GREEN INFRASTRUCTURE VISION

VERSION 2.3 ECOSYSTEM SERVICE VALUATION

VALUATION OF ECOSYSTEM SERVICES FOR LAKE, PORTER, AND LaPORTE COUNTIES, INDIANA PROVIDED BY THE CHICAGO WILDERNESS GREEN INFRASTRUCTURE VISION

Final Report

Prepared by The Conservation Fund

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EXECUTIVE SUMMARY

Ecosystem services are the collective benefits from an array of resources and processes that are supplied by nature. Forests, wetlands, prairies, water bodies, and other natural ecosystems support our existence. Green infrastructure is the interconnected network of forests, wetlands, waterways, grasslands, and other natural areas that support native species, maintain natural ecological resources and processes, and contribute heavily to human health and quality of life.

Since 2004, the Chicago Wilderness Green Infrastructure Vision (GIV) has served as a visual representation of the Chicago Wilderness Biodiversity Recovery Plan, but it also served as a spatial representation of the region's ecosystem services. Only recently has it become possible to reliably estimate the contributions the GIV makes to human well being and to measure the benefits that nature provides us for free. The Chicago Wilderness GIV is being used every day by planners and decision makers at the local, state, regional, and federal levels to guide existing planning efforts and evaluate conservation and restoration opportunities that support preserving and managing the GIV network. Balmford et al. (2002) found that if the values of ecological services are considered, the benefits from conserving natural land gives a return on investment of at least 100 to 1.[1]

The Conservation Fund recently completed GIV Version 2.3, which focused on mapping ecosystem services within the Chicago Metropolitan Agency for Planning (CMAP) seven-county region. That study found that natural ecosystems contribute $8 billion per year in economic value to the seven-county CMAP region in Illinois. Using the GIV 2.3 to estimate the monetized social benefit of conservation in comparison with the investments required to protect land will lead to increased awareness of decision makers and the general public regarding the importance and contribution of green infrastructure to the region's quality of life. This project provides ecosystem service valuation models from GIV 2.3 data for Lake, Porter, and LaPorte Counties for six services (with estimates):

- Water flow regulation/flood control ($4 billion/year)
- Water purification ($393 million/year)
- Groundwater recharge ($1.4 billion/year)
- Carbon storage ($4.3 million/year)
- Air purification ($319 million/year)
- Recreation and ecotourism ($1.9 billion/year just for existing public land, including $121 million/year for Indiana Dunes State Park and $168 million/year for Indiana Dunes National Lakeshore)

It is also important to note that the GIV 2.3 is a land-based network and does not take into account the ecosystem services provided by Lake Michigan. The shoreline, near shore submerged habitat, and the lake itself have abundant ecosystem service values for recreation and ecotourism, and, to some extent, carbon storage beyond the $8 billion/year estimated in this study.

The final deliverables of this project include raster GIS datasets (30m pixels) depicting the economic value of ecosystem services provided by the GIV in Lake, Porter, and LaPorte Counties, Indiana. ESRI ArcGIS™ models facilitate running different scenarios of ecosystem service valuation and can be updated over time as new data and studies become available.

[1] Balmford, A., A. Bruner, P. Cooper, R. Costanza, S. Farber, R. E. Green, M. Jenkins, P. Jefferiss, V. Jessamy, J. Madden, K. Munro, N. Myers, S. Naeem, J. Paavola, M. Rayment, S. Rosendo, J. Roughgarden, K. Trumper, and K. Turner. 2002. Economic reasons for conserving wild nature. Science 297:950- 953.reasons for conserving wild nature. Science 297:950- 953.

1. GIV 2.3 PROJECT SUMMARY

What are Ecosystem Services?

Ecosystem services are the collective benefits to humans from an array of resources and processes that are supplied by nature. Forests, wetlands, prairies, water bodies, and other natural ecosystems support our existence. They provide services like cleaning the air, filtering and cooling water, storing and cycling nutrients, conserving and generating soils, pollinating crops and other plants, regulating climate, sequestering carbon, protecting areas against storm and flood damage, and maintaining hydrology and water supplies. These resources also provide marketable goods and services like forest products, fish and wildlife, and recreation. They serve as vital habitat for wild species, maintain a vast genetic library, provide scenery, and contribute in many ways to human health and quality of life.

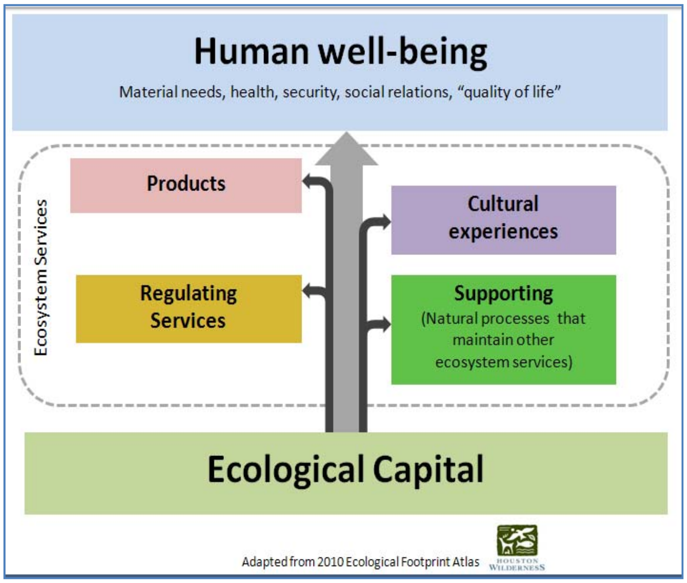


Figure 1. Ecosystem services and their relationship to ecology and human well being. Source: Houston Wilderness

Table 1 provides a comprehensive list of ecosystem services distilled from multiple literature sources (please see the accompanying literature review for more details). The nine services researched in this report are ***bolded***.

Table 1. List of ecosystem services

Ecosystem Service	Description
REGULATING & SUPPORTING	
Hazard Amelioration	
Water Flow Regulation / Flood Control	***Maintain water flow stability and protect areas against flooding (e.g., from storms).***
Water Purification	***Maintain water quality sufficient for human consumption, recreational uses like swimming and fishing, and aquatic life.***
Erosion Control and Sediment Retention	Maintain soil and slope stability, and retain soil and sediment on site.
Groundwater Recharge	***Maintain natural rates of groundwater recharge and aquifer replenishment***
Air Purification	***Remove particulates and other pollutants from the air***

Ecosystem Service	Description
	Climate
Microclimate Moderation	***Lower ambient and surface air temperature through shading***
Regulation of Water Temperature	Moderate water temperature in streams
Carbon Storage	***Sequester carbon in vegetation and soils, thereby reducing atmospheric CO_2 and global climate change***
	Biological
Native Flora and Fauna	***Maintain species diversity and biomass***
Pollination	Provide pollinators for crops and other vegetation important to humans
Pest and Disease Control	Provide biota which consume pests and control diseases
	Provisioning
Food Production	Production of plant or fungal-based food for human consumption
Game and Fish Production	Production of wild game and fish for human consumption
Fiber Production	Production of wood and other natural fibers for human use
Soil Formation	Long-term production of soil and peat for support of vegetation and other uses
Biochemical Production	Provision of biochemicals, natural medicines, pharmaceuticals, etc.
Genetic Information	Genetic resources for medical and other uses, including those not yet realized
	Cultural
Recreation and Ecotourism	***Outdoor, nature-based experiences like hiking, birding, hunting, camping, etc.***
Savings in Community Services	Savings in community services from not converting natural land to houses
Increase in Property Values	***Provide attractive location for homes and businesses***
Science and Education	Existence of natural systems and areas for school excursions, advancement of scientific knowledge, etc.
Spiritual and Aesthetic	Aesthetic enjoyment or spiritual or religious fulfillment
Bequest value	The value placed on knowing that future generations will have the option to utilize the resource.
Existence value	The non-use value of simply knowing that particular resources exist, even if they are not used.

What is Green Infrastructure?

Figure 2. Green infrastructure at multiple geographic scales. Source: The Conservation Fund

Green infrastructure is our natural life support system. At the landscape level, it is an interconnected network of forests, wetlands, waterways, grasslands, and other natural areas that support native species, maintain natural ecological resources and processes, and contribute heavily to human health and quality of life. At the regional scale, green space can help protect water quality and help ensure the availability of drinking water. Green infrastructure can also provide key recreational areas that link people to natural lands and facilitate the use of transportation modes other than automobiles. At the site scale, green infrastructure enhances communities through environmentally-sensitive site design techniques, urban forestry, and stormwater management systems that reduce the environmental impact of urban settlements. A recognized and delineated green infrastructure network serves as a shared vision that can lead to collaborative efforts. It can provide a systematic and strategic approach to land conservation and restoration, encouraging land use planning and practices that are beneficial to nature and people.

What is the Chicago Wilderness Green Infrastructure Vision?

In 2004, the Northeastern Illinois Planning Commission completed a Green Infrastructure Vision (GIV 1.0) for the Chicago Wilderness region to serve as a visual representation of the Chicago Wilderness Biodiversity Recovery Plan. This product included a map that identified large Resource Protection Areas (RPAs) and recommended protection approaches for each, including additional land preservation and ecological restoration. The second generation GIV, completed in 2012 and currently in version 2.2, is a refinement that is more spatially explicit in classifying and characterizing important resources in a consistent and analytically robust manner. Its primary products are GIS datasets that describe and characterize the regional green infrastructure network. According to the 2004 Chicago Wilderness report, the GIV gives "a high priority… to identifying and preserving important but unprotected natural communities, especially those threatened by development, and to protecting areas that can function as large blocks of natural habitat though restoration and management".

What is GIV 2.3?

In November 2014, the GIV 2.3 – CMAP ESV edition was completed, which included an extensive review and visualization of ecosystem service values for six services within the CMAP 7-county region: water flow regulation/flood control, water purification, groundwater recharge, carbon storage, native flora and fauna, and recreation and ecotourism. This project constitutes an additional release of the GIV 2.3 – NIRPC ESV edition. This project provides ecosystem service valuation models from GIV 2.3 data for Lake, Porter, and LaPorte Counties for six services: water flow regulation/flood control, water purification, groundwater recharge, carbon storage, air purification, and recreation and ecotourism. The estimated economic value of these services totals approximately $8 billion, not including services that we didn't assess.

- Water flow regulation/flood control ($4 billion/year)
- Water purification ($393 million/year)
- Groundwater recharge ($1.4 billion/year)
- Carbon storage ($4.3 million/year)
- Air purification ($319 million/year)
- Recreation and ecotourism ($1.9 billion/year just for existing public land, including $121 million/year for Indiana Dunes State Park and $168 million/year for Indiana Dunes National Lakeshore)

How does GIV 2.3 support land use planning and decision making?

The Chicago Wilderness GIV is being used every day by planners and decision makers at the local, state, regional, and federal levels to guide existing planning efforts and evaluate conservation and restoration opportunities that support preserving and managing the GIV network. Green infrastructure is protected, enhanced, and restored through the work of many different kinds of organizations, including forest preserve and conservation districts, the state and federal governments, park districts, and non-profit and for-profit organizations, among others. The GIV is used to target conservation investments, such as land purchases or restoration. It is also used to help shape future growth, minimizing loss of green infrastructure as the region grows and develops.

It is also important to note that the GIV 2.3 is a land-based network and does not take into account the ecosystem services provided by Lake Michigan. The shoreline, near shore submerged habitat, and the lake itself have abundant ecosystem service values for recreation and ecotourism, and, to some extent, carbon storage.

Balmford et al. (2002) found that if the values of ecological services are considered, the benefits from conserving natural land gives a return on investment of at least 100 to 1. Using the GIV 2.3 to estimate the monetized social benefit of conservation in comparison with the investments required to protect land can lead to increased awareness of decision makers and the general public regarding the importance and contribution of green infrastructure to the region's quality of life as well as a greater understanding of the relationship between the built environment and the region's ecological capital.

Local governments are responsible for planning and permitting development. One way to help ensure that local development is balanced with the protection of critical green infrastructure is for local governments to use the GIV 2.3 data in developing their comprehensive plans. These plans guide local growth patterns and typically include an open space component that can be enhanced by also including the GIV data. Local governments should also consider implementation strategies for ensuring that the regional green infrastructure network is legally protected from future disturbance, which could include such measures as an overlay ordinance for green infrastructure protection, a conservation design ordinance that permits higher densities in exchange for protecting sensitive areas, or land donation requirements for green infrastructure areas, among many options. A similar balancing approach is being done at the regional level. One of the goals of CMAP's GO TO 2040 is to help make sure that gray infrastructure expansion does not come at the expense of the green infrastructure network.

As most ecosystem services do not have established markets, it is challenging to make such estimates without providing detailed information on a variety of assumptions and caveats. The estimates developed for this project are estimates only and will only reflect a portion of the economic benefits of ecological capital. We have attempted to report a range of values for a particular ecosystem service, particularly since aggregate estimates over larger areas are more reliable than parcel level estimates. But even if the estimates change over the time, the key message from this project is that the Chicago Wilderness GIV has economic benefits that can be measured and should be evaluated accordingly in land use planning and decision making across the region.

GIV 2.3 NIRPC ESV Edition Technical Products

The final deliverables for the GIV 2.3 – NIRPC ESV edition include a literature review of the six ecosystem services mapped, as well as GIS layers and models that facilitate ecosystem service valuation to be updated over time as new data and studies become available. The development of the literature review and GIS layers was drawn from research completed for the GIV 2.3 CMAP ESV edition. For more information, please see the GIV 2.3 CMAP ESV final report.

2. ECOSYSTEM SERVICES MAPPED IN THE NIRPC REGION

The GIS layers for GIV 2.3 were developed by adapting Characterization Models developed by The Conservation Fund for GIV 2.2 using Esri's ArcGIS™ 10 and the ModelBuilder™ framework that allowed the user to identify the relative suitability of locations within the GIV network for particular conservation or restoration purposes. These models were re-engineered to utilize dollar value input and to allow for aggregated values across multiple GIV data layers. Dollar values estimates were selected based on a synthesis of the existing ecosystem services literature. We used studies and figures from the Chicago Wilderness area where possible, and within the Midwest as our second choice, and elsewhere in the U.S. as a third choice. In a few cases, only global values were available.

Table 2. Ecosystem services mapped for Chicago Wilderness GIV 2.3 NIRPC ESV edition

Ecosystem Service	Description
Water Flow Regulation / Flood Control	Maintain water flow stability and protect areas against flooding (e.g., from storms).
Water Purification	Maintain water quality sufficient for human consumption, recreational uses like swimming and fishing, and aquatic life.
Groundwater Recharge	Maintain natural rates of groundwater recharge and aquifer replenishment
Carbon Storage	Sequester carbon in vegetation and soils, thereby reducing atmospheric CO_2 and global climate change
Air Purification	Remove particulates and other pollutants from the air
Recreation and Ecotourism	Outdoor, nature-based experiences like hiking, birding, hunting, camping, etc.

Valuation Methods

Farber et al. (2002) listed six methods for valuing methods for valuing ecosystem services in monetary terms[2]:

- **Avoided cost**: Services allow society to avoid costs that would have been incurred in the absence of those services (e.g., natural flood control preventing property damages or natural waste treatment preventing health costs)
- **Replacement cost**: Services could be replaced with man-made systems (e.g., natural waste treatment having to be replaced by costly engineered systems)
- **Factor income**: Services provide for the enhancement of incomes (e.g., water quality increasing commercial fisheries catches and fishermen incomes)

[2] Farber, S.C., R. Costanza and M.A. Wilson. 2002. Economic and ecological concepts for valuing ecosystem services. Ecological Economics 41: 375-392.

- **Travel cost**: Service demand may require travel, whose costs can reflect the implied value of the service (e.g., value of ecotourism or recreation is at least what a visitor is willing to pay to get there)
- **Hedonic pricing**: Service demand may be reflected in the prices people will pay for associated goods (e.g., increase in housing prices due to water views or access to parks)
- **Contingent valuation**: Service demand may be elicited by posing hypothetical scenarios that involve some valuation of alternatives (e.g., how much people are willing to pay for increased availability of fish or wildlife).

The following table summarizes relevant metrics and types of economic analyses for the ecosystem services examined in this project that are relevant to the Chicago Wilderness GIV.

Table 3. Ecosystem services metrics and economic analyses

Ecosystem Service	Metrics	Types of economic analyses
Water Flow Regulation / Flood Control	- Reduction of flood damage - Reduction of stormwater flows - Reduction of peak discharges - Reduction of combined sewer system costs - Reduction of soil erosion	- Avoided cost of constructing and operating stormwater management infrastructure - Replacement cost of damaged infrastructure
Water Purification	- Reduction of N, P, Cl^-, sediment, bacteria, and other pollutants for drinking water, swimming, fishing, aquatic life, and other uses.	- Avoided cost of tertiary water treatment - Replacement cost of water treatment infrastructure
Groundwater Recharge	- Supply of water to groundwater rather than surface runoff	- Avoided cost of water constructing and operating supply infrastructure - Replacement cost of deeper wells - Price of public water supply
Carbon Storage	- Reduction of atmospheric CO_2 and associated climate effects (increased storm intensity, droughts, and heat waves)	- Avoided additional costs of climate change damage because of carbon sequestration
Recreation and Ecotourism	- Money spent on nature-based recreation (hunting, fishing, birding, hiking, etc.)	- Money spent on nature-based recreation
Air Purification	- Removal of SO_x, NO_x, O_3, CO, and PM_{10} from the air (pollutants with public health impacts)	- Avoided cost of air quality improvement systems - Replacement cost of infrastructure due to poor air quality

These ecosystem service metrics and economic analyses have been used in the scientific literature to estimate the dollar value of these ecosystem services.

Ecosystem Service Value Estimates

The table on the following page is a summary of the ecosystem services estimates that were selected for the GIS models based on expert judgment and a thorough analysis of each study. For most models, the median of all studies reviewed for a particular service and associated landscape type was selected for the models. For some services, we selected a value higher or lower than the median if there was a particularly relevant and reliable study from the Midwest. Please see the literature review for information about each of the studies used to generate the table values.

The estimated aggregated values from the ecosystem service valuation models from GIV 2.3 data for Lake, Porter, and LaPorte Counties for six services were:

- Water flow regulation/flood control ($4 billion/year)
- Water purification ($393 million/year)
- Groundwater recharge ($1.4 billion/year)
- Carbon storage ($4.3 million/year)
- Air purification ($319 million/year)
- Recreation and ecotourism ($1.9 billion/year just for existing public land, including $121 million/year for Indiana Dunes State Park and $168 million/year for Indiana Dunes National Lakeshore)

GIV Landscapes

This table shows a crosswalk between the GIV landscape types and the GIV layers that are used in ecosystem service valuation modeling.

Table 4. GIV layers used in ecosystem service valuation estimates

Crosswalk GIV layer	GIS Model Reference	GIV 2.2 Data Inputs for CMAP Region
Woodlands/Forest		
Core woodland/forest designated areas	**Woodland/Forest Layers 3a & 3b**	Forest Blocks derived from land cover, State Natural Heritage databases, Audubon Important Bird Areas, NIRPC environmental assets data layers, Indiana Dunes National Lakeshore Vegetation mapping
Core woodland/forest	**Woodland/Forest Layer 4**	
Woodland sites	**Woodland/Forest Layer 5**	
Woodland/forest corridors	**Woodland/Forest Layer 7**	Forest land cover to facilitate functional connectivity modeling

Crosswalk GIV layer	GIS Model Reference	GIV 2.2 Data Inputs for CMAP Region
Prairie/Grassland/Savanna		
Core prairies	**PGS Layer 1**	State Natural Heritage databases, Indiana Dunes National Lakeshore Vegetation mapping
Core savannas	**PGS Layer 2**	State Natural Heritage databases
Grassland blocks	**PGS Layer 3**	National Land Cover Database herbaceous grasslands
Wetlands		
Core wetland designated areas	**Wetland Layers 4a & 4b**	NIRPC wetlands data, State natural heritage databases, Ducks Unlimited enhance NWI data, The Nature Conservancy's Shorebird Site Priority & Waterfowl Site Priority, Indiana Dunes National Lakeshore Vegetation mapping
Core wetlands	**Wetland Layer 5**	
Wetland sites	**Wetland Layer 6**	
Wetland complexes	**Wetland Layer 7**	NIRPC Hydric Soils
Wetland corridors	**Wetland Layer 8**	Wetland land cover to facilitate functional connectivity modeling
Streams and Lakes		
Undeveloped NHD+ stream buffer	**Steams/Lakes Layer 2**	National Hydrography Dataset Plus (NHDPlus) Waterbodies and Flowlines, NIRPC Floodplains, Indiana Outstanding Rivers, Indiana Salmonid Streams, NIRPC groundwater protection data
Core lakes and streams	**Steams/Lakes Layer 3**	
Undeveloped freshwater systems	**Steams/Lakes Layer 5**	

Table 5. Ecosystem service valuation estimates used on maps

		LANDSCAPE TYPE				
ECOSYSTEM SERVICE		**Woodlands / Forest**	**Prairie / Grassland / Savanna**	**Wetlands**	**Natural Floodplains**	**Lakes**
Water Flow Regulation/ Flood control	Selected	$1,603	$16,000	$22,000	$6,500	$37,000
	Median	$1,415	$16,000	$4,900	$3,700	$43,000
Water Purification	Selected	$1,300	$57	$4,350		$0
	Median	$1,060	$57	$3,429		$0
Groundwater Recharge	Selected	$269	$269	$660	$4,806	$566
	Median	$269	$269	$2,479	$4,806	$566
Carbon Storage	Selected	USED SPATIALLY EXPLICIT DATA FROM NBCD + gSSURGO				
	Median	$133	$82	$136		$0
Air Purification	Selected	$390	No data	No data	No data	No data
	Median	$390				
Recreation and Ecotourism	Selected	ESTIMATED EXPENDITURES USING PARK VISITATION AND CENSUS TRACT DATA				
	Median	$48	$1	$1,434	$2,229	$335

The following section provides a brief summary of each of the six ecosystem services researched and mapped for the NIRPC 3-county region. The summary points are derived from the comprehensive literature review.

3. GIS LAYERS AND MODELS FOR GIV ECOSYSTEM SERVICES

The following table provides a summary of the GIV layers and model references that are referenced in the tables associated with each ecosystem service in this section.

Table 6. GIV layers and model references for ecosystem service valuation

GIV 2.3	GIV Layer	Model Reference
GIV landscape features		
	Core woodland/forest designated areas	**Woodland/Forest Layers 3a & 3b**
	Core woodland/forest	**Woodland/Forest Layer 4**
	Core prairies	**PGS Layer 1**
	Core savannas	**PGS Layer 2**
	Core wetland designated areas	**Wetland Layers 4a & 4b**
	Core wetlands	**Wetland Layer 5**
	Core lakes and streams	**Steams/Lakes Layer 3**
Functional connections		
	Woodland/forest corridors	**Woodland/Forest Layer 7**
	Wetland corridors	**Wetland Layer 8**
	Undeveloped NHD+ stream buffer	**Steams/Lakes Layer 2**
	Undeveloped freshwater systems	**Steams/Lakes Layer 5**
Restoration building blocks		
	Forest Sites	**Woodland/Forest Layer 5**
	Pre-settlement woodland/forest	**Woodland/Forest Layer 6**
	Grassland blocks	**PGS Layer 3**
	Pre-settlement prairie/grassland	**PGS Layer 4**
	Pre-settlement savanna complexes	**PGS Layer 5**
	Prairie/grassland corridors	**PGS Layer 7**
	Wetland sites	**Wetland Layer 6**
	Wetland complexes	**Wetland Layer 7**
	NHD+ raster buffer	**Steams/Lakes Layer 1**
	Freshwater Systems	**Steams/Lakes Layer 4**
Composite layers		
	GIV ecological network	**Hub Layer 1**
	Protected lands raster	**Hub Layer 2**
	GIV network + protected lands	**Hub Layer 3**

Water Flow Regulation / Flood Control

Why this service is important

Natural systems are the least costly and most efficient way to control flooding. This is particularly important for local governments who have ongoing concerns about the cost to maintain infrastructure and to comply with stormwater management regulations. More frequent and intense storm events due to climate change will result in more stormwater and higher peak discharges. This can result in increased sediment and pollutant runoff as well as increase sanitary/combined sewer back-ups that can contaminate drinking water sources and create public health hazards in neighborhoods.

One way the GIV provides flood control and water flow regulation is through reductions in peak discharges of stormwater flows. Maintaining green infrastructure helps ensure that water can infiltrate in the soil and recharge the groundwater rather than enter the combined sewer and stormwater systems. This can help reduce flood damage to community infrastructure and damage to natural hydrology that could result in a loss of native riparian vegetation and loss of wildlife habitat.

Flooding has significant economic and social costs, and investment in green infrastructure helps avoid some of these costs to repair and replace gray infrastructure and helps reduce private property losses and damages. In addition to being a cost-effective means of mitigating flooding and stormwater impacts, green infrastructure also has many other benefits such as recreation and wildlife habitat that single-purpose engineered systems often do not.

Fortunately, the GIV contains nearly all of the natural interconnected wetlands and riparian zones that provide this ecosystem service. Existing natural systems cannot manage all of the flood control needs of communities, but protection of green infrastructure can help avoid the problem getting worse in locations where the GIV absorbs flood waters before entering engineered flood control infrastructure. Restoration can help improve it.

Summary points

- A large tree can reduce 5,400 gallons of stormwater runoff per year in the Midwest. A forest stand can intercept over 200,000 gallons per acre per year.
- An acre of forest provides an annual avoided stormwater treatment cost of $21 per acre per year and over $9,000 per acre per year in avoided gray infrastructure investment costs.
- An acre of wetlands can typically store 1-1.5 million gallons of floodwater.
- In Wisconsin, watersheds with 30% wetland or lake area had flood peaks 60-80% lower than watersheds with no wetland or lake area.
- Not building in floodplains in the Chicago metropolitan area could save an average $900 per acre per year in flood damages.

Opportunities to maintain and enhance this service provided by the GIV

Conservation and Restoration Implementation Activities

- ✓ Preserve land within unprotected areas of GIV cores, corridors, and sites. GIV layers are listed in order of estimated ecosystem services value. (Note: PGS = Prairie-Grassland-Savanna)

GIV Layer	GIS Model Reference	Economic Benefit (2014$/acre/year)
[Lakes] from Core lakes and streams	**Steams/Lakes Layer 3**	$37,000
Core wetland designated areas	**Wetland Layers 4a & 4b**	$22,000
Core wetlands	**Wetland Layer 5**	$22,000
Wetland corridors	**Wetland Layer 8**	$22,000
Wetland sites	**Wetland Layer 6**	$22,000
Core prairies	**PGS Layer 1**	$16,000
Core savannas	**PGS Layer 2**	$16,000
[Streams] from Core lakes and streams	**Steams/Lakes Layer 3**	$6,500
Core woodland/forest designated areas	**Woodland/Forest Layers 3a & 3b**	$1,603
Core woodland/forest	**Woodland/Forest Layer 4**	$1,603
Woodland/forest corridors	**Woodland/Forest Layer 7**	$1,603
Woodlands sites	**Woodland/Forest Layer 5**	$1,603

- ✓ Prevent land use conversion within functionally connected freshwater systems and stream buffers. GIV layers are listed in order of estimated ecosystem services value.

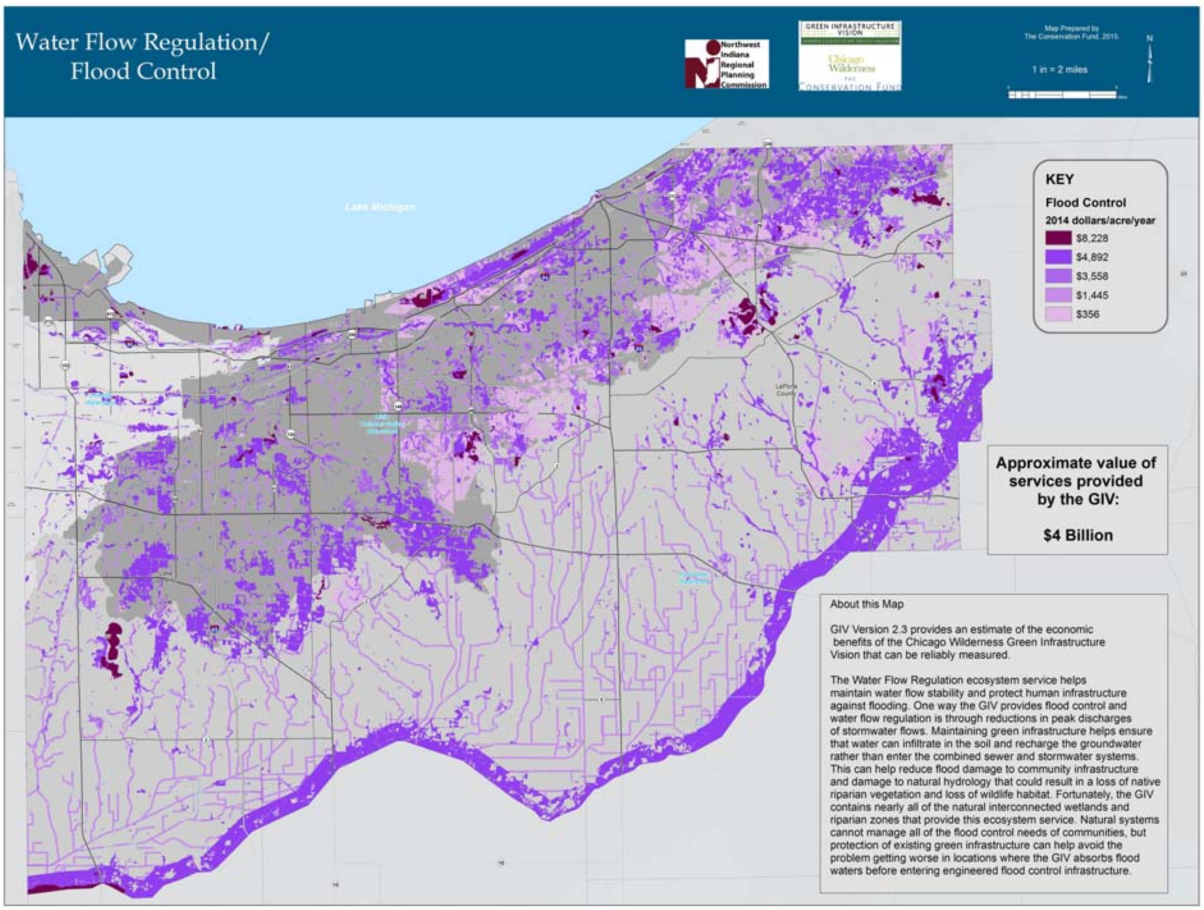
GIV Layer	GIS Model Reference	Economic Benefit (2014$/acre/year)
Undeveloped freshwater systems	**Stream/Lakes Layer 5**	$6,500
Undeveloped NHD+ stream buffer	**Streams/Lakes Layer 2**	$6,500

Restore land to a suitable GIV landscape feature appropriate for the site. GIV layers are listed in order of estimated ecosystem services value.

GIV Layer	GIS Model Reference
Wetland complexes	**Wetland Layer 7**
Prairie/grassland corridors	**PGS Layer 7**
Grassland blocks	**PGS Layer 3**
Pre-settlement prairie/grassland	**PGS Layer 4**
Pre-settlement savanna	**PGS Layer 5**
Freshwater Systems	**Streams/Lakes layer 4**
NHD+ raster buffer	**Streams/Lakes Layer 1**
Pre-settlement woodland/forest	**Woodland/Forest Layer 6**
Protected lands raster	**Hub Layer 2**

Map Methodology

The GIV 2.2 is the foundation for developing the approximate value of water flow regulation and flood control services provided by the GIV in the CMAP region. Using ArcGIS for Desktop 10.2.2 we built GIS models within the Model Builder environment. The resulting valuation from literature review and expert opinion was spatially explicit and transferred to the GIV layers using raster analysis (cell size = 30mX30m). Each cell was assigned a dollar value according to landscape type. The GIV layers were mosaicked into one raster layer and always preserving the maximum value assigned to each cell when there was any overlap between the layers. Having a dollar value for each cell allowed us to calculate the total value in dollars provided by the GIV for water flow regulation and flood control. Values range from $1,603/acre/year - $37,000 acre/year.



Map 1: Ecosystem service values in NIRPC region for Water Flow Regulation / Flood Control

Water Purification

Why this service is important

Clean water is essential to public health and ecosystem health. Natural systems can be an effective way to reduce nonpoint source pollution, sediment, nutrients (i.e. nitrogen, phosphorus), bacteria, and other pollutants from water supplies that provide drinking water and opportunities for fishing and swimming. Natural systems also can help avoid the need to invest in or replace expensive, energy intensive gray infrastructure systems that treat water or manage stormwater. Poor water quality can have other significant economic impacts, including beach closures due to high bacteria levels, the need for dredging due to sedimentation, and limits on water-based recreational activities. The Chicago Wilderness GIV contains nearly all the wetlands and other natural land that currently provide this ecosystem service.

Summary points

- Forested buffers can remove up to 21 pounds of nitrogen and 4 pounds of phosphorus per acre per year from upland runoff. Forest buffers can reduce up to 98% of nitrogen, phosphorus, sediments, pesticides, pathogens, and other pollutants in surface and groundwater.
- Wetlands can filter 70-90% of nitrogen, 45% of phosphorous, and retain more than 70% of sediment.
- In a comparison of 11 types of best management practices (BMPs) for treating stormwater runoff, constructed wetlands were the most effective for improving water quality. The wetland removed 100% of suspended solids, 99% of nitrate, 100% of zinc, and 100% of petroleum byproducts, and reduced peak flows by 85%. This greatly exceeded the performance of standard retention ponds, as well as expensive manufactured devices.
- The average wastewater treatment costs using conventional methods are $4.36 per 1,000 gallons, but through wetlands construction, the cost is only $0.63/1,000 gallons ($2014).
- The cost of restoring and operating wetlands to remove nitrogen and phosphorus can be 50-70% less than the cost of constructing and operating engineered wastewater treatment systems.

Opportunities to maintain and enhance this service provided by the GIV

Conservation and Restoration Implementation Activities

- ✓ Preserve land within unprotected areas of GIV cores, corridors, and sites. GIV layers are listed in order of estimated ecosystem services value.

GIV Layer	GIS Model Reference	Economic Benefit (2014$/acre/year)
Core wetland designated areas	**Wetland Layers 4a & 4b**	$4,350
Core wetlands	**Wetland Layer 5**	$4,350
Wetland corridors	**Wetland Layer 8**	$4,350

GIV Layer	GIS Model Reference	Economic Benefit (2014$/acre/year)
Core woodland/forest designated areas	**Woodland/Forest Layers 3a & 3b**	$1,300
Core woodland/forest	**Woodland/Forest Layer 4**	$1,300
Woodland/forest corridors	**Woodland/Forest Layer 7**	$1,300
Woodlands sites	**Woodland/Forest Layer 5**	$1,300
Core prairies	**PGS Layer 1**	$57
Core savannas	**PGS Layer 2**	$57

✓ Prevent land use conversion within functionally connected freshwater systems and stream buffers.

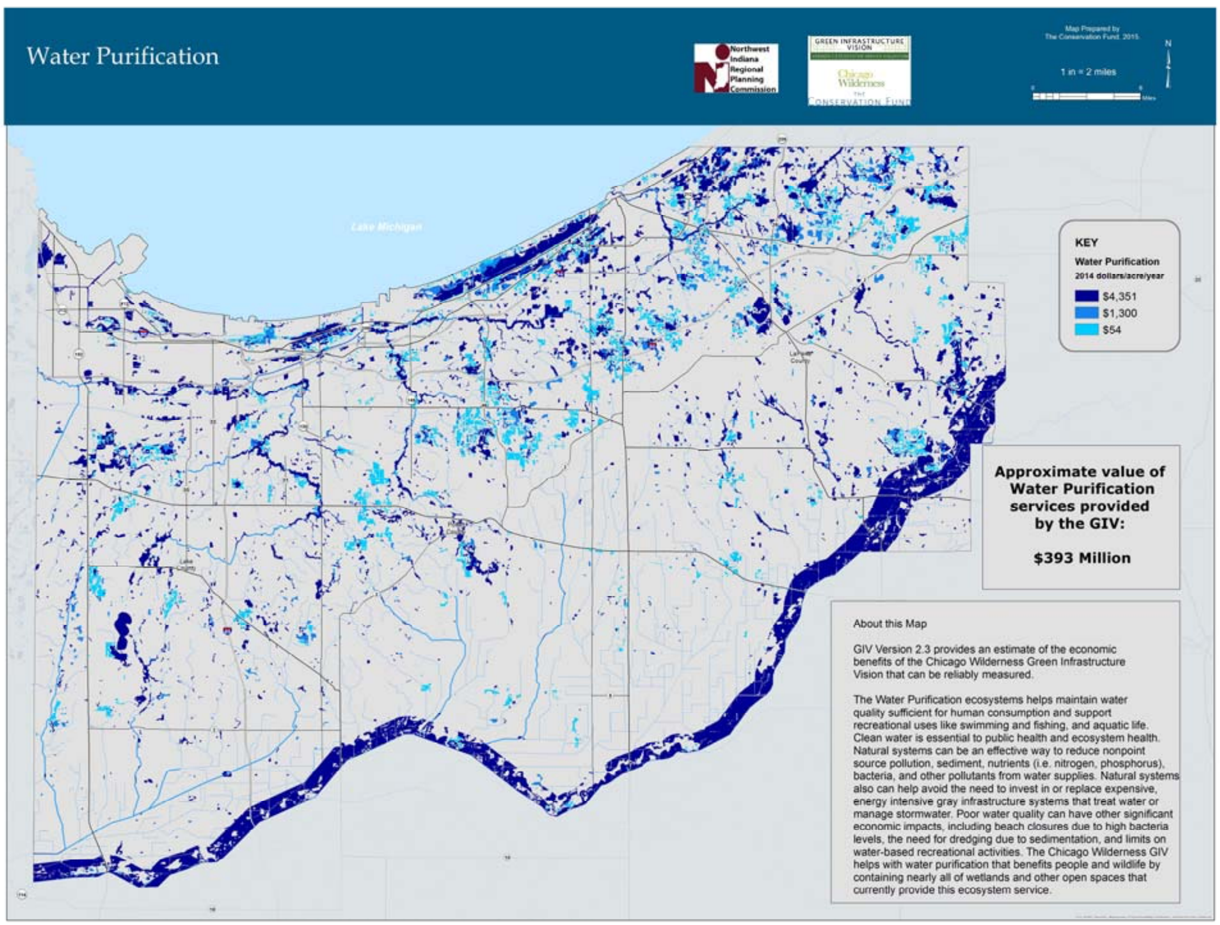
GIV Layer	GIS Model Reference
Undeveloped freshwater systems	**Stream/Lakes Layer 5**
Undeveloped NHD+ stream buffer	**Streams/Lakes Layer 2**

✓ Restore land to a suitable GIV landscape feature appropriate for the site.

GIV Layer	GIS Model Reference
Wetland complexes	**Wetland Layer 7**
Pre-settlement woodland/forest	**Woodland/Forest Layer 6**
Prairie/grassland corridors	**PGS Layer 7**
Grassland blocks	**PGS Layer 3**
Pre-settlement prairie/grassland	**PGS Layer 4**
Pre-settlement savanna	**PGS Layer 5**
Freshwater Systems	**Streams/Lakes layer 4**
NHD+ raster buffer	**Streams/Lakes Layer 1**
Protected lands raster	**Hub Layer 2**

Map Methodology

The GIV 2.2 is the foundation for developing the approximate value of water purification services provided by the GIV in the CMAP region. Using ArcGIS for Desktop 10.2.2 we built GIS models within the Model Builder environment. The resulting valuation from literature review and expert opinion was spatially explicit and transferred to the GIV layers using raster analysis (cell size = 30mX30m). Each cell was assigned a dollar value according to landscape type. The GIV layers were mosaicked into one raster layer and always preserving the maximum value assigned to each cell when there was any overlap between the layers. Having a dollar value for each cell allowed us to calculate the total value in dollars provided by the GIV for water purification. Values ranged from $57 acre/year - $4350 acre/year.



Map 2: Ecosystem service values in NIRPC region for Water Purification

Groundwater Recharge

Why this service is important

Groundwater recharge is a key to adequate water supplies for people and wildlife, particularly for those municipalities that rely on groundwater aquifers for their drinking water supplies. Significant costs can be incurred when there is a need to develop, treat, and maintain deeper wells and associated treatment systems. Groundwater also helps maintain the natural base flow of rivers and streams. The geology of groundwater infiltration and capture is complex, but one of the keys is minimizing impervious surface that diverts water into combined sewers and other stormwater management infrastructure before it can soak into the ground. The Chicago Wilderness GIV includes the natural river and stream network, and land that serves as infiltration areas to underground aquifers.

Summary points

- Forests, wetlands, and prairies can help maintain natural rates of groundwater recharge and aquifer replenishment and can contribute significantly to recharging regional groundwater.
- Forested wetlands overlying permeable soil can release up to 100,000 gallons per acre per day of groundwater.

Opportunities to maintain and enhance this service provided by the GIV

Conservation and Restoration Implementation Activities

- ✓ Preserve land within unprotected areas of GIV cores, corridors, and sites. GIV layers are listed in order of estimated ecosystem services value.

GIV Layer	GIS Model Reference	Economic Benefit (2014$/acre/year)
[Floodplains]	**Multiple GIV layers**	$4,806
[Streams] from Core lakes and streams	**Steams/Lakes Layer 3**	$4,806
Core wetland designated areas	**Wetland Layers 4a & 4b**	$660
Core wetlands	**Wetland Layer 5**	$660
Wetland corridors	**Wetland Layer 8**	$660
[Lakes] from Core lakes and streams	**Steams/Lakes Layer 3**	$566
Core prairies	**PGS Layer 1**	$269
Core savannas	**PGS Layer 2**	$269

Core woodland/forest designated areas	**Woodland/Forest Layers 3a & 3b**	$269
GIV Layer	GIS Model Reference	Economic Benefit (2014$/acre/year)
Core woodland/forest	**Woodland/Forest Layer 4**	$269
Woodland/forest corridors	**Woodland/Forest Layer 7**	$269
Woodlands sites	**Woodland/Forest Layer 5**	$269

- ✓ Prevent land use conversion within functionally connected freshwater systems and stream buffers. GIV layers are listed in order of estimated ecosystem services value.

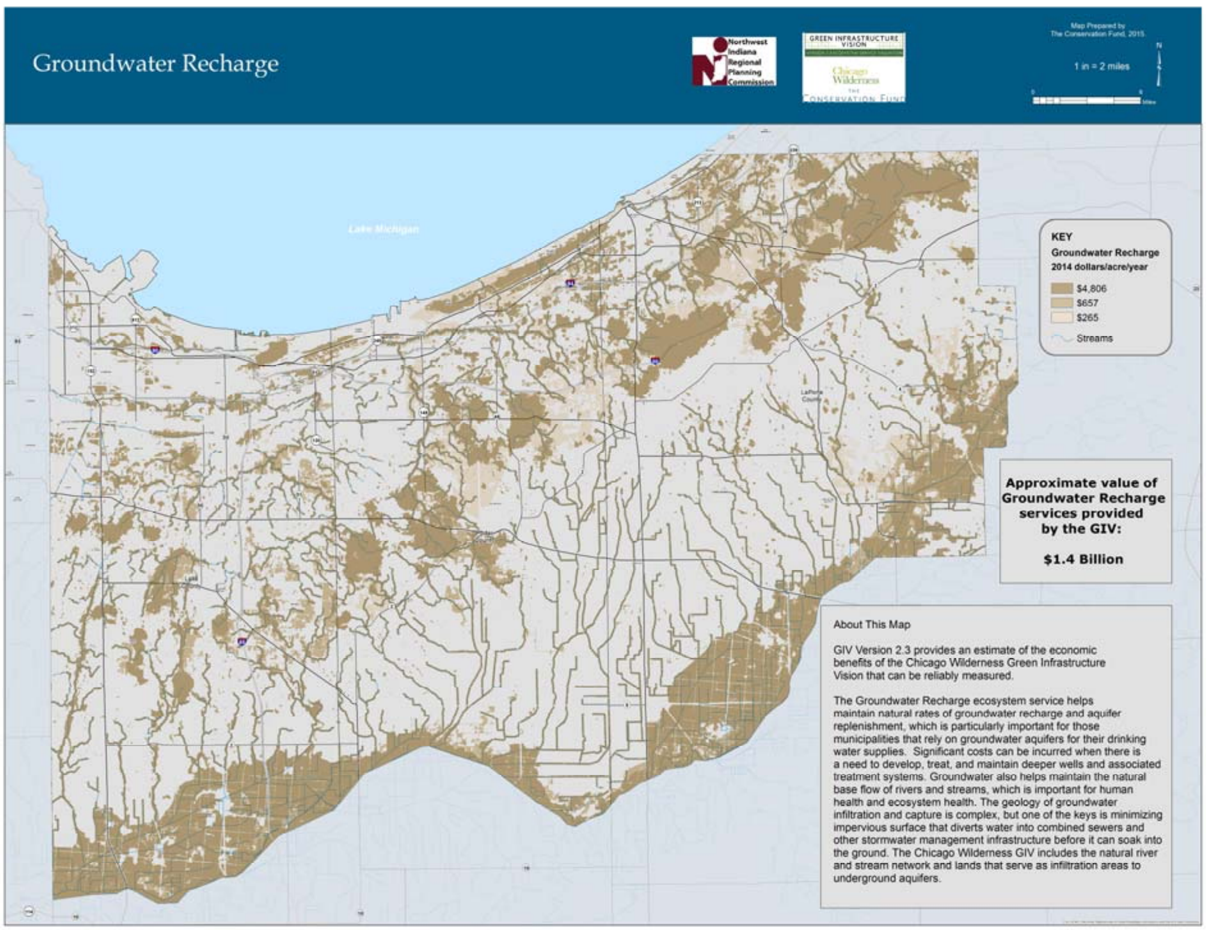
GIV Layer	GIS Model Reference	Value (2014$/acre/year)
Undeveloped freshwater systems	**Stream/Lakes Layer 5**	$4,806
Undeveloped NHD+ stream buffer	**Streams/Lakes Layer 2**	$4,806

- ✓ Restore land to a suitable GIV landscape feature appropriate for the site.

GIV Layer	GIS Model Reference
Wetland complexes	**Wetland Layer 7**
Prairie/grassland corridors	**PGS Layer 7**
Grassland blocks	**PGS Layer 3**
Pre-settlement prairie/grassland	**PGS Layer 4**
Pre-settlement savanna	**PGS Layer 5**
Freshwater Systems	**Streams/Lakes layer 4**
NHD+ raster buffer	**Streams/Lakes Layer 1**
Pre-settlement woodland/forest	**Woodland/Forest Layer 6**
Protected lands raster	**Hub Layer 2**

Map Methodology

The GIV 2.2 is the foundation for developing the approximate value of groundwater recharge services provided by the GIV in the CMAP region. Using ArcGIS for Desktop 10.2.2 we built GIS models within the Model Builder environment. The resulting valuation from literature review and expert opinion was spatially explicit and the values were transferred to the GIV layers using raster analysis (cell size = 30m x 30m). Each cell was assigned a dollar value according to landscape type. The GIV layers were mosaicked into one raster layer and always preserving the maximum value assigned to each cell when there was any overlap between the layers. Having a dollar value for each cell allowed us to calculate the total value in dollars provided by the GIV for groundwater recharge. Values ranged from $269 acre/year - $4,806 acre/year.



Map 3: Ecosystem service values in NIRPC region for Groundwater Recharge

Carbon Storage

Why this service is important

The ability for natural systems to capture carbon helps mitigate the emission of greenhouse gases like carbon dioxide (CO_2) into the atmosphere, and thereby helps reduce future climate change. Carbon is stored above ground in leaves and woody matter, and below ground in roots and the soil. The GIV includes natural areas and areas of pre-settlement native vegetation that, for the most part, represent areas where carbon storage is occurring and where new opportunities exist through habitat restoration. Protecting the existing GIV also supports the region's Climate Action Plans.

Summary points

- Forests remove large amounts of CO_2 from the air. During photosynthesis, trees convert CO_2 into oxygen; carbon is also stored in the body of the tree, in the soil surrounding its roots, and in debris that falls to the ground. Larger and healthier trees sequester carbon at greater rates.
- A large tree can remove over 1,000 pounds per year of CO_2 from the atmosphere.
- A mature oak-hickory forest can contain over 130 tons of carbon per acre.
- Restoring prairie vegetation rebuilds organic matter in the surface soil and sequesters carbon, taking centuries to reach maximum storage potential.
- Remnant prairie at Fermi National Accelerator Laboratory contained around 0.76 kg of carbon per square meter above ground and 13.5 kg per square meter below ground.

Opportunities to maintain and enhance this service provided by the GIV

Conservation and Restoration Implementation Activities

- ✓ Preserve land within unprotected areas of GIV cores, corridors, and sites. GIV layers are listed in approximate order of estimated ecosystem services value. Please see the Map Methodology section below that explains how specific values were generated.

GIV Layer	GIS Model Reference
Core woodland/forest designated areas	**Woodland/Forest Layers 3a & 3b**
Core woodland/forest	**Woodland/Forest Layer 4**
Woodland/forest corridors	**Woodland/Forest Layer 7**
Woodlands sites	**Woodland/Forest Layer 5**
Core wetland designated areas	**Wetland Layers 4a & 4b**
Core wetlands	**Wetland Layer 5**

GIV Layer	GIS Model Reference
Wetland corridors	**Wetland Layer 8**
Core prairies	**PGS Layer 1**
Core savannas	**PGS Layer 2**

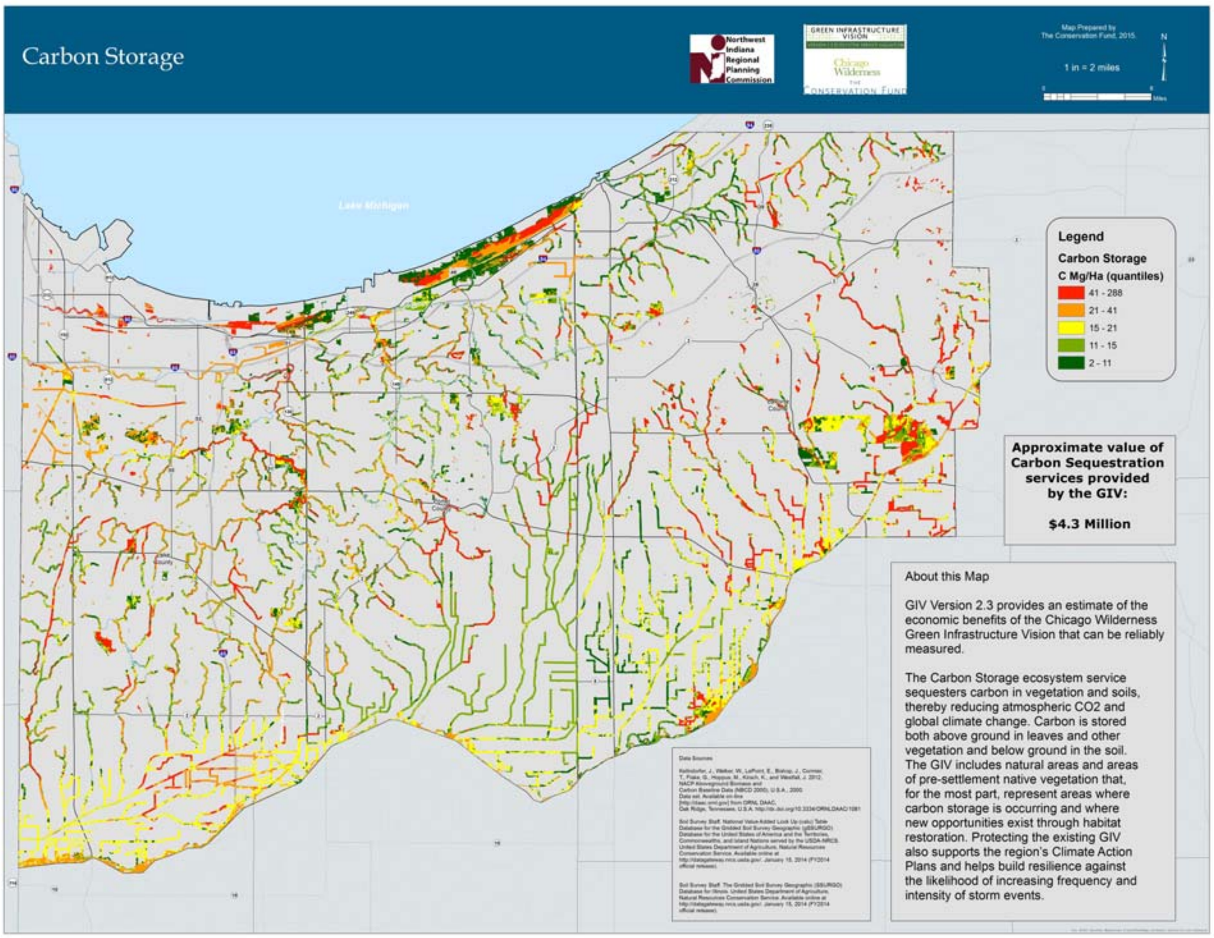
- ✓ Restore land to a suitable GIV landscape feature appropriate for the site.

GIV Layer	GIS Model Reference
Pre-settlement woodland/forest	**Woodland/Forest Layer 6**
Wetland complexes	**Wetland Layer 7**
Prairie/grassland corridors	**PGS Layer 7**
Grassland blocks	**PGS Layer 3**
Pre-settlement prairie/grassland	**PGS Layer 4**
Pre-settlement savanna	**PGS Layer 5**
Protected lands raster	**Hub Layer 2**

Map Methodology

The GIV 2.2 is the foundation for developing the approximate value of carbon stock services provided by the GIV in the CMAP region. Using ArcGIS for Desktop 10.2.2 we built GIS models within the Model Builder environment. The resulting valuation from literature review, expert opinion and spatially explicit data were clipped to the NIRPC region. Each cell was assigned a dollar value after calculating the combine value of above and belowground carbon stock. Having a dollar value for each cell allowed us to calculate the total value in dollars provided by the GIV for carbon stock.

We converted both data sets to the same units and added them using Raster Calculator. To calculate the dollar value of carbon storage per grid cell = (C_{above} + C_{below}) * $2/tonne/year.



Map 4: Ecosystem service values in NIRPC region for Carbon Storage

Air Purification

Why this service is important

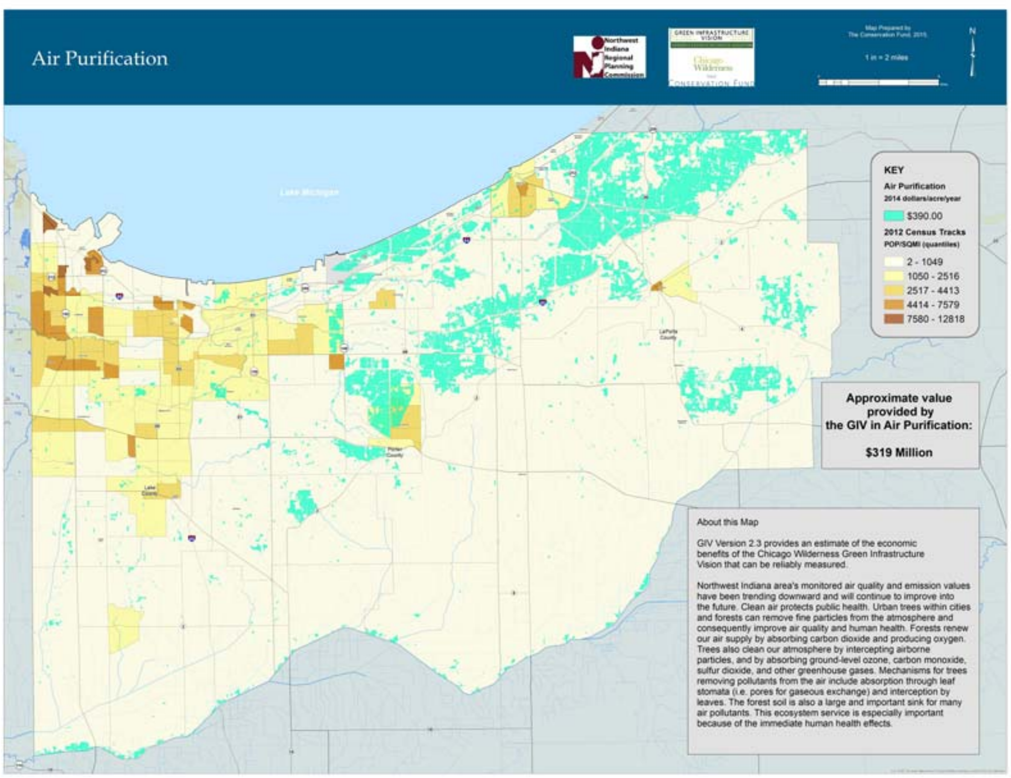
Forests and urban trees can remove sulfur dioxide, nitrogen oxide, ozone, carbon monoxide, and fine particles from the air, all of which can be harmful to humans. Mechanisms for trees removing pollutants from the air include absorption through leaf stomata (i.e., pores for gaseous exchange) and interception by leaves. The forest soil is also a large and important sink for many air pollutants. This ecosystem service is especially important because of the immediate human health effects.

Summary points

- Trees in the seven-county Chicago region removed 18,080 tons of air pollution (CO, NO2, O3, PM10, SO2) per year with an associated value of $157 million.
- Trees in the Baltimore-Washington urban corridor were found to have an air pollutant removal value of $206/ac of trees.

Map Methodology

The GIV 2.2 is the foundation for developing the air purification value provided by the GIV in the NIRPC region. Using ArcGIS for Desktop 10.2.2 we built GIS models within the Model Builder environment. Each cell was assigned a value according to landscape type. The GIV layers were mosaicked into one raster layer and always preserving the maximum value assigned to each cell when there was any overlap between the layers. The median and selected ecosystem service value for air purification was $390/acre/year.



Map 5: Ecosystem service values in NIRPC region for Air Purification

Recreation and Ecotourism

Why this service is important

Natural systems provide opportunities to experience the outdoors and participate in healthy activities like hiking. The number of licenses sold for fishing and hunting, number of boats registered, and the number of visits to natural areas gives an indication of the economic value of recreation lands in the region, but given that many publicly owned natural areas have no entrance fees, the known economic value of these lands is much lower than what can be documented through the purchase of licenses and equipment.

In addition to supporting the local economy, recreation and ecotourism build support for the value of natural areas and biodiversity—and therefore builds the support and stewards for tomorrow. The GIV is a connected network of natural lands and open spaces that contain most of the best recreation venues and sites that are aesthetically pleasing and provide habitat for an interesting array of plants and animals.

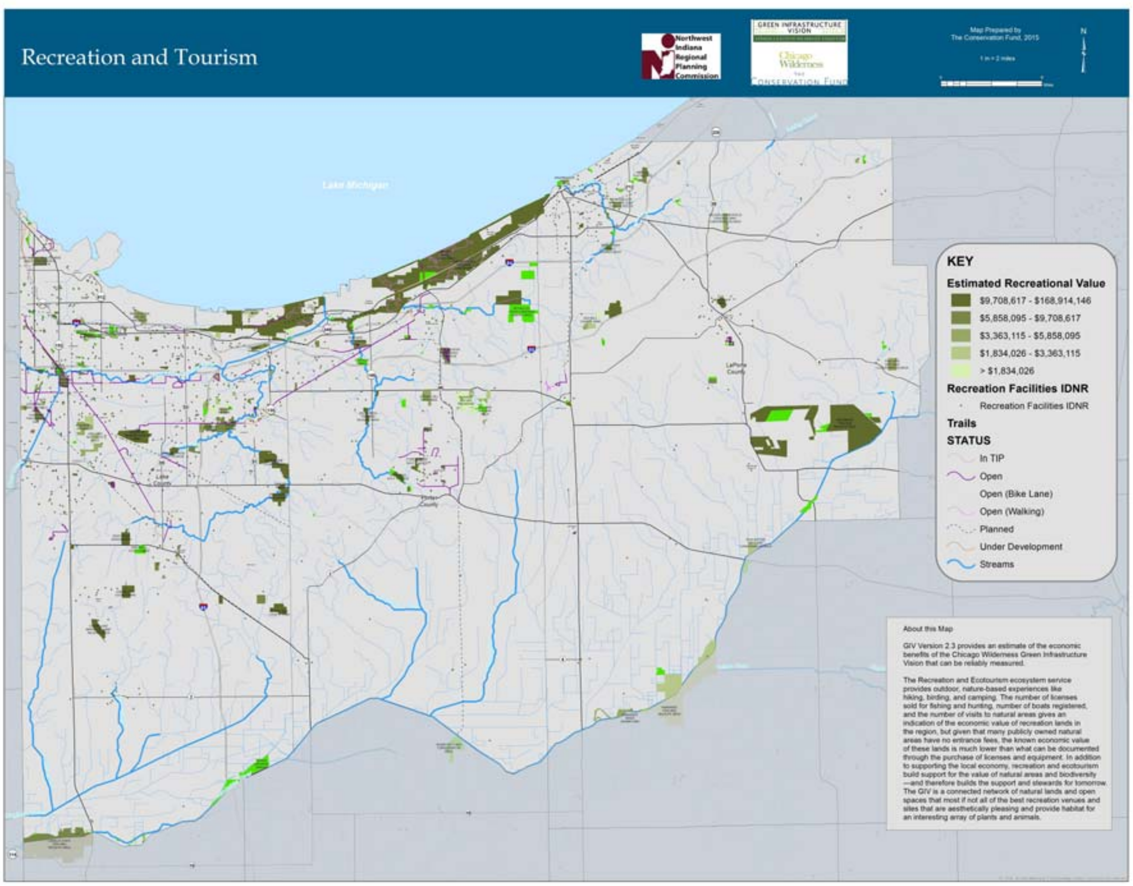
Summary points

- Nationally, more than half of all adults hunt, fish, bird watch or photograph wildlife, spending $59.5 billion annually. Nature-related recreation is the fastest growing sector of the tourism industry.
- In 2011, 2.3 million persons 16 years old and older engaged in fishing, hunting, or wildlife-watching activities in Indiana. Of these, 801 thousand fished, 392 thousand hunted, and 1.7 million (the majority) participated in passive observing, feeding, and photographing wildlife. In the same year, state residents and non-residents spent $1.7 billion on wildlife-associated recreation in Illinois.
- When previously inactive adults incorporated moderate physical activity into their routines, annual mean medical expenditures were reduced by $865 per person.
- We estimated a recreation value of $1.9 billion/year for existing parks and preserves, including $121 million/year for Indiana Dunes State Park and $168 million/year for Indiana Dunes National Lakeshore.
- Access to open space, parks, and recreation is a top factor used by small businesses in choosing a new location.

Map Methodology

The consumer surplus value, or net economic benefit, is the difference between the amount an individual would be willing to pay to enjoy a particular non-market amenity versus the actual costs incurred to obtain or enjoy that amenity.[3] We used survey data from Illinois on how money respondents were willing to spend per year on their favorite outdoor recreation activity (including cost of equipment, training, travel, etc.) and how far they were willing to travel one way to participate in their favorite outdoor recreation activity. We also used visitation data for two recreation destinations in the three NIRPC counties: Indiana Dunes State Park and Indiana Dunes National Lakeshore. The visitation data was used in conjunction with spending per person estimates and a multiplier to generate the annual economic impacts of the two destinations.

As an estimate for the recreation destinations without visitation data, we reasoned that most visits are to the nearest destination. We used the Euclidean Allocation tool in ArcGIS to identify the area in the NIRPC counties closest to each destination. Then we used Zonal Statistics to sum the population within each area closest to a particular destination. To get estimated expenditures, we calculated total recreation value by multiplying the nearby population number by estimated number of visits and then by spending per visit. Total annual recreation value for parks varied from $18,000 (probably an underestimate) to $168 million.



Map 6: Ecosystem service values in NIRPC region for Recreation and Ecotourism

[3] Otto, D., D. Monchuk, K. Jintanakul, and C. Kling. 2007. The economic value of Iowa's natural resources. Iowa State University Department of Economics.