and additional access to enhance the public's understanding and access to natural environments relevant to SGCN.
- Create an incentive opportunity for both the public as well as partner VBWT sites for visitors

FUNDING GENERATION AND INCREASED AGENCY RECOGNITION

Recommendation: Develop a communication strategy to share both internally and externally the DWR mission, the role of DWR in conservation and outdoor recreation, and the agency's commitment to diverse constituencies including wildlife viewers.

Specific Actions:

- Communicate about the relevance of DWR in wildlife management and its commitment to support non-consumptive user groups (e.g. wildlife viewers, hikers, paddlers, etc.).
- Communicate about the State Wildlife Action Plan, how it focuses on conserving wildlife to benefit people, and how it is a blueprint of strategies for the agency to address SGCN.
- Consider the utilization of targeted marketing as a call to action for users to donate funds for wildlife and habitat conservation specifically earmarked for SGCN.
- Promote documentation from external informative sources to further clarify the role of state agencies and outline policy actions that can support DWR's SGCN conservation work. For example, the North American Bird Conservation Initiative's State of the Birds report typically contains information on the role of U.S. state agencies to bird conservation.
- Increase training and awareness of the ways in which wildlife viewers financially support DWR.
- Train DWR staff about the importance of wildlife viewing to DWR's mission, agency programs that support wildlife viewing, and ways in which viewers support the agency (e.g., donations, licenses, volunteers) and the economy of Virginia through nature tourism.
- Establish and communicate mechanisms through which wildlife viewers can provide input to the agency (e.g., by providing comments on revisions to the Virginia Wildlife Action Plan).
- Highlight the relevance of the DWR's work and Virginia Wildlife Action Plan to wildlife viewers through content published in partner and DWR communication channels.
- Develop corporate and organizational recognition opportunities for their contributions to DWR and wildlife conservation of SGCN

Recommendation: Increase monetary contributions of wildlife viewers to support DWR's work with wildlife and habitat conservation.

Specific Actions:

- Streamline and expand external promotion of existing funding mechanisms through which wildlife viewers can and already do support DWR.

- Communicate about current funding mechanisms that viewers can and already participate in to support the agency (e.g., communicating the role of HB 38 funds to birders and viewers).
- Promote purchase of a Virginia Wildlife license plate as a mechanism for contributing to the agency and wildlife conservation.
- Grow membership for the Restore the Wild program and use the program's funding to support significant and sustainable habitat projects with a specific and measurable outcome for SGCN species. These results will form the basis for outreach efforts to generate further support for Restore the Wild.
    - Streamline and expand promotion of Restore the Wild memberships to communicate the value of this program for wildlife viewers and additional target communities.
- Provide a variety of mechanisms through which constituents can support DWR, from volunteering to donating.
- Develop a set of standardized materials (e.g., logos, presentation slides, handouts) to advertise donation opportunities at major DWR-sponsored events.
- Implement DWR-sponsored events in which registration fees support wildlife or habitat conservation.
- Explore opportunities to work with corporate or retail partners to generate funding for wildlife conservation and viewing-related programming.
- Find new and innovative funding mechanisms and market existing funding mechanisms that provide a source of revenue from non-consumptive wildlife users to generate revenue for statewide initiatives that impact SGCN.
    - Develop and enhance materials to incorporate into all DWR education and outreach programs that explain the importance of funding wildlife conservation programs.

APPENDIX 4: VIRGINIA MARINE MAMMAL CONSERVATION PLAN

(To be included once completed.)

APPENDIX 5: VIRGINIA SEA TURTLE CONSERVATION PLAN

(To be included once completed)