

THE ECONOMIC BENEFITS OF NATURAL CLIMATE SOLUTIONS IN MINNESOTA

2023



Prepared by:





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Photo by Richard Hamilton Smith





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Land Acknowledgment

The name Minnesota comes from the Dakota name for the region, Mni Sota Makoce—"the land where the waters reflect the clouds." We recognize the Native Nations of this region who have called this place home for thousands of years, including the Dakota, Anishinaabe (Ojibwe), Lakota, Nakota, Ho-Chunk, and Cheyenne. Today, the State of Minnesota shares geography with 11 Tribal Nations—the Ho-Chunk, Cheyenne, Oto, Iowa, Hidatsa, Arikara, A'aninin, Cree, Blackfeet, Assiniboine, and the Sac and Fox tribes—who also acknowledge Minnesota as important to their tribal histories.

EXECUTIVE SUMMARY

Climate change poses severe threats to human well-being, livelihoods, and economic health. Nature is resilient, but the pace and scale of climate change impacts are outpacing nature's ability to adapt. Natural Climate Solutions (NCS), such as reforestation, aim to mitigate these impacts by protecting, managing, and restoring natural lands while also avoiding degradation of natural systems.¹ NCS provide multiple economic benefits beyond climate change mitigation, including ecosystem services benefits such as clear water, clean air, and disaster mitigation. They also support the economy through project spending and job creation.

Understanding the economic value of nature's benefits is critical for decision-making around degradation and loss of natural areas, as well as their protection and renewal. Economists use a method called ecosystem services valuation to determine a monetary value for nature's benefits. Including ecosystem services benefits—in economic terms—in decision-making processes supports the business case for NCS, which are often less costly than built infrastructure (e.g., costs of restoring a wetland is typically less than the cost of building a new water treatment facility).

Earth Economics partnered with The Nature Conservancy in Minnesota to quantify the economic benefits of implementing 12 NCS practices in Minnesota. This report

summarizes key findings of the ecosystem services valuation, benefit-cost analysis (BCA), and economic contribution analysis of three different implementation scenarios in Minnesota within different geographies.

We included economic estimates for three different implementation scenarios to help decision makers weigh costs and level of effort to reach climate mitigation targets against the benefits NCS could provide. Our results show that even with the minimum level of implementation (which is the least amount of acreage applied, consistent with current trends), NCS practices would support an average of 2,700 local jobs every year until 2050. Additional impacts of the minimum implementation scenario include over \$110 million in annual wages for Minnesota workers, as well as \$173 million in annual gross domestic product (GDP). Should decision makers opt for the maximum implementation scenario, it could support 5,200 jobs every year until 2050.

100 percent implementation of all NCS practices would provide Minnesota residents with \$37 billion in ecosystem services every year.

That total includes substantial co-benefits—totaling over \$4 billion every year—that would be preserved by



Photo by Stan Tekiela

preventing any further loss of these natural systems. This does not include nearly \$357 million worth of carbon that would be drawn down every year by extant forests, grasslands, wetlands, and peatlands.

In addition to avoiding further loss, restoration of the full potential extent of Minnesota ecosystems can generate net benefits of over \$32 billion every year. Soil quality practices on croplands (including no-till/low-till, improved nutrient management, and cover cropping) would provide over \$600 million in ecosystem services, in addition to \$278 million in net income to Minnesota farmers.

Minnesota’s habitats already store \$142 billion in carbon, which is the main focus of climate mitigation strategies like NCS practices, and restoration will increase that reserve of carbon storage.

Because these benefits have generally been unevenly distributed across communities, this report also explores the value of benefits on lands within historically disadvantaged communities. These communities include Tribal lands, where NCS practices would protect and provide \$753 million in benefits, as well as “environmental justice areas”—where the majority of the population identify as people of color and face poverty—that would see \$425 million in benefits from NCS.

NATURAL CLIMATE SOLUTIONS INVESTMENTS WOULD SUPPORT*:



2,700 to 5,200 jobs per year through 2050



\$110 million to \$148 million in wages per year for MN workers through 2050.



\$173 million to \$221 million in annual GDP through 2050.

*Sum of all NCS practices in the minimum to maximum implementation scenarios

The net present value (NPV)ⁱ of all NCS practices combined would range from \$49 billion in net benefits with minimum implementation to \$539 billion in the maximum scenario.ⁱⁱ Furthermore, **for every dollar invested in NCS practices, Minnesota would receive \$8.55 in public benefits by 2050.**

Figure 1. Ecosystem services values provided by NCS practices if implemented to their full extent.



DISASTER RISK REDUCTION
\$291 MILLION per year



HABITAT VALUE
\$73.1 MILLION per year



WATER STORAGE & SUPPLY
\$95.7 MILLION per year



RECREATION
\$370 MILLION per year



WATER QUALITY
\$3.44 BILLION per year



AIR QUALITY
\$4.6 MILLION per year

ⁱ Net present value = A measure of the total value in today's dollars of all future benefits derived from an investment, minus the current costs of purchasing that investment, including future contributions which have been annually discounted (using a discount rate) over a pre-determined period of time (e.g., project period).

ⁱⁱ Using a 3.124% discount rate used by the Army Corps of Engineers for restoration projects in 2021.



Figure 2. Ecosystem services values, by land cover, provided by avoiding the conversion of natural ecosystems to other land uses, along with restoration, with maximum implementation.



FORESTS

\$4.5 BILLION per year
in ecosystem services preserved by avoided conversion

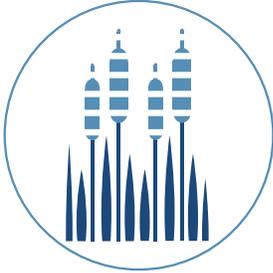
\$32 BILLION per year
in ecosystem services generated by reforestation



GRASSLANDS

\$3.8 MILLION per year
in ecosystem services preserved by avoided conversion

\$65 MILLION per year
in ecosystem services generated by restoration



WETLANDS + PEATLANDS

\$114 MILLION per year
in ecosystem services preserved by avoided conversion

\$210 MILLION per year
in ecosystem services generated by restoration



INTRODUCTION



Land-use decisions are often framed around dollars and cents; however, the natural world also offers intangible benefits, such as the value of recreation or clean air. This report aims to support decision making by clarifying the benefits and costs of NCS practices at varying levels of implementation.

The 2022 Congressional Infrastructure Investment and Jobs Act sets aside \$1.4 billion for the U.S. Department of the Interior to invest in ecosystem restoration, and the 2022 Inflation Reduction Act provides another \$250 million toward these efforts.^{2,3} These investments demonstrate not only the U.S. government’s commitment to funding NCS projects, but also the importance of having economic benefit estimates ready for decision makers who are looking to fund NCS projects.

Earth Economics partnered with The Nature Conservancy (TNC) in Minnesota to quantify and value the economic benefits of 12 NCS practices, including economic activity and ecosystem services.

Investing in climate solutions such as those described in Nature and Climate Solutions in Minnesota (2021)¹ would support economic activity in the state. These projects have labor, equipment, and supply costs that have a ripple effect through the local and state economy via supply chains and workers spending their wages (i.e., economic contribution). Economic contributions include jobs, tax

revenue, labor income, and GDP that can be estimated through an economic contribution analysis.

In addition to supporting Minnesota’s economy, NCS can also help to preserve and generate other co-benefits—ecosystem services. Simply put, ecosystem services are the non-market benefits that nature provides to all of us. Natural systems produce water, clean air, food, and other vital goods and services that support human well-being and sustain communities.

Economic value can be assigned to these services by employing ecosystem services valuation, a method that economists use to ascribe monetary value to ecological benefits. Including ecosystem services in economic terms in the decision-making process can make the business case for NCS, which are often less costly than built infrastructure.

Ecosystem services are essential to the health and well-being of local, regional, and global communities. They are also essential to local, regional, and global economies. The role that ecosystem services play in an economy depends on whether the value of a service can be monetized. In other words, can a market be established around an

A 2021 comparison of the costs of nature-based solutions—which are similar to NCS—and built infrastructure revealed that nature-based approaches returned \$10 for every dollar invested, compared with \$3.6 for built infrastructure. On average, nature-based solutions are half as expensive as built infrastructure, but they provide 29 percent more value, largely as co-benefits (e.g., improvements to air and water quality, as well as fish and wildlife habitat).⁴



ecosystem service so that dollars exchange hands?

Carbon sequestration is an ecosystem service that illustrates the difference between a service that provides value and a service that can be monetized. For example, forests sequester and store carbon all over the world. This valuable service, which helps offset the global impacts of human activity, is provided simply because forests exist. The value of carbon sequestration can be identified using ecosystem services valuation. In addition, carbon markets have been established to facilitate payment for the carbon sequestration services that forests provide, primarily through markets where participants can buy or sell carbon credits. Carbon markets “monetize” an ecosystem service and allow the owners of healthy forests to generate income and economic activity, relying on the services that nature provides.

Utilizing carbon markets can help fund NCS that do much more than mitigate the consequences of climate change. This report has demonstrated the tremendous value (\$4.2 million per year) that existing forests provide to Minnesota residents in addition to carbon sequestration, but there is an opportunity for NCS to utilize financial instruments like carbon markets. Credits can be used to raise revenue for opportunities like land acquisition and easements and meet TNC’s targets for NCS. NCS practices include avoided conversion, restoration, and soil quality practices for different ecosystems (Table 1).

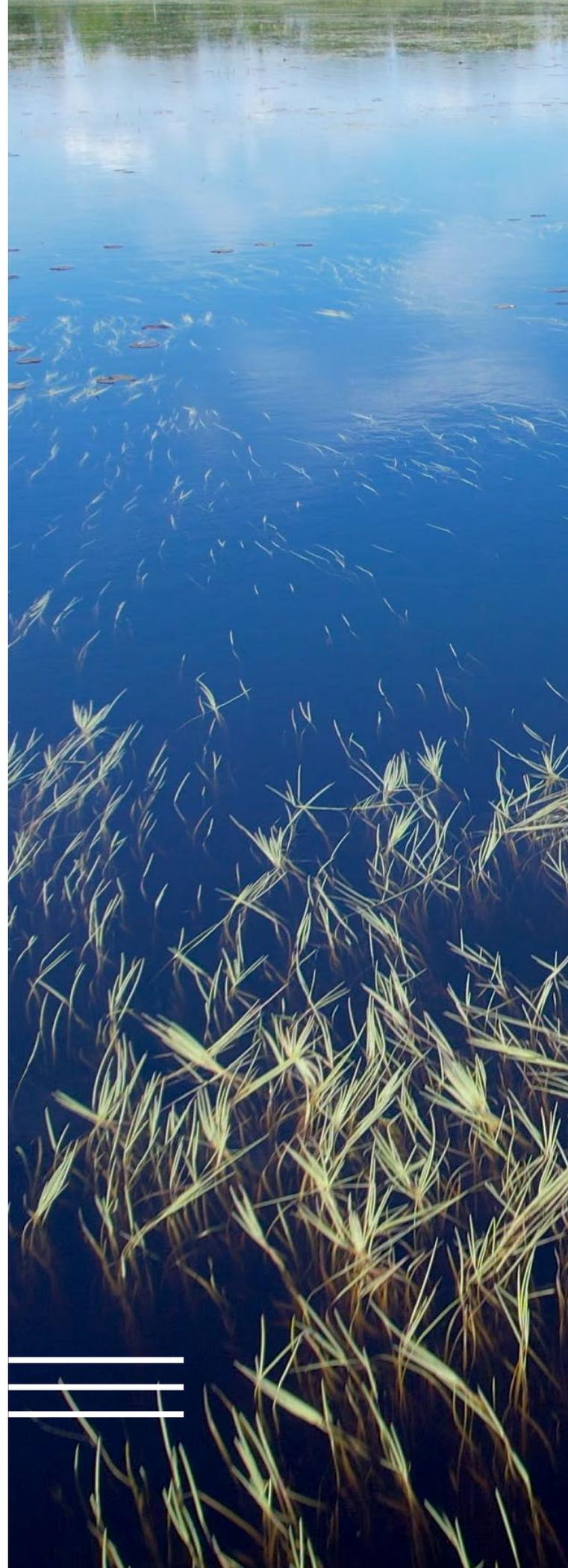


Table 1. Categorization and definitions of natural climate solutions (NCS) as defined in Nature and Climate Solutions in Minnesota (2021).

Category	Practice	Definition
Avoided Conversion	Avoided Forest Conversion	Reduction of persistent forest clearing, through which forest land is converted to another land use such as row crops or housing developments, resulting in losses of carbon in biomass and soil
	Avoided Grassland Conversion	Maintenance of the significant carbon stocks available in native grasslands by storing carbon above and belowground
	Avoided Wetland Conversion	Reduction of carbon loss from wetlands, as stored in plant biomass, soil organic matter, and sediment
	Avoided Peatland Conversion	Retention of current carbon stocks in peatlands because organic matter decomposes more slowly in peatlands
Restoration	Reforestation	Stores carbon above and belowground by planting trees in historically forested areas, including degraded, converted, agricultural, and urban lands
	Riparian Forest Buffers	Protection of land adjacent to streams, lakes, or other water bodies that increases plant diversity, biomass, and soil carbon
	Grassland Restoration	Stores carbon in soil and plant biomass when land that had been converted to other uses is returned to a grassland ecosystem
	Wetland Restoration	Rebuilding carbon lost from plants, soils, and sediments by restoring wetlands that have been drained or altered for agricultural activity
	Peatland Restoration	Rewetting and restoration of former peatlands that have been drained or ditched
Soil Quality	Cover Cropping	Soil carbon sequestration by growing crops in fallow seasons between main crops, especially when the main crops are row crops like corn or soy
	Improved Nutrient Management	Reduction of N ₂ O emissions from nitrogen-based fertilizers by reducing nutrient application rates, transitioning from anhydrous ammonia to urea, improving fertilizer application timing, or using variable fertilizer applications
	No-Till / Low-Till	Reduction in soil aeration that accelerates decomposition rates and greenhouse gas releases

KEY CONCEPTS & METHODS





IMPLEMENTATION SCENARIOS

We estimated benefits across three different implementation scenarios, each of which includes 12 NCS practices that represent varying levels of effort. The minimum level scenario is most commonly associated with 10 percent changeⁱⁱⁱ over a 10-year lifespan, and the maximum scenario is often described as 100 percent change over 30 years. In this report, we highlight some of the results from the minimum and maximum scenarios, but the full results and medium scenario can be found in Appendix B.

ENVIRONMENTAL JUSTICE AND TRIBAL GROUPS

Economic and environmental benefits have been unevenly distributed among communities, historically. Climate change is already impacting human health and well-being and creating risks (such as urban heat, wildfires, and flooding) that harm communities and disproportionately affect those who are socially or economically disadvantaged. In addition to estimating statewide benefits, we used environmental justice regions within the state as determined by 2016 U.S. Census Data to capture benefits to communities that have been disproportionately impacted by environmental degradation.^{iv}

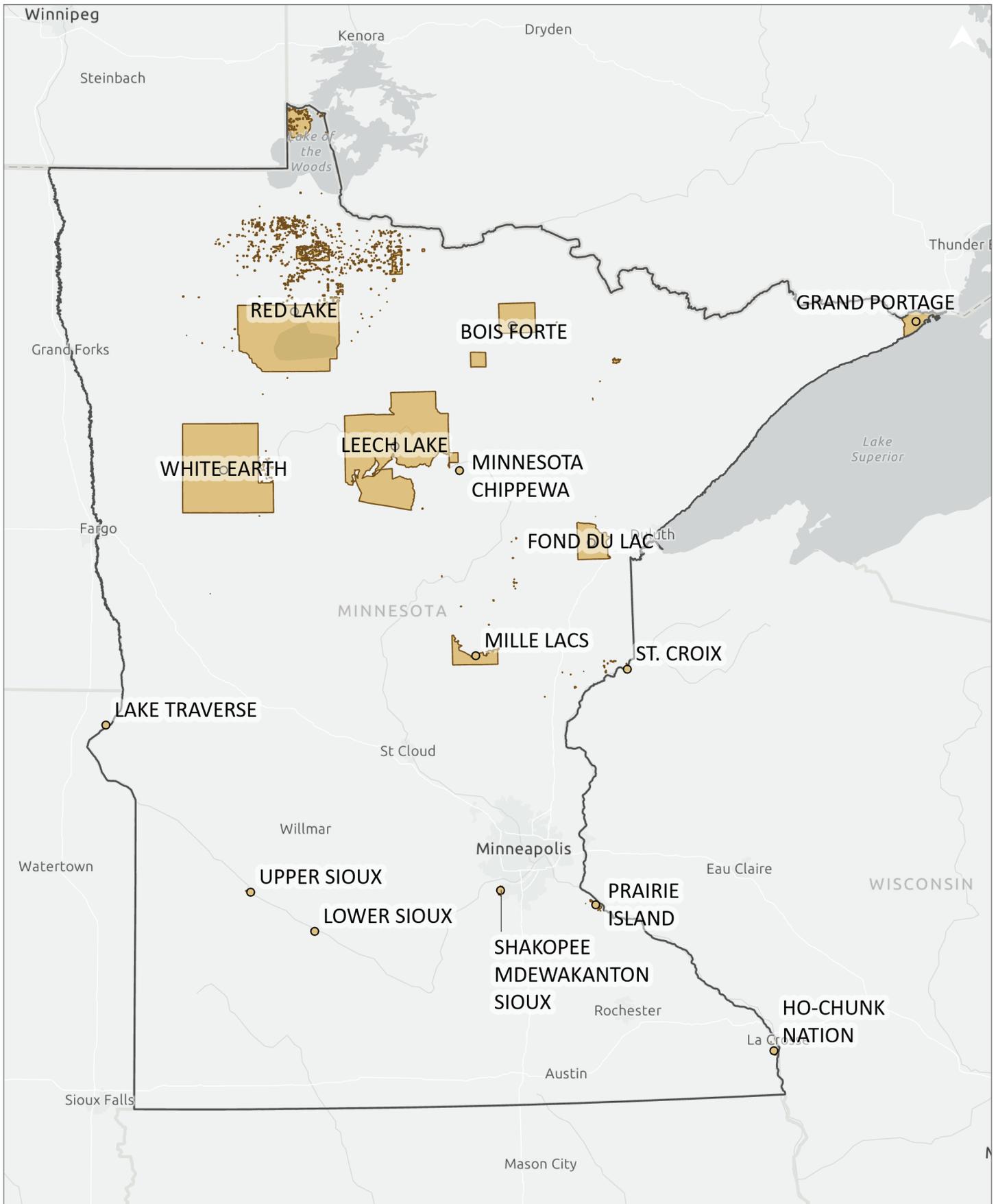
1. Federal- and state-recognized Native American reservations and Tribal lands (Tribal Areas; Figure 3)
2. “Environmental justice areas” that meet both of the following criteria:
 - 50 percent or more of residents identify as people of color
 - At least 40 percent of people reported income less than \$21,978 (for a 1 person household).

It’s important that the costs and benefits of deploying NCS are recognized for all communities and taken into account when making policy.

ⁱⁱⁱ This change is often associated with less conversion for avoided conversion practices or potential acreage restored, by practice.

^{iv} Environmental justice and Tribal areas overlap with the Minnesota state region, as well as with one another; thus the results of these regions should be considered separately.

Figure 3. Map of Tribal areas included in the analysis.



Sources: U.S. Census Bureau, Esri
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MAPPING ASSUMPTIONS

Results in this report are highly dependent on the spatial extent (i.e., number of acres) of the practices that are implemented. Because one acre could be a good fit across multiple practices, we developed a prioritization structure to ensure that only one practice would be implemented on every potential acre. We prioritized avoided conversion over restoration practices, and prime agricultural lands⁶ were prioritized over restoration practices (except riparian buffer reforestation, due to Minnesota law requiring riparian buffers—MINN. STAT. 103F.48 (2021)). We would expect restoration practices to occur only on non-prime farmland.

ECONOMIC CONTRIBUTION OF NATURAL CLIMATE SOLUTIONS

We estimated how much investment would be required to implement each NCS practice in all three implementation scenarios. This report includes the economic contributions of NCS investments and the anticipated losses in the agricultural sector from reduced cropland. Contributions include jobs, labor income, value added (i.e., GDP), and tax revenue, all of which are broken down into direct and secondary effects (including indirect and induced effects). See glossary for contribution definitions.

ECOSYSTEM SERVICES VALUATION

To estimate the value of ecosystem goods and services (Table 2), we applied the benefit transfer method.^{v,7} This approach has the benefit of providing reasonable, broad-based estimates more easily than other methods, such as conducting primary research on community perceptions of multiple ecosystem services. In the simplest form of the benefit transfer method, non-market benefits are regularized to per-acre, per-year estimates, which are then scaled by the extent of each ecosystem to estimate the total annual value of nature within the region of analysis. In this analysis, we used the Social Cost of Carbon⁸ to value carbon sequestration and carbon storage.

Each NCS category requires a different valuation approach

using this method:

- **Avoided conversion:** a land cover–based approach multiplying per-acre, per-year value estimates of each ecosystem service provided by a given landcover type—and associated attributes (e.g., urban proximity).
- **Restoration:** a land cover change framework estimating the net difference in value between two land cover types. By comparing differences in the value of ecosystem services across land cover types (e.g., forest vs. agriculture, grasslands vs. developed areas), we approximate the gains and losses associated with land cover change. For example, the benefits associated with converting cropland to forest can be estimated as the benefits produced by the new land cover (forest) minus those produced by the former land cover (cropland).
- **Soil Quality:** valuing change to ecosystem services or added services for cropland management practices. This practice-based analysis uses values derived from literature for changes to ecosystem services that occur within the same land cover. For example, improved soil quality is provided by increased organic matter as a result of cover cropping.

^v Benefit-transfer method = when primary valuation research on goods and services provided by similar ecosystems in similar contexts (e.g., location, climate, proximity to coasts) are “transferred” to similar settings in the study area.

Table 2. Gap analysis of ecosystem goods and services included by land cover type.
 Source: Earth Economics, 2022. See Appendix A for definitions.

Ecosystem Services	Land Cover Types				
	Forests	Grasslands	Wetlands	Peatlands	Cropland*
Aesthetic Information	✓		✓	✓	
Air Quality	✓	✓	○		
Biological Control	○	○	○		✓
Carbon Sequestration	✓	✓	✓	✓	✓
Carbon Storage	✓	○	○	○	○
Climate Stability	✓	○	○	○	
Disaster Risk Reduction	✓	○	○	○	
Habitat	○	○	✓	✓	
Recreation & Tourism	✓	✓	✓	✓	
Soil Quality	○	○	○	○	✓
Soil Retention	○	○	✓	✓	○
Water Capture, Conveyance, Supply	✓	○	○	○	✓
Water Quality	✓	○	○	○	○

* Limited to the following NCS Practices: Cover Cropping, No-Till / Low-Till, Improved Nutrient Management

KEY

- ✓ Ecosystem service provided by land cover and valued in this report
- Ecosystem service provided by land cover, but not valued in this report

ECONOMICS OF NATURAL CLIMATE SOLUTIONS



Although the primary goal of NCS is to mitigate climate change impacts, our results illustrate the considerable value that nature provides to Minnesotans beyond climate stability. Fully implementing NCS practices across Minnesota would add \$32 billion per year in ecosystem services with restoration practices, protect \$4.3 billion per year with avoided conversion practices, and provide \$600 million per year with soil quality practices. An estimated \$753 million in benefits would be realized on Tribal lands and \$425 million within environmental justice areas.

AVOIDED CONVERSION

SUMMARY

- Preventing forest conversion would retain \$3.2 billion to \$81 billion in NPV of ecosystem services benefits for the minimum and maximum scenarios, respectively, returning \$24 per dollar invested.
- Avoided conversion practices at 100 percent implementation (on an acreage basis) would provide over \$146 million and \$264 million in annual water quality benefits for environmental justice and Tribal areas, respectively.
- Protecting Minnesota's remaining 58,000 acres of prairie from conversion would retain \$195,000 in ecosystem services benefits every year thereafter.
- For every dollar invested in avoided conversion, \$10.67 in ecosystem services benefits would be protected across the practices' lifespans (up to 2050). Avoided conversion practices are thus the most cost-effective investments based on return.
- Avoided conversion practices only produce a positive contribution to Minnesota's economy per dollar spent in the statewide maximum scenario, adding to the case for this level of investment.
- \$16 million to \$442 million in state tax revenue would be supported by avoided conversion NCS due to spending on labor and supplies needed to protect these lands.

Table 3 details avoided conversion benefits per-acre, per-year, by practice.^{vi}

Only one percent of Minnesota's historic 18 million acres of prairie remains.⁹ However, protecting over 58,000 acres of remaining prairie from conversion to development or cropland would preserve at least \$195,000 in benefits every year, and offer an additional \$3.6 million in carbon sequestration value. Prairies (grasslands) have extensive

root systems that are highly effective at sequestering carbon, but because the carbon sequestration value was not included in the NPV, prairie was undervalued in this analysis. This is why grasslands appear to be negative in Table 4. Should carbon benefits be included, NPV would increase dramatically. This same caveat—of not including carbon in the NPV—explains why wetlands appear to have a negative value, as well.

Forests also play a key role in sequestering and storing carbon, but Minnesota has lost almost half of its forests since European settlement.¹⁰ Preventing additional losses to forests would protect \$318 million and \$142 billion every year in carbon sequestration and storage, respectively.

In addition to the value of carbon, another \$4.2 billion per year in additional ecosystem services benefits, such as air quality and disaster risk reduction, would also be protected. By 2050, avoided forest conversion will return \$24 in benefits per dollar invested.

These practices would support between 71 and 2,100 local jobs per year with \$3.3 million to \$95 million in wages in the minimum and maximum scenarios, respectively.

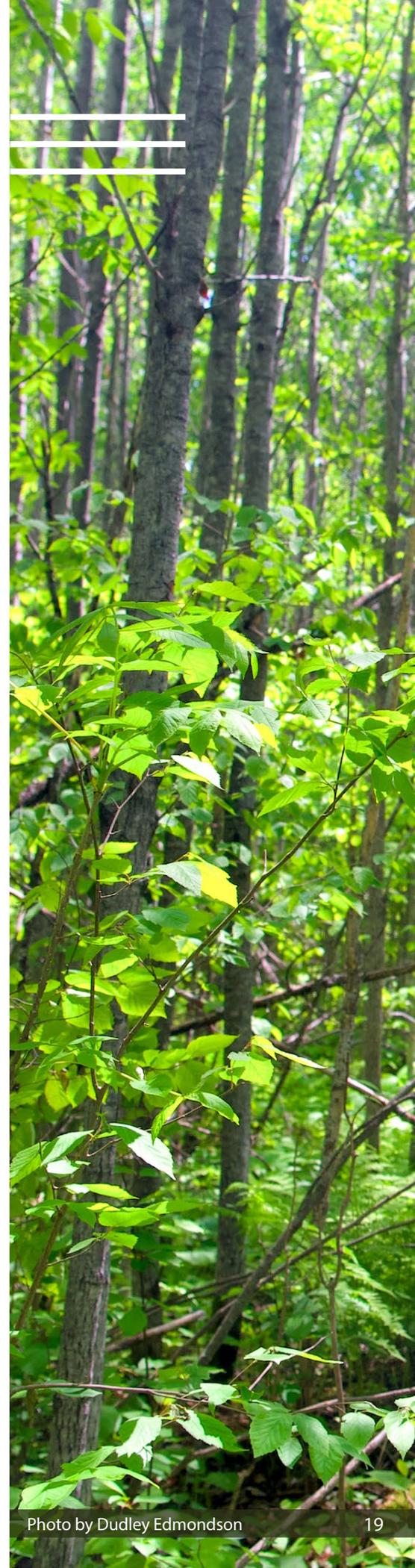
^{vi} Because carbon sequestration can vary by ecosystem type and age, we separated the ecosystem services value from the carbon value for each practice.

Table 3. Annual per-acre benefits of avoided conversion for various land types

NCS Avoided Conversion Practice	Per-Acre, Per-Year Benefits
Minnesota	
Forest	\$8,783
Grassland	\$39
Wetland	\$296
Peatland	\$700
Environmental Justice Areas	
Forest	\$8,944
Grassland	\$43
Wetland	\$290
Peatland	\$701
Tribal Areas	
Forest	\$8,976
Grassland	\$43
Wetland	\$316
Peatland	\$699

Table 4. Net present value of NCS avoided conversion in Minnesota, by implementation scenario (minimum and maximum), in thousands of dollars (2021 USD)

NCS Avoided Conversion Practice	Discount Rate = 3.124%	
	Minimum	Maximum
Minnesota		
Forest	\$3,243,401	\$81,495,985
Grassland	\$(16,914)	\$(210,385)
Wetland	\$(56,622)	\$(434,361)
Peatland	\$3,504	\$96,520
Environmental Justice Areas		
Forest	\$140,979	\$3,540,348
Grassland	\$(455)	\$(5,592)
Wetland	\$(2,652)	\$(21,268)
Peatland	\$0.5	\$14
Tribal Areas		
Forest	\$255,211	\$6,408,329
Grassland	\$(462)	\$(5,672)
Wetland	\$(4,469)	\$(28,705)
Peatland	\$0.1	\$2.8



RESTORATION

SUMMARY

- NCS restoration practices would provide \$32 billion per year in ecosystem services at maximum implementation.
- Every dollar spent on NCS restoration practices with minimum implementation would support \$1.47 in economic activity in Minnesota while also generating \$9.98 in ecosystem services by 2050.
- NCS restoration practices combined would provide \$9,000 in benefits per acre every year in the maximum scenario, with most of that value in reforestation (Table 5).
- For Tribal areas, restoration practices would support \$1.25 to \$1.16 in additional economic activity per dollar spent on investments (minimum and maximum scenarios, respectively), with most of this driven by wetland restoration (\$4.86 per dollar spent, maximum scenario).
- There would be seven-fold, six-fold, and five-fold increases in economic activity for every dollar spent on wetland restoration in Minnesota, environmental justice, and Tribal areas, respectively (maximum scenario).
- If 318,000 acres of Minnesota prairie are restored, at least \$65 million in benefits would be generated annually.
- \$364 million to \$1.1 billion in state tax revenue would be generated by NCS restoration.

In addition to preventing more loss and degradation of Minnesota’s ecosystems, NCS restoration efforts could add an additional 400,000 to 4 million acres of natural lands (minimum and maximum scenarios, respectively), including up to 60,000 in environmental justice areas and 84,000 in Tribal areas. Figure 4 illustrates reforestation and peatland ditch rewetting implemented in the Redeye River watershed.

If minimum action is taken, reforesting 300,000 acres in Minnesota would generate significant return on investment in terms of ecosystem services benefits—over \$21 for every dollar of investment. In terms of return on investment to Minnesota’s economy, wetlands are the biggest driver, supporting \$7.06 per dollar of investment in the minimum scenario of restoring 32,000 acres. This is mostly due to the more equipment-intensive activities

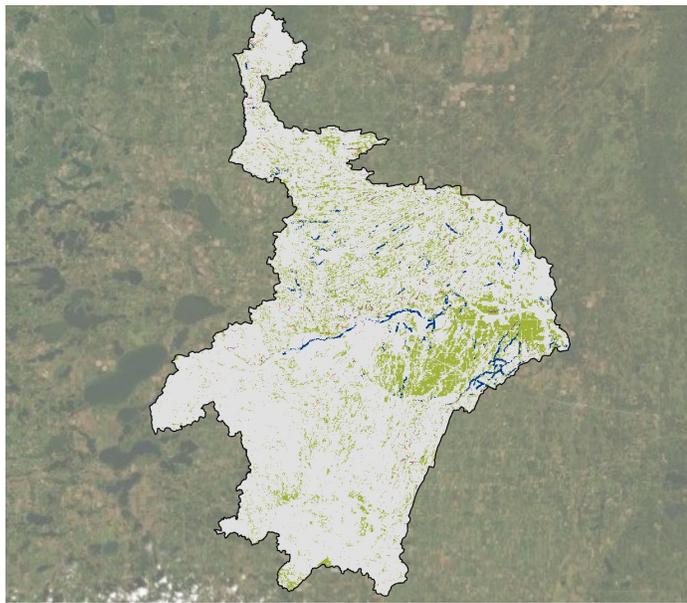
and greater easement payments needed to accomplish wetland restoration projects.

Because reforestation activities are highly labor intensive and would take place across a larger area, they would support 2,300 total jobs every year—including both direct and secondary effects—in the minimum scenario across the project lifespan. Decreases in crop production are taken into account for economic activity effects; thus the maximum scenario supports about 2,000 fewer jobs, annually. As acreage increases in the maximum scenario, so do losses to (non-prime) agricultural lands replaced by restoration practices.

Table 5. Annual per-acre benefits of restoration

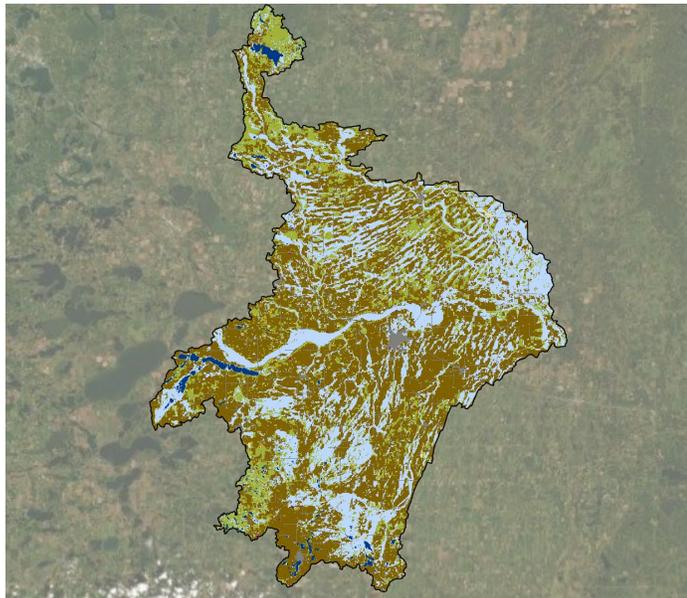
NCS Restoration Practice	Per-Acre, Per-Year Benefits
Minnesota	
Reforestation	\$7,832
Grassland Restoration	\$137
Wetland Restoration	\$290
Riparian Buffer	\$181
Riparian Buffer on Prime Ag Land	\$280
Peatland Restoration	\$185
Environmental Justice Areas	
Reforestation	\$8,063
Grassland Restoration	\$137
Wetland Restoration	\$296
Riparian Buffer	\$182
Riparian Buffer on Prime Ag Land	\$348
Peatland Restoration	\$184
Tribal Areas	
Reforestation	\$8,155
Grassland Restoration	\$137
Wetland Restoration	\$292
Riparian Buffer	\$168
Riparian Buffer on Prime Ag Land	\$341
Peatland Restoration	\$186

Figure 4. Hypothetical restoration scenario in the Redeye River watershed, for illustrative purposes only.



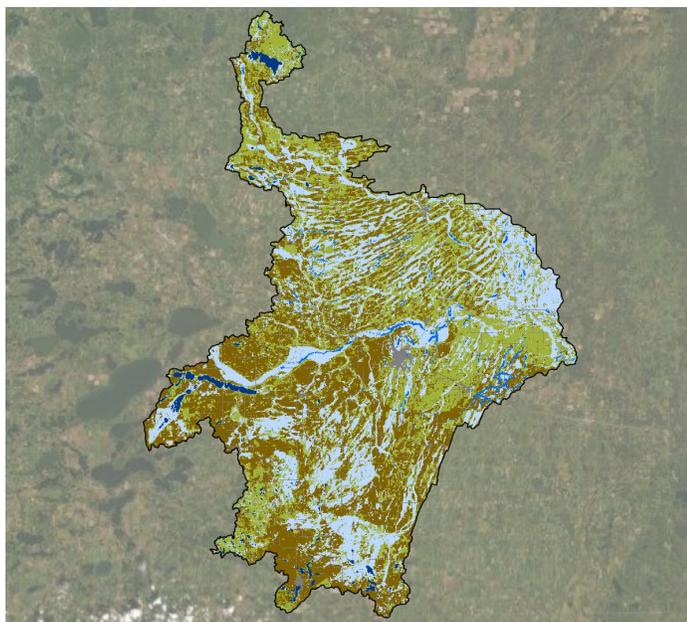
Restoration Practice Extent

- Peatland ditch rewetting
- Reforestation



Pre-Implementation Scenario Land Cover

- Agricultural land
- Barren land
- Developed
- Forest
- Herbaceous
- Open water
- Peatland ditches
- Shrub/scrub
- Wetlands



Post-Implementation Scenario Land Cover

- Agricultural land
- Developed
- Forest
- Herbaceous
- Open water
- Peatland ditches
- Shrub/scrub
- Wetlands

Sources: USGS, Esri, U.S. Census Bureau

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SOIL QUALITY

SUMMARY

- Improved soil quality practices like cover cropping and no-till/low-till could lead to greater cost savings, adding between \$8.6 million and \$278 million in net income for Minnesota farmers.
- Net farm income across environmental justice and Tribal areas could reach over \$2.9 million and \$3 million, respectively.
- NCS agriculture practices combined would provide between \$16 million and \$384 million every year in ecosystem services benefits to Minnesota residents (in the minimum and maximum scenarios, respectively), with nearly three-quarters of that value in carbon sequestration.
- Farmers would save significant money by spending less, but this would result in negative economic activity in sectors where farmers currently spend money.

See Table 6 for the annual benefits of NCS soil quality practices.

Agriculture can play a role in mitigating climate change not only by reducing impact (e.g., reduced runoff) but also by encouraging the draw-down of carbon from the atmosphere. As crops grow, they sequester carbon into the soil, where it can be stored or used as food by plants. NCS best management practices for soil quality lead to more carbon stored in soil, reducing greenhouse gas emissions for agricultural supply chains and moving us closer to net zero. The value of carbon sequestration from NCS soil quality practices would be greater than \$280 million across the state at maximum implementation.⁸

Cover cropping not only sequesters carbon, but also provides nutrients to plants—reducing the need for chemical nitrogen fertilizers and saving farmers money. If cover cropping was implemented on 232,000 acres of Minnesota cropland (the minimum scenario), it would save farmers \$182,000 in fertilizer costs. Cover cropping also provides weed control benefits, reducing the need for herbicides, by \$3.8 million to \$92 million.

Overall, the economic contribution of cover cropping and no-till practices support economic activity, whereas improved nutrient management results in lower spending, thus net negative economic activity in terms of jobs, wages, and GDP. However, state tax revenue would increase from net negative in the minimum scenario (-\$3.3

billion) to net positive in the maximum scenario (\$120 million) due to decreased subsidies paid for products from non-prime farmland.

Table 6. Annual benefits of NCS soil quality practices (minimum and maximum scenarios)

Benefits, by Region	Per-Year Benefits
Minnesota	
Farmer net income	\$8.6M–\$210M
Water storage and supply	\$103K–\$2.5M
Soil quality (fertilizer replacement)	\$363K–\$8.9M
Pest control (herbicide replacement)	\$3.8M–\$92M
Carbon sequestration	\$11.5M–\$280M
Environmental Justice Areas	
Farmer net income	\$110K–\$2.7M
Water storage and supply	\$1.3K–\$33K
Soil quality (fertilizer replacement)	\$4.7K–\$115K
Pest control (herbicide replacement)	\$48K–\$1.2M
Carbon sequestration	\$148K–\$3.6M
Tribal Areas	
Farmer net income	\$120K–\$2.9M
Water storage and supply	\$1.4K–\$35K
Soil quality (fertilizer replacement)	\$5.1K–\$125K
Pest control (herbicide replacement)	\$53K–\$1.3M
Carbon sequestration	\$160K–\$3.9M

CONCLUSION





Photo by Kristen Blann/TNC

This report quantifies the value of NCS in Minnesota so that stakeholders and policy makers can decide on the best approach to implement these practices. This is a complex analysis exploring multiple scenarios with different implementation thresholds for avoided conversion and restoration across four ecosystems—forest, grassland, wetland, and peatland—and three best management practices to improve soil quality on farmland. Minimum and maximum scenarios for implementation are presented for every practice. However, the alternative of taking zero action was not included, because allowing continued loss and degradation of Minnesota’s ecosystems is not a viable option in the face of climate change consequences.

These implementation scenarios are expected to be deployed together, and this report should not be viewed as a tool to compare different practices. Some ecosystems have been more studied than others, and the value of NCS practices is largely dependent on ecosystem type. For example, wetlands are well researched, whereas grasslands have not been studied as extensively. This report presents the value of these practices as a whole and their potential impacts on Minnesota’s economy.

Investments in NCS solutions would protect and restore \$37 billion every year in ecosystem services benefits that humans rely on—like clean air, clean water, and flood mitigation. Compared with their costs, preventing further loss of ecosystems through avoided conversion practices would return ecosystem benefits tenfold.

NCS can also support Minnesota’s economy. For example, every dollar invested in restoring the minimum of 32,000 acres of wetlands would support over \$7 in spending. Investments across all 12 practices would also support between 2,700 to 5,200 jobs per year. By 2050, these investments would support at least \$4.5 billion in GDP. Policy makers must take into account the impact of these scenarios on environmental justice and Tribal populations. We found that the value of avoided conversion and restoration per acre per year for each habitat in their areas varied only slightly from the statewide amount. For example, avoided conversion for forests statewide is \$8,783, but it reaches \$8,944 in environmental justice areas and \$8,976 in Tribal areas. The total ecosystem services valued in the maximum scenario also includes preserving water quality benefits in Tribal areas, valued at \$264 million per year. Water quality is culturally significant to Indigenous communities that rely on wild rice (a.k.a. manoomin) as a dietary staple. It’s also important to note that nearly all NCS restoration practices provide substantial economic activity in Tribal areas across all scenarios, due to their impactful expenditures on sectors that are highly present in Tribal areas. Coupled with significant returns in terms of ecosystem services benefits, the data make a strong case for partnering with Tribal nations that are interested in restoration investments.

This report includes the social value of carbon. Sequestering carbon can provide an additional stream of revenue for landowners, which we have not taken into account. The Voluntary Carbon Market is an established



Photo by Bruce Leventhal

mechanism to credit for carbon sequestered in “Reducing Emissions from Deforestation and Forest Degradation (REDD+)” projects and best management practices that increase soil organic carbon. However, the carbon credit value generated by nature-based solutions is volatile and may be further affected by the development of carbon capture and storage technology. Furthermore, we have not provided annual values for carbon storage nor lifespan estimates for carbon sequestration because each ecosystem has a threshold at which it stops sequestering and storing additional carbon.

Landowners might also eventually benefit from biodiversity credits. The biodiversity market is still emerging, but a credit system exists in Australia, and there is international cooperation on establishing a framework. The value of these habitats would be influenced by the restoration strategy followed, heterogenous native species having more value than homogenous nonnative species.

Both implementation scenarios would extend the coverage of habitats. In the maximum scenario, it is likely that a percentage of restoration would extend contiguous swathes of habitat. This may reverse the effects of habitat fragmentation, such as forest fragmentation, which creates “edge” habitat where the environment and micro-climate is different from intact forest and has reduced biodiversity.

This report is focused on net present value in present climate conditions, projected at a discount rate. Climate models forecast change to ambient temperatures, weather disruption, and an increased risk of natural disasters. The value placed on habitats and their associated ecosystem services values (especially disaster risk reduction) to mitigate the effects of climate change will likely increase beyond our projections. This is not something we are able to quantify in the face of such uncertainty, but if properly stewarded, investment in nature will return dividends.



REFERENCES

¹ Ahlering, M., Blann, K., Cornett, M., Graber, S., Lenhart, C., and White, M. 2021. Nature and Climate Solutions for Minnesota. The Nature Conservancy.

² U.S. Department of the Interior. 5/12/2022. Press Release: Biden-Harris Administration Announces More than \$68 Million from Bipartisan Infrastructure Law to Conserve and Strengthen Ecosystems and Economies. Available online at: <https://www.doi.gov/pressreleases/biden-harris-administration-announces-more-68-million-bipartisan-infrastructure-law>.

³ Elliott, N.M., Viola, B.A., Coulter, H., et al. 2022. The Inflation Reduction Act: Summary of Budget Reconciliation Legislation. Holland & Knight Law Firm. Available online at: <https://www.hklaw.com/en/insights/publications/2022/08/the-inflation-reduction-act-summary-of-the-budget-reconciliation-act>

⁴ Bassi, A.M., Bechauf, R., Casier, L., and Cutler, E., 2021. How Can Investment in Nature Close the Infrastructure Gap?, Nature-Based Infrastructure, Global Resource Center. International Institute for Sustainable Development, Winnipeg, Manitoba, Canada.

⁵ MPCA. Environmental Justice Areas of Concern and Census Tribal Areas. Minnesota Pollution Control Agency. Available online at: <https://gisdata.mn.gov/dataset/env-ej-mpca-census>

⁶ USDA Natural Resources Conservation Service, Soil Survey Staff. Gridded National Soil Survey Geographic (gNATSGO) Database for Minnesota. United States Department of Agriculture, Natural Resources Conservation Service. Available online at <https://nracs.app.box.com/v/soils/file/895774276550>. (FY2022 official release).

⁷ Rosenberger, R. S., & Loomis, J. B. (2003). Benefit Transfer. In A Primer on Non-Market Valuation (pp. 445–482). Springer, Dordrecht.

⁸ Interagency Working Group on Social Cost of Greenhouse Gases. 2021. Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990.

⁹ Minnesota Prairie Plan Working Group. 2018. Minnesota Prairie Conservation Plan, 2nd Edition. Available online at: https://files.dnr.state.mn.us/eco/mcbs/mn_prairie_conservation_plan.pdf.

¹⁰ Minnesota Department of Natural Resources. 2008. Chapter Five: Forests Today. In: All About Minnesota's Forests and Trees. Available online at: <https://files.dnr.state.mn.us/forestry/education/primer/chapterfive.pdf>.

APPENDIX A: GLOSSARY OF TERMS

Aesthetic information: Information ecosystem service defined as enjoying and appreciating the scenery, sounds, and smells of nature.

Air quality: Regulating ecosystem service defined as providing clean, breathable air.

Benefit-cost analysis: A common tool that compares the present-day cost of a project with its long-term benefits, often used by decision makers to determine whether or not a project will be funded.

Benefit Transfer Methodology (BTM): BTM is an ecosystem service valuation method that uses values derived from published studies for application in similar ecosystems. It resembles a house or business appraisal that is based on comparable characteristics of similar houses or businesses.

Biological control: Regulating ecosystem service defined as providing pest, weed, and disease control.

Carbon sequestration: The process by which plants drawn down carbon dioxide from the atmosphere through photosynthesis.

Carbon storage: Carbon held in soils and biological materials (e.g., plant matter) that has been drawn down from the atmosphere through carbon sequestration.

Climate stability: Regulating ecosystem service defined as supporting a stable climate at global and local levels through carbon sequestration and other processes.

Direct contribution effects: Economic activity of industries where expenditures are made. For example, garden supply retailers where equipment and supplies are purchased for a restoration project.

Disaster risk reduction: Regulating ecosystem service defined as preventing and mitigating natural hazards such as floods, hurricanes, fires, and droughts.

Discount rate: The rate at which people value current consumption or income, compared with later consumption or income. It determines the present value of future cash, due to uncertainty, productivity, or time preference for the present.

Economic activity: The direct, indirect, and induced contributions to a region's economic activity (e.g. sales, production and consumption of goods and services, employment, tax payments, etc.). Gross domestic product (GDP) is a common measure of economic activity.

Economic contribution: The portion of an initial expenditure that circulates throughout the local economy. Total economic contribution consists of three key elements: direct contribution, indirect contribution and induced contribution.

Economic contribution analysis: Examines how spending in one industry translates to additional spending in related industries, and the cumulative effect of that spending on the regional economy using input-output modeling.

Ecosystem goods and services: Benefits obtained from ecosystems. Goods are tangible, and often traded in markets (e.g., potable water, fish, timber). Services provide less tangible, often nonmarket benefits (e.g., flood protection, water quality, climate stability).

Ecosystem services valuation (ESV): Assigning dollar values to goods and services provided by a given ecosystem, allowing proposed management policies to be considered in terms of their ability to improve ecological processes that produce the full diversity of valuable ecosystem goods and services. Commonly employed valuation methods include: avoided cost, replacement cost, hedonic pricing, contingent valuation, group valuation, marginal product estimation, travel cost and factor income.

Habitat: Supporting ecosystem service defined as providing shelter, promoting growth of species, and maintaining biological diversity.

Indirect contribution effects: Secondary economic activity from sales to industries where expenditures are made (e.g. intermediary inputs bought in the supply chain). A gas station buying gasoline refined in-state, or a grocery store buying produce grown in-state creates an indirect contribution to the state economy.

Induced contribution effects: Secondary economic activity from sales of goods and services purchased by employees of directly and indirectly affected businesses. An employee who buys locally-produced milk is creating an induced contribution for the local economy.

Jobs: Organization—or company—spending supports local employment beyond those who work directly for the organization. Restoration project spending, for example, spurs construction companies and retailers (among others) to expand their full- and part-time positions. Expenditures from these industries support jobs in industries that provide necessary services to these sectors, such as facilities maintenance, government services, real estate, and medicine. In this report, job numbers are not full-time equivalents.

Labor income: Input-output models estimate the wages paid to workers whose jobs are supported by spending. Investments in restoration projects, for example, directly support wages in construction, forestry, and landscaping, as well as retail. As these employees pay for necessities such as food and housing, workers in other industries are also supported. Finally, as firms use the income from project contracts to purchase the goods and services they need to function, the initial investment supports wages in other industries, such as wholesalers and business services.

Natural capital: Earth's stock of organic and inorganic materials and energies (renewable and nonrenewable) and living biological systems (ecosystems) which constitute the biophysical context for the human economy and human wellbeing.

Natural Climate Solutions: Conservation, restoration and improved land management actions that increase carbon storage or avoid greenhouse gas emissions in landscapes and wetlands across the globe.

Net present value: The measure of the total value in today's dollars of all future benefits derived from an investment minus the current costs of purchasing that investment, including future contributions which have been annually discounted (using a discount rate) over a pre-determined period of time (e.g., project period).

Recreation and tourism: Information ecosystem service defined as experiencing the natural world and enjoying outdoor activities

Riparian areas: Habitat which is immediately adjacent to freshwater areas (e.g. marshes, forests, etc.).

Social Cost of Carbon: A measure of the global impacts of every additional ton of atmospheric carbon, including damages to agriculture, public health, and property.

Soil quality: Regulating ecosystem service defined as maintaining soil fertility and capacity to process waste inputs (bioremediation).

Soil retention: Regulating ecosystem service defined as retaining arable land, slope stability, and coastal integrity.

Tax revenue: Spending supports additional state and local tax revenues, typically in the form of sales and property taxes paid by the contractors and their employees.

Value added: Also known as gross domestic product (GDP) – a subset of total economic output and is calculated by removing the value of intermediate inputs (e.g., raw materials, semi-finished goods, and business-to-business services) from the total economic output to better represent the value of final goods and services added to the regional economy.

Water capture, conveyance, and supply: Regulating ecosystem service defined as regulating the rate of water flow through an environment and ensuring adequate water availability for all water users.

Water quality: Regulating ecosystem service defined as removing water pollutants via soil filtration and transformation by vegetation and microbial communities.



Prepared by:



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