CONTENTS:

MAXIMUM YIELD?

Sustainable Agriculture as a Tool for Conservation

DEFORESTATION IS ONE of the primary threats to biodiversity in tropical forests around the world. Deforestation has many direct causes, including conversion of forests to pasture for livestock, expansion of agricultural lands, commercial logging, and urbanization. Indirectly, deforestation is influenced by a host of other factors, including road construction, technological change, agricultural prices, household incomes, and land tenure and security.

In recent decades, the destruction of tropical forests has been a primary concern of conservation organizations. These organizations have tried many different approaches to reduce deforestation, including direct protection, restoration, education, policy changes, and the use of various incentives. However, relatively little practical guidance exists for conservation project

WHY STUDY SUSTAINABLE AGRICULTURE?
THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
TO HELP YOU ON YOUR WAY
TO LEARN MORE

managers in the field to compare different conservation tools to determine which one has the highest probability of success at their site. What is missing are clear, useful, and practical principles for designing, managing, and monitoring conservation strategies to reduce threats to biodiversity.

To make wise choices about best practices — what works, what doesn't, and why — we must learn about the conditions under which specific strategies are most effective. This is no easy task. To gauge the appropriate use of a given conservation tool, learning must be systematically and routinely incorporated into project implementation, and it must be done across a suite of projects to determine the conditions under which the tool works.

In recent years, sustainable agriculture has been promoted as an effective tool to reduce deforestation in tropical areas. This analysis explores the conditions under which sustainable agriculture works to achieve conservation in tropical forest settings.

Looking up into the canopy of giant treefern, Sierra de las Minas, Guatemala.

In much of the tropical world, traditional agriculture requires burning primary and secondary forest to clear land for cultivation.

WHY STUDY THE LINK BETWEEN SUSTAINABLE AGRICULTURE AND CONSERVATION?

In many tropical areas of the world, farmers practice swidden agriculture, which is sometimes referred to as "slash-and-burn." In this traditional approach to agriculture, farmers typically cut down a forested area, let it dry, and then burn it. Ash from the fire increases soil fertility, and fields normally maintain crop yields for about two to three years. After a few years, however, weed infestation becomes problematic and soil fertility declines to the point that farmers are forced to start the cycle of cutting forest, burning, and planting again. In areas with vast amounts of available land and low population densities, swidden agriculture may not pose a major threat to biodiversity. But such places are becoming increasingly difficult to find.

In the 1980s, sustainable agriculture projects gained popularity among international conservation organizations that were attempting to control deforestation. Sustainable agriculture has since been promoted as a conservation strategy in much of the tropical world, including Latin America, the Caribbean, Asia, the Pacific, and Africa. For many decades before the advent of sustainable agriculture, development organizations had promoted household level agricultural intensification as a strategy to increase family farm yields while decreasing required labor inputs.

The term *sustainable agriculture* is used by many people to mean many different things. In the context of some conservation projects, and for the purposes of this study, sustainable agriculture programs are designed to promote farmer-based technologies that intensify production and that, according to implementing conservation organizations, will reduce deforestation. These programs typically incorporate a number of techniques such as those listed in the following box.

For detailed discussion on the direct and indirect causes of deforestation in tropical areas, see the articles by D. Kaimowitz and A. Angelsen, listed in the References section of this publication.

WHY STUDY SUSTAINABLE AGRICULTURE?
THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
TO HELP YOU ON YOUR WAY
TO LEARN MORE

SUSTAINABLE AGRICULTURE TECHNIQUES

Conservation organizations have promoted a number of sustainable agriculture techniques focused on subsistence farmers to reduce deforestation in tropical countries. These techniques are employed primarily to reduce erosion, increase soil productivity, decrease labor requirements, and decrease the effects of agricultural pests while decreasing farmers' reliance on chemical inputs. We include some techniques below as examples.

Cover Crops. Sometimes referred to as "green manures," these primarily leguminous plants are used to fix nitrogen in the soil, improve soil texture, decrease water run-off and soil erosion, and suppress weeds during fallow and planting seasons. Cover crops also can provide supplementary crop harvests, serving as livestock feed and alternative food sources.

Minimum Tillage. After harvest, farmers leave uncollected crop residue to decompose and provide nutrients to the soil. In minimum tillage, the farmer does minimum plowing to prepare the land for planting. In a related technique called "no-till," farmers do not plow their fields but instead directly seed fields using a planting stick.

Barriers. Farmers use either live barriers or dead barriers to reduce soil erosion along the contours of their fields. Live barriers are made up of rows of plants or secondary crops, and dead barriers are usually made of rocks and debris cleared from the farmer's field. Both types of barriers work by trapping soil and sedimentation rather than letting them wash away.

Contour Planting. To reduce water run-off and soil erosion in hilly areas, farmers plow and plant their fields in lines that match the contour of the hill rather than planting uniformly across the entire field.

Integrated Pest Management. This technique involves the control of insect and rodent infestations through reduced pesticide use and manual and natural pest control techniques.

Crop Rotation. This technique involves planting different crops each planting season to maintain or increase the nutrient levels of the soil.

Terraces. On hillside farms, terraces are simultaneously the best form of soil protection and the most expensive structure to build. Terraces are essentially benches cut deep into hillsides. The cut portion of the slope is often reinforced with retaining walls and provides a nearly level bed on which to plant crops. The cheapest way to build terraces is to start with dead barriers and let soil gradually fill in behind the barriers as it naturally moves downhill, which slowly causes the bench to form.

Composting. Using soil, lime, and kitchen and farm wastes, farmers create compost piles for use in small vegetable production or other high-value crops.

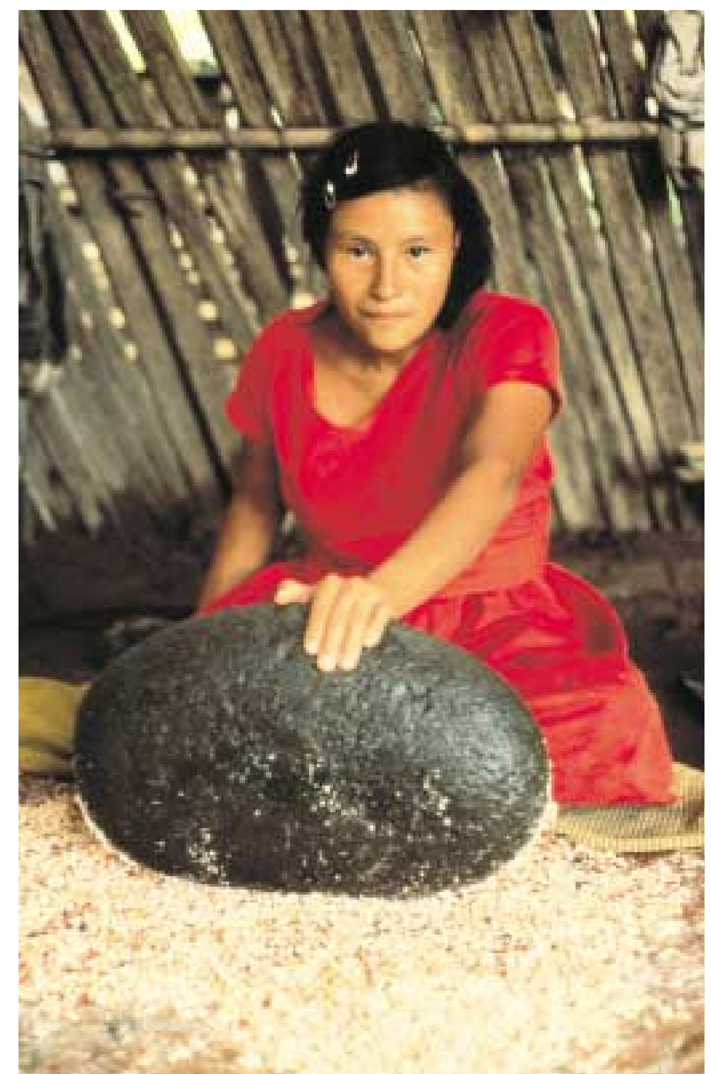
Most sustainable agriculture techniques used in tropical hillside conditions – such as this example of terracing – help reduce erosion.

WHY STUDY SUSTAINABLE AGRICULTURE?
THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
TO HELP YOU ON YOUR WAY
TO LEARN MORE

In recent years, some conservation and development organizations have begun to use ***agroforestry*** *as a way to increase crop yields, promote cash crops, and conserve biodiversity. According to the International Center for Research in Agroforestry (ICRAF), agroforestry is "a dynamic, ecologically based, natural resources management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels." (ICRAF 2001) This study does not focus on agroforestry systems.*

The type of sustainable agriculture that is the focus of this research has been promoted by both conservation and development organizations to increase the production of subsistence crops, such as maize and beans, that farmers grow primarily for household consumption. Many of these techniques, however, can also be applied to cash crops such as coffee and cardamom. One major assumption of the conservation community has been that expansion of subsistence crops — not cash crops — is the major cause of deforestation in fragile tropical areas.

Sustainable agriculture, as we define it in this publication, is meant to decrease the need to cut and burn new lands every few years. According to implementing conservation organizations, the major underlying assumption is that, by increasing investments in land and increasing yields, farmers will be less likely to move as frequently and will, ultimately, need less land to produce the amount they require to feed their families.



Maize is the main staple crop for the families that were included in this study.

As conservation organizations have gained experience in implementing sustainable agriculture projects, they have discovered some of the challenges in making it work as a conservation strategy. Given their various experiences, conservation project managers want to know: Under what conditions do sustainable agriculture projects work to help reach conservation goals? To what extent does sustainable agriculture decrease rates of deforestation? How do sustainable agriculture projects affect recovery of damaged and fragmented forestlands? To what extent do sustainable agriculture projects enable conservation organizations to win the confidence and trust of community members so they will be more open to conservation messages and programs in the future? What specific tools and techniques are most useful in promoting sustainable agriculture as a conservation strategy? Are there other conservation benefits to sustainable agriculture projects that have not been previously contemplated? What do we know at this point about sustainable agriculture that will allow us to enhance its effectiveness for future conservation efforts? These questions, which must be answered to gauge the utility of sustainable agriculture as a conservation tool to address biodiversity loss around the world, drove our research.

What We Wanted to Know

Numerous studies have assessed the socioeconomic benefits of sustainable agriculture projects. These studies have looked primarily at variables such as changes in household agricultural productivity and yield, returns to labor, and income (in particular, see Buckles et al. 1998; Faris 1999; Lutz et al. 1994). Very few studies, however, have addressed the conservation benefits of sustainable agriculture projects per se. Even fewer studies have attempted to quantitatively measure the effects of sustainable agriculture on conservation goals. We also found relatively little practical guidance for conservation project managers on how to implement successful (in terms of conservation outcomes) sustainable agriculture projects. Although the insights and conclusions of many of the studies we reviewed are useful to practitioners, they are for the most part communicated in a way that most practitioners find difficult to interpret and use.

In recent years, sustainable agriculture techniques – such as minimum tillage – have been incorporated into conservation projects that work with local community members.

Much of the Biodiversity Support Program's (BSP) programmatic work focuses on areas of high biodiversity that are, to some extent, formally protected. Many of the local or national partner nongovernmental organizations (NGOs) with which we have worked use sustainable agriculture as a conservation tool around protected areas. In recent years, some BSP partners have expressed skepticism concerning the efficacy of sustainable agriculture as a conservation strategy. In 1996, BSP and two of its local NGO partners in Latin America — Defensores de la Naturaleza in Guatemala and Línea Biósfera in Mexico — decided to collaborate to learn about the conditions under which sustainable agriculture is effective in achieving conservation success.

Based on the scarcity of practical guidance for using sustainable agriculture as a conservation tool, we developed two main goals for this study.

1. **To better understand the conditions under which sustainable agriculture can be used as an effective strategy to reach conservation goals.**
2. **To determine key principles that can help project managers more effectively use sustainable agriculture projects to reach conservation goals.**

In addition to these two collective goals, BSP had a third goal that focused on the process of doing partner-based, applied research in the context of *adaptive management*. BSP wanted to learn about some of the requirements of designing and implementing an effective *learning portfolio*. This approach is designed to bring together multiple project partners to learn about the conditions under which a specific conservation tool or strategy (in this case, sustainable agriculture) works and does not work.

Adaptive management *incorporates research into conservation action. Specifically, it is the integration of design, management, and monitoring to systematically test assumptions in order to adapt and learn. For this definition and a complete description of the process and principles of adaptive management, see Salafsky, N., R. Margoluis, and K. Redford. 2001. Adaptive Management: A Tool for Conservation Practitioners. Washington, D.C.: Biodiversity Support Program, or visit the BSP Web site at* ***www.BSPonline.org****.*

To this end, we included the following additional goal:

3. **To learn how to determine the conditions under which a specific conservation tool works across multiple projects and sites and to determine how to build capacity in local project partners to facilitate their own applied research and learning.**

For more information on ***learning portfolios****, see Salafsky, N. and R. Margoluis. 1999. Greater than the sum of their parts: Designing conservation programs to maximize results and learning. Washington, D.C.: Biodiversity Support Program at* ***www.BSPonline.org*** *or go to* ***www.FOSonline.org****.*

RESULTS IN BRIEF

The main purpose of this study was to determine the conditions under which sustainable agriculture functions as an effective conservation tool. We used a list of Conventional Wisdom, distilled from the literature and based on the perceptions of project managers, to guide our inquiry into sustainable agriculture. Following is a brief summary of what we found, organized around the main themes of the Conventional Wisdom.

Area planted to subsistence crops and its relationship to deforestation

Sustainable agriculture, as defined in this study, does not necessarily contribute to decreases in area planted to subsistence crops. In Guatemala, farmers who used sustainable agriculture techniques planted *more* area to maize than farmers who did not use sustainable agriculture. In Mexico, farmers who used sustainable agriculture techniques planted *less* area to maize than their non-user counterparts. This leads us to conclude that sustainable agriculture, as defined in this study, does not always lead to decreased pressure on new lands for subsistence agriculture.

Sustainable agriculture, as defined and used in this study, was associated with *increased* investments in labor per hectare in Mexico and *decreased* investments in labor per hectare in Guatemala. Farmers who used sustainable agriculture in Guatemala put their saved labor to use in ways that worked against conservation goals by increasing the amount of area planted to maize or establishing cash crops in forest areas. Involvement in sustainable agriculture programs, therefore, does not necessarily lead farmers to labor input savings or motivate them to act in ways that are supportive of conservation.

Access to land is an important determinant of area planted and, thus, deforestation. In Guatemala, where land is relatively available, farmers lacked appropriate incentives to be efficient in their use of land and increased their maize production by increasing area planted. In Mexico, where land access is restricted, farmers were much more efficient in their use of land and increased maize production by increasing yield. We conclude that sustainable agriculture programs that promote the same techniques farmers used in our study sites are unlikely to contribute to decreased rates of deforestation where access to land is not restricted.

Based on the results of this study, reduction in the use of fire was perhaps the greatest conservation benefit of the sustainable agriculture techniques farmers used at our two sites. In traditional agriculture, fire is used to prepare agricultural plots and control weeds and pests. Sustainable agriculture discourages the use of fire, which is one of the primary threats to habitat in the Sierra de las Minas and El Ocote Biosphere Reserves.

WHY STUDY SUSTAINABLE AGRICULTURE?
THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
TO HELP YOU ON YOUR WAY
TO LEARN MORE

Fallow and its relationship to forest recovery

In our study, sustainable agriculture did not contribute to fallow amount or duration and, therefore, had no effect on forest recovery.

Use of chemical inputs and contamination of the environment

The farmers included in our study used very little, if any, chemical fertilizers or pesticides. Because of these small numbers, there was no evidence that sustainable agriculture contributed to decreased contamination from chemical inputs. However, as sustainable agriculture use contributed to decreases in the use of fire to prepare fields, we can conclude that it reduces air pollution from smoke.

Attitudes about the environment

In general, farmers who used sustainable agriculture techniques were more aware of the importance of biological resources and their relationship to agricultural practices. In addition, sustainable agriculture programs proved to be crucial to building trust and confidence in the communities in which Defensores de la Naturaleza and Línea Biósfera work.

Community organization as a mechanism to contribute to conservation

Community organization played different roles in the sustainable agriculture projects at our study sites. In Guatemala, Defensores de la Naturaleza's sustainable agriculture program served as a mechanism to encourage farmers to participate in subsequent conservation activities. In Mexico, the highly organized nature of communities provided the foundation for the adoption and diffusion of sustainable agriculture throughout the project area.

THE CONVENTIONAL WISDOM ON SUSTAINABLE AGRICULTURE AND CONSERVATION

BSP, Línea Biósfera, and Defensores de la Naturaleza wished to test some of the major underlying assumptions related to the use of sustainable agriculture as a tool for achieving conservation. The assumptions that we include here come from our review of the available literature and discussions with researchers, project managers, and other professionals in the fields of conservation and development. Based on our review, we generated a list of key hypotheses that we have summarized into our list of *Conventional Wisdom* or presently held beliefs and assumptions related to the linkages between sustainable agriculture interventions and biodiversity conservation.

We have intentionally not included the literature review we conducted for this study in order to keep this publication as short as possible. If you are interested in the extensive literature available on sustainable agriculture, please refer to the many books and articles cited in the References section of this publication or go to ***www.BSPonline.org*** *for a copy of our literature review.*

We divide the Conventional Wisdom into two main sections: Conventional Wisdom related to the direct impacts of sustainable agriculture on biodiversity conservation and Conventional Wisdom related to its indirect impacts. We first define the main variable we wish to investigate and the Conventional Wisdom most associated with this variable.

Direct Impacts of Sustainable Agriculture on Biodiversity

The literature and conservation professionals generally assume that sustainable agriculture will have a direct impact on conservation by decreasing rates of deforestation through reduction of demand for new agricultural lands by farmers. This linkage seems simple enough: increase crop production per unit of land around areas of high biodiversity, and rural poor farmers will not need to deforest more land for agriculture to meet household demands. The belief is, in essence, that if you can attract farmers living around areas of high biodiversity to a development intervention that has such high economic returns to labor, then the conservation benefits will flow naturally. As a result of these sustainable agriculture interventions, it follows that project managers could expect to see a deceleration of the advance of the *agricultural frontier* into areas of high biodiversity and, therefore, decreased rates of deforestation. In addition to affecting rates of deforestation, the Conventional Wisdom holds that sustainable agriculture programs have a direct impact on forest regeneration and contamination of the environment.

Agricultural frontier *refers to the boundary that divides land that is devoted to agriculture and land that remains as intact natural area. Because of pressure from human populations living in adjacent areas, this frontier increasingly shifts into the natural areas.*

WHY STUDY SUSTAINABLE AGRICULTURE?
THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
TO HELP YOU ON YOUR WAY
TO LEARN MORE

Rates of Deforestation

Definition: Deforestation is the loss of primary or mature secondary forest through cutting or burning. In the case of much subsistence agriculture — the target of the sustainable agriculture programs that are the focus of this study — farmers cut down and burn forests for agriculture. Once land is depleted of its nutrients and weed infestation becomes difficult to control after only a few years, farmers slash-and-burn more to open new agricultural fields. As population pressures intensify, or technologies, market forces, and policies change, this process of cyclical forest destruction leads to increased rates of deforestation.

Conventional Wisdom: Adoption of sustainable agriculture techniques for subsistence crops leads to decreased rates of deforestation because farmers need less land to feed their families.

Forest Regeneration

Definition: Forest regeneration refers to the extent of forest regrowth after land is no longer used for agriculture.

Conventional Wisdom: Adoption of sustainable agriculture leads to greater rates of forest regeneration because farmers intensify labor inputs on less land thereby allowing other land, once used for agriculture, time to return to a forested state.

Farmers often clear new agricultural lands either immediately adjacent to or within heavily forested areas.

Contamination of the Environment

Definition: Contamination of the environment from agricultural practices is evident in many forms, including pollution from chemical fertilizers and pesticides, erosion of agricultural lands that causes sedimentation of rivers and streams, and production of smoke from burning during field preparation.

Conventional Wisdom: Adoption of sustainable agriculture techniques leads to decreased contamination of the environment.

Indirect Impacts of Sustainable Agriculture on Biodiversity

Many project managers believe that sustainable agriculture's greatest value to biodiversity conservation is the indirect benefit it provides by functioning as a way for conservation organizations to win the trust and confidence of community members. Project managers believe that by focusing on issues that are most important to rural poor populations (such as agriculture), community members are more inclined to work with conservation organizations on future projects more directly linked to conservation (such as strict protection or environmental education). This approach has been recently classified as the *bridge strategy* for integrating conservation goals and development activities.

*For a complete analysis of the **bridge strategy** and other related strategies for integrating conservation goals and development activities, see Margoluis, R., S. Myers, J. Allen, J. Roca, M. Melnyk, and J. Swanson. 2001. An ounce of prevention: Making the link between health and conservation. Washington, D.C.: Biodiversity Support Program, or visit the BSP Web site at **www.BSPonline.org**. Adapting the definition from this publication, the bridge strategy involves undertaking an agriculture project with the intention of linking it conceptually (i.e., in the minds of project personnel and farmers) to conservation activities. Communities may initially only see the agriculture benefit of the project; however, in the future, they may realize the connection between their own agricultural needs and conservation. This perception, it is assumed, will prompt community residents to participate in other future conservation activities.*

The Conventional Wisdom holds that community members' attitudes will become more supportive of conservation activities and messages once a conservation organization wins the trust of the community. In addition, organization of the community around an issue unrelated to conservation will increase a community's capacity to organize itself for other conservation-related activities in the future.

Gaining the trust of local people – such as this village mayor in Guatemala – is key to conservation success.

Attitudes Concerning Conservation

Definition: Attitudes concerning conservation include perceptions by farmers related to the relationship between biodiversity and the quality of their agriculture, their family's health, and the environment in which they live, including water and air.

Conventional Wisdom: Farmers who participate in sustainable agriculture projects have attitudes about conservation that are more positive than those who do not participate. These attitudes leave them more open to participating in future conservation activities.

Participation in Community Organizations

Definition: In many rural communities, local organizations are an important part of the social structure and management of community affairs. Community members may participate on development, education, or infrastructure committees. Organizations such as cooperatives and religious groups also play a vital role in community life. In some countries, communities participate in broader regional or national organizations as well. Many conservation organizations view community organization as a mechanism to work efficiently with dispersed communities.

Conventional Wisdom: Farmers who participate in sustainable agriculture projects are more likely to be involved in other community and outreach activities than those farmers who do not participate.

This Conventional Wisdom serves as our basic framework to better understand the conditions under which sustainable agriculture is an effective strategy to reach conservation goals.

WHY STUDY SUSTAINABLE AGRICULTURE?
THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
TO HELP YOU ON YOUR WAY
TO LEARN MORE

WHAT DID WE DO?

This study was designed primarily to determine the conditions under which sustainable agriculture is effective as a conservation tool and to determine principles for its implementation. But the study also was designed to determine the best way to promote learning within implementing organizations and how to effectively share lessons learned with the broader conservation community. Our approach to this project can, therefore, be divided into two main sections: (1) determining conditions and principles and (2) helping project partners to answer their own questions.

Partner Organizations and Study Sites

This study included two sites from Guatemala and Mexico managed by local NGOs. In Guatemala, Defensores de la Naturaleza manages the Sierra de las Minas Biosphere Reserve. In Mexico, Línea Biósfera works in the El Ocote Biosphere Reserve. (For the complete case studies, including more detailed information about both of these sites, go to ***www.BSPonline.org****.)*

The Sierra de las Minas Biosphere Reserve

The Sierra de las Minas is located in northeastern Guatemala between the Polochic and Motagua valleys. It includes about 240,000 hectares of mostly mountainous terrain that extends across five departments. In 1990, the Guatemalan Congress declared the Sierra de las Minas a protected area and resolved that Defensores de la Naturaleza would be primarily responsible for its management. The core area of this biosphere reserve is rich in plant and animal species and is home to the beautiful quetzal bird, howler monkeys, harpy eagles, and jaguars. The Sierra de las Minas is also home to numerous communities scattered throughout the Reserve's multiple use and buffer zones. Much of Defensores de la Naturaleza's sustainable agriculture efforts have focused on the north side of the Reserve, which is inhabited primarily by the Q'eqchí indigenous people. This study took place in two watersheds on the north side: Río Pueblo Viejo and Río Zarco.

The Sierra de las Minas stretches from lowland tropical forest to high mountain cloud forest and harbors a wealth of plants and animals.

The El Ocote Biosphere Reserve

El Ocote encompasses some 50,000 hectares and was declared a protected area in 1982. The Reserve is located in the northeastern zone of the state of Chiapas in Southern Mexico and is part of the larger Selva Zoque ecoregion. El Ocote is considered one of Mexico's most important centers of biological diversity and is home to some 570 species of terrestrial vertebrates. This Reserve contains 45% of all vertebrate species in Chiapas and 23% of all vertebrate species in Mexico. El Ocote also is culturally diverse and is home to Tzotzil, Zoque, Tzeltales, and mestizo groups. Línea Biósfera has been working in the El Ocote Biosphere Reserve for more than 10 years to find a balance between the socioeconomic needs of the people who live in the Reserve and its conservation needs. Since 1993, Línea Biósfera has been working with farmers who are part of la Unión de Ejidos Triunfo de los Pobres — the focus of this study in Mexico.

Water produced by the El Ocoto Biosphere Reserve helps maintain the Nezahualcóyotl reservoir.

Determining Conditions and Principles

Determining the conservation effects of sustainable agriculture projects was a much more difficult task than we originally expected. Because proponents of sustainable agriculture argue that adoption of sustainable agriculture techniques slows the advance of the agricultural frontier and, therefore, slows rates of deforestation, our initial response was to examine this relationship at a broad geographical or regional level.

When we mention broad geographical or regional scales in this publication, we refer to a unit of area that is larger than that which a single family or community affects through its agricultural practices. This unit necessarily encompasses many communities and the land they use for agriculture and it may cut across municipal, county, state, or departmental boundaries.

At first, it all seemed to be pretty easy. All we had to do was determine where farmers were using sustainable agriculture techniques, measure the changes in the movement of the agricultural frontier, and presto! we would be able to measure the effects of sustainable agriculture on deforestation! But unfortunately, the puzzle of determining causality is much more complex.

We had to look for a different approach to making the link between sustainable agriculture and deforestation. Trying to do it on a broad geographical scale was impossible for a variety of reasons, including the following:

- **Precise rates of deforestation are difficult to calculate and the information did not exist for our sample.** In the two sites that were a part of this study, no reliable data existed to calculate rates of deforestation either before or after the sustainable agriculture projects began. Therefore, there was no way we could measure how rates changed over time. Although some aerial photography existed for one of the sites, it was incomplete for the years included in the project. Finally, on a regional scale, the mechanism through which the expansion of agriculture leads to deforestation is a relatively slow process. Although the immediate effects of clearing of forest for agriculture are readily seen on a scale of a couple of hectares, rates of deforestation are much more difficult to calculate and measure over short periods of time (for example, two or three years) when examining large geographic areas.
- **Determining control or comparison groups is difficult.** Some adoption of sustainable agriculture techniques by farmers occurred in many of the communities across both study sites. Finding comparison communities, or areas in which there was no sustainable agriculture but that were otherwise similar enough to those sites included in our study, proved nearly impossible. In other words, we could not control for differences between communities — something we would have had to do if our unit of analysis was the community.
- **The proportion of farmers who adopted sustainable agriculture varied over space and time.** In some communities in our two study sites, only a handful of families used sustainable agriculture techniques. In other communities, adoption was close to 100%. Likewise, in some communities, adoption rates increased over time while in other communities, adoption rates decreased over time. This variability made it challenging, if not impossible, to link adoption of sustainable agriculture at the community level to changes in deforestation rates.
- **Many other variables affect deforestation.** Although expansion of subsistence agriculture is a direct cause of deforestation, it is not the only cause. Deforestation may also occur because of clearing of land for pasture, construction of homes and new communities, and commercial logging. In addition, many underlying or indirect factors influence the relationship between agriculture and deforestation, including market, sociodemographic, political, and cultural factors (Kaimowitz and Angelsen 1998). We had no way to control for these factors across communities and regions in order to look at the sustainable agriculture-deforestation link on a broad geographic scale. This particular issue proved to be the biggest hurdle to overcome — one that in the end was insurmountable.

WHY STUDY SUSTAINABLE AGRICULTURE?
THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
TO HELP YOU ON YOUR WAY
TO LEARN MORE

So, if we could not look at how sustainable agriculture influenced rates of deforestation on a regional level, how then could we measure this relationship? How could we precisely and specifically measure causality between sustainable agriculture and conservation if we could not do it by looking across a large region where sustainable agriculture is practiced? The answer required a fundamental shift in the way we had conceived the study.
We decided that, if we could not measure the effects of sustainable agriculture on deforestation at a regional scale, then perhaps we could measure this relationship at a different scale.

The Conventional Wisdom we outlined in the previous section is clear about the mechanism through which sustainable agriculture influences conservation. Although the expected impact is regional in nature, it starts with individual farmers and their families making decisions about land-use management — where and how they carry out agricultural activities. In its most basic form, therefore, the effects of sustainable agriculture on conservation should be detectable in individual household-level plots of agricultural lands.

As the need for new farmland expands, the agricultural frontier increasingly shifts into previously untouched areas.

Understanding deforestation attributable to subsistence agricultural expansion at a regional scale can be simplified by understanding deforestation from agricultural expansion at a family farm scale. In essence, regional deforestation attributable to subsistence farming is the sum of all deforestation that occurs at the household level for agricultural purposes, assuming no changes in other variables that affect the number of farmers or their behavior. Deforestation at the household level is a reflection of the amount of land farmers need to clear to plant crops to provide for their families. It is relatively easy to measure changes over time in area planted and, thus, the demand for new land, at the household level.

Similarly, it is difficult to accurately measure regional rates of forest regeneration. We can, however, measure the extent to which individual farmers allow forest recovery to take place. We can measure this by looking at the amount of land farmers have in *fallow* and the length of time they leave the land in fallow. The reasoning is similar to that for the relationship between rates of deforestation and household area planted: the greater the amount and duration of land left in fallow by a farmer, the greater the contribution to forest regeneration.

***Fallow** refers to agricultural land that is left inactive for a period after harvest so the soil can recuperate some of its nutrients. During the time land is left in fallow by farmers, natural regeneration of forest generally occurs (this type of regeneration is often referred to as "secondary forest").*

Decisions regarding land use in rural subsistence societies occur principally at the household level. It is also at this level where the myriad factors that affect land-use patterns have their greatest impact. For these and the above reasons, our best option for measuring the association between sustainable agriculture and conservation outcome proved to be at the household level. At this level, we could compare the conservation outcome of those farmers who used sustainable agriculture techniques with those of farmers who did not use such techniques. For some of our analysis, it was necessary to disaggregate the household-level data even further into agricultural plot units, because some farmers had more than one plot of land and their agricultural practices sometimes varied between plots. This approach allowed us to compare plots in which farmers used sustainable agriculture techniques with plots in which farmers did not use sustainable agriculture techniques. These scales — household and plot — enabled us to deduce the impacts of sustainable agriculture on conservation at a regional scale.

FOCUSING THE CONVENTIONAL WISDOM

Based on our analysis of the challenges of measuring deforestation and forest regeneration on a regional scale and the advantages of measuring them on a household scale, we have rephrased the Conventional Wisdom that we outlined in the preceding section.

Measuring Deforestation

Area Planted to Subsistence Crops

Definition: Sustainable agriculture is based largely on the assumption that farmers destroy intact forest to open new agricultural lands for subsistence crops. Sustainable agriculture also is based on the assumption that it will decrease the amount of land that a farmer needs to feed his or her family as crop yields increase. Area planted is the amount of land (in acres or hectares) that farmers have under cultivation to specific crops — in the case of our sample, primarily maize and beans. The amount of area planted is often a function of available inputs such as land, labor, seeds, fertilizers, pesticides, and other technologies. It also is a function of demand such as that caused by family size or the need for cash.

Conventional Wisdom: Adoption of sustainable agriculture techniques for subsistence crops leads to a reduction in the area of land farmers need to have under cultivation to meet household demands. Reduction in demands for new agricultural lands decreases the need to deforest new lands, thus reducing rates of deforestation.

Measuring Forest Regeneration

Fallow Area and Duration

Definition: Fallow area refers to the amount of land that farmers have in fallow. Fallow duration refers to the length of time a plot of land is left in fallow by a farmer.

Conventional Wisdom: Adoption of sustainable agriculture leads to increases in fallow area and duration, thereby allowing for greater recovery of forested areas.

Our Sample

The sample for this study was determined, in large part, by the organizations that were involved with BSP in the initial conceptualization of this research project. Línea Biósfera and Defensores de la Naturaleza have historically worked in two protected areas that, in many respects, are very similar. In addition, since about 1991, they have been involved in promoting sustainable agriculture as a conservation tool in and around protected areas.
The two organizations were, in fact, two of the original NGOs in Central America and Mexico that were involved in a World Wildlife Fund (WWF-US)-supported project designed to promote sustainable agriculture as a conservation tool. Additionally, organizations from Brazil, Peru, and Honduras were originally involved in this WWF-US

project that lasted until about 1998. Serving as the primary trainer and facilitator for the project was a Honduran NGO, COSECHA, founded to promote sustainable agriculture in Latin America and around the world.

To address the first two goals of this study, we had to carefully select the sites and farmers to include in our sample. If we had selected wildly different sites, with completely different environmental, social, and cultural factors influencing sustainable agriculture adoption and conservation, then it would have been virtually impossible for us to determine useful guiding principles for project managers working under similar conditions. If we had selected sites that were very similar to each other in many respects, then we would have run the risk of producing principles that were applicable only to those sites and not generalizable to other sites. The challenge was to come up with a sample of sites and households that were similar enough to control for some of the major confounding factors that could influence the sustainable agriculture-conservation relationship, but different enough that we could compare the influence of specific factors and conditions between sites.

The trade-off was clear. We could either include a wide range of projects under widely varying conditions and generate very general guiding principles, or work with a small, focused subset of projects to establish precise and specific principles that could also be applied to other projects under similar conditions. We decided to pursue the latter because there is little concrete guidance that project managers can use to select and implement various interventions under different conditions. In addition, we thought it prudent to test our assumptions and methods on a smaller sample, and then possibly include other sites in a subsequent study. Finally, for reasons related to available budget and staff time, working with a limited number of sites that were close to each other was the best option.

In order to strike this balance, we developed the following list of criteria that we used in selecting sites for the study:

Environmental and Geographic Factors

- **Project is located in Mesoamerica.** Primarily for logistical reasons, we needed to find projects that were relatively close to each other. By selecting only projects in Mesoamerica, we also controlled for a variety of social and cultural factors.
- **Project takes place in a mountainous area.** Different sustainable agriculture techniques have different uses depending on the environmental conditions in which they are applied. Many techniques are used solely to combat some of the challenges to farming in mountainous areas, such as erosion. Selection of techniques and their utility is thus often dependent on slope.
- **Project is located in tropical moist forest.** Selection of sustainable agriculture techniques is also dependent on rainfall and other climatic conditions. The techniques most used in arid conditions, for example, are often different from those selected for areas that receive much rain.

Social, Cultural, and Economic Factors

- **Farmers live in communities that are rural and agrarian, situated next to or in a protected area.** Land-use patterns often are determined by the socioeconomic situation of the people who live in a given region. People living in urban areas will use land differently from people living in rural areas. As sustainable agriculture use is related to agricultural practices in general, it is important to select farmers who are similar in this respect. Location near a protected area is important because, for our purposes, sustainable agriculture must be implemented as a tool to achieve biodiversity conservation goals.

Families included in this study live in or near biosphere reserves – often very close to the core areas.

- **Farmers own small family farms.** Farmers who plant crops almost exclusively to feed their families are different from farmers who plant crops for primarily commercial reasons. In addition to employing different agricultural practices, amount and types of inputs are usually different between these two types of farmers, as is the area of land that they cultivate. Only *subsistence farmers* whose primary crops were maize and beans were included in the study because the planting of these crops has been the primary focus of sustainable agriculture projects in the past.
- **Farmers are relatively poor and have access to limited resources.** Socioeconomic status has some bearing on how farmers work their fields and on their willingness to try the sustainable agriculture techniques that are promoted in these types of projects. Likewise, access to resources will have some bearing on adoption rates and conservation outcomes.

Management Factors

__Subsistence farmers__ in our study include those farmers who plant maize and beans primarily to feed their families. These farmers may, however, sell some of their harvests to earn cash income to buy household items and services needed by family members. In addition, these farmers may plant cash crops for additional income.

- **Sustainable agriculture is used as a biodiversity conservation tool in and around a protected area.** For our study, the goal of the sustainable agriculture intervention must be conservation. Because sustainable agriculture is believed to have both socioeconomic and environmental impacts, the outcome of these two factors would probably be different depending on the primary goal of the implementing organization.
- **Project is managed by an NGO and is implemented in multiple communities.** Implementation of a sustainable agriculture project by different types of institutions will influence outcome as well. For example, the conservation impact of implementation by a national agriculture agency focused on family production will probably be different from that of a local NGO focused on biodiversity conservation.
- **Implementing NGO has worked in the relevant sustainable agriculture extension program for five years.** The effects of sustainable agriculture projects do not happen overnight. Time is needed to determine how adoption of sustainable agricultural techniques influences factors in both the socioeconomic and conservation realms.

After an extensive search, we found three sites that fit these criteria. In the end, we included only the El Ocote Biosphere Reserve and the northern side of the Sierra de las Minas Biosphere Reserve described above.

Because we wanted to measure the conservation impacts of sustainable agriculture and we had decided to use households and agricultural plots as our units of analysis, we needed to compare farmers who used sustainable agriculture techniques with farmers who did not use these techniques. We were particularly careful to define precisely what it meant to be included in the study as a farmer who uses sustainable agriculture (referred to here as "SA User") and what it meant to be a farmer who did not use sustainable agriculture ("SA Non-User"). If farmers used any of the sustainable agriculture techniques that had been promoted by the participating NGOs, then they were classified as SA Users.

WHY STUDY SUSTAINABLE AGRICULTURE?
THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
TO HELP YOU ON YOUR WAY
TO LEARN MORE

In addition to classifying farmers, we also classified individual plots because some farmers had more than one plot (although most had only one plot) and SA Users did not necessarily use sustainable agriculture in all of their plots. If any sustainable agriculture technique was used in a plot, we classified it as an "SA Plot." If no sustainable agriculture techniques were used in the plot, we classified it as a "Non-SA Plot." During preliminary interviews with candidate farmers, we determined user status in order to immediately classify each household. We classified plot status later during farmer interviews.

It turned out that not all the techniques initially promoted by the implementing NGOs were adopted by participating farmers. Of the 10 techniques originally promoted by Defensores de la Naturaleza in the Sierra de las Minas, 3 were used by farmers: planting a cover crop known as velvetbean (*Mucuna pruriens*), minimum tillage, and live barriers. Línea Biósfera originally promoted more than 15 techniques and then focused its efforts on 6. In the end, farmers in El Ocote adopted primarily three of these, including planting velvetbean, minimum tillage, and integrated pest management. In both sites, the technique used most frequently by farmers was planting velvetbean.

The Attraction of Velvetbean

Velvetbean is a leguminous climbing plant that has been used in agriculture for many centuries. Originally from India and China, velvetbean has found its way to Africa; South, Central, and North America; and the Caribbean. Farmers in Mesoamerica have been using velvetbean since the 1920s. It is believed that velvetbean was introduced into Guatemala from the United States by the United Fruit Company to control weeds on banana plantations. The use of velvetbean in maize fields on the north side of the Sierra de las Minas, Guatemala, and in Chiapas, Mexico, was first reported in the 1950s.

Like most legumes, velvetbean has the potential to fix atmospheric nitrogen and store it in its leaves, vines, and seeds. This important nutrient becomes available to other surrounding crops such as maize and beans as leaf litter decays, after the plant has been slashed with a machete, or when the velvetbean plant is turned into the soil. For this reason, in many parts of Mesoamerica, velvetbean is known as frijol abono *or "fertilizer bean" in English.*

Velvetbean helps control weeds and provides mulch and nitrogen — all-important for the cultivation of maize.

In the 1970s, development organizations incorporated velvetbean into their suite of sustainable agriculture techniques for a variety of reasons. In addition to its ability to fix nitrogen, it is extremely effective at controlling weeds in agriculture plots. It is also a hardy plant that grows quickly, is easy to cultivate, and is drought-resistant. Regular use of velvetbean decreases labor requirements to prepare, plant, and weed agricultural plots, making it very attractive to farmers.

Adapted from Buckles, D., B. Triomphe, and G. Sain. 1998. Cover crops in hillside agriculture: Farmer innovation with mucuna. Ottawa, Canada: IDRC/CIMMYT.

WHY STUDY SUSTAINABLE AGRICULTURE?
THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
TO HELP YOU ON YOUR WAY
TO LEARN MORE

In each site, we selected communities in which the implementing NGO had promoted sustainable agriculture for at least five years. From each of these communities, we selected our sample of SA Users and SA Non-Users. We used a sampling technique called *quota sampling*, which required the selection of a predetermined number of individual cases (in this case, SA Users) and an equal number of comparison individuals (in this case, SA Non-Users) to provide sufficient statistical power to discern a difference, if in fact one exists, between the two groups. The accepted practice is to collect at least 100 representatives in each group, giving a sample of at least 200 at each site. In fact, both Línea Biósfera and Defensores de la Naturaleza exceeded this minimum, with Línea Biósfera sampling 300 and Defensores de la Naturaleza sampling 308. The even split between SA Users and SA Non-Users can be seen in the following table. With these samples, we were able to analyze the data for each site separately, and then combine the samples to do analysis across our two sites.

Number of SA Users and SA Non-Users Included in the Study – Guatemala and Mexico

SITE	SA USERS	SA NON-USERS	TOTAL
Guatemala	*154*	*154*	*308*
Mexico	*150*	*150*	*300*
TOTAL	*304*	*304*	*608*

We selected the two groups for our quota sampling using a technique called *frequency matching*. This step in the data-collection phase was extremely critical because it provided us with a sample that made it possible for us to isolate the effects of sustainable agriculture use. Using a sheet that profiled a typical household found in the study site — including household, demographic, and socioeconomic factors — we matched SA Users to Non-Users to ensure that the two groups were as similar as possible, except for their user status. We controlled for the following potentially confounding variables: gender of primary farmer in the family (all primary farmers in the study were men), family size, access to goods and services, and family wealth. If an equal number of families could not be selected from the same community, SA Non-User families were selected from another community that was most similar to the SA User community with respect to environment, infrastructure, socioeconomic status, and access to goods and services.

Results of Matching SA Users and SA Non-Users – Guatemala

FACTOR	SA USERS (%)	SA NON-USERS (%)
Family's principal crop is maize	*154 (100)*	*154 (100)*
Family has 4-6 children	*86 (55.8)*	*86 (55.8)*
House has tin roof	*94 (62.7)*	*90 (59.6)*
House has wooden walls	*96 (63.2)*	*99 (66.0)*
House has dirt floor	*149 (99.3)*	*154 (100)*
House has no electricity	*146 (98.6)*	*154 (100)*
House has potable water	*84 (55.6)*	*86 (57.3)*

Data Collection

Field teams that spoke the local languages (Q'eqchí in Guatemala and Tzotzil in Mexico) were recruited and organized by the two implementing NGOs and trained by BSP. All data-collection instruments were developed and field-tested jointly by the three participating organizations. In this way, we were able to standardize the instruments so that both quantitative and qualitative data were collected using the same questionnaire or topic guide at each site. All field data collection took place during the fall of 1998. We developed the following four instruments to collect quantitative data:

For copies of the data-collection instruments we used for this study, see ***www.BSPonline.org****.*

Direct Observation Checklist. This checklist allowed interviewers to quickly assess the socioeconomic status of the interviewee and ensure that the family fell within established general selection criteria.

Family Matching Sheet. This instrument allowed the interviewers to appropriately match SA Users and SA Non-Users. On each form, a profile of the SA User was filled out and an SA Non-User was then sought that matched this profile, except for user status. We matched (and therefore controlled for) the following variables: primary occupation of father, observed socioeconomic status, family size, and access to electricity and a potable water system.

Household Questionnaire. Interviewers asked each farmer a series of questions from this form to determine his (all interviewees were men) knowledge, attitudes, and practices related to agriculture and conservation. In addition, interviewers recorded household characteristics, including socioeconomic status, level of education, age structure of the family, and sources of income.

Plot Survey. Some farmers had more than one plot of land. For each plot, the interviewer recorded the size and age of the plot, what crops were being planted; techniques used, including sustainable agriculture; inputs; problems with agricultural pests; and yields. This instrument also was used to collect historical data on each plot. In addition to answering questions about the year in which the survey was conducted (1998), farmers were asked about area planted, production, and inputs for the three previous years (1995-97).

Qualitative data were collected using two types of instruments: focus group topic guides and key informant interviews. The results of these sessions were used primarily to complement the quantitative results.

Focus Group Topic Guides. These topic guides were developed primarily to explore the knowledge, attitudes, and practices of farmers in the study sites. The guides covered general agricultural practices, use of sustainable agriculture techniques, and perceptions of the relationship between agriculture and the environment. Focus groups were conducted only with male farmers who were actively engaged in subsistence agriculture. At each of the two sites, focus group interviews were conducted with both SA User and SA Non-User groups.

Key Informant Interviews. Informal interviews were conducted with key informants in each of the two sites. These interviews were used primarily at the beginning of data collection in the communities to help orient the interviewers and to serve as an "ice breaker" with community leaders. The questions asked included many of the same topics covered in the focus group topic guides.

WHY STUDY SUSTAINABLE AGRICULTURE?
THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
TO HELP YOU ON YOUR WAY
TO LEARN MORE

Helping Project Partners to Answer Their Own Questions

To address the third goal of this project, BSP worked with Defensores de la Naturaleza and Línea Biósfera to design and implement this research project and analyze and communicate the results. One of the coauthors of this publication, a representative of the Center for International Forestry and Research (CIFOR), provided additional assistance in the conceptualization and design phases of the project. In October 1997, BSP facilitated a meeting of experienced researchers and practitioners to discuss the concept of investigating the conditions under which sustainable agriculture works as an effective conservation tool. The project was formally launched with a design workshop in June 1998 that included members of BSP, Defensores de la Naturaleza, Línea Biósfera, CIFOR, and WWF-US. This meeting provided us the opportunity to develop a learning framework that included the specific operational questions we wished to address and the process we would use to answer those questions.

In August 1998, BSP facilitated a training workshop during which the data-collection instruments were finalized and field-tested. At the same time, BSP trained project staff in data-collection techniques and interviewing. Fieldwork continued through the fall of 1998 at each of the two sites.

In early 1999, BSP hired a statistician to assist in analyzing the data. Once data were collected, BSP worked with Defensores de la Naturaleza, Línea Biósfera, and the statistician to clean the data and input them into a database. In August 1999, we conducted the first in a series of analysis workshops to develop the findings from each site and to begin cross-site comparisons. BSP staff worked with both organizations as they interpreted and began to write up their results.

In August 2000, we had a final meeting to discuss findings. The purpose of this meeting was to look across both sites to determine the conditions under which sustainable agriculture works, develop guiding principles for practitioners around the world, and document our analysis of the learning process.

Some Things to Keep in Mind...

As you read through our findings, please keep in mind the following caveats to help you interpret our results as accurately as possible:

- **Association is not the same as causality.** Our research design is cross-sectional, and our sampling is not random. We can, therefore, say that there is an association between two variables, but not a causal link. If we had wanted to more accurately identify causality, we would have needed to conduct a randomly sampled longitudinal study. Nevertheless, the associations we see in the results provide a fairly compelling description of the possible association between sustainable agriculture and conservation.
- **Our research design does not allow us to quantify the regional impacts of sustainable agriculture.** For the reasons we mentioned above, our best option to test the relationship between sustainable agriculture and conservation outcome was at the household level. Using the household unit, we were able to study direct effects of sustainable agriculture use on conservation. But we did not attempt to quantify the total impact of sustainable agriculture on a regional scale. To do so, we would have had to spend precious time to determine accurate prevalence rates of adoption, control for myriad additional confounding factors, and ascertain variation in

sustainable agriculture use throughout the entire region of each site. We did not have the time or resources to do this. We do, however, discuss some implications of sustainable agriculture for regional deforestation impacts in the ***Putting the Findings in Perspective*** section of this publication.

- **Our data on crop outcomes and inputs are primarily recall data.** Almost all of our data came from farmers' recollection of past agriculture outcomes over a four-year period. These data may, therefore, be influenced by farmers' ability to remember details about past years. We overcame this problem, in part, by using the data for the most recent complete year of harvests for most of our analysis. Some of our results may be biased because farmers who use sustainable agriculture may have been inclined to answer questions in a way they thought would please the interviewers. This potential bias may be particularly noteworthy in our results on the use of fire to prepare agricultural fields. We did, however, attempt to triangulate farmers' responses as much as possible to minimize bias.
- **Our results are limited to the characteristics of our samples.** By narrowing our sample, we were able to come up with clear and precise findings for the areas included in our study. Our findings are, therefore, particularly useful to other sites with similar environmental, physical, socioeconomic, cultural, and institutional characteristics.
- **Our analysis is limited to specific sustainable agriculture techniques.** The farmers included in our samples only adopted a limited subset of sustainable agriculture techniques. We can, therefore, say little about the potential conservation impacts of the techniques that were not adopted by farmers. Farmers' willingness to adopt a specific technique, however, can be interpreted as an indicator of the technique's success in terms of its socioeconomic value and, to a lesser extent, its conservation importance. Although farmers chose to adopt only one or two techniques, this does not compromise the representativeness of the study results. In fact, because two independent projects arrived at the same primary technique, there is some evidence that supports the notion that these two sites, and the behavior we observed in farmers related to sustainable agriculture adoption and use, are typical.
- **We only included projects carried out by NGOs.** Our research is limited to those sustainable agriculture projects that are implemented by local conservation organizations. Results may be different for similar projects implemented by development organizations or government agencies.
- **Our sample came from one region of Latin America.** The distance between our two studies sites is relatively small and, in many ways, the characteristics of these two sites are very similar. Had we included other sites from around the world, our results might have been different. However, many of the characteristics found in our sample also are found in many other countries, and we believe that our results will be useful to others working under similar conditions.
- **We included only subsistence crops in our analysis.** We did not look at cash crops because most sustainable agriculture projects with a conservation goal have focused on subsistence farmers in agricultural frontiers. We believe that the results would be different for cash crops, especially those that mimic secondary forests, such as shade-grown coffee and cardamom.

Despite these caveats, the strength of association and consistency in the study results lead us to believe that we arrived at some pretty telling insights. While prudence should be used to interpret and generalize our results — as is the case with all studies of this nature — we believe that the findings can be of great use to conservation project managers around the world who are attempting to implement similar projects.

WHAT DID WE FIND?

*For the complete in-depth results from both study sites, see the two case studies listed in the Reference section of this publication or visit **www.BSPonline.org**.*

In this section, we present the results of our analysis from our study sites in Guatemala and Mexico. Much of our analysis is associated with agricultural outcomes, and it is a well-known fact that agricultural production and yield often vary from harvest to harvest. At both sites, farmers generally enjoy two harvests annually: the first takes place in April-May, and the second, main harvest occurs in November-December. In addition to collecting the same data for each of these harvests, we also collected data for four years of harvests from 1995 to 1998. We collected these additional data to control for variation between years. All data were based on farmers' recollections of past outcomes.

In our analysis, we combined area planted, production, and yield data for the two crops for each year to create total annual amounts. For much of our analysis, we wished to link sustainable agriculture use with conservation outcome. Therefore, we wanted to allow as long as possible for project implementation at each site to increase our chances of observing any possible effects. Ideally, we would have used the crop data we collected for 1998. Unfortunately, because of issues related to the timing of the study, we had to complete the data-collection phase just before the second harvest of 1998, so our data are incomplete for that year. Therefore, for those analyses in which we want to observe the maximum effect of sustainable agriculture, we use the latest year for which we have complete crop data — 1997.

Subsistence maize production was the focus of this study.

We designed the study to examine both subsistence and cash crops. After completing the data-collection phase, however, we concentrated our analysis on maize production because there appeared to be little variation between the SA User and SA Non-User groups with respect to the cultivation of other crops, including beans, pepper, coffee, and cardamom. As we mentioned earlier, most sustainable agriculture interventions, including those that took place at the two sites in our study, focus principally on subsistence crops. At both of our study sites, maize is the primary subsistence crop and is the major target of sustainable agriculture activities. For these reasons, almost all of our analyses of crop characteristics, including area planted, production, yield, and inputs, center on maize.

Although we designed the data-collection instruments to collect information on multiple plots cultivated by each farmer, we discovered during the data-collection phase that most farmers had only one primary plot of land devoted to maize. In our analysis, note that we use either farmers or plots of land as our unit of analysis, depending on the question we are trying to answer.

The data analysis phase of this study proved to be the most challenging aspect of our work. Given the complexity of trying to isolate the effects of sustainable agriculture projects on conservation outcomes, we needed to use many different types of data analyses and statistical tests. In addition to requiring a sophisticated level of knowledge related to statistics, our analysis also required a high level of proficiency in the use of statistical software. For these reasons, we found it necessary to hire a statistician to assist us with the analysis.

While this specialist was not part of the study team during the conceptualization and design phases of the project, she was integrated into the team soon after data collection began. She worked closely with BSP, Línea Biósfera, and Defensores de la Naturaleza to help analyze the data from each of the sites individually and in combination for our final analysis. During the data-collection phase of the study, each country team met frequently with BSP and our analysis specialist.

In this section, we provide separate analyses from the Guatemala and Mexico sites, and we provide combined analyses from the two sites where the results are insightful. Most of the results we present compare only two factors (*bivariate* analysis) but, where appropriate, we also present the results of looking across more than two factors (*multivariate* analysis).

*The **P value** is a way of gauging the likelihood that the difference we see in our analysis is due to chance or some random distribution of the data. So, for example, a P value of 0.01 simply means that there is a 1% chance that the difference we see is the result of chance and, conversely, we can be 99% confident that the difference we see is a real one. With our research design and sample, a P value of less than 0.05 ($P < 0.05$) can be regarded as being statistically significant. When an analysis is statistically significant, it means that the pattern or association that we see between two variables is very strong. Throughout this document, we are careful to use the word "significant" only in the statistical sense.*

For our bivariate analysis, we used two types of statistical tests to see if there was a difference between the two variables we were analyzing. If the data we were analyzing were continuous, we used the t-test of significance. If the data we were analyzing were categorical, we used a X^2 (chi-square) test of significance. We also include the *P value* for each of our statistical analyses. And we use the convention of "n" to denote the sample size. In some of the results, you will see "n (%)" in titles or headers, signifying that both numbers and percentages are shown in the corresponding tables. Sometimes the number of farmers or plots in a particular analysis will be lower than the totals we have in the sample. This is most commonly the result of missing data and information.

In addition to statistical significance, we discuss programmatic significance in our analysis. At times, statistical analysis may produce results that, in the real world, have little relevance. In other words, just because a relationship between two variables may be statistically significant, it does not mean that the relationship is noteworthy. Conversely, sometimes an analysis does not turn out to be statistically significant, but the results are extremely important from a practical perspective. We might find, for example, that a certain sustainable agriculture technique consistently saves, on average, 20% of the total amount of labor farmers need to invest in their plots to prepare them for planting. While this relationship may not prove to be statistically significant for a variety of reasons, it is probably extremely important to farmers!

The Importance of Looking Beyond Statistical Significance

Paying attention to both statistical and programmatic significance is extremely important when conducting data analysis, particularly as it relates to testing the utility of a specific tool or strategy for achieving conservation success. Relying merely on statistical significance can be dangerously misleading. For example, we might find that there is a statistically significant relationship between farmers' maize yields and their use of a particular brand of machete that appears to be physically identical to all other brands. Perhaps we find that farmers who use Macho brand machetes have consistently and significantly higher yields than farmers who use other brands. Do we immediately run out and buy a whole bunch of Macho brand machetes and distribute them to farmers all over our project area with the expectation that they will suddenly, and somewhat magically, lead to increases in crop yields? Probably not.

Upon further investigation, we might find that those farmers who live in the valley where land is flat and fertile have higher crop yields. Investigating even further, we find that it just so happens that the sole storeowner who sells agricultural tools in the valley carries only the Macho brand of machete, whereas the storeowners further up the mountainside carry many different brands. A more meaningful relationship, we discover, is between geographic location — including environmental, physical, and biological factors — and crop yield.

In our bivariate analysis, we sometimes talk about *odds ratios.* An odds ratio (OR) indicates the increased likelihood one group has over another for a given factor. So for example, let us compare yields for farmers who use chemical fertilizers with those of farmers who don't. If we came up with an OR of 2.3 for those who use fertilizer, that means that farmers who use fertilizer are 2.3 times as likely to have a high yield than those who don't.

The purpose of our multivariate analysis was to determine what combination of variables is most predictive of a certain outcome. So, for example, you will see below that the outcome of the amount of area planted to maize by farmers in Mexico is primarily a function of: (1) total amount of labor invested in the plot, (2) number of years a farmer has worked his plot, (3) family size, and (4) user status. The advantage of multivariate analysis over bivariate analysis is that it provides the opportunity to gauge the relative importance of one variable over others.

The R^2 statistic is expressed as a value from 0 to 1. It reflects the extent to which the independent variables in the model explain the variance in the dependent variable. The closer the value is to 1, the better the model describes the dependent variable. A value of 1 would mean that the independent variables explain 100% of the variance in the dependent variable.

For our multivariate analysis, we used two types of statistical tests as well. If the variable we were trying to predict (the *dependent* variable) was continuous, we used linear regression. If the dependent variable was categorical, we used logistic regression. In both of these types of analysis, our goal was to find those variables that best predict the outcome of the dependent variable. Each of these analyses provides information about how changes in multiple variables can be predictive of the dependent variable. The combination of these predictor variables (or *independent* variables) is often referred to as a "model." The statistic we use that describes the extent to which the model of independent variables accurately describes the dependent variable is called the R^2.

We evaluate the extent to which our analysis supports each Conventional Wisdom with the scale and symbols shown below. This design allows you to quickly assess our findings.

Conventional Wisdom Scale

There is strong evidence that agrees with the Conventional Wisdom.
AGREES DISAGREES

There is some evidence that agrees with the Conventional Wisdom.
AGREES DISAGREES

It is unclear whether the evidence agrees or disagrees with the Conventional Wisdom or the results are mixed.
AGREES DISAGREES

There is some evidence that disagrees with the Conventional Wisdom.
AGREES DISAGREES

There is strong evidence that disagrees with the Conventional Wisdom.
AGREES DISAGREES

Direct Impact of Sustainable Agriculture on Biodiversity

The first section of our framework looks at the direct impacts of sustainable agriculture projects on biodiversity, including amount of area under cultivation, fallow area and duration, and contamination.

Area Planted to Subsistence Crops

Conventional Wisdom: Adoption of sustainable agriculture techniques for subsistence crops leads to a reduction in the area of land that farmers need to have under cultivation to meet household demands. Reduction in demands for new agricultural lands means less need to deforest new lands, thus reducing rates of deforestation.

OUR ANALYSIS AGREES DISAGREES WITH THE CONVENTIONAL WISDOM

According to the Conventional Wisdom, for sustainable agriculture to affect rates of deforestation, it is necessary for two intermediate outcomes to occur: crop yield (production/unit of area) must improve and this must, in turn, lead to a decrease in the amount of land a farmer needs to plant to feed his family. So, in addition to looking solely at area planted, we need to examine the results of our analysis of farmers' yields at both our study sites. In addition, to understand what influences yield, we need to look at a variety of other factors besides the use of sustainable agriculture. These factors, such as the use of fertilizer and pesticide and the amount of labor the farmer invests in his plots, could disproportionately increase yield between farmers. Other factors, such as pest infestation, could decrease yield. We included these factors and other potentially confounding variables in our data collection and analysis.

Similarly, area planted can be influenced by many different environmental and social factors other than sustainable agriculture. We controlled for many of these variables, including family size, soil quality, rainfall, and slope, in our sampling strategy. We included others, such as the sale of crops, availability of labor, access to credit, and land ownership, in our data collection and analysis.

Bivariate Analysis

If we look at area planted to maize at the farmer level at both sites, we see that Guatemalan farmers who use sustainable agriculture are significantly more likely to plant *more* area to maize than those who do not use sustainable agriculture — just the opposite of what the Conventional Wisdom predicts. But Mexican farmers who use sustainable agriculture plant significantly *less* area than farmers who do not use sustainable agriculture — just what the Conventional Wisdom predicts. On the surface, these results seem to be contradictory. As you will see later, they are, in fact, completely logical.

Average Area Planted to Maize in Hectares for SA Users and SA Non-Users, for 1997 – Guatemala and Mexico

SITE	SA USERS (n)	SA NON-USERS (n)	P VALUE
Guatemala	*1.2 (152)*	*0.9 (150)*	*0.002*
Mexico	*1.9 (149)*	*2.4 (150)*	*0.015*

As shown in the following table, the average plot size is significantly different between plots in which sustainable agriculture is used and plots in which it is not used in both Guatemala and Mexico. Note, however, that again the relationship is opposite between the two sites. In Guatemala, SA Plots are significantly larger than Non-SA Plots. In Mexico, SA Plots are significantly smaller than Non-SA Plots. These results are similar to the user-level results because most farmers have only one plot.

Average Area Planted to Maize in Hectares for SA Plots and Non-SA Plots, for 1997 – Guatemala and Mexico

SITE	SA PLOT (n)	NON-SA PLOTS (n)	P VALUE
Guatemala	*1.2 (167)*	*1.0 (147)*	*0.056*
Mexico	*1.8 (150)*	*2.4 (145)*	*0.000*

Farmers experiment with sustainable agriculture – used on the right side, but not on the left side of the photo.

WHY STUDY SUSTAINABLE AGRICULTURE?
THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
TO HELP YOU ON YOUR WAY
TO LEARN MORE

When we look at the yield data, we see some even more interesting results. SA Users and SA Non-Users in Guatemala have almost identical yields. But in Mexico, yield is significantly higher for the SA Users than for the SA Non-Users. As far as programmatic significance goes, the difference in Mexico is extraordinary: SA Users yield on average 1.5 times more maize than SA Non-Users.

Average Yield of Maize in Kilograms (kg) for SA Users and SA Non-Users, for 1997 – Guatemala and Mexico

SITE	SA USERS (n)	SA NON-USERS (n)	P VALUE
Guatemala	*1081.7 (151)*	*1072.6 (144)*	*0.890*
Mexico	*1300.1 (146)*	*845.5 (145)*	*0.000*

The plot-level results confirm these findings. There is really no difference in yield between SA Plots and Non-SA Plots in Guatemala. But in Mexico, the difference is statistically significant on the same order of magnitude as we saw at the user level.

Average Yield of Maize in Kilograms (kg) for SA Plots and Non-SA Plots, for 1997 – Guatemala and Mexico

SITE	SA PLOTS (n)	NON-SA PLOTS (n)	P VALUE
Guatemala	*1076.7 (167)*	*1087.2 (147)*	*0.870*
Mexico	*1333.0 (146)*	*853.0 (145)*	*0.000*

In addition to selling some surplus maize and cash crops, some families in the Sierra de las Minas collect plant materials from the Reserve to weave baskets that they sell in regional markets to earn extra cash.

To make sure we were truly looking at the effects of sustainable agriculture use, and not some other factor, we looked at inputs that might affect this outcome. For use of fertilizer and pesticide and access to credit, there were virtually no differences between SA Users and SA Non-Users and between SA Plots and Non-SA Plots. When we looked at the total amount of labor (family members plus paid labor) invested in maize production, we found no statistical relationship between SA Users and SA Non-Users in either Guatemala or Mexico. But there may be important differences between these two groups and our two sites from a programmatic perspective. In Guatemala, it appears that SA Users use about five days of labor per hectare *less* than SA Non-Users. In Mexico, it appears that SA Users use about 5.5 days of labor per hectare *more* than their SA Non-User counterparts.

WHY STUDY SUSTAINABLE AGRICULTURE? | THE CONVENTIONAL WISDOM | WHAT DID WE DO? | WHAT DID WE FIND? | FINDINGS IN PERSPECTIVE | TO HELP YOU ON YOUR WAY | TO LEARN MORE

Average Amount (in Days) of Total Labor Used by SA Users and SA Non-Users, Controlling for Size of Plot (Days/Hectare), for 1997 – Guatemala and Mexico

SITE	SA USERS (n)	SA NON-USERS (n)	P VALUE
Guatemala	*60.5 (149)*	*65.5 (144)*	*0.174*
Mexico	*69.8 (148)*	*64.0 (147)*	*0.489*

We also looked to see if one type of farmer was more likely to sell surplus maize than the other. Indeed, in both Guatemala and Mexico, SA Users were significantly more likely to sell maize than SA Non-Users. The numbers for Guatemala, however, show only marginal programmatic significance because they are relatively small.

Number of SA Users and SA Non-Users Who Sold Maize, From 1997 Harvest – Guatemala and Mexico

SITE	SA USERS (%)	SA NON-USERS (%)	P VALUE
Guatemala	*33 (21.4)*	*13 (8.4)*	*0.004*
Mexico	*77 (51.3)*	*55 (36.7)*	*0.014*

In terms of how much farmers sold, there was virtually no difference between SA Users and SA Non-Users in Guatemala. In Mexico, however, SA Users sold significantly more than SA Non-Users — almost 450 kg more, representing on average an added income of 675 pesos (U.S. $87 at the 1997 exchange rate).

Amount of Maize Sold in Kilograms (kg) for SA Users and SA Non-Users, From 1997 Harvest – Guatemala and Mexico

SITE	SA USERS (n)	SA NON-USERS (n)	P VALUE
Guatemala	*416.3 (31)*	*428.1 (12)*	*0.944*
Mexico	*1457.6 (71)*	*1021.6 (43)*	*0.040*

While we were looking for the direct links between sustainable agriculture and deforestation through changes in crop yields and area planted, we came across what is arguably sustainable agriculture's greatest benefit to conservation — fire reduction. This factor has not been addressed widely in previous studies but demonstrates a high degree of association (in the same direction) at both study sites. Fire is one of the major threats to habitat in tropical forests near human settlements. Most often, people set fires that burn large tracts of primary forest. In the traditional preparation of plots for cultivation, farmers burn vegetation before planting to increase soil fertility. Sustainable agriculture discourages burning and instead encourages farmers to turn agricultural waste back into the soil to increase fertility.

In both the Sierra de las Minas in Guatemala and El Ocote in Mexico, fire is one of the biggest threats to the reserves. Often, serious forest fires are started by agricultural fires that burn out of control. We found that, by an overwhelming majority, SA Users in Guatemala and Mexico were less likely to use fire to prepare their plots than SA Non-Users. In fact, in Guatemala SA Non-Users were 7.7 times more likely to use fire than SA Users; in Mexico, SA Non-Users were 16.6 times more likely to use fire!

Number of SA Users and SA Non-Users Who Use Fire To Prepare Agriculture Land, for 1997 – Guatemala and Mexico

SITE	SA USERS (%)	SA NON-USERS (%)	P VALUE	ODDS RATIO
Guatemala	*33 (21.6)*	*140 (90.8)*	*0.000*	*7.7*
Mexico	*4 (2.7)*	*141 (94.0)*	*0.000*	*16.6*

We were able to cross-check these results because in the first half of our interview with farmers, we asked the simple question: "Do you use fire in the preparation of your agricultural fields?" The results are in the table above. Later on, as we collected data on each of the farmer's plots, we asked how the land was prepared — through use of any combination of the following techniques: simple cutting of vegetation, mixing vegetation into the soil, burning, and use of herbicides. We then compared plots in which fire was used with plots in which fire was not used. At the plot level, SA Plots are 5.4 times less likely to be burned in Guatemala and almost 20 times less likely to be burned in Mexico. The positive effects of sustainable agriculture are clear for this factor.

Although burning can be extremely destructive to biodiversity, it controls weed growth and adds nutrients to the soil so some farmers prefer it for cultivating maize.

Number of SA Plots and Non-SA Plots in Which Fire is Used for Preparation, for 1997 – Guatemala and Mexico

SITE	SA PLOTS (%)	NON-SA PLOTS (%)	P VALUE	ODDS RATIO
Guatemala	*16 (10.7)*	*67 (60.7)**	*0.000*	*5.4*
Mexico	*7 (5.2)*	*132 (96.4)*	*0.000*	*19.4*

**This is from a total of n = 110 because there were many missing data for this question.*

Multivariate Analysis

In our multivariate analysis, we looked at the combination of factors at each site that were most predictive of four main outcomes: (1) user status (whether a farmer was an SA User), (2) area planted to maize, (3) yield of maize, and (4) whether farmer used fire to prepare his fields. For each factor, variables are listed in order of importance (i.e., the proportion of the outcome variable they describe). From the multivariate analysis, we can also determine the direction (positive or negative) of the relationship. The R^2 of the model is included as well.

User Status

In Guatemala, the combination of variables that best predicted whether or not a farmer is an SA User included: (1) use of fire, (2) age of the farmer, (3) perception of positive effects of sustainable agriculture, and (4) visits by an extensionist. Our analysis showed that sustainable agriculture users were less likely to burn their plots, older, more likely to perceive benefits of sustainable agriculture, and more likely to receive a visit from an extensionist than non-users. The R^2 was 0.97.

In Mexico, the variables that best describe user status are: (1) use of fire, (2) age of the farmer, and (3) visits by an extensionist. SA Users were less likely to burn their plots, younger, and more likely to receive a visit from an extensionist than SA Non-Users. The R^2 was 0.90.

Combining the Guatemala and Mexico data, we found that the variables most predictive of sustainable agriculture use across both sites are: (1) use of fire, (2) visits by an extensionist, and (3) perception of positive effects of sustainable agriculture. SA Users were less likely to use fire, more likely to be visited by an extensionist, and more likely to perceive benefits of sustainable agriculture. Age dropped out of the model because it had the opposite relationship to user status in Guatemala and Mexico. The R^2 for the combined analysis was 0.88.

Area Planted to Maize

Variables that predict the amount of area planted to maize in Guatemala include: (1) user status, and (2) number of years a farmer has worked his plot. Area planted is greater when the farmer is an SA User and the longer the plot has been cultivated. The R^2 is a very low 0.052, meaning we could not come up with a model that was very predictive of area planted in Guatemala.

In Mexico, variables in the model for area planted include: (1) total amount of labor invested in the plot (not controlling for size), (2) number of years a farmer has worked his plot, (3) family size, and (4) user status. Area planted is greater with increased investments of labor, the longer the plot has been cultivated, the greater the family size of the farmer, and when the farmer is an SA user. The R^2 is 0.27.

WHY STUDY SUSTAINABLE AGRICULTURE?
THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
TO HELP YOU ON YOUR WAY
TO LEARN MORE

Combining Guatemala and Mexico, variables that predict the amount of area planted to maize include: (1) total amount of labor invested in the plot, (2) number of years a farmer has worked his plot, (3) age of farmer, (4) visits by an extensionist, and (5) problems with agricultural pests. Area planted is greater with increased investments of labor, the longer the plot has been cultivated, the older the farmer, the greater the likelihood the farmer has been visited by an extensionist, and the more likely the farmer has problems with agricultural pests. The R^2 is 0.20.

Maize Yield

In Guatemala, maize yield is most predicted by (1) number of years a farmer has worked his plot, and (2) the area of the plot. Yield is higher in older, smaller plots. The R^2 is a low 0.05.

In Mexico, maize yield is most predicted by (1) the area of the plot, and (2) user status. Yield is higher in smaller plots farmed by an SA User. The R^2 is 0.13.

Looking at both Guatemala and Mexico combined, yield is described best by (1) the area of the plot, and (2) user status. Yield is higher in smaller plots farmed by an SA User. The R^2 is a low 0.08. This low R^2 is to be expected because yield is a function of very different conditions in Guatemala and Mexico, as we will see later.

Use of Fire

In Guatemala, variables that best describe whether a plot is burned are (1) user status, and (2) total amount of labor invested in the plot. Plots that are burned are more likely to be farmed by an SA Non-User with higher total amounts of labor invested. The R^2 is 0.61.

In Mexico, variables that best describe whether or not a plot is burned are (1) user status, (2) age of the farmer, and (3) use of herbicides. Plots that are burned are more likely to be farmed by an older SA Non-User who uses more herbicides. The R^2 is 0.90.

Combining Guatemala and Mexico, variables that best describe whether a plot is burned are (1) user status, and (2) age of the farmer. As for Mexico, plots that are burned are more likely to be farmed by older SA Non-Users. The R^2 is 0.75.

Farmland that is left in fallow often leads to regeneration of forests.

Fallow Area and Duration

Conventional Wisdom: Adoption of sustainable agriculture leads to increases in fallow area and duration, thereby allowing for greater recovery of forested areas.

OUR ANALYSIS AGREES ▭ ▭ ▭ ▭ ■ DISAGREES WITH THE CONVENTIONAL WISDOM

We looked at three main factors for this analysis: (1) whether or not farmers had land in fallow at the time of the interview, (2) the amount of land in fallow, and (3) the length of time the land has been in fallow. For all three of these analyses, there was no statistical difference between SA Users and SA Non-Users. For our first factor, actual land in fallow, there were, in fact, almost exactly equal numbers for SA Users and SA Non-Users.

Number of SA Users and SA Non-Users Who Had Land in Fallow in 1998* – Guatemala and Mexico

SITE	SA USERS (%)	SA NON-USERS (%)	P VALUE
Guatemala	*135 (87.7)*	*139 (90.3)*	*0.549*
Mexico	*85 (57.4)*	*90 (60.0)*	*0.653*

** At the time of the survey.*

With respect to the amount of land in fallow, farmers in the two groups in Guatemala were almost identical. In Mexico, however, while there is similarly no statistical difference between the two groups, it appears that SA Users tend to have slightly less land in fallow.

Amount of Land in Fallow (ha) for SA Users and SA Non-Users in 1998 – Guatemala

AMOUNT (ha)	SA USERS (%)	SA NON-USERS (%)	P VALUE
< 0.7	*48 (31.2)*	*46 (29.9)*	*0.941*
0.7 < 2.1	*61 (39.6)*	*66 (42.9)*	
2.1 < 3.5	*20 (13.0)*	*19 (12.3)*	
3.5 < 7	*3 (1.9)*	*5 (3.2)*	
7+	*3 (1.9)*	*3 (1.9)*	

Amount of Land in Fallow (ha) for SA Users and SA Non-Users in 1998 – Mexico

AMOUNT (ha)	SA USERS (%)	SA NON-USERS (%)	P VALUE
< 1	*4 (2.7)*	*2 (1.3)*	*0.710*
1 < 3	*25 (16.7)*	*20 (13.3)*	
3 < 5	*21 (14.0)*	*28 (18.7)*	
5 < 10	*22 (14.7)*	*27 (18.0)*	
10+	*13 (8.7)*	*13 (8.7)*	

Concerning the amount of time farmers have left land in fallow, both groups of farmers are nearly identical in both Guatemala and Mexico.

WHY STUDY SUSTAINABLE AGRICULTURE?
THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
TO HELP YOU ON YOUR WAY
TO LEARN MORE

WHY STUDY SUSTAINABLE AGRICULTURE?
THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
TO HELP YOU ON YOUR WAY
TO LEARN MORE

Amount of Time (Years) Land Has Been in Fallow for SA Users and SA Non-Users in 1998 – Guatemala

TIME (YEARS)	SA USERS (%)	SA NON-USERS (%)	P VALUE
< 1	*27 (17.5)*	*29 (18.8)*	*0.603*
1 < 3	*102 (66.2)*	*102 (66.2)*	
3 < 5	*5 (3.2)*	*6 (3.9)*	

Amount of Time (Years) Land Has Been in Fallow for SA Users and SA Non-Users in 1998 – Mexico

TIME (YEARS)	SA USERS (%)	SA NON-USERS (%)	P VALUE
< 1	*4 (4.7)*	*1 (1.1)*	*0.246*
1 < 3	*43 (50.6)*	*43 (47.8)*	
3 < 5	*31 (36.5)*	*42 (46.7)*	
5 < 10	*5 (5.9)*	*4 (4.4)*	
10+	*2 (2.4)*	*0 (0.0)*	

Contamination of the Environment

Conventional Wisdom: Adoption of sustainable agriculture techniques leads to decreased contamination of the adjacent environment.

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It turns out that relatively few farmers in either the SA User or SA Non-User groups use chemical fertilizer or pesticide. At both sites, farmers reported that they have problems with agricultural pests, but the relationship is the opposite between Guatemala and Mexico. In Guatemala, SA Plots were more likely to have problems with pests than were Non-SA Plots. In Mexico, SA Plots were less likely to have problems with pests than were Non-SA Plots. Both relationships are statistically significant.

Reported Problems With Agricultural Pests in SA Plots and Non-SA Plots, for 1997 – Guatemala and Mexico

SITE	SA PLOTS (%)	NON-SA PLOTS (%)	P VALUE
Guatemala	*161 (97.0)*	*127 (87.6)*	*0.001*
Mexico	*116 (77.9)*	*134 (92.4)*	*0.000*

According to the project teams, some SA Users in Guatemala have problems with insect infestations in plots they do not burn because burning acts to control insect populations. In Mexico, project team members often found that initial use of sustainable agriculture techniques caused an increase in rodent infestations. They also found, however, that SA Users sometimes used a variety of integrated pest management techniques, primarily natural insect repellents made from garlic and onion, which proved to be very effective.

In Guatemala, only 15 farmers reported using pesticides in their plots and virtually none reported using chemical fertilizer. In Mexico, farmers used pesticides more frequently. In both sites, however, pesticide use was lower in SA Plots than in Non-SA Plots. According to the project managers in Mexico, SA Users are less inclined to use pesticides because velvetbean decreases insect infestations and weeds. Nevertheless, the number of farmers who use pesticides is so small that this result is not programmatically significant.

Use of Pesticides in SA Plots and Non-SA Plots, for 1997 – Mexico

INPUT	SA PLOTS (%)	NON-SA PLOTS (%)	P VALUE
Insecticide	*21 (17.4)*	*37 (27.6)*	*0.050*
Herbicide	*22 (14.9)*	*69 (49.3)*	*0.000*

In addition to the destruction of forests they cause when they go uncontrolled, fires set for agricultural purposes contribute to severe air pollution during the dry season.

As we saw in a previous analysis, there is a significant difference between SA Users and SA Non-Users in the use of fire in agriculture. Smoke is another form of contamination, and it is clear that sustainable agriculture is effective at reducing the amount of smoke released into the atmosphere from preparation of agricultural lands. In addition, because agricultural fires sometimes escape into nearby forests — especially during particularly dry periods — reduced burning by farmers most likely reduces contamination of the atmosphere from forest fires.

Indirect Impact of Sustainable Agriculture on Biodiversity

The second section of our framework looks at the indirect impacts of sustainable agriculture projects on biodiversity, including attitudes related to biodiversity and conservation and involvement in community-level organizations.

Attitudes Concerning Conservation

Conventional Wisdom: Farmers who participate in sustainable agriculture projects have attitudes about conservation that are more positive than those who do not participate. These attitudes leave them more open to participating in future conservation activities.

OUR ANALYSIS AGREES — DISAGREES WITH THE CONVENTIONAL WISDOM

According to our quantitative data, significantly more SA Users than SA Non-Users perceive that sustainable agriculture has positive effects. But it is less clear the extent to which SA Users have more positive attitudes about

WHY STUDY SUSTAINABLE AGRICULTURE?
THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
TO HELP YOU ON YOUR WAY
TO LEARN MORE

Number of SA Users and SA Non-Users Who Perceive Positive Effects of Sustainable Agriculture – Guatemala and Mexico

SITE	SA USERS (%)	SA NON-USERS (%)	P VALUE
Guatemala	*151 (98.0)*	*7 (4.6)*	*0.000*
Mexico	*127 (84.7)*	*67 (45.3)*	*0.000*

Environmental education often goes hand-in-hand with sustainable agriculture projects. Here, Defensores de la Naturaleza staff set up a megaphone with a car battery to do a presentation to farmers.

the environment. We asked farmers if sustainable agriculture had any positive effects on water, soil, air, and the forest. The only significant difference between SA Users and SA Non-Users was in Guatemala, for water. According to the results from Mexico, 65 (44.8%) of farmers who use sustainable agriculture say that the reason they do not use fire to prepare their agricultural plots is to protect the forest. In Guatemala, 143 (93%) SA Users and 103 (66.7%) SA Non-Users report that they do not use fire in their fields in order to protect the forest (P = 0.035).

During some of the focus group interviews we conducted in both Guatemala and Mexico, SA Users demonstrated a clear awareness of the connection between their actions and the environment. Representatives of both Defensores de la Naturaleza and Línea Biósfera attribute this awareness to the environmental education activities that accompanied their sustainable agriculture extension projects.

Selected Focus Group Comments

At times, it is nice to burn your fields, but the truth is we haven't realized that we, in fact, are the ones responsible for polluting the environment — we're destroying nature. We're the ones lighting the fires, but still we ask "Where is all this smoke coming from?"

José, SA User, Mexico

We could reduce the amount of pollution if people would just understand the causes — if all farmers would quit burning we could then stop the forest fires.

Antonio, SA User, Mexico

Fire is a problem because when we burn our fields, fertility drops and the rains wash away the soil...

Anonymous SA User, Guatemala

Sustainable agriculture] is good, because we know that if we were to cut down the entire forest, after awhile, it would stop raining.

Juan, SA User, Mexico

To unite the community, we must teach everyone to prepare their plots with hoe and machete alone [as opposed to using herbicides] because that way, we will not contaminate the water.

Miguel, SA User, Mexico

Participation in Community Organizations

Conventional Wisdom: Farmers who participate in sustainable agriculture projects are more likely to be involved in other community and outreach activities than farmers who do not participate.

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We looked at various ways that farmers might participate in community activities or be exposed to other opportunities that might foretell their involvement in future conservation activities. In addition to looking at membership in community organizations, we also looked at the extent to which farmers are visited by an extensionist. Finally, we looked at the extent to which farmers have participated in cross-community exchanges to learn new agricultural techniques or other technological innovations.

In Guatemala, SA Users were significantly more likely to report belonging to a community organization than SA Non-Users. In Mexico, however, there was no significant difference. According to the project teams, these results reflect the relatively low level of official community organization in Guatemala and the high level of community mobilization in Mexico. In Mexico, most farmers belong to *ejido* organizations that are part of greater regional organizations, so the need for community organizations per se is minimal. In Guatemala, on the other hand, communities are often required to self-mobilize in order to take any collective action.

Ejidos *were established in Mexico during the land-reform movement of the last century. They are a form of land tenure in which farmers are guaranteed use-rights to fixed amounts of land.*

Number of SA Users and SA Non-Users Who Participate in a Community Organization – Guatemala and Mexico

SITE	SA USERS (%)	SA NON-USERS (%)	P VALUE
Guatemala	*59 (38.4)*	*26 (16.7)*	*0.000*
Mexico	*89 (59.7)*	*96 (65.8)*	*0.285*

In both Guatemala and Mexico, SA Users are significantly more likely to have been visited by an extensionist than SA Non-Users. This makes sense because the programs of both Defensores de la Naturaleza and Línea Biósfera rely heavily on extension programs to train farmers. In addition, these results are clearly biased by the fact that these organizations conducted the data collection and necessarily sampled SA Users with whom they had interacted to include in the study. We also looked at the extent to which community members participated in cross-community exchanges or visits, but very few farmers were involved in these.

Number of SA Users and SA Non-Users Visited by an Extensionist – Guatemala and Mexico

SITE	SA USERS (%)	SA NON-USERS (%)	P VALUE
Guatemala	*130 (84.2)*	*24 (15.9)*	*0.000*
Mexico	*69 (46.0)*	*16 (10.7)*	*0.000*

A Defensores de la Naturaleza field extentionist discusses with farmers progress on a field where dead barriers are being tried.

PUTTING THE FINDINGS IN PERSPECTIVE

We divide our discussion in this section into three parts that parallel our three goals: (1) the conditions under which sustainable agriculture contributes to conservation, (2) principles for using sustainable agriculture as a conservation tool, and (3) process lessons — learning to learn better. In the first two sections, we try to make sense of our findings by looking across factors and our two study sites. In the last section, we take a critical, internal look at how we planned and implemented this study.

Many of the insights and interpretations we include in this section came about from the final analysis meeting we held in August 2000. During that meeting we discussed each site individually and then compared and contrasted the two sites in an effort to determine how different characteristics might have contributed to our findings. The last day of the meeting was spent evaluating the research process itself.

The Conditions Under Which Sustainable Agriculture Contributes to Conservation

The first goal of this study was to better understand the conditions under which sustainable agriculture can be used as an effective strategy to reach conservation goals. For this portion of our discussion, we will examine our findings using the conventional wisdom as a framework. As you go through this section, keep in mind that we necessarily narrowed our sample to a fairly limited set of social, cultural, and environmental characteristics to come up with a relatively precise understanding of what makes for a successful sustainable agriculture program. While we believe that many of these insights and observations are generalizable, we also realize that they are derived from some fairly specific situations.

Area planted to subsistence crops

We found that area planted was associated with sustainable agriculture use in completely opposite ways in Guatemala and Mexico. In Guatemala, SA Users plant significantly more area to maize than SA Non-Users. In Mexico, SA Users plant significantly less area to maize than SA Non-Users. We conclude from these findings that, in Guatemala, use of sustainable agriculture does not reduce expansion of agriculture and, therefore, reduce rates of deforestation. In fact, it appears to have just the opposite effect: It appears that sustainable agriculture as practiced in the Sierra de las Minas increases agricultural expansion and, thus, deforestation. In Mexico, on the other hand, we conclude that sustainable agriculture use does reduce expansion of agriculture, and, therefore, reduce rates of deforestation.

WHY STUDY SUSTAINABLE AGRICULTURE?
THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
TO HELP YOU ON YOUR WAY
TO LEARN MORE

During our analysis, we discovered that SA Users in both countries produced more maize than their SA Non-User counterparts. But this increase in production was a function of two different factors in our two sites. In Guatemala, it was a function of increased area planted because yield was equal between SA Users and SA Non-Users. In Mexico, however, SA Users planted less than SA-Non-Users, but demonstrated yields that were, on average, 1.5 times greater than SA Non-Users. In the case of Mexico, the difference in production is a function of increased yields achieved by SA Users. So, according to our user-level data, area planted is a function of the efficiency with which farmers manage their fields. Our plot-level data confirm this: in Guatemala, yield between SA Plots and Non-SA Plots was virtually the same but in Mexico the yield from SA Plots was significantly higher than that from Non-SA Plots.

In the Sierra de las Minas, farmers who used sustainable agriculture produced more maize than farmers who did not use sustainable agriculture by increasing area planted. In El Ocote, sustainable agriculture users increased production by intensifying yield.

But why then are SA Users in Mexico so much more efficient in their use of land than SA Users in Guatemala? Why was the Conventional Wisdom supported in Mexico, but not in Guatemala? What difference between these two sites would cause this divergence?

As we mentioned in our findings, area planted and yield are also a function of many other factors. But we controlled for many of the potentially determining factors in our sample selection within and between each site. In addition, there was virtually no difference between the SA User and SA Non-User samples within sites and between Guatemala and Mexico in the use of fertilizer and pesticide and access to credit. In fact, almost no farmers had access to these inputs because of their high costs.

When we looked at labor inputs, however, we found a different story. It appears that SA Users in Mexico invest proportionately more labor per hectare than SA Users in Guatemala. In fact, SA Users in Mexico use almost 10 days of labor per hectare more than their Guatemalan counterparts. One of the distinctions between the two study sites that probably accounts for some of this difference is that SA Users in Mexico use integrated pest management in addition to the two techniques also used in Guatemala — velvetbean and minimum tillage. But it is unlikely that this difference accounts for all of the dissimilarity in labor between the two sites.

So, SA Users in Mexico invest more labor in their maize fields, which leads them to achieve higher yields and require less land to feed their families than SA farmers in Guatemala. This relationship in Mexico is strongly supported by our multivariate analysis: Agricultural fields in Mexico with high yields tend to be smaller plots farmed by SA Users. So, SA Users in Mexico and Guatemala use sustainable agriculture to increase production of maize in different ways: In Mexico, SA Users use sustainable agriculture as part of a strategy of *intensive* agricultural production whereas in Guatemala, SA Users use sustainable agriculture as a strategy of *extensive* agriculture.

The differences in labor investment between Guatemala and Mexico explain much of the differences in yields and area planted between the two sites. SA Users in Guatemala ultimately invest less labor per hectare than Guatemalan SA Non-Users and Mexican SA Users and SA Non-Users. But we also saw that SA Users in Guatemala plant significantly more area to maize than SA Non-Users in Guatemala. It is clear that these SA Users in Guatemala are using their surplus labor — saved through the use of sustainable agriculture — to invest in planting more area to maize. These results support earlier work on the relationship between technological innovation and deforestation mentioned by some researchers in the literature (Kaimowitz and Angelsen 1998; Angelsen and Kaimowitz 1999).

Project managers in Guatemala conjecture that farmers with extra time on their hands are also investing it in cash crops. These project managers report that the main driver of deforestation on the north side of the Sierra de las Minas is indeed the planting of cash crops such as coffee and cardamom rather than the expansion of maize fields. In fact, we found that SA Users in Guatemala were significantly more likely to plant fruit trees and programmatically more likely to plant coffee (102 SA Users and 89 SA Non-Users plant coffee).

We thought that perhaps the desire or need to sell surplus maize might be driving farmers to increase production. Indeed, we found that SA Users were more likely to sell surplus maize than SA Non-Users. We also found that SA Users in Mexico sold about 1.5 times more maize than SA Non-Users and sold 3 times more maize than SA Users in Guatemala. It appears that SA Users in Guatemala and Mexico use sustainable agriculture as different economic strategies as well. SA Users in Guatemala seem to use sustainable agriculture to save labor that then can be used on greater agricultural expansion and investment in cash crops to generate income. SA Users in Mexico, however, use their labor to focus on maize production for household consumption and as a way to earn additional income.

What else accounts for the differences in labor input, yield level, and area planted that we found between SA Users and SA Non-Users in Guatemala and Mexico? Because the differences are so marked between our two study sites, it seems that there must be some other factor influencing farmer behavior. And, indeed, there is. It turns out that the biggest influence on increases in farming efficiency — reflected in yield level, area planted, and labor investment — is access to land for agriculture.

In the study site in Mexico, farmers in the *ejido* are given about 20 hectares of land; they do not have access to any other land. The incentive to be efficient is very high. In Guatemala, on the other hand, farmers on the north side of the Sierra de las Minas live in an area in which few community residents actually have title to their land (although they say they “own” it, ownership is more a function of claim than right). At this site, farmers actually have incentive to plant *more* area — the opposite situation as in El Ocote, Mexico. In Guatemala, government policy up to the 1980s actually encouraged farmers to deforest land to create larger agricultural plots. Farmers could claim land, including primary forest, that did not appear to be owned by anyone. According to the government, as long as farmers improved “the productive capacity” of the land — that is, used it for crops or livestock — they could maintain indefinite usufruct rights to it. Although this policy is no longer formally in effect, it still

WHY STUDY SUSTAINABLE AGRICULTURE?
THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
TO HELP YOU ON YOUR WAY
TO LEARN MORE

WHY STUDY SUSTAINABLE AGRICULTURE?
THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
TO HELP YOU ON YOUR WAY
TO LEARN MORE

influences farmers' perceptions and behavior related to the acquisition and use of land. In the absence of owning title to their land, Guatemalan farmers have less land security. They have every incentive, therefore, to plant more area, not less, and to make as little investment in the land as possible.

We conclude that, in tropical forest sites similar to our sample, unless access to land is limited, sustainable agriculture techniques such as those used at our two study sites will not successfully reduce the amount of area planted and, therefore, rates of deforestation. Conversely, in areas where farmers have a greater incentive to be as efficient as possible because of limited access to land, sustainable agriculture can reduce area requirements and, thus, rates of deforestation. Farmers must be secure in their rights to land and government policy must support — rather than discourage —– agricultural practices that are compatible with conservation. Adoption rates for sustainable agriculture techniques support these relationships: from 1994 to 1997, adoption in Mexico increased fivefold to 500 SA Users while in Guatemala it increased only 1.4-fold to 613 SA Users. In Mexico, farmers were more eager to try new agricultural techniques that held the promise of increasing yield. In addition, it appears that SA Users in Mexico are more committed than their counterparts in Guatemala because SA Users in Mexico tended to participate in the project longer.

Our analysis clearly and consistently demonstrates that the use of sustainable agriculture techniques is associated with reduced use of fire. As we mentioned, forest fires — many of which start as a result of poor fire management during the burning of agricultural plots — are perhaps the greatest threat to biodiversity conservation in both the Sierra de las Minas and El Ocote. In fact, 20,000 hectares and 19,000 hectares of primary forest in the Sierra de las Minas and El Ocote reserves, respectively, were lost to fire in 1998. At both sites, SA Users were overwhelmingly less likely to use fire to prepare their lands than SA Non-Users. After controlling for all other variables in our multivariate analysis, use of fire was the most important determinant of user status in Guatemala and Mexico. Similarly, our multivariate analysis also showed that older SA Non-Users were more likely to use fire to prepare their lands.

Fallow Area and Duration

We found no differences in fallow amount and duration between SA Users and SA Non-Users in either Guatemala or Mexico. Sustainable agriculture does not appear to have an impact on fallow land under the conditions found in our two study sites. We did find, however, that plots with reduced fallow times produced higher yields if farmers had previously used sustainable agriculture.

According to the results of our study, if there are no restrictions to access to land, sustainable agriculture will not work to decrease rates of deforestation.

Farmers who use sustainable agriculture are less likely to use fire. They help, therefore, to decrease the threat of forest fires and reduce the amount air pollution caused by smoke.

Contamination of the Environment

Use of chemical fertilizers and pesticides by farmers was limited in both Guatemala and Mexico. Pollution from these threats, therefore, was not a major concern in our study sites. Nevertheless, we infer that contamination of the environment from smoke was greatly reduced by use of sustainable agriculture in both Guatemala and Mexico.

Attitudes Concerning Conservation

As expected, SA Users in both Guatemala and Mexico tend to perceive more positive effects of sustainable agriculture than SA Non-Users. In Guatemala, SA Users were more likely than SA Non-Users to report that they do not use fire in order to protect the forest. According to the results of the focus groups in Guatemala and Mexico, SA Users generally perceive the importance of biodiversity conservation.

Perhaps most important is the conclusion by both Defensores de la Naturaleza and Línea Biósfera that their sustainable agriculture programs are crucial for building trust and confidence in the communities in which they work. This result is supported by field experience and the results of the focus group analysis. Both organizations believe that their sustainable agriculture programs have served as an effective *bridge approach* to reach conservation goals. In both cases, farmers originally perceived little connection between their agricultural practices and conservation and the importance of conservation alone. By working with farmers on their self-perceived priorities and building relationships with community members, both organizations were able to demonstrate to farmers the links between agriculture and biodiversity conservation. This link was supported by outreach and education programs to clarify and bolster perceptions of this relationship. At the same time, establishing these relationships enabled each organization to work on other conservation issues that were not originally perceived by community residents as top priority.

Participation in Community Organizations

In Guatemala, SA Users were more likely to belong to a community organization than SA Non-Users. In Mexico, there was no difference because everyone belonged to the same *ejido* and regional organizations.

Organizations and the organization of communities played different roles in Guatemala and Mexico. In Guatemala, communities on the north side of the Sierra de las Minas are dispersed, with little communication and interaction between them. Similarly, within communities, organization is fairly decentralized — there are few formal community structures to pull residents together. In addition, these communities are subject to a high level of conflict, perhaps due in part to their lack of organization.

WHY STUDY SUSTAINABLE AGRICULTURE?
THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
TO HELP YOU ON YOUR WAY
TO LEARN MORE

At the beginning of the program in the Sierra de las Minas, Defensores de la Naturaleza found it very difficult to gain access to individual farmers because of the lack of formal community mechanisms. In this case, the sustainable agriculture program served as a catalyst for community mobilization. It increased formal mechanisms for communication within communities and decreased the amount of conflict between communities and individuals. The increased level of organization provided Defensores de la Naturaleza with the means to more efficiently work with communities on important conservation issues.

In Mexico, the level of community organization was quite high and influenced adoption of sustainable agriculture in a different way. While Línea Biósfera reports that it was difficult initially to gain access to communities because *ejido* organizations acted as a buffer to outsiders, once accepted and trusted, official endorsement by the *ejido* gave the organization virtually unlimited access to all community members. Adoption rates of sustainable agriculture were very high in Mexico compared with Guatemala.

Principles for Using Sustainable Agriculture as a Conservation Tool

Our second goal was to determine key principles that can help project managers use sustainable agriculture projects more effectively to reach conservation goals. The principles in this section are the result of our analysis of the data and discussions we had concerning conditions at each site. Although they are not meant to be a recipe that guarantees success, we offer these principles as guidelines to help you implement effective sustainable agriculture programs. These principles are derived from two sites that are very similar in many ways. We believe, therefore, that these principles can be generalized to other similar sites. The more dissimilar the site, the more unlikely it is that the principle will hold. We divide the principles as they relate to two phases of project management: design and implementation.

Design

Be clear about the threats to conservation that sustainable agriculture is designed to address. Sustainable agriculture is effective as a conservation tool only if it is appropriately directed at addressing a particular threat. We have seen that sustainable agriculture, as defined in this study, does not necessarily reduce deforestation resulting from expansion of subsistence crops. In Guatemala, we saw that, although sustainable agriculture activities focused on subsistence crops, the main threat was expansion of cash crops. In our sample, sustainable agriculture proved to be an exceptional tool for reducing forest fires — although this was not an explicitly intended objective of the sustainable agriculture program at its inception. In our sample, focusing sustainable agriculture on the reduction of pollution caused by use of chemical pesticide and fertilizer turned out to be a worthless

Expansion of cash crops – such as coffee – is a major threat to biodiversity in the Sierra de las Minas. In addition, the collection of firewood to fuel coffee processing and drying systems contributes to deforestation.

endeavor. Had proper assessments occurred before the project began, it is likely the program would not have been designed to influence environmental contamination. Similarly, the assumption that sustainable agriculture would increase recovery of forested lands proved unfounded.

Be clear about the mechanism through which sustainable agriculture impacts conservation. The mechanism through which sustainable agriculture influences conservation outcome is relatively complex. There is a long series of assumed intermediate steps to get from intervention to outcome: Adoption of sustainable agriculture leads to increased yield, which leads to the need for less land, which leads to lower area planted and reduced labor needs, which leads to a reduced likelihood of cutting down forested areas to plant new fields. To make a causal link between sustainable agriculture and conservation, project managers must understand each intermediate step. We saw, for example, that adoption of sustainable agriculture does not necessarily mean increased yield or decreased area planted.

Where there is little incentive to be efficient, sustainable agriculture will not reduce the amount of area planted to subsistence and cash crops.

Do not use sustainable agriculture to reduce rates of deforestation where there is relatively open access to land. Access to land may be one of the biggest predictors of sustainable agriculture's utility as a conservation tool. In our study, where land was relatively available, the sustainable agriculture techniques adopted by farmers did not work to reduce area planted. Where access to land was limited, farmers had greater incentive to be efficient in their use of land, and sustainable agriculture was associated with reductions in area planted.

Use sustainable agriculture where farmers have greater land security. Land security — either in the form of tenure or usufruct rights — provides the opportunity for farmers to make investments for future production in their agricultural plots and is, therefore, another important factor related to the efficacy of sustainable agriculture as a conservation tool. In areas where farmers have little land security and perceive that the land they work could be taken away from them at any time, they have little incentive to make investments in their plots that might increase yield and reduce area needs. In Mexico, where there is relatively high land security, farmers were willing to make greater investments in their agricultural plots.

Consider the use of sustainable agriculture in areas where local, state, and national government policy is supportive of greater agricultural efficiency. Government policy can influence farmers to plant either more or less area. In countries where the government's policy is to exploit natural resources and promote development without consideration for conservation, it is likely that sustainable agriculture will have minimal impact on conservation. In countries where government policy encourages greater efficiency in land use and management

WHY STUDY SUSTAINABLE AGRICULTURE?
THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
TO HELP YOU ON YOUR WAY
TO LEARN MORE

and where conservation is valued, chances are sustainable agriculture will be a more effective conservation tool. In Guatemala, government policy is a major driver in the expansion of agricultural fields. In Mexico, the *ejido* system actually encourages farmers to be more efficient in their use of land.

Do not assume that labor saved using sustainable agriculture techniques will be used on activities that are supportive of conservation. Over time and in some situations, the sustainable agriculture techniques adopted by farmers included in this study may reduce the amount of labor required to work a particular field, but farmers may put this saved labor to use in destructive ways. In Guatemala, for example, we saw that farmers who use sustainable agriculture techniques actually plant more total area and invest their time in other activities — such as extensive cash crop expansion without intensification — that can work against conservation.

Implementation

Begin your sustainable agriculture project by testing only a few techniques. Inundating farmers with too many tools at the beginning of a project may discourage them from participating in sustainable agriculture activities. Farmers are more likely to use a few, very effective techniques rather than many moderately useful ones. This proved to be the case in both Guatemala and Mexico. At the beginning of the program, both organizations promoted up to 15 different techniques at the insistence of the organization that trained and supervised them in sustainable agriculture. Farmers, however, only wanted to use two or three techniques. In addition, rather than assuming that each technique has high rates of return, it is important to fully test each technique on a small scale before promoting it widely. This supports earlier findings on what makes for successful sustainable agriculture extension (Bunch 1982).

A farmer in El Ocote holds up velvetbean pods – harvested for use in the next agricultural season.

Select specific sustainable agriculture techniques carefully on the basis of returns to labor. Farmers look for ways to increase productivity while reducing labor demands. They will not adopt practices that require high amounts of labor, especially if the return on labor is not favorable. In our study, farmers were more likely to use those techniques that required extremely low labor investments or that were sure to save them time over the long run. Planting velvetbean, perhaps the easiest technique to use, was the most popular in both sites. Furthermore, investing less labor in smaller areas adds to the efficiency sought by farmers. This result was clear in our regression analysis on yield.

Be prepared not to see immediate results. The effects of sustainable agriculture take time to become apparent. Investments are often incremental over multiple years, so results might be slow in coming or difficult to discern. Reduction of area planted will occur only after improvements in yields are attained, which requires significant amounts of time. In our study sites, project managers reported that the effects of sustainable agriculture were not observable for three to five years. As a project develops, it is important to keep this in mind to address potential concerns farmers may have during the initial phases. With agricultural production and yield improvements slow in coming, it will undoubtedly be longer before conservation benefits are apparent.

Establish a flexible system of sustainable agriculture extension that will adapt to local conditions. Sustainable agriculture projects must be based on the needs of local farmers to have any chance of conservation success. In addition, the way an organization works with farmers is extremely important. In some cases, as in Mexico, it may be best to work through local, volunteer promoters. In other cases, as in Guatemala, paid employees may need to be contracted to carry out project activities. When opportunities arise to promote new avenues of extension, such as cross-community exchanges, the implementing organization must be ready to make the most of them.

Integrate sustainable agriculture activities with other interventions that create the conditions for sustainable agriculture to contribute to conservation success. Sustainable agriculture, like most other interventions, will not achieve conservation on its own. Other project activities, such as environmental education or community mobilization, create the conditions necessary for sustainable agriculture to take hold, flourish, and positively affect conservation outcomes. In both Guatemala and Mexico, supplemental project activities led farmers to more readily support sustainable agriculture activities.

Use sustainable agriculture as a bridge approach to conservation — to win the trust and confidence of communities. The bridge approach provides the opportunity for an organization to gain the confidence of a community while promoting the natural links that occur between a particular activity and conservation. In effect, it builds a bridge between an intervention and conservation. In the case of sustainable agriculture, reduction in erosion through the use of cover crops, for example, may also contribute to improved drinking water quality in surrounding rivers and streams. The bridge approach may also create the conditions for future conservation actions. In Guatemala, sustainable agriculture participants formed the nucleus of natural resources management and environmental committees that were established several years into the program.

Use sustainable agriculture as a mechanism to organize communities and help reduce conflict. Sustainable agriculture can serve as a mechanism to organize communities that are highly decentralized or unorganized. In this way, sustainable agriculture contributes to the social and political conditions that are required to interact with and mobilize communities to take conservation action. It can also serve as a neutral opportunity for farmers who do not normally interact to work together to solve problems of mutual concern. In Guatemala, in particular, sustainable agriculture served this purpose.

WHY STUDY SUSTAINABLE AGRICULTURE?
THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
TO HELP YOU ON YOUR WAY
TO LEARN MORE

WHY STUDY SUSTAINABLE AGRICULTURE?
THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
TO HELP YOU ON YOUR WAY
TO LEARN MORE

When implementing sustainable agriculture as a conservation tool, stay focused on conservation! Sustainable agriculture interventions are necessarily highly social endeavors that have many intermediate production, economic, and social outcomes. Because so many of these intermediate social outcomes are required, there is a higher risk that project managers may lose sight of the ultimate conservation goals determined at the beginning of the project. To prevent project managers from being satisfied merely with increased yields, for example, they should constantly have conservation goals at the forefront of their minds.

Process Lessons — Learning to Learn Better

The third goal of this research – primarily BSP's in its role as organizer and facilitator of this project – was to learn how to determine the conditions under which a specific conservation tool works across multiple projects and to determine how to build capacity in local project partners to facilitate their own applied research and learning.

This project proved to be extremely rewarding to those of us who worked on it together. Working as equal partners, BSP, Línea Biósfera, and Defensores de la Naturaleza, with the support of CIFOR, constantly shared ideas, creating a strong, mutual learning environment. During our many meetings to discuss results of the study, honest and constructive exchanges allowed us to determine what was and wasn't working, and why, in the Sierra de las Minas and El Ocote sustainable agriculture programs. We were able to openly discuss successes and failures, and this level of objectivity allowed us to gain a better understanding of the conditions under which sustainable agriculture works as a conservation tool.

This study provided Defensores de la Naturaleza and Línea Biósfera an opportunity to ask specific operational questions about the efficacy of one of their cornerstone programmatic interventions. It also allowed them to figure out the best way of addressing those questions in order to learn how to improve project success. It improved their capacity in applied research design and implementation and in data analysis and communications. It also sparked interest in future research to analyze other pressing issues at each site. This interest was demonstrated by Línea Biósfera's declaration that it would use what it learned from this study to research the effects on conservation of cattle and the opening of new pastures in El Ocote — a threat identified as being perhaps greater than agricultural encroachment. In the Sierra de las Minas, Defensores de la Naturaleza determined it would further investigate the role that expansion of cash crops plays in deforestation in the Reserve.

Sustainable agriculture projects that are designed to have conservation benefits must remain clearly focused on conservation goals.

*For candid self-assessments of the programs managed by Línea Biósfera and Defensores de la Naturaleza, see their respective case studies at **www.BSPonline.org**.*

Based on our final meeting and discussions related to the process of conducting this research, we can recommend the following process principles for conducting similar inquiries.

Focus research on a specific tool. By focusing on a specific tool, we can learn about the conditions under which it is most effective. We can also come up with concrete, operational recommendations for other practitioners around the world to use the tool more effectively in the future.

Design research around the interventions your partners are most interested in learning about. Experience in implementing a specific conservation tool is extremely important. This experience allows project partners to ask the right questions, determine the best way to answer them, interpret the results of the analysis, and put the results to immediate use. Working across multiple sites provides the opportunity to look across many different conditions to determine which are most associated with successful implementation of the tool.

At both of the study sites, partner organizations had at least five years of experience implementing and testing sustainable agriculture – such as the use of velvetbean – as a conservation tool.

Work with project partners that demonstrate a high level of individual and institutional curiosity. Field-based practitioners and organizations that spend most of their time implementing and managing projects often have little time to sit back and analyze what they are doing. But the desire to improve, willingness to question the efficacy of interventions, and drive to learn are all-important ingredients in a successful joint-learning effort.

Involve project partners in all phases of the research. Include all project partners from the beginning of the research project, especially during the conceptualization and design phases. Their questions should drive the research. Constant involvement in the research and responsibility for its successful completion will help keep partners engaged throughout the process. By being involved in all phases of the research, project partners will more likely see the benefit and utility of the results and put them to good use.

Identify potential gaps in capacity and plan to fill them early on. In any joint-learning endeavor, there will be gaps in capacity to carry the work through to the end. Be prepared to fill these gaps with additional training or technical assistance. By building capacity throughout the research cycle, partner organizations will be able to conduct the research on their own in the future. If possible, work

WHY STUDY SUSTAINABLE AGRICULTURE?
THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
TO HELP YOU ON YOUR WAY
TO LEARN MORE

with partners that have similar research-related skill levels to ensure that partners move through the learning process in unison. We discovered that the aspect of research most likely to be deficient in partner organizations is data analysis. If you intend to contract someone from outside to assist in data handling and analysis, hire this person at the beginning of the project so he or she can participate in the design, planning, and implementation of the research.

Select sites to be included in the study in a systematic and precise fashion to obtain specific principles. Developing the sampling framework for the study is key. To obtain relatively precise principles, you must limit your sample so you can control for potentially confounding factors that may affect the outcome of interest. To obtain principles that are also generalizable, however, your sample must be large enough to be able to look across a range of important conditions. By including multiple sites in your sample, you can vary the circumstances you are studying in order to determine the conditions under which the conservation tool of interest is most effective.

Standardize data-collection instruments and methods and analytical approaches in order to learn across sites. To learn across sites effectively, data must be collected and analyzed in a standardized fashion. To standardize approaches and instruments it is crucial to have as much time to interact as possible. To increase the power of the analysis you wish to conduct, it is essential to collect and analyze the same variables using the same analytical and statistical tools.

Develop an agreed-upon learning framework that maps out the questions you will ask, the way you will research and analyze the questions, and the results you hope to communicate. Developing a learning framework at the beginning serves as a guide throughout the life of the research project. When in doubt, project partners can always refer back to the learning framework to orient their work. This provides partners the opportunity to avoid miscommunication and misunderstandings about the goals or approach of the research. The framework must, however, be flexible. You must be prepared to modify it based on the reality of the situation as you collect and analyze data.

Develop and stick to a mutually agreed-upon workplan and timeline. Coordinating this type of research is extremely challenging. Multiple partners, sites, and instruments all add to the need to develop and adhere to a common workplan. As research moves through various phases — design, data collection, analysis, communication — it is important to keep the process going at a steady rate. We found that periodic field visits and meetings helped keep us on track throughout the learning process. We also found, however, that competing job responsibilities meant that project partners were not always available to work on this project, which caused costly delays. Managing and sticking to the workplan is especially critical for the organization that takes on the responsibility of facilitating and coordinating the learning project.

Try to keep it simple. Plan to ask what you believe to be relatively easy operational questions. We guarantee that, as you move through the learning process with multiple partners and sites, the challenge to effectively address your questions will become increasingly difficult and complex!

Conclusions and Next Steps

This project has clearly demonstrated that sustainable agriculture does not always have its intended impact. But no tool or strategy is ever completely and singularly effective in meeting conservation goals. The purpose of this study was not to prove that sustainable agriculture works or does not work. Rather, we undertook this research to determine the conditions under which sustainable agriculture serves as an effective conservation tool. The results included in this publication shed some light on these conditions.

In recent years, some conservation organizations have begun to use agroforestry as a way to increase crop yields, promote cash crops, and conserve biodiversity.

This research project also was designed to develop concrete guidance for practitioners around the world who are working with sustainable agriculture. We have addressed this goal by distilling relevant principles from our analysis. We hope they prove useful.

Finally, we had hoped to learn the best way to go about asking and answering important operational questions in conservation. During the research process, we learned many things about how to work effectively across a portfolio of projects to learn most effectively. Our learning on this theme is summarized in the process principles we present in the preceding section.

This research has generated a number of questions that conservation practitioners must address to advance our collective understanding of how to best integrate agriculture interventions into conservation projects. These questions include the following:

- What role does sustainable agriculture play in reducing deforestation and other threats when cash crops such as coffee and cardamom are involved?
- What role does household ownership of cattle play in deforestation in tropical forest areas, and how can sustainable agriculture be used as a tool to address this issue?
- Since one of the major contributions of sustainable agriculture to conservation is fire prevention, are there approaches to this goal that will engage farmers more quickly than aiming to reduce rates of deforestation through increased yields? Can we promote techniques that require less labor and that allow farmers to see more immediate results so that the effects on fire prevention are even more extensive and immediate?
- To what extent does sustainable agriculture affect other conservation-related issues such as emigration from communities to fragile forested lands? Do the investments that sustainable agriculture requires serve to encourage farmers to remain on their land rather than leaving their community in search of more productive areas?

WHY STUDY SUSTAINABLE AGRICULTURE? THE CONVENTIONAL WISDOM WHAT DID WE DO? WHAT DID WE FIND? FINDINGS IN PERSPECTIVE TO HELP YOU ON YOUR WAY TO LEARN MORE

WHY STUDY SUSTAINABLE AGRICULTURE?
THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
TO HELP YOU ON YOUR WAY
TO LEARN MORE

- What are the conditions under which sustainable agriculture will work as a conservation tool in areas of the world that are dissimilar to our sample?
- To what extent would labor-intensive sustainable agriculture techniques, unlike those used by the farmers in our sample, contribute to reducing rates of deforestation? What labor-intensive techniques are most useful, appropriate, and equitable in socioeconomic and conservation terms?
- What is the role of diversified, agroforestry programs that can be sustainably managed to produce cash crops and increase family livelihoods while reducing or substituting for subsistence grain production?

As we conducted this learning inquiry, the study generated even more questions. To continue to learn how to learn better, we provide the following questions as potential guides:

- What is the optimum number of projects and sites that make up a learning portfolio?
- What are the basic skills required of project partners for their participation to contribute effectively to the learning process?
- What is the best way to deal with gaps in knowledge and capacity — for example, in data handling and analysis — to complete the learning process?
- What is the most effective role for a facilitating organization to encourage and support local partners to conduct sound and precise learning?
- What is the role of outside technical support and assistance from third-party individuals and institutions that are not directly involved in the day-to-day implementation of the learning project?
- What is the best way to communicate the results of individual project partners and the work across the entire learning portfolio?

This study has provided a wealth of learning on both the conditions under which sustainable agriculture succeeds as a conservation tool and the process by which partner organizations can develop precise, operational, and useful management principles across sites. We encourage others to continue to question, investigate, and improve our understanding of the use of sustainable agriculture and other conservation tools around the world and to share what they learn with the rest of the conservation community.

Clouds move into the forest surrounding the village of Albores in the Sierra de las Minas Biosphere Reserve, Guatemala.

TO HELP YOU ON YOUR WAY

If you or the organization with which you work is considering using sustainable agriculture as a conservation tool, you may want to ask yourself the following questions.

First, ask about your organization's capacity to do sustainable agriculture

- ❑ To what extent are we willing to get involved in an agriculture project when we are a conservation organization?
- ❑ Do we have the necessary staff, capacity, and funding to design, manage, and monitor a sustainable agriculture project?
- ❑ Do we adequately understand the pros and cons of promoting sustainable agriculture at the project site?
- ❑ Can we team up with other local organizations to promote sustainable agriculture at the project site?

Then, ask about the underlying assumptions and design of your project

- ❑ What are our conservation goals and objectives? How can we measure them? How will we be able to tell if our sustainable agriculture project affects our goals and objectives?
- ❑ What are the major threats to conservation at the site? To the best of our knowledge, is sustainable agriculture the best possible tool to address these threats? What is the mechanism through which we think sustainable agriculture will affect conservation success?
- ❑ How will we determine which specific sustainable agricultural techniques to promote?
- ❑ What other project activities would best complement and support sustainable agriculture?
- ❑ What is our long-range strategy to reduce threats? Once sustainable agriculture is established, what follow-up activities would be best suited to long-term conservation?
- ❑ What is the best way to assess the needs of the communities in which we plan to work and what are the best mechanisms for interacting with community members?

Then, ask about the environmental conditions at your site

- ❑ What environmental conditions at the site in which we work will affect rates of adoption of sustainable agriculture techniques? What will affect the extent to which sustainable agriculture is effective?
- ❑ Have other sustainable agriculture or related programs been attempted at the site before? How successful were they? How did environmental factors influence their success?
- ❑ Is the site at the agricultural frontier? Where is agriculture expansion most likely to occur?

WHY STUDY SUSTAINABLE AGRICULTURE?
THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
TO HELP YOU ON YOUR WAY
TO LEARN MORE

Then, ask about the social conditions at your site

- ❑ To what extent are community members organized? How unified or dispersed are the communities? What existing communications channels can be used?
- ❑ Is there preexisting community infrastructure that can be used to promote sustainable agriculture activities?
- ❑ To what extent are the communities open to involvement of outside organizations and individuals?
- ❑ Do community members legally own their land or have formal usufruct rights? How secure are they in their access to the land they farm? To what extent do government policies encourage or discourage the efficient use of land resources? Is government policy supportive or unsupportive of biodiversity conservation?
- ❑ What other projects have been promoted in the area in the past? To what extent did residents participate?

Finally, ask about the costs and benefits of sustainable agriculture

- ❑ How much will it cost to implement the program over the next five years? Over the next 10 years? How many farmers do we intend to reach?
- ❑ Are there other projects that may have higher returns than sustainable agriculture? What are the short-, medium-, and long-term benefits of sustainable agriculture? How do these compare with other potential interventions?
- ❑ What are the opportunity costs of implementing this project? Are there other activities we will not be able to undertake because of our focus on sustainable agriculture?

WHY STUDY SUSTAINABLE AGRICULTURE?
THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
TO HELP YOU ON YOUR WAY
TO LEARN MORE

TO LEARN MORE

*For inquiries related to the results of this study, please contact Richard Margoluis at **Richard@FOSonline.org** or **www.FOSonline.org**.*

We encourage others to continue learning more about the conditions under which sustainable agriculture programs can be used as an effective strategy for achieving conservation success. These resources can help support that learning.

Results From the Two Study Sites

The final reports from Guatemala and Mexico are available in Spanish only in the publications section of the BSP Web site at **www.BSPonline.org**.

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Summary Literature Review

A brief literature review for this study is available online in the **publications** section of the BSP Web site at **www.BSPonline.org**.

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THE CONVENTIONAL WISDOM
WHAT DID WE DO?
WHAT DID WE FIND?
FINDINGS IN PERSPECTIVE
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The Biodiversity Support Program (BSP) is a consortium of World Wildlife Fund, The Nature Conservancy, and World Resources Institute, funded by the United States Agency for International Development (USAID). BSP's mission is to promote conservation of the world's biological diversity. We believe that a healthy and secure living resource base is essential to meet the needs and aspirations of present and future generations. BSP began in 1988 and will close down in December 2001.

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Foundations of Success (FOS) is a legacy of BSP, born out of its Analysis and Adaptive Management (AAM) Program and the Biodiversity Conservation Network (BCN). FOS is a non-profit organization dedicated to improving the practice of conservation by working with practitioners to develop and communicate tested knowledge about what works, what doesn't, and why. FOS works with conservation practitioners around the world to clearly define conservation success, develop guiding principles, and build the capacity to do adaptive management. FOS operates as a network of learning portfolios — clusters of projects focused on testing specific conservation tools or strategies. FOS partners share and document lessons learned and contribute to building capacity throughout the FOS network. For more information on Foundations of Success, go to **www.FOSonline.org** or send an e-mail to **info@FOSonline.org**.

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Linea Biósfera is an NGO dedicated to the conservation of biodiversity and the development of indigenous communities in the State of Chiapas, Mexico. **Defensores de la Naturaleza** is a Guatemalan NGO whose mission is to work efficiently for the care, recuperation, understanding, and sustainable use of nature with the active participation of society for the benefit of all citizens. It works in the Sierra de las Minas Biosphere Reserve, the Bocas del Polochic Wildlife Refuge, the Seirra del Lacandón National Park, and the United Nations National Park.

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