Agriculture Strategic Plan

September 2009

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August 2009[1]

Goal and Theory of Change

Goal

Within a thriving agriculture and food system that meets needs for nutrition, employment, and economic development, **the goal of the Foundation's agriculture strategy is to achieve a 20 percent reduction by 2020 in projected net greenhouse gas emissions and nitrogen pollution caused by agriculture in the United States and biofuels production globally.**[2] (See Appendix 1.) Although the environmental performance of agriculture is an important focus of this strategy, it is not an exclusive one. The future of agriculture – what we grow and where and how we grow it – will profoundly influence progress toward two of the major priorities of the David and Lucile Packard Foundation: strengthening environmental conservation and improving the lives of children. Through this strategy we seek to support work that broadly strengthens the role of agriculture in our society by improving the environment, improving nutrition and health, addressing hunger, and strengthening farming communities.

Theory of Change

Agriculture is essential for human well-being. It is also the single most extensive human use of the land. As such, it can have profound impacts on the environment. Growing food, feed, and fuel crops requires water and energy, and can be a driver of habitat loss and a source of pollution. The future health of the global environment hinges to a significant extent on engaging agriculture in managing and mitigating these impacts on the environment.

Many of the most direct environmental impacts of agriculture, including habitat loss, pesticide risks and soil erosion have long been the focus of conservation efforts and public policy with some success. However, it is increasingly apparent that agriculture is causing changes to the major global cycles of carbon, nitrogen and phosphorus, that these changes are causing ever greater environmental harm, and that solutions are elusive. (See Appendix 2.)

In particular, agriculture accounts for approximately 6 $GtCO_2e$ per year, or 15 percent of global greenhouse gas emissions (excluding the impact that agricultural expansion has on additional emissions associated with deforestation).[3] Greenhouse gas emissions from agriculture principally

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[1] Strategy originally released in April 2008. This version has been revised based on the first year's implementation.

[2] This goal is explained in detail in Appendix 1 and will be refined through additional research and analysis. For U.S. agriculture, we use projected "business as usual" emissions derived from existing studies as our 2020 baseline for this goal. Our baseline for biofuels emissions will be based on expected 2020 biofuel use assuming achievement of current U.S. and European biofuel targets.

[3] U.S. EPA. 2006. *Global Mitigation of non-CO_2 Greenhouse Gases*. EPA 430-R-06-005. Washington, D.C.

involve methane gas (from manure, livestock, and rice cultivation) and nitrous oxide (associated with the use of nitrogen fertilizers). Excessive use of nitrogen in agricultural systems not only contributes to greenhouse gas emissions but also impairs water quality, reduces biodiversity and threatens human health. Within the United States, for example, two-thirds of coastal rivers and bays are moderately to severely degraded by nutrient pollution (primarily nitrogen pollution). As serious as the agriculture-related greenhouse gas and nitrogen problems are now, they are poised to worsen significantly in coming decades due to rapid growth in biofuels production.

The Foundation's agriculture strategy has the goal of addressing both greenhouse gas emissions and nitrogen pollution because of the strong interlinkages between these issues. In order to reduce greenhouse gas emissions associated with agriculture, actions are needed to improve the management of nitrogen in agricultural systems. And, the market and policy changes that will be necessary to reduce emissions of greenhouse gases provide one of the strongest opportunities ever to tackle the other major problem associated with nitrogen pollution – degradation of water quality in our rivers, groundwater and coastal ecosystems. Our strategy aims to catalyze significant changes in U.S. agriculture that would move crop production toward sustainability, reversing more than a century of increasing reliance on fossil fuels and industrially-produced fertilizers that have magnified agriculture's environmental footprint.

In focusing on nitrogen pollution and greenhouse gas emissions, our strategy aims to broadly strengthen the role of agriculture in society. The acute need over the coming decade to address greenhouse gas emissions and nitrogen pollution will provide a unique opportunity to transform agricultural systems in ways that address a range of social and environmental concerns. More specifically, our strategy will:

- help to improve farmer livelihoods and create new business opportunities, since the most effective means of changing farming practices is through the use of economic incentives;
- help to reduce the loss of biodiversity by reducing pollution and reducing rates of habitat loss resulting from the expansion of biofuels production;
- reduce soil erosion and water pollution associated with phosphorus and other chemicals through changes in management practices;
- improve soil fertility through strategies to increase organic matter in soils as a means of carbon sequestration; and,

While many policy and management reforms that improve environmental outcomes also yield social benefits, these "win-win" outcomes are not inevitable. We will only pursue strategies and outcomes that do not harm low-income communities and that complement or advance efforts to fight hunger, improve nutrition and reduce the prevalence of obesity.

The Intergovernmental Panel on Climate Change (IPCC) has concluded that there are significant and cost-effective opportunities within the agriculture sector for reducing greenhouse gas emissions.[4] The IPCC concluded that low-cost emission mitigation options associated with agriculture are comparable to those associated with energy and transportation – sectors that currently receive far greater attention and resources for climate change mitigation. Immediate action is needed if the mitigation opportunities associated with agriculture are to be captured. If agriculture is not fully incorporated in the new policy frameworks and carbon markets that will be

[4] Smith, P., D. Martino, Z. Cai, et al., 2007: Agriculture. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds.), Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

developed over the next five to ten years, then it will be extremely difficult to add this sector in the future. Under that scenario, the significant emissions associated with agriculture and the foregone mitigation opportunities associated with conservation tillage (which alone counts for one of the climate 'stabilization wedges' alongside efficient vehicles, carbon capture and storage, and wind power[5]) will be "locked in" for decades to come. Agriculture also holds the key to addressing the growing global problem of nitrogen pollution: agriculture accounts for roughly three-quarters of human contributions of reactive nitrogen to the global environment.[6]

Our strategy focuses on reducing greenhouse gas emissions and nitrogen pollution stemming from:

- *U.S. agriculture*, because of the significant global mitigation opportunities associated with U.S. agriculture (emissions from U.S. agriculture alone are greater than total greenhouse gas emissions in all but ten other countries), the substantial direct harm caused by nitrogen pollution in the U.S., and the potentially powerful opportunities that exist to address the problem by creating incentives through federal policy and carbon markets; and,

- *Global biofuels developmen*t, because of the likelihood that the rapid growth in biofuels production will substantially increase greenhouse gas emissions (even though these fuels are often promoted because of their perceived greenhouse gas benefits), the impacts that biofuels development may have on food prices and developing countries, and the time-limited opportunity that exists to set this agricultural sector on a development path with much higher standards for environmental performance than exist for other agricultural commodities.

Addressing greenhouse gas emissions and nitrogen pollution associated with U.S. agriculture and global biofuels development will require a wide array of actions (See Figure 1). Although all of those actions are needed, not all are logical priorities for philanthropic investment. We have concluded that the most highly leveraged opportunities for our new philanthropic investments are the strategies highlighted in bold font in Figure 1. Our grantmaking strategy (shown in Figure 2) is derived from these priorities and involves activities focused on *Food and Farm Policy and Practice, Climate Policy and Practice,* and *Biofuels Policy and Markets,* as well as cross-cutting activities including work to raise awareness of the findings of research on nitrogen science. This work on nitrogen science will help to advance each of the other components of the strategy and lay the foundation for longer-term progress in addressing the problem of nitrogen pollution. The theories of change for the three core elements of our strategy and the cross-cutting initiatives are discussed below.

Food and Farm Policy and Practice

Improvements in the environmental performance of agriculture in the United States can be achieved through strategies including improved technologies and management practices, stricter environmental regulation, increased incentives, and changes in consumer demand. While philanthropy could contribute to many of these approaches, we have decided to focus the Packard Foundation's strategy primarily on work to create economic incentives for improved performance.

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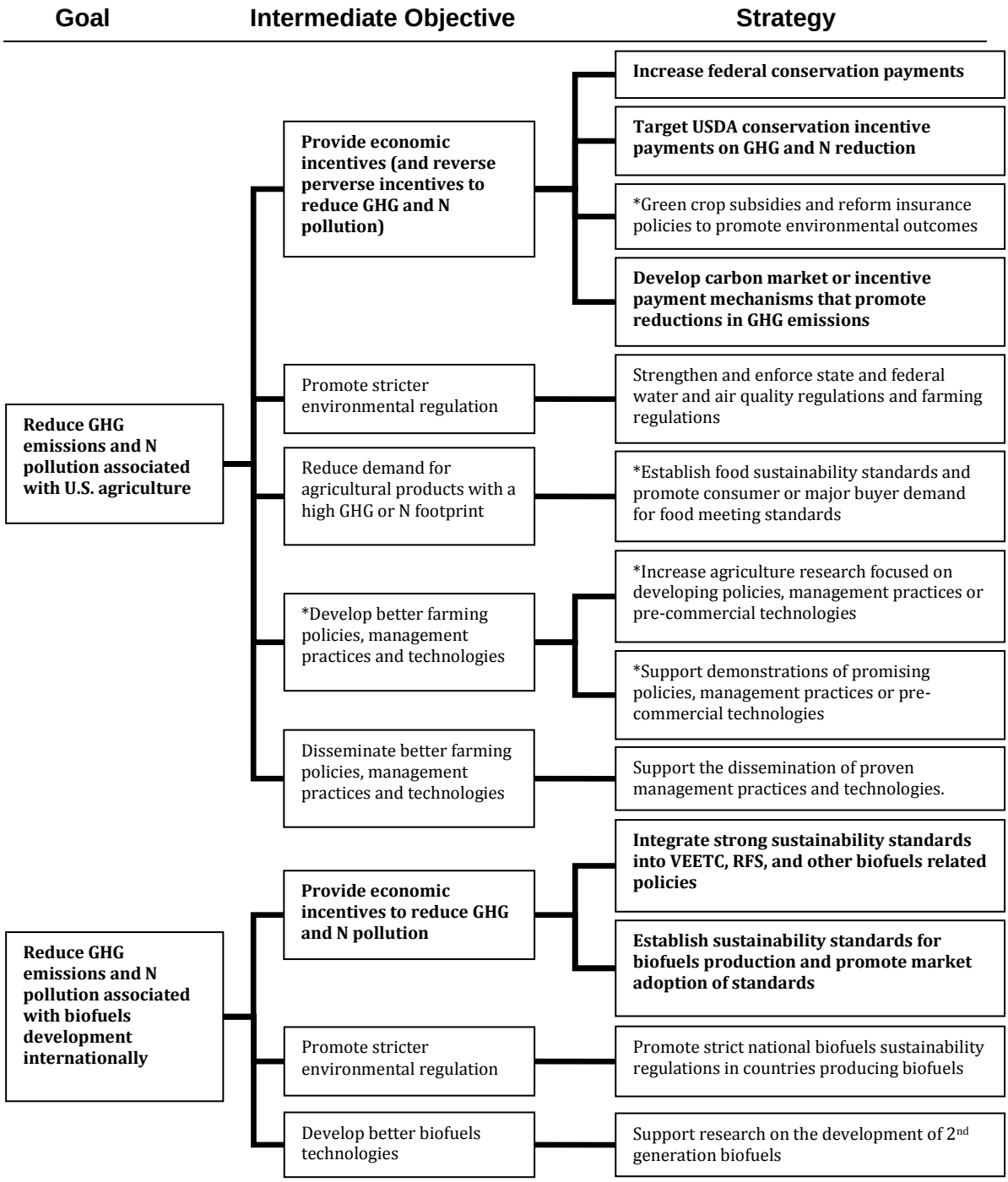
[5] Pacala, S. and A. Socolow. 2004. Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies. *Science.* 305:968-972

[6] Excessive use of nitrogen in agriculture is a problem in most of the world but not in Africa where the nutrient depletion in agriculture is a major problem and increased use of fertilizers is necessary.

Figure 1. Agriculture Strategy Priorities. This figure summarizes the strategies that we have explored for achieving the objectives of reducing GHG emissions and N pollution associated with agriculture in the U.S. and biofuels internationally. Strategies highlighted in bold indicate those that we have selected as the core of our grantmaking strategy after considering the potential return on investment; that is, the relative influence and timeliness of the strategy, the cost associated with the strategy, and the potential role for philanthropic investment. Our original strategy approved in 2008 also included an emphasis on strategies marked with asterisks, but we have had to significantly scale back support in these areas due to reductions in our grant budget.



The impacts of agriculture on nitrogen and carbon cycles are classic market externalities – although these impacts are costly for society at large, they do not factor into the decision-making of individual farmers. The most effective way to encourage change in farmer practices is to align economic incentives with conservation goals.

Current federal farm policy already provides significant conservation incentives for improved environmental performance through such programs as the Conservation Reserve Program (CRP) and the Environmental Quality Incentives Program (EQIP). However, the impact of the conservation programs could be significantly increased if they were expanded and if the funding were better targeted at the highest priority opportunities for improved environmental performance. (Our support for work on climate policy and practice is also geared to help create incentives for improved performance; see below.)

Not only can positive incentives be established to improve environmental performance, but also perverse incentives that block the adoption of environmentally sound practices can be removed. The current structure of the federal commodity support programs, for example, encourages excessive use of fertilizers and provides a disincentive for farmers to switch from crops supported by the commodity programs to crops that may have greater consumer demand and a lower environmental impact. Ideally, these subsidy payments could be "greened" by using payments to encourage changes in management practices that minimize market externalities by, for example, enhancing nitrogen use efficiency or increasing carbon sequestration.

Philanthropy can play a pivotal role in advancing these opportunities by supporting research to identify the necessary changes and advocacy for federal policy reform.

In addition to the above opportunities, we investigated the potential to create a market "pull" for improved environmental performance related to food crops through expansion of organic and sustainability certification. These approaches can be influential for certain crops such as fruits and vegetables, but consumer demand is unlikely to create a pull for environmental improvement among the commodity crops such as corn, rice, soy, and wheat that account for the bulk of greenhouse gas emissions and nitrogen use.

Agricultural practices have historically not been subject to strict environmental regulations. Environmental goals have generally been pursued through the promotion of best management practices, voluntary programs, or incentive payments. This is beginning to change with growing concern about the impacts of agriculture on air and water quality. States are increasingly adopting and enforcing regulations aimed at improving environmental performance of agriculture. While regulatory approaches will play a key role in improving environmental performance, we generally do not see major opportunities for philanthropy to promote these approaches given the decentralized processes for developing regulations and the significant costs associated with establishing and enforcing regulations. That said, philanthropy can support research, outreach and advocacy that can help in the design of appropriate regulations.

Climate Policy and Practice

While many actions can improve the environmental performance of agriculture, a "game changing" opportunity involves the potential to more fully incorporate agriculture into the emerging climate policy. Because agricultural emissions reductions can be low-cost, new regulations, incentive payments, or carbon market arrangements could create significant

incentives for changes in farming practices that, for example, reduce applications of nitrogen fertilizer, improve manure management, increase the prevalence of agricultural practices that restore soil organic carbon and increase water use efficiency. Although there is a great upside potential in the use of incentives to reduce GHG emissions or increase carbon sequestration (either through a carbon market or through a conservation payment program), there is also a high risk that philanthropic investments to achieve this goal will not be successful. The political, technical and institutional barriers to the full incorporation of agriculture in carbon markets or incentive programs are significant, and even with philanthropic investments these barriers may prove impossible to overcome. Nevertheless, a number of methodologies and protocols have been developed to quantify agriculture greenhouse gas reductions and there is considerable political momentum to incorporate agricultural greenhouse gas reductions in the emerging U.S. climate policy.

Philanthropy can play a pivotal role in advancing the potential for agriculture to provide high quality greenhouse gas reductions by supporting: a) research to identify the necessary policy changes, b) advocacy for federal policy reform, c) work to develop improved methods to link agricultural practices to carbon markets, and d) technical assistance to farmers to help them understand and benefit from these emerging markets.

Biofuels Policy and Markets

The growth of the biofuels industry and the many policies globally that address biofuels production may provide an opportunity to reduce the greenhouse gas emissions associated with fuel use and potentially expand economic opportunities in developing countries. At the same time, biofuels pose significant environmental risks. When full lifecycle emissions associated with the energy used in growing crops and producing biofuels are taken into account, many first generation biofuels show little if any net reductions in greenhouse gas emissions and sometimes result in net increases in emissions. Biofuels production also results in a net increase in nitrogen pollution and water use. Moreover, the indirect effect of biofuels production on increased rates of forest loss – and consequently increases in greenhouse gas emissions – are significant.[7]

Although the bulk of our agriculture strategy is focused on the United States, the biofuels component is international. Given the structure of this industry, a significant opportunity exists to have a global impact on biofuels production practices (which in turn will influence U.S. production) through the development of globally harmonized sustainability standards and the promotion of government and business adoption of those standards. If sound standards become widely accepted and if major commercial buyers and governments require that the biofuels they are purchasing or importing meet those standards, a significant incentive (market access and/or price premium) will be created for environmentally sound production practices. The potential for standards to influence production practices is high because of the presence of "choke points" in the supply chain where decisions by governments or large buyers could force adherence to standards, and because perceived environmental benefits are a primary justification for the use of biofuels. Nevertheless, there is only a time-limited window of opportunity to establish such standards while the industry is still young and policies are still under development.

In addition to the promotion of sustainability standards, two other strategies could help to improve the environmental performance of biofuels (see Figure 1), but neither lends itself to

[7] J. Fargione, J. Hill, D. Tilman, S. Polasky, and P.Hawthorne. 2008. Land Clearing and the Biofuel Carbon Debt. *Science Express.* 7 February.

philanthropic interventions. First, the environmental threats of biofuels development could be reduced if producing countries adopted strict regulations governing production. Since any country that adopted such regulations would be at a competitive disadvantage in global biofuels trade, this strategy would confront significant obstacles. Therefore, it is not a promising goal for philanthropic intervention unless the efforts to establish global standards fail. Second, while the first generation biofuels do not appear to provide the clear environmental benefits that were long assumed, so-called second and third generation biofuels such as cellulosic ethanol and fuel produced from algae may provide more significant savings in greenhouse gas emissions with less environmental impact. Further development of these technologies is urgently needed, but the role for philanthropy appears limited because of the investments being made by existing energy companies and venture capital firms.

Cross-Cutting Opportunities

Although the decision-making venues for food and farm, climate, and biofuels policies are distinct, there are strong overlaps in the stakeholders and institutions that are involved. For that reason, the Foundation's grantmaking strategy will include support for activities that could contribute to progress in more than one area. This will include in particular limited support for four cross-cutting issues:

- ***Communications and Polling***
  There are critical communications needs including message and framing work in each of the strategy areas: food and farm, climate, and biofuels. While there may be overlap, a significant portion of the messaging work will be targeted at specific issues or strategy areas as opportunities arise. To inform the Foundation's strategy development and the work of the advocacy community, we conducted focus groups and a national poll to gain a baseline understanding of public awareness, concern, and support around key food, farm, and energy issues. We conducted in-depth interviews with farmers to shed light on the interests and attitudes of these key stakeholders in federal food and farm policy. We will continue to fund similar work to gauge change in attitudes and activities over time. We will fund communications work as part of the three core activity areas and not as its own strategic initiative.

- ***Grassroots mobilization***
  A growing national conversation about food and its relationship to health, environmental, and economic issues is beginning to shape a broad dialogue about the role of agriculture in society. There is a need to keep exploring the connections between the issues addressed in this strategy and the expanded set of food and farm issues to find a frame that can define the "movement" and give voice to the grassroots. Such a powerful constituency could leverage further change. We will do a limited amount of grantmaking to help mainstream the movement.

- ***Nitrogen Science***
  For a century, rising agricultural productivity has been built on a foundation of increasing application of nitrogen fertilizers and increasing mechanization relying on fossil fuels. While the environmental costs of fossil fuels have become evident, the substantial burdens of nitrogen application have remained obscure to citizens, governments, and even to those within the scientific community. The problem of nitrogen pollution is probably the most significant global environmental threat today that is virtually unknown to the public and most decision-makers. In many respects, the status, visibility and technical understanding of the issue of nitrogen pollution today is similar to that associated with the issue of climate change

two decades ago. As recognized by the recent Nobel Peace Prize granted to the Intergovernmental Panel on Climate Change, one of the most important factors that ultimately led to the current global political focus on the need to address the problem of climate change was a long-term process of building the scientific base of knowledge and providing policy-relevant assessments of that knowledge. Given the significant scientific concerns surrounding nitrogen pollution, there is an opportunity for philanthropy to help strengthen the scientific field working on these issues. Consequently, our strategy includes support for work to: strengthen the international scientific network working on problems and solutions associated with nitrogen pollution; increase the level of funding for that work; and, enhance communication of policy relevant findings to managers and decision-makers.

- ***Research and demonstration of new policies, management practices and technologies to reduce agriculture greenhouse gas emissions and nitrogen pollution***
  The public and private sector agriculture research and outreach systems in the U.S. are among the best – and most well-funded – in the world. However, only a small fraction of that research and outreach is focused on practices that aim to improve environmental performance. In particular, significant needs exist for expanded research on the potential for agricultural management practices to help mitigate climate change. Philanthropy can contribute significantly to two aspects of this objective. First, philanthropy can help to strengthen research exploring new technologies and management practices to reduce agricultural greenhouse gas emissions and nitrogen pollution. For example, significant reductions in nitrogen pollution could be achieved by focusing conservation actions on the specific counties or watersheds that are responsible for the bulk of the pollution load in any particular region. And, new monitoring technologies could greatly increase the efficiency of use of nitrogen fertilizers (and reduce farmer costs). Second, philanthropy can support pilot demonstrations of promising management practices or pre-commercial technologies. Both of these philanthropic approaches, however, are relatively expensive and at the current level of funding for this strategy, we have only a very limited ability to support work in this area.

Portfolio Considerations

Each of the three core components of the strategy - Food and Farm Policy and Practice; Climate Policy and Practice; and Biofuels Policy and Markets – could stand alone and result in positive environmental outcomes. Together, however, the synergies among these components will significantly increase the impact of each. For example, successfully decreasing the environmental impact (such as nutrient pollution and habitat destruction) from expansion of biofuels production globally will directly address one of the most urgent needs associated with the environmental performance of U.S. agriculture. Conversely, U.S. state and federal policies on biofuels development are likely to be one of the most pivotal factors influencing whether it is possible to successfully establish globally harmonized biofuels sustainability standards. Finally, even though much of the impact of the support given to nitrogen science and communications will be felt after the 10-year time frame of this strategy, the greater visibility that this work will give to the problem of nitrogen pollution and potential solutions will help to strengthen both the U.S. and biofuels components of the strategy.

Donor Landscape

The overall scale of philanthropic support for work on the environmental performance of agriculture is relatively small. In recent years, two foundations, W.K. Kellogg Foundation and McKnight Foundation, have each provided more than $5 million per year in support in this field (not including the related support that these foundations provide for other agricultural issues) and a number of other foundations provide support of up to $3 million per year to organizations working on agriculture and environment issues, including the William and Flora Hewlett Foundation, Jesse Smith Noyes Foundation, Joyce Foundation, Columbia Foundation, Energy Foundation and the Clarence E. Heller Charitable Foundation. Total U.S. funding is difficult to estimate but probably amounts to less than $30 million per year. (By way of comparison, issues such as climate change, marine conservation, and western lands conservation all receive more than $200 million per year in philanthropic support.)

The funding that has been available for work in the U.S. on federal policy reform has tended to be relatively cyclical, timed to support research and advocacy only during the several years surrounding the five-year cycle of farm bill reauthorization.

There is very limited attention within the philanthropic community given to the issues of nitrogen pollution and agricultural greenhouse gas emissions, although several foundations such as the McKnight Foundation, Walton Family Foundation, and the Linden Conservation Trust are funding some work on these issues.

Given this existing donor landscape, the marginal value of additional support from the Packard Foundation to issues related to environmental performance of agriculture is relatively high. This fact, along with a number of other considerations, have factored into the Packard Foundation's decision to develop this grantmaking strategy. (See Box 1.)

Box 1. Why Packard Foundation?

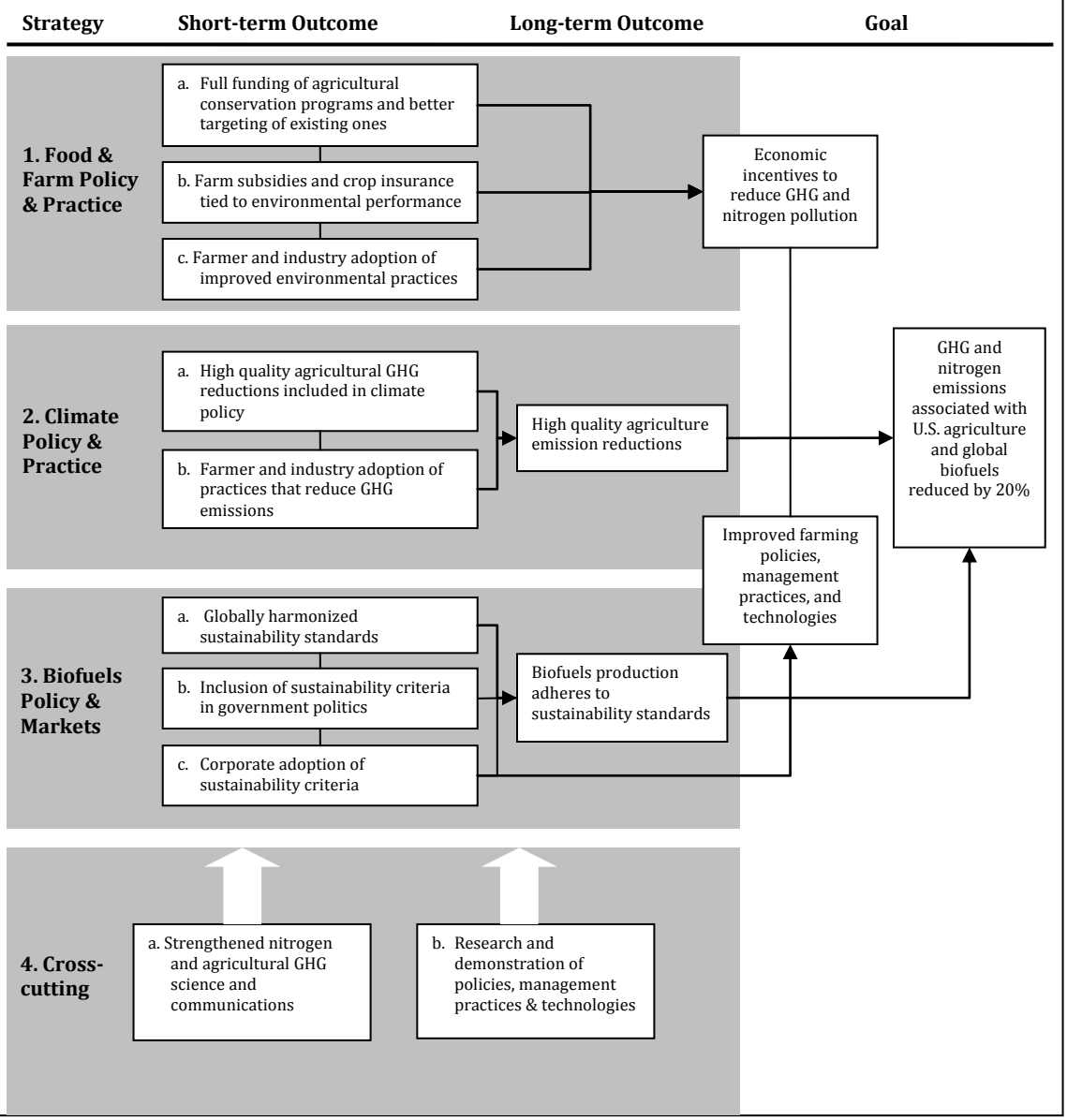
Factors that have influenced the Foundation's decision to support work on these issues include:

- The relevance of agriculture to two of the Foundation's priorities: environmental conservation and improving the lives of children.
- The relatively small total current philanthropic investments in improving the environmental performance of agriculture when viewed in relationship to the very major influence that agriculture has on the environment.
- The even smaller level of philanthropic investment in work to reduce nitrogen pollution and greenhouse gas emissions associated with agriculture.
- The rapid growth in biofuels production, which could cause significant environmental harm.
- The connection between this strategy and Packard's past support for the Millennium Ecosystem Assessment, which helped to elevate the attention given to the global problem of nitrogen pollution.
- Packard's ability to support efforts over the relatively long time frame (~10 years) that will be needed for significant progress on several elements of this strategy.
- Strong synergies with the Foundation's climate-related grantmaking strategies including support for ClimateWorks and the Tropical Forest Carbon Strategy.

Grantmaking Strategy

Our agriculture strategy is divided into three primary components: Food and Farm Policy and Practice, Climate Policy and Practice, and Biofuels Policy and Markets. The summary logic model is shown in Figure 2. Here we provide greater detail on the types of activities that the Foundation will consider supporting within the three components of the strategy. Although we provide examples of specific activities that the Foundation might support, we give priority to projects that clearly articulate a plan to accomplish significant, measurable results in support of one or more of the strategy objectives. Such a project typically would involve a number of the types of activities that we describe below (and often could entail collaboration among several NGOs). We also list indicative five-year outcomes for the strategy. We will refine these outcomes during 2009 and 2010 as part of the establishment of the monitoring and evaluation program.

Figure 2. Agriculture Strategy Logic Model



I. Food and Farm Policy and Practice

Initiative 1. Obtain full funding of authorized agricultural conservation programs and better target existing programs on GHG reduction and environmental performance.

2013 Outcomes:

- Obtain full funding of authorized agricultural conservation programs.
- Increase in federal agricultural conservation payments for 'public goods' (carbon sequestration, clean water, clean air, biodiversity protection, etc.)
- Improve the targeting of conservation payments on the highest environmental priorities.

Changes to federal farm and energy policy provide some of the greatest opportunities to increase the incentives for improved environmental performance of agriculture. There is considerable reason to believe that upcoming rounds of Farm Bill reauthorization could lead to increased conservation incentives. (See Box 2.) Many of these same factors are likely to create opportunities for reform within energy policy as well.

The Conservation Title of the 2008 Farm Bill increased funding for conservation programs from just under $4 billion per year in 2008 to just under $6 billion in 2012 (the year the current farm bill expires). When contrasted with the approximate amount of foundation funding focused on agriculture in the U.S. (~$30 million per year), the significance of a federal policy focus is evident. The goal for this initiative is to ensure that the existing conservation funding is utilized as effectively as possible and to build support for continued growth in conservation payments in future years.

We will seek to achieve this goal by supporting research to build the evidence base for advocacy and then supporting a broad range of stakeholders involved in that advocacy, including farmers, environmental organizations, and sportsmen's groups. (The Foundation does not support lobbying activities.[8])

Examples of the types of activities we would consider for support include:

1. Research to identify the potential benefits of improved conservation title program design including, for example:
    - Research to identify the potential conservation benefits from improved targeting of farm program payments.
    - An assessment of how Farm Bill conservation programs can help the nation reduce greenhouse gas emissions and what changes could make them more effective at doing so.

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[8] As a private family foundation, we do not advocate for candidates, legislation, or ballot initiatives. The Packard Foundation is permitted to use its funds to influence public policy as long as the activities are outside the definitions of lobbying or are within exceptions created by the Internal Revenue Code and Regulations. There are many activities the Packard Foundation can fund, including research, analysis, data collection, discussions of important, broad social and economic issues, project work, and direct service, to name a few. Grantees often have more latitude in what they can do. Grantees that are 501 (c)(3) public charities can engage in lobbying activities, up to the limits established by the law. The law provides clear guidance on how private foundations can support public charities that lobby. Like many other foundations, we follow those rules when supporting grantees who choose to advocate specific public policies.

Box 2. Prospects for Farm Policy Reform

U.S. farm policy has evolved slowly over past decades despite mounting evidence that existing crop subsidies and other provisions are costly to taxpayers, undermine the welfare of many farmers, and propel increasing environmental damage to agricultural landscapes. The resistance to change is anchored in a powerful alignment of political interests: farm-state representatives in Congress; deeply entrenched bureaucratic interests in other agencies at the federal and state levels; and, farm and processor interests well-organized to protect the privileges of the producers of a small number of crops.

Change is in the air, however. During each of the recent rounds of Farm Bill reauthorization, some progress has been achieved in improving conservation incentives. And further changes could be achieved when the Farm Bill next comes up for reauthorization in 2013.

Some of the factors that will help to promote further change in farm policy include:

- Significant growth in public concern about the interlinked issues of food supply, human health, obesity, and environmental protection.
- Unraveling of the historically unified farming constituency as the needs and interests of different states and commodity groups diverge.
- Changing attitudes among farmers: Agriculture is no longer the dominant economic force that it once was in the United States. As environmental threats loom ever-larger in the United States and globally, progressive farmers are aware that their "license to operate" hinges in part on their ability to produce agricultural products in ways that minimize environmental harm.
- Potential game-changing implications of climate change on agriculture and on the politics of farm and energy policy.
- Changing attitudes and approaches of NGOs. The U.S. environmental community increasingly works in partnership with farmers in efforts to experiment with and implement environmentally sound practices. The barriers to effective collaboration to improve environmental performance of agriculture are lower today than at any time in recent memory.
- Costs associated with the use of some of the most environmentally harmful inputs (fossil fuel, nitrogen).
- The growing federal deficit, which will make subsidy payments increasingly suspect.
- Continued pressure from World Trade Organization decisions to change the nature of U.S. farm commodity payments.
- Increasing need to differentiate U.S. grown (as opposed to foreign grown) products based on attributes other than low cost.
- Increasing awareness among consumers about the sources and characteristics of the food they eat (organic, local, etc.) although this doesn't always translate into changed buying practices.

    - An assessment of where federal expenditures on conservation programs are at cross-purposes with other expenditures including subsidy programs.
    - An assessment of alternative designs for conservation programs that might better achieve environmental outcomes and make the programs more user-friendly for farmers to access.

2. Communications and advocacy to build support for changes in agricultural conservation programs or improved targeting of payments that might be identified through the research described above.
3. Advocacy and communications to encourage full funding of USDA conservation programs.
4. Advocacy and communications designed to support future increases in federal conservation funding.

Some programs, such as the Cooperative Conservation program authorized under the 2008 Farm Bill, have been designed to encourage better targeting of conservation funding. We will explore whether we can help to expand the resources available to these programs by either supporting efforts to communicate the effectiveness of these programs or possibly providing assistance to organizations seeking to catalyze broader adoption of the existing programs.

Initiative 2. Green federal farm subsidies and crop insurance through strong compliance measures and incentives for "green" practices, including those that curb greenhouse gas emissions.

2013 Outcomes:

- Conservation incentives are increased (and disincentives decreased) in farm subsidy and crop insurance programs.

Changes in the design of existing subsidy and insurance programs could significantly enhance the environmental performance of agriculture without undermining the safety net that they provide for farmers. More specifically, significant environmental benefits could be obtained through policy changes that: a) direct subsidy payments toward "ecosystem services"; b) decouple payments to farmers for what is grown from how much is grown and where it is grown; and, c) reduce incentives for agriculture on environmentally sensitive lands.

As with Initiative 1, we will seek to promote these reforms by supporting research to build the evidence base for advocacy and then supporting a broad range of stakeholders involved in that advocacy, including farmers, environmental organizations, and sportsmen's groups.

Examples of the types of activities we would consider for support include:

1. Research to identify the impact of the current structure of subsidies and insurance programs on environmental outcomes and options for improving the environmental performance of these programs.
2. Advocacy, communications and leadership to reform these programs in ways that enhance environmental performance without undermining farmer safety nets.

Done right, these policy changes to improve environmental performance can be very much in the interest of farmers as well. In carrying out this strategy, we will thus support efforts to build and strengthen coalitions within agriculture that are committed to real improvement in the environmental performance of agriculture. This initiative represents a longer-term priority for the Agriculture sub-program and as such, funding will be limited but made available over the duration of the strategy.

Initiative 3: Promote farmer and industry adoption of practices that improve the environmental performance of agriculture.

2013 Outcomes:

- Farmers, industry organizations, and buyers have active and engaged staff and departments supporting improved on-farm environmental practices.

- Farmers, industry organizations, and buyers have improved access to decision-making tools, which allow them to see economic benefits of improved practices as well as give them options for making change.

Growing demand in green products and services creates an opportunity to engage large buyers, farmers, and industry organizations in promoting sustainability. Developing leaders and champions for sustainable agricultural practices within large organizations could influence greater industry support and change. However, the necessary information, tools, and consumer demand do not always exist for industry to move on its own. Forging partnerships between NGOs and industry to move forward collectively could take advantage of corporate and farmer interest while providing these groups additional resources and support.

Examples of the types of activities we would consider for support include:

1. NGO/industry collaborations and partnerships
2. Advocacy and outreach to companies, coalitions, and farmer organizations

Due to a limited budget, we will only provide a small amount of funding to this area.

II. Climate Policy and Practice

Initiative 4. Promote the inclusion of high-quality agricultural greenhouse gas emission reductions and carbon sequestration in federal and state climate policy.

2013 Outcomes:

- Incentives for high quality agriculture emission reductions and carbon sequestration are included in federal climate policy.
- Agricultural mitigation and sequestration options are included in the implementation of California's global warming legislation (AB32).
- Changes in farming practices are producing high-quality emission reductions.

The single greatest obstacle to effective incorporation of agriculture in state and federal climate policy is the lack of sound methodologies for quantifying and verifying emission reductions associated with changes in management practices. In the absence of these methodologies, there is a risk that climate policies could be developed that result in payments to farmers for practices that do not reduce emissions (thereby undermining the integrity of the climate policy) as well as a risk that incentives for agriculture are excluded from climate policy (thereby increasing the cost of climate change mitigation and reducing the co-benefits associated with changes in agricultural practices.)

Examples of the types of activities we would consider for support include:

1. Development of credible and rigorous methodologies and protocols for monitoring, measuring and verification of agricultural emission reduction and carbon sequestration activities. Such protocols must have high scientific integrity and work well for both farmers and investors.
2. Research, advocacy and communications to support the inclusion of incentives for high quality agricultural emission reductions and sequestration in state and federal policy.

Although much of this work is national in scope, we are particularly interested in supporting the incorporation of agricultural sequestration and mitigation as part of the implementation of California's global warming legislation. The strategies used to implement this legislation are likely to be models for other states and ultimately for federal legislation. California also has a strong research base to inform the development of these strategies and a capable and adaptive farming sector that could respond quickly to new incentives created under this legislation.

Initiative 5. Promote farmer and industry adoption of management practices that reduce GHG emissions and increase sequestration.

2013 Outcomes:

- Public agencies and farmers and growers associations have active and engaged staff and departments supporting farmers in their pursuit of mitigation and sequestration opportunities.
- Three agriculture sectors, in addition to dairy, set targets for emission reductions.

Even if policies are established that provide economic incentives to reduce agricultural emissions, changes in management practices are likely to be relatively slow because the price per ton of carbon will be relatively low, and cultural, institutional and commercial barriers may slow the adoption of new farming practices. The uptake of new management approaches can be

accelerated through efforts within farming groups to provide technical support and outreach to farmers and by efforts to support the adoption of emission reduction goals within agricultural sectors. For example, in 2009 the Dairy Marketing Institute adopted a voluntary goal of reducing emissions from dairy 25% by 2020.

Examples of the types of activities we would consider for support include:

1. Research and analysis to identify the most economically attractive opportunities for farmers to take advantage of the emerging carbon market.
2. Supporting farmer outreach and engagement in the design and implementation of effective mitigation and sequestration protocols.
3. Research and analysis to develop "cost curves" for agricultural sectors that identify the cost effectiveness of different emission reduction strategies within the sector.

III. Biofuels Policy and Markets

This strategy includes two components: a) supporting the development of and widespread support for globally harmonized biofuels standards; and, b) supporting efforts to ensure those standards are incorporated into government policies and buyer decisions. During both these phases, we will support research and communications efforts designed to build pressure for the adoption of standards and to inform the design of standards and policies.

Initiative 6. Support biofuels sustainability standards and a harmonized global standards framework.

2013 Outcomes:

- Broadly endorsed global biofuels sustainability standards.
- Governments and corporations have scientifically rigorous tools available to inform biofuels purchasing policies and practices.

Examples of the types of activities we would consider for support include:

1. Support for international biofuels roundtable including, in particular, stakeholder engagement in the standards processes.
2. Support for NGO capacity-building and participation in the roundtable process.
3. Selective support for work on individual feedstock standards, including in particular stakeholder engagement and collaboration with the international biofuels roundtable.
4. Communication efforts to reinforce support for creation and adoption of sustainability standards.
5. Support development of tools for certification, registration and mapping of HCV lands, and other tools as strategic to help with implementation of the voluntary standards.

Initiative 7. Incorporate sustainability standards into major policies in major biofuels consuming countries.

2013 Outcomes:

- Biofuels used in California (under the low-carbon fuel standard) are required to adhere to sustainability standards.
- OECD countries responsible for at least half of biofuels imports adopt policies requiring that biofuels imports adhere to sustainability standards.
- One quarter of U.S. biofuels use adheres to sustainability standards by 2013.

Examples of the types of activities we would consider for support include:

1. Support for NGO capacity-building.
2. Support for communication of science and message development.
3. Partnerships between NGO groups and diverse stakeholders to develop common messages and policy goals.
4. Support for analyses as crucial to policy development.
5. Leverage industry interest in sustainability to achieve policy goals.

Initiative 8. Support adoption of sustainability standards in the marketplace.

2013 Outcomes:

- At least ten commercial "major buyers" of biofuels adopt policies requiring that biofuels imports adhere to sustainability standards.
- One quarter of U.S. biofuels use adheres to sustainability standards by 2013.

Examples of the types of activities we would consider for support include:

1. NGO/industry collaborations and partnerships.
2. Advocacy and outreach to companies, coalitions, and farmer organizations.

IV. Cross-cutting Initiatives

Initiative 9. Strengthen nitrogen and agricultural greenhouse gas science and assessment and the communication of those findings to policy makers.

2013 Outcomes:

- Increased participation, collaboration, information sharing, and research output associated with the International Nitrogen Initiative.
- Regional policy-relevant and user driven assessments of nitrogen dynamics, impacts and solutions in: a) states or regions that are a focus for grantmaking in this strategy such as California; b) two or more large geographic regions such as North America and sub-Saharan Africa, possibly leading to a global assessment along the lines of the Intergovernmental Panel on Climate Change (IPCC).
- At least one center of excellence established that pursues technical and policy research focused on reductions of agricultural greenhouse gas emissions and nitrogen pollution.
- Increase in media attention to: a) nitrogen pollution, and b) policy, management and technology solutions.
- Increased federal research budget focused on nitrogen dynamics, impacts and solutions.

There are significant needs for additional research as part of a broad strategy to improve the environmental performance of agriculture. Philanthropy is not well-suited to fund this type of basic research. However, within this broad array of research needs we believe that there is a niche for some limited philanthropic funding to support work to synthesize and communicate the findings of science related to nitrogen and in particular the potential to improve the efficiency of the use of nitrogen.

Examples of the types of activities we would consider for support include:

1. Assessments of nitrogen dynamics in states or regions that will be the focus of other portions of this strategy (e.g., California).
2. Regional nitrogen assessments, building eventually to a global IPCC-like assessment.
3. Syntheses, assessments and selective research focused on the consequences of nitrogen pollution for health, the environment and the economy.
4. Syntheses, assessments and selective research focused on potential solutions to the problem of nitrogen pollution (e.g., methods to increase nitrogen use efficiency; low-cost methods for real-time field monitoring of nutrient status, etc.).
5. Media and communications efforts to: a) publicize the results of scientific research related to nitrogen pollution and to policy, management and technology solutions; b) strengthen advocacy aimed at addressing problems associated with nitrogen pollution.
6. Work to synthesize and communicate information linking health, environmental, and economic problems associated with current agriculture system to frame the nitrogen problem more holistically.

The Foundation will also support work aimed at improving understanding of the barriers that may exist to the diffusion of promising solutions.

Box 3. A Focus on California

The Agriculture strategy focuses particular attention on work in California. This is consistent with the Packard Foundation's long-standing commitment to the state, and it also reflects the unique needs and opportunities in California. More specifically:

- California is the top producer of agricultural products in the United States and agriculture is a significant source of environmental degradation in the State.
- California's global warming legislation (AB32) provides an important opportunity to explore how carbon markets could be structured to enable the maximum incorporation of agricultural mitigation and sequestration opportunities.
- California's universities are at the forefront of agricultural research.
- California plays a unique role in federal farm policy, since it currently receives a relatively small amount of federal subsidy despite having the largest agricultural economy. This provides a strong incentive for California to seek changes in farm policy that could increase benefits for producers in the state.
- California's farming sector is unusually adaptive and already strives to improve environmental performance. The potential for developing and exploring new practices and technologies is thus high.

Initiative 10. Research and demonstration of new policies, management practices and technologies to reduce agriculture greenhouse gas emissions and nitrogen pollution.

Given the current funding level for this strategy, we are currently able to provide only minimal support to this initiative. Through this initiative we seek to provide support to promising new management strategies and technologies that can improve the environmental performance of agriculture, particularly in relation to greenhouse gas emissions but that may not yet be in a position to attract commercial, government or other support. The majority of this funding will go towards initiatives in California. (See Box 3.)

We consider the following criteria in selecting projects:

- Potential impact on nitrogen pollution or greenhouse gas emissions.
- Co-benefits (potential benefits for other environmental or social goals).
- Potential for the model to be replicated widely, leverage other funding, or be catalytic in stimulating policy changes that could provide broader benefits.
- Practicality and likelihood of success.
- Cost effectiveness.
- Urgency of the issues addressed.

Timing and Exit Plan

We anticipate that ten years of investment will be needed to achieve substantial progress toward the overall goals and objectives of this strategy. That said, the first five years of implementation (2008 to 2013) provide a number of opportunities for measurable impact, particularly in the context of the regular cycles of reauthorization of federal farm and energy legislation, rapidly moving developments concerning biofuels standards and production (including the 2007 Energy Bill's mandate to use 7.5 billion gallons of ethanol and biodiesel in the nation's fuel supply by 2012, growing to 36 billion gallons by 2022), ongoing debates about federal climate policy and the development of California's plans for the implementation of the state's greenhouse gas mitigation strategies. Additionally, depending on how the World Trade Organization negotiations progress, the next round of federal farm policy reform may begin as early as 2011 or 2012.

During 2009 we will establish the monitoring and evaluation process for the strategy, revise our overall outcomes and finalize 5-year targets. In 2012, using the results of our monitoring and evaluation activities we will revisit our overall goals and objectives and develop a new set of outcomes and targets to guide the final 5 years of the strategy beginning in 2013. We will develop a specific close-out plan as part of the refreshed strategy.

In situations where the Packard Foundation becomes a dominant source of funding for an individual grantee, we will work with that grantee to help it diversify its funding in anticipation of the likely end of Packard Foundation funding within the ten-year planning horizon for this strategy.

We would exit part or all of the U.S. agriculture component of this strategy in less than ten years under the following circumstances:

- Full achievement of the policy goals laid out during our 2008 planning process in the next round of farm and energy policy reauthorizations.
- Clear evidence that technical or political barriers make the full incorporation of agriculture in the emerging carbon market impossible.

We would exit from the existing biofuels component of this strategy in less than the five year planning horizon for this work: if: a) harmonized biofuels standards were developed and adopted under shorter time frames, b) it became clear that standards would not have the leverage on this market that we believe is possible, or c) there appears to be no prospects for an environmentally sustainable biofuel (whether 1st or 2nd generation) on the horizon and governments and industry abandon their interest in this market. Under the second scenario, we would assess whether an alternative strategy might be pursued to reduce the environmental harm from biofuels expansion.

We do not believe that it is likely that we will exit from the nitrogen science component of this strategy before the end of our ten-year planning horizon. One key goal of this work is to strengthen the foundation of work on these issues and more rapid than expected progress toward that goal would simply mean that we could set higher targets.

Monitoring and Evaluation

We will develop the monitoring and evaluation plan for this strategy and refine the indicators and outcomes listed above (pp. 13 – 22) during 2009 and 2010. We anticipate spending up to five percent of the budget on monitoring and evaluation.

We expect that the monitoring and evaluation for the federal policy portion of the strategy will be undertaken jointly with other donors involved in that activity. We will develop a "real time" framework for evaluation geared to providing both the donors and grantees input on the impact of the work in order to facilitate learning and adaptation.

Similarly, much of the information that the Foundation will need to monitor the impact of the biofuels strategy will also be valuable to the NGOs and other stakeholders and so will be made available to those groups.

For other components of the strategy, we will retain one or more independent experts to help in compiling information on progress toward targets, interview practitioners, scientists, NGOs, policy-makers and business leaders, and provide written reviews of our grantmaking and achievements.

Funding Plan

For 2010, this strategy has an annual grant budget of approximately $9 million per year.[9] The planned 5-year budget allocation is shown in Table 3. The strategy has been approved through 2013 with the understanding that it will likely be approved for a subsequent 5 years. The Foundation's support for activities under this strategy will be coordinated with other foundations supporting work on agriculture and biofuels nationally (e.g., W.K. Kellogg Foundation, McKnight Foundation, William and Flora Hewlett Foundation, Walton Family Foundation, Energy Foundation, Moore Foundation) and within California (e.g., Columbia Foundation and Clarence E. Heller Charitable Foundation).

We plan to utilize other funding sources available to us including Program Related Investments (PRIs) and Organizational Effectiveness grants. Some projects supporting the goals of this sub-program may lend themselves well to PRI funding.

[9] The strategy was initially developed in 2008 assuming a budget of $15 million per year. The current draft has been revised in light of the reduced budget.

Appendix 1. Strategy Goal

The Foundation's proposed agriculture strategy goal is: **To achieve a 20 percent reduction by 2020 in projected net greenhouse gas emissions and nitrogen pollution caused by agriculture in the United States and biofuels production globally.** More precisely, we seek to achieve reductions of 20 percent in net greenhouse gas emissions and nitrogen pollution, relative to a business as usual baseline, for agriculture in the United States and for biofuels development globally. The derivation of these goals is explained separately for U.S. agriculture and biofuels below. This analysis (and the goal) will be refined through further research during 2008.

U.S. Agriculture

U.S. agricultural emissions – associated primarily with emissions of nitrous oxide and methane – account for approximately 530 MMt CO_2e per year, or 7 percent of total U.S. GHG emissions.[10] The agriculture sector can also sequester CO_2 in soils through changes in agricultural practices. The current rate of carbon sequestration in U.S. cropland is estimated to be approximately 44 MMt of CO_2e per year.[11] (Net agricultural emissions are thus 486 MMt CO_2e (530 – 44 MMt CO_2e)). Potential sequestration of carbon in U.S. cropland is estimated to be approximately 250 to 800MMt CO_2e per year. [12]

Cost curves for carbon mitigation suggest that at a price of $14 per ton of CO_2, an economic incentive would exist to sequester approximately 36 to 256 MMt of CO_2e annually.[13] Similar cost curves do not exist for agricultural emissions. Best management practices are thought to be able to achieve reductions in agricultural N_2O emissions of 30-40 percent.[14] Since N_20 accounts for approximately 48% of the warming potential of emissions in the U.S.,[15] this reduction in emissions would amount to 76 to 100 MMt CO_2e per year.

A very rough estimate of net reductions in GHG emissions that could be achieved nationally through best management practices or cost-effective practices at prices less than $15 per ton of CO_2 is thus 112 to 356 MMt CO_2e per year or 23 to 73% of current net emissions.

Focusing only on California, California emitted 492 MMt CO_2e in 2004.[16] Agricultural lands were responsible for 23 MMt CO_2e, or about 5% of California's emissions.[17] The Tellus Institute estimated that improved manure management and conservation tillage could yield reductions of

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[10] U.S. Environmental Protection Agency. 2007. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005.* U.S. EPA, Washington, D.C.
[11] Paustian, K., J.M. Antle, J. Sheehan, and E. Paul. 2006. *Agriculture's Role in Greenhouse Gas Mitigation*. Pew Center on Global Climate Change, Washington, D.C.
[12] Ibid.
[13] Ibid.
[14] Ibid.
[15] Paustian, K., J.M. Antle, J. Sheehan, and E. Paul. 2006. *Agriculture's Role in Greenhouse Gas Mitigation*. Pew Center on Global Climate Change, Washington, D.C. (p. 14)
[16] California Energy Commission. 2006. *Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2004.* California Energy Commission, Sacramento, CA
[17] California Air Resources Board. *Draft California Greenhouse Gas Inventory (MMTCO2e) – By IPCC Category*. California Air Resources Board, Sacramento.

3.3 MMt CO_2e by 2020 or 14% of current emissions.[18] These estimates were based on reductions that could be achieved at either no or relatively low ($5.5 per ton of CO_2e) net cost to farmers.

Based on these calculations, we suggest that a reasonable goal for national net emission reductions associated with the Foundation's strategy is a net reduction of emissions of 20% from the projected baseline by 2018. This is lower than the range estimated above for national reductions, but those reductions assume that a carbon price signal will exist and assume complete adoption of best management practices. It is higher than the estimate for California, but that estimate does not include potential reductions associated with changes in nitrous oxide emissions or potential increased reductions if a carbon price signal existed. This goal assumes progress within the U.S. to establish a carbon price signal at a federal level through either a cap-and-trade or tax mechanism.

We have not separately estimated a quantitative goal for reductions in nitrogen pollution and instead adopt the 20% goal calculated above as a first approximation pending additional research. This is a plausible target given the fact that nitrous oxide is one of the key greenhouse gases addressed in this estimate. For comparison, the 2001 Federal-State-Tribal Action Plan for the Mississippi drainage called for a 30% reduction in nitrogen load to reduce the hypoxic area in the Gulf of Mexico to less than 5000 km^2 by 2015.

Global Biofuels

Given the rapid growth in the biofuels sector and the rapidly evolving government policy framework initially promoting, and now in some cases slowing, biofuels development, there is substantial uncertainty surrounding the definition of a business as usual trajectory for biofuels development. Currently, the indirect effect of biofuels development on deforestation is overwhelmingly the greatest impact of biofuels expansion on greenhouse gas emissions associated with biofuels.

By adopting a goal of 20 percent reduction in net emissions relative to a business-as-usual scenario, we are thus essentially stating a goal of reducing the potential deforestation associated with biofuels by 20 percent. If successful in establishing strong standards and ensuring that government and large buyer policies adhere to those standards, a 20 percent reduction in deforestation relative to a business-as-usual scenario is likely to be a minimum expected reduction. However, if the strategy is not successful, then little if any reduction would be expected.

[18] Bailie, A., and M. Lazarus. 2005. *California Leadership Strategies to Reduce Global Warming Emissions.* Tellus Institute, Boston MA.

Appendix 2: Environmental Impacts of Agriculture

Agriculture, essential as it is for human well-being, has profound impacts on the environment. It is a driver of habitat loss, a source of pollution, and a consumer of water and energy. As the single most extensive human use of the land, the future fate of the global environment hinges to a significant extent on our success in managing and mitigating agriculture's impact on the environment. Many of the most direct environmental impacts of agriculture, including habitat loss, pesticide risks and soil erosion have long been the focus of conservation efforts with some success. However, it is increasingly apparent that the impacts of agriculture on the major global biogeochemical cycles of nitrogen (N), carbon (C), and phosphorus (P) are causing ever greater environmental harm and these impacts are proving to be exceedingly difficult to control.

Nutrient Pollution

By far the least-recognized major environmental threat associated with agriculture involves the water and air pollution created by excessive human inputs of the nutrients N and P. Human activities have now doubled the rate of creation of reactive nitrogen (that is, nitrogen available in a form that can be used by plants and animals) on land, and this rate is projected to increase another 60 percent by 2050. Agriculture is the primary source of nitrogen pollution,[19] accounting for roughly three-quarters of human contributions, with the remainder largely created through combustion of fossil fuels. Agricultural sources include both fertilizers and livestock waste. While significant progress in reducing phosphorus pollution has been made over the past 30 years in industrialized countries, nitrogen pollution has grown worse in both industrialized and developing countries.

Nutrient pollution is a major water quality problem in coastal and freshwater systems:

- Nutrient pollution represents the largest pollution problem in U.S. coastal waters and, worldwide, is generally considered to one of the top two or three threats to coastal and marine ecosystems.
- Within the United States, two-thirds of coastal rivers and bays are moderately to severely degraded by nutrient pollution.[20]
- Nitrogen pollution degrades water quality, can lead to harmful algal blooms (including blooms of toxic species) in coastal waters, and can create conditions of hypoxia (lack of oxygen) in coastal waters resulting in the death of animal life.
- More than 150 coastal regions around the world now become hypoxic during parts of the year, twice the incidence found in 1990. [21]
- In California, nutrient pollution is second only to sediment pollution as a factor responsible for impaired river and lake water quality, affecting 7,100 miles of water bodies in the state.

Human modification of the N cycle is a significant contributor to global warming and air quality problems:

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[19] Excessive use of nitrogen in agriculture is a problem in most of the world but not in Africa where the nutrient depletion in agriculture is a major problem and increased use of fertilizers is necessary.
[20] Howarth et al., 2000; Issues in Ecology No. 7.
[21] Millennium Ecosystem Assessment. 2005. Chapter 9: Nutrient Management, Volume 3 – *Policy Responses.* Island Press, Washington, D.C.

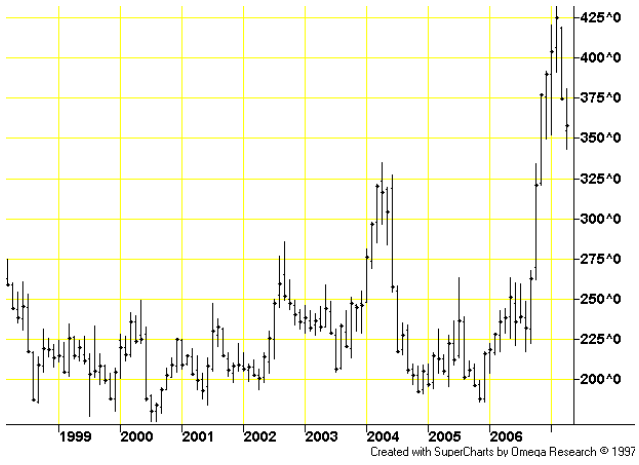
- Nitrous oxide (released from fertilized fields and manure from feedlots) is a potent greenhouse gas and contributes three to four percent to climate forcing (and also contributes to the depletion of stratospheric ozone).
- Nitrogen released from fields and feedlots in the form of nitric oxide and ammonia gasses contributes to the creation of ground level ozone and the formation of photochemical smog and acid rain.

Nitrogen pollution also poses direct and indirect threats to human health:

- Ozone pollution, caused in part by nitric oxide, contributes to lost respiratory function. Increased pollen production stemming from nutrient deposition may contribute to increased asthma and allergies.
- Nitrate pollution in water has been linked to a variety of diseases including increased risks of blue-baby syndrome, cancer and other chronic diseases, and disruption of the endocrine system.
- Increases in the number of harmful algal blooms have been linked to increased nutrient pollution in coastal waters.

In the case of nitrogen pollution, and likely for a number of other environmental impacts of agriculture as well, there is a growing scientific recognition that the problem is relatively localized and might be characterized by the "80:20 rule" where 80 percent of the problem stems from just 20 percent of the landscape. For example, the Gulf of Mexico hypoxia problem stems from a relatively localized source. Farms in counties comprising just 15 percent of the total land area of the Mississippi Basin are responsible for 80 percent of the critical spring surge of nitrate pollution into the Gulf. Farms in just 124 counties in the basin account for 40 percent of the runoff.

Figure 3. Monthly Corn Price, Chicago Board of Trade



The rapid growth in investment in biofuels introduces a new dimension to agriculture's influence on the environment. Current U.S. biofuels production is based largely on ethanol produced from corn and corn production, in turn, is one of the major sources of nitrogen pollution in the Midwest. Nitrogen from Midwestern agriculture is the primary cause of the large dead zone created in the Gulf of Mexico each year, which results in the death of all animal life over an area roughly the size of the state of Rhode Island. Until 2006, prices for corn were relatively low but the expansion of the biofuels industry has led to a significant increase in corn prices. (See Figure 3.) Experts predict that the acreage planted to corn will grow by more than 10 percent in the next two years in response to the price increase. Farmers are also shifting from corn-soy rotations (where fields are planted first with nitrogen-fixing soybeans then with fertilizer-intensive corn in a repeating cycle) to more environmentally harmful corn-corn rotations.

Nutrient pollution from agriculture has not been effectively regulated under U.S. environmental statues since much of the problem involves so-called "non-point" sources of pollution. Given the

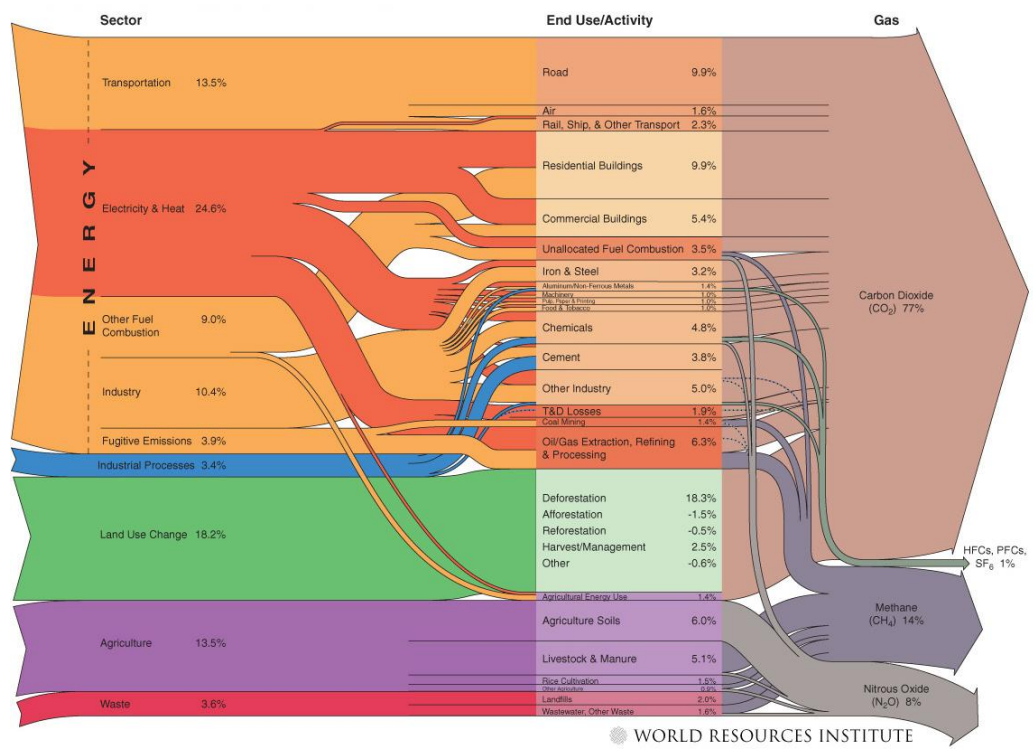


Figure 4. World GHG Emissions flow chart

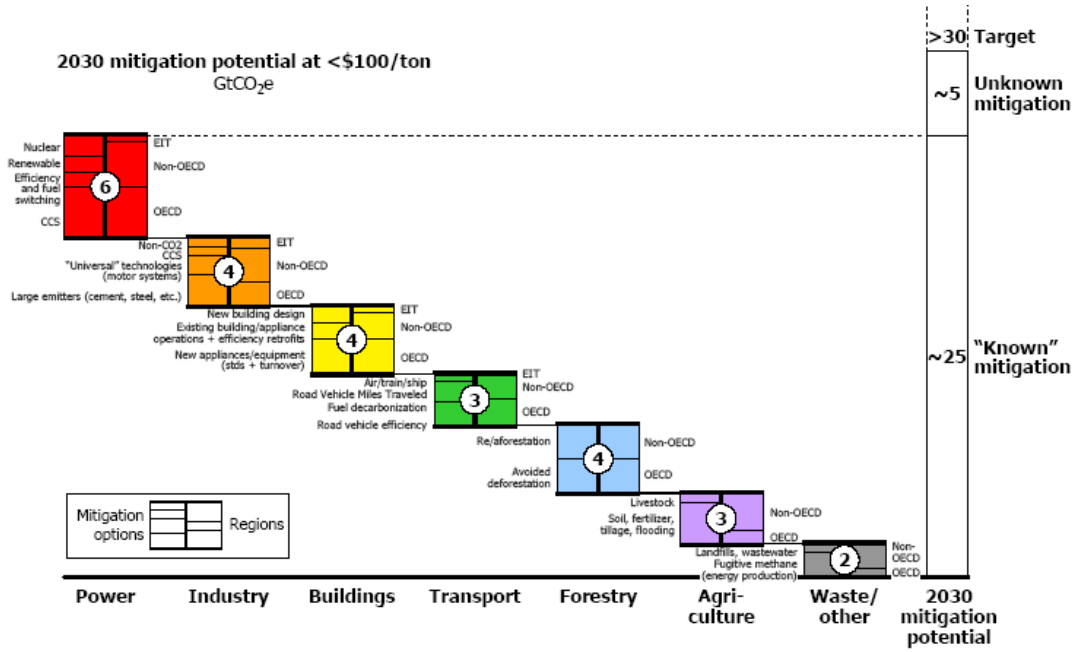
diffuse nature of the problem—runoff from farmer's fields across the country—standard regulatory approaches used to address point sources of pollution can not be readily applied to agriculture. For their part, CO_2 and methane emissions associated with agriculture have only relatively recently come to be considered an environmental threat.

At the same time, agriculture, although the dominant source of nitrogen pollution, is not the only source. Reactive nitrogen is also produced through the combustion of fossil fuels. For example, an estimated 30 percent of the nitrogen contributing to pollution problems in the Chesapeake Bay watershed is airborne nitrogen emitted from vehicles and power plants upwind of the bay. In addition, large quantities of reactive nitrogen are discharged into the environment in sewage.

Greenhouse Gas Emissions

Even apart from the contributions of N_2O to global warming, agriculture is a major contributor of greenhouse gases. By one estimate, livestock production alone (including deforestation caused by pasture expansion, emissions of methane, and emissions from feed production) accounts for 9 percent of CO_2 emissions and 18 percent of total greenhouse gas emissions measured in CO_2 equivalent.[22, 23] More generally, agriculture (excluding emissions associated with deforestation

[22] Steinfeld et al., 2006. *Livestock's long shadow*. FAO, Rome.
[23] The total GHG emissions include nitrous oxide emitted from manure and this includes both C and N cycle impacts.



Source: IPCC and USEPA, 2006 (2030 potentials); IEA ETP Map and Vattenfall (detailed breakdowns); team analysis (large uncertainties for most estimates)

Figure 5. GHG Mitigations options identified by Design to Win

caused by the expansion of agriculture) is thought to account for ten to twenty percent of current annual greenhouse gas forcing potential. [24, 25]

The recent "Design to Win" analysis of the potential role of philanthropy in reducing greenhouse gas emissions indicates that in order to achieve the reduction in emissions of 30 gigatons of carbon dioxide equivalent that would be needed to maintain climate and temperature within a relatively safe range, approximately 3 gigatons in reductions -- one tenth of the total and the same amount that is needed from transportation -- should be obtained from agriculture.[26] (See Figure 5.)

Other environmental threats

Nitrogen pollution and greenhouse gas emissions are by no means the only environmental threats posed by agriculture:

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[24] Smith, P., D. Martino, Z. Cai, D. Gwary, H. Janzen, P. Kumar, B. McCarl, S. Ogle, F. O'Mara, C. Rice, B. Scholes, O. Sirotenko, 2007: Agriculture. In *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds.), Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[25] Millennium Ecosystem Assessment. 2005. *Volume 1: Current State and Trends.* Island Press, Washington, D.C.

[26] California Environmental Associates. 2007. *Design to Win: Philanthropy's Role in the Fight against Global Warming.* (http://www.ceaconsulting.com/pdf/DesignToWin_FinalReport.pdf)

- The global expansion of agriculture has been the primary cause of habitat loss worldwide and consequently the primary cause of the loss of biodiversity. Cultivated systems now cover 25% of the earth's terrestrial surface;
- Agriculture accounts for 70% of global freshwater use and is thus a primary factor responsible for growing water scarcity around the world;
- Agriculture continues to be responsible for significant releases of toxic chemicals into the environment. California agriculture alone applies more than 200 million pounds of pesticides to crops each year.