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The
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for the Environment
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Biodiversity

sustain

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The Kentucky Institute for the Environment and Sustainable Development (KIESD) was created in July 1992 within the Office of the Vice President for Research, University of Louisville.

The Institute provides a forum to conduct interdisciplinary research, applied scholarly analysis, public service and educational outreach on environmental and sustainable development issues at the local, state, national and international levels.

KIESD is comprised of eight thematic program centers: Environmental Education, Environmental Science, Land Use and Environmental Responsibility, Sustainable Urban Neighborhoods, Pollution Prevention, Environmental and Occupational Health Sciences, Environmental Policy and Management, and Environmental Engineering.

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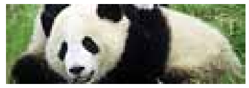

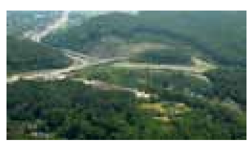

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Cover Photo by Michael Butler, Trent University

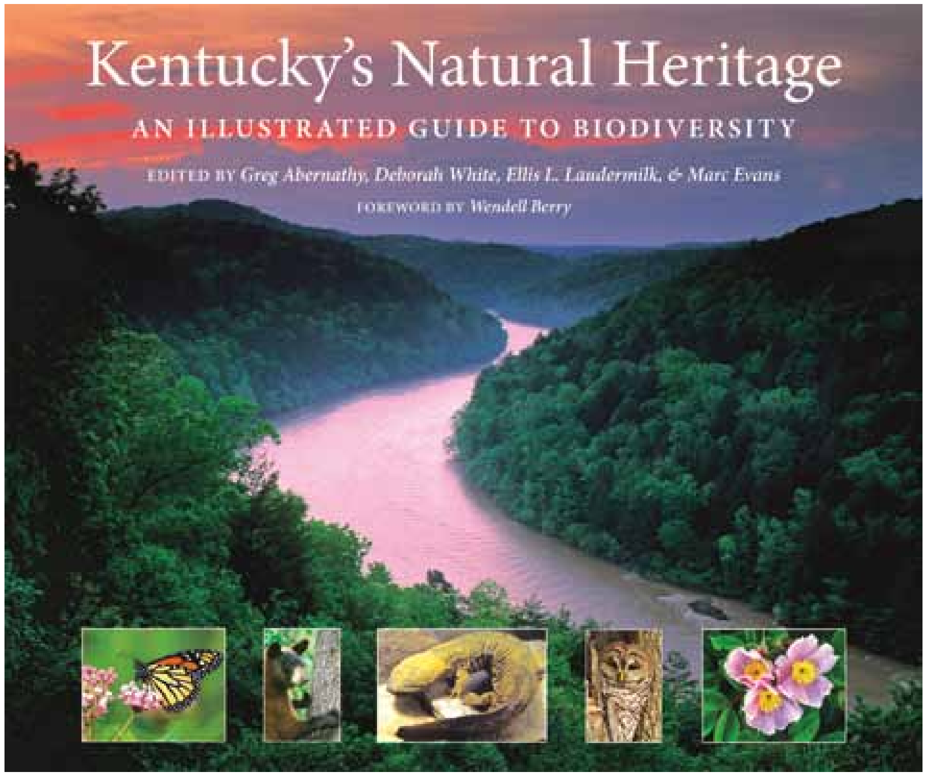
Black-throated Green Warbler

The hemlock wooly adelgid is a tiny invasive insect that feeds on the needles of carolina hemlocks and eastern hemlocks. They feed on the sap in hemlock needles and typically cause an infested tree to die within two to 12 years. In 2006 the adelgid was first documented in eastern Kentucky. The loss of eastern hemlock trees will likely jeopardize the black-throated green warbler too. In Kentucky, breeding pairs use large hemlocks to raise their young, often building nests high in trees that are 60 to 80 feet tall.

Kentucky's Biodiversity Conservation: Natural Heritage Methodology

The following is a modified excerpt from *Kentucky's Natural Heritage: An Illustrated Guide to Biodiversity*. University Press of Kentucky, Lexington, Kentucky, USA.

Abernathy, G., D. White, E. L. Laudermilk, and M. Evans, editors.



Biodiversity

Biodiversity is the variety of all living things and their roles and connections within ecosystems. Simply put, it is the web of life. All species fulfill a specific role or task, called a niche, in an ecosystem, and other species depend on this role. Remove one species and it may affect the entire natural community or ecosystem. Remove too many species and the community and ecosystem may be irretrievably changed or damaged. Ultimately, biodiversity is part of the earth's life-support system.

There are basically three levels of biodiversity: genetic, species, and ecosystem. The genetic makeup of each individual plant or animal contributes to the health of a population and the ability of that population to withstand the stress of life on Earth. These challenges may be as short-term as an exceptionally cold winter or as lasting as a decade-long drought. Species, the next level of biodiversity, are interconnected through their roles in each natural community. Building on this elaborate web of life is the third level, ecosystems, the connections among natural communities across the landscape.

Estimates of the number of species living on Earth range from 3 to 30 million or more; however, the commonly accepted estimate is 10 to 15 million.[1-4] More than 200,000 species are known from the United States alone, but the real number may be twice that many.[5] Many groups of species are not well-known, and new species previously undescribed by scientists are still found each year. Like the rest of the planet, the exact number of species in Kentucky is unknown, though a reasonable estimate is that there are 19,400 species in the state (see Figure 1). This estimate does not include very poorly known groups such as worms, fungi, lichens, bacteria, and other microorganisms.

Kentucky's Place in the World

Several animal groups in the state are remarkably diverse. Salamanders, aquatic organisms, and cave-dwelling species attain some of their highest levels of diversity in the nation right here in Kentucky, primarily for two reasons. First, Kentucky is located in the southeastern United States, a global center of distribution for salamanders and a very rich area for various groups of aquatic organisms (e.g., fishes, mussels, crayfishes). Second, the combination of the state's climate and its extensive limestone geology created ideal conditions for cave formation and subsequent habitat for cave-dwelling species to evolve.

In fact, Kentucky is so rich in species that it ranks in the top five nationally for several groups. Below are some of the highlights of the state's rankings and overall contributions to national and global biodiversity.

- Kentucky's diverse aquatic fauna is of global and national significance. The state has more native fish species than all other states except Tennessee and Alabama, with approximately 30% of the North American total. It ranks fourth in the nation in native freshwater mussel species, with approximately 35% of the North American total, and fifth in the nation in number of crayfish (crawdad) species, with about 10% of the world's total.[6] The Green River watershed is nationally recognized as among the most ecologically significant rivers in the United States.[7]
- Kentucky ranks approximately fifth in the nation in total number of obligate cave-dwelling species, which are ecologically adapted to live in caves and their underground streams or groundwater.[8]

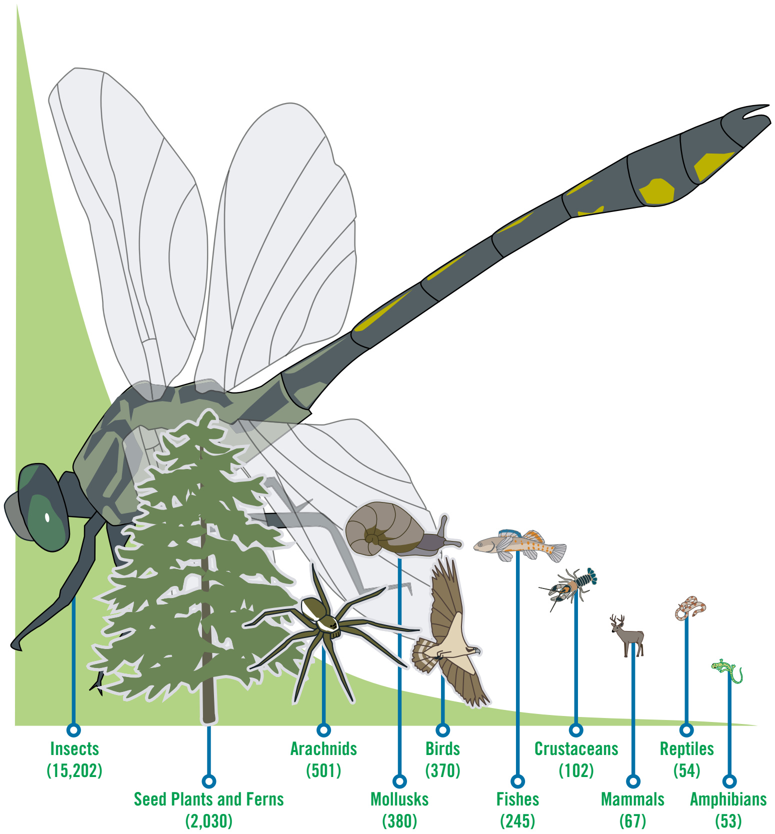
Figure 1

Number of Species by Select Groups

Group name	World	North America	Kentucky (native)
Fungi Kingdom			
• True fungi	56,200	34,000 †	Unknown
• Lichens	13,500	3,800 †	Unknown
Fungi subtotal	69,700	37,800	Unknown
Plant Kingdom			
• Mosses	10,000	1,400 †	317
• Liverworts	6,000	700 †	114
• Hornworts	100	11 †	3
• Seed plants and ferns	247,786	15,990 †	2,030
Plant subtotal	263,886	18,101	2,464
Animal Kingdom			
• Mollusks	28,918 △	2,179 △	380 *△
○ Freshwater snails	4,000	679	67 *
○ Land snails and slugs	24,000	1,005	210 *
○ Freshwater mussels	918	300	103
• Arachnids	41,141 △	3,890 △	501 *△
○ Spiders	39,882	3,807	500 *
○ Scorpions	1,259	83	1
• Crustaceans	45,000 △	9,675 †△	102 *△
○ Crayfishes	530	363	54
○ Other crustaceans	44,470	9,312	48 *
• Insects	900,000 △	87,107 △	15,202 *△
○ Mayflies	3,000	670	111
○ Dragonflies and damselflies	5,600	518	156
○ Stoneflies	2,000	690	110
○ True bugs	56,000	3,834	650 *
○ Beetles	350,000	27,000	4,000 *
○ Ants, bees, and wasps	161,500	17,777	3,000 *
○ Caddisflies	12,627	1,412	250
○ Butterflies and moths	160,000	13,000	2,400
○ True flies	124,000	16,914	2,875 *
○ Other insects	25,273	5,292	1,650 *
• Freshwater fishes	11,500	790	245
• Amphibians	5,918	258 †	53
• Reptiles	8,240	295 †	54
• Birds	9,964	783 †	370
• Mammals	5,416	421 †	67
Animal subtotal	1,056,072 **	105,191 **	16,974 **
Total number of species	1,389,658 **	161,092 **	19,438 **

† = United States only
△ = Sum of species groups included in this table only (numbers in green). This number is the best estimate based on references listed.
* = KSNPC estimate
** = Sum of major groups included in this table only. It does not include all species that occur in the world, North America, or Kentucky (e.g., algae, worms).
Note: a complete list of references for the species numbers is available in *Kentucky's Natural Heritage: An Illustrated Guide to Biodiversity*

Select Species Groups in Kentucky
(Graphics scaled to represent number of species in group)



Mammoth Cave, the longest known cave in the world, has more obligate cave species than any other U.S. cave.[9, 10]

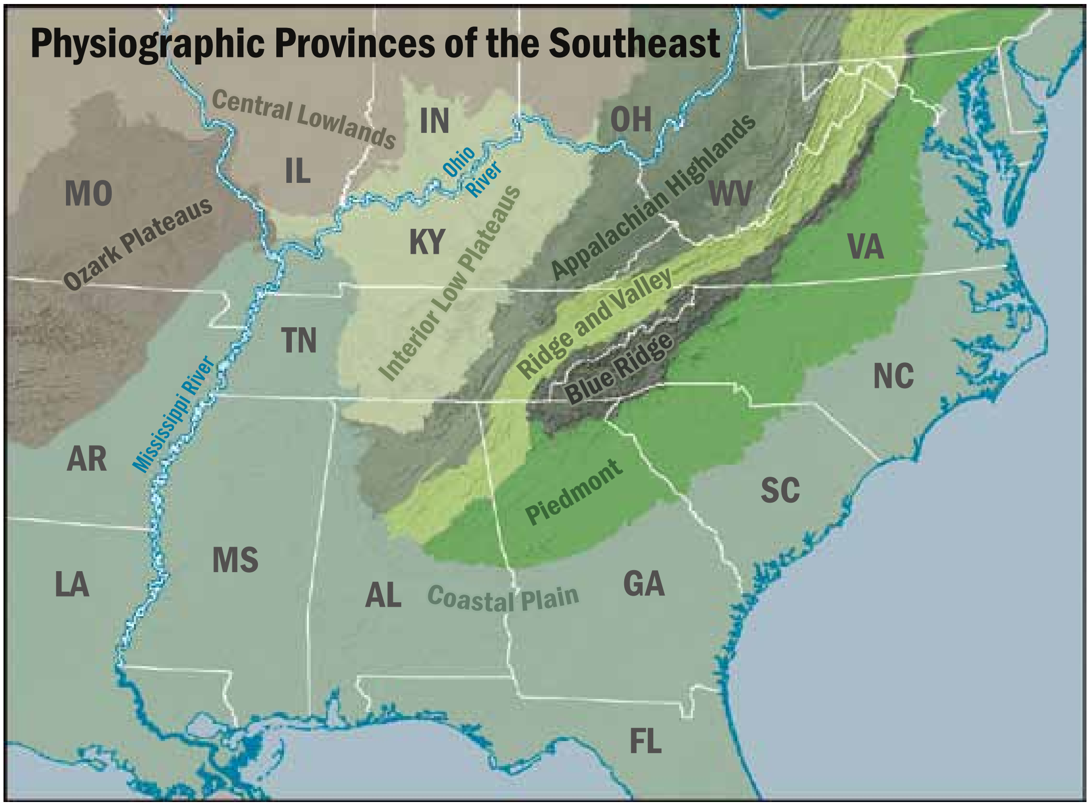
- Kentucky is home to 102 taxa (species, subspecies, and varieties) believed to be endemic to the state or found nowhere else in the world.[11]
- In many regards, the southeastern United States has the greatest salamander diversity in the world.[12] Kentucky supports approximately 26% of the total U.S. salamander fauna.
- One of the largest prairie remnants east of the Mississippi River occurs on Fort Campbell (in Trigg and Christian counties), primarily in Kentucky.
- The mixed mesophytic forest in the mountains of eastern Kentucky is considered one of the most diverse temperate deciduous forests in the world.[13]

The state's geologic history and the resulting physical landscape have helped to shape its biodiversity. Located at a midlatitude of the North American continent, Kentucky has a temperate climate and is situated among several distinct ecoregions. Northern, southern, and midwestern influences are evident in the flora and fauna found here. A 12,000-year history of human activity in Kentucky has greatly influenced the state's biodiversity. Since European American settlement, human impacts have escalated until they now threaten many of the state's species and natural communities. Eighteen species that once lived in Kentucky are either possibly or presumed globally extinct, which is the ninth-highest total among states.[14] This number is so high primarily because of the number of aquatic animals that are now extinct. Even the one plant from Kentucky that is considered extinct, the stipuled scurfpea, was associated with riverine habitat in an area altered by dam construction. These extinctions are a signal of profound changes in the landscape. Information on the state of the environment—from its soil, water, and air to its smallest creature—is critical to understanding and conserving our natural heritage.

Physiographic Provinces and Natural Regions

Natural regions are areas that share a general similarity in geology, topography, hydrology, soils, climate, and vegetation. The natural regions of Kentucky[15] are divisions of the three major physiographic provinces that occur in the state: the Coastal

Figure 2.



Plain, Interior Low Plateaus, and Appalachian Highlands (see Figure 2).[16] The diversity within these physiographic provinces is one reason Kentucky supports a rich flora and fauna. The natural regions represent unique localized environmental and physical conditions within the physiographic provinces that affect the distribution of species and natural communities.

The Coastal Plain physiographic province occurs in far western Kentucky. Covered by the ocean as recently as the late Cretaceous Period, around 70 million years ago (hereafter abbreviated "mya"), the Coastal Plain is the youngest region in the state in geologic terms.[17] Kentucky is near the northern interior extent of this province, which stretches from coastal Texas to Massachusetts and inland along the Mississippi River valley to southern Illinois. The eastern border of the province is defined by a hilly area composed of gravel and sand deposits that mark the different ancient shorelines of the Gulf of Mexico. The flora and fauna of this province are more typical of regions found farther south. Bald cypress swamps and many southern species reach their northern limits near here.

Turk's cap lily and pipevine swallowtail.
The highest elevations of the Appalachian Highlands physiographic province in Kentucky are in the Cumberland Mountains. These mountains support a unique microclimate providing habitat for the Turk's cap lily, a favorite nectar source of the pipevine swallowtail. This northern hardwood forest is home to many species found nowhere else in Kentucky. Photo by Thomas G. Barnes.

The Interior Low Plateaus physiographic province occupies the midsection of Kentucky. This province extends from northern Alabama through much of Tennessee and north through Kentucky to southern Illinois, Indiana, and Ohio. It is composed of a series of plateaus, basins, and domes, often separated by distinct escarpments (steep slopes that separate two areas). Some parts of the province are hilly, while others are flat to rolling. Due to its large size and diversity of landforms, the flora and fauna of this province range from Coastal Plain to midwestern species, including many that are typical of prairie, glade, and oak–hickory forests.

Most of eastern Kentucky is in the Appalachian Highlands physiographic province, a large province that extends from New England to northern Georgia and Alabama. The biodiversity of this province in Kentucky is influenced by its central location in the Appalachian Mountain chain; it contains species typical of both the southern and northern Appalachians. This region was an important refugium for plants and animals during past periods of glaciation, and it continues to serve as an important migration corridor.

Species

Species and their genetic diversity are the bricks and mortar of biodiversity, the building blocks of ecological health. It is important to know how many species are found in the state, to assess whether they are common or rare, and to keep track of how many are being lost.

If species are to be used as indicators of ecological health, it is important to be able to distinguish one from another. Taxonomists provide the method to do this. Taxonomy uses the differences, similarities, and evolutionary relationships among organisms to group them into categories. Each category is called a taxon (plural taxa, which for the purpose of this article refers to species and may include subspecies or varieties). Closely related species are grouped together into a larger category called a genus; closely related genera (plural for genus) are grouped into a family; and so forth.

Wehrle's salamander.
Wehrle's salamander is probably Kentucky's rarest amphibian. It is known from only a few rock outcrops in the southeastern part of the state. Photo by John R. MacGregor.

Assessing the rarity of a species is also important to monitoring ecological health. In determining which species are secure (common) and which are in decline, a standardized method for assigning conservation status or rank has been established. Species are ranked for their vulnerability to extinction on a scale of 1 to 5. Species with ranks of G1 to G3 are vulnerable to extinction at the global level, and those with ranks of S1 to S3 are vulnerable to extirpation at the state or regional level. Species are designated endangered, threatened, or special concern based on their global and state conservation status. In Kentucky, state-level designations are assigned by the Kentucky State Nature Preserves Commission (KSNPC), and state-vulnerable species are referred to as KSNPC-listed.

Species on the Brink

Kentucky's biodiversity is in an unfortunate state of decline. Although the causes of this decline are varied, virtually all of them can ultimately be traced to people and our use of resources. Habitat loss has clearly had the most adverse impact on biodiversity in Kentucky and continues to be the most significant threat to it. Loss of habitat results from conversion of natural areas to other land uses (e.g., forest cleared for a building site) and degradation of habitat quality due to invasive species, pollution, and climate change. Additionally, overexploitation of species is a threat that has resulted in species loss.

Nineteen plants and 47 animal taxa that once lived in Kentucky have been extirpated.[18] Hundreds of taxa are perilously close to joining Kentucky's list of extirpated species. Currently 734 (one lichen, 387 plants and 346 animals) taxa and 36 natural communities are rare and KSNPC-listed; however more species are added to the list nearly every year.[18] Over 50% of the KSNPC-listed taxa are considered critically imperiled (S1) and in risk of extirpation. The highest priority for conservation efforts should be given to critically imperiled species. Each population has the potential to contribute to the species' genetic diversity and may ultimately be vitally important to its survival.

Conservation Science: Natural Heritage Methodology

Effective biodiversity conservation depends on scientific information on ecosystems. The Natural Heritage Program Network, which operates primarily in North, Central, and South America, is focused on gathering information on elements of biodiversity (mostly species and natural communities) and applying standardized techniques to map and manage this information. KSNPC is a member of the network, which was originally created by The Nature Conservancy in 1974 and is now administered by NatureServe. The natural heritage methodology is the framework used to identify and protect the best occurrences of species or natural communities vulnerable to extirpation (i.e., elimination from an area, such as Kentucky) or extinction. To accomplish this task, each program follows the same methodology to assign global and state ranks based on the total number of populations or individuals in each region.

One remarkable aspect of this method is that all information on a species or natural community, from Manitoba to Maui, is available in one place. This standardized methodology allows each natural heritage program to determine the most important plant and animal populations, communities, or natural areas within their political boundaries. Collectively, this information is used to make global assessments. For instance, these data helped determine that more than 90% of the Braun's rockcress populations worldwide, and 100% of the Shawnee darters, occur in Kentucky. For some species and communities, such as the fanshell mussel and Cumberland pine barrens, respectively, Kentucky has the best known occurrences in the world.

Another tenet of the natural heritage methodology is that protection of species and communities vulnerable to extinction also results in protection of species and communities that are more common. If one thinks of biodiversity as a fabric, with the threads being the species and ecosystems that support life on Earth, then reinforcing the individual threads—especially those threads or

species that appear vulnerable to breaking—will ensure that the fabric as a whole remains intact.

Natural heritage programs maintain species and natural community data that are collected during field surveys conducted by biologists or retrieved from both published and unpublished literature. Heritage program staff collect much of the data; however, universities, government agencies, companies, and individuals also contribute. Data are mapped and stored using Biotics, NatureServe's biodiversity data management software. Data in the system are stored with a spatial reference (i.e., coordinates associated with the surface of the earth). Natural Heritage Program Network data are widely used by state and federal agencies, as well as private consultants, and the network has become a key source of data on rare species and natural communities.

Conservation Easement.
The landowners of a significant gray myotis (bat) maternity cave donated a conservation easement around the cave, ensuring permanent legal protection from development or other harmful land uses. Photo by John W. Newman.

Conservation

There are conservation efforts that are forging ahead with the hope of protecting and restoring the state's natural heritage. Information gathered through inventory and monitoring is used to assess the status of species and natural communities. Land preservation and species-recovery efforts are diverse and growing, as are other more indirect but equally important efforts, such as recycling, treating wastewater, and improving air quality.

A. Land conservation effort: Conservation lands are either public (lands owned by federal, state, or local governments) or private (lands owned by individuals, nongovernmental organizations, or foundations) areas that offer some designated or recognized degree of natural-area protection. These lands are essential to the protection of Kentucky's biodiversity. There are more than 1.6 million acres of conservation lands in Kentucky,[19,20] which account for approximately 6.4% of the state's land area. Management of these lands may be solely the landowner's responsibility, or it may be shared through partnerships that provide additional expertise and funding. Management objectives vary considerably due to different legislative mandates, philosophies, or land-use policies; these objectives may focus on multiple uses, or they may be specific to a particular purpose, such as protection of habitat or rare species. The common thread is that all of these lands directly or indirectly protect Kentucky's biodiversity to some degree and therefore have conservation value.

B. Conservation planning: Conservation planning is focused on long-term support for all native species, both rare and common, and sustaining biodiversity at all levels. Effective planning involves field surveys and data gathering; analysis of species distributions and existing protected areas; evaluation of threats and identification of additional areas in need of protection; and ongoing monitoring of protected areas to assure they continue to support biodiversity.[21, 22] The goal of conservation planning is the use of sound science to identify priority areas for the protection of biodiversity.[22]

Geographic information systems (GIS) are being widely used by conservation organizations to aid with planning efforts. The mapping and modeling capabilities of GIS assist with everything from species tracking and monitoring to inventory and management.

The distribution and concentrations of rare species are of particular interest for developing conservation strategies that target biodiversity. GIS greatly assist with the analysis of species observation data and the identification of biologically important areas, large contiguous tracts of forest, and ecological corridors.

C. Citizen contributions: Biodiversity conservation is not the exclusive responsibility of government. With more than 90% of the state in private ownership, conservation of natural lands and imperiled species cannot be achieved without the efforts of private citizens. The contributions of citizens include amateur naturalists who contribute their knowledge, volunteers who participate in conservation projects across the state, and landowners voluntarily protecting rare species on their property.

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Additional Information on Kentucky's Natural Heritage: An Illustrated Guide to Biodiversity





From the Foreword by Wendell Berry: "A publication and an event of inestimable significance...No other book that I have read has helped me so much to think about the *land* of Kentucky, of the reciprocity of influence and the sharing of fate between the land and ourselves...It gives us a competent sense of the state's native health and abundance before European settlement, of what and how much we have lost or wasted or used up, and of what is left—differences heartbreaking to think about."

From the Inside Flap: An essential reference to the remarkable natural history of the commonwealth and is a rallying call for the conservation of this priceless legacy. Organized by a team from the Kentucky State Nature Preserves Commission, the book is an outgrowth of the agency's focus on biodiversity protection.

Richly detailed and lavishly illustrated with more than 250 color photos, maps, and charts, Kentucky's Natural Heritage is the definitive compendium of the commonwealth's amazing diversity. It celebrates the natural beauty of some of the most important ecosystems in the nation and presents a compelling case for the necessity of conservation.

How to Get a Copy:

- KSNPC's Bookstore: http://naturepreserves.ky.gov/pubs/Pages/bookstore.aspx
- University Press of Kentucky www.kentuckypress.com/live/title_detail.php?titleid=2377
- Most bookstores throughout the state

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KSNPC Mission Statement

The authors of *Kentucky's Natural Heritage* are associated with Kentucky State Nature Preserves Commission (KSNPC), an entity created in 1976 to protect the 59 nature preserves that together amount to 24,000 acres of land. According to the KSNPC website, the mission of the organization is "to protect Kentucky's natural heritage by (1) identifying, acquiring, and managing natural areas that represent the best known occurrences of rare native species, natural communities, and significant natural features in a statewide nature preserve system; (2) working with others to protect biological diversity; and (3) educating Kentuckians as to the value and purpose of nature preserves and biodiversity conservation."

KSNPC, of the Energy and Environmental Cabinet, is part of an international network of programs that monitor biodiversity. The 1976 Kentucky legislature created the commission to protect the best remaining natural areas in the state, with the purpose of not only preserving our natural heritage, but also recognizing the link between ecosystem and human health.

Since 1976, KSNPC has developed a database of over 13,000 records on rare species and communities around the state and serves as a resource for environmental planning and biological research. Staff biologists have uncovered a wealth of information about species and their habitats. From this information, more than 50 nature preserves have been established to protect the rich natural heritage of Kentucky.

KENTUCKY STATE NATURE PRESERVES COMMISSION

Greg Abernathy is a geographic information specialist at KSNPC.

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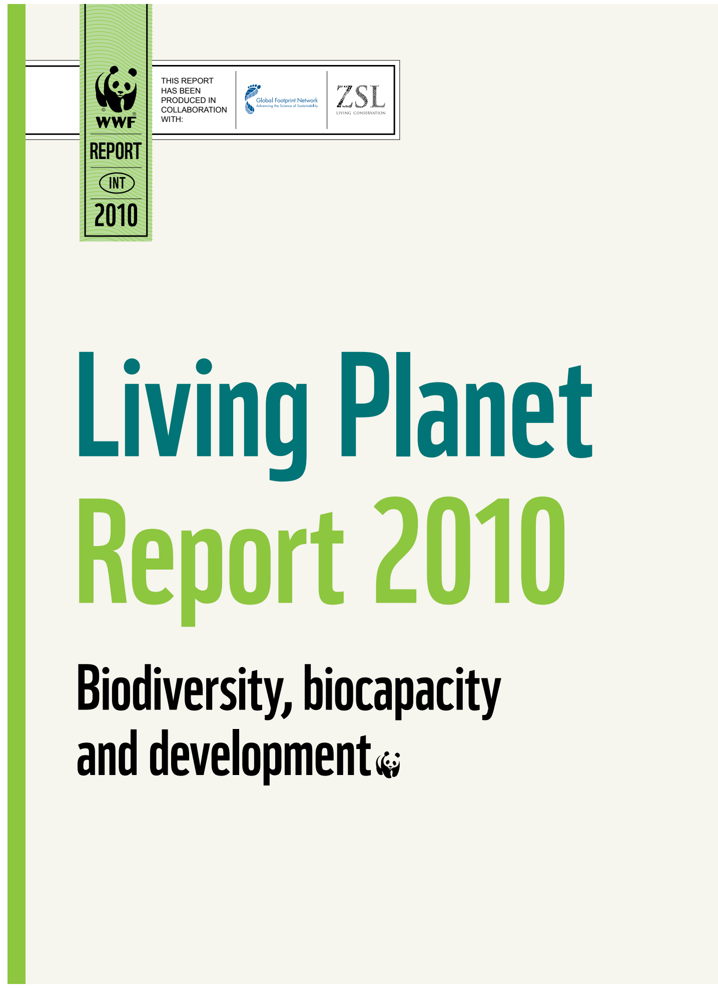
Marc Evans, senior ecologist retired from KSNPC, is a coauthor of *Rare Wildflowers of Kentucky* and *Landscape Restoration Handbook*.



Living Planet Report 2010 Biodiversity, biocapacity and development.

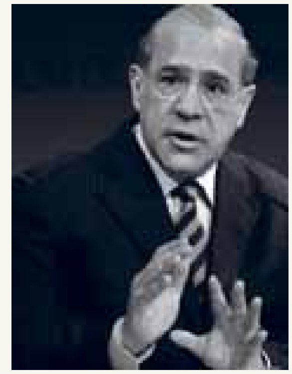
Colby Loucks
Acting Director, Conservation Science Program
World Wildlife Fund, United States

Executive Summary from the Living Planet Report reprinted with permission from the World Wildlife Fund.

Introduction

The 2010 Living Planet Report relates humanity's demands on the Earth's natural resources – our Ecological Footprint – to the health of the planet's biodiversity and ecosystems – the Living Planet Index (LPI). One of the main take-home messages from this report is that we – as a global community – are consuming the resources of 1.5 planet Earths. Put simply, we are consuming 50% more than the Earth can regenerate in a year – and this is largely driven by an eleven-fold increase in our CO_2 emissions over the past 50 years. Against this backdrop we have seen a steady global decline in the LPI, most pronounced in the world's tropical and poorer countries. The mission of World Wildlife Fund (WWF) is the conservation of nature. Yet to achieve our mission we need to not only protect species and habitats, but help build a future where the needs of humans are also met. WWF is actively exploring options in which nature's value can be quantified and resources returned to the local stewards of healthy ecosystems. Further, we are testing our interventions in rigorous, scientific ways, enabling us to quantify the impact of our work to people and nature and understand what works and why. The increase in greenhouse gas emissions is a major driving factor in the Ecological Footprint's global increase. WWF is actively engaging local, national, and global actors to develop policies that reduce greenhouse gas emissions and support alternative 'green' technologies, while at the same time working with local communities to help them adapt to impending changes in the climate. WWF is also engaged with many of the global companies that hold sway over the decisions that occur locally, from the expansion of soy or palm oil to the extraction of timber and wood products. We want to make natural resource sustainability a pre-condition to competition. As this report demonstrates, "business as usual" will not be good enough to tip the Ecological Footprint back towards consuming within our means. We need to influence the behaviors of people, governments and businesses, with the understanding that we can protect biodiversity and ecosystems *and* build a stronger, fairer and cleaner world economy.

FOREWORD



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The protection of biodiversity and ecosystems must be a priority in our quest to build a stronger, fairer and cleaner world economy. Rather than an excuse to delay further action, the recent financial and economic crisis should serve as a reminder of the urgency of developing greener economies. Both WWF and the Organisation for Economic Co-operation and Development (OECD) are contributing to this goal.

The Living Planet Report is helping raise public awareness of the pressures on the biosphere and spreading the message that "business as usual" is not an option. The report contributes to fostering action, as what gets measured gets managed.

The OECD is developing a Green Growth Strategy to help governments design and implement policies that can shift our economies onto greener growth paths. Central to this is identifying sources of growth which make much lighter claims on the biosphere. This will require fundamental changes to the structure of our economies, by creating new green industries, cleaning up polluting sectors and transforming consumption patterns. An important element will be educating and motivating people to adjust their lifestyles, so we can leave a healthier planet to future generations.

Policy makers and citizens need reliable information on the state of the planet, combining various aspects without getting lost in the details. Although the Living Planet Report indices share the methodological challenges that all aggregated environmental indices face, their merit is their ability to convey simple messages about complex issues. They can reach out to people and hopefully influence behaviour change among audiences that may otherwise receive little environmental information.

I commend WWF for its efforts. The OECD will continue to work to further refine green growth indicators and improve the way in which we measure progress.

Angel Gurría
Secretary General,
Organisation for Economic Co-operation and Development

EXECUTIVE SUMMARY

2010 — The International Year of Biodiversity
— The year in which new species continue to be found, but more tigers live in captivity than in the wild
— The year in which 34 per cent of Asia-Pacific CEOs and 53 per cent of Latin American CEOs expressed concern about the impacts of biodiversity loss on their business growth prospects, compared to just 18 per cent of Western European CEOs (PwC, 2010)
— The year in which there are 1.8 billion people using the internet, but 1 billion people still without access to an adequate supply of freshwater

1.5 YRS
TO GENERATE THE RENEWABLE RESOURCES USED IN 2007

This year, biodiversity is in the spotlight as never before. As is human development, with an upcoming review of the Millennium Development Goals. This makes WWF's 8th edition of the Living Planet Report particularly timely. Using an expanded set of complementary indicators, the report documents the changing state of biodiversity, ecosystems and humanity's consumption of natural resources, and explores the implications of these changes for future human health, wealth and well-being.

A wide range of indicators are now being used to track the state of biodiversity, the pressures upon it, and the steps being taken to address those trends (Butchart, S.H.M. *et al.*, 2010; CBD, 2010). One of the longest-running measures of the trends in the state of global biodiversity, the Living Planet Index (LPI) shows a consistent overall trend since the first Living Planet Report was published in 1998: a global decline of almost 30 per cent between 1970 and 2007 (Figure 1). Trends regarding tropical and temperate species' populations are starkly divergent: the tropical LPI has declined by 60 per cent while the temperate LPI has increased by almost 30 per cent. The reason behind these contrasting trends likely reflects differences between the rates and timing of land-use changes, and hence habitat loss, in tropical and temperate zones. The increase in the temperate LPI since 1970 may be due to the fact that it is starting from a lower baseline, and that species' populations are recovering following improvements in pollution control and waste management, better air and water quality, an increase in forest cover, and/or greater conservation efforts in at least some temperate regions.

In contrast, the tropical LPI likely starts from a higher baseline and reflects the large-scale ecosystem changes that have continued in tropical regions since the start of the index in 1970, which overall outweigh any positive conservation impacts.

Figure 1: Living Planet Index
The global index shows that vertebrate species populations declined by almost 30 per cent between 1970 and 2007 (ZSL/WWF, 2010)

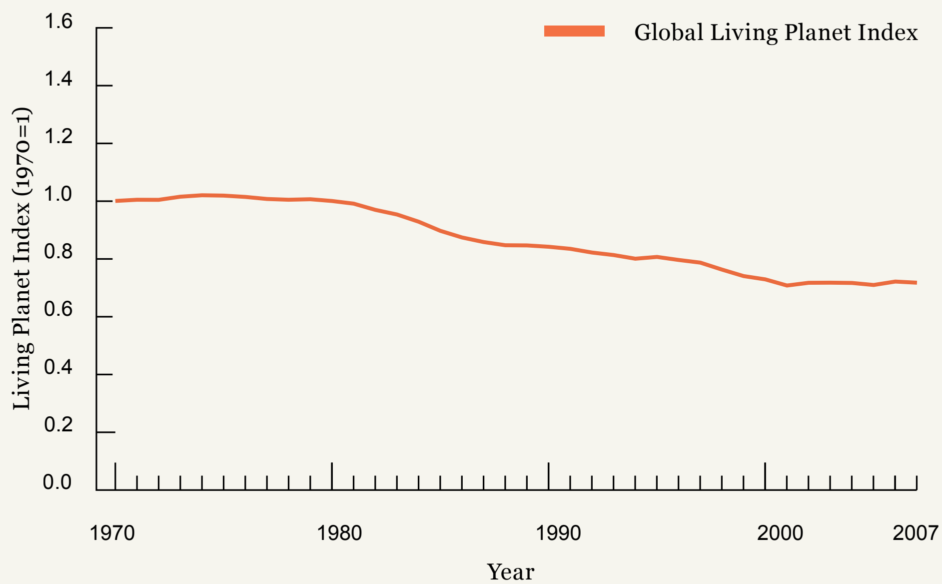
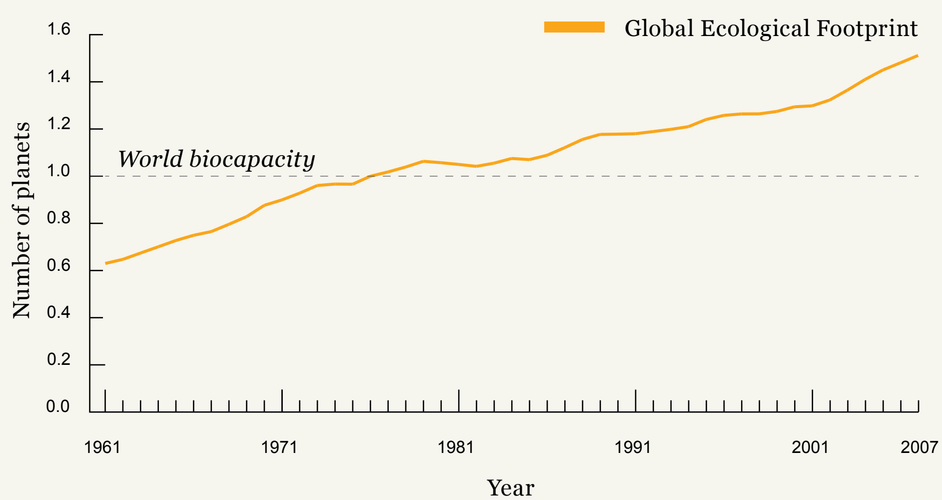


Figure 2: Global Ecological Footprint
Human demand on the biosphere more than doubled between 1961 and 2007 (Global Footprint Network, 2010)



The Ecological Footprint tracks the area of biologically productive land and water required to provide the renewable resources people use, and includes the space needed for infrastructure and vegetation to absorb waste carbon dioxide (CO2). It also shows a consistent trend: one of continuous growth (Figure 2). In 2007, the most recent year for which data is available, the Footprint exceeded the Earth's biocapacity — the area actually available to produce renewable resources and absorb CO2 — by 50 per cent. Overall, humanity's Ecological Footprint has doubled since 1966. This growth in ecological overshoot is largely attributable to the carbon footprint, which has increased 11-fold since 1961 and by just over one-third since the publication of the first Living Planet Report in 1998. However, not everybody has an equal footprint and there are enormous differences between countries, particularly those at different economic levels and levels of development. Therefore, for the first time, this edition of the Living Planet Report looks at how the Ecological Footprint has changed over time in different political regions, both in magnitude and relative contribution of each footprint component.

The Water Footprint of Production provides a second measure of human demand on renewable resources, and shows that 71 countries are currently experiencing some stress on blue water sources — that is, sources of water people use and don't return — with nearly two-thirds of these experiencing moderate to severe stress. This has profound implications for ecosystem health, food production and human well-being, and is likely to be exacerbated by climate change.

The LPI, Ecological Footprint and Water Footprint of Production monitor changes in ecosystem health and human demand on ecosystems, but do not provide any information on the state of ecosystem services — the benefits that people get from ecosystems and upon which all human activities depend. For the first time, this edition of the Living Planet Report includes two of the best-developed indicators for ecosystem services at a global level: terrestrial carbon storage and freshwater provision. While such indicators require further development and refinement, they nevertheless help make it clear that conserving nature is in humanity's own interest, not to mention that of biodiversity itself.

As in previous reports, the relationship between development and the Ecological Footprint is examined, and minimum criteria for sustainability are defined based on available biocapacity and the Human Development Index. This analysis indicates that it is

71
COUNTRIES EXPERIENCING STRESS ON BLUE WATER RESOURCES

in fact possible for countries to meet these criteria, although major challenges remain for all countries to meet them.

For the first time this report also looks at trends in biodiversity by country income, which highlights an alarming rate of biodiversity loss in low-income countries. This has serious implications for people in these countries: although all people depend on ecosystem services for their well-being, the impact of environmental degradation is felt most directly by the world's poorest and most vulnerable people. Without access to clean water, land and adequate food, fuel and materials, vulnerable people cannot break out of the poverty trap and prosper.

2

THE NUMBER OF EARTHS WE'LL NEED BY 2030

Ending ecological overshoot is essential in order to ensure the continued supply of ecosystem services and thus future human health, wealth and well-being. Using a new Footprint Scenario Calculator developed by the Global Footprint Network (GFN), this report presents various future scenarios based on different variables related to resource consumption, land use and productivity. Under a "business as usual" scenario, the outlook is serious: even with modest UN projections for population growth, consumption and climate change, by 2030 humanity will need the capacity of two Earths to absorb CO2 waste and keep up with natural resource consumption. Alternative scenarios based on different food consumption patterns and energy mixes illustrate immediate actions that could close the gap between Ecological Footprint and biocapacity — and also some of the dilemmas and decisions these entail.

The information presented in this report is only the beginning. In order to secure the future in all its complexity for generations to come, governments, businesses and individuals urgently need to translate these facts and figures into actions and policies — as well as anticipate both future opportunities and obstacles in the path to sustainability. Only by recognizing the central role that nature plays in human health and wellbeing will we protect the ecosystems and species on which we all depend.

To view the full WWF Report, visit
http://wwf.panda.org/about_our_earth/all_publications/living_planet_report/

Growing a Park: A Narrative Journey through the Natural Areas Vision of The Parklands of Floyds Fork

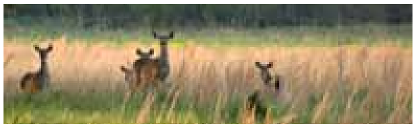
Dan Jones, Chairman and CEO
21st Century Parks

Introduction:

The Parklands of Floyds Fork is a planned 4000 acre addition to Louisville's public park system that reapplies Frederick Law Olmsted's brilliant vision of preserving land ahead of development on the edge of a city for large public parks. Running north to south along Floyds Fork of the Salt River between Shelbyville Road and Bardstown Road, it will encompass numerous recreational amenities (playgrounds, ballfields, bike and hiking trails, a paddling trail, a scenic park drive, among others), as well as preserved agricultural lands, all embedded within a restored natural mosaic of meadows, scrublands, wetlands, and forests. The planners divided The Parklands into four parks (ranging in size from 600 to over 1000 acres), each named for a tributary of Floyds Fork: from north to south, Beckley Creek Park, Pope Lick Park, Turkey Run Park, and Broad Run Park. A connecting green corridor called "The Strand" links Pope Lick and Turkey Run Parks. While much of the attention to date has focused on the recreational aspects of the project, the natural areas planning is largely complete and we are beginning to initiate the first major restoration projects. The overall goal of the natural areas plan is to preserve and enhance both terrestrial and aquatic habitats to maximize the diversity of landscapes and species. While the landscape today is largely agricultural, or recently abandoned fields and pastures, what we call the " 100 Year Vision" seeks to reestablish and use natural processes of succession to create an integrated mosaic of early-, middle-, and late-successional areas that promote the growth and reproduction of native species, both flora and fauna. These landscapes are designed to both function ecologically and be part of the educational and recreational experience of The Parklands.

The 21st Century, the demographers tell us, will be an urban century. As cities are created, or continue to grow, it becomes critical to integrate nature into their geography, for both human health and the health of the environment. The essay below attempts to illustrate, through the natural areas work of The Parklands of Floyds Fork, the challenges and methods required to achieve this kind of vision. While much design work on sustainable cities focuses on issues of energy, transportation, and infrastructure, the creation of healthy, functioning green space is an equally important and fundamental infrastructure requirement of a livable city. While systemic green infrastructure planning does not guarantee a quality urban landscape, its absence almost certainly means limited progress towards these goals. As many land managers have demonstrated in nature preserves and large national parks and forests, it is possible to restore and manage for ecological health and diversity. The challenge illustrated here is how to do that in an urban setting, applying those same techniques in concert with higher human population densities, and the demands of the modern city. As the story below illustrates, it not only requires the basics of land acquisition, preservation, and planning, but a truly long-term vision, and the resources necessary to execute and maintain that vision over time. We can grow a forest that functions as an "old growth" forest, but only with patience and quiet care. We have many good (and bad) lessons learned from the great early urban park systems in New York and other large cities, as well as from natural areas management in nature preserves and rural and wild parks. How to apply those in an urban setting, alongside other demands such as recreation, health, and local food production, is one of the challenges we set for ourselves in the planning for The Parklands. Illustrated below are some of the solutions we adopted. While the presentation is impressionistic, it is grounded in the latest conservation science, and is based on a detailed natural areas inventory and plan.

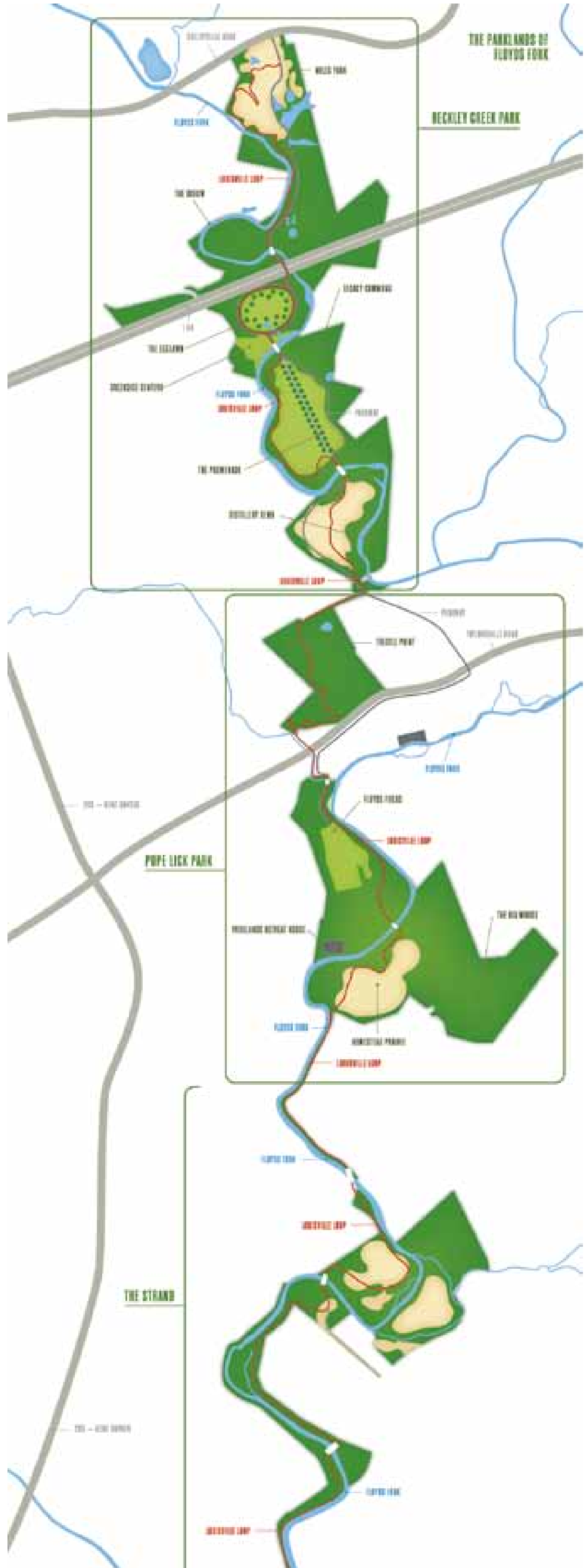
2015—The View from the Path: 5 Years from now were I to decide, on a sunny summer Saturday morning, to go out to The Parklands of Floyds Fork and recreate, here is what I find.

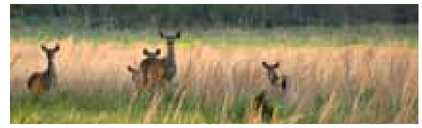


Beckley Creek Park:

I take the Shelbyville Road exit off the Gene Snyder Freeway, where I see a large brown sign advertising "The Parklands of Floyds Fork, Next Right." Following a set of well-designed park signs I catch my first glimpse of a family of bikers crossing Shelbyville Road at the light at Beckley Station Road. As I continue down the hill to Floyds Fork, to my right I see a well-maintained bike path with another group of bikers. As I cross Floyds Fork there is a lovely view of the restored bridge that now hosts the Middletown Eastwood Trail; under the bridge, Floyds Fork is a ribbon of silver in the early morning light. As I come up the hill, Beckley Creek Park, the first of four parks within The Parklands, unfolds to my right. Gone is the old narrow and barely visible entrance to Miles Park. Replacing it is an obvious park gateway that stretches up the hill—its prairie garden my first glimpse of the natural wonders to come. It welcomes me into the park and makes clear that I am entering a special place—4000 acres of public green space stretching for miles.

Once into the park, I see on my left a parking area, and beyond that an impressive set of community gardens. They surround a trailhead, with bathrooms and signs introducing The Parklands. I stop in to see what I can learn. Within the trailhead is a series of maps. One shows all the recreational amenities of the greenway: canoeing, biking, hiking, picnicking, playgrounds, ball fields. I'm amazed at the diversity of recreational opportunities. There is also a set of photos that show the history of the land and the landscape. I had no idea that Floyds Fork was a crossroads of geology, civil war history, and is today so filled with natural wonders. I did not know the story of William F. Miles and his pioneering efforts in urban conservation. I also learn that the entrance road is actually the beginning of a scenic byway that stretches all the way from Shelbyville Road to Bardstown Road. The sign that really catches my eye outlines the park's "100 Year Vision," the natural areas master plan to bring natural diversity back to Louisville's landscape. The map shows the "big idea" of that plan: two large blocks of "interior forest" (one in the north, one in the south) linked by a braided natural corridor of meadows, scrublands, and connecting canopy forest, running fifteen miles along both sides of Floyds Fork. The narrative explains that each habitat type hosts a relatively unique suite of plant and animal species—the maximization of biological diversity stems directly from the maximization of habitat diversity. By restoring the natural process of succession from meadows to scrublands to canopy forest, The Parklands will host the maximum diversity of associated species. By linking them together in corridors along the stream and in the uplands, we create living and migration spaces for a variety of both terrestrial and aquatic creatures and their varied demands for resources and living space. By restoring and preserving the lands in perpetuity, we allow the landscape to gradually develop a mosaic of ages and structures that will follow a natural trajectory of disturbance, succession, and change. The map also outlines the natural "special places" of Beckley Creek Park, some already existing, like the oak hickory forest in the uplands, which is the largest in The Parklands. Others are new, like the prairie meadows in the bottomlands, the newly forested riparian corridor along Floyds Fork, and the scrublands of the Oxbow, just west of the MSD plant. The narrative reiterates the key point: many of these areas will not reach their intended character for fifty to seventy-five





A small tributary of Floyds Fork. Reforestation along tributaries is key to protection of The Fork.

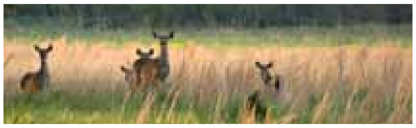
years. Because these lands are protected in perpetuity for public access and use, the project is able to make these kinds of long-term investments today.

I hop on my bike and head south down the Louisville Loop to explore. As I make the first turn down the hill into the floodplain the valley opens before me. I see a burst of colors from wildflowers in a restored meadow in the lowlands. By intent, the selected species attract and host a varied group of butterflies and other insects. The link between native plants, insects, and insectivores further up the food chain is an important, if subtle, part of ecological restoration. On my left is a savanna of large, old white oaks. At their feet sway prairie grasses. I remembered that this slope was once a tangled mass of invasive Bradford Pears, which have all been removed to allow the growth of a younger generation of oaks and hickories, just emerging above the tall grasses. In one hundred years, when the savanna oaks begin to die, these trees will be reaching maturity, demonstrating the use of natural regeneration as a tool in maintaining ecological integrity. Many older urban parks planted their trees with only one generation in mind, with the result that these landscapes are crumbling today. As the loop approaches the creek, I see a puzzling tangle of scrubby vegetation with scattered trees poking above it. A sign explains that this is a "riparian reforestation area." Apparently, the site was initially cleared of a mass of invasive bush honeysuckle, then planted in native trees and shrubs. These areas are intended to be part of a continuous riparian (meaning streamside) forest that will one day connect the entire length of Floyds Fork with the project. Ranging from seventy-five to three hundred feet in width, it establishes a buffer against pollutants, captures silt runoff, and helps to stabilize the creek bank and channel, while creating a connected corridor for wildlife migration, movement, and nesting. The stream ecologists who worked on the project emphasized that this effort will do more to protect water quality in the stream, enhance wildlife habitat, and stabilize the stream bank, than almost any other effort. Much of the lowland reforestation work within The Parklands is centered on these areas.

Floyds Fork's diverse natural beauty is accessible for hikers and paddlers as part of The Parklands of Floyds Fork new trail system.

As I follow the Louisville Loop through the woodlands, I pass several old "wolf trees," large open grown trees that are relics from a time when this entire area was farm pasture and the trees provided shade for cows. Once farming halted and the forest began to regrow, these trees stand as silent sentinels to an earlier time, but they also anchor a great deal of wildlife diversity, as they host a number of bird, mammal and insect species. Managing for these "legacy trees" is another important component of the planning. After a short climb up the hill I pass MSD's Floyds Fork Treatment Plant, screened behind a fast growing patch of trees. To my right is an explosion of densely packed small trees—box elders, walnuts, and sycamores. This is the famous "Oxbow" curve of Floyds Fork, and a sign explains that it is being released back into a process of natural succession. The long-term goals for this site are to integrate its small "patches" of forest fragments into a much larger block of floodplain forest (over forty acres) and then link that area into the longer riparian corridor. Forest fragmentation, the sign explains, is one of our critical ecological issues. A legacy of agriculture and urban development, small fragmentary patches lack "interior forest" which represent critical habitat for many terrestrial species. Small patches also create a large amount of "edge" habitat, which introduces a number of threats, such as cowbirds, which invade the nests of species such as warblers that inhabit interior forest areas. In another forty years, this site will host a large area of riparian forest, connected to the overall riparian corridor: a safe home for these woodland residents.

As I bike south, I pass The Egg Lawn—a place of Frisbee throwers and picnickers—and the PNC Achievement Center for Education and Interpretation, which is the gateway for a well-developed partnership between The Parklands and area schools. A group of young students are just heading out on an expedition by canoe to learn about invertebrates in the creek and to participate in the sampling study that tracks long-term changes in the water quality of Floyds Fork. With almost a million and a half people within a field trip bus ride, this is an ideal place to teach Kentucky's incredible natural history and biodiversity



by immersing children and adults in an outdoor classroom and engaging them in the process of restoration through observation, research, and volunteer conservation projects that help to implement the vision.

From there, I pass south through additional areas of young, fast-growing riparian forest, until I reach "The Valley of the Giants," one of the oldest floodplain sites in the park, and a template for the riparian reforestation efforts in the project. Huge sycamores, walnuts, and box elders line the creek in an almost open woodland. A crew of Student Conservation Association interns is in their last season of a three year project of bush honeysuckle removal, which has opened up the herbaceous and shrub layers to native plants dormant in the seed bank. Large trunks of fallen trees litter the ground, and a recent tree fall has opened a gap in which new growth has rapidly sprouted. This kind of forest structure is characteristic of a mature forest, and hosts a diverse set of animal species, which colonize the rotting trunks of fallen trees, and the cavities of older trees. A number of snags also dot the landscape, excellent roosts for predators such as hawks; as if on cue, a broad-winged hawk swoops quietly through the understory.

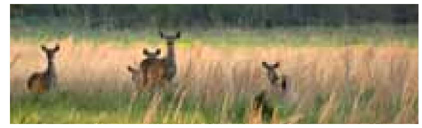
Pope Lick Park:

For a few miles I let my mind wander and just enjoy the ride along the creek and through woods, open fields, and patches of scrubby vegetation. Indigo buntings and bluebirds flit into the bushes at my approach. A strenuous push up the hill out of the floodplain reminds me of the distinctive topography of Floyds Fork, with its broad floodplain, its steep slopes, and its rolling uplands. Derived from the underlying soft shale rock of the Ordovician Period, so different from the tough, massive limestones of Cherokee Park, they erode easily. This distinctive landscape is one of the delights and challenges of managing for ecological diversity. A delight because it offers many distinctive habitats, from lowland to upland, the combination of which creates a broad cross section of diversity in a fairly narrow geographic range. Succession in each area results in a different group of plant and animal species at each phase, resulting in a truly diverse matrix—a challenge to manage, a delight in terms of biodiversity.

My next milestone comes when I cross Taylorsville Road, the only major road crossing in The Parklands, and the major impediment to a continuous habitat corridor. The challenge of creating safe passage across the road—for both humans and slow-moving species such as the box turtle—is still ongoing. On the south side I enter Pope Lick Park, one of the most remarkable combinations of landscapes in The Parklands. Just past the entrance I cross Pope Lick Creek and stop to chat with another group of students, who have grounded their canoes and are studying invertebrates in both Floyds Fork and Pope Lick Creek, sampling for a range of species. Just past the confluence I enter a section the park map indicates as some of the best birding habitat in the park. The bike path skirts the edges of a long, linear area of scrublands, which hosts a number of species unique to these mid-successional areas. While challenging to maintain in the long-term (they want to grow into more mature forest), the natural areas plan seeks to maintain this area as shrublands in order to support these distinctive bird species. As I cross Floyds Fork on a bike bridge, I pass a research team overseeing a study for The Parklands' creek restoration plan. Focused on everything from streambank stabilization to adding structure for fish species to the restoration of native otters and freshwater mussels, they are mapping the stream cross-sections and channel profiles, as well as inventorying species and habitat areas. It is in our streams that the most dramatic biodiversity in Kentucky is found—our freshwater fish and mussel species are some of the most diverse in the world. On the other side of the Fork, I enter an area marked as a "native grassland." Building on work initiated by Metro Parks, The Parklands has continued burning periodically a set of lowland fields that now host native bluestem, Indian grass, and other warm-season species. These open fields again host a distinctive suite of insect, bird, and mammal species. High overhead a red-tailed hawk circles the site. As a species that requires a much larger habitat area for hunting, they symbolize the ability of a project this size to provide habitat on a range of geographic scales, something critical to the restoration of diversity. Simply put, a coyote requires more space than a squirrel. As I move through the grasslands, I cross a small culvert (cleverly designed to allow the passage of both water and small creatures) over a small tributary recently restored to its natural meanders after a century of labor as a straightened channel for farm drainage.

The riparian forest and a gravel bar adorn the banks of Floyds Fork.

At the edge of the meadow, I park my bike and hike up into The Big Woods, one of The Parklands' most distinctive areas of upland forest. Centered on an old, mature beech forest, and hosting over 30 species of woody plants, I enter a different world than I've seen thus far: a dark, cool, quiet woodland. Signs of invasive species removal are present, but I find very few non-native species. Again, this area marks a template, in this case an upland "old-growth" forest structure. Fallen trees, diverse tree ages, vertical structure as smaller trees like dogwoods and vibur-



nums have filled in the understory, all reveal telltale signs of an older landscape, a longer passage of time since the last natural or human disturbance. As I think through my path to this point, I begin to see clearly the idea that landscape ecologists embrace of a landscape "mosaic" with a variety of habitats and a variety of age classes. Here I see old trees, but I climbed into this old forest through a section of much younger trees. There I saw a few remnant Eastern Red Cedars, telling me that it was open pasture only a few decades before, but the mature hardwoods towering over those cedars also told me that a new section of canopy forest was filling in a gap to contribute to a much bigger block of interior forest. In the section of old beeches, I again saw the distinctive signs of an old forest: fallen trees rotting on the ground, gaps from more recently fallen trees, which were beginning to create the varied age structure characteristic of an older forest. The linear elements of the broader plan also became clear. This large block of forest, once isolated, would gradually connect with other areas to the north and south as the fast-growing restoration areas matured and linked together a continuous canopy. My last goodbye was the tropical call of a pileated woodpecker, as I made my way back to bike. It was past noon, and I wasn't even halfway to the end!

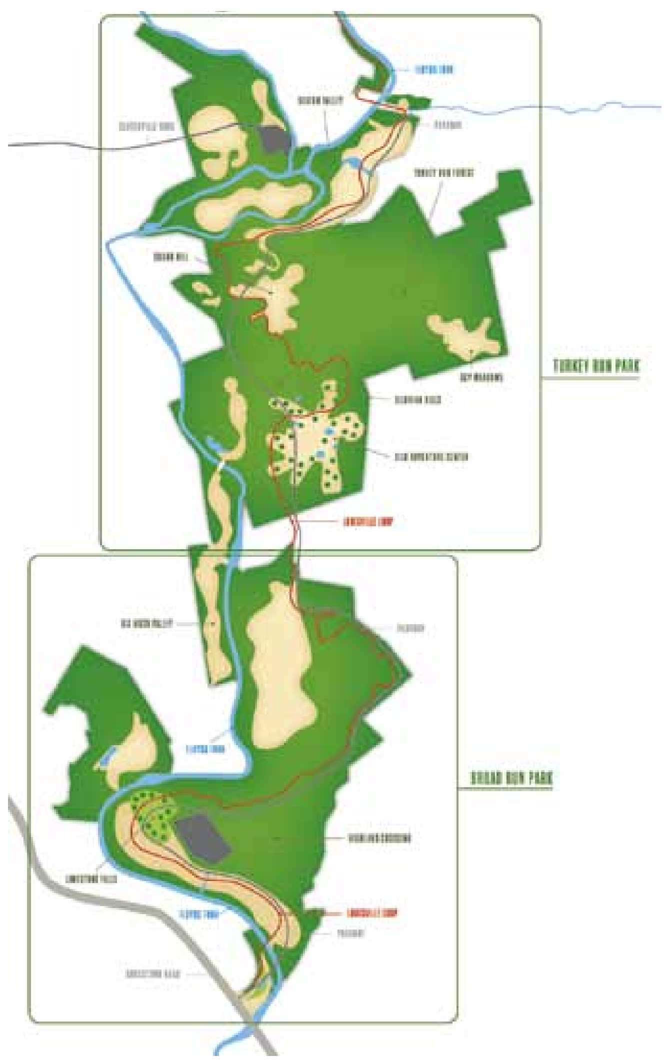
The Strand:

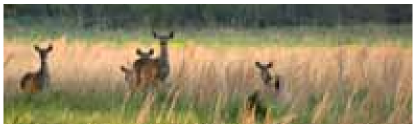
Back on the bike path, I enter The Strand, a narrow linear section of the park, that winds along Floyds Fork in the bottomlands, connecting the two northern parks to Turkey Run and Broad Run Parks in the south. The value of this area, the information on the map explains, is that we were able to assemble land on both sides of Floyds Fork. One side contained mature forest, the other was grazed horse pasture. That area, I clearly see as I bike through it, is fast restoring into a wide riparian buffer that mirrors the more mature existing forest on the other side of the creek. This several mile long section represented a critical acquisition as it allowed the project to extend a natural connecting corridor between the large blocks of protected land to the north and south, while also enhancing the quality of aquatic habitats along this section of the stream.

Turkey Run Park:

At Seatonville Road, I enter Turkey Run Park, the largest park in The Parklands at over 1000 acres. A mélange of old farm pastures, existing agricultural fields, an abandoned golf course, cedar groves and healthy second-growth hardwood forests, it represented a challenge and test for the broader vision of recreating and reconnecting an integrated natural landscape within the parks. At the trailhead for the Loop, I pause for a drink of water and a walk down to the stream edge. A blue heron passes on the stream, headed towards a large rookery just to the north, evidence of what natural spaces can accommodate, even on the edge of a major city. Gnawed trunks are a clue that beavers have recently been at work. Although I find no evidence, I know that both otters and mink also inhabit Floyds Fork. I cross a gravel bar filled with fossils from the time when these rocks sat at the equator, and hosted tropical species, evidence for a fascinating tale of ancient diversity, moving continental plates, evolution, and extinction. A tale for another day, but important, because Louisville hosts some of the finest Ordovician Period rock outcrops in the world, and the gravel bars of Floyds Fork gather their many fossil species in a wonderful outdoor classroom. After a few more minutes of streamside quiet, punctuated only by the quiet passage of two kayakers, I head back to the trailhead and its maps and interpretive signs.

The challenge in Turkey Run Park, the signs explain, was how to manage the existing agricultural mosaic towards a more integrated natural ecology. The first key was to inventory and map the property, in order to locate areas of invasive species, and areas that required specific management. From that came the plan to shape a trajectory that would gradually fill in the gaps, so that in 75 years there would be a large (approximately 1000 acres) block of interior forest, linked with the lowland riparian corridor and other forest blocks to the north and south. Each area was mapped and a management prescription drafted and executed. In some cases, it involved simply removal of invasive species, and a hands-off approach that allowed the existing regeneration





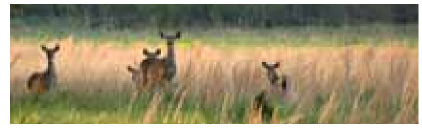
Classic Kentucky Oak-Hickory forest. The branching tree trunks reveal a history of prior logging and land use.

to grow. In other cases, such as an area called the Stout Bottoms, federal conservation funds were secured to execute a full-blown restoration of bottomland forest through halting of agriculture, and planting of literally thousands of young trees of great diversity. Many of these were mast trees, such as Bur Oaks, that would not only create a forest, but provide forage for a range of wildlife species. I hopped on my bike and rode to the Stout Bottoms. While today, it is largely a regenerating forest—a thick tangle of young saplings, what foresters call a "doghair thicket"—in twenty to thirty years it will begin to mature into 55 acres of dense interior forest, another critical link in the connective tissue of The Parklands.

I strain to climb the hill again on my bike, then cross a spectacular bike bridge high in the canopy over Turkey Run. In the springtime, I'm told, you can watch one of nature's great shows: the springtime passage of colorful Neotropical migrants, many of which have come all the way from South America. On the other side, I reach The Silo Center, a cluster of restored farm buildings that includes a silo, now converted to an observatory. I climb its winding staircase and at the top, a wonderful view of southern and eastern Louisville presents itself. A series of panoramas explains what I see; one lays out a view of the 19th century farm landscape that is quickly vanishing. From here I really get a sense of the mosaic of natural areas. I can see the connecting corridor of forest along Floyds Fork, and although the area of the Stout Bottoms is a light tan in comparison to the lush green of the mature trees beside it, I can see its role filling the gap and linking patches into a broader forest—it won't take many years of growth for the trees to catch up with their neighbors. The immensity of 1000 acres of urban forest becomes tangible. I see the gash of the gorge of Turkey Run and realize that almost all of its watershed is within the parklands. This is incredibly valuable as it offers stream ecologists a "reference reach," a stream that can be managed and studied for its undisturbed characteristics, offering a chance to understand what can be done to restore more impaired streams in urban watersheds.

Broad Run Park:

From The Silo Center I follow the Louisville Loop past a series of farm ponds, preserved for their cultural legacy, their recreational fishing value, and for their value as habitat for frogs and other species whose natural wetland habitats have been drained. While not part of the original natural landscape, a conscious decision was made to retain them for this habitat value. From here I cross a savanna area of large open grown oaks, another preserved legacy from the agricultural era. Persimmon trees fat with fruit dot the uplands. After a short ride along a beautiful old country road I rise into The Highland Crossing, an area of upland forest connectivity, where massive old field-grown chinquapin oaks are now part of a second-growth oak hickory forest. Through the trees I catch a glimpse of a wet field in the lowlands below, part of a series of restored wetland sites in Broad Run Park. This chain of wetlands, which will one day dot the length of The Parklands, was created by removing drain tile inserted by farmers years ago to make the fields usable for agriculture. While they are in the process of restoration, they will ultimately host a variety of plant, bird and animal species, adding yet another habitat to the mosaic of the parklands. On the steep slopes are the last remnants of the spring wildflower bloom. Although originally cleared, these steep slopes reforested through the 20th century, and are the major armature of the chain of upland forests. In springtime they host a diverse wildflower display, and local naturalists have helped to sow local provenance seed in order to restore them to their native diversity. This is also the waterfall district in the park, and in areas all along the small tributaries of Floyds Fork are found botanical hotspots that host the highest level of herbaceous diversity within the parks. The rich limestone and dolomitic soils are perfect habitat for a riot of spring color. On the drier out-



crops, preserved by grazing cattle and their heavy hoofs, is The Parklands' special management zone for Kentucky gladecress, the most truly endangered species within the boundaries of the park.

Finally, I reach the last bridge over Floyds Fork at Bardstown Road, and park my bike. As I turn my eyes back north I see the flat fields of Broad Run Park—the remnants of a Pleistocene lakebed—and realize that I've seen only the beginnings of a 100 year process of natural change, succession, and growth. If I could return in 100 years, I would see areas that today are second-growth woodlands transformed into old-growth canopy forest, gaps filled in the forest to create a continuous pathway for migrating spring warblers, or slow moving box turtles. Hopefully, I would also see these kinds of initiatives extended up the tributaries of Floyds Fork into the lands surrounding the park, where new forests will have sprouted to help sustain healthy waters in Floyds Fork.[1]

Conclusion:

The techniques described in this narrative will not surprise a land manager, a forester, or a conservation biologist. They are novel mostly in their application within an urbanized environment, and because of the range of diversity they attempt to support. Many conservation sites target specific plants and animals, or seek to preserve habitat that already exists. The challenge offered to the natural areas plan of The Parklands of Floyds Fork is to bring back a post-agricultural landscape in a way that creates habitats for a wide range of native and migratory species. A great deal of complexity underlies these plans, and a great deal of work needs to be done to execute them, but the basic pieces of the puzzle are in place: the land has been acquired, funds have been raised for both park amenities and natural areas restoration, and funds are in place to support the maintenance and operations staff needed to both run the parks and restore them. It will be an exciting project, in which many folks—from local scientists to local volunteers—can participate and help us to leave a legacy that in 100 years will truly be a natural wonderland, nestled on the edge of a large and vibrant city. A place for our children, grandchildren and great grandchildren to come and experience an authentic and healthy touch of Kentucky's wonderful natural legacies within the context of their busy lives.

References

1 The literature on ecological restoration and landscape ecology is vast. We have worked with a number of consultants in the inventory, planning, and design stages of this project, and much of the description here draws on that work. There are a number of useful texts, however, that are very accessible. The ones I find most useful are: Malcolm L. Hunter, Jr., *Wildlife, Forests, and Forestry: Principles of Managing Forests for Biological Diversity* (New Jersey: Prentice Hall, 1990); Dramstad, Olson, and Forman, *Landscape Ecology Principles in Landscape architecture and Land-Use Planning* (Washington: Island Press, 1996); Gary Bentrup, *Conservation buffers: design guidelines for buffers, corridors, and greenways* (Asheville: Department of Agriculture, Forest Service, Southern Research Station, 2008); Leslie Jones Sauer, *The Once and Future Forest: A Guide to Forest Restoration Strategies* (Washington: Island Press, 1998): DeGraaf, Yamasaki, Leak, and Lester, *Landowner's Guide to Wildlife Habitat: Forest Management for the New England Region* (Burlington: University of Vermont Press, 2005); James Grant MacBroom, *The River Book* (Hartford: DEP Natural Resources Center, 1998); For a great summary of Kentuckys biodiversity, see Abernathy, White, Laudermilk, and Evans, *Kentucky's Natural Heritage: An Illustrated Guide to Biodiversity* (The University Press of Kentucky, 2010).

Meeting the Challenges to Preserving Kentucky's Biodiversity

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This is an exciting time for biological diversity— more than 15,000 species are discovered each year, and there are currently ca. 1.5 million described species, with many millions more yet to be described (May 1988). However, we are at a crossroads in terms of preservation of biodiversity. The earth is drastically different than it was even 200 years ago and especially compared to 10,000 years ago because of the expansion of human populations and continued encroachment on natural areas. Humans have altered every ecosystem on earth (Groom et al. 2006). There have been five mass extinction events through the history of life, and most scientists recognize that we are currently in the midst of a sixth, human-caused mass extinction event (Pimm et al. 1995). Whereas each of the historical events occurred over hundreds of thousands or millions of years, the current event is occurring much faster: on the order of hundreds of years. Many groups of organisms are declining at rates far greater than historic background rates of extinction; for example, amphibians are declining at more than 200 times the background rate (McCallum 2007). As many as one-fifth of all vertebrate species are threatened with extinction; however, without conservation efforts, the number of threatened species would likely be 20% greater (Hoffmann et al. 2010). Thus, conservation works, but maintaining biodiversity will require new perspectives on management, preservation, and conservation. Although these are global issues, they are manifest right here in Kentucky.

The current and historical geography of Kentucky have contributed to the rich diversity present in the state. In the West, biodiversity is influenced by the landscapes associated with the Mississippi Alluvial valley, including bottomland hardwood forests and cypress swamps. In eastern Kentucky, mountains and plateaus formed hundreds of millions of years ago and have shaped a diverse geology, which further supports the rich biodiversity. For example, Kentucky harbors thousands of species including over 2,000 plants, 54 crayfishes, 56 mussels, 12 aquatic snails, over 15,000 insects, 245 fishes, 43 amphibians, 54 reptiles, 67 mammals (including 15 bats), and 370 species of birds. At least one hundred species are endemic to Kentucky (found in no other states). Kentucky also has numerous species of cave-obligate species (10% of our endemics). However, dozens of species have gone extinct in recent decades (probably thousands over the geological time span), including up to 20% of mussel species (Abernathy et al. 2010). Forty-three species are currently listed as federally threatened or endangered in Kentucky including 9 plants, 20 mussels, 1 shrimp, 1 beetle, 6 fish, 1 reptile, 2 birds, and 3 bats. Additionally, 1 species of fish and 4 species of mussels have been proposed for listing, and 12 species are candidates for the federal endangered species list (http://www.fws.gov/frankfort/pdf/ky_te_list_apr_11.pdf). In addition to the federal listing, the Kentucky State Nature Preserves Commission maintains a list of state-listed rare species that includes 727 taxa.

Counting the number of species is the simplest way to evaluate biodiversity, and this level of diversity can be measured locally, regionally, or in terms of variation or change across the landscape. However, other units of measuring biodiversity are important to understanding the evolutionary and ecological value of biological diversity in Kentucky. Genetic diversity measures the variety of unique alleles and can provide insight into the evolutionary potential as well as historical population limitations. Biological diversity can also be measured by the community and ecosystem interactions of species. Some species are richly connected such as in complex food webs, whereas others function in relatively simple communities with few inter-species interactions. Species at high trophic levels can act as keystone species by causing trickle-down changes to populations of other species such as through predation (e.g., wolves). By contrast, producer species can serve as foundation species by providing resources to support a large chain of consumers at higher trophic levels, such as the historic role of the American chestnut. In addition to the community-level interactions among species, foundation species may also play a disproportionate role in affecting ecosystem-level processes such as biogeochemical cycling. Several species in Kentucky also create important connections with other regions of the world. For instance, monarch butterflies populations are connected over time and space by migration to Mexico, and the black-throated blue warblers that breed in Kentucky's southeastern Appalachians tend to winter in distinct regions of the Caribbean (Webster et al. 2002) Thus, the biological, physical, and geochemical interactions of species provide a much broader level to our understanding of the function and value of diversity.

Threats to biodiversity

It is difficult to assess the pre-Columbian effects of humans on the regional landscape, but since European colonization beginning in the late 1700s, human-caused effects on the biodiversity and distribution of habitats have been substantial. At least 50 species have gone extinct (Abernathy et al. 2010). In addition to the lost species, ecosystem interactions and community composition have been substantially altered by several historical factors, including the loss of the American Chestnut as a foundation species to forests of the eastern United States in the 1930s and 40s and conversion of natural forested ecosystems to human land uses for agriculture, pastures, and silviculture over the last two centuries.

Continuing the legacy of the past two centuries, humans continue to alter natural landscapes for agriculture, forestry, and other land use practices. In Kentucky, conversion of natural areas is primarily for coal mining, agriculture, pastureland, and human development. Some land-use changes are irreversible (e.g., urbanization), while others are at such a high level of disturbance that recovery to original natural condition is improbable and recovery to another natural state will take centuries (e.g., mountain top removal and valley fill for coal extraction). Other land uses are reversible in that converted lands can be restored to somewhat natural conditions (e.g., pastures and agricultural fields). Currently, the most severe impact to natural areas globally is urbanization. Regardless of the type of land use, as suitable habitat becomes fragmented, natural ecosystems are impacted with most non-human organisms experiencing declines. This reduction in numbers and connectivity across the landscape has synergistic effects with other factors that result in low biodiversity, altered community dynamics and structure, lower long-term population viabilities, and reduced abilities to respond to environmental changes (Young and Clarke 2000, Rosenzweig 2001). In addition to land-use changes, other threats to biodiversity include the spread of invasive species, infectious diseases, pollution, overharvesting, and climate change.

In the following sections we use two case studies to illustrate the complexities of the threats to biodiversity in terms of the different sources, the interactive ecological effects, and the challenges to managing natural resources. In the first example, we describe the potential ecological effects of an invasive insect pest and discuss integrative management approaches for addressing the problem. In the second case study, we describe the loss of natural isolated wetland habitats, which lost federal protection as a result of a 2001 US Supreme Court ruling, and illustrate the role of adaptive habitat management as a tool to mediate the impacts to biodiversity. Additionally, each case study demonstrates the importance of understanding population processes at local scales and how these vary for different species in the same community experiencing the same landscape conditions. These local-scale processes drive regional patterns of biological diversity.

Case Study 1: Bird communities predicted to shift with decline of eastern hemlock forests in Kentucky.

The eastern hemlock (*Tsuga canadensis*) is a long-lived conifer with a range that extends across the Appalachian mountains of eastern North America, and includes much of eastern Kentucky. This shade-tolerant species occupies understory habitat in stream drainages, and can also be found along some ridges. Where abundant, hemlock plays a foundation role in the ecosystems by stabilizing various ecosystem dynamics and influencing composition of animal communities (Ellison et al. 2005). Eastern hemlocks influence the environmental and ecological conditions of a forest including local air and hydrologic temperatures, soil pH, and the physical structure of the forest (Snyder et al. 2002, Ellison et al. 2005). These specific habitat conditions influence the biodiversity of the forest and neighboring streams.

Hemlock woolly adelgid (*Adelges tsugae*), hereafter HWA, is a non-native invasive insect responsible for widespread mortality of eastern hemlock across eastern North America (Figure 1). HWA is a small insect in the Family Hemiptera that feeds by sucking starches and other photosynthates from the base of leaves. It appears to disperse during the first instar stage via wind, hikers, birds, and other animals (McClure 1990). In recent decades, HWA has spread over most of the native range of eastern hemlock resulting in changes to forest structure and ecosystem functions (Figure 2) (Ellison et al. 2005, Stadler et al. 2005, Nuckolls et al. 2009). For instance, in New England, infested

Figure 1. Hemlock woolly adelgid infestation of an eastern hemlock tree branch. *Photo by Chris Evans, www.bugwood.org.*

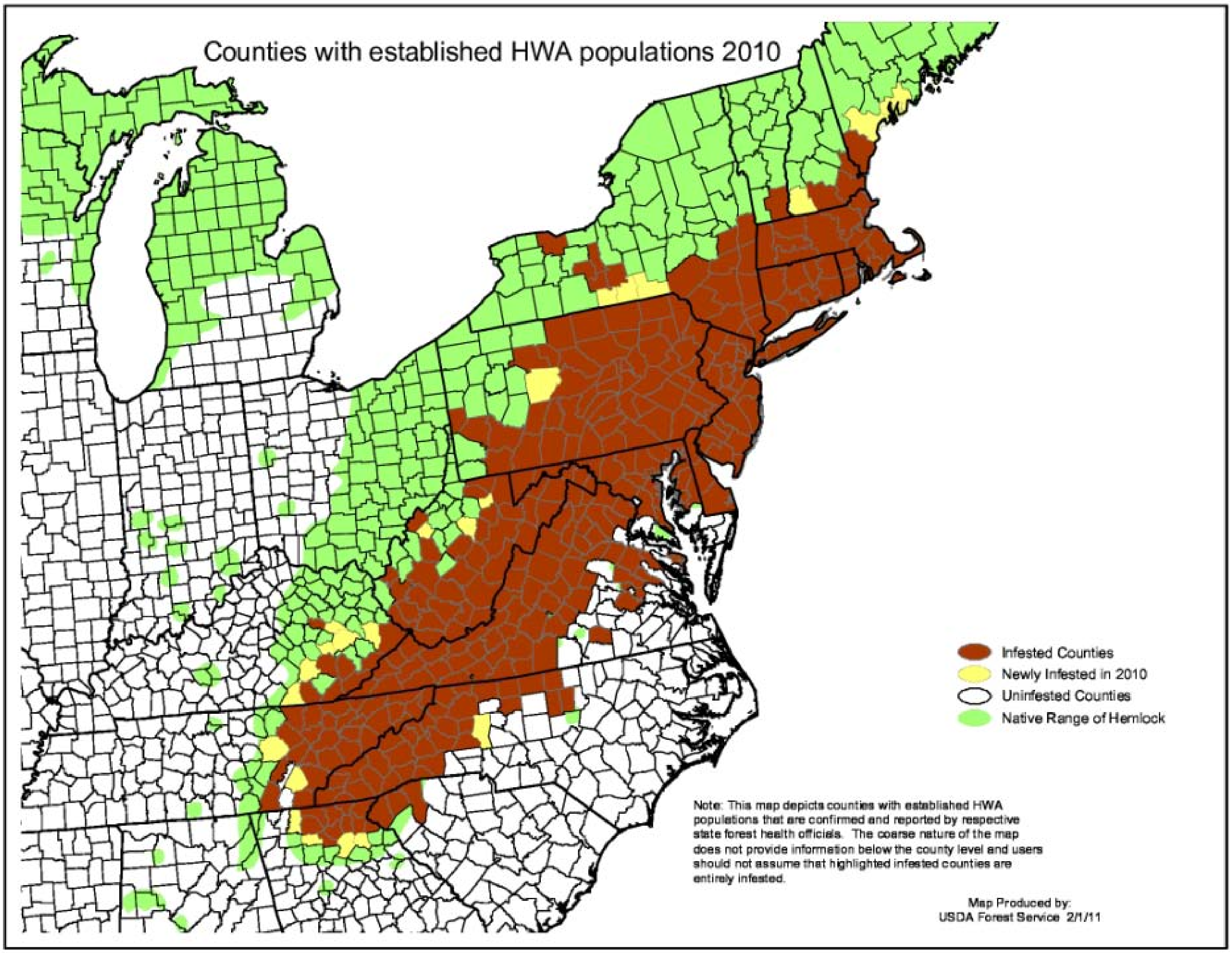

Figure 2. County-level distribution of hemlock woolly adelgid (red and yellow) and the uninfested natural range (green) of eastern hemlock as of 2010. From U.S. Forest Service.

trees had a higher abundance of epiphytic microorganisms and different patterns of precipitation throughfall than uninfested trees (Stadler et al. 2005), and as hemlocks died back, they were replaced by birch, maple and other hardwood species (Orwig et al. 2002). In North Carolina, hemlock infestation and mortality dramatically altered the forest carbon cycling over a short time span of just several years (Albani et al. 2010).

The range of HWA has recently expanded to include parts of Kentucky, and is predicted to spread throughout most of the range of hemlock in Kentucky (Clark 2010). Selected areas are being preemptively treated to protect hemlock trees, but the hemlock forests of Kentucky will likely experience drastic change. Hemlock mortality can exceed 95% of trees and may occur within as little as 5 years, but in some regions trees survive for decades (Orwig and Foster 1998, Onken and Reardon 2010). Whereas HWA spread seems to be limited by cold temperature at its current northern range limit (Paradis et al. 2008), southern states are becoming infested and experiencing mortality more rapidly. It is likely that extensive hemlock mortality will significantly alter the local-scale structure, biodiversity and ecological interactions. Many fear that the forest changes will be analogous to the effects following the loss of the American chestnut last century. Land managers need guidance and accurate information on how communities will respond during this critical period of early invasion in Kentucky.

Here in Kentucky, researchers are approaching the HWA problem from several directions. Researchers at the University of Kentucky, Lynne Rieske and Songlin Fei, and their students, Heather Spaulding and Josh Clark, have been studying the ecology and distribution of hemlock and HWA in an effort to predict the impact of the pest. Clark and Fei have found that most of the hemlock forests in eastern Kentucky are susceptible to HWA, and their modeling has provided managers with detailed maps of the distribution of hemlock forests (Clark 2010). These maps provide managers with basic information that is vital to developing and implementing good conservation strategies. Spaulding and Rieske used a short-term field study of forest responses to HWA to develop predictions of expected changes in forest structure and composition during the coming decades. They predict that HWA will lead to increased canopy gaps and succession of hardwood deciduous trees. In this case study, we describe research conducted by Eastern Kentucky University faculty, David Brown, and his student, Todd Weinkam, to describe bird species-hemlock forest associations and to develop predictions of which Kentucky bird species are at risk from the spread of HWA.

Several studies have highlighted strong associations of bird species with hemlock forests in other regions of the eastern United States including Acadian flycatcher (*Empidonax virescens*), blue-headed vireo (*Vireo solitarius*), black-throated green warbler (*Dendroica virens*), blackburnian warbler (*Dendroica fusca*), and hermit thrush (*Catharus guttatus*) (Ross et al 2004, Tingley & Orwig 2002). For at least one species, Acadian flycatcher, breeding density was negatively correlated with HWA-induced hemlock defoliation, indicating that this species may experience decline due to HWA (Allen et al 2009). Some bird species are negatively associated with hemlock (Tingley and Orwig 2002), but these are of less concern from a conservation perspective since habitat availability for these species will likely increase with the decline of hemlock forests.

We used bird survey data collected in 2009 from 271 locations including sites with hemlock forest (N = 123) and sites with other forest types (N = 148). Birds were surveyed using standard point count procedures by biologists with special training in bird identification and included personnel from Eastern Kentucky University, Kentucky Department of Fish & Wildlife Resources, and the United States Forest Service. To illustrate the overall difference in bird communities in hemlock compared to other forest types, we present graphical results of an ordination technique, non-metric multidimensional scaling. Based on the clear spatial separation of hemlock and other forest sites, the ordination analysis suggests strong differences in the composition of bird communities between these hemlock and other forest habitats in the Appalachian mountain region of Kentucky (Figure 3).

To describe habitat associations for individual species, we used logistic regression to model presence/absence of birds based on presence/absence of hemlock within 50 m of each survey location. We statistically controlled for variation attributable to the clustered distribution of survey locations by including local watershed as a blocking variable in the logistic regression model. We applied this analysis to 23 species detected at 50 locations or more. We found four bird species to be positively associated with hemlock: Acadian flycatcher, blue-headed Vireo, black-throated green warbler, and black-and-white warbler (Mniotilta varia). Black-throated green warblers were more than nine times more likely to be detected in hemlock than other forest types, and blue-

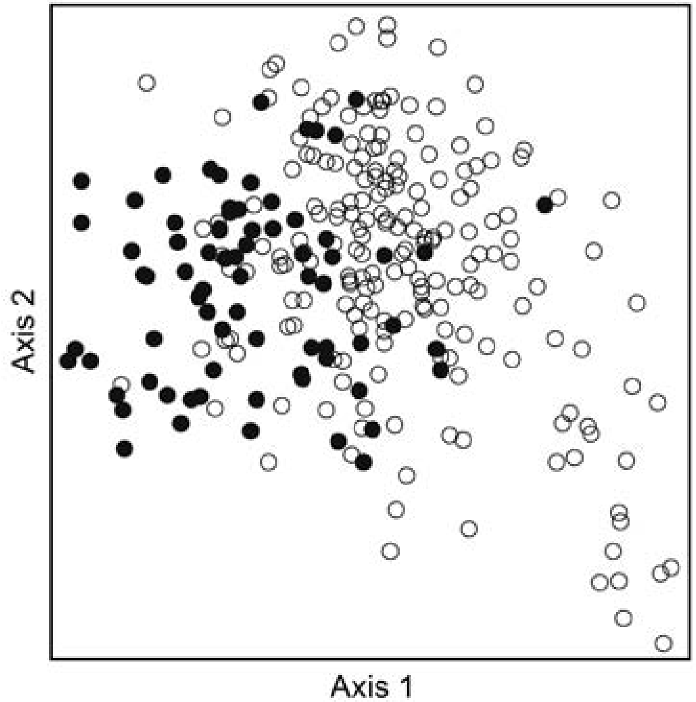

Figure 3: Graphical analysis illustrating difference in bird communities in hemlock forests (solid dots) compared to other forest types (open dots) in the Appalachian mountain region of Kentucky. Each dot represents a field site. Axis 1 and 2 represent summary values of presence and abundance for all bird species detected.

headed warblers were almost six times more likely to be found in hemlock. All of these species have been found to associate with hemlock in other states (Tingley et al. 2002, Keller 2004, Ross et al. 2004, Becker et al. 2008, Allen et al. 2009). Thus, our results are consistent with other research from across the range of eastern hemlock and provide state-specific information on bird-hemlock associations.

As HWA spreads through Kentucky, land managers are using a combination of chemical and biological control methods to protect individual and stands of trees. Unfortunately, there are few guidelines and almost no research on the number, density, and spatial extent of trees that need to be preserved to maintain biodiversity and ecosystem functions. To provide such information for at-risk bird species, we used Poisson regression to statistically model the area of hemlock at the watershed-scale that best predicts bird presence. We applied this model to black-throated green warbler and blue-headed vireo because they had the strongest associations with hemlock. Hemlock density was estimated from an eastern hemlock distribution map developed specifically for eastern Kentucky using the overlap of three separate species distribution models applied to Landsat data (Clark 2010). We predicted that the minimum area of hemlock per watershed necessary for the presence of black-throated green warblers to be 320 hectares (95% CI 100 -1000 ha). Blue-headed vireos appear to require even greater extent of hemlock with a minimum area of 1100 hectares (95% CI 870 – 4000 ha). This suggests that relatively large patches of forest containing hemlock are necessary to ensure that species, such as black-throated green warbler and blue-headed vireo, maintain current population densities. Further research will be necessary to determine the necessary density and spatial arrangements of hemlocks within these areas.

Swainson's warbler (*Limnothlypis swainsonii*), a species of special concern in Kentucky, may also be at further risk from the spread of HWA. This species preferentially nests in young hemlocks in North Carolina (Lanham and Miller 2006), and other habitats with dense shrub layers (Graves 2002, Bassett-Touchell and Stouffer 2006). Swainson's warbler are notoriously difficult to detect using traditional survey methods, yet we detected Swainson's warblers in more than 25% of hemlock sites where we used playback vocalizations of the bird's song and call (N = 60 sites). Thus, this species may also be associated with hemlock habitat, but additional targeted research is needed.

The bird communities in hemlock forest of Kentucky will likely change in predictable patterns as hemlocks die and are replaced by other tree species. Several bird species appear to be at risk of losing preferred habitat as hemlock disappears from eastern Kentucky. Species that are the most closely associated with hemlock including Acadian flycatcher, blue-headed vireo, and black-throated green warbler, will likely experience the most dramatic change in abundance due to HWA, and it is possible that these species will disappear entirely from some areas. As hemlock is replaced and forests transition to other forest types such as early successional mixed-deciduous forest, some bird species will likely benefit by the addition of breeding areas. This study focused on breeding birds and does not address the impact of hemlock loss on birds during migration or the winter season. However, we would predict the impacts during the non-breeding season to be minimal because species present during those periods tend to be more generalist in their habitat use. Based on these findings, we argue that it is imperative to protect hemlocks, especially relatively large patches with high density of hemlock.

The Kentucky Department of Fish and Wildlife Resources (KDFWR), the state agency responsible for monitoring biodiversity in Kentucky, has closely followed the spread of HWA. In anticipation of the effects of HWA, KDFWR recently listed the black-throated green warbler as a Species of Greatest Conservation Concern under the state Wildlife Action Plan. This proactive approach to management suggests that managers appreciate the risk of HWA. We recommend resources managers continue to monitor bird populations and forest ecology, and maintain flexibility to adjust management approaches as research advances.

Management for HWA typically involves insecticide treatments of individual trees or release of beetles as HWA predators. Soil and tree injections of insecticide appear to be the most effective and efficient short-term methods and provide protection for several years. Recent research on the primary pesticide used for such treatments, imidacloprid, suggests that it has minimal negative effects on nearby stream invertebrates (Churchel et al. 2011). The US Forest Service has conducted an ecological risk assessment of imidacloprid and found no substantial adverse effects when applied by soil or tree injection (http://www.fs.fed.us/foresthealth/pesticide/pdfs/122805_Imidacloprid.pdf). Although additional research on the ecological effects of this pesticide is warranted, the benefits it provides to protecting hemlock appear worthwhile. In the Smoky Mountains, land managers have treated more than one hundred thousand trees. In Kentucky, the number is probably closer to ten to twenty thousand treated trees. For biological control efforts, rearing of predatory beetles is now occurring at six institutions and hundreds of thousands of beetles have been released across the range of eastern hemlock. In some cases, predator populations have become established and appear to be related to increased health of hemlocks (Onken and Reardon 2010). Thus, there is hope that biological control efforts will be successful.

Kentucky is in the early stages of infestation, but land managers here appear to have learned lessons from other states, and are taking a more proactive approach in treatment efforts that include preemptive treatments which combine biological (beetle introductions) and chemical methods (Imidacloprid pesticide root injections). However, the challenge will only increase as HWA spreads and initial pesticide treatments have to be repeated. Many hope that HWA will move in a wave and populations of the insect will eventually decrease, but realistically, land managers must be prepared to combat HWA for decades to come.

Successful monitoring and management of ecological problems occurring at large spatial scales require long-term coordination and planning. At a regional level, HWA research and management is coordinated by the US Forest Service's HWA Initiative with a budget of more than $1 million for each of the last four years. Within Kentucky, management varies among locations in an ad-hoc fashion, and research centers on the work of the UK Invasive Species Working Group. Numerous state and federal agencies, universities, and non-governmental organizations such as *Save-the-Hemlocks* have been actively involved in research and management but there is no state-wide plan to address the long-term and wide-scale nature of the problem. We suggest that the land managers and HWA researchers of Kentucky need to better communicate and coordinate to develop a state-wide plan that includes spatial considerations such as the density and distribution of hemlocks and standardized monitoring and management approaches. Such a plan will facilitate research into more effective management methods. In the long run, the key to success will be vigilance (i.e. monitoring) and persistence (i.e., reapplication of insecticide treatments), and integrative management that includes coordination of state and federal agencies, NGOs, and universities to secure funding and continue management. The HWA issue is representative of numerous ecological threats to biodiversity. These types of wide-scale threats are best addressed by integrative management approaches tightly coordinated among multiple management and research institutions to leverage funds and other resources including citizen volunteers.

Case Study 2: Ridge-top wetland ecosystem of eastern Kentucky

Wetlands are one of the most important ecosystems on earth because of the functions they perform and the unique habitat they provide (Mitsch and Gosselink 2007). Wetlands are typically considered as transitional areas between water and land and naturally function to reduce the severity of flood and drought events, to filter sediments and pollutants from surface water, to provide habitat for diverse biological communities, and to serve as important carbon sinks and climate stabilizers (Mitsch and Gosselink 2007). These processes serve ecological functions, provide services to humans, and enhance biological diversity.

Kentucky has a diversity of wetland types primarily due to the variety of ecological regions including the Appalachian Mountains and the Mississippi River alluvial valley. Unfortunately as of 1980, Kentucky had lost > 80% of its wetlands, which ranked in the top 15% of US states in terms of wetland loss (Dahl 1990). In fact, most natural wetlands in the U.S. and in other industrialized nations have been lost. Consequently over the past four decades, wetlands have been constructed for wildlife management or as mitigation in response to the Clean Water Act. However, the success of most constructed wetlands in replacing original functions and biological communities is unknown, and scientific research following construction or restoration is needed to determine success of the project and inform future projects.

In this case study, we focus on one particular type, forested ridge-top wetlands, and their associated biological communities, with particular focus on amphibians. Although most of Kentucky's historic and remaining wetlands are in the western portion of the state, forested ridge-top wetlands are found primarily in the eastern portion of the state, scattered across the Cumberland and Allegheny Plateaus and Appalachian Mountains. While wetlands on slopes are ecologically and hydrologically important and provide services to humans, wetlands in bottomlands and ridge tops with somewhat flat topography are the primary breeding habitats for amphibians. Bottomland wetlands tend to have permanent to semi-permanent hydrology, whereas ridge-top wetlands are typically ephemeral and are not necessarily situated between land and water. Wetlands like these on ridge tops, for which the hydrologic link is not obvious, are termed isolated wetlands because they are not connected to surface waters of streams, rivers, or lakes. However, the name is misleading because they are associated with groundwater and their hydrology is sufficient to support hydrophytic species (Mitsch and Gosselink, 2007). So although wetlands located on ridge tops have different hydrological, ecological, and human-service functions from those on slopes or in bottomlands, their importance should not be undervalued.

Biological communities in wetlands are structured primarily by hydroperiod (duration of surface water), and to a less extent, water depth. Here we focus on how hydroperiod affects amphibian communities, a group of organisms experiencing sharp population declines and local extinctions for many species worldwide and within Kentucky. Wetlands with permanent hydroperiods support fish and other aquatic top predators, but environmental conditions tend to be more stable than for ephemeral wetlands, which completely dry down. Ephemeral wetlands lack aquatic top predators but offer a less predictable environment for reproductive success (Wellborn et al. 1996). A community of amphibians that specializes in ephemeral, isolated wetlands of eastern Kentucky includes wood frogs (*Lithobates sylvaticus*), marbled salamanders (*Ambystoma opacum*), spotted salamanders (*A. maculatum*), Jefferson's salamanders (*A. jeffersonianum*), four-toed salamanders (*Hemidactylium scutatum*), eastern spadefoot toads (*Scaphiopus holbrookii*), spring peepers (*Pseudacris crucifer*), mountain chorus frogs (*P. brachyphona*), American toads (*Anaxyrus americanus*), and Fowler's toads (*An. fowleri*).

The ability of pond-breeding amphibian species to persist on the landscape depends primarily on availability of suitable wetland breeding sites. Therefore, understanding what characteristics make a wetland suitable is obviously important, especially given the ongoing decline of amphibian species. One third of all amphibian species are listed as threatened or endangered on the Red List of the International Union for Conservation of Nature, and although there are multiple causes for declines and extinctions, habitat loss and alteration are the primary cause (Stuart et al. 2004). Wetland destruction has contributed to amphibian declines and local extinctions in Kentucky and globally.

Ridge-top forested wetlands are no different from other wetland types in that most have been altered or destroyed by humans. Because of their small size and depth, landscape position, and limited hydrology, they can be efficiently drained and filled. Frequently, these wetlands are also altered to make them larger, deeper, and permanent. Because these isolated wetlands are typically not jurisdictional (Environmental Law Institute 2008), replacement wetlands are not required and loss and alteration continues to be under-documented. Nonetheless, isolated, ridge-top wetlands have been constructed in the Daniel Boone National Forest (DBNF) and in various Wildlife Management Areas of eastern Kentucky for wildlife management and habitat enhancement for > 50 years. Eastern Kentucky University faculty, Stephen Richter, and his students, Rob Denton, Andrea Drayer, and Susan King, have been studying constructed wetlands on ridge tops in the DBNF and comparing their characteristics and amphibian communities to natural wetlands to determine their suitability for species of the natural community of amphibians. Two graduate student Master's theses have resulted (Denton 2011, Drayer 2011) and one study is ongoing (S. King, in progress). Here we summarize our primary results and discuss an adaptive approach to management and wetland construction to preserve natural biodiversity.

Figure 4a *Photo taken in winter 2011 by Stephen Richter*

Figure 4b *Photo taken in spring 2010 by Rob Denton*

Figure 4. Natural ridge-top wetlands in eastern Kentucky: (a) example with less vegetative complexity and (b) example with vegetative complexity.

We found that natural wetlands in this ecosystem vary in plant species composition and abundance, habitat complexity, and size whereby some are small and devoid of much plant life (Figure 4a) and others are large with complex habitat (Figure 4b). The original intent of constructed wetlands on DBNF was for game wildlife (i.e., turkey and deer) management. Constructed wetlands were typically built within or adjacent to openings cleared in the forest and planted with grasses for game population enhancement. These original constructed wetlands were bowl shaped, deep, and had high dams (Figure 5a). The goal was to provide a reliable supply of water to wildlife on ridge tops where permanent sources typically did not occur. In recent years, the purpose for constructing wetlands has shifted to include non-game wildlife, including bats and amphibians. Similar to wildlife ponds, bat ponds were constructed with permanent hydroperiods, but in areas with open canopies to allow bat flyways.

In recent years, we initiated contact with Tom Biebighauser, who is a biologist with the US Forest Service, about the wetlands he had been constructing in the DBNF. Andrea Drayer began research to compare amphibian communities between constructed and natural wetlands. She found that constructed wetlands were dominated by amphibian species that require long hydroperiods (bullfrogs, green frogs, and newts), which are top amphibian predators (Drayer 2011). Conversely, she found that natural wetlands only supported amphibians specialized to short hydroperiods (e.g., wood frogs and marbled salamanders; Figure 6). Subsequently, she investigated the role of constructed wetland depth in controlling amphibian communities and found that shallow constructed wetlands tended to be more similar to natural wetlands (Figure 5b). Rob Denton focused his research on the newest generation of wetlands that were built with an amphibian focus (Figure 5c), so they included more coarse woody debris,

Figure 5a *Photo taken in fall 2009 by Stephen Richter*

Figure 5b *Photo taken in fall 2009 by Stephen Richter*

Figure 5c *Photo taken in spring 2011 by Rob Denton*

Figure 5. Constructed ridge-top wetland in eastern Kentucky: (a) deep, original construction method, (b) shallow, original construction method, and (c) shallow, amphibian-focused (2nd generation) construction method.

Figure 6a *Photo taken in winter 2011 by Stephen Richter*

Figure 6b *Photo taken in fall 2010 by Rob Denton*

Figure 6. Two amphibian species that are specialized for breeding in ephemeral wetlands: (a) wood frogs, Lithobates sylvaticus, and (b) marbled salamanders, Ambystoma opacum.

had small dams, less slope to center, were shallower, and were designed to dry out for at least part of the year (Denton 2011).

The results from their research indicated that most constructed wetlands did not dry even though some were < 12" deep and that the natural amphibian community as a group was only found in natural wetlands. However, some species of this natural community were found in constructed wetlands and varied in abundance along the hydrologic gradient. As a result, many species of the natural community co-occurred with the species adapted for permanent hydroperiods, which historically were absent (bullfrogs and green frogs) or in lower abundance (newts) in this ecosystem because of the lack of permanent wetlands. To quantify differences in amphibian species and physical characteristics between natural wetlands and wetlands of each construction type, we present a generalized figure based on ordination results from a redundancy analysis of Rob Denton's study sites. Natural wetlands are clearly separated from all old construction method sites and most new construction method wetlands in terms of species presence, abundance, and site characteristics (Figure 7). The primary variables responsible for this separation are canopy closure, course woody debris, depth, and hydroperiod. Species that are exclusively found in either natural or constructed wetlands are included along the gradient of characteristics to indicate wetlands with which they were associated (e.g., wood frogs were found in wetlands that had high canopy closure, more coarse woody debris, shorter hydroperiods, and shallower depths).

What does this mean for the natural amphibian community and natural ridge-top wetland ecosystem? To date, we have documented patterns of amphibian communities that can be used to adjust construction methods to benefit amphibians and other native species. However, we need to understand better the mechanisms that drive these patterns to inform more effectively the construction of wetlands. Studies need to focus on amphibians and on construction methods. Amphibian-focused studies need to investigate the factors that affect survival and reproductive success of species of the natural amphibian community in constructed wetlands. Presence of adults, larvae, or eggs in constructed wetlands does not necessarily indicate that a population is established, growing, and acting as a source for other wetlands. For example, Andrea Drayer observed wood frogs breeding in permanent constructed wetlands, but because newts were already in the wetland, they immediately began consuming the eggs. During subsequent sampling, she found no wood frog larvae. Additionally, she found four-toed salamander egg clutches at constructed wetlands but did not determine their success. The ongoing thesis research of Sue King will address survival of this species in constructed compared to natural wetlands.

One other major research need is in the area of disease ecology and transmission. Species of the natural community are

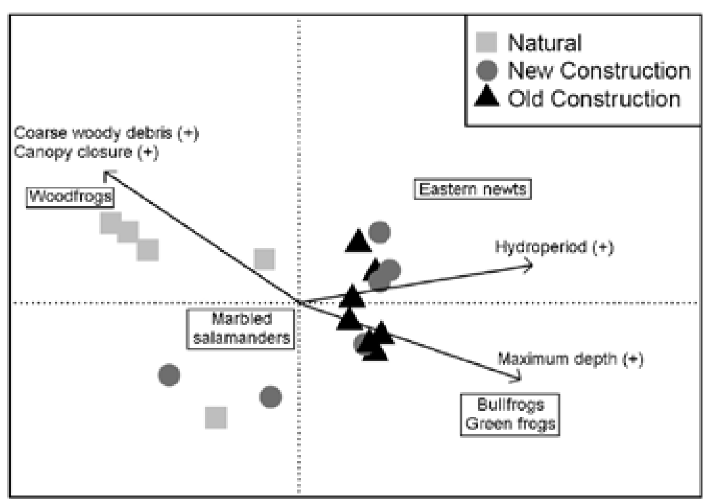

Figure 7. Summary graph of multivariate ordination results depicting clustering of wetlands based on similarity of amphibian communities and habitat characteristics.

Figure 8a

Figure 8a

Figure 8. (a) Example of newest (3rd generation) construction method and (b) remodeled original construction ridge-top wetlands in eastern Kentucky. *Photos taken in winter 2011 by Rob Denton*

susceptible to multiple amphibian diseases; however, populations tend to persist in the presence of disease, unless natural conditions are altered. Diseases are less virulent in ephemeral ponds because they dry and in shallow ponds because they reach high temperatures that typically kill diseases. Based on previous studies, we predict that the construction of permanent wetlands in the ridge-top ecosystem has increased the probability of diseases affecting the natural community because deep, cool, permanent ponds offer optimal conditions for disease persistence in the environment and in amphibians. Perhaps more threatening is that, in addition to being top predators, bullfrogs are reservoirs of disease (i.e., they carry but typically do not die from them). Because bullfrogs are highly mobile and reservoirs of disease, constructing wetlands across the ridge-top landscape that have optimal conditions for diseases and serve as breeding sites for bullfrogs allows an unnatural abundance of diseases and of bullfrogs that is predicted to have major negative impacts on natural amphibian community persistence.

Studies also need to be designed with construction techniques as a focus. We have documented patterns in canopy closure and hydroperiod across natural and constructed wetlands. We found that canopy closure varied among wetlands, especially between natural and constructed. Canopy closure affects water chemistry (i.e., pH, dissolved oxygen), temperature, and primary productivity (algae and plant abundance), which are documented to affect species composition in wetlands and affect less obvious factors like predator-prey interactions, competitive ability, and disease susceptibility. In natural wetlands, hydroperiod is primarily driven by size of the watershed, underlying soil composition, and depth of concavity. In constructed wetlands, we have found that depth and watershed size are less important and that as long as soil composition is primarily clay, soil compaction drives hydroperiod. Compaction also impedes the ability of trees and herbaceous vegetation to colonize sites. Future studies will address soil compaction and composition in constructed wetlands in an effort to determine conditions necessary to replicate the natural drying cycle.

What are the next steps that need to be taken? The solution appears to be simple— construct wetlands that replicate natural wetlands. However, defining natural is not straightforward, especially because the natural landscape now has hundreds of constructed wetlands. We need more data to understand what natural is and if and how the current spatial configuration of wetlands needs to be altered. We have been working closely with the US Forest Service, especially Tom Biebighauser, with an adaptive management approach that uses our research results to develop modified construction methods. Adaptive management is a cyclical process used to refine the effectiveness of natural resource management using scientific research to evaluate the success of management, making adjustments to management policy, and following this with implementation and additional research to further refine management (Salafsky et al. 2001). As new methods are recommended and implemented, we plan to study their effectiveness. As an example, based on our data and interactions with the Forest Service, wetlands are now being constructed with more complexity and likelihood for drying (Figure 8a), and original constructed wetlands are being remodeled by lowering dams, adding complexity, and adding shallow areas (Figure 8b). Rob Denton began studying these wetlands this field season, and the results of this research will undoubtedly guide future construction methods.

Historically, a diversity of wetlands existed across the landscape of Kentucky with a variety of hydrologies, proximities to streams and rivers, and plant communities. These wetlands along with streams and rivers in the area provided essential water resources for most native organisms. Because > 80% of Kentucky's wetlands have been lost and the hydrology of most streams and remaining wetlands have been heavily degraded (Parola and Hansen 2011), restoration of both is critical to providing water to the natural community of all organisms, especially during drought periods. Construction of wetlands to replace those lost is a critical practice to combat the loss of biodiversity dependent on wetland systems. Organisms at risk include obligate wetland species (e.g., many species of amphibians, invertebrates, and plants) and species that depend on wetlands as sources of water as they move across the terrestrial environment (e.g., many amphibians, reptiles, bats and non-volant mammals, and birds). Scientific studies with a community-based perspective of biodiversity can help inform and improve restoration and management.

Conclusions

Although many new species are being discovered globally, biological diversity is threatened as populations decline and species go extinct because of human population growth. Kentucky has a rich biodiversity at the level of genes, species, and ecosystems. The Cumberland Plateau and Appalachian Mountains region, in particular, harbors globally high levels of mollusks, fish, amphibians, and birds. The habitat of Kentucky is threatened by human activities including energy development, logging, introduction of non-native species, and global climate change. Maintaining biodiversity will require new perspectives. Intensive research to characterize the biodiversity and the interactions of species is critical to developing sound policies and integrative management solutions to govern land use and respond to other threats to biodiversity. We have highlighted two problems facing this region, the spread of the invasive hemlock woolly adelgid and the loss of wetlands, to illustrate the environmental problems affecting our region and the complexity of addressing these problems. These examples also illustrate different approaches to management, and the role of scientific research as a tool for guiding restoration and management. Other challenges, including energy development, pose an even greater risk to the preservation of biodiversity and the ecological interactions of the region and will require unique and challenging management solutions that include adaptive approaches based on the best available science. Slowing the loss of biodiversity is best approached through the cooperation of scientists, agencies, and citizens with coordinated and integrated initiatives.

The case studies also make obvious that preserving and restoring all ecosystems to a more natural state is a massive undertaking and will require not only the concerted efforts of scientists, governmental agencies, and non-governmental (NGO) agencies, but also activists, politicians, and the general public. For example in Kentucky, there is a major ongoing project, Pine Mountain Wildlife Corridor Project, that seeks to connect existing protected natural areas along almost 120 miles of contiguous forest on Pine Mountain (www.knlt.org/pmwc.html). In Kentucky, this project is primarily a collaboration between an NGO (Kentucky Natural Lands Trust) and a state agency (Kentucky State Nature Preserves Commission) but requires communication with other agencies in Kentucky, Virginia and Tennessee, as well as significant citizen and political support. Kentucky has a diverse and well distributed collection of nature preserves, wildlife management areas, managed forests, and other natural areas that are owned by state and federal agencies, NGOs, and colleges and universities (Richter et al. 2010). These areas are sanctuaries for the biological diversity of Kentucky and offer opportunities for collaborative efforts to expand and link them.

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David Brown is an assistant professor of biological sciences at Eastern Kentucky University in Richmond. His primary area of research is wildlife population ecology, and much of his work takes place in wetlands habitats and with wintering birds. His teaching interests include Wetland Wildlife Management and Biostatistics. He received a B.A. from the University of Colorado, Boulder, an M.S. from Southeastern Louisiana University, a Ph.D. from Tulane University, and held a post-doc position at Louisiana State University.

Stephen Richter is an associate professor of biological sciences at Eastern Kentucky University. His research focuses primarily on amphibian evolutionary ecology and wetland conservation, and all of his studies have applied goals of producing recommendations for land planners and wildlife managers. Currently, he is working with David Brown and the Kentucky Division of Water to develop a rapid assessment method for wetlands of Kentucky while simultaneously studying the biological integrity of wetlands. Originally from Tennessee, he received a B.S. in Biology from Berry College in Georgia, an M.S. in Biology from Southeastern Louisiana University, and a Ph.D. in Zoology from the University of Oklahoma.

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The Hidden Confluence - Physicians, Communities, and Biodiversity

Vicki H. Holmberg, M.D.
Former President of the Kentucky Conservation Committee

At a recent educational event, a man approached me who wanted to know why a doctor of any caliber would be sitting at a table explaining biodiversity to the public. It was of particular concern to him that I was talking about mussels and their contribution to human health, outside of the culinary context.

This man appeared both well and educated. He was about the same economic and ethnic demographic as I am and the same age, which means that the word *biodiversity* had not been coined when we were both in our early years of school. He went on to say that his modern life was good, that his water came clean from the tap, without apparent help from mussels, and that “no matter how many species go extinct, human affairs on earth don’t stop, or at least they haven’t yet.”

Biodiversity, the interconnected variety of life, has always changed. But many physicians, like me, are concerned about its rate of decline in our lifetimes and about the unpredictable effects on human health in this rapid transition; and we struggle to convey this concern to the public.

In the heart of Kentucky, where this conversation was taking place, mussels (*Mytilus*) are among the first organisms to decline in contaminated streams, especially in the presence of metals and pesticides. In concert, large beds of mussels can process thousands of gallons of water daily. Drinking water standards are determined by how much pollution these organisms and other small sentinels can tolerate before they perish, all of us being beneficiaries of their presence and vulnerability.[1]

At this moment, mussels are providing what science calls *ecosystems services*, clearing bacteria and particles from our watersheds as they feed, providing food for wildlife, acting as sinks into which chemicals are collected, and protecting the folks downstream.

Mussels used to be plentiful; their shells used to make lovely iridescent buttons. Today, where I live in Kentucky, over half of them are threatened by stream destruction, overwhelming toxins, and invasive species. Even as their numbers retreat, we are discovering new ways they can help us.

In order to feed, a mussel anchors its foot to wet rock with waterproof glue, a modification that has allowed mussels to thrive in flowing water for millions of years. This year, adhesives designed to mimic these sticky mussel proteins are being tested as a nontoxic treatment to stop miscarriages from leaking membranes (Bilic 2010).

All these contributions are examples of nature’s services, which together provide a continual turnover of nutrients, water and gases; products, including modern and traditional medicines, food, wood and cloth; and more abstract offerings of beauty, inspiration and comfort, collectively supporting a decent life, as we are accustomed to it.

In good times, having over one hundred types of mussels, filtering water in Kentucky, may seem like an overabundance, but in times of disease or injury, it is apparent how important redundancy can be. Communities of living things often exhibit redundancy, and it is not always clear that any harm is done by the disappearance of a few representatives. The same can be said of an organ like the kidney, where having two can insure our well being.

Our physical relationship to biodiversity has numerous analogies. Each species has been compared to a rivet in an airplane; we are not certain how many of these rivets can loosen or fail and still allow the plane to stay airborne (Ehrlich 1981). But biodiversity is organic and more fluid than a plane. Like our bodies, an ecosystem and its components can cope with some fairly extreme changes, adapting when certain parts are damaged. But loss of a single organ can mean death, much as the loss of an important pollinator may cause an ecosystem to fail completely. A mathematical model, offered by researchers this year, predicts

how an ecosystem may function as a body does, as a framework, with diverse species being similar to cells and organs (Capitán 2011).

As physicians and scientists try to address the importance of biodiversity and ecosystems, we can appeal to the economic estimates of their value. In the United States, figures in the hundreds of billions of dollars are mentioned. But in the face of much of the world's desperation, translation of unique forms of life and natural services into hard cash values may become irrelevant. What value does a glass of clean water have, once it is exceedingly scarce- nothing, or everything? Many physicians and scientists have begun to reject, as unethical or pointless, the application of conventional measurements to the costs of creating or replacing such services, knowing that there is no realistic means of doing so. (Nunes 2001; Giles 2005)

For a rough guide to what making a human habitat from scratch would look like, I visited the Biosphere 2 in Arizona not long ago. White domes and glass arrays above the desert, it is three enclosed acres, half space station and half terrarium. This was an ambitious project of the 1990's, a prototype for a self-contained human colony on another planet. But it was not difficult to read between the lines, to discern a vision of a post-apocalyptic or utopian refuge.

Plants and animals were added to create functional biomes, including a forest and savannah, plus 500 tons of stainless steel and an underbelly called the Technosphere, for plumbing and electrical. Yet the eight dedicated biospherians who tried to live and work there were beset by the old familiar ills. There was not enough food and not enough clean air. Other deficiencies were substantial: Trees were unhealthy, because no wind was there to stress and toughen the wood; insect populations lacked balance and migration; humans toiled but found little tranquility, judging from their recorded interpersonal strife.

From the sci-fi novel beginning to the tabloid end, Biosphere 2 has been called a stunt, but it demonstrated how an enormous technological achievement can fall short of creating a sustainable earth-like environment for even a few people.

Since the 1990's, new genetic tools have revealed the communities of microorganisms in water, soil, and in ourselves, as we explore the foundations of human life. With every breath, we inhale more nitrogen than oxygen, nitrogen being far more abundant in the air. It's a shame that we cannot simply capture and use nitrogen to make the basic components of protein. For this we are dependent on soil and water bacteria. Their enzymes can break and bind sticky nitrogen molecules to other elements, allowing nitrogen's entry into the food chain, where it is built into muscle and genetic components, such as our DNA. Eventually bacteria will reverse this process, break down protein, and release nitrogen as a gas.

Seeing microscopic communities in context, confirms that many bacteria, fungi and viruses are not yet known to science.

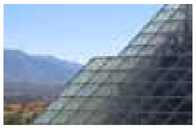
Biosphere 2, completed in 1991, contains over 6000 windows and cost over 100 million dollars to build. It was a mesocosm, originally housing nearly 4000 species, with an ocean and a rainforest.

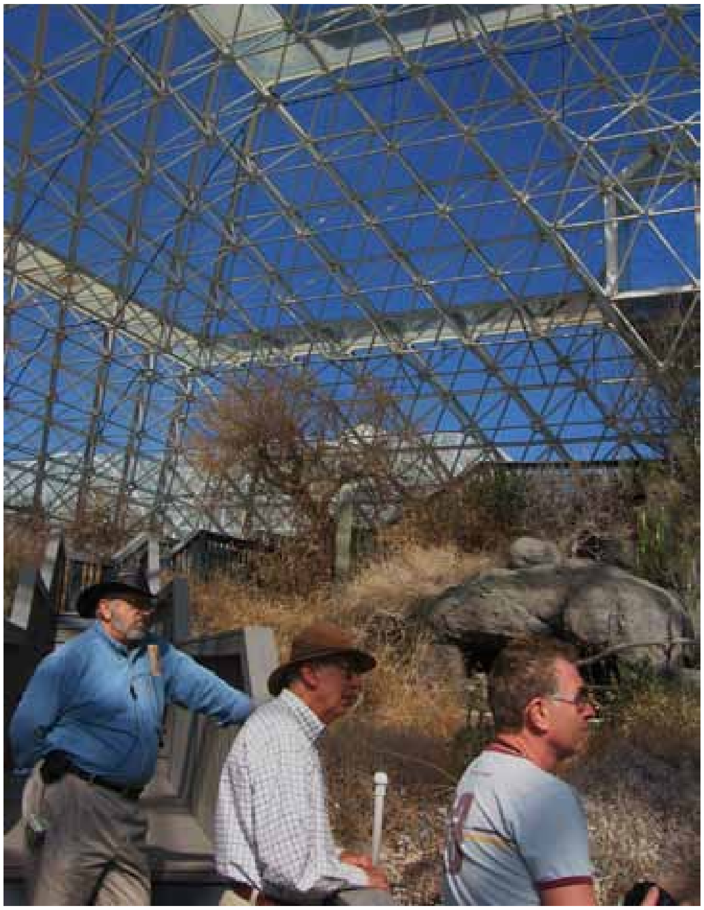
They represent startling numbers of novel opportunities for pharmaceutical and industrial applications (DOE).

For perspective, let's recall that one type of fungus originally produced penicillin to manipulate its own environment, probably to keep nearby bacteria from consuming nutrients. Penicillin was first noticed as a fascinating, anecdotal substance that killed staphylococcus in a dish. There was no guarantee that the 'mould juice' would kill bacteria in a living person, or would be nontoxic.

There was a decade-long lag between the discovery of penicillin and its availability to the public. The final breakthrough required a team of technicians and physicians, plus financial support from pharmaceutical firms. In the interim, meningitis, pneumonia, gangrene and diphtheria killed thousands, as they always had; as these diseases are unresponsive to traditional remedies, or to old sulfa drugs.

Since 2000, hundreds of products have been approved by the FDA, half of which have origins in natural plant or animal compounds. Ideally, biodiversity would be preserved for the potential value of undiscovered treasures, but overharvesting may lead to





Tourists visit the Biosphere 2, formerly an advanced system sealed from the outside that allowed precise measurements of ecological and human variables.

scarcity, or cultivation to the destruction of relatively pristine habitats. With the recent popularity of herbal medicines, raw materials flow predominantly to more developed nations, depriving less developed regions of the direct benefits of employment in processing and refinement.

Many pharmaceutical companies support biodiversity protection in principle, but in fact, they find producing medicines in the lab can be economically attractive. Once a substance is identified, it can often be refined and synthesized without the original source. Alexander Fleming received cash from the Nobel Prize for his discovery of penicillin, but he did not share in the bulk of wealth generated by its sale. Like Fleming, the person who provides a medicinal discovery from nature may not benefit from further income, creating little incentive to conserve its source's habitat. The future gives us no guarantee that bioprospecting will insure preservation.

As time goes on, the usefulness of antibiotics has been distorted by the emergence of bacterial resistance, a phenomenon that Fleming mentioned in 1945, when he spoke about the dangers of 'underdosage.'[2] For instance, low doses of antibiotics employed in agriculture, leave a few bacteria alive to reproduce and pass along their lucky, variant genes. Their offspring, like those causing the current epidemic of resistant staphylococcus, or MRSA, may be equipped with penicillinase, an enzyme that literally cuts penicillin.

Thanks to the diversity of the biological world, broader spectrum antibiotics are being found, including a prototype from soil samples that has a two pronged effect on bacterial enzymes. But concerns about resistance have prompted researchers to widen their nets. The next moves may be to mimic other types of defenses that organisms have developed or to employ the killing efficiency of viruses.

Living entities, many of whom tolerate extremes of habitat, or perform feats of endurance and migration, can provide new solutions for human ills, valuable materials, and models for manufacturing and physics.[3] We could list many examples, but the heavily-studied naked mole rat is a celebrity. He lives ten times longer than a comparable rodent, and ages elegantly, showing little evidence of wear until the very end. Better yet, none of his kind has ever been documented to have cancer. In 2011, a genetic process was identified in the mole rat that shuts off uncontrolled cell production faster and better than in other animals (Edrey). Of course, the medical community hopes to someday apply information like this to human well being.[4]

No discussion of biodiversity can be complete, without noting the role of viruses. A few years ago, most physicians might have said that viruses are troublesome and expendable bits of genetic material, not really life forms. As recently as the 1980's seawater was thought to contain few viruses, but now we know that viral populations on earth defy comprehension-millions in each drop of seawater – and ten times as many in a few grams of soil.[5] As the nonpareil predator, a virus locks onto precise cell markers, injects its own genes, and then uses the cell's machinery to make more viruses. If all of them needed human hosts, we would surely be extinct, but their usual prey is bacteria. Rupturing many of the bacteria in the ocean daily, viruses create a turnover of nutrients that drives life on earth. Carbon from the dying becomes food for new bacteria and replenishes the depths. The scale of this process makes it globally significant (Suttle 1994).

Viruses are nimble, having few parts to encumber them. They often pick up genetic components and trade them; can hide themselves in the DNA of a host and can drive evolution in bacteria. Viruses can infect aquatic food sources, but they also clear the ocean of harmful algae overgrowths. Among the dead are cholera-causing bacteria from the genus, *Vibrio*, often found living with large algal blooms, traceable by satellite. In other contexts, *Vibrio* and viruses can work together. Viral genes, 'loaned' to *Vibrio*, arm it with the toxin that causes diarrhea and dehydration in cholera outbreaks, which kill roughly 100,000 persons per year (WHO).[6] Recently, large viruses have been shown to experience predation by smaller viruses, and the trend by many researchers is to redefine them as 'living'.[7]

The idea of using the versatility of bacteria-killing viruses (*bacteriophages*) to cure disease is surprisingly old; having been a fad in the early 20th century and now making a late comeback. Today, the dream is to engineer safe viruses to target specific bacteria or to disrupt cancer cells. Anyone could be forgiven for viewing such a prospect with some ambivalence.

For the physician, much of the anxiety related to biodiversity losses revolves around the resultant changes in ecosystems that bring about resurgences of diseases, like cholera, malaria or dengue; and new illnesses and food shortages that emerge, as a result of displacements, degradation and extinctions (Daszak 2000).

We see this ebb and flow in recent history where viruses, such as HIV, have jumped the diminished physical barriers between wildlife and humans. Measles may pass from people to animals as well, endangering biodiversity further. As a result of deforestation and resulting wildlife movements, a retrovirus, Simian Foamy virus (SFV) has been transmitted, via monkey bites, to tourists in Indonesia. For now, SFV has remained quiet in the bodies of human carriers.

Similar outbreaks of illness occur when human developments degrade or fragment habitats, or when a habitat loses a key predator from an ecosystem, allowing rises in rodents, ticks and other populations that carry disease-causing organisms, such as Hantavirus.

Many well intentioned human efforts to control disease, aiming to eliminate carriers and sources, may have unexpected consequences. Standing water, an old enemy, has been sprayed to kill mosquitoes, carriers of malaria (*Plasmodium*). Pesticides, unfortunately, can induce resistance, or can kill insect predators that control mosquitoes, creating a cycle of resurgence. We drain the wetlands, only to build reservoirs; build sewers only to expand haphazard cities, where rooftops or discarded garbage will collect rain. To meet our needs for more energy, we construct dams, nearly always altering more biologically diverse areas that preceded them, leaving an imbalance that favors the development of pathogens.

Wilderness and undisturbed landscapes are fewer, while recreation and respite are needed more than ever. Nature's transformative power is evident. Even in trivial or limited forms– urban parks, flowers in the sick room--contacts with nature increase human productivity, promote faster healing, enable better learning, and ease social interactions (Groenewegen). Green space has a particularly notable effect in lessening depression (Takano 2003, Ulrich 1984). Poverty can be decreased by local resource conservation, with reciprocal support of communities (Andam 2010). Yet urgent multinational efforts, ending with The United Nations International Year of Biodiversity in 2010, have not met their benchmarks.

Otherwise sane people speak now of massive geoengineering; of large-scale DNA archiving, of substituting exotic species in some instances to preserve ecosystems, or mitigating climate change by seeding our oceans with iron.

The AMA and other prominent physicians' organizations have called their membership to the fray, viewing biodiversity's decline as a clarion call to the threat to public health (Auerbach 2008; Bernstein 2008). But the average physician, deluged by the demands of patient care, treats high anxiety and blood pressure with medications, not by advocating more parkland. No one would question the correctness of a physician who sat at a table, advising diet and exercise; but extending the physician's role to promote biodiversity, challenges preconceptions all around.

A positive sign of public awareness is the resurgence of interest in the healing, sustainable and symbolic role of food. Organic farming--with an emphasis on soil health, ecological protection, and less dependence on petroleum based fertilizers--will enhance our food security and can spare biodiversity (Hodgson 2010). Farmers' markets are booming, along with home gardens, and people are seeking a sanctuary in their own bodies from the uncertainty of chemical exposures (USDA).[8]

'Eating local' can bolster community vigor and eating what is local can support biodiversity, as food products, native pol-

Food, commerce, art , exercise, and social interaction all in one place, some of the ingredients for a healthy society. The Lexington Farmers Market, in Fayette County, Kentucky.

linators and other species intertwine beneficially. Witness the renewed popularity of the understory fruit tree, the pawpaw, (*Asimina*). A staple in the diet of pioneers and Native Americans, pawpaw produces a delicious berry-like fruit, rich in nutrients, but has a bitter chemical in the leaf that possesses antimalarial and antitumor properties, and that repels most insects. The Zebra Swallowtail butterfly (*Eurytides*), uses the pawpaw uniquely, as a place to lay eggs and where its caterpillars can acquire a noxious taste that will repel predators in adulthood (McLaughlin 2008; Pomper 2009). When mature, the Swallowtail is a pollinator for a number of plant species, supporting the web of our food supply.

Looking further within, we can see that the human body carries its own miniature versions of biodiversity. For many years the *gut flora*, microbes in the human intestine, were known to produce vitamin K and aid in digestion. As this bacterial community is being charted via gene sequences, we find it to be fully engaged in our behalf. Gut flora function as an organ, protecting the walls of the intestine, promoting immunity, regulating fat storage, and, occasionally, being injured by antibiotics (Mueller 2006).

Mainstream researchers already call this an 'ecosystem,' without apparent irony. The Human Microbiome Project will examine this new frontier, investigating whether a study of bacterial populations (enterotyping) can diagnose and treat illness.

More surprises are coming: Nanoparticles will change us as nothing has before; open source technology will put new capabilities in the hands of every man; biopunks will test themselves at our peril, and the world's population will grow. Talks are underway to discuss the ethical impacts of bioengineered mosquitoes that can fill the niche of regular mosquitoes, but cannot carry malaria (Ostera 2011). In time we may be able to heal the world and bring it into balance or we may fail. As a last resort, our wistful *biophilia* (love for nature) might be medicated, as though it were a maladaptive behavior (Wilson 1984).

To conclude, I would like to pass along other gifts from nature- inspiration and hope. The Monarch butterfly (*Danaus*), on an epic transcontinental journey, is guided by both magnetism and sun compass navigation, integrated by sophisticated neural pathways (Heinze 2011). But none of this is as remarkable, in my opinion, as the fact that several generations of this species will complete a separate leg of each migration and eventually rendezvous. They determine the right direction, and combine efforts to accomplish, magnificently, a feat that no one of them could ever do alone.

An adult monarch(*Danaus pleixippus*) feeding on swamp milkweed (*Asclepias incarnata*) in Fayette County, Kentucky.

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Endnotes

1. Unionid mussels, (*Mytilus*) may be the most endangered group of organisms in North America, and are acknowledged as contributors and indicators of freshwater health. As they filter water to feed on phytoplankton and bacteria, mussels clear turbid streams and diminish algae overgrowths. Several states are initiating mussel restoration to improve water quality. Mussel embryo-larval stages are very sensitive to dissolved metals, including copper, zinc, cadmium and nickel. See the ECOTOX Database at: http://cfpub.epa.gov/ecotox/.

2. Sir Alexander Fleming received The Nobel Prize in Medicine or Physiology in 1945, along with Ernst B. Chain and Sir Howard Florey. At his prescient Nobel Lecture in the same year, Fleming spoke about the prospect of bacterial resistance to antibiotics.

3. Biodiversity related observations can advance physics and engineering. Large wilting movements, found in species of mimosa, are made possible by the flow of water in and out of plant cells. Rapid shape changes ensue, without corresponding changes in the plants' basic infrastructure. Engineers have studied this with the hope of creating hydraulic machines adaptable to a number of tasks. Similarly, studies of the efficient burrowing mechanisms of sandfish lizards have suggested new designs for robotic search and rescue machines.

4. Naked Mole Rats (*Heterocephalus glaber*) can live up to 30 years of age. Cancer, an uncontrolled growth of cells, may activate genes in mammals that prevent overcrowding; but many tumors can subvert this process. The mole rat has an additional genetically programmed defense, so effective that experimental efforts to induce tumors in the species have failed; neither humans nor mice have a comparable redundant system.

5. In spite of many advances, such as short term vaccines, cholera is still with us. Though the causative organism (*Vibrio*) is exquisitely sensitive to chlorine, and the disease is very responsive to therapeutic rehydration, much of the world lacks these capabilities. The World Health Organization (WHO) estimates that many cases go unreported; it is the young, the poor, and the displaced who die in disproportionate numbers. *Vibrio* strains exist in food or water contaminated with fecal material, awaiting breaks in sanitation, to emerge in human populations. Worldwide, millions of cases occur yearly and many individuals survive or exhibit mild illness; but cholera can be quick to incubate-sometimes hours- and fulminant in character, with overwhelming diarrheal losses of fluid. The disease has an observed association with warmer temperatures, making climate change a factor in its continued presence.

6. Viruses have been estimated to number 10^{30} in the ocean, and 10^{10} g -1 in soil. (Suttle) Most viruses have not been studied yet. Originally mistaken for bacteria, two giant viruses, mimivirus and mamavirus were discovered in a coolant tank, in 2003 and 2008, respectively. Since then, mamavirus has been found to be capable of manufacturing its own genetic material, bringing such viruses closer to the traditional definition of 'living.' In 2008 a much smaller virus was noted in association with mamavirus particles, dubbed the Sputnik virophage (viral parasite) that co-opts mama's functions to reproduce itself. To the extent that viruses can now be said to become 'ill,' they have joined the rest of us, as 'life forms,' in the opinions of many.

7. From the USDA, as of mid-2010, there were over 6,000 farmers markets operating throughout the U.S. This is a 16 percent increase from 2009.

8. The Human Microbiome Project (HMP) began in 2009 as a five year plan by the NIH (http://nihroadmap.nih.gov), to study each of the human microbiomes in the digestive system, oral cavity, nasal passages, skin and vagina. The goal of this 115 million dollar project is to determine microbial patterns in healthy and diseased persons and to develop applications for medical and forensic purposes. See http://www.ncbi.nlm.nih.gov/pubmed/19819907.

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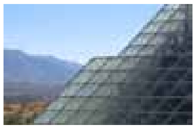

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America's Great Outdoors: A Promise to Future Generations

The following is a precis of the 104 page America's Great Outdoors. For the full report, go to http://americasgreatoutdoors.gov/

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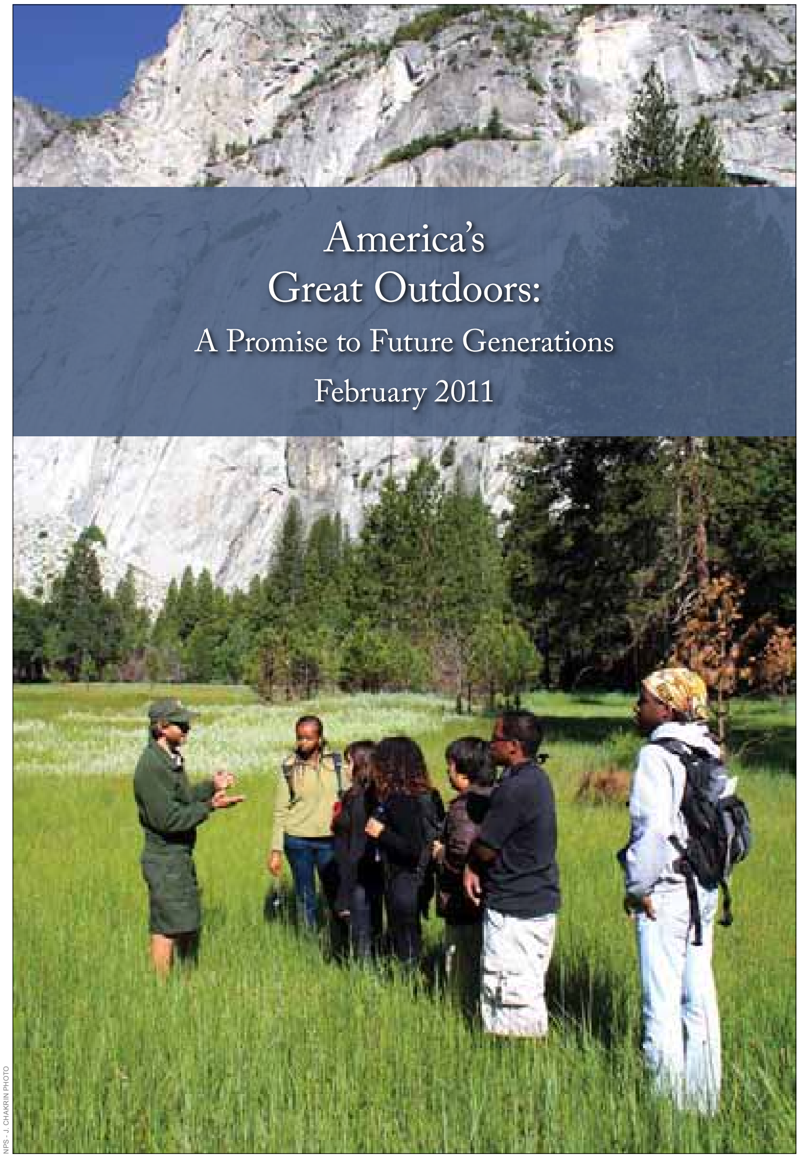

Letter to the President

Dear Mr. President,

On April 16, 2010, you introduced America's Great Outdoors, an initiative aimed at reigniting our historic commitment to conserving and enjoying the magnificent natural heritage that has shaped our nation and its citizens. We are pleased to present you with the America's Great Outdoors report to begin implementation of this 21st-century conservation agenda. The report was created in consultation with the American people. It reflects their ideas on how to reconnect people with America's lands, waters, and natural and cultural treasures, and it builds on the conservation successes in communities across the nation. To develop this plan, you asked us to travel outside of Washington, D.C., and to listen and learn from the American people.

Citizens from across the country, including farmers, ranchers, hunters, anglers, outdoor recreation enthusiasts, parents, teachers, and young people, as well as representatives of conservation organizations, state, local, and tribal governments, historic preservation groups, faith communities, and businesses, shared specific and creative ideas. We heard from all ethnic and age groups, political parties, and thousands of young people. The message was clear: Americans care deeply about our outdoor heritage and want to enjoy and protect it.

This America's Great Outdoors agenda builds on the stewardship legacy championed by President Theodore Roosevelt more than 100 years ago. Now, as then, the basis for our proposed actions is the value that Americans place on conserving the extraordinary and diverse lands and waters that sustain, restore, nourish, and support us. This initiative is about the government empowering and partnering with people and communities to protect and restore the places they cherish.

Americans today have become increasingly disconnected from our great outdoors. We find ourselves cut off from the natural and cultural inheritance that has shaped our lives and history. Our natural resources remain central to our economic vitality, yet they are under intense pressure from development and fragmentation, unsustainable use, pollution, and impacts from a changing climate. On April 16, 2010, President Obama launched the America's Great Outdoors (AGO) Initiative and charged the Secretaries of the Departments of the Interior and Agriculture, the Administrator of the Environmental Protection Agency, and the Chair of the White House Council on Environmental Quality to develop a 21st-century conservation and recreation agenda that addresses these challenges.

America's leaders have acted to secure the future of our natural heritage out of a keen awareness that it inspires us as a people and sustains us as a nation. During the Civil War, President Abraham Lincoln protected the magnificent resources of California's Yosemite Valley by setting aside lands that would eventually become part of our third national park. At the turn of the 20th century, President Theodore Roosevelt furthered the concept of federal protection of public natural and cultural resources by protecting some 230 million acres as national forests, parks, wildlife refuges, and preserves and by establishing national monuments. President Franklin Delano Roosevelt championed conservation and development of our natural resources in the 1930s and 1940s to put Americans back to work during the Great Depression.

Together, our public, private, and tribal lands and waters embody one of our nation's founding principles: the right of all Americans to enjoy and benefit from America's natural treasures and the obligation to pass that heritage along to future generations.

Fulfilling that promise—and the shared obligation—to preserve and protect our natural and cultural heritage for present and future generations is one of the daunting challenges for 21st-century America. Busy lives and limited access to clean, safe, open spaces discourage many Americans from taking part in outdoor activities. The nearly 80 percent of Americans who live in or near cities find it particularly difficult to connect with the outdoors. The outdoors has increasingly lost its relevance in the lives of our children, who now spend only half as much time outside as their parents did, but who spend an average of seven hours a day using electronic devices. Studies show that access to the outdoors can help reverse the obesity epidemic that has tripled among our children in the last generation. They show that time spent in nature can reduce stress and anxiety, promote learning and personal growth, and foster mental and physical health. We have also grown from a nation of 92 million people 100 years ago to 308 million today, and the Census Bureau projects that our population will grow to nearly 400 million in the next 40 years. Land and natural resource development have fragmented our lands, disrupted natural systems, and imperiled productive farmland and woodlands. One out of three acres that has been developed in the United States was developed from 1982 to 2007. Annually, we now lose about 1.6 million acres of our working farms, ranches, and forests to development and fragmentation. Many of our rivers, lakes, coasts, and streams are polluted. Fish advisories and beach closures occur frequently. Our natural legacy faces new challenges, including new types of pollution and a changing climate, whose full consequences are yet to unfold.

NATIONAL PARK SERVICE PHOTO / CAPE COD NATIONAL SEASHORE, MASSACHUSETTS

CONNECTING AMERICANS TO THE GREAT OUTDOORS

America's natural heritage has defined the nation and shaped American culture. Since our earliest beginnings, our relationship with the outdoors has influenced our national character. Both our strong sense of community and our rugged individualism are products of our interactions with nature. Today, even a walk in the woods, a family picnic in a city park, a jog along an urban waterfront, or a fishing trip with a grandchild can restore our connection to the outdoors and create lasting memories that contribute to who we are as a people. Each camping trip to a park or forest or visit to a historic battlefield can strengthen our sense of individual pride and shared responsibility for our lands and waters and the history they contain.

1. Provide Quality Jobs, Career Pathways, and Service Opportunities

The importance of job- and service-based learning opportunities related to protecting and restoring the outdoors was a constant theme raised in the listening sessions, especially in the 21 sessions devoted to youth. Americans are committed volunteers, and service is a powerful way to build skills and make a difference. According to the Corporation for National and Community Service (CNCS), in 2009, more than 63 million Americans contributed 8.1 billion hours of service, valued at nearly $169 billion.

Goal A1

Develop quality conservation jobs and service opportunities that protect and restore America's natural and cultural resources.

Recommendation 1.1

Catalyze the establishment of a 21st-Century Conservation Service Corps (21CSC) to engage young Americans in public lands and water restoration.

Recommendation 1.2

Work with OPM to improve career pathways and to review barriers to jobs in natural resource conservation and historic and cultural preservation.

Recommendation 1.3

Improve federal capacity for recruiting, training, and managing volunteers and volunteer programs to create a new generation of citizen stewards and mentors.

2. Enhance Recreational Access and Opportunities

As highlighted in the AGO vision, recreation provides one of the easiest and most natural ways to connect with the outdoors. America's lands and waters offer a multitude of outdoor recreation activities that enhance health and wellness, encourage appreciation for natural and cultural resources, and present enjoyable opportunities to connect with family and friends.

Goal A2

Increase and improve recreational access and opportunities.

Recommendation 2.1

Support outdoor recreation access and opportunities on public lands by establishing a Federal Interagency Council on Outdoor Recreation (FICOR).

Recommendation 2.2

Support community-based efforts to increase access to outdoor recreation.

3. Raise Awareness of the Value and Benefits of America's Great Outdoors

The outdoor experience has lost its currency for many Americans. Increasingly busy schedules, shifting cultural norms, financial barriers, and the lure of new technology often keep many people from venturing outdoors for recreation, play, work, or service. During the listening sessions, participants spoke about the need to make the outdoors desirable and relevant to America's young people. Many people articulated a need to redefine the "great outdoors" to include iconic national parks and forests, wildlife refuges, and cultural and historic sites, as well as neighborhood and city parks, community gardens, and school yards. One of the most frequent recommendations was to launch a national public awareness initiative. It would use 21st-century communications technology and techniques to show Americans that going outdoors is fun, safe, easy, and healthy.

Goal A3

Cultivate stewardship and appreciation of America's natural, cultural, and historic resources through innovative awareness-raising partnership initiatives and through education.

Recommendation 3.1

Launch a public awareness initiative to show that experiencing America's great outdoors is fun, easy, and healthy.

Recommendation 3.2

Work with the Department of Education and other federal agencies to align and support programs that advance awareness and understanding of the benefits of nature.

Recommendation 3.3

Promote and support replicable programs that teach about and connect children and families with their natural and cultural heritage.

4. Engage Young People in Conservation and the Great Outdoors

Youth participation in AGO had a tremendous impact on the themes of this report and influenced its recommendations. At 21 youth-specific listening sessions across the nation, government officials met with hundreds of young people, each of whom had a personal perspective on—and experiences with—the outdoors. From a uniformed conservation corps in Missoula, to a room of high school kids in Orlando, to Native American youth in two BIE schools, these voices were diverse, passionate, and thoughtful. As we look to protect America's great outdoors for current and future generations, it is imperative that we continue to engage, empower, and learn from our young people. They are our future farmers, ranchers, hunters, anglers, conservationists, scientists, teachers, business leaders, and elected officials who

will inherit and carry on the stewardship of our nation's outdoor legacy.

Goal A4

Build stewardship values and engage youth in conservation and recreation.

Recommendation 4.1

Engage young people in the implementation of AGO.

CONSERVING AND RESTORING AMERICA'S GREAT OUTDOORS

At the beginning of the 20th century, Americans realized the immense natural wealth of the United States was limited, as symbolized by the closing of the western frontier and the disappearance of the vast bison herds on the Great Plains. In response, President Theodore Roosevelt made natural resource conservation a primary goal of his administration. Roosevelt focused on the public estate, placing some 230 million acres under public protection. He created five national parks, signed the 1906 Antiquities Act, established 18 national monuments, established the U.S. Forest Service, placed 16 million acres in the new National Forest System, and set aside the first lands to become national wildlife refuges.

5. Strengthen the Land and Water Conservation Fund

The Land and Water Conservation Fund (LWCF) is a primary source of federal funding for states and federal agencies to protect and conserve America's national treasures and to promote outdoor recreation. LWCF revenue is primarily generated from outer continental shelf oil and gas drilling activities, and collection is authorized up to $900 million, subject to congressional appropriations. Its purpose is to fund federal land acquisition; conserve threatened and endangered species; and provide grants to state governments for recreation planning, development of recreation facilities, and acquisition of lands and waters. This fund program has enjoyed a broad base of popular support and oversight since it became law in 1964.

Goal A5

Invigorate the LWCF to better meet conservation and recreation needs.

Recommendation 5.1

Provide full funding for LWCF programs.

Recommendation 5.2

Focus a portion of federal LWCF funds on projects that achieve AGO goals related to large-scale land conservation, urban

Recommendation 5.3

Broaden guidelines for Statewide Comprehensive Outdoor Recreation Plans (SCORPs) to align with AGO priorities.

6. Establish Great Urban Parks and Community Green Spaces

In an 1870 essay, Frederick Law Olmsted, the central architect of New York City's Central Park, extolled the virtues of outdoor space, especially for urban communities. He wrote, "We want a ground to which people may easily go after their day's work is done, and where they may stroll for an hour, seeing, hearing, and feeling nothing of the bustle and jar of the streets…." Today, urban parks and community green spaces play an even more important role as special public places that promote health, provide economic benefits, and nurture democratic values by inviting casual interaction among citizens. Eighty percent of Americans now live in or near cities and lead even busier lives than previous generations could ever have imagined. For many Americans, our nation's iconic parks and forests, such as Yellowstone National Park, Tongass National Forest in Alaska, and the Adirondack State Park in New York, are far away and difficult to access. As a result, urban parks and community green spaces are essential for providing places for people to recreate outdoors, to find quiet and solitude, and to generally improve their quality of life.

Goal A6

Create and enhance a new generation of safe, clean, accessible great urban parks and community green spaces.

Recommendation 6.1

Establish the AGO Great Urban Parks and Community Green Spaces initiative by targeting increased funding for the NPS LWCF stateside program to leverage investment in new and enhanced urban parks and community green spaces.

Recommendation 6.2

Support and align federal agency programs and initiatives to promote the creation, expansion, and enhancement of urban parks and community green spaces.

Recommendation 6.3

Target technical assistance support to communities to create and enhance urban parks and community green spaces.

Recommendation 6.4

Connect people with urban parks and community green spaces.

NATIONAL PARK SERVICE - DOVE PHOTO / RIO DE LOS ANGELES STATE PARK, CALIFORNIA

7. Conserve Rural Working Farms, Ranches, and Forests Through Partnerships and Incentives

Conservationist Aldo Leopold wrote that trying to accomplish conservation entirely on public land was like trying to keep dry with only half an umbrella. Made more than 70 years ago, his observation resonates today. More than 70 percent of land in the contiguous United States is in private ownership—largely as farms, ranches, and forests, with more than 56 million acres held in trust by the United States for Indian tribes and other individuals. These privately owned lands are vital to conserving our water resources, ecosystems, and wildlife, to provide recreation for hunters, anglers, and other outdoor enthusiasts, and to preserve our natural heritage for generations to come. Even in areas with large government ownership of land, privately owned lands often provide important wildlife habitat and migration corridors. Through their stewardship practices, farmers, ranchers, and forest landowners play a critical role in helping the nation address climate change and in making sure the air we breathe and the water we drink are clean and healthy. Despite their importance for the environment and recreation it is becoming ever more challenging for landowners to keep private lands intact. The Natural Resources Conservation Service (NRCS) reports that one out of three acres ever developed in the United States was developed from 1982 to 2007. Each year some 1.6 million acres of privately owned farms, ranches, and forests are sold off, in whole or in part, for development. The costs to clean air, wildlife, cultural heritage sites, and farm and forest economies are significant.

Goal A7

Catalyze large-scale land conservation partnership projects through economic incentives and technical assistance.

Recommendation 7.1

Support collaborative landscape conservation through competitive processes, including increases in LWCF funding and other programs.

Recommendation 7.2

Support landscape partnerships by targeting existing federal dollars, policies, and other resources toward conservation of private and tribal working lands and coordinating expenditures, where appropriate, across federal agencies.

Goal B7

Significantly increase the pace of working farms, ranch, and forest land conservation.

Recommendation 7.3

Extend the enhanced deductions for conservation easement donations beyond 2011.

Goal C7

Increase financial incentives for land stewardship for farmers, ranchers, forest landowners, and tribes.

Recommendation 7.4

Develop and expand new markets, including those for the environmental services provided by working lands, for local agricultural or sustainable forest products, sustainable energy, and others.

Recommendation 7.5

Support financial and other incentives to encourage access for hunting, fishing, hiking, recreation, and other outdoor activities on or across private working lands.

Recommendation 7.6

Promote tools such as safe harbor agreements that provide certainty to landowners who agree to carry out stewardship activities that benefit fish and wildlife and protect water resources.

8. Conserve and Restore Our National Parks, Wildlife Refuges, Forests, and Other Federal Lands and Waters

Nearly 30 percent of lands in the United States—more than 635 million acres—are managed and protected by the federal government. These federal lands and their waters contain ecosystems as diverse as the coastal mountains of California's King Range National Conservation Area, southern Appalachian ecosystems of the Great Smoky Mountains National Park, and the tropical rainforests of the Caribbean National Forest in Puerto Rico, as well as an inspiring array of natural, cultural, and historic resources. Some of these exceptional natural and cultural places have been designated as World Heritage Sites. Public lands offer American and international visitors wide-ranging opportunities to make a personal connection to the outdoors. They may do this through the solitude of wilderness or bird watching at dawn, the exhilaration of motorized trails, climbing, skiing, snowboarding, or river rafting, the pride of historic places, or the satisfaction of volunteer service. Our public lands provide water resources, wildlife habitat, recreation access and opportunities, educational value, and other benefits to the American people. The nation's mountains, prairies, forests, coasts, deserts, lakes, estuaries, and rivers also provide essential ecosystem services that benefit all Americans. Public lands contain important watersheds that supply drinking water to millions. These lands also sequester significant amounts of carbon annually, thereby reducing atmospheric greenhouse gases. Many of America's most iconic wildlife species—bison, elk, and grizzly bears, among them—greatly depend on public lands for survival.

Likewise, federal lands and waters sustain people, providing recreation, relaxation, and renewal. Be it a hike, bike, or horseback ride along a local trail, a family ski vacation, a visit to a historic or cultural site, or a weekend fishing or boating trip, access to the great outdoors through our public lands and waters improves our quality of life, while also bringing economic benefit to local communities.

Although the federal government manages some of the nation's most extraordinary lands and waters—places such as Red Rock Canyon National Conservation Area, the Monongahela National Forest, Okefenokee National Wildlife Refuge, and Eglin Air Force Base— federal lands often occur within a patchwork that includes other public and private properties. In some cases, federal forests and grasslands occur in a "checkerboard" pattern of mixed federal, state, tribal and private ownership. There is a growing awareness among federal agencies that protecting large landscapes, wildlife, and watersheds requires collaborative management across ownerships. Federal land managers must partner beyond their boundaries with many landowners and other land managers to achieve the benefits that come from managing land and water resources at a landscapes level, such as the creation of wildlife migration corridors. The need to help wildlife adapt to a rapidly changing climate, which is altering habitats, further highlights the importance of a landscape approach to conservation that emphasizes connectivity. Federal lands and waters face diverse and increasing threats. Insect and disease infestations have weakened our forests. Examples are the mountain pine beetle on the Arapaho and Roosevelt National Forests, a legacy of fire suppression; and invasive species, such as the tallowtree and the Asian gypsy moth. Grasslands and sagebrush ecosystems face similar stresses. Climate change exacerbates these stressors, and considerable impacts on federal lands from a rapidly changing climate are already apparent. To help natural and human communities that depend on public lands and waters in adapting to climate change, it is imperative that management of federal lands and waters be focused on restoration and building resilience in ecosystems and be informed by science. This will help ensure that federal lands continue to fulfill their basic role in providing water resources, wildlife habitat, recreation access and opportunities, and educational and other benefits to the American people.

Goal A8

Conserve, restore, and manage federal lands and waters to ensure access and enjoyment for future generations while contributing to the protection of a larger natural and cultural landscape.

NATIONAL PARK SERVICE - AUSTIN/JONES PHOTO / YELLOWSTONE NATIONAL PARK, IDAHO, MONTANA, WYOMING

Recommendation 8.1

Manage federal lands and waters within a larger landscape context to conserve and restore ecosystems and watershed health.

Recommendation 8.2

Manage federal lands and waters to increase their resilience to climate change.

Recommendation 8.3

Manage federal lands and waters to create and protect critical wildlife corridors and maintain landscape connectivity in collaboration with other public and private stakeholders.

GOAL B8

Advance national, regional, and community-supported work to preserve and enhance unique landscapes, natural areas, historic sites, and cultural areas while ensuring openness and transparency in any land designations.

Recommendation 8.4

Engage the public to identify and recommend potential sites on existing federal lands for protection under the 1906 Antiquities Act.

Recommendation 8.5

Identify potential areas for congressional designation that have strong local support.

Goal C8

Protect America's historic and cultural resources.

Recommendation 8.6

Provide financial and technical support to states and local communities, tribes, and private sector organizations for historic preservation and cultural resources protection.

Recommendation 8.7

Continue to protect and interpret historic sites and cultural landscapes on federal lands.

9. Protect and Renew Rivers and Other Waters

Water is life. The more than 3.6 million miles of rivers and streams that wind through our nation provide America's drinking water, fuel the economy, sustain critical ecosystems, and offer endless opportunities for recreation and enjoyment. From the Columbia River to the upper Midwest prairie potholes to the Tennessee and Penobscot valleys, water has shaped the nation's social, cultural, and economic development and enabled its prosperity. Virtually all of our cities and towns are next to waterways, making these waters an outdoor opportunity close to home for all. Today, American life remains inextricably linked to the rivers and shores on which it was founded. Federal projects are underway to restore and conserve large-scale, aquatic ecosystems in Florida's Everglades, Chesapeake Bay, Great Lakes, Gulf Coast, California Bay-Delta, Mississippi River Basin, Washington's Puget Sound, and many others. Federal, state, and local governments and private organizations and landowners have built effective partnerships to restore and protect these remarkable systems. Under this Administration, a number of these efforts have been given additional emphasis and resources. Because these projects are well underway, this report offers no specific recommendations for these ecosystems. However, these large restoration projects can serve as laboratories for—and have spurred— many smaller watershed-level projects, expanding water conservation whether in wetlands of California's Klamath Basin Nation Wildlife Refuge or in a city-scale project such as the Los Angeles River. This existing work can further benefit from many recommendations in this report.

Goal A9

Empower communities to connect with America's great outdoors through their rivers and other waterways.

Recommendation 9.1

Establish the AGO National Recreational Blueway Trails Initiative to increase access to recreation.

Recommendation 9.2

Facilitate recreational access to the nation's waterways.

Goal B9

Support restoration and conservation of rivers, bays, coasts, lakes, and estuaries for recreation, healthy fisheries, and wildlife habitat.

Recommendation 9.3

Enhance and restore local waterways and the surrounding land by partnering with state, local, and tribal government, and the private sector to support community efforts.

Recommendation 9.4

Coordinate and align federal water resource management programs and resources.

Working Together for America's Great Outdoors

10. Make the Federal Government a More Effective Conservation Partner

Partnerships will be critical to the success of the America's Great Outdoors Initiative, a fact confirmed by many public com-

ments. People across the nation called for better collaboration between the public and private sectors; state, local, and tribal governments; and between local communities and the federal government to help citizens realize the wide-ranging benefits of a revitalized connection to the outdoors.

No single entity, whether federal, state, local, or private, can provide the resources needed to achieve the breadth and depth of action proposed in this report. American citizens expressed their desire for better coordination among federal agencies and better delivery of services to the public to achieve these goals for enhanced conservation and outdoor recreation. They noted the frustrations that can occur as partners work with the federal government. Some even lose interest because of excessive and uncoordinated procedures and reviews for new proposals. Others want federal agencies to engage underserved communities, as partners with local governments and the private sector, to identify the financial, cultural, and safety barriers to these populations' accessing and enjoying the outdoors. People want strategies to overcome these obstacles.

Goal A10

Improve federal government performance as a conservation partner.

Recommendation 10.1

Establish the interagency AGO Council to achieve more cooperation and collaboration among federal agencies engaged in conservation and recreation.

Goal B10

Amplify the impact of the AGO Initiative by creating the Partnership for AGO.

Recommendation 10.1

Launch the Partnership for AGO.

YOUTH AND AMERICA'S GREAT OUTDOORS

What We Heard from America's Young People

From the start, President Obama recognized the importance of young people. He directed that "special attention… be given to bringing young Americans into the conversation" and worried about the fact that young people today spend about half as much time outdoors as their parents did. To honor and capture the youth voice, the America's Great Outdoors team launched a series of listening sessions aimed to hear from you—America's young people. We wanted to know how you relate to the outdoors and why it is special to you. We also asked you why the American people are losing touch with the natural world, to identify the obstacles that keep you from spending more time outdoors, and we challenged you to give us your ideas about how they might be overcome. After hearing from you at 21 youth listening sessions—and through hundreds of comments you submitted online—we have a broader understanding of your passion, commitment, experiences, opinions, and expectations—and some great ideas to help us move forward together.

U.S. ARMY CORPS OF ENGINEERS PHOTO / ANACOSTIA RIVER, WASHINGTON, D.C.

A Youth Agenda for America's Great Outdoors

Through your participation in listening sessions and the comments you submitted online, you explained why you want to connect with the outdoors and described the challenges you face in doing so. You proposed constructive suggestions for breaking down these barriers, and discovered a shared purpose along the way. Together—based on your priorities, abilities, and aspirations—we have begun to shape an agenda for connecting youth to America's great outdoors in the 21st century. This agenda encompasses four key goals:

A. Make the outdoors relevant to today's young people: make it inviting, exciting, and fun;

B. Ensure that all young people have access to outdoor places that are safe, clean, and close to home;

C. Empower and enable youth to work and volunteer in the outdoors;

D. Build upon a base of environmental and outdoor education, both formal and informal.

A. Make the outdoors relevant to youth—make it inviting, exciting and fun.

Your ideas for making the outdoors relevant to youth:

- Bridge the gap between technology and the outdoors by developing innovative tools, like nature-based mobile phone applications, GPS devices, and online challenges.
- Launch a national outdoor youth campaign to raise awareness of the importance of the outdoors to health and our nation's history and economy, including concerts, rallies, and youth summits.
- Keep the conversation going by continuing to hold regional listening sessions for youth.
- Create a user-friendly web portal that shows young people where to go and what to do in the great outdoors.
- Host free events to introduce youth and their families to outdoor activities they can enjoy for a lifetime.
- Help native youth reconnect with their heritage by enabling them to practice traditional outdoor activities, like hunting, fishing and archery

B. Ensure that all young people have access to outdoor places that are safe, clean, and close to home.

Your ideas for ensuring that all young people have access to safe clean, and close to home outdoor places:

- Create more parks near and in communities, including networks of connected trails, bike paths, and greenways, and urban gardens and community "pocket parks."
- Improve access to open spaces, both within cities and beyond their limits, by expanding options for public transportation and linking sidewalks and pathways to create safe routes to parks,
- Reduce barriers to using parks by lowering entry fees for young people and families.
- Make outdoor recreation more affordable through innovative concepts like "gear libraries" or other low-cost options for sharing recreational and safety equipment.
- Make parks more welcoming, safe, and usable by cleaning up garbage, and taking better care of existing facilities like trails, signage, and restrooms.
- Work with individual communities to reduce crime and gang activity in neighborhood parks and open spaces, and on native lands

C. Empower and enable youth to work and volunteer in the outdoors.

Your ideas for empowering and enabling youth to work and volunteer in the outdoors:

- Increase interest in and access to careers in land and resource management through mentoring, training, and internships for young farmers, ranchers, and conservationists.
- Raise awareness of job and service opportunities on public lands and streamline the application process through better and easier access to information online.
- Build a modern Youth Conservation Corps to engage America's young people, veterans, and underserved populations in the stewardship and conservation of our lands and waters.
- Bring communities together for environmental cleanups and restoration projects, including work on native reservations, urban gardens, brownfields, and vacant lots.
- Promote inclusion and diversity in outdoor recreation, education, and in conservation related jobs and volunteer opportunities Youth Report 93

D. Build upon a base of environmental and outdoor education, both formal and informal.

Your ideas for building upon a base of environmental and outdoor education, both formal and informal:

- Expand outdoor education programs to engage more young people in hands-on, place-based learning experiences.
- Provide more opportunities for kids to get outside during the school day, through curriculum-based activities, service-learning projects, and outdoor recess and P.E.
- Link outdoor professionals, including park and forest rangers, to local school districts to educate teachers and students on the significance of their natural and cultural surroundings, and inspire them to get out and explore the outdoors.
- Increase cultural literacy and cultivate civic pride by helping families and school groups visit historic sites and landscapes.

- Leverage grants and other existing resources to make it easier and more affordable for school groups to access public and private lands.
- Use mentor and ambassador programs to bring young people outdoors and teach them the skills necessary to connect with and enjoy nature.
- Increase outdoor learning experiences in native schools, and incorporate more lessons about sacred sites and practices.

Conclusion

The report to the President marks the beginning of what we believe will be a long and transformative dialogue and partnership between the federal government and the people we serve. As we begin to implement the recommendations in the report, we will seek new ways of doing business, looking to replicate and expand successful models we witnessed at the local level. We will collaborate with groups in the public and private sectors, and we will pledge to be a better partner by stepping up transparency, efficiency, and coordination. We will continue to engage with people we met over the summer, and will reach out to new audiences as we seek to advance the President's agenda on America's Great Outdoors. We hope you will join us.

ENVIRONMENTAL PROTECTION AGENCY - VANCE PHOTO

The Commonwealth Challenge: Meeting the Needs of Nature and People

Terry Cook
The Nature Conservancy of Kentucky

Introduction

In May of 1769, Daniel Boone and a small party departed North Carolina on a two year hunting expedition that would bring them across the rugged Appalachian Mountains into the wilderness of *Kanta-ke*. Boone and his companions crossed through Cumberland Gap and then through the final gateway, Pine Mountain Gap, into Kentucky. Crossing the Cumberland River, Laurel River, and Rockcastle River, Daniel Boone climbed nearby Pilot Knob in June of 1769. There before Boone was a land he had heard about as a boy and young man; a hunter's paradise, a wild area of rich land, land of abundant deer and buffalo and game of every kind. From the summit of Pilot's Knob Boone could see to the western horizon and below a mosaic of bluegrass meadows and great forests. The Kentucky River stretched before him blanketed on each side by miles of canebrakes mixed with grazing herds of buffalo.

In 1976, more than 200 years after Daniel Boone's summit, a newly formed chapter of The Nature Conservancy purchased Pilot's Knob. It was a remarkable accomplishment for this newly formed non-profit conservation organization guided by a handful of dedicated volunteers.

In the 200 years since Daniel Boone's first expedition to Kentucky, significant changes to the lands and waters have occurred. Kentucky's population has grown to over 4 million people and by 2035 Kentucky's population will likely exceed 5 million.[1] When the Kentucky Chapter of The Nature Conservancy was founded in 1975, the state's population was more than 3.3 million people, roughly 83 people per square mile. By 2050 Kentucky's population density will be close to 139 people per square mile. The need for land, water, food, fiber, and energy will place greater and greater demands on the state's natural resources and threaten our ability to sustain a quality of life that has characterized and shaped Kentucky's unique identity since the time of Daniel Boone. Today, the Commonwealth of Kentucky faces a growing challenge: *how do we meet the needs of a growing population while maintaining human well-being and the preservation of species and ecosystems?*

Kentucky's Natural Legacy

The diversity of Kentucky's land and waters has inspired and nurtured generations. From its mountain tops and hollows of eastern Kentucky to the bottomland forests and wetlands of western Kentucky, to the rivers and streams that nourish our healthy fisheries and provide ecological services to our communities and businesses, Kentucky landscapes have been a dominate role in shaping its people and history.

From a conservation perspective, biologists and scientists often focus their efforts on protecting, conserving, and restoring biodiversity. Biodiversity is the variety of species, their genetic make-up, and the natural communities in which they occur. Kentucky, blessed with biodiversity, is home to over 20,000 different species of organisms, and of this total, over 100 are considered to be rare, threatened, or endangered.[2] For many groups of organisms, such as insects, fungi, and algae, very little is known about them – and there are likely many hundreds, if not thousands, in Kentucky that are yet to be described.

What we do know is that compared to other states, Kentucky ranks 23rd in overall species diversity and 4th in the nation for its freshwater species diversity.[3] Yet Kentucky also ranks 9th in the nation in the number of species extinctions.[3] So, despite the diversity of our landscapes and richness of our streams and rivers, relative to other states Kentucky has a disproportionate number of species and natural communities that are at risk.

The Kentucky Department of Fish and Wildlife Resources has identified over 100 terrestrial and freshwater animal species of conservation concern.[4]

The Kentucky Nature Preserves Commission has identified 733 plant and animal species and 36 natural communities as rare.[5]

Sixty-six species are considered extirpated or extinct from Kentucky.[5]

Within Kentucky, 37 species are listed as threatened or endangered by the U.S. Fish and Wildlife Service.[6]

Another 16 species are either candidates for listing or proposed for listing under the Endangered Species Act.[6]

36 aquatic, wetland and riparian species are under review to determine whether they warrant protection as endangered species.[7]

Habitat Loss

The list of potential threats to biodiversity and wildlife habitats is lengthy and includes such things as invasive exotic species, inappropriate and destructive land use practices, overexploitation, nonpoint source water pollution, aquatic habitat modifications such as dam construction and channelization of streams, and climate change. Of these threats, habitat loss and fragmentation are often identified as primary culprits in the degradation of wildlife habitats and the subsequent loss and decline of species.

Habitat fragmentation and loss are often closely associated with one another. However, there are distinct differences between the two. Habitat fragmentation is the transformation of large contiguous habitat blocks, such as grasslands or forests, into a patchwork of small isolated habitat remnants.

Habitat loss is the conversion or destruction of natural habitats to the extent that they no longer support the native populations of plants and animals that previously inhabited the area. Habitat loss is thought to be the leading cause of imperilment of federally threatened and endangered species[8] and contributes significantly to the population declines in many more common species.

- The Kentucky Department of Fish and Wildlife Resources estimated that Kentucky loses 47,000 acres of wildlife habitat per year.[9] That is over 900 acres per week or over 128 acres per day.
- From 1988 to 2004, 729,000 forested acres, or approximately 6% of the forests of Kentucky, were lost.[10]
- From 2001 to 2005, an estimated 105 acres of forest were lost every day in Kentucky due to conversion.[11]
- Kentucky has lost approximately 81% of its original 1,566,000 forested wetland acreage found in the 1780's, putting it in the top 10 states with most wetland acreage by percent lost.[12]
- 64% of Kentucky's rivers and streams are considered impaired.[13]
- 68 % of Kentucky's river and streams are considered impaired as "primary contact recreation water" meaning people cannot swim in them without risk of adverse human health effects.[13]
- Sedimentation and siltation are listed as a cause of impairment across more stream and river miles than any other cause, and loss of riparian habitat was listed as the probable source of impairment across more stream and river miles than any other source.[13]

While habitat loss and fragmentation are drivers of species loss, they are also a concern because our landscapes and rivers and streams are sources of aesthetic beauty, recreation and inspiration. They provide valuable ecosystem services that help cleanse the air that we breathe and the water that we drink. These uniquely Kentucky places contain memories of our childhood and they foster the imagination of our children.

The Economics of Conservation

The conservation of Kentucky's lands and waters not only helps sustain our wildlife, but contributes billions of dollars to the Kentucky economy in jobs, taxes, tourism and other revenue. Preserving critical habitats, urban and wildlife habitat and natural areas, creating new state and local parks and trails, and providing access to our rivers, streams and lakes creates recreation opportunities for residents and visitors and generates revenue and jobs in the local economy. Outdoor recreation activities that rely on natural areas, such as hiking, biking, camping, boating, wildlife watching, equine activities, sport fishing and hunting are also significant generators of revenue and local economic activity.

Wildlife Watching

Contributes $542 million in retail sales and services annually to the Kentucky economy.[14]

Sport Fishing

Contributes $881 million in retail sales and service to the Kentucky economy.[14]

Supports 15,000 jobs across Kentucky, yielding $420 million in job income.[14]

Generates $80 million in state and local tax revenues.[15]

Hunting[16]

Contributes $439 million in retail sales and services annually to the Kentucky economy.

Supports 8,400 jobs across Kentucky, yielding $206 million in job income.

Generates $53 million in state and local tax revenues.

Equine Activities[17]

Kentucky's vibrant horse industry has a direct economic impact of $2.3 billion annually on the Kentucky economy.

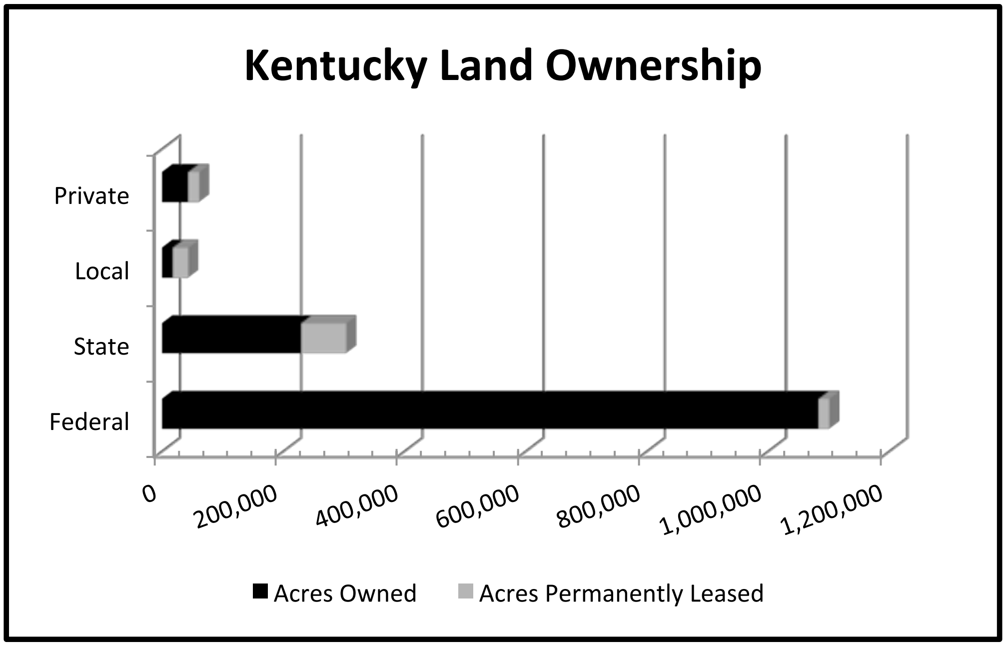

Figure 1. Kentucky Landownership.

The equine industry generates $121 million annually in federal, state and local taxes.

Almost 5200 direct jobs and 96,000 total jobs are created by the industry.

The lands and waters of Kentucky form the foundation for a strong a vibrant tourism industry in Kentucky. In 2010 Kentucky tourism generated over $11.3 billion in sales, $1.2 billion in state and local taxes and $2.5 billion in wages.[18]

In addition to revenue generated from land conservation, studies of Kentucky counties consistently show that unlike residential land, farmland and open space generate more in public revenues than they receive back in public services such as roads, utilities, police and fire. For example, for every $1 paid in local taxes, working and non-developed land in three Kentucky counties (Campbell, Kenton, and Shelby) required an average of $0.43 in services compared to an average of $1.20 in services for a typical urban residential property.[19]

The Current Status of Land Conservation

The establishment of protected areas, such as nature preserves, state and national parks, state forests, and wildlife management areas, has been an important and leading conservation strategy. Protected areas provide the long-term protection and management of natural areas while also providing opportunities for millions of citizens to enjoy the mix of lands and waters that make Kentucky home to so many outdoor enthusiasts.

Currently less than 6%, or 1.46 million acres, of Kentucky's lands are classified as permanently protected by local, state, or federal government agencies (Figure1).[20] Non-profit organizations currently own and protect an additional 60,000 acres.20 While "permanently protected" is a general term, in this instance it is meant to refer to lands that are managed in such a way that there is little risk of habitat loss and fragmentation through land use changes. It does not mean that the lands and waters under protection are always managed in ways that best contribute to maintaining or restoring the native biodiversity of the area. Currently the federal government is the largest protected area manager in Kentucky and the U.S. Forest Service the largest federal land manager in the state with over 817,000 acres.[20] The State of Kentucky currently owns just over 243,000 acres and permanently leases an additional 76,800 acres.[20]

State land holdings tend to be small and isolated with little connectivity between parcels. The Kentucky Division of Forestry has the largest average size of ownership at 2,936 acres followed by the Kentucky Department of Fish and Wildlife Resources at 1,572 acres (Figure 2).[21] Other state agencies average tract size is typically less than 1,000 acres.[21] From a conservation perspective, the ability of state ownership to maintain healthy and viable populations of species and natural communities that characterize the land and waters of Kentucky is severely limited by the small size of the tracts and the lack of connectivity.

Small isolated parks, nature preserves and other conservation lands are impacted by the landscape context in which they are found. In heavily fragmented landscapes, there are a number of physical barriers that impact many species, barriers such as highways, powerlines and other development by disrupting natural seasonal migrations and immigration/emigrations of the populations. The cumulative effect of fragmentation on our natural areas reduces the overall viability of our state natural areas to maintain

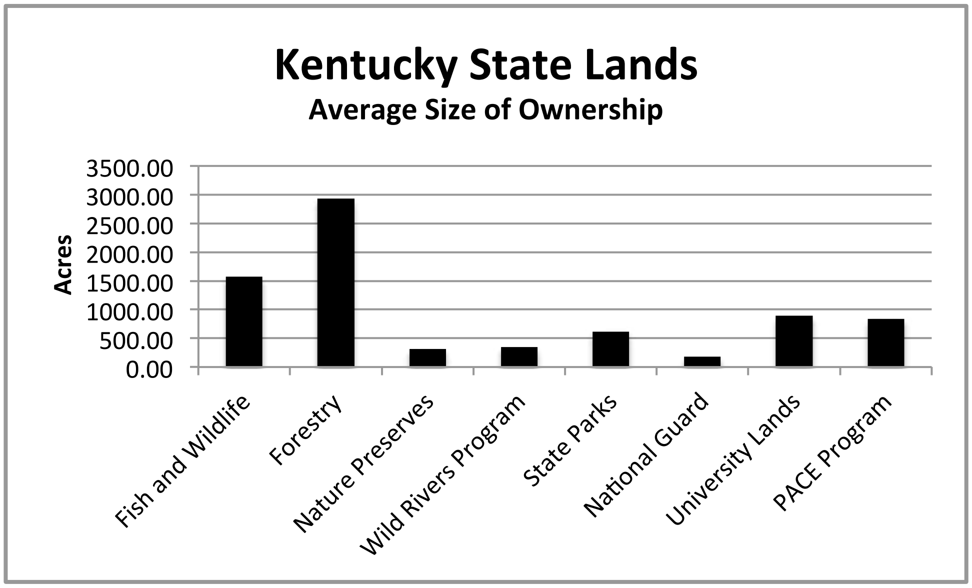

Figure 2. Kentucky State Lands: Average Size of Ownership.

the wildlife populations they harbor. In addition, management of these smaller isolated properties tends to be more costly and intensive because many of the natural ecosystem processes have been highly altered.

State Land Protection Programs[22]

To fund the purchase of protected areas, such as easements, and improve the management and stewardship of these lands, the state has passed several key pieces of legislation over the last 20 years. Below are highlighted three of the most significant.

The Kentucky Heritage Land Conservation Fund

The Kentucky Heritage Land Conservation Fund (KHLCF) was created in 1994 to fulfill the funding requirements of the Kentucky Heritage Land Conservation Act of 1990. The fund is managed by a 12-member board appointed by the governor. Revenue is generated through a portion of the unmined mineral tax, environmental penalties, and from the sale of environmental license plates. Fifty percent of the revenue deposited in the KHLCF is divided evenly among the Nature Preserve Commission (10%), Department of Fish & Wildlife Resources (10%), the Division of Forestry (10%), the Department of Parks (10%), and the Wild Rivers Program (10%). The remaining 50% is available on a competitive basis to local governments, state colleges, universities and public agencies.

The legislation establishes four priorities for acquiring properties, which include:

> Natural areas that possess unique features such as habitat for rare and endangered species;
>
> Areas important to migratory birds;
>
> Areas that perform important natural functions subject to alteration or loss;
>
> Areas to be preserved in their natural state for public use, outdoor recreation and education.

Since 1995, KHLCF has helped to protect and conserve over 37,000 acres at a cost of $41.6 million. Not including FY 2010 this amounts to 118 properties that cover 55 different counties. Approximately 76% of the total acreage is conserved by state agencies, 20% by local governments and conservation districts and 4% by universities. Table 1 provides more detail on the number of projects, acres conserved and total funding provided to each grant applicant. On average, the program has conserved a total of 2,519 acres per year.

The Kentucky Heritage Land Conservation Fund is the primary source of public financing for land conservation in Kentucky. However, the amount of revenue received for KHLCF falls well short of providing enough funds for the acquisition of large tracts of land that have and will continue to become available as corporations and individuals with large acreage (1000s of acres) divest of land holdings.[8]

The current revenue components of the fund vary widely from year to year, which creates uncertainty about the next round of funding at the agency level. To understand the strengths and weaknesses of the land conservation programs in Kentucky, the House of Representatives authorized the Land Stewardship and Conservation Task Force which conducted a survey of Kentucky's main conservation agencies. The findings identified a significant need for additional land conservation funding. Agency employees indicated that there is a gap between the lands available to be purchased and available dollars to make needed acquisitions.

Kentucky Farmland Protection and Easement Program

The Kentucky General Assembly established the Purchase of Agricultural Conservation Easement Program (PACE) in 1994. Initial funding was provided through a $10 million state bond issuance paid by tobacco settlement funds. The program requires a minimum General Assembly appropriation of $400,000. Through 2007, the program has received this annual appropriation, however since 2008 the state has failed to fully fund the program. PACE gives the state the authority to purchase agricultural conservation easements to ensure that lands currently in agricultural use will continue to remain available for agriculture. Donors of conservation easements are eligible to receive federal income tax credits, but no state income tax credits.

Table 1. Kentucky Heritage Land Conservation Fund: Project Overview by Applicant.[22]

Applicant	# of Projects	Acreage Conserved	Funding*
Fish and Wildlife Resources	8	4,318	$4,451,521
Division of Forestry	12	3,229	$3,315,134
Nature Preserves	31	7,015	$5,760,321
State Parks	10	945	$1,622,854
Wild Rivers	7	2,192	$2,377,905
Multiple Agencies	7	7,405	$8,112,546
County Governments	25	4,561	$8,294,937
City Governments	6	438	$1,318,805
Metro Governments	5	1,265	$3,303,318
Colleges/Universities	5	1,369	$3,069,576
Conservation Districts	2	201	$1,179,784
TOTAL	**118**	**32,938**	**$42,806,701**

*Includes both acquisition and management costs.

Since its inception the PACE program has purchased agricultural conservation easements on 89 farms totaling 21,451 acres for approximately $18 million. In addition, there have been 46 donated easements on 6,611 acres, which brings the combined inventory to 135 farms containing 28,062 acres.

While the number of farms protected through the PACE program is significant, the program cannot keep up with the demand. PACE has received applications to protect over 160,000 acres, many of which met requirements, but could not be purchased due to a lack of funding. Figure 3a and 3b show the funding and acres conserved through the PACE program. No additional farms have been conserved through the PACE program since 2007 due to the lack of funding.

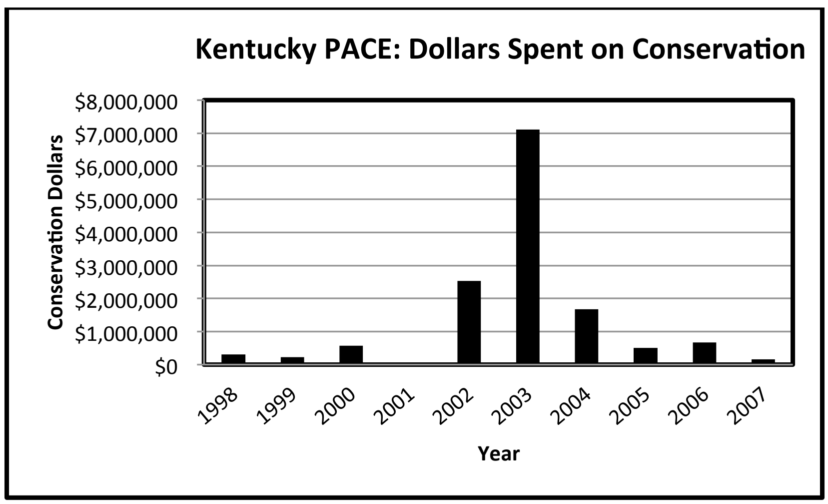

Figure 3a. Kentucky PACE: Dollars Spent on Conservation.

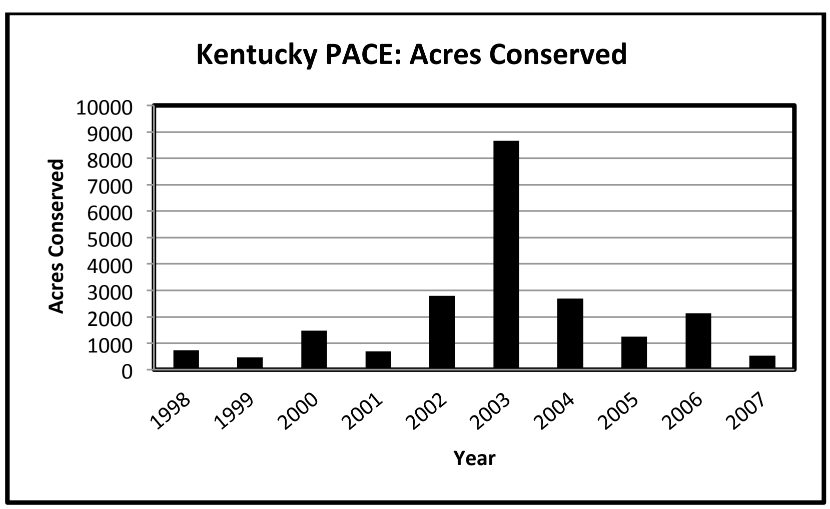

Figure 3b. Kentucky PACE: Acres Conserved.

Kentucky's Agricultural Districts Program

In 1982 The Kentucky General Assembly passed the Agricultural District and Conservation Act which created a program within the Division of Conservation, called the Agricultural District Program. The act established the goal of protecting the best agricultural land for food and fiber production and to prevent its conversion to nonagricultural usage.

Land enrolled in the Agricultural District Program cannot be annexed, cannot be condemned without mitigation, is taxed at the agricultural rate, is eligible for deferred assessment costs when water lines are extended, and receives extra points when applying for state cost share programs or to the PACE Program.

A landowner or group of landowners with at least 250 contiguous acres in active agricultural production is eligible to form an agricultural district. Individual parcels of land must contain at least 10 acres or 11 acres with a homestead. Participation is strictly vol-

untary, and a landowner may withdraw land anytime without penalty or without jeopardizing the status of the existing agricultural district.

Currently, there are 3,552 landowners participating in the Agricultural District Program, totaling 502 certified agricultural districts consisting of approximately 510,500 acres in 80 of Kentucky's 120 counties.

Public Attitudes towards Conservation

In the introduction, the question was posed: How do we meet the needs of a growing population while sustaining the links between human well-being and the preservation of species and ecosystems? A first step in determining what more we can do to conserve the natural legacy of our lands and waters is to understand the degree to which the people of the Commonwealth are willing to invest public resources to protect and sustain the natural landscapes of Kentucky.

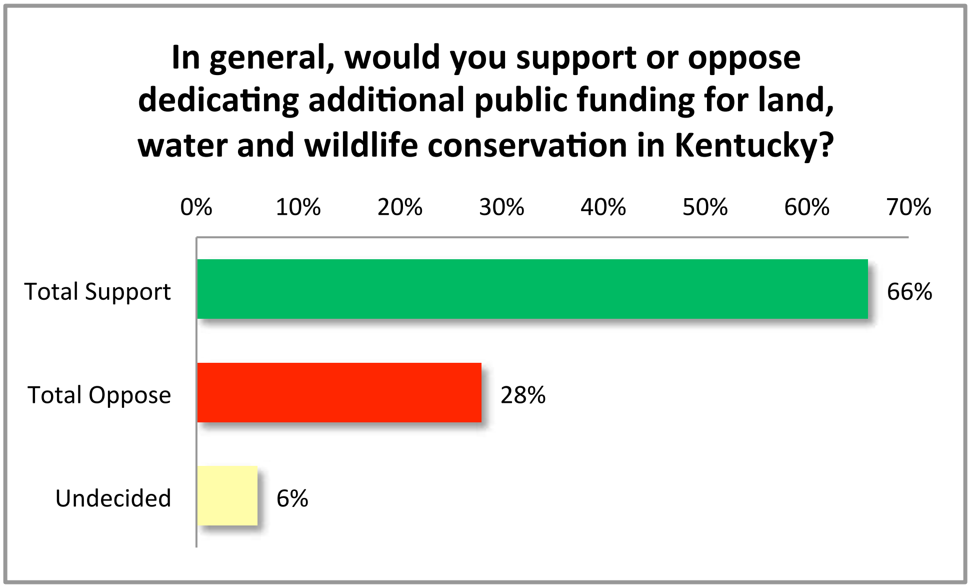

Figure 4. Results from a June 2011 Kentucky Statewide Public Survey.

In 2011, the bipartisan research team of Fairbank, Maslin, Maullin, Metz & Associates (Democrat) and Public Opinion Strategies (Republican) conducted a survey of voters in Kentucky to assess their attitudes on a variety of issues related to the conservation of land, water and wildlife in the state.[23] Overall, the survey results show that Kentucky voters enthusiastically support a number of proposals to increase investment in conservation of the state's natural resources. This support remains strong despite voter concerns about the economy and unemployment.

Key findings of the survey include:

> **Two-thirds (66%) of voters support dedicating additional public funding for land, water and wildlife conservation in Kentucky.** When asked directly if they would "support or oppose dedicating additional public funding for land, water and wildlife conservation in Kentucky," two-thirds (66%) of survey respondents indicated they would support such a dedication, including one-quarter (25%) who expressed "strong" support (Figure 4). Only a little more than one-quarter (28%) of respondents expressed opposition, with another six percent undecided.
>
> **Protecting drinking water and flood prevention are top priorities for voters.** Survey respondents were also asked to rate the importance of a variety of specific types of projects that might be carried out if additional funding were available for conservation in Kentucky, indicating whether they found each to be "extremely important," "very important," "somewhat important," or "not important." As shown in Table 2, more than 8 in 10 voters see it as "extremely" or "very" important to protect "sources of drinking water," "water quality in lakes, rivers and streams," and "natural areas along rivers to help prevent flooding." Three-quarters (75%) also place a high priority on "protecting working farmland;" while more than two thirds see it as "extremely" or "very" important to protect "forests," "natural areas," and "fish and wildlife habitat."

There is overwhelming support for a constitutional amendment dedicating existing sales taxes to protect land, water, and wildlife in Kentucky. Survey respondents were offered the following draft ballot language for a potential measure amending the state constitution to finance land conservation.

> *"Are you in favor of providing additional state funding to: protect and restore the state's lakes, rivers and streams, and wetlands; protect fish and wildlife habitat; preserve working farms and agricultural lands; create and expand parks, trails and natural areas; and promote tourism in the state, by dedicating the revenue from existing sales taxes on sporting goods for hunting, fishing, and other outdoor recreation?"*

Given that description, more than four in five (83%) survey respondents said that they would vote for the proposed constitutional amendment (Figure 5), including a majority (52%) who said they would "definitely" vote for the measure. Only 15 percent indicated they would oppose the measure and two percent were undecided.

Table 2. Results from a June 2011 Kentucky Statewide Public Survey.

Project	Percentage (%)		
	Ext. Import.	Very Import.	Total Ext./Very
Protecting sources of drinking water	45	46	**91**
Protecting water quality in lakes, rivers and streams	41	42	**83**
Protecting natural areas along rivers to help prevent flooding	40	40	**80**
Protecting working farmland	35	40	**75**
Protecting forests	32	37	**69**
Protecting natural areas	31	36	**67**
Protecting fish and wildlife habitat	28	39	**67**

The proposed constitutional amendment received majority support from every major subgroup of the Kentucky electorate. For example, the measure is supported by:

88% of Democrats, 79% of Republicans, and 75% of independents;

84% of women and 82% of men;

83% of college-educated voters and 83% of those without a four-year degree;

87% of voters under age 50 and 81% of those age 50 and over;

92% of self-described liberal voters, 91% of moderates, and 78% of conservatives;

78% of those who support the Tea Party; and

86% of urban voters, 86% of rural voters, 83% of small town voters, and 68% of suburban voters.

Furthermore, nine in ten (91%) of the respondents indicated that no matter how they think they would vote on this amendment, they want the State Legislature to allow Kentucky voters the opportunity to vote on this issue. In fact, two-in-five (39%) said they would be more likely to re-elect their state legislator if they supported the amendment, compared to only nine percent who said they would be less likely to do so. (51% indicated that a position on the amendment would not make a difference to them one way or another when voting to re-elect their state legislator.)

Voters strongly support a variety of mechanisms to support conservation in Kentucky. Survey respondents were also presented with several other ways to support conservation in Kentucky, from dedicating portions of existing taxes to providing tax credits for land donations. For example, four in five (82%) expressed support for "providing state tax credits to those who voluntarily donate land for conservation purposes." Additionally, at least seven in ten supported dedicating some portion of existing sales taxes or gas and oil extraction taxes to fund land and water conservation in Kentucky.

Kentucky voters' support for conservation is strong despite significant concern about economic issues. Strong support for each of the potential approaches to funding and/or promoting land and water conservation in Kentucky comes despite voters' concerns about the economy. For example, nine in ten survey respondents indicated that "jobs and the economy" (90%) and "the price of gasoline" (89%) were "extremely" or "very" serious problems facing Kentucky. This is likely due to the fact that the vast majority of voters believe that a strong economy and clean environment are not in conflict with each other. When presented with two different statements about the relationship between the environment and the economy, three-quarters (74%) of survey respondents agreed that Kentucky can have a "clean environment and a strong economy at the same time" (Figure 6).

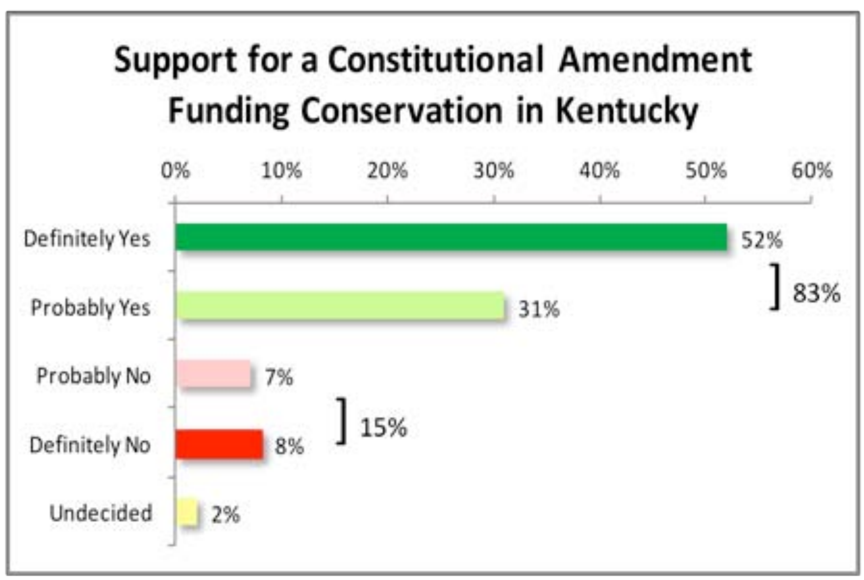

Figure 5. Results from a June 2011 Kentucky Statewide Public Survey.

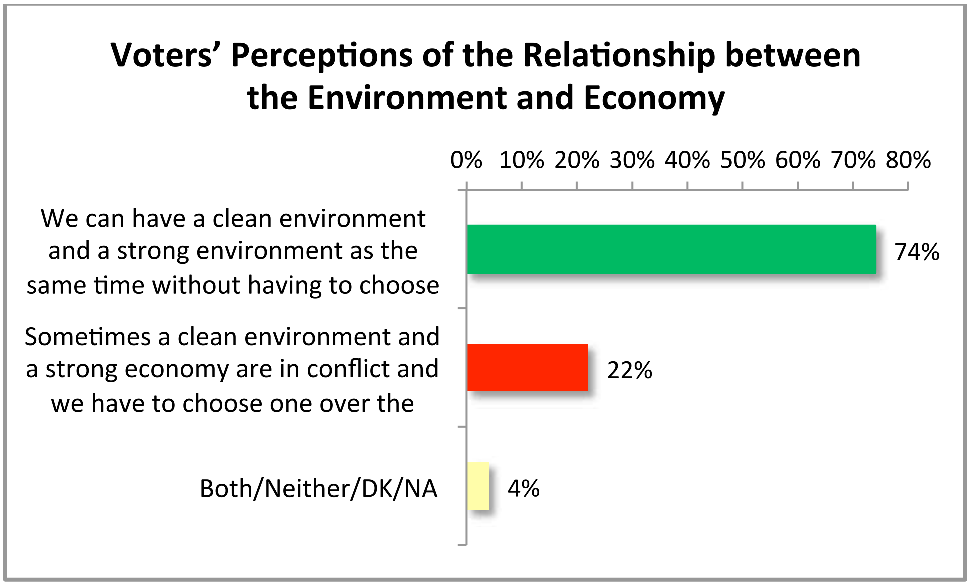

Figure 6. Results from a June 2011 Kentucky Statewide Public Survey.

This sentiment is shared by voters across the ideological spectrum, including two-thirds (66%) of conservative Republicans and 63 percent of those who support the Tea Party.

Overall, the survey results show that Kentucky voters value conservation, and in particular say it is important to protect the state's water, wildlife habitat, and working farmlands. Despite significant concerns about the economy – particularly jobs and gas prices – voters are highly supportive of additional funding to support land and water conservation in Kentucky.

Conclusions

We live in a special place, Kentucky. Its landscapes have raised generations of children and will forever embrace generations that have passed away. Our history and culture are inseparable from the mountains, forests, rivers and streams. Yet the population growth projected over the next several decades will likely result in accelerated rates of land conversion and water use as the demands for housing, food and energy increase. The impacts of land conversion and habitat loss are already evident in the decline of our forests, loss of native species, and the impairment of our freshwater ecosystems.

Overwhelmingly, Kentuckians recognize the link between a healthy environment and a strong economy. Perhaps no other natural resource is more valued than clean and abundant freshwater. Our rivers and lakes and freshwater ecosystems are critical economic drivers as they generate revenue for a wide variety of manufacturing and agricultural businesses. Our rivers and lakes support commercial and sport fisheries and offer recreation opportunities. Floodplains and riparian habitats help protect against floods and buffer our waterways against excessive runoff that is contaminated with fertilizers and pesticides. Despite our economic and human-well being dependence on freshwater, scientists are able to document the cumulative effects of habitat loss, pollution, and other non-sustainable uses. Strikingly, freshwater dependent species are the most threatened organisms in the world.[25] The extinction rate of freshwater species in North America is estimated to be 5 times that of terrestrial species.[26]

The Commonwealth faces a challenge it can no longer ignore. The landscapes of Daniel Boone have seen dramatic changes since he first climbed Pilot's Knob and surveyed the natural wonders of Kentucky. Yet, between 1998-2008 we spent a only $11 per capita on land conservation and conserved just over 52,000 acres.[24] During that same period, Tennessee spent $20 per capita and conserved over 100,000 acres.[24] Virginia spent $109 per capita and conserved over 550,000 acres.[24]

If future generations are to enjoy and experience the natural places that enhance our lives, sustain our economy, and support Kentucky's rich biodiversity, we must rethink this complex set of interdependencies and forge new solutions that are supported by environmental, recreation, and business interests. Conservation cannot be viewed as anti-people. Development will always be in conflict if it does not sustain and conserve nature's resources for future generations.

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