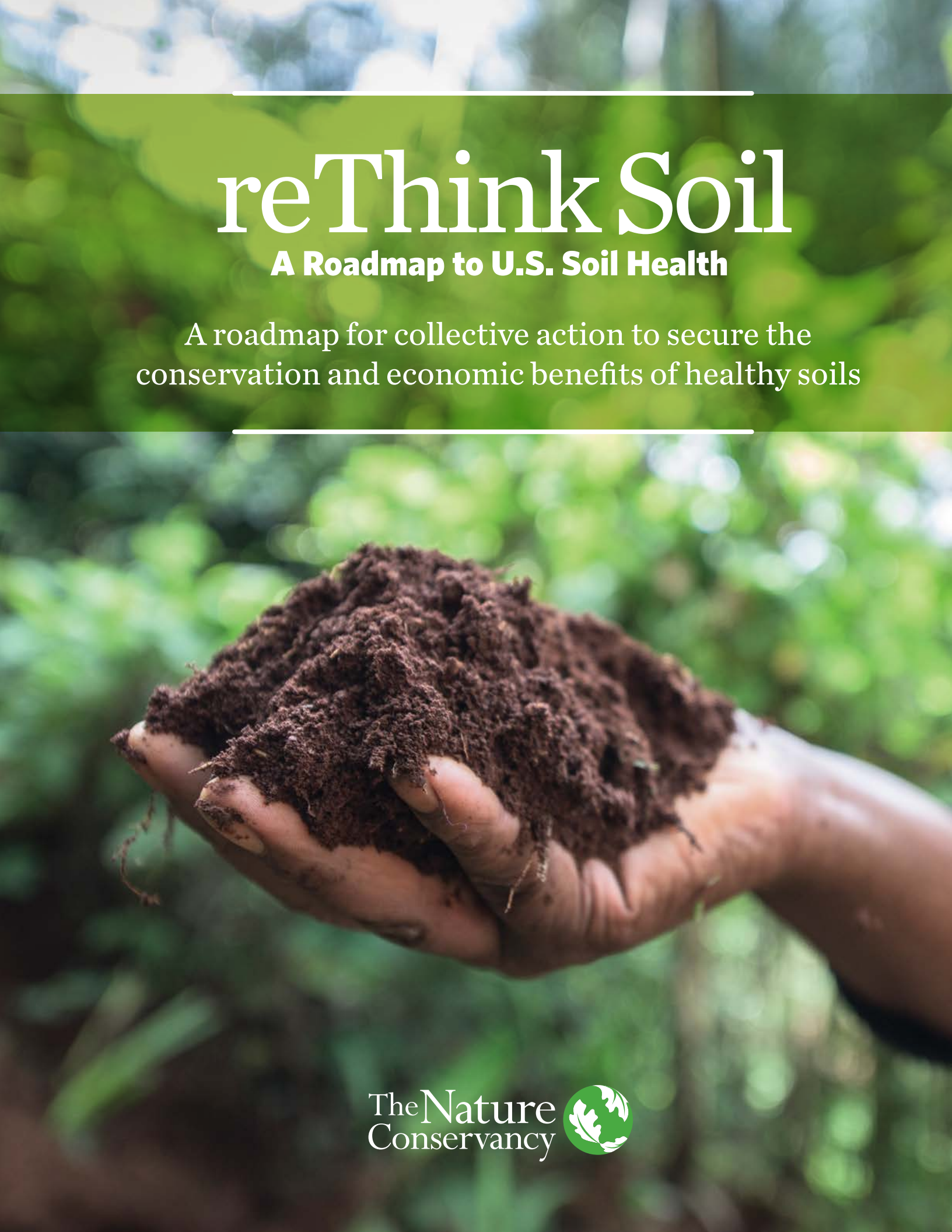
reThink Soil

A Roadmap to U.S. Soil Health

A roadmap for collective action to secure the conservation and economic benefits of healthy soils



The Nature Conservancy

reThink Soil: A Roadmap for U.S. Soil Health

Soil health is inextricably linked to broader conservation goals

Improving soil health on U.S. agricultural land holds the potential for achieving meaningful conservation and economic benefits, as well as mitigating the growing threat of climate change. Healthy soil is the cornerstone of life on earth, facilitating ecosystem biodiversity, ample food production, effective water filtration and storage, and carbon sequestration.

Advancements in agricultural technology throughout the past century have allowed farmers to feed a population that has grown from less than 2 billion people to more than 7 billion today. Over the same time period, however, soil managed for agricultural purposes in the U.S. has degraded, losing as much as 60% of its original organic carbon content.[1] The degradation of soils has undermined the productivity of farmers and the resilience of croplands while leading to significant direct and indirect environmental impacts annually on a national level:

- 346 million metric tons of greenhouse gas emissions[2]
- 4.4 billion pounds of nutrient loss to the environment[3]
- 996 million metric tons of soil erosion[4]
- 48.4 million acre-feet of water used for irrigation[5]

Drawing upon respected analyses in soil health literature, The Nature Conservancy estimates the annual societal and environmental costs of the status quo are up to $85.1 billion annually through unintended effects on human health, property, energy, endangered species, loss of biodiversity, eutrophication, contamination, agricultural productivity, and resilience. As global food demand grows, U.S. agriculture needs to be competitively positioned to increase production to meet both domestic and international food requirements. Managing for soil health serves as a nexus for achieving increased production while reducing the societal and environmental impacts of the current U.S. row crop production system.

Improving soil health can yield significant benefits

The U.S. Department of Agriculture's (USDA) Natural Resources Conservation Service (NRCS) defines soil health as "the continued capacity of the soil to function as a vital living ecosystem that sustains plants, animals, and humans." The concept of adaptive management is inherent in this well-accepted definition. Adaptive management for soil health means minimizing soil disturbance while optimizing plant diversity, allowing more continuous plant and residue covers to create vital, living ecosystems in the soil. In turn, the soil nurtures a complex web of microbes with the healthiest soils often being those with the greatest diversity and abundance of life. Healthy soil more efficiently stores and recycles carbon, water, and nutrients such as nitrogen and phosphorous.

The full version of this abridged paper (available at nature.org/soil) presents The Nature Conservancy's vision for soil health in the U.S., with the goal of a majority of farms managed for soil health by 2025, and a proposed roadmap for collective action amongst key stakeholders. The full version includes a situation analysis, estimation of economic and conservation benefits of soil health, citations to literature used in writing the paper, and additional soil health resources.

Soil health as a scalable conservation opportunity

The mission of The Nature Conservancy is to conserve the land and water upon which all life depends. Over the past 65 years, the Conservancy has protected millions of threatened lands, waters, and species. Yet the vision of the organization is a world where people and nature thrive together. To achieve this vision, we must attend to the major global challenges facing humanity and support the solutions that can be found in nature.

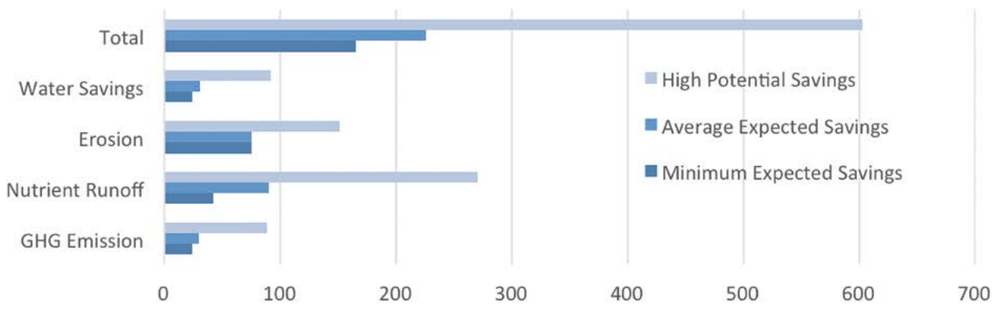
For this purpose, The Nature Conservancy examined the opportunity to deliver scalable conservation gains in the U.S. by focusing on the adoption of soil health management systems across row crop agricultural landscapes. The Conservancy assembled a multidisciplinary team of internal experts, interviewed internal and external stakeholders, developed an analytical approach to estimate the technical benefits, and developed a strategic theory of change consistent with our Conservation by Design 2.0 methodology.

While the conservation opportunity is sufficiently large, the barriers to widespread adoption of soil health systems are multiple and persistent. Therefore, more collaborative efforts across capable and committed partners, coupled with greater levels of sustained investment, will be required to make meaningful progress. The Conservancy recommends taking collective action across a "roadmap" of highly coordinated set of strategic inventions toward realizing benefits which accumulate among farmers, communities, and future generations. In doing so, we can "reThink" our opportunities with soil.

At the farm level, the benefits of improved soil health include higher rates of productivity and profitability over the long term, as well as reputational value for farmers who put conservation at the center of their management approach. At the societal level, the benefits of boosting soil health are even more profound, including improved water quality, filtration, and storage; richer biodiversity; and reduced greenhouse gas emissions, mitigating the impacts of climate change.

In order to estimate the scale of benefits attributable to changes in soil health, the Conservancy chose three management practices—reduced tillage, cover cropping, and crop rotations—to serve as proxies for the adaptive soil health systems, which will vary geographically. Reduced tillage decreases disturbance of the soil, thereby improving the soil's ability to retain nutrients and sequester carbon dioxide from the atmosphere. Cover cropping between cash crop seasons is a heritage practice that maximizes the time each year that living roots are building soil nutrients and keeping the surface protected. Diverse crop rotations help build nutrients, limit erosion, and foster soil carbon sequestration. While these three practices do not represent the full spectrum of soil health solutions available, they serve as valuable measurement proxies because of the extensive, validated research on the conservation and economic benefits of each.

Economic benefits ($M) of increased adoption by 1% of U.S. corn-soy-wheat acres



Estimated benefits based on minimum, average, and maximum potential impacts of cover crops, conservation tillage, and increased rotation practices

Value of soil

Healthy soils can deliver tangible economic and environmental benefits for farmers, businesses and communities for generations to come.

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SCIENCE AND RESEARCH

Overcome the science and research gap to support expansion of soil health management

1. Create cost-effective soil health measurement standards and tools
Create accurate, accessible, and standardized methods for rapid measurement of key soil health indicators at a scale that impacts management choices by farmers and landowners

LEAD ACTORS: Research institutions, private sector, Soil Health Institute, grower organizations

2. Develop operational management strategies for adaptively integrating soil health practices and systems
Build evidence and understanding among farmers regarding operational strategies locally tailored for integrating multiple soil health practices on a farm, including optimal cover crop programs

LEAD ACTORS: Research institutions, extension, conservation districts, NRCS, grower organizations, agricultural retailers, private sector

3. Advance the science of soil health benefits
Further quantify the economic costs, benefits and environmental impacts of different management practices on soil health, including organic systems, with consideration for different regions, soil types, and cropping systems

LEAD ACTORS: Research institutions, Soil Health Institute

ECONOMIC

Overcome economic obstacles by providing the market systems to secure soil health

4. Align incentives between landowners and farmers
Cultivate understanding among absentee landowners of soil health benefits for society and land value, encouraging new lease arrangements integrating soil health systems and practices

LEAD ACTORS: Landowners, farm management companies, lenders, etc.

5. Leverage technological innovation to overcome operational hurdles
Leverage technological innovations, such as sensors, drones, cover crop seeding equipment, precision agriculture software and hardware to advance adoption and continued implementation of soil health systems and practices

LEAD ACTORS: Public and private research institutions, agricultural retailers

6. Provide broader access to products and services supporting soil health
Develop new business models with agricultural retailers providing broader access to new products and services in order to accelerate the adoption of soil health systems and practices

LEAD ACTORS: Agricultural retailers

7. Create market signals in sustainability programs for soil health
Develop improved indicators rewarding soil health management outcomes in sustainability assessment programs, aligning the incentives of farmers and society

LEAD ACTORS: Field to Market, food companies, agribusinesses, leading sustainability programs and farmers

8. Reward farmers who optimize long-term soil health with lower crop insurance premiums
Advocate for federally subsidized crop insurance programs to value the benefits generated from improved soil health profiles through lower insurance premiums

LEAD ACTORS: Commodity organizations, agri-food sector, conservation organizations seeking to expand constituency, federal and state governments

POLICY

Improve the policy environment to advance soil health

9. Support policies that enable greater investment in soil health
Support state and federal policy improvements focusing on reducing barriers to soil health practice adoption, targeting priority areas for implementation, and comprehensively assess impacts for societal value

LEAD ACTORS: State and federal governments, conservation organizations seeking to expand constituency

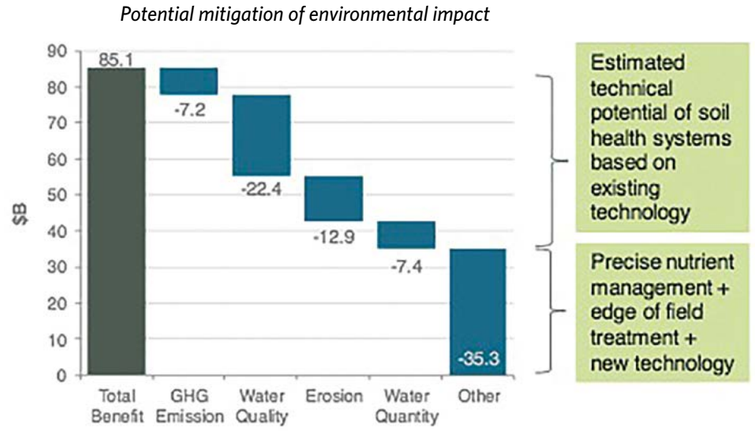
10. Build a more diverse constituency for soil health policy
Build a strong and diverse network of supporters for soil health policy, including farmers, landowners, the agri-food sector, community leaders, and societal interest groups

LEAD ACTORS: Farmers, landowners, agri-food sector, community leaders, societal interest groups

Significant benefits

Healthy soil more efficiently stores and recycles carbon, water, and nutrients such as nitrogen and phosphorous.

At the high end estimates, the combined potential impact of increased soil health practices could mitigate environmental impacts by almost $50B annually



Restoring soil health can create net economic benefits for farmers while removing environmental and societal costs associated with intensified agricultural production that will otherwise amass into an unfunded liability to be passed along to future generations.

The Nature Conservancy estimates that the benefits or "size of the prize" for adopting adaptive soil health management systems in the U.S. are significant. Our base case scenario for estimating benefits suggests that for each 1% of cropland[6] adopting an adaptive soil health system, annual economic benefits translate into $226 million of societal value through increased water capacity, reduced erosion and nutrient loss to the environment, and reduced greenhouse gas emission, as well as $37 million of on-farm value through greater productivity. In the most optimistic case, the team estimated soil health solutions could address up to $50 billion in social and environmental impacts annually across the U.S.

Off-farm economic benefits (corn, soy & wheat acres) [gross]

U.S. Potential Societal Benefits (in $ millions / year)	Effect of increased adoption by 1% of U.S. acres of corn-soy-wheat	Effect of adoption on 50% of U.S. acres of corn-soy-wheat	Effect of adoption on 100% of U.S. acres of corn-soy-wheat
GHG emission	$29.7	$903	$2,387
Nutrient loss	$90.1	$2,951	$7,457
Erosion	$75.8	$2,657	$6,447
Water benefits	$30.6	$923	$2,453
Total	$226	$7,435	$18,744

On-farm economic benefits (corn acres only) [net]

	Effect of increased adoption by 1% of U.S. acres of corn	Effect of adoption on 50% of U.S. acres of corn	Effect of adoption on 100% of U.S. acres of corn
On-farm profit potential; corn only (in $ millions / year)	$36.7	$1,156	$2,991

Estimates of GROSS societal off-farm economic benefits and NET on-farm economic benefits accruing to farmers attributable to adoption of the adaptive soil health system. Benefits are listed with the mean estimated value of economic benefits.

Restoring soil health can create net economic benefits for farmers while removing environmental and societal costs associated with intensified agricultural production that will otherwise amass into an unfunded liability to be passed along to future generations. The Nature Conservancy has a rich history achieving conservation goals for the most important landscapes in the world, and this must include the agricultural landscapes that meet society's critical need for food, fiber, and energy, as well as the people whose livelihoods depend on those lands. The Conservancy views soil health restoration as the primary way to bring economic value to farmers while achieving conservation goals. Yet, this strategy is part of an emerging conservation solution set—which also includes targeted edge-of-field and in-stream solutions for water quality and more precise nutrient management timed to plant needs.

Barriers to achieving soil health are multifaceted

A small yet influential segment of farmers, including organic farmers, have catalyzed a movement toward a new array of both innovative and heritage soil health practices that protect and build soils. Despite these efforts, widespread adoption of soil health systems appears unlikely unless the multiple barriers to adoption are systemically identified and addressed. These barriers, which are undeniably complex, cluster around three key areas: science, economics, and policy.

First, the science of soil health is still evolving. Accurate, standardized, and cost-effective on-field soil health measurement tools have yet to be developed and widely implemented. As a result, soil health is not easily measured, thus limiting the ability for timely management responses by farmers, or the development of useful policy and economic signals in the marketplace. Likewise farmers contemplating this change need more evidence and demonstration of operational strategies locally tailored for integrating specific soil health practices on their farms.

The Nature Conservancy seeks a transformation of the U.S. cropland paradigm, with soil health becoming the leading indicator of economic and environmental outcomes on the majority (>50%) of farms by 2025.

Second, current business models between landowners, farmers, and agricultural retailers do not adequately encourage soil health management. Conservation systems and practices to restore soil health introduce potential operational complexities and may require farmers to make higher capital or variable cost outlays in the short term. Recouping these investments requires a longer planning horizon. Yet the majority of farmers in the U.S. lease the land they manage. While lease terms vary, most incent short-term planning and do not allow the farmer to recover costs or plan for a longer horizon. Large segments of landowners have not been brought into the broader conversation about the value of soil health improvements for society and land value. Therefore, lease arrangements do not adequately factor in soil health improvements. Likewise, agricultural retailers are often trusted advisors to farmers, and opportunities exist for engaging retailers in providing agronomic knowledge about the transition to soil health systems as well as selling products and services designed to improve soil health.

Finally, public policy has not been fully developed and implemented to encourage landowners and farmers to reduce production risk and support soil health investments requiring longer planning horizons. Given the value creation potential to address important social and environmental challenges, broadening the coalition of interested stakeholders who advocate for these improvements in state and federal policies is essential.

A roadmap to transform the agricultural management paradigm

A notable change is underway, and momentum is gathering around the opportunity presented by soil health systems. The Nature Conservancy is not alone in recognizing the potential of soil health to be the catalyst for delivering conservation and productivity benefits at a meaningful scale.

Innovative initiatives by government agencies such as USDA, NRCS, and the U.S. Department of Energy (DOE), as well as newer public-private entities such as the Soil Health Partnership and the Soil Health Institute, are already making important progress. The Conservancy is partnering with these efforts and other public and private sector organizations to help further a paradigm shift, but greater coordination, innovation, and investment is still needed.

Rather than a constellation of well-intended efforts, the Conservancy calls for a coordinated and aligned approach toward the goal of transforming the U.S. cropland management paradigm, with soil health becoming the leading indicator of economic and environmental outcomes on the majority (>50%) of farms by 2025. In doing so, we can significantly improve the pace and certainty of reversing the negative trends on water quality over the next decade while establishing one of the most cost effective natural climate solutions. Specific and measureable benefits of attaining the proposal goal in the U.S. are summarized on an annual basis:

- Mitigating 25 million metric tons of greenhouse gas emissions,
- Reducing 344 million pounds of nutrient loss to the environment,
- Eliminating 116 million metric tons of soil erosion,
- Creating 3.6 million acre-feet of available water capacity in cropland soils.

Taken together, these improvements will create a diverse basket of environmental and social benefits valued at $7.4 billion annually. Through higher rates of productivity resulting from higher yields or lower production costs, farmers stand to gain modest, albeit meaningful net economic benefits of $37 million for each one percent of cropland transformed, or $1.2 billion annually across the U.S. corn belt.

The Conservancy proposes a roadmap for collective action to secure the conservation and economic benefits of healthy soils. Coordinated and collective actions across ten priorities spanning science, economic, and policy outcomes will overcome the multiple barriers to widespread adoption. The roadmap is offered as a starting point for greater collaboration. In time, it will conform to the combined knowledge and capacity of committed partners, as well as the evolving state of the science, economics, and public policy environment regarding soil health.

Conclusions and invitation

Managing U.S. croplands for soil health offers an exciting value proposition to farmers and society. The Nature Conservancy is compelled—by both our mission and the size of the benefits for people and nature—to lend our support to this important cause. In doing so, we intend to bring about a more concerted and coordinated effort, accelerating the adoption of soil health systems and achieving economic and environmental outcomes at a scale that addresses our most pressing global challenges.

The Conservancy is committed to expanding our capacity to seize this important and timely opportunity. The science agenda for soil health will require significant, long-term investments and collaborations. The Conservancy is expanding scientific capacity through the addition of a new lead scientist role for soils. As such, the Conservancy will be a more capable partner with organizations charting the future of soil health research.

It is clear new business models will be necessary to align the economic interests of farmers, landowners and agricultural retailers on soil health benefits. The Conservancy seeks to be a collaborative and positive force for the advancement of new value creation opportunities. Expanding on the successful model of the Soil Health Partnership will be a priority given the importance of farmer-to-farmer knowledge transfer with adaptive and locally tailored soil health solutions.

The Conservancy has actively engaged in discussions about the current and future opportunities for improved public policies in support of soil health at the state and federal level. These efforts include targeting existing conservation programs for the highest impact as well as policy planning efforts on the future of crop insurance. The Conservancy's network of state chapters and trustees can serve as effective advocates for public policies in support of the soil health movement.

The Nature Conservancy invites interested organizations and individuals to share feedback and expressions of interest in the ideas articulated in this paper by emailing soil@tnc.org.

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[1] Lal, R. (2004) Soil Carbon Sequestration Impacts on Global Climate Change and Food Security. Science. Vol 304 pp 1623-1627 Special Section: Soils-The Final Frontier.

[2] As estimated using USDA ERS data of fossil fuel combustion, crop residue burning, and soil management (http://www.ers.usda.gov/media/434512/tb1909_1_.pdf)

[3] As estimated using average nitrogen application reported by USDA ERS and typical leaching as reported by a USDA NRCS study (http://www.ers.usda.gov/data-products/fertilizer-use-and-price.aspx, Tables 10, 22, 28 and http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/crops/?cid=nrcs143_014202)

[4] As estimated using USDA NRCS figures for wind and water erosion (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/nri/results/?cid=stelprdb1041678)

[5] As estimated using figures from a USDA ERS report (http://www.ers.usda.gov/media/884158/eib99.pdf)

[6] While there are more than 400 million acres of cropland in the U.S., our estimates include the three largest commodity crops: corn, soybeans, and wheat. One percent of these acres is equivalent to 2.3 million acres.