SOIL MANAGEMENT COLLABORATIVE RESEARCH SUPPORT PROGRAM

PROJECT YEAR 5
ANNUAL PROGRESS REPORT

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MONTANA STATE UNIVERSITY
NORTH CAROLINA STATE UNIVERSITY
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Soil Management C♦R♦S♦P

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Five years of research activities supported by the U.S. Agency for International Development through the Soil Management CRSP ended contractually on February 10, 2002. There were five soil constraints identified by an independent panel of experts to be addressed by the newly re-structured Soil Management CRSP in 1996. The five constraints were as follows:

1. Nitrogen management, especially technologies that improve nitrogen use efficiency;
2. Phosphorus management, especially decision aids to promote enlightened fertilization policies, and technologies that increase efficiency of use of phosphorus amendments;
3. Acidity management, especially decision aids that help apply current knowledge to soil management;
4. Management of water deficiencies, especially through better understanding of the interactions between nutrient management and water use efficiency; and
5. Erosion and land degradation.

Over the past five years, the SM CRSP has developed products and practices that can be adopted by farmers and policy makers to improve performance of the agricultural sectors by mitigating the collective impact of the five soil constraints listed above. These products and practices were accomplished through the SM CRSP's alliances with host country scientists in Mali, Senegal, The Gambia, Cape Verde, Malawi, Uganda, Ethiopia, and Kenya in Africa, in Ecuador, Peru, Honduras, Nicaragua, Costa Rica, Haiti, and Brazil in Latin America, and in Bangladesh, Nepal, Thailand, and the Philippines in Asia and in working with scientists from participating U.S. universities: Auburn University, Cornell University, Montana State University, North Carolina State University, Texas A&M University, and the Universities of Florida and Hawaii. The products consist of the following:

- A decision aid for diagnosing and prescribing remedies for soil fertility problems;
- An integrated suite of biophysical and economic models that enable policy makers to evaluate tradeoffs between productivity and sustainability;
- Practices that include technologies that can singly increase rice and wheat yields by 15 to 40 percent and often produce additive benefits when used in combination;
- Soil conservation technologies that can anchor the topsoil using biophysical means, including terraces stabilized by Vetiver grass or fruit and fodder trees, and rock retention walls;
- Development of a new liquid inoculant formulation (G5) that improved the performance of *B. japonicum* at 65 percent of the materials cost of earlier generations and less than half the cost of conventional products.

Over the five years, field support activities were provided to the AID Missions in Bangladesh and in Ethiopia through buy-ins and to the Office of Disaster Relief (ODR). The CRSP stands ready to support Missions to achieve their strategic objectives (SO). It can do so by matching its strengths and capabilities with Mission priorities and needs.

PROGRAM AREA PROGRESS REPORTS (PR)

Global Plan for the Restructured CRSP

A customer-focused, results-oriented program is expected to emerge from the restructured Soil Management CRSP. An even balance of researchers from the biophysical and socio-economic sciences enables this CRSP to form interdisciplinary teams capable of producing knowledge products that will enable customers to improve soil management practices and formulate sound economic and environmental policies. A major aim of this CRSP is to empower customers by enabling them to apply knowledge captured in decision aids to make better economic and environmentally sustainable choices.

The goal of the restructured CRSP is to attain food security for all without compromising the sustainability of the natural resource base. Its purpose is to improve agroecosystem performance by resolving the integrated nutrient and soil management constraints of nitrogen deficiency, phosphorus deficiency, acidity, water deficiency and soil erosion and degradation. Its objectives are to enable CRSP customers to implement natural resource management practices and policies that will:

1. Increase productivity of agroecosystems by raising yields and incomes of host countries and U.S. families.
2. Increase stability of agroecosystems by reducing fluctuations in productivity by factoring uncontrollable production variables such as weather and climate into prescriptions for managing sustainable agroproduction systems.
3. Increase resiliency of agroecosystems by prescribing soil management practices and policies that enable the system to recover quickly from externally imposed stresses and perturbations.
4. Increase equitability by enabling women and men to share fairly in benefits derived from the agroecosystems and by enabling women to participate in the decision making process.

Productivity refers to yield or income per unit area and time. High productivity is essential for food security, but too much emphasis on productivity at the expense of other systems properties has created problems for agriculture. The second agroecosystems property, stability, has been neglected and is the cause for much of the food security crises. Stability refers to the year-to-year fluctuations in yield or profit caused by random factors or events such as weather and climate over which humans have little or no control. The feast to famine fluctuations add risk and uncertainty to decision making and prevent farmers, policy makers and bankers from making reliable decisions. The restructured Soil Management CRSP, unlike the old, has the capability to develop user-friendly products that will enable CRSP customers to assess risk associated with adopting and implementing promising but untried soil management innovations. Resiliency, the third property of sustainable agroecosystems refers to the capacity of soils to recover quickly from stresses and perturbations imposed on them. The previous Soil Management CRSP did excellent research in this area including work on soil erosion control, organic matter residue management, utilization of biological nitrogen fixation technologies and agroforestry. Soil resiliency is preserved by wise use and conservation of soil resources. The fourth and last agroecosystems property is equitability. This property refers to the equal sharing of benefits derived from agroecosystems. One of the most serious inequities occurs along age and gender lines. This CRSP will focus on intergenerational inequities caused by natural resource depletion and on empowering women to make key decisions related to improving agroecosystems performance.

Customer participation in priority setting and product development will be key elements of this CRSP. Customer feedback will aid in knowledge synthesis and the form CRSP products will take. This process will be dynamic and self-correcting so that customer demand for CRSP products will be assured.

The restructured CRSP is based on the premise that the goal of food security can be achieved by focusing its energies on increasing productivity, stability, resiliency and equitability of agroecosystems. This CRSP will be results-oriented. It will allocate resources on the bases of performance and delivery of promised results. It will be accountable to customers who will be the final judges of CRSP performance.

Summary of Goal, Purpose and Objectives

Goal
Attain food security for all without compromising the sustainability of the natural resource base.

Purpose

Improve agroecosystem performance through rectification of soil nitrogen, soil phosphorus, soil acidity, soil water and soil degradation constraints using an integrated nutrient management approach.

Objectives

1. Increase productivity of agroecosystems by raising yields and incomes of host countries and U.S. families.
2. Increase stability of agroecosystems by reducing fluctuations in productivity by factoring uncontrollable production variables such as weather and climate into prescriptions for managing agroproduction systems.
3. Increase resiliency of agroecosystems by prescribing soil management practices and policies that enable the system to recover quickly from externally imposed stresses and perturbations.
4. Increase equitability by enabling women and men to share fairly in benefits derived from the agroecosystems and by enabling women to participate in the decision making process.

Table 1. List of participating U.S universities with project title, principal investigators, participating institutions and host countries.

Project Title	Principal Investigator	Participating Institution	Host Countries
Tradeoffs in Sustainable Agriculture and the Environment in the Andes: A Decision Support System for Policy Makers	John Antle	Montana State University	Peru, Ecuador
Decision Aids for Integrated Nutrient Management	T. Jot Smyth	North Carolina State University	Costa Rica, Philippines, Thailand, Mali
Soil Management Practices for Sustainable Production on Densely Populated Tropical Steeplands	Thomas Thurow/ Anthony Juo	Texas A&M University	Haiti, Honduras, Nicaragua
Improved Agricultural Productivity through Biological Nitrogen Fixation Technologies and Legume Management	Paul Singleton	University of Hawaii-NifTAL	Thailand, Kenya, Nicaragua, Philippines, Bangladesh
Sustainability of Post-Green Revolution Agriculture: The Rice Wheat Cropping System of South Asia	John Duxbury	Cornell University	Bangladesh, Nepal, India, Pakistan
Gender and Soil Fertility	Christina Gladwin	University of Florida	Malawi, Zambia, Uganda

PR1: Tradeoffs in Sustainable Agriculture and the Environment in the Andes: A Decision Support System for Policy Makers

The principal goal of this project is to develop a decision support system for assessing *tradeoffs* between agricultural production and the environmental impacts of agriculture for different economic, agricultural and environmental policies, and agricultural research. The decision support system was developed initially for, and tested in, the potato/pasture production system of the Andean region and was then generalized for application to other production systems in the Andes and elsewhere. This decision support system has the following key features:

- Provides decision makers with information on tradeoffs between key sustainability indicators under alternative policy and technology scenarios
- Links disciplinary data, models in a GIS framework
- Utilizes minimum data necessary for decision support and policy analysis
- Is transportable, i.e., can be adapted to other applications
- Results extrapolated or generalized in a GIS framework.

The specific objectives of the project were to:

1. Link crop and livestock models, soil processes (erosion and fertility), and other environmental processes (pesticide leaching, soil C dynamics) with the tradeoffs model of Crissman, Antle and Capalbo, 1998.
2. Modify the economic components of the tradeoffs model to facilitate linkages with other disciplinary models such as DSSAT crop growth models and bio-physical process models.
3. Develop a policy decision support system (Tradeoff Analysis and the TOA Model) that can be used to quantify impacts of existing and proposed agricultural practices and policies on the sustainability of selected Andean agro-ecosystems.
4. Utilize the TOA Model to screen proposed agricultural technologies such as integrated pest management and various types of soil husbandry for their potential impact on the sustainability of selected Andean agro-ecosystems.
5. Assess the usefulness of the methods developed for the TOA Model to extrapolate results to a regional basis.
6. Based on the TOA Model, develop recommendations for research priorities for national and international research systems in the Andean region.
7. Provide training to individuals and groups in interdisciplinary research tools, including the TOA Model and the use and interpretation of integrated economic and bio-physical modeling.
8. Communicate the empirical results of the Ecuadorian and Peruvian studies to the appropriate sets of users in the Andean region.

The Carchi (Ecuador) and La Encanada (Peru) Study Sites

Please see the 1998 Annual Report at www.tradeoffs.montana.edu for background information on the study sites, including maps and descriptions of soils.

Accomplishments

A monograph on the TOA approach and software was published and distributed widely, and made available at the project web site. The monograph provides a general description of the basic concepts of the Tradeoff Analysis Model (TOA) and describes the usages of the software. The monograph is based on the Carchi study sites and uses examples from that research. Approximately 300 copies of the monograph have been distributed to people interested in the approach and who have requested a copy.

Documentation and instructional materials for the TOC software were developed. Because of the expanding user group, a separate web site, www.tradeoffs.montana.edu, was developed that deals with updates, data and training material. The web site will play an important role in the second phase of the SM CRSP when an increasing number of applications are available. The web site has been redesigned, making it more user-friendly and incorporating material for Phase 2.

Various reports, publications and presentations based on Phase 1 research of this SMCRSP project were prepared. (See *Publications* later in this document for reports and publications completed during this reporting period.)

The collaboration with PRONAMACHCS in Peru provided the TOA team with the first opportunity to test the TOA process from beginning to end. The collaboration began with a stakeholder meeting in Fall 2000, where indicators and scenarios were discussed. Training of collaborators was carried out in Winter-Spring 2001, and a week-long workshop was held in June 2001 in Cajamarca, at which time collaborators utilized the TOA software to construct and run scenarios of interest to PRONAMACHCS. At the end of the week, the TOA team and collaborators made a presentation of results to PRONAMACHCS in Cajamarca and in Lima. These PowerPoint presentations are available on the web site. A written report was completed in Fall 2001 and presented to PRONAMACHCS.

We learned several important lessons from this experience:

1. The process of discussing tradeoffs and scenarios of outcomes with stakeholders is a valuable experience for both the stakeholders and the research team, because stakeholders easily grasp the concept of tradeoffs and scenarios if presented in the context of situations relevant to them.
2. Some national institutions, particularly those lacking a research orientation, may not have personnel with the training needed to use the TOA tool without a high level of support from our team.
3. In Phase 2, we need to explore and develop training materials and flexible approaches that are compatible with the potentially diverse background and time constraints of different users.

PR2: Decision Aids for Integrated Nutrient Management

A fertilizer divide separates the developed from the developing world. In the developed world, fertilizer is cheap and plentiful, used in excess and pollutes the environment. In the developing world, fertilizer is expensive or unavailable, crops suffer from nutrient deficiencies and food insecurity rather than environmental pollution is the problem. In both cases, however, a prayer diagnosis of the problem is required to prescribe economically and/or environmentally sound solutions to customers. NuMaSS is the Soil Management CRSP answer to global nutrient management.

Nutrient Management DSS Developed

The Nutrient Management Support System (NuMaSS) is Windows 9x/NT-compatible software developed to assist in soil acidity, nitrogen and phosphorus management decisions for crops in tropical regions of Africa, Asia and Latin America. Three software modules assist in making nutrient management decisions to grow a crop under user-specified field conditions. The *Diagnosis* module addresses the question of whether an acidity, nitrogen or phosphorus problem exists based on observations provided about geographical location, climatic conditions, soil type, previous crop yield and nutrient management, nutrient deficiency symptoms and indicator plants. Soil and plant analytical data are considered, if available, but are not required. The *Prediction* module recommends lime and nutrient inputs to correctly-identified acidity, nitrogen and phosphorus problems that could limit achievement of the yield level specified by the user for the selected crop. Lime and fertilizer recommendations provided by NuMaSS account for differences in available nutrient sources and nutrient requirements among crop species and cultivars, but user input of a minimum soil analytical data set is required. The soil analysis data are restricted to measurements that are determined on a routine basis by soil testing laboratories. With user input of commodity prices and lime/fertilizer costs, the *Economics* module estimates net returns to applied nutrients. Users can compare different types of elemental fertilizers, available commercial blends and organic sources. For each combination of nutrient sources, NuMaSS will estimate amounts of input for either the best profit or the best yield. Economic estimates can also be constrained by specifying a maximum amount of fertilizers to be applied or a given amount of cash to be invested in fertilizers and application costs. For each of the various user-selected scenarios, NuMaSS estimates whether a surplus or deficit in applied lime, nitrogen and phosphorus will exist.

NuMaSS Benefits to U.S. Agriculture

Agricultural issues in North Carolina have benefited from development of NuMaSS. Regulations established in 1998 for the North Carolina Neuse River Basin required that all pollution sources (point and nonpoint) reduce nitrogen (N) loading into the Neuse Estuary by 30 percent. Agriculture is believed to contribute over 50 percent of the total N load to the river. In order to reduce these N inputs, agricultural best management practices (BMPs) are necessary to control the delivery of N from agricultural fields to water resources. Producers were given a choice: either use standard BMPs or join a local area committee (county group) and as a county, reduce N loads by 30 percent. In order to track these 30 percent reductions by each county, an accounting and tracking tool had to be developed. This tool, Nitrogen Loss Estimation Worksheet (NLEW), was developed to track N reductions due to BMP implementation, including nutrient management. NLEW uses a modified N-balance equation that accounts for some inputs as well as N reductions from BMPs at both field- and county-scale levels. Each county in the Neuse River Basin used the NLEW tool to determine which BMPs were needed and the farmers who must implement them.

Much of the programming structure and the N mass balance approach for NLEW were adapted from NuMaSS. Some of the program algorithms and databases for NLEW were also taken directly from NuMaSS. Thus, the time and cost for development of NLEW was minimized by the application of information in NuMaSS. Currently, NLEW is under review by agencies in several states where total maximum daily nutrient loads have been imposed on particular water resources. USDA-NRCS is also reviewing NLEW as a potential accounting tool for nitrogen.

Impacts in Africa, Asia and Latin America

Project activities, in collaboration with the *Institut d'Economie Rurale* staff in the Sahel region of Mali, focused on crop productivity potentials from improved nutrient management in an agricultural region where nutrient inputs are traditionally restricted to the recycling of composted mixtures of crop residues and animal manures. On-farm trials have documented increasing deficits in soil nutrient reserves with traditional farming practices and the nutrient inputs that would be required to sustain a neutral balance with annual nutrient exports and losses. Initial surveys revealed that 25 percent of farmers supplemented compost applications with purchased fertilizers in millet production to ensure annual household stocks of this food staple. In the project's fifth year, a survey revealed that nearly all farmers were supplementing their traditional field applications of compost with purchased fertilizers. The primary reason given by farmers for their increased use of fertilizers was the increased crop productivity on their limited land area, which reduced their costs in crop establishment and management to achieve their desired household production goal.

The Philippine Rice Research Institute, in collaboration with the CRSP, has broadened its scope of public service from paddy rice production to crop production in upland regions with acid, nutrient-poor soils. The interest of farmers and agricultural agents in the successful production of corn, peanut, soybean, mungbean and upland rice in the Ilagan-Isabela region of Luzon island, via NuMaSS project activities, have led PhilRice to apply similar nutrient management technologies to research and development efforts with upland farming areas on other islands in the Philippines. Recent updates in national soil survey information have also revealed that land area under acid, infertile soils are considerably larger than previously estimated, thus increasing the potential for application of the soil nutrient management technologies and approaches developed through the CRSP project.

Peach palm is a native food tree of Latin American humid tropical regions, wherein cultivation for heart-of-palm production in over 40,000 hectares provides a viable cash-crop option for smallholder farmers in response to a growing international market demand. As a non-traditional crop, there is limited information and access to the knowledge needed to diagnose soil nutrient limitations and prescribe agronomically- and economically-sound corrective strategies. Project collaboration with investigators in Brazil and Costa Rica has focused on the development and assembly of knowledge on agronomic traits, nutrient requirements and management options for this crop. Comparison of our findings with current practices suggest that lime, nitrogen and phosphorus inputs for heart-of-palm production can be significantly reduced, thus minimizing both farmer costs and potential risks of nutrient pollution.

PR3: Soil Management Practices for Sustainable Production on Densely Populated Tropical Steeplands

Conversion of tropical steeplands for cropping and grazing is leading to increased risks for upstream soil erosion and landslides and downstream flooding and sedimentation. Major research achievements by the Soil Management CRSP in Central America and Caribbean region are summarized as follows:

1. The risk of soil erosion on sloping areas differs according to slope and soil type. The major form of soil erosion affecting Alfisols and Inceptisols derived from quartz-rich parent materials are block slumping and landslide. In collaboration with INTSORMIL and a USAID Mission-supported national extension project, LUPE, SM CRSP scientists have evaluated and promoted soil conservation technologies that can anchor the topsoil using biophysical means, including terraces stabilized by Vetiver grass or fruit and fodder trees, and rock retention walls. In Nicaragua and Haiti, the highly permeable Andisols derived from volcanic ash and Mollisols and Alfisols derived from limestone and basalts are less vulnerable to erosion. Practicing minimum tillage on such soils is the best soil management practice, and contour grass or tree barriers are recommended to prevent gradual movement of soil downhill. Benchmark watershed sites were established in Honduras and Nicaragua with the dual purposes of research and demonstration and were widely used by Central American national extension, NGO workers and students as a field laboratory.

2. Soil slumping is the primary cause of soil erosion on steep slopes and research on farmlands with slope ranging from 20 to 60 percent in Honduras and Nicaragua has shown that the small Universal Soil Loss Equation (USLE) erosion plots (0.004 ha) are not suitable for soil erosion prediction at watershed levels. Thus, large erosion plots or catchments (i.e., 0.2 ha of larger) are recommended.

a. In Haiti, severely eroded farmlands are widespread and the most important task of soil management is rejuvenation of soil fertility. SM CRSP scientists, in collaboration with NGO workers, screened over 30 soil conserving tree species for alley cropping. At low altitude, *Leucaena leucocephala* and *Gliricidia sepium* are among the best N sources. One pruning of these species yielded about 70 kg of N per ha within eight weeks of growth. *Delonix regia* is unpalatable to ruminants, which makes it advantageous in areas with free-grazing livestock during the dry season. In mid-elevation (900-1200 m), *Acacia angustissima* produced the highest amount of biomass and N yield (40kg N per ha in eight weeks).

b. Socioeconomic studies explored (i) the linkages between steepland soil erosion and downstream sedimentation and (ii) the per hectare cost of extension programming to support the adoption of three conservation technologies (rock wall, Vetiver grass barrier and mulching). The first study sought to broaden the policy justification for soil conservation by demonstrating the costs of sedimentation to one important group of downstream stakeholders; namely, the commercial shrimp producers. The accounting for downstream costs of steepland erosion makes a strong case for increased public support extension programming to support subsistence farmers to adopt soil conservation technologies. The costs per ha of promoting each of the three conservation technologies and the cost per ton of soil saved for each have been estimated.

3. GIS analysis based on physical landscape attributes and remote sensing-based vegetation and landslide (associated with hurricane Mitch) data was conducted to (a) evaluate the effect of landscape-scale factors on landslide risk and (b) develop GIS-based models for predicting landslide risk. The results showed that the likelihood of landslide was significantly influenced by slope: it was low on gentle slopes, increased sharply on moderately steep slopes and peaked on steep slopes. The likelihood of landslide was generally high in areas under bare soil, crops and grass fallows, while low in shrub fallows and very low in forests. As slope increased, the percentage of land affected by landslides increased sharply in crop areas and bare soil areas, indicating that agricultural activity and removal of permanent vegetation increased the risk of having landslides in steep lands. Shrub fallow and forests had a low incidence of landslides. Trees seemed to offer a protective cover to the landscape and thus reduced the percentage of land affected by slumps (Figure 1). The GIS model of landslide risk is being developed based on data from the Namasique (67.3 km^2) watershed and was validated in the Namasique and El Triunfo watersheds (Figure 2).

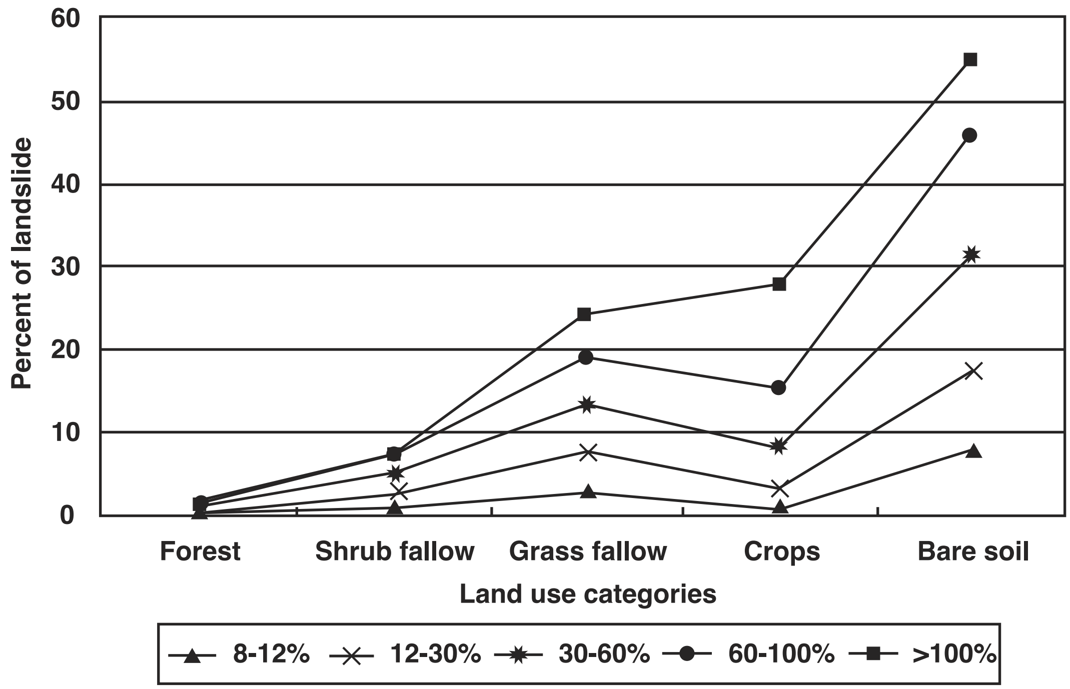

Figure 1. Landslide frequency as a function of slope and land cover.

4. A GIS model of orographical distribution of soils, based on landform attributes derived from digital elevation model (DEM), has been developed from synthesis of the extensive fieldwork in our study site in Honduras that revealed consistent trends in orographic distribution of soils in the steeplands. This model has been used with the database of the carbon storage and profiles of soils in the steeplands sites developed by Dr. Larry Wilding's group at Texas A & M, as well as the GIS model of landslide risk, to: a) estimate the quantity and spatial distribution of carbon sequestration in watershed, b) evaluate the impact of landslides on carbon sequestration, and c) help develop spatially-explicit soil conservation strategies to enhance carbon sequestration.

5. The project trained ten M.S. and Ph.D. degree students and nine non-degree technicians.

6. Five SM CRSP technical publications (in English and Spanish) were distributed to a large number of users, including extension workers, policy makers and researchers. Titles of the publications are: a) Assessment of soil and water conservation methods applied to cultivated steeplands of southern Honduras, b) Sustainable management of tropical steeplands: an assessment of terraces as a soil and water conservation technology – a review, c) Soil erosion and conservation as affected by land use and land tenure in El Oital watershed, Nicaragua, d) A watershed-level economic assessment of the downstream effects of steepland erosion on shrimp production in Honduras, e) Linkage between investment extension services and farmer's adoption of soil conservation practices in southern Honduras.

7. Participating institutions: Texas A&M University, Auburn University, North Carolina State University. Pan American School of Agriculture, Honduras, National Agricultural University of Nicaragua, and Center for Agricultural Research and documentation, Haiti.

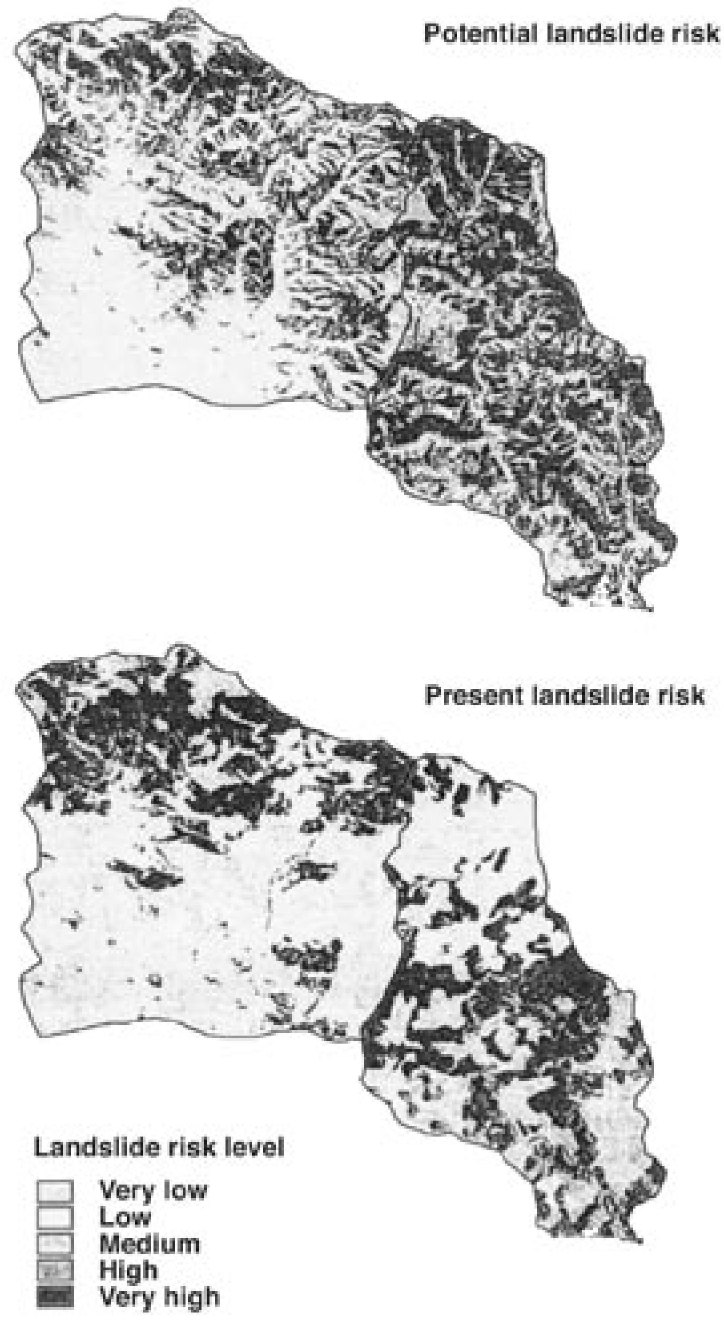

Figure 2. Potential and and present (1998) landslide risk in Namasigue (left) and El Triunfo (right) watersheds.

PR4: Improved Agricultural Products Through Biological Nitrogen Fixation Technologies and Legume Management

Although inoculation of legumes is a cost-effective technology in developed and developing countries, inoculant products are not widely available in the latter owing to technical and logistical constraints that prevent U.S. manufacturers from exporting to developing country markets. NifTAL has addressed these constraints by: i) modifying existing technologies; ii) developing new products; and iii) designing technologies and products with the assistance of end-users in industry and research institutes.

Accomplishments
Project accomplishments include the following:

1. Developed a new liquid inoculant formulation (G5) that improved the performance of *B. japonicum* at 65 percent of the materials cost of earlier generations and less than half the cost of conventional products.

2. Developed a laboratory bioassay measuring survival of *B. japonicum* on seed as a predictor of inoculant performance in drought and heat stressed soil.

3. Identified strains of *B. japonicum* with improved survival after inoculation.

4. Determined that culture age had little effect on survival characteristics of *B. japonicum*.

5. Developed a method to enumerate viable and dead bradyrhizobia in peat inoculant using direct microscopic evaluation, reducing the time required to evaluate inoculant quality from five days to several hours.

6. Developed a database of inoculant producers.

7. Communicated research results to 102 inoculant producers and scientists in 36 countries.

8. Developed experimental protocols to test new inoculant and quality control technologies.

9. Formed a network of 24 producers and agronomists in 16 countries to evaluate formulations and quality control methods.

10. Provided network participants with standard materials (media components, strains, and anti-sera) to conduct trials and provided six with some financial support.

11. Provided technical assistance to collaborators in strain identification, quality control of local inoculants and experimental design and procedures.

12. A new generation of liquid soybean inoculant (G6) reached 3 X 10^{10} cells/mL under experimental conditions that is 5-10 times that of normal YM media.

13. Developed two prototype liquid media (G5 and G6) that supports cell numbers in excess of 1 X 10^{9} mL^{-1} when stored for six months at 25 C comparable to the best peat inoculants. With the protecting additive polyvinylpyrrolidone (PVP), the G6 media reduced the rate of cell death after application to seed by 50 percent compared to G5 media. The G5 and G6 with PVP media increased cell survival on seed by 100-fold compared to cells with no protecting additives.

14. Results from the first network field trials of 42 experimental comparisons demonstrated the G5 formulation nodulated legumes more productively (freq. = 77%) and increased seed yield 68 percent of the time compared to local inoculant products (see Table 2).

15. Discovered common antifoam agents used in large-scale production of rhizobia limit cell growth.

16. Determined optimum airflow and agitation rates for producing liquid media.

17. Preliminary evaluation of several common gums indicates some may have protective activity approaching that of PVP.

18. Communicated research results in a second research report to 127 inoculant producers and scientists in 36 countries.

19. Developed new experimental protocols to test next generation (G6) liquid inoculant formulation.

20. Provided technical assistance to collaborators in strain identification, quality control of local inoculants and experimental design and procedures.

Table 2. Field performance summary of G5 inoculant formulation compared to uninoculated control and local inoculant products (Network Trial 1)

Response Indicator:	**Response of G5 inoculant above:**			
	Control		**Local Inoculant**	
	Relative frequency	**Percent Increase**	**Relative frequency**	**Percent Increase%**
Seed Yield[1]	100	92	68	7
Total Seed N	100	126	53	3
Nodule no.	100	>1000	74	21
Nodule wt.	100	>1000	68	10

Table 3. Seed yield and nodulation response to inoculation with NifTAL's liquid formulations (G5 & G6) and a sterile peat-based formulation (Network Trial 2)

Response Indicator	**Uninoculated Control**	**Formulation**		
		G5	**G6**	**Peat**
Seed Yield (kg/ha)	1318	2078	2050	1933
Nodule wt (kg/ha)	20.3	80.7	87.3	82.8
Nodule no. (millions/ha)	2.5	7.9	8.4	7.2

N=29 sites X strain combinations except for Peat treatment N= 28

21. Agreements were reached with 20 collaborators in 16 countries to conduct a second network field trial to evaluate the performance of G5 and G6 liquid inoculants compared to a sterile Canadian peat based carrier. Trial data (29 comparisons of each liquid with a sterile Canadian peat-based carrier product and un-inoculated control showed our G5 and G6 liquid products increased average seed yield by 760 kg/ha and 733 kg/ha above un-inoculated controls and 130 kg/ha and 102 kg/ha above the sterile peat carrier product (see Table 3 above).

22. Nodulation measurements followed a similar trend as yield except the G5 inoculant produced an average of 5.1 kg nodules/ha less than the peat formulation.

23. The frequency of responses to inoculation observed with the G5 and G6 formulations were 100 percent and 97 percent compared to the un-inoculated controls and 61 percent and 61 percent compared to the peat based product.

Projected Impact

Results from the network field trials show an expected yield increase of 6 percent above local products in the market and an increase of 90 percent compared to uninoculated crops. If this product is adopted in existing inoculant markets we can expect an average yield increase of 98 kg/ha worth approximately $24.50 U.S. (based on 1991 yields and Rotterdam prices) compared to local inoculants. If we assume this product is adopted by 5 percent of inoculant producers, and since soybean inoculants penetrate about 45 percent of the potential market, then the aggregate marginal yield increases in LDCs could be as much as 68,000 metric tonnes worth U.S. $16.7 million. Potential gains on other legumes could be as large.

PR5: Sustainability of Post-green Revolution Agriculture: The Rice-Wheat Cropping System of South Asia

The overall goal of the project was to identify and address factors that threaten the sustainability of the rice-wheat cropping system, which provides staples for 20 percent of the world's population. Secondary objectives were to: a) simultaneously improve the cropping system as a source of nutrients for people, with emphasis on micronutrients because deficiencies of these have grown to epidemic levels with the green revolution; and b) enhance the capacity of national programs to address sustainability issues in the cropping system.

The following are generalized observations and accomplishments relative to soil management in the rice-wheat system of the Indo-Gangetic Plains (IGP).

1. Rice is more vulnerable than wheat. Analysis of long-term nutrient management experiments across the IGP and district level of production data from Punjab and Haryana Sates in India showed that declining yields in experiments, and stagnating and possibly declining farm productivity, were most associated with rice. This result is surprising because puddling of the soil for rice leaves a poor soil physical condition for wheat, especially in finer textured soils.

2. Poor soil biological health is the greatest soil constraint to productivity in the rice-wheat cropping system in South Asia. This conclusion was reached from more than seventy soil solarization diagnostic trials on farms and research stations. In this technique, moist soil is covered with clear plastic for several weeks and heated by solar radiation to temperatures that kill pathogens and nematodes. It is estimated that overcoming soil borne pathogen and nematode problems could increase crop yields by 50 percent or more. Although every site that was evaluated was responsive to soil solarization, the technique is not practical for large areas of land, and alternative strategies to accomplish the same outcome need to be developed. This will likely require a long-term research effort utilizing molecular and other methods to better characterize soil microbial and nematode communities, and shifts in community structure and function in response to soil solarization and alternatives to solarization. However, the concept of producing "healthy rice seedlings" by solarization of nursery soil and/or seed treatment with fungicide is practical and proved very worthwhile. Use of healthy seedlings, without any other change in practice, increased rice yield by 20-40 percent on farms in Bangladesh and resulted in new farmers asking to be taught the technology. Solarization proved to be the more important of the two technologies used. The "healthy seedling concept" is being extended in Bangladesh through NGOs; CARE for rice, and the Bangladesh Rural Advancement Committee (BRAC) for vegetable seedlings. The latter application began as a farmer initiative after dramatic responses to tomato seedling survival and growth were observed in solarization trials that had a rice-vegetable rotation.

3. Micronutrient deficiencies are prevalent in Bangladesh and Nepal and reduce yields of rice, wheat and grain legumes. Key micronutrient deficiencies are boron, zinc (Zn) and molybdenum (Mo). Most farmers do not know that Zn and Mo deficiencies are a problem because deficiency symptoms hardly exist for rice and wheat, and soil testing for these elements is not widely available. *In vivo* seed enrichment was used to combat deficiencies of Zn and Mo. This unusual approach was selected because it reduces the need for widespread application of micronutrients to soil, and it has the potential to increase seedling resistance to soil borne pathogens. Seedling emergence, vigor and root health of wheat were dramatically improved using micronutrient-enriched seeds. Without targeting micronutrient deficient areas, the seed enrichment technology was shown to increase wheat yield on farms in Bangladesh by an average of 24 percent (0.69 t/ha) with a frequency of one in every four trials (total of 47 carried out over four years). Similarly, in yields of BR 32 rice, a newly released, short duration aman (monsoon) season variety, enrichment was also often found to be more effective than soil application of micronutrients.

   Boron deficiency was addressed in other ways because seed could not be enriched naturally with this element. Boron (B) deficiency is a major cause of crop sterility and has soil, weather and genetic components. A large percentage of soils analyzed from national rice-wheat research sites in Bangladesh and Nepal were found to be below the critical level for B. Both soil and foliar applications of B successfully overcame B deficiency at highly deficient sites. Response to B application at these sites and a shading technique to simulate fog were two approaches used to screen wheat germplasm for genetic susceptibility to sterility and were incorporated into national breeding programs after genetic susceptibility was found in a significant number of breeder lines. Similarly, it was shown that a number of newly released varieties of both rice and wheat in Bangladesh were susceptible to Zn and Mo deficiencies and breeding for micronutrient efficiency was initiated in the national breeding programs in Bangladesh.

4. Novel approaches to rice production have great potential to improve both rice and cropping system productivity together with increased nitrogen (N) and water use efficiencies. The latter is especially critical in the higher yielding areas of the IGP where groundwater resources are being used in a non-sustainable manner. The new technologies challenge conventional wisdom that the paddy is an optimal environment for rice production.

   The system of rice intensification (SRI) uses a single seedling at wider than conventional spacing without continuous flooding. Yields of up to 16 t/ha are claimed for this technique. In our experience, yields were increased by 15-40 percent and crop lodging was eliminated, potentially allowing higher N inputs and greater yields as lodging prevents the yield potential of current varieties from being achieved. Moreover, additional yield increases can be expected as other management practices are optimized for the SRI method. Conceivably, rice yields can be doubled at a country scale while conserving resources.

   Permanently raised beds with furrow irrigation and without flooding led to increases in yields of all three crops in a rice-wheat-mungbean rotation on a heavy textured soil and to increases in wheat and mungbean yields with similar rice yields on a light textured soil. Yield increases for the individual crops ranged from 20-40 percent and system productivity was substantially enhanced. Most importantly, irrigation water use was reduced by 40-50 percent, higher yields were achieved at lower N inputs, and weed pressure was reduced for all crops in the rotation compared to conventional practices on flat land. Yields and input use efficiencies may be increased further as management practices are optimized.

5. The success of the green revolution with cereal production in S. Asia has been accompanied by a decline in the production and availability of grain legumes (pulses), leading to imbalances in the supply of essential amino acids and deficiencies of mineral micronutrients (principally Fe and Zn and possibly also Cu) in human diets. An analysis of declines in grain legume (chickpea) production in northwest India showed that government price support policies for cereal and oil crops, coupled with high risk associated with chickpea production, were the principal reasons for the large decrease in the land area used for production of this crop. Research to improve pulse productivity is beginning to show returns in the latter phases of the project, especially for mungbeans where improved short duration (60-70 days) varieties are coupled with production on raised beds to avoid excessive moisture and associated disease pressures with traditional flood irrigation on flat soils. Seed treatments with fungicides and bio-control fungi to improve stand establishment coupled with micronutrient fertilization (especially B) are also showing returns with chickpea and lentil. The best yields of pulses achieved by the project are still in the 1 to 1.5 t/ha ranges, but this would be a substantial improvement over average yields of around 0.5 t/ha averages, provided that yield stability can also be achieved. Continued research effort on grain legume productivity is essential if agriculture is to address negative human health outcomes associated with current food systems in the region.

6. Capacity building was addressed through a variety of conventional approaches including degree programs, short-term training, support of traveling seminars in different zones of the IGP, scientist exchanges within the region, participation in American Society of Agronomy and International Society meetings, annual CRSP review and planning meetings, upgrading computer and laboratory analytical capabilities and use of newer technologies such as geographic information systems (GIS). Most importantly, emphasis was placed on multidisciplinary participation in planning and implementation of projects. Collaborations between major institutes such as BARI and BRRI in Bangladesh were achieved and for now, at least, are self-sustaining. Rice scientists are making significant contributions to soil fertility issues in wheat, and wheat scientists initiated the work on effects of soil biological health on rice

productivity. Research programs have moved from research centers to farmer fields and farmer participatory research approaches are slowly becoming accepted. None of this has occurred without frictions and disputes, but progress has exceeded our expectations. National scientists have contributed as much as Cornell and International Center scientists to the program, which has been a true partnership.

Some specific accomplishments in relation to the soil nutrient and acidity constraints targeted in the SM CRSP program were:

Deficiencies

Nitrogen

Technologies to improve returns to N inputs and N use efficiency in the rice-wheat system were identified. Use of straw mulch in the rice paddy lowered floodwater pH and reduced N losses by ammonia volatilization. Rice yields at 60 kg with mulch were the same as those achieved at 120 kg N/ha without mulch. An identical result was obtained when wheat was grown on raised beds with furrow irrigation to reduce N leaching losses, and maximum yield was increased from 3.5 to 5 ton/ha. Adoption of these technologies will increase rice and wheat yields of resource poor farmers who use low N inputs and will reduce N inputs in high yielding areas where fertilization rates sometimes exceed recommendations, e.g., Punjab State, India. These technologies increase crop productivity, economic return and have environmental benefits.

Phosphorus

Phosphorus (P) efficient wheat lines have been identified in Bangladesh. This breeding program is expected to lead to reduced needs for inputs of P fertilizer, which is an expensive import for Bangladesh and Nepal, is not always available or affordable for farmers and may be of questionable quality.

Potassium and Zinc

Widespread deficiencies of potassium (K) and zinc (Zn), affecting both rice and wheat, were documented in the Nepal Terai. Deficiencies of these elements were related to soil texture, and a GIS based strategy for targeting nutrient management programs to high return environments was developed. Similarly, K deficiency was identified in Bangladesh. Soil fertility survey data has documented the generally low fertility conditions in rice-wheat production areas in Bangladesh and Nepal, and data is being analyzed within a GIS framework.

Soil Acidity

Experiments have demonstrated yield responses in the range of 15-25 percent to liming of acid soils in Bangladesh for both rice and wheat. Interactions between liming and Zn and B confirm concerns that liming would exacerbate micronutrient deficiencies. Nevertheless, a properly implemented liming program has high potential impact since 50 percent of the soils in Bangladesh, and many areas in Nepal, are acid. Liming is essentially not currently practiced in Bangladesh and Nepal.

Multidisciplinary Approach

Perhaps the most important outcome from the project is its demonstration of the need for soil management research to be more strategically developed *and* applied within a multidisciplinary context, both within and beyond soil science. Our work on soil biological health and the more traditional areas of soil management, such as tillage and nutrient management, emphasized the need to focus on identification problems of critical constraints to crop productivity, whether biophysical or otherwise. For example, use of deep tillage to reduce soil compaction and promote deeper rooting increased wheat yields by 15-25 percent, whereas soil solarization increased yields by up to 65 percent (from 3 to 5 ton/ha) and eliminated the tillage effect. Similarly, on-farm research showed that applying fertilizer according to a soil test-based recommendations could increase farmer wheat yields up to 30 percent, but greater yield increases were achieved in soil solarization trials with current nutrient management. The same research also found that high yield variability amongst farms persisted despite following the best nutrient recommendations. Addressing this issue was at least as important as improving nutrient recommendations, and involved non-soil constraints.

The project also identified a fairly large number of technologies (not all discussed here) that individually increased yields of rice and wheat in the range of 15-40 percent. Combining technologies has the potential to obtain additive and synergistic interactions that could increase crop yields more dramatically. For example, the effects of soil solarization and vitavax seed treatment on the performance of "healthy rice seedlings" were additive. Many other combinations of technologies are possible. Unfortunately, too much of the soil management research being carried out on the rice-wheat system remains ineffective as it takes a single factor approach in traditional areas for small returns.

PR6: Gender and Soil Fertility

African women on small farms produce up to 70-80 percent of the domestic food supply in most African societies. Soil fertility continues to be the number one bio-physical constraint to efficient and adequate food production.

The purpose of this project was to test the many different ways African governments, NGOs and international agricultural institutions can improve the soil fertility on women farmers' fields for their food crops. The following examples illustrate the type of research conducted to achieve the project purpose:

Soil Fertility Depletion
We monitored progress of agricultural projects in Ethiopia, Kenya, Malawi, Mali, Senegal, Uganda and Zambia to document:

1. What effects soil fertility depletion in Africa has had on farmers' yields, incomes, and quality of life in these countries: a summary report on these effects from well over 1000 interviews with farmers in their fields and homes in different geographic regions of each country is being assembled.
2. What soil fertility amendments are adoptable or adaptable by small-scale farmers, including female headed households (FHH: a report on monitoring "naturally-occurring" experiments conducted by governments and NGOs to encourage adoption and adaptation of practices related to soil fertility replenishment is planned at the end of the 5 years.

Results to date from activities in Africa indicate the following:
- African farmers are too well aware that their soils are depleted.
- Nutrient-management model shows farmers are aware they are losing essential nutrients when they switch from high-protein cereals like maize to lower-protein root crops like cassava.
- Men farmers in male-headed households (MHH) do adopt and adapt but to a lesser extent.
- Female-headed households do *not*. (The *only* solutions that are now being adopted by FHHs on a significant scale are agroforestry innovations in the form of *improved fallow* (IF) developed by ICRAF).

Improved Fallow
In an era of dismal reports and horror stories from Africa (prevalence of AIDs, corruption, weak governments), improved fallow technologies are a true African success story. Improved fallow technologies with various tree species (*Sesbania sesban, Tephrosia vogelee, Gliricida sepium)* have been tested and evaluated at the Msekera Research Station in Eastern Zambia by ICRAF since 1988, and in 1992/93 some on-farm trials of the improved fallows (IFs) began. Improved fallow plot, ranging from 10 meters by 10 meters to 30 meters by 20 meters, are planted for two years with nitrogen-fixing tree species (*Sesbania or Gliricida* seedlings or direct-seeded *Tephrosia vogelii* or *Cajanus Cajan* (pigeon pea), and followed by two or three years of maize. By far the most promising, although it may look like a "dinky little tree," is *Sesbania sesban*, which is grown in a nursery three to six weeks before the rainy season. Results over the five-year cycle showed improved fallows increase total maize production eighty-seven percent over unfertilized maize (even without any yield in years one and two).

Moreover, with the rising prices of fertilizer in Zambia, fully fertilized maize is no longer an option, and even partially fertilized maize is not an option for many farmers who have neither the cash nor the access to credit to purchase fertilizer. By 1997, over 3,000 farmers, forty-nine percent of whom were women farmers, according to ICRAF, had participated in the multi-year trials of improved fallow technologies. By 2001, two years after the start of the World Vision project to extend the IF technology in the Eastern Zambia, 10,000 farmers participated in planting IFs.

Yet the question still unanswered is: *why* are improved fallows being adopted so readily in Eastern Zambia, especially by women and FHHs, when other methods haven't been adopted? Results from the UF Soils CRSP show their success is due to two facts:

1. Eastern Zambia is a region of lower population density than other African regions (e.g., western Kenya or southern Malawi) so that women farmers have enough land to put some of it in fallow.
2. Adoption of improved fallows is a delayed reaction to structural adjustment policies that have raised the price of inorganic fertilizers to levels so high that women farmers have finally "adjusted" by deciding to "grow their own fertilizer" and adopt a substitute soil-fertility amendment.

These results were described with the use of decision tree modeling and ethnographic linear programming models. Both were complemented with political-science studies of indigenous institutions and governance structures in Eastern Zambia.

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PROJECT MANAGEMENT

Management Entity (ME)

The University of Hawaii serves as the Management Entity for the Soil Management CRSP. Dr. Goro Uehara serves as Director and Dr. Gordon Y. Tsuji serves as Deputy Director. As the Management Entity, the University of Hawaii administers grant funds received from the Agency for International Development under Grant No. AID/LAG-G-00-97-00002-00. The Management Entity is responsible for the overall implementation of the research program and for coordination of project activities under five sub-agreements with participating institutions and one direct project at the University of Hawaii (NifTAL). Principal investigators for the six projects prepare annual work plans and budgets associated with each of their respective project objectives and submit them to the Management Entity for transmittal to the Technical Committee for review and evaluation.

The Management Entity reports on the overall progress of program activities and represents the SM CRSP in negotiations with AID and in meetings and teleconferencing of the CRSP Council. The CRSP Council consists of directors of the nine different CRSPs managed by the Office of Agriculture and Food Security of USAID. Additionally, the Management Entity represents the interest of the SM CRSP in responding to requests for technical support and/or participation in forums received from the Office of Agriculture and Food Security and from USAID missions.

Operationally, the office of the Management Entity is in the Department of Tropical Plant and Soil Sciences in the College of Tropical Agriculture and Human Resources at the University of Hawaii.

Administratively, the Management Entity utilizes the services of the Research Corporation of the University of Hawaii (RCUH) to implement and manage its sub-agreements with participating institutions. The RCUH is a non-profit organization established by the State Legislature in 1965 to support "off-shore" research and training programs of the University of Hawaii. The University of Hawaii has oversight responsibilities of the RCUH.

The CRSP Guidelines established in 1975 by the Board for International Food and Agricultural Development (BIFAD) for USAID and federal regulations serves as a guide to manage the SM CRSP by the Management Entity. A revised version of the Guidelines was distributed in August 2000. Those guidelines direct each of the CRSP programs to establish a Technical Committee, a Board of Directors, and an External Evaluation Panel. The office of the Management Entity is responsible for administrative and logistical support to members of these "bodies." A description of the role and composition of each follows.

Participating Entities

Board of Directors (BOD)

The CRSP guidelines states: "The Board consists of representatives of all of the participating institutions and may include individuals from other organizations and host country institutions. The AID Program Officer and the ME Director serve as ex-officio members. The institution, which serves as the ME, will have a permanent member on the Board. Participating institutions select their board members based on their administrative responsibilities and relevant expertise. They should not be chosen solely to represent their respective institutions or projects, but to function in the objective interest of the CRSP. The Board operates under a defined charter to deal with policy issues, to review and pass on plans and proposed budgets, to assess progress, and to advise the ME on these and other matters. While the ME institution has the authority to make final decisions relative to program assignments, budget allocations and authorizations, the ME must, in the collaborative spirit, carefully consider the advise and guidance of the Board and other CRSP advisory groups. Any departure from the Board's recommendations should be justified, recorded in minutes of the meeting, and reported in writing by the ME."

Members and officers of the Board of Directors include:

- Dr. John Havlin, North Carolina State Univ., Chair
- Dr. Thomas McCoy, Montana State University, Vice-Chair
- Dr. Andrew Hashimoto, University of Hawaii
- Dr. Philip Thornton, ILRI, Edinburgh

Technical Committee (TC)

The CRSP Guidelines states: "The Technical Committee is established with membership drawn primarily from principal scientists engaged in CRSP activities, known as principal investigators (PIs), and host country scientists involved in CRSP or IARC activities. The ME Director and the AID Program Officer serve as ex-officio members. The TC meets from time to time to review work plans and budgets, program performance, to propose modifications in the technical approach to achieve program objectives, and to recommend allocation of funds. The TC reports its findings in writing to the ME who will share them with the BOD."

Members of the Technical Committee include the following:

- Dr. T. Jot Smyth, North Carolina State Univ., Chair
- Dr. John Duxbury, Cornell University
- Dr. E.B. (Ron) Knapp, Retired, CIAT
- Dr. Thomas Walker, CIP, Lima, Peru

External Evaluation Panel (EEP)

The CRSP Guidelines states: "The EEP is established with membership drawn from the scientific community to evaluate the status, funding progress, plans, and prospects of the CRSP and to make recommendations thereon. In accordance with the CRSP guidelines, the panel shall consist of an adequate number of scientists to represent the major disciplines involved in the CRSP, normally no more than five members. This number will vary with program size and cost-effectiveness. The term of office shall be long-term to retain program memory. A five-year term is recommended for the initial panel and subsequently rotated off on a staggered time base. Provisions should be made for replacements for low attendance, for resignations or for other reasons. In instances where a minor discipline is not represented on the EEP, the Chairman may request the assistance of an external consultant from the ME."

Panel members will be internationally recognized scientists and selected for their in-depth knowledge of a research discipline of the CRSP and experience in systems research and/or research administration. International research experience and knowledge of problems and conditions in developing countries of some members are essential. The members are selected so that collectively they will cover the disciplinary range of the CRSP, including socioeconomic components that can influence research and technology adoption. Panel members should be drawn from the United States (some with experience in agricultural research and knowledge of the Land Grant University system) and the international community and should include at least one scientist from a developing host country. Availability to devote considerable time to EEP activities is an important criterion for membership."

Nomination of candidates was solicited by AID from the principal investigators and the ME. A five-member panel was appointed. Members of the External Evaluation Panel (EEP) include the following individuals.

- Dr. David MacKenzie, Chair, EEP, and Director, NERC/CREES/USDA, College Park, Maryland
- Dr. Will Blackburn, Area Director, ARS/USDA, Ft. Collins, Colorado
- Dr. Eric Craswell, Director-General, IBSRAM, Bangkok, Thailand
- Dr. Jean Kearns, Executive Director, CID, Phoenix, Arizona
- Dr. Amit Roy, President and CEO, IFDC, Muscle Shoals, Alabama

CRSP Council

Principal communication links among the CRSP programs are established through the CRSP Council. Directors of nine CRSPs constitute membership of the CRSP Council. Current chair of the Council is Dr. John Yohe, Director of the INTSORMIL CRSP at the University of Nebraska with Dr. Michael Carter of the University of Wisconsin serving as Vice-Chair. Members of the Council are as follows:

Director	CRSP	Institution
Michael Carter	BASIS	Wisconsin
Irv. Widders	Bean and Cowpea	Michigan State
Tag Demment	Global Livestock	Davis, CA
John Yohe	INTSORMIL	Nebraska
Brhane Gedbrekidan	IPM	Virginia Tech
Tim Williams	Peanut	Georgia
Hillary Egna	Pond Dynamics	Oregon State
Carlos Perez	SANREM	Georgia
Goro Uehara	Soil Management	Hawaii

The CRSP Council serves as a communication link among the nine CRSPs and as a conduit for information flow to and from USAID and other organizations such as NASULGC (National Association of Universities and Land Grant Colleges). Communication involves either teleconferencing, e-mail correspondence through the Internet, and meetings as necessary, typically on an annual basis.

The INTSORMIL staff at the University of Nebraska created a web site for the CRSP programs. The URL for the site is http://www.ianr.unl.edu/crsps/.

FINANCIAL SUMMARY

Core funding for the SM CRSP in PY5 was reduced from $2.7M for 12 months to $2.146,428 for 10 months and 10 days. The 10-month period corresponds with the incremental award (Mod #7) date of May 1, 2001 to the contractual end date of the Grant, February 10, 2002.

A no-cost extension was also provided in Mod #8 to extend the end date of the Grant to September 30, 2002. The purpose of this extension was to allow the Grant to continue expending its pipeline funds and to prepare for implementation of the second phase of the Grant to 2007. Both the Office of Agriculture and the Office of Procurement later apprised the ME that additional funding (bridge funds) to support activities during this interim period would be provided.

Table 4 lists the incremental awards to the Grant since its inception on February 11, 1997. Eight modifications to the Grant were received. The total obligated amount was $14,945,428. The authorized level of funding or the initially proposed budget for the first 5 years was $19,254,050.

Table 4. Incremental funding awards obligated to the SM CRSP for the period starting on February 11, 1997 to February 10, 2002.

Award	PY	Amount	Period
Initial Grant	1	$2,467,975	Feb 11, 1997-Sept 30, 1997
Mod # 1	1 & 2	$1,131,025	Oct 01, 1997-Apr 30, 1998
Mod # 2	2	$2,500,000	May 01, 1998-Apr 30, 1999
Mod # 2[a]	2	$200,000	May 01, 1998-Apr 30, 1999
Mod # 3[b]	2	$1,000,000	May 01, 1999-Jul 31, 1999
Mod # 4	3	$2,500,000	May 01, 1999-Apr 30, 2000
Mod # 5[c]	3	$200,000	May 01, 1999-Apr 30, 2000
Mod # 6	4	$2,500,000	May 01, 2000-Apr 30, 2001
Mod # 6[c]	4	$100,000	May 01, 2000-Apr 30, 2001
Mod # 6[d]	4	$200,000	May 01, 2000-Apr 30, 2001
Mod # 7	5	$2,146,428	May 01, 2001-Feb 10, 2002
Mod # 8[e]	5	N/A	Feb. 11, 2002-Sept 30, 2002

Notes: Superscripts a, b and c refer to field support funds received by the SM CRSP from the Office of Disaster Relief, the AID mission in Bangladesh, and the AID mission in Ethiopia, respectively. Superscript d refers to supplement funding to the core budget from AID for impact assessments. Superscript e: AID/M/OP provided approval for a no-cost extension.

FISCAL REPORT

Summaries of expenditures, cost sharing and funding for each project are listed in Tables 5 a-c.

Three projects completed their respective research activities at the end of PY5. They included the NifTAL project at the University of Hawaii and projects at Texas A&M University and the University of Florida. Final accounting of expenditures will be reported to USAID as part of the expenditure reports submitted by the University of Hawaii's Office of Research Services on quarterly basis.

Table 5. Financial summary statement ($'000) of expenditure, cost sharing and funding for PY 5 (Feb 11, 2001 to Sept 30, 2002) from vouchers received.

a. Summary of Expenditures reported during PY 5 (Feb 11, 2001 to Sept 30, 2002)

Institution	MSU	NCSU	CU	TAMU	NifTAL	UFL	ME/UH	Total
Total	361	1,252	698	40	230	163	458	3,563

b. Cost Sharing for PY 5 (Feb 11, 2001 to Sept 30, 2002)

Total	50	389	138	194	105	191	N/A	1,067

c. Summary of Cumulative Core Funding (February 11, 1997 to September 30, 2002)

Mod #2	194	1,000	483	361	190	58	214	2,500
	0	0	0	0	0	168	32	200[a]
Mod #3	39	173	604	57	36	0	61	1,000[b]
Mod #4	142	765	773	293	143	0	384	2,500
Mod #5	0	0	0	0	0	0	200	200[c]
Mod #6	176	876	523	276	173	95	380	2,499
Mod #6[d]	0	0	0	0	0	0	200	200[d]
Mod #7	138	784	470	200	140	74	340	2,146
Mod #8[e]	0	0	0	0	0	0	0	0

Notes: Superscripts a, b and c refer to field support funds received by the SM CRSP from the Office of Disaster Relief, the AID mission in Bangladesh, and the AID mission in Ethiopia, respectively. Superscript d refers to supplement funding to the core budget from AID for impact assessments. Superscript e: AID/M/OP provided approval for a no-cost extension.

FIELD SUPPORT, COST SHARING AND LEVERAGING

Field Support

Support provided to a USAID field mission is commonly referred to as “buy-ins.” The term “buy-in” reflects the transfer of funds from the mission to the CRSP to undertake support-role type activities of the mission’s strategic objectives (SO). To facilitate a “buy-in” an individual from a mission, the CTO of the CRSP in DC, a principal investigator or researcher with a CRSP project, and the ME will collaborate to negotiate the terms of reference of the research support requested by a local institution or organization to the field mission. The agreement is generally a sub-grant from the mission to the ME via the AID Office of Procurement. The ME, in turn, will amend agreements with participating institutions to allocate additional funds over and above the core to a participating institution or collectively among participating institutions at the request of a USAID field mission.

Bangladesh
As reported last year, the field support buy-in from the USAID mission in Bangladesh amounted to $1million over a period of 2 years (1999 to 2001). Principal scientist involved in the nutrition studies was Dr. Gerald Combs of Cornell University. Low levels of calcium in soils in the region of Cox’s Bazaar, Bangladesh resulted in low intake of calcium in the diet and nutrition of the population. The relatively high incidence of rickets in children and adults was linked to calcium deficiency. Typically, rickets is associated with deficiency in vitamin D.

Ethiopia
Field support from the USAID mission in Addis Ababa was provided to the SM CRSP as the lead CRSP and involved inputs from the SANREM, IPM, and INTSORMIL CRSPs. As a final activity under this buy-in, scientists from the Soil Management CRSP and IPM CRSP were invited to participate in the annual meeting of the national soil science society of Ethiopia in PY5 (2001). That meeting was held in Amhara. Goro Uehara and Richard Ogoshi of the University of Hawaii, representing the SM CRSP, and Kevin Brannan of Virginia Tech, representing the IPM CRSP, made presentations during the 3-day meetings.

Cost Sharing

Table 6 lists the cost sharing contributions from each of the participating U.S. institutions involved in the Soil Management CRSP.

Cost sharing refers to the required match of 25 percent of grant funds from USAID. Matching can range from in-kind support such as facilities and utilities to salaries or wages and fringe benefit costs. Funds for matching must be from non-Federal sources. The CRSP Guidelines (1975) states the following costs are exempt from cost sharing: (1) funds to operate the ME, (2) funds committed under terms of a formal CRSP host country sub-agreement, (3) costs of training participants in the CRSP, and (4) hospital and medical costs of U.S. personnel of the CRSP while serving overseas.

Leveraging

Leveraging of human, fiscal and material resources from collaborating institutions, organizations, agencies and individuals is reported herein. Values of these resources in dollars are best estimates asked of and provided by each of the principal investigators. The following lists the estimates of leveraged resources from national, regional and global collaborators of the SM CRSP.

Summary

Alliances with local host country counterparts, NGOs, CGIAR partners, CRSP partners and other international agencies cannot be fully measured in terms of the dollar amounts listed above. The estimated total leveraged funds were near $1 million in PY5.

Many individuals and organizations have contributed time and in-kind costs to support activities to achieve project objectives that are likely not listed or reported here. We apologize for any omissions.

Table 6. Estimates of resources leveraged from agencies, institutions and organizations in countries hosting SM CRSP activities.

Africa

Country	Institution	Leveraged resources
Mali	L'Institut d'Economique Rurale (IER)	$75,000
Cape Verde	INIDA	10,000
The Gambia	NARI	10,000
Senegal	ISRA	25,000
Kenya	CIP/Nairobi	25,000
	University of Nairobi	5,000
Total		$150,000

Asia

Bangladesh	BARI/BRRI	20,000
	CIMMYT/Dhaka	10,000
Nepal	NARC	7,500
	IAAS	5,000
Philippines	PhilRice	75,000
	IRRI	10,000
Thailand	Kasetsart University	50,000
	Land Development Department	25,000
Total		$202,500

Latin America

Peru	CIP/Lima	$120,000
	INIAP	10,000
	PRONAMACHCS	10,000
Ecuador	PORMSA	25,000
	FundAgro Pov & Env proj	10,000
Costa Rica	Univ of Costa Rica	150,000
	Los Diamantes Ex'pt Sta	45,000
Haiti	SECID/PLUS	25,000
	PADF/PLUS	2,500
	CRDA	2,500
Honduras	Pan American Univ	25,000
Nicaragua	Universidad de Nacional	25,000
Total		$450,000

Others

USA	CIIFAD, Cornell Univ	30,000
	INTSORMIL CRSP	25,000
	PDA CRSP	10,000
	NASA/SANREM CRSP	150,000
Switzerland	Swiss Dev Corp	25,000
Netherlands	Wageningen Agr Univ	53,750
Canada	IDRC Ecosalud proj	10,000
Total		$303,750

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Internet

Information dissemination through the world wide web (WWW) is accessible through the SM CRSP web site at the following URL, http://agrss.sherman.hawaii.edu/sm-crsp.* Linkages to each of the SM CRSP projects are available through “hot links” to each respective project site.

*Note: Since this report was drafted, the URL is now http://tpss.hawaii.edu/sm-crsp.

ACRONYMS

AB-DLO	Research Institute for Agrobiology and Soil Fertility, the Netherlands
ADEFOR	Association Civil para la Investigacion y Desarrollo Forestal
ADSS	Acidity Decision Support System
AFS	Agricultural and Food Security Office, USAID
ARS	Agricultural Research Service
ATI	Appropriate Technology International
BARI	Bangladesh Agricultural Research Institute
BINA	Bangladesh Institute for Nuclear Agriculture
BNF	Biological Nitrogen Fixation
BOD	Board of Directors
BRAC	Bangladesh Rural Advancement Committee
BRRI	Bangladesh Rice Research Institute
CARE	Cooperative for American Relief Everywhere
CGIAR	Consultative Group for International Agricultural Research
CIAT	International Center for Tropical Agriculture
CID	Consortium for International Development
CIDA	Canadian International Development Agency
CIMMYT	International Center for Maize and Wheat
CIP	International Potato Center
CONCADE	Counter-Narcotics Consolidation of Alternative Development Efforts
CONDESAN	Consortium for the Sustainable Development of the Andean Ecoregion
CRDA	Center for Agricultural Research and Documentation, Haiti
CREES	Cooperative State Research, Education, and Extension Service
CSR	Center for Social Research
CU	Cornell University
DME	direct microscopic enumeration
DSS	Decision Support System
EAP	Pan American School of Agriculture, Honduras
EIA	enzyme immuno assay
EEP	External Evaluation Panel
EGAD	Economic Growth and Agricultural Development
EMBRAPA	Empresa Brasileria de Pesquisa Agropecuaria Vinculada Ao Ministerio de Agricultura
EPA	Environmental Protection Agency, U.S.
ESPOCH	Escuela Politenica de Chimborazo, Ecuador
FAO	Food and Agriculture Organization
FHH	Female Head of Household
GCTE	Global Change in Terrestrial Ecosystems
GoM	Government of Malawi
GSFC	Gujarat State Fertilizer and Chemical Ltd.
GIS	Geographic Information System
IAAS	Institute for Agriculture and Animal Science
IARC	International Agricultural Research Centers
IBSRAM	International Board for Soils Research and Management
ICAR	Indian Council of Agricultural Research
ICDDRB	Int. Center for Diarrheal Disease Research, Bangladesh
ICRAF	International Center for Research in Agro-Forestry
ICRISAT	International Center for Research in the Semi-Arid Tropics
IDB	Inter-American Development Bank
IDRC	International Development Research Council, Canada
IER	L'Institut d'Economie Rurale
IF	Improved Fallow
IFDC	International Fertilizer Developmental Center
IGP	Indo- Gangetic Plains
IFPRI	International Food Policy Research Institute, United States
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
INIA	National Institute for Agricultural Research, Peru
INIAP	National Institute for Agricultural and Livestock Research, Ecuador
INPA	Instituto Nacional de Pesquisas da Amazonia
IntDSS	Integrated nutrient management Decision Support System

INTSORMIL International Sorghum and Millet Collaborative Research Support Program
IPM Integrated Pest Management
IRRI International Rice Research Institute
ISNAR International Service for National Agricultural Research
ISRA L'Institut Senegalais de Recherche Agricole
LDC Lesser Developed Country
LIBIRD Local Initiatives for Biodiversity, Research & Development
LUPE Land Use Productivity Enhancement Project, Honduras
MAFEP Malawi Agroforestry Extension Project
MAHYCO Mahrashtra Hybred Seed Co.
MARNDR Ministry and Agriculture, Natural Resources and Rural Development, Haiti
MCC Mennonite Central Committee
ME Management Entity
MERC Middle East Research Corporation
MHH Male Head of Household
MoA Ministry of Agriculture
MSU Montana State University
NARC Nepal Agricultural Research Council
NARES National Agricultural Research and Extension Systems
NARS National Agricultural Research Systems
NCSU North Carolina State University
NDSS Nitrogen Decision Support System
NERC North East Regional Center
NGO Non-Governmental Organizations
NifTAL Nitrogen Fixation of Tropical Agricultural Legumes
NRM Natural Resource Management
NuMaSS Nutrient Management Support System
OMB Office of Management and Budget
PADF Pan American Development Foundation
PARC Pakistran Agricultural Research Council
PATH Programme for Appropriate Technology in Health (Canada)
PAU Punjab Agricultural University, Ludihana, India
PCCMCA Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos y Animales
PDSS Phosphorus Decision Support System
PES nets Productivity-Enhancing Safety nets
PhilRice Philippine Rice Research Institute
PI Principal Investigator
PRGA Participatory Research and Gender Analysis
PLUS Productive Land Use Systems Project
PVO Private Voluntary Organization
PY Project Year
RCUH Research Corporation of the University of Hawaii
RWC Rice Wheat Consortium
SADP Smallholder Agribusiness Development Program
SARPV Social Assistance and Rehabilitation for the Physically Vulnerable
SECID South-East Consortium for International Development
SIDA Swedish International Development Agency
SM CRSP Soil Management Collaborative Research Support Program
SUBSTOR Subterranean storage crop model
TAMU Texas A&M University
TC Technical Committee
TNAU Tamil Nadu Agricultural University
UFl University of Florida
UNA National Agriculture University, Nicaragua
UNC Universidad Nacional de Cajamarca
UNICEF United Nations International Children's Emergency Fund
URL Universal Resource Locator
USAID United States Agency for International Development
USDA United States Department of Agriculture
WAU Wageningen Agricultural University
WV World Vision
ZIAP Zambian Integrated Agroforestry Program