WILDLIFE CORRIDORS IN FREDERICK COUNTY:

CONSERVING NATURE IN MARYLAND'S APPALACHIAN HEART

Responding to Climate Change and Biodiversity Loss by Creating an Enduring Landscape through Green Infrastructure

climate CHANGE WORKING GROUP OF FREDERICK COUNTY

A Climate Change Working Group of Frederick County White Paper
by Karen Russell

Climate Change Working Group

Founded in 2016, the Climate Change Working Group's mission is to assist Frederick County administrators and residents in adapting to and mitigating the impacts of climate change through responsible planning, education and advocacy.

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Rt. 355 bridge over the Monocacy River by Scott Norris, others by Karen Russell

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Foreword

One consequence of Frederick County's population growth has been the loss and fragmentation of habitat on which many plants and animals depend. Some species are now classified by the State of Maryland as rare, threatened, or endangered. Add to this local challenge the global one of climate change. Many plants and animals that we know and treasure are in trouble. Their habitats are changing and their food sources are, in some cases, disappearing. Fortunately, we already have the tools we need to make a difference on these related challenges. By focusing locally, Frederick County can lay a cornerstone for creating a grand Appalachian Climate Corridor.

Frederick county and neighboring Washington county lie within the broader Appalachian mountain landscape. The Appalachian Mountains represent the most connected landscape and the most heavily travelled wildlife migration corridor in North America. The Appalachian Trail, stretching 2,180 miles from Maine to Georgia, passes through Frederick and Washington counties. Frederick County is uniquely situated to provide access to the Appalachians for plants and animals needing to migrate toward these ranges. Creating contiguous wildlife corridors that connect fragmented habitat facilitates species movement along the Appalachians and ensures continued biodiversity in the changing natural systems on which survival depends.

But we must act now. The implications go much farther than small animals and plants most of us rarely see. They impact our way of life, from trout fishing in Catoctin Mountain streams, to countryside tourism, clean drinking water, and, for locals, the experience of simply enjoying time outdoors.

By prioritizing wildlife corridors in its Livable Frederick green infrastructure plan, Frederick County can mitigate the local impact of both increased temperatures from climate change and reduce the threat of biodiversity loss. However, Green Infrastructure must be addressed before more land use decisions are made.

Using Maryland's green infrastructure assessment, along with Livable Frederick, we should:

- Clearly map existing hubs and corridors and work with private landowners to preserve them using available programs and funding.
- Update maps that show gaps in green infrastructure, including wildlife crossings over highways.
- Create a plan to fill in those gaps, including the major and most expensive obstacles.
- Identify current funding programs that align with creating wildlife corridors, then work to develop new ones.

Frederick County is a leader in preserving land, planting forest buffers, and implementing practices to expand grasslands. Now it's time for everyone to think beyond one restorative project at a time, and instead about a connected, living landscape.

David E Lillard

David Lillard
Executive Director
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Introduction

While the unabated effects of climate change are known to threaten human existence (Ask MIT), it is less understood that human existence is also threatened by the global loss of biological diversity or biodiversity. Biodiversity can be thought of as the rich variety of living things in nature, from microbes in the soil to plant and animal species. Wildlife corridors enable species to migrate as their habitats shift north or to higher elevations, in response to increased temperatures from climate change. By increasing the total amount of contiguous habitat available, they support biodiversity.

In 2021, the Intergovernmental Panel on Climate Change and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services co-sponsored a workshop on Biodiversity and Climate Change. The resulting report states that while both scientific and policy-making circles recognize the interconnection between biodiversity loss and climate change, they have been largely addressed within their own domains, without recognizing the interconnections. "This functional separation creates a risk of incompletely identifying, understanding and dealing with the connections between the two. In the worst case it may lead to taking actions that inadvertently prevent the solution of one or the other, or both issues" (Pörtner et al… 2021, p. 4). It also identifies wildlife corridors (migration corridors) as an effective conservation measure.

Recognized as a globally significant region, the Appalachian Mountains represent the most heavily travelled migration corridor in the United States for mammals, birds and amphibians (TNC). In a July 2022 report, an Appalachian Landscape Climate Advisory Group recognized that rapid loss of biodiversity and increasing range shifts can have cascading effects hindering human health and well-being. The Appalachian Trail, stretching 2180 miles from Maine to Georgia, passes through both Frederick and Washington counties. As the Catoctin and South Mountain ranges represent the eastern edge of the Appalachian mountains, Frederick County is uniquely situated to provide access for plants and animals migrating toward this range from points east, e.g. the Patuxent Research Refuge. Maintaining contiguous wildlife corridors that connect fragmented habitat facilitates species movement and ensures continued biodiversity in the changing natural systems on which survival depends.

By implementing a Livable Frederick green infrastructure plan that prioritizes wildlife corridors, Frederick County can mitigate the impacts of increased temperatures from climate change and the loss of biodiversity, contributing both to local resilience and to that of the entire Appalachian corridor. However, plans for green infrastructure must be in place before more land use decisions are made.

The natural world is our life support system. Protecting it and ensuring its continued function is our best chance of ensuring economic, public and environmental health in an uncertain future.

Biodiversity Loss and Climate Change

Biodiversity enables the functioning of ecosystems — the functions of the natural world that enable life to exist (Kellert & Wilson, 1993). This includes converting atmospheric carbon dioxide into the oxygen we breathe and cleaning the water we drink. Intact ecosystems with healthy forests, meadows, wetlands, and biologically active soils support and are supported by the species that live within them. However, more than 70% of the Earth's land surface has been altered by human expansion and this encroachment into the natural world has resulted in the loss of species and their habitats (Ehrlich et al… 2021). The International Union for Conservation of Nature estimates that some 20% of all species are in danger of extinction over the next few decades (Bradshaw, 2021), which greatly exceeds the background (or normal) rate (Neilson, 2005)— roughly one species per million, or .0001% per year (Wilson, 2016, 54).

Population growth in urbanized areas will impact future accessibility to, and cause overall loss of natural spaces (Seymour, 2016). According to the 2020 census, Frederick County population was 264,780. A conservative projected population increase rate of 1% per year, assuming a business-as-usual scenario, would lead to growth of approximately 100,000 to over 363,000 in 2050. This does not consider human migration away from Maryland's more than 3,000 miles of shoreline due to sea level rise and/or coastal damage from extreme storms. It is worth noting that between July 2020 and July 2021, Frederick was the fastest growing county in the state of Maryland, with population increasing by 2.6%. Increased demand for housing in Frederick County places pressure on local governments to accommodate development, most often done by expanding into farmland or natural areas. Rural residential development and urban fringe development affect biodiversity patterns by reducing native species richness and survival, and increasing the presence of exotic (non-native) species (Hansen, 2005).

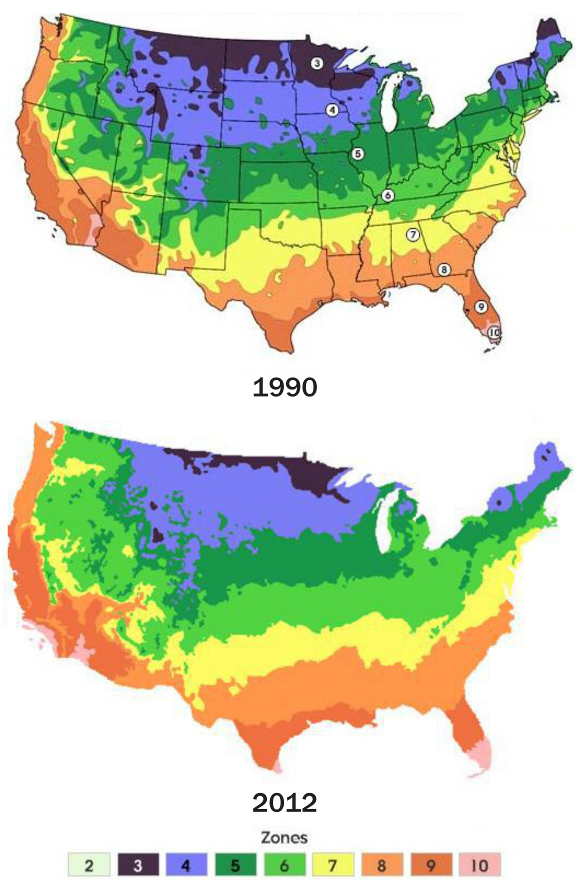


FIGURE 1

USDA Plant Hardiness Zones based on average annual minimum temperatures. Source: USDA

Temperature shifts resulting from global warming between 1990 and 2012 are shown in the two United States Department of Agriculture (USDA) Plant hardiness zone maps in figure 1. Each band represents the average minimum annual temperature for that zone, with the southern tip of Florida being the warmest. Plant hardiness zone boundaries are

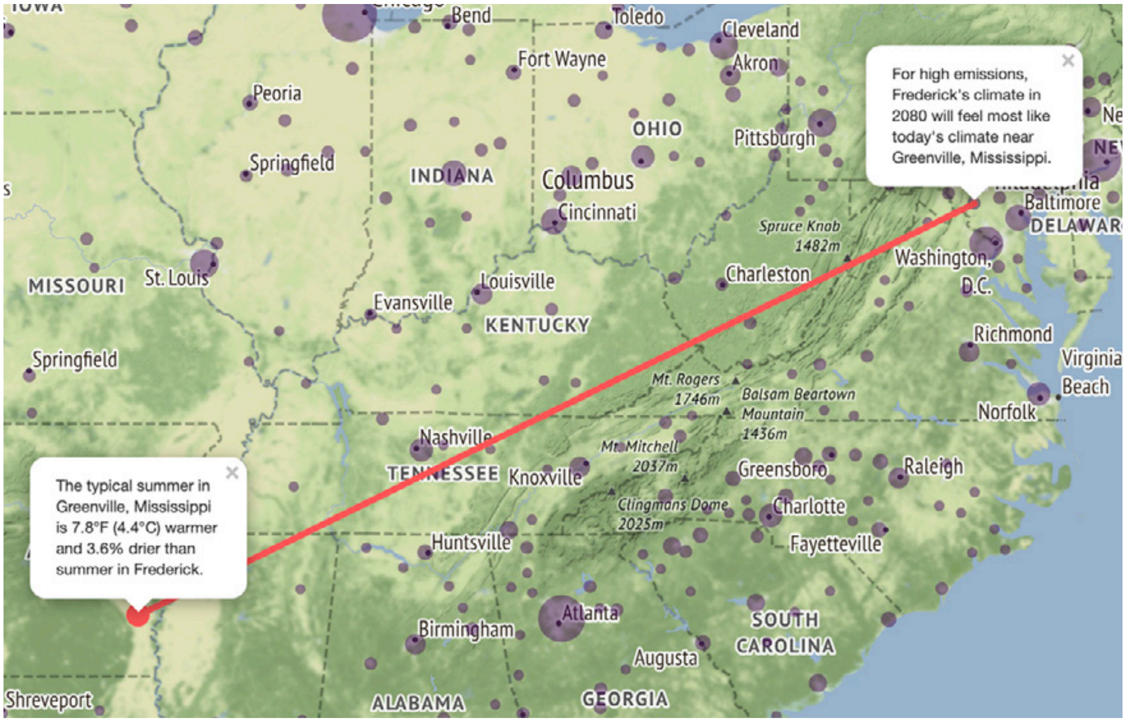


FIGURE 2

Biological displacement under coming climate conditions.
Source: Matt Fitzpatrick, University of Maryland Center for Environmental Science

shifting northward by 13 miles per decade (Jones 2018). Based on research from the University of Maryland Center for Environmental Science, plants and animals now in Greenville, Mississippi will be more adapted to our area by 2080, as shown in figure 2 (Mongilio, 2019).

The Maryland Department of Natural Resources (DNR) Natural Heritage Program collects, manages, analyzes, and distributes spatial data regarding the habitats of the state's rarest plants and animals, high quality and rare natural communities, and other living resources of conservation concern. These data are collected in a five-tiered ranking system called Biodiversity Conservation Network, or Bionet, and include:

- 1,000 rare, threatened or endangered plants and animals; 41 animal and 167 plants in Frederick County, as of November 2021 (DNR);
- 1,500 places where rare, threatened or endangered species live;
- 200 additional animals of greatest conservation need;
- 200 Watch List plants; and
- 27 of 75 ecological communities considered rare in Maryland.

Within Bionet, even those in Tier 5 (the lowest in biological significance) are still important to conserve, both for the species they directly support, as well as for the maintenance of the larger fabric of our natural landscape (DNR, 2016). Figure 3 shows biodiversity in Frederick County ranked by Bionet priority areas for conservation.

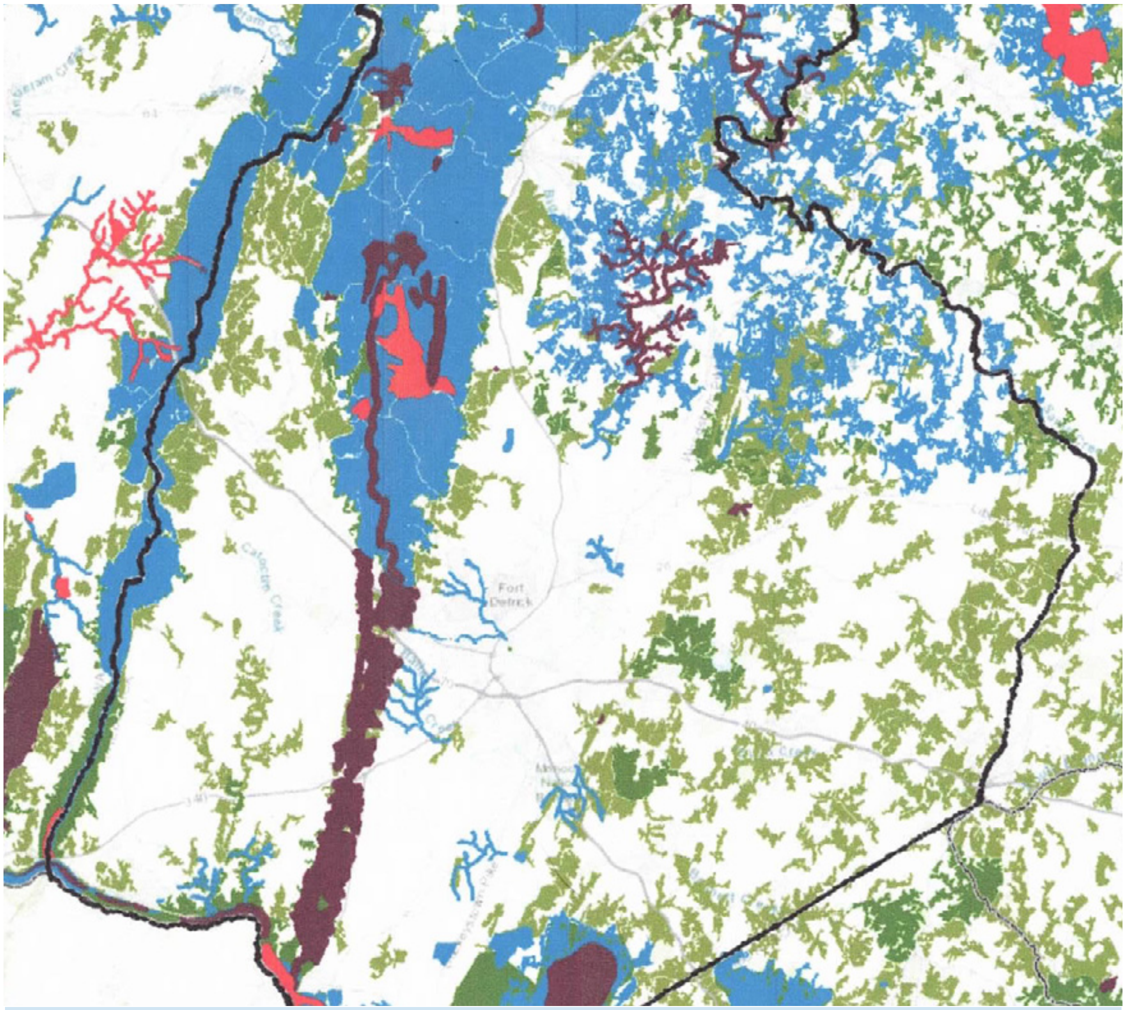


FIGURE 3

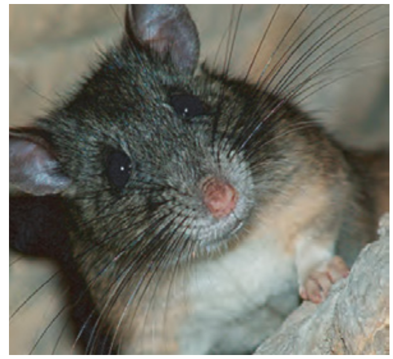
Biodiversity in Frederick County ranked by Bionet priority areas.
Source: Maryland Environmental Resources and Land Information Network

Habitats and Species: Freshwater, Forest Interior, Grassland

Some species require specialized habitats in order to survive. Brook trout, our only native trout, are currently at the limit of suitable habitat in Frederick County. Brook trout require cold, clean freshwater as well as gravels on the bottom for spawning in the autumn. Current populations are trending downward in the Catoctin Mountains, threatened by rising stream temperatures; however, efforts to preserve their habitat could succeed if measures are taken to protect ground water and stream water quality (Hitt, 2021). Livable Frederick, the county's master plan, specifically addresses Brook Trout with an initiative to protect and re-stabilize populations (p. 191). Otherwise, assisted migrations may be required and this once plentiful native fish would be lost.

Other species need the insulating effect of a large forest interior free from human disturbance to breed successfully and maintain viable populations. Identified as Forest Interior Dwelling Species, examples include birds (e.g. owls, wood thrush); turtles (e.g. Eastern box, wood turtle); bats, frogs and salamanders. The Natural Resources Conservation Service (USDA, NRCS, MD) describes forest interior wildlife habitat as:

- Forests of at least 50 acres with 10 or more acres of forest interior habitat;
- Riparian forests of at least 50 acres containing streams; or
- Forests of at least 10 acres containing isolated depressional wetlands of one acre or more that are either too small or too shallow to form lakes or reservoirs.



DAVE KAZYAK

FIGURE 4
Allegheny woodrat, commonly called the pack rat.

Still other species thrive in warm season grassland habitat which existed in large portions of the northeastern area of Frederick County, but has steadily declined, not only locally, but across Maryland. According to the Maryland State Wildlife Action Plan 2015–2025 (SWAP 2-16) grasslands developed as early as 10,000 years ago, when Native Americans introduced human-made fires for hunting and farming. Vegetation adjusted to the occurrence of these periodic ground fires and over time, prospered, attracting associated species. Wild turkeys often nest and rear broods in large fields of dense grasses. Songbirds such as field sparrows, indigo buntings, prairie warblers, eastern meadowlarks, loggerhead shrikes and grasshopper sparrows use warm season grasses for cover while raptors like American kestrels and northern harriers use the areas as hunting grounds. Raptors are often attracted to the cottontail rabbits, voles and field mice that make their homes in the grasses (DNR Habitat for Wildlife). Today, farming practices and utility right-of-way management that favor grassland and shrub-scrub nesting species, such as late mowing, hedgerow establishment, and reduced pesticide use, benefit a number of declining grassland species (SWAP 3-38).

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FIGURE 5
Appalachian Hardwood Forest Interior.

Numerous local species are vulnerable to climate change (SWAP, 6-34), including the Allegheny woodrat (figure 4) and beavers. The endangered and important Allegheny woodrat, commonly called the pack rat, brings organic material into nutrient-poor cave ecosystems, which supports a specialized cave invertebrate (animals without backbones) community. Decreases in beaver populations could exacerbate climate effects, as the presence of beavers has been associated with increased groundwater recharge, higher summer stream flows, and refugia (areas naturally buffered from extreme variation in environmental conditions for cold-adapted species such as some amphibians).

According to the SWAP, freshwater mussels, amphibians, and fish were scored as either extremely or highly vulnerable to climate change, and almost 40% of Maryland's globally rare plants are extremely vulnerable (SWAP, 6–17). The Appalachian Northern Hardwood Forest (figure 5) is critically vulnerable to climate change. See the Appendix for a list of vulnerable trees (NIAC, 2021).

Wildlife Corridors

Wildlife corridors are a land use strategy for increasing biodiversity that expands habitat range and accommodates movement northward or to higher elevations, in response to higher temperatures associated with climate change. A wildlife corridor is an interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife (Benedict & McMahon, p. 1). The terms Conservation Corridors, Migration Corridors, Biodiversity Corridors, Ecological Corridors, Dispersal corridors and Environmental Corridors are also used to refer to wildlife corridors and include the natural habitats of both plants and animals.

Maintaining connected landscapes is a strategy widely cited in the scientific literature for building climate change resilience (Heller & Zavaleta, 2009). Habitat fragmentation isolates species, limiting the available gene pool for reproduction and resulting in weaker, less viable populations. Connecting habitat fragments allows plants and animals greater range and increases the probability that populations can be sustained (Anderson, 2016). For example, an 18-year plant experiment in South Carolina found that habitat connectivity increased annual colonization rates by 5% and decreased annual extinction rates by 2%, when compared with unconnected fragments. Compounded over time, these percentages generated large increases in species richness in fragments connected by corridors (Damschen et al., 2019).

Connecting fragmented habitat along waterways (riparian buffers), which are natural corridors, not only helps wildlife migrate, it helps ensure future clean sources of water. Leaves on vegetation slow the velocity of rainfall and roots aerate the soil, creating a spongy effect that allows absorption into the ground, where the "sponge" filters out impurities, before recharging the water system. Riparian buffers also slow runoff during rain storms, lessening downstream flooding (Rhea, 2022).

Degraded water quality compromises the biodiversity of natural systems. In Frederick County, the Gas House Pike waste water treatment plant was forced to add Enhanced Nutrient Removal equipment at a cost of about $50 million (paid with public funds) to filter out excess nitrogen derived from the land (Borda 2011, Panuska 2019). According to a water quality assessment of the Monocacy River, USGS researchers have identified multiple compounds that may be responsible for 70–100% frequencies of intersex (male and female sex tissue in the same fish) in Monocacy River smallmouth bass populations, potentially reducing the ability to reproduce and resist disease (Sellner & Ferrier, 2020).

The Nature Conservancy's Migrations in Motion map (figure 6) shows the average direction mammals, birds, and amphibians need to move to track hospitable climates as they shift northward in the continental United States. It also shows the Appalachian Mountains as the most heavily travelled corridor. As Frederick County is a gateway to the Appalachians, connecting fragmented habitat that facilitates species movement toward and along the Appalachians ensures continued biodiversity in the changing natural systems on which survival depends.

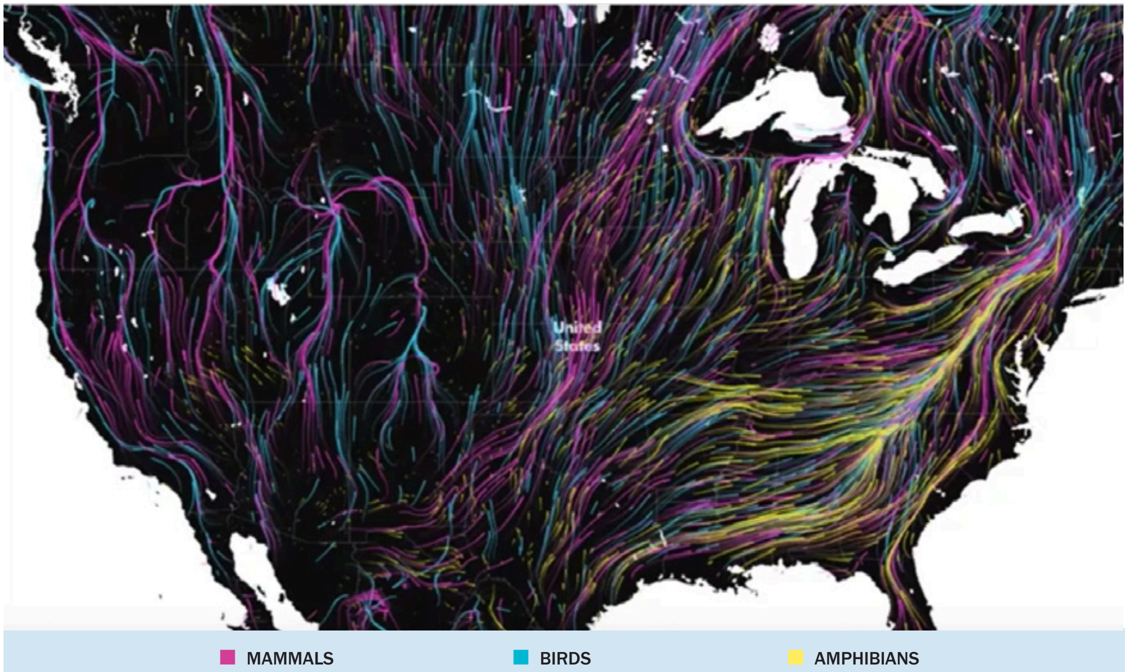


FIGURE 6
Average direction mammals, birds and amphibians need to move to track hospitable habitats as they shift northward. Source: The Nature Conservancy, Migrations in Motion, Web. https://maps.tnc.org/migrations-in-motion/#4/19.00/-78.00

Wildlife Corridor Characteristics and Features

Wildlife corridors (figure 7) are networks of hubs connected by habitat corridors, plus transition zones or buffers (Weber 2003, 50–51). Dimensions play an important role in determining what species occur within a corridor and the potential speed with which species pass through the corridor (Hilty et al, 136). In general the size of hubs and distance from each other influence the dimensions of corridors— the longer the corridor, the wider it needs to be. However, wider, shorter corridors are more likely to provide connectivity. One study estimates that habitat patches of 12.4 to 124 acres would need corridors of no longer than .25 to .65 miles and at least 66 to 164 ft. wide to maintain connectivity (Hilty et al, 136–141). Further, plants have different movement requirements than animals. For example, wind direction can affect seed and pollen transfer.

The 2003 Maryland Green Infrastructure Assessment (MGIA) defined hubs as large ecological patches vital to retaining biological diversity and containing one or more of the following:

- sensitive plant or animal species;
- large blocks of contiguous interior forest of least 250 acres, plus a 300 ft. transition zone;
- wetland complexes with at least 250 acres of unmodified wetlands
- streams or rivers and their associated riparian forests and wetlands, with:
  - aquatic species of concern
  - representative populations of the full suite of native fish, amphibians, and reptiles

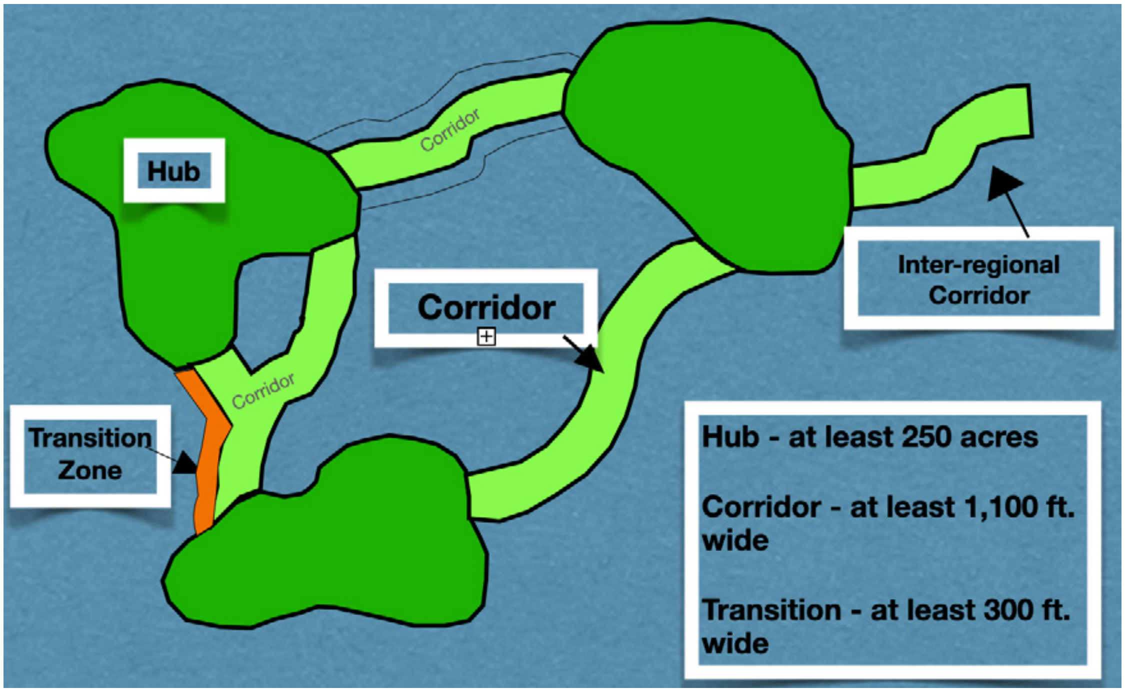


FIGURE 7

Hubs, corridors and transition zones.
Source: Maryland Green Infrastructure Assessment (2003)

- rare cold-water or blackwater (low-gradient, slow flowing streams fed by water seeping through sandy soils that underlie floodplains and swamps) ecosystems, or
- anadromous (migrating upstream to spawn) fish
- conservation areas already protected by public and private organizations.

Corridors of at least 1,100 ft. in width represented "least cost pathways" to link hubs together. Transition zones were characterized as buffers to mitigate the effects of noise, light pollution, domestic animal intrusion, and other sources of disturbance that could intrude along hub/corridor edges and affect the ecological processes in the core area (Weber, 23,85).

In 2010, hubs were re-mapped using newer Landsat data; corridors were not re-mapped. In this update, the size of forest hubs was defined as greater than 50 acres and containing at least 10 acres of Forest Interior Dwelling Species (FIDS) habitat— a reduction from the 250 acre dimension used in the 2003 assessment. This was most likely due to human encroachment into natural areas.

In 2022, the Department of Natural Resources partnered with the Chesapeake Conservancy to remap Maryland's green infrastructure network using the Conservancy's new Land Use/Land Cover dataset based on aerial imagery collected in 2018/2019. This dataset enables image resolution down to 1-meter. For this update, the size of forest hubs remains the same as in 2010; however, wetland hubs are defined as areas of contiguous wetland of at least 50 acres, again a reduction from the 2003 assessment. Major new data enhancements, however, facilitate restoration and decision making:

- Hub and corridor information is retained to distinguish between hub type: forest, wetland, and aquatic, as well as corridor type: forest and aquatic.
- Corridors are further broken down to distinguish between existing forest/wetland/aquatic habitat,

restorable gaps (plantable areas) and non-restorable gaps (impervious surfaces).

- Added data layers include the mapping of all forests across the state, an updated FIDS map, and a mapping of the Cell Ecological Value, which scores land area across the state based on a number of datasets, e.g. habitat conditions, biological data, habitat connectivity, patch size.

MARYLAND STATE HIGHWAY ADMINISTRATION

FIGURE 8

Intercounty Connector “bottomless arch” wildlife passage.

Elements that address barriers, such as bridges-over and passages-under roads and highways are becoming common worldwide, facilitating connectivity and greatly reducing vehicle collisions with animals. For example, a wildlife passage project for Maryland’s Inter-county Connector (connecting Montgomery and Prince Georges Counties) includes “bottomless arches” (figure 8) that span streams and natural passages. Right-of-way fencing directs wildlife to these crossings and limits their access to the roadway. Post-construction monitoring of the bottomless arches indicates that efforts to support fish populations and passage have been successful. Heavy use by deer, raccoons, opossums, squirrels, turtles, and foxes has been documented (USDOT 2012).

In Banff National Park (Alberta, Canada), there are currently 41 wildlife crossing structures (6 overpasses and 35 underpasses) that help wildlife safely cross the busy Trans–Canada Highway (figure 9). Since monitoring began in 1996, 11 species of large mammals, including bear, elk and cougar, have used crossing structures more than 200,000 times. The Netherlands was one of the first countries to deploy a network of wildlife crossings across the landscape. There are wildlife bridges

ROSS MACDONALD/BANFF NATIONAL PARK

FIGURE 9

A wildlife overpass in Banff national park, in the Canadian Rockies.

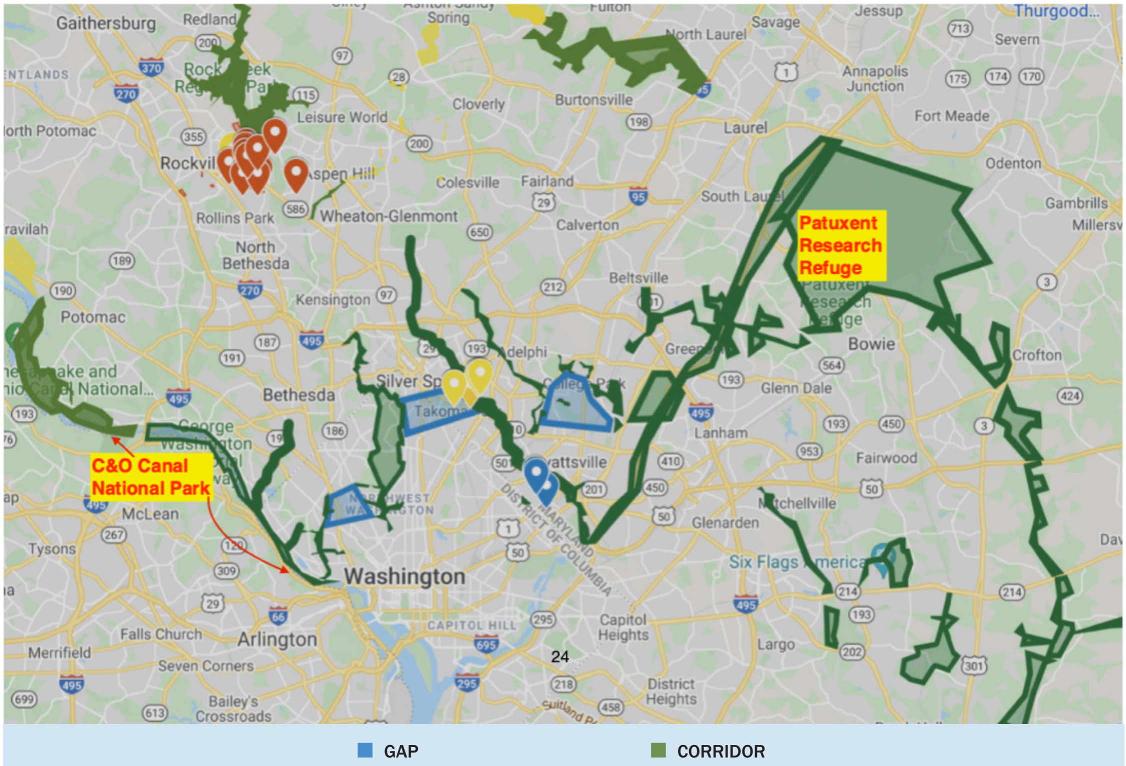


FIGURE 10

Maryland Sierra Club Natural Places Committee wildlife corridor map. Source: Sierra Club Maryland Wildlife Network, Maryland Wildlife Corridors (Accessed 9.20.22) https://marylandcorridors.wordpress.com/

in Germany, France, and Australia (World Geography). Endangered mountain lions in California benefit from highway overpasses that connect fragmented habitat and significantly reduce vehicle collisions. The recently begun Wallis Annenberg Wildlife Crossing over the Route 101 freeway on the western side of Los Angeles County will allow mountain lions to easily cross eight lanes of traffic, substantially expanding their habitat and reducing genetic diversity problems related to inbreeding.

The Sierra Club Maryland Natural Places Committee is mapping a wildlife corridor across the State. This group's vision is based on the work of wildlife ecologist and entomologist Doug Tallamy, a University of Delaware professor who advocates for a "Home Grown National Park," where private land owners connect vegetated areas on their properties to create wildlife corridors (Roth, 2020). The Committee is designing and developing a native wildlife network driven by volunteers and residents of Maryland. The movement started in the city of Mount Rainier, in Prince Georges County, as an idea from Council member Luke Chesek to create the Mount Rainier Native Plant Network — an effort to educate and incentivize residents on the importance of planting native.

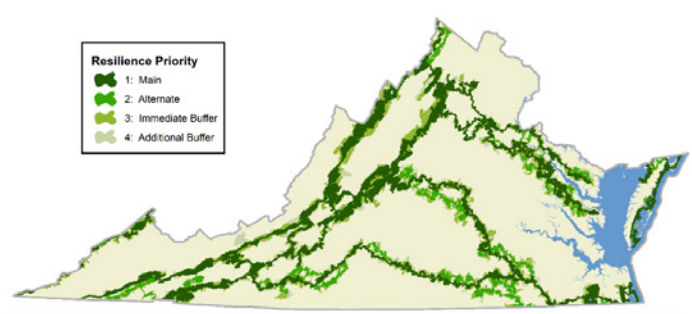


FIGURE 11

Virginia Wildlife Biodiversity Corridors. Source: Virginia Wildlife Action Plan

The idea is expanding into other Maryland counties, with the goal of eventually connecting to other corridors in surrounding states. Figure 10 shows a corridor from the Patuxent Research Refuge to the C&O Canal.

In 2020, Virginia passed legislation (HB 1695, SB 1004)) to create a Wildlife Corridor Action Plan (figure 11). Motivated to reduce vehicle-animal collisions, the legislation required Virginia's Departments of Transportation, Conservation and Recreation; and Game and Inland Fisheries to collaborate on a plan to be delivered in September 2022 and every four years thereafter (Moomaw, 2020). March 2023 saw the delivery of that plan.

In 2021, the Florida Wildlife Corridor Act passed the State Senate and House unanimously and was signed into law by Governor Ron DeSantis. The act formally recognizes the existence of the corridor (figure 12) and earmarks $300 million toward conservation easements from private landowners.

Anne Arundel County finalized a Green Infrastructure Master Plan in April, 2022. It includes the largest natural areas in the County and connections between them, as well as conserved agricultural lands, cultural and historic resources, and trails. The network does not include all natural lands in the County or even all of the parks. Only lands that meet the size and connectivity criteria are included. The criteria prioritize areas that best inform how to apply limited land conservation resources. See figure 13.

FIGURE 12

Source: Florida Wildlife Corridor.org

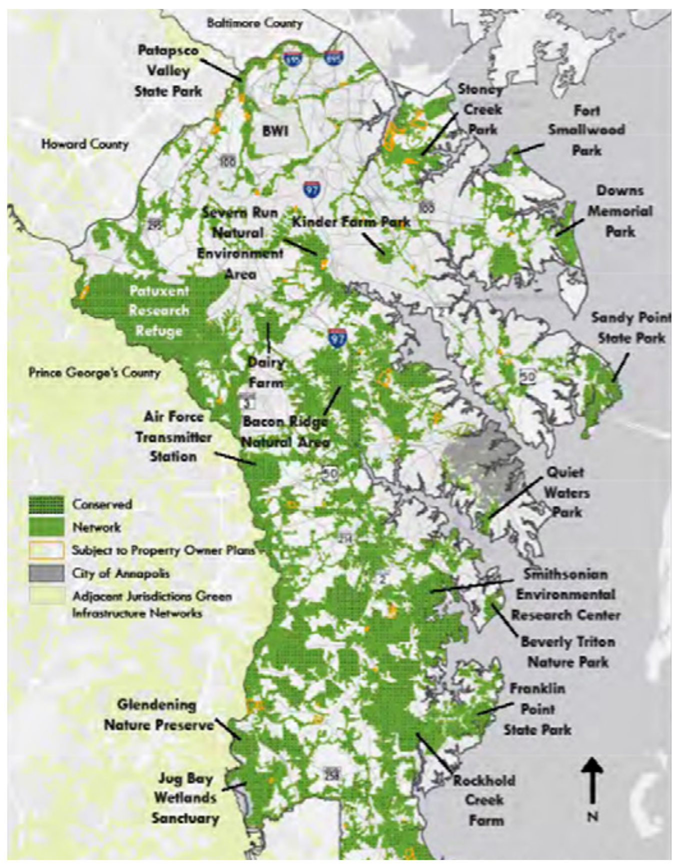


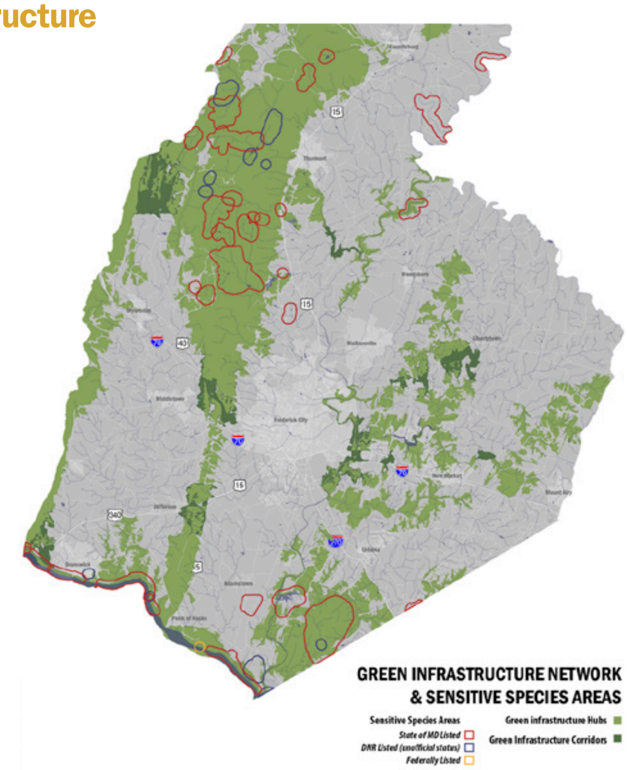
FIGURE 13

Anne Arundel County Green Infrastructure Plan map.
Source: aacounty.org

Wildlife Corridors in Green Infrastructure

Green infrastructure (GI) is defined as an "interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife. It is the ecological framework for environmental, social, and economic health— in short, our natural life support system" (Benedict & McMahon, p. 1). Figure 14 shows two maps from the Livable Frederick Master Plan (Frederick County, 2019). There are obvious corridors along the Catoctin Mountain and South Mountain ranges, as well as vegetated floodplains along waterways such as the Monocacy River. The Monocacy River flows under bridges on both Route 40 and I-70, avoiding those barriers to movement. The C&O Canal National Historic Park is a dramatic corridor along the Potomac River, with tributaries such as Catoctin Creek leading from the river to the Catoctin and South Mountain ranges.

The Livable Frederick Master Plan highlights the ongoing fragmentation of our natural resource areas, specifically stating that in the future it is important "… to direct urban/suburban growth away from GI and sensitive areas, and to ensure the protection and integration of GI where it exists within areas targeted for growth" (p.48). To accomplish this, the county will pursue the "…development of a Livable Frederick GI Sector Plan" (p. 48), re-stating a similar commitment from the County in 2010 (Frederick County, 2010).



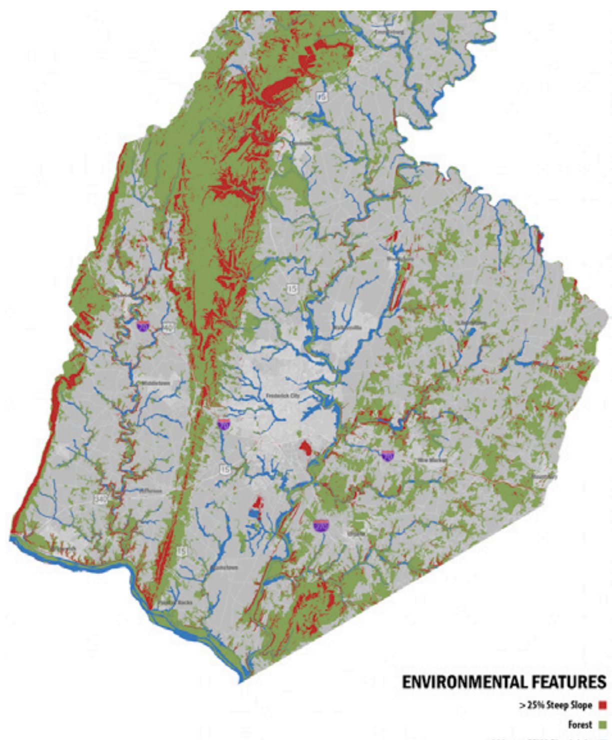


FIGURE 14
Green infrastructure, sensitive species and environmental features maps. Source: Livable Frederick Master Plan (2019)

Livable Frederick includes initiatives consistent with protecting biodiversity and accommodating wildlife movement, such as: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- Including a comprehensive review of natural resources during the creation of community and corridor plans and during the development review process (p. 189);
- Respecting the stewardship of natural resources in the provision of water and sewer infrastructure (p. 101);
- Evaluating infrastructure projects in terms of their capacity to facilitate wildlife survival by preserving contiguous habitats and connecting habitats that are fragmented (p. 104);
- Studying methods to mitigate the conflict between wildlife and motorists by examining the concentration of wildlife crash incidents along county and state roads…(p. 100);
- Advocating for wildlife and pedestrian connections over roads, e.g. I–270 (p. 189); and
- Creating options and incentives that encourage voluntary landowner participation in the establishment of greenways and trails (p. 101).

Green Infrastructure Mapping in Maryland

Maryland's Environmental Resources and Land Information Network (MERLIN Online) is a web map created and actively managed by the Department of Natural Resources (DNR). It is a central, state run repository for Geographic Information Systems (GIS) data collected from all state run agencies and is publicly accessible. In figure 15, a Frederick County green infrastructure map shows

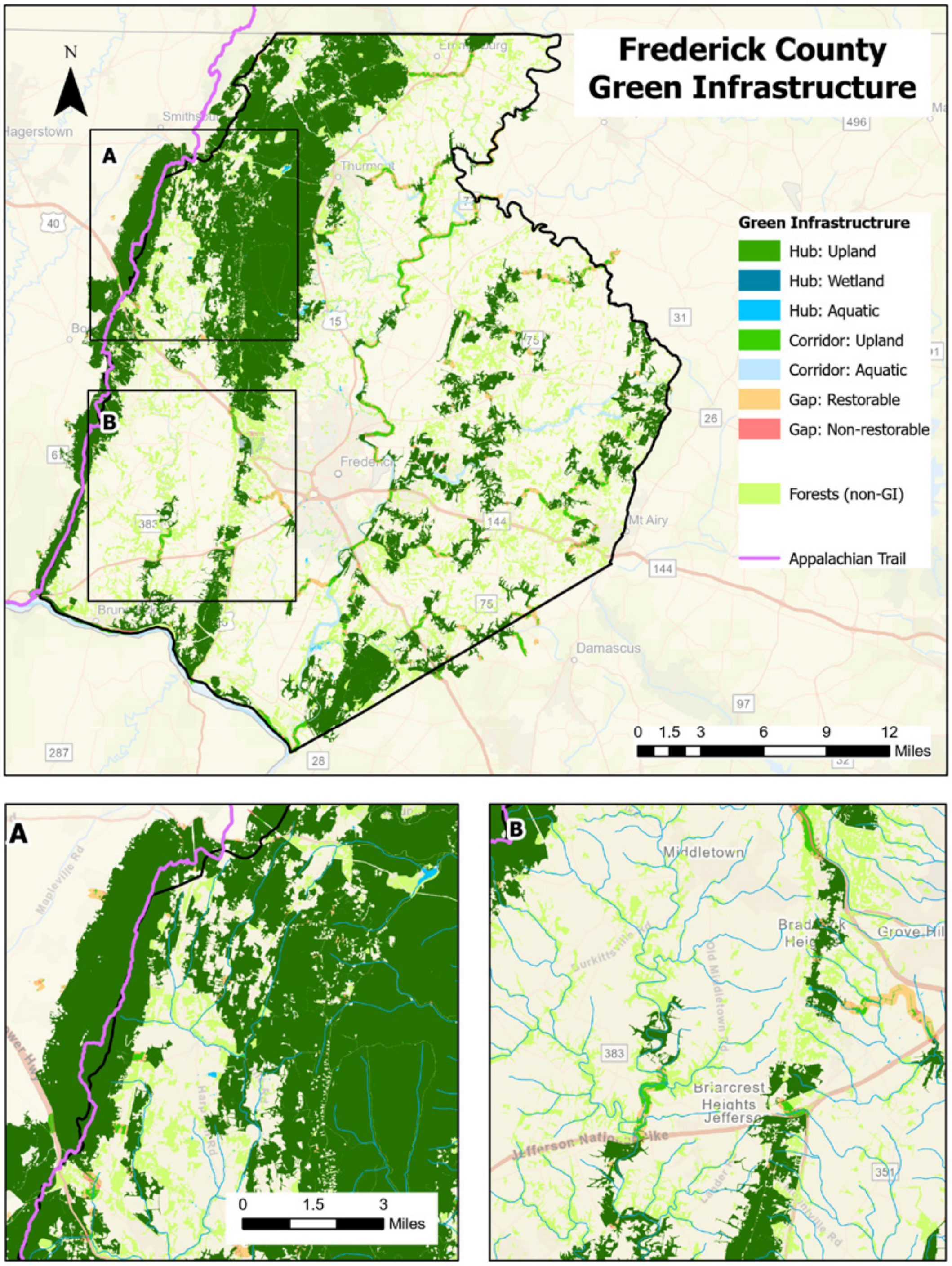

FIGURE 15

Green infrastructure map example for Frederick County. Source: Maryland Department of Natural Resources examples of forest, wetland and aquatic habitat hubs, connecting corridors, and gaps in those corridors that make them unusable, without restoration.

The Appalachian Trail is shown in the map as a purple line running along the western boarder of the county. Two vertical strips of forest can be seen running north to south, both of which are part of the Appalachian Range. The most western strip containing the Appalachian Trail is the South Mountain range, which connects to the C&O Canal National Historical Park along the Potomac River. It includes Greenbriar and South Mountain State Parks. The second strip is the Catoctin Mountain range comprised of a large patchwork of hub and other forest areas that include Gambrill State Park, The Frederick Municipal Forest, Cunningham Falls State Park, and Catoctin Mountain National Park.

Map inset A zooms in on the north western portion of the County, where a patchwork of forest hubs and other forest areas could provide a possible connection between the areas of South Mountain State Park and Cunningham Falls State Park. Map inset B shows a narrow network of hub and other forest areas, including Gambrill State Park and Catoctin Creek, that could provide connection to the C&O Canal National Park/Potomac River area. Together, these maps begin to allow for identification of existing important green infrastructure and other forest features, as well as for the identification of areas where connectivity is currently lacking.

In addition to updated mapping of Maryland's existing GI network, the MD DNR has developed a number of additional conservation and restoration targeting and prioritization geospatial datasets, which allow for identification of conservation and restoration opportunity areas, as well as for analysis of the relative value of ecological and climate resiliency co-benefits that might be realized through project implementation. Together, this suite of data could be used to support the development of a comprehensive GI plan for Frederick County, as well as to strategically guide the development of individual conservation and restoration projects across the county.

According to the DNR Digital Data and Products webpage (DNR, 2022), nearly 10,000 distinct locations of rare species, in Maryland, have been documented over the last 30 years. Protecting as many species as possible, particularly those that are rare, threatened or endangered is important. This data layer can be overlain onto hub/corridor information and factored into hub/corridor identification.

The Appalachian Landscape Climate Advisory Group

The Appalachian Trail runs through both Frederick and Washington counties along the South Mountain range. In 2021, an Appalachian Landscape Climate Advisory Group (CAG) was formed to envision the future of this globally significant landscape through stakeholder conversations, resulting in a report entitled Conserving an Intact and Enduring Appalachian Landscape: Designing a Corridor in Response to Climate Change. Efforts are underway to address biodiversity loss and climate change by improving connectivity at continental scale (figure 16, CAG, 20).

The report identifies two goals. The first, "ecological integrity" gauges the "wholeness" of landscapes, or ecosystems, and indicates how an ecosystem will face stressors. According to the report, achieving the goal requires sustaining and improving terrestrial and aquatic connectivity and conserving a climate change refugia network. Climate change refugia are "homes" for species that remain relatively buffered, even when areas around them get warmer. For example, protecting groundwater in Brook Trout habitat can maintain cold stream temperatures and allow the species to remain in Frederick County (Hitt). The second goal, “human connection to nature” acknowledges that climate change will directly and universally affect quality of life. According to the report, achieving this goal involves engaging communities in understanding how local ecosystems affect well-being, economic prosperity, quality of life, and traditional culture. It also involves understanding the spectrum of involvement and relationships that communities have with the landscape and co-creating solutions that build stronger relationships and engagement.

Locally, the Catoctin Land Trust convenes the Heart of Maryland Conservation Alliance. The Alliance’s Stewardship Work Group collaborates on biodiversity, climate change resilience, and re-forestation. The work group’s vision is a landscape connected via hubs and corridors centered on South Mountain. Participants in the work group include the Maryland Forestry Service, the Frederick Department of Climate and Energy, the Climate Change Working Group of Frederick County, the Sierra Club Catoctin Group, Stream-Link Education, Frederick Green, and others.

FIGURE 16

Appalachian Landscape data and image courtesy of The Nature Conservancy.
Source: Appalachian Landscape Climate Advisory Group (July 2022)

Human Life, Health and Economic Benefits of Green Infrastructure

Green Infrastructure (GI) that preserves ecosystem values and functions (ecosystem services) supports human life, health, and economies. Ecosystem services include the purification of air and water, the detoxification and decomposition of wastes, and the maintenance of biodiversity (Daily, 1997).

For example, without Earth's diverse plant material, there would be no food from either plant or animal sources and human life would cease. GI supports water quality by filtering out pollutants that fall with the rain and those collected in surface runoff. Trees remove tons of air pollution annually (Coutts & Hahn, 2015), and of course recycle carbon dioxide into oxygen that we breathe.


WIKIMEDIA COMMONS

FIGURE 17
Pokeberry

GI provides protection against floods and hurricanes and a place for outdoor recreation, relaxation, and exercise. Exposure to nature reduces stress, as well as blood pressure, and improves mental clarity and emotional well-being. Hospital patients exposed to natural scenery from a window view after surgery, were shown to experience decreased levels of pain and shorter recovery time. (Seymour, 2016)

Further, "at least half of all prescribed drugs in the US come either directly from natural sources or are derived from natural sources, and 30% of the drugs sold worldwide contain compounds derived from plant material....Without the conservation of GI that supports biodiversity, many bioactive compounds and their potential health benefits could be lost (Coutts & Hahn 2015)." The Frederick County Forest Conservancy Board (2022) notes that chemicals derived from the locally found Pokeberry (figure 17) are used to treat diseases such as AIDS and rheumatoid arthritis.

Frederick County's tourism industry benefits from those who explore the outdoors. Page-views from the Visit Frederick website show a steady increase in people interested in parks and outdoor activities such as biking, from 51,926 in 2018 to 110,374 in 2020. In 2021, a record 21.7 million (Dance, 2022) people visited Maryland State Parks, compared to 21.5 million in 2020 and 14.9 million in 2019 (DNR, 2021). A 2010 Maryland State Parks Economic Impact and Visitor Study (Dougherty, 2011) showed that visitors spent more than $567 million on food and drinks in restaurants or grocery stores and camping supplies during their trips, producing a total economic impact of more than $650 million annually. Calculating for inflation (Saving.org), those figures equate to about $779 million and $893 million respectively, in 2023. The study did not break out parks by county, however, positive economic impacts of park visits were documented.

Recreational fishing is a popular activity in Frederick County. A 2016 survey of Maryland non-tidal anglers estimates that about $2.5 million was spent on approximately 60,000 fishing trips taken in 2015 to the following Frederick County waterbodies: Monocacy River, Fishing Creek, Big Hunting Creek, Owens Creek, and Friends Creek. Frederick County also borders and provides access to a portion of the Potomac River, which is the most frequently fished non-tidal river/stream in the State of Maryland. In 2015, there were an estimated 239,000 fishing trips taken to the Potomac River (from North Branch/South Branch junction to Little Falls), with anglers spending an estimated $23,000,000 on these trips (DNR, 2017).

Conclusion

Frederick County has a responsibility to address climate change and biodiversity loss in the Appalachian corridor. By working on a GI plan that includes wildlife corridors, with the Department of Natural Resources, the Heart of Maryland Conservation Alliance and other interested stakeholders, the County can equitably and sustainably address land use needs for human health, agriculture, population growth and the economy. This model can then be replicated and incorporated on a regional and national level.

Recommended Actions

In light of the significant foresight and planning required to address habitat reduction and fragmentation, the following actions are recommended:

Administrative

- The County Planning Office prepares a functional GI plan that identifies strategies to protect natural resources and enhance biodiversity, including wildlife corridors, before undertaking further Livable Frederick small area plans. This includes:
  - Establishing a Geographic Information System database to identify and monitor protection of wildlife corridor tracts, in cooperation with the Maryland Department of Natural Resources
  - Reviewing administrative structures and operational procedures to facilitate implementation
  - Providing funding information and technical assistance to landowners and nonprofit organizations involved in land conservation/preservation
- The County hires a Natural Resource Manager to provide a strong, science-based voice in all land use planning/decision-making and oversees the implementation of the GI plan.
- The Division of Energy and Environment cooperates with community-based nonprofits and government organizations to identify and secure land conservation project funding.

Community

- Public and non-governmental organizations engage property owners and other community stakeholders in understanding how a GI plan supports social, economic and human health.

Legislative

- Review existing County policies, codes, and ordinances to better protect the natural GI network; recommend legislative changes as necessary.
- Approve, fund and implement the County GI plan; coordinate with the City as needed to connect habitat corridors
- Engage adjoining jurisdictions to broaden this effort across jurisdictional boundaries; work toward a Maryland Wildlife Corridor Act similar to Florida's

Advocacy

- Advocate for a City GI plan
- Advocate for the C&O Canal National Park to be a designated wildlife corridor.
- Press for passage of the Federal Wildlife Corridor Act.
- Pursue national wild and scenic status for the Monocacy River.

Appendix

Climate Change Projections for Individual Tree Species

Piedmont (Subregion 5)

This region's forests will be affected by a changing climate and other stressors during this century. A team of managers and researchers created an assessment that describes the vulnerability of forests in the region (Butler-Leopold et al. 2018). This report includes information on observed and future climate trends, and also summarizes key vulnerabilities for forested natural communities. The Landscape Change Research Group recently updated the Climate Change Tree Atlas, and this handout summarizes that information. Full Tree Atlas results are available online at www.fs.fed.us/nrs/atlas/. Two climate scenarios are presented to "bracket" a range of possible futures. These future climate projections (2070 to 2099) provide information about how individual tree species may respond to a changing climate. Results for "low" and "high" emissions scenarios can be compared on the reverse side of this handout.

The updated Tree Atlas presents additional information helpful to interpret tree species changes:

- Suitable habitat - calculated based on 39 variables that explain where optimum conditions exist for a species, including soils, landforms, and climate variables.
- Adaptability - based on life-history traits that might increase or decrease tolerance of expected changes, such as the ability to withstand different forms of disturbance.
- Capability - a rating of the species' ability to cope or persist with climate change in this region based on suitable habitat change (statistical modeling), adaptability (literature review and expert opinion), and abundance (FIA data). The capability rating is modified by abundance information; ratings are downgraded for rare species and upgraded for abundant species.
- Migration Potential Model - when combined with habitat suitability, an estimate of a species' colonization likelihood for new habitats. This rating can be helpful for assisted migration or focused management (see the table section: "New Habitat with Migration Potential").

Remember that models are just tools, and they're not perfect. Model projections can't account for all factors that influence future species success. If a species is rare or confined to a small area, model results may be less reliable. These factors, and others, could cause a particular species to perform better or worse than a model projects. Human choices will also continue to influence forest distribution, especially for tree species that are projected to increase. Planting programs may assist the movement of future-adapted species, but this will depend on management decisions. Despite these limits, models provide useful information about future expectations. It's perhaps best to think of these projections as indicators of possibility and potential change.

SOURCE: *This handout summarizes the full model results for the Mid-Atlantic region, available at www.fs.fed.us/nrs/atlas/combined/resources/summaries. More information on vulnerability and adaptation in the Mid-Atlantic region can be found at www.forestadaptation.org/mid-atlantic. A full description of the models and variables are provided in Iverson et al. 2019 (www.nrs.fs.fed.us/pubs/57857 and www.nrs.fs.fed.us/pubs/59105) and Peters et al. 2019 (www.nrs.fs.fed.us/pubs/58353).*

CLIMATE CHANGE CAPABILITY

POOR CAPABILITY	
Balsam fir	Pitch pine
Bigtooth aspen	Quaking aspen
Black ash	Red pine
Black cherry	Red spruce
Bur oak	Shingle oak
Eastern cottonwood	Striped maple
Eastern hemlock	Swamp white oak
Eastern white pine	Sweet birch
Jack pine	Tamarack (native)
Northern pin oak	White ash
Paper birch	White spruce
Pin oak	Yellow birch
FAIR CAPABILITY	
American basswood	Shagbark hickory
Flowering dogwood	Silver maple
Hackberry	Sycamore
Osage-orange	Virginia pine
GOOD CAPABILITY	
American beech	Loblolly pine
American elm	Mockernut hickory
American holly	Northern red oak
Bitternut hickory	Pignut hickory
Black locust	Post oak
Black oak	Red maple
Black walnut	Sassafras
Blackgum	Scarlet oak
Boxelder	Southern red oak
Chestnut oak	Sugar maple
Chinkapin oak	Sweetbay
Eastern hophornbeam	Sweetgum
Eastern redcedar	White oak
Green ash	Yellow-poplar
NEW HABITAT WITH MIGRATION POTENTIAL	
Atlantic white-cedar	Shortleaf pine
Bald cypress	Sourwood
Blackjack oak	Swamp tupelo
Cherrybark oak	Water oak
Laurel oak	Water tupelo
Pond pine	Winged elm

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Climate Change Projections for Individual Tree Species

Piedmont (Subregion 5)

ADAPTABILITY: Life-history factors, such as the ability to respond favorably to disturbance, that are not included in the Tree Atlas model and may make a species more or less able to adapt to future stressors.

- \+ HIGH *Species may perform better than modeled*
- • MEDIUM
- – LOW *Species may perform worse than modeled*

HABITAT CHANGE: Projected change in suitable habitat between current and potential future conditions.

- ▲ INCREASE *Projected increase of >20% by 2100*
- ● NO CHANGE *Projected change of <20% by 2100*
- ▼ DECREASE *Projected decrease of >20% by 2100*
- ★ NEW HABITAT *Tree Atlas projects new habitat for species not currently present*

ABUNDANCE: Based on Forest Inventory Analysis (FIA) summed Importance Value data, calibrated to a standard geographic area.

- \+ ABUNDANT
- • COMMON
- – RARE

CAPABILITY: An overall rating that describes a species' ability to cope or persist with climate change based on suitable habitat change class (statistical modeling), adaptability (literature review and expert opinion), and abundance within this region.

- △ GOOD *Increasing suitable habitat, medium or high adaptability, and common or abundant*
- ○ FAIR *Mixed combinations, such as a rare species with increasing suitable habitat and medium adaptability*
- ▽ POOR *Decreasing suitable habitat, medium or low adaptability, and uncommon or rare*

			LOW CLIMATE CHANGE (RCP 4.5)		HIGH CLIMATE CHANGE (RCP 8.5)	
SPECIES	ADAPT	ABUN	HABITAT CHANGE	CAPABILITY	HABITAT CHANGE	CAPABILITY
American beech	•	•	▲	△	▲	△
American basswood	•	–	▲	○	▲	○
American elm	•	•	●	○	▲	△
American holly	•	–	▲	△	▲	△
Atlantic white-cedar*	–		★		★	
Bald cypress	•		★		★	
Balsam fir	–	–	▼	▽	▼	▽
Bigtooth aspen	•	–	▼	▽	▼	▽
Bitternut hickory*	+	•	▲	△	▲	△
Black ash	–	–	▼	▽	▼	▽
Black cherry	–	•	●	▽	●	▽
Black locust*	•	•	▲	△	▲	△
Black oak	•	•	▲	△	▲	△
Black walnut*	•	•	▲	△	▲	△
Blackgum	+	•	▲	△	▲	△
Blackjack oak	+		★		★	
Boxelder*	+	•	●	△	▲	△
Bur oak	+	–	▼	▽	▼	▽
Cherrybark oak	•		★		★	
Chestnut oak	+	•	●	△	●	△
Chinkapin oak	•	–	▲	△	▲	△
Eastern cottonwood*	•	–	▼	▽	●	▽
Eastern hemlock	–	•	▼	▽	▼	▽
Eastern hophornbeam*	+	•	▲	△	▲	△
Eastern redcedar	•	•	▲	△	▲	△
Eastern white pine	–	•	▼	▽	▼	▽
Flowering dogwood	•	–	▲	○	▲	○
Green ash*	•	•	▲	△	▲	△
Hackberry	+	–	●	○	●	○
Jack pine	+	–	▼	▽	▼	▽
Laurel oak	•		★		★	
Loblolly pine	•	–	▲	△	▲	△
Mockernut hickory	+	•	▲	△	▲	△
Northern pin oak	+	–	▼	▽	▼	▽
Northern red oak	+	•	●	△	●	△
Osage-orange	+	–	▼	▽	●	○
Paper birch	•	–	▼	▽	▼	▽
Pignut hickory	•	•	▲	△	▲	△
Pin oak*	–	•	●	▽	●	▽
Pitch pine	•	•	▼	▽	▼	▽
Pond pine	–		★		★	
Post oak	+	–	▲	△	▲	△
Quaking aspen	•	–	●	▽	▼	▽
Red maple	+	+	●	△	▼	△
Red pine	–	–	▼	▽	▼	▽
Red spruce	–	–	▼	▽	▼	▽
Sassafras*	•	•	▲	△	▲	△
Scarlet oak	•	•	▲	△	▲	△
Shagbark hickory	•	•	●	○	●	○
Shingle oak	•	–	▼	▽	▼	▽
Shortleaf pine	•		★		★	
Silver maple*	+	–	●	○	●	○
Sourwood	+		★		★	
Southern red oak	+	–	▲	△	▲	△
Striped maple	•	–	▼	▽	▼	▽
Sugar maple	+	•	●	△	●	△
Swamp tupelo	–		★		★	
Swamp white oak*	•	•	▼	▽	▼	▽
Sweet birch	–	•	▼	▽	▼	▽
Sweetbay	•	–	▲	△	▲	△
Sweetgum	•	–	▲	△	▲	△
Sycamore*	•	–	▲	○	▲	○
Tamarack (native)	–	–	▼	▽	▼	▽
Virginia pine	•	–	●	▽	▲	○
Water oak	•		★		★	
Water tupelo	–		★		★	
White ash	–	•	●	▽	▼	▽
White oak	+	•	▲	△	▲	△
White spruce	•	–	▼	▽	▼	▽
Winged elm	•		★		★	
Yellow birch	•	–	●	▽	●	▽
Yellow-poplar	+	•	●	△	●	△

**Species with low model reliability based on five statistical metrics of the habitat models that affect change class. See maps and tables for more information (www.fs.fed.us/nrs/atlas/combined/resources/summaries).*

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