REGIONAL SCALING OF FIELD-LEVEL ECONOMIC-BIOPHYSICAL MODELS (DME-NOR)

PROGRESS REPORT #4

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International Potato Center (CIP)

Organization: CIP
Duration of the project: October 1996 – September 1999
Reporting period: May, 1998- October 1998
Date of reporting: September 30, 1998

Based on the annual work plan, during this third reporting period, project participants continued to work on methods development and data collection in Peru and Ecuador. Recall that we are jointly executing the DME-Nor project with the SM-CRSP project financed by USAID. The SM-CRSP project began officially on Feb. 11, 1997 and will continue until 2002. Because they are managed jointly, this document reports on activities attributable to both projects.

Two new allied projects were proposed during the period, one was funded and the other is pending. The funded project is “Human Health and Changes in Potato Production Technology in the Highland Ecuadorian Agro-Ecosystem. This three year IDRC-funded project will make it possible to include human health scenarios within the existing set of applications for the Decision Support System. This project will be jointly executed with the existing projects and its presence can be noted in the logframe under Objective 5. The pending project titled “An Integrated Assessment of ENSO and Climate Change Impacts on Andean Agriculture” is before scientific reviewers of the Collaborative Research Network (CRN) program of the Inter-American Institute for Global Change Research (IAI) and will make it possible to include ENSO and global climate change scenarios into the set of applications of the DSS and provide support to some of the methods issues pertaining to scaling and minimum data sets needed for extrapolation of research results. If funded this project will also be jointly executed with the existing three projects. See Appendix 1 and 2 for a summary of the two projects.

1. PROJECT PROPOSAL ORIGINAL GOALS AND OBJECTIVES

Goal:
To provide analytical/descriptive regional level analysis from field-scale economic-biophysical models that guide evaluation of policy or technology changes by national, regional and local level policy makers, rural development professionals, and agricultural researchers.

Objectives:
- To develop methods for scaling integrated economic-biophysical modeling results from field to regional levels.
- To develop methods that allow linkages between statistical economic decision making models and process-based crop simulation models to facilitate analysis of economic, agricultural and environmental impacts of policy or technology change.
- To develop methods to link geo-referenced databases to the integrated biophysical-economic models for importing data to run the models and for display of simulated results.

2. MAY TO OCTOBER 1998 PLANNED ACTIVITIES (The numbered objectives in this and the following section relate to those operational objectives in the year 3 logframe found in Annex 4.)

Objective 1: Bio-physical model calibration
1. Complete Carchi field work for parameterizing LEACHP and Hydrus 2D leaching models.
2. Start carbofuran adsorption-desporption, percolation, degradation, and half life studies in Carchi
3. Continue evaluations of WEPP model in Ecuador and Peru.
4. Collect soil and climate data sets.

Objective 2: Pasture - milk model calibration
1. Evaluate Andean pasture/milk simulation models, select best model and make compatible with Tradeoffs Model.

Objective 3: Crop growth model calibration
1. Plan potato models validation experiments.
2. Continue calibration of DSSAT maize, beans (Ecuador), wheat and barley (Peru) models.

Objective 4: Regional extrapolation
1. Downscaled soil maps completed for Carchi.
2. Plan soil map downscaling for Cajamarca.
3. Start extrapolation reliability evaluation through K3-K5 model comparisons

Objective 5: Scenario development and testing
1. Continue development of user shell.
2. Modularize economic model to establish linkages to biophysical models

3. Continue parcel level technological and economic data collection in Cajamarca.

Objective 6: Communications and recommendations

1. Invited presentation at American Agricultural Economics Association Meeting.

Objective 7: Group and individual training

1. Ecuador MS students to enroll in WAU.
2. Peru MS student to enroll in Montana State.
3. Peru Ph.D. student to enroll in WAU.
4. Peru MS students at U. Cajamarca to finish theses.
5. Ecuador Ing. Agr. Students working at INIAP to continue thesis research.

Objective 8: Management and planning

1. Provide required progress and financial reports.
2. Conduct Annual Planning meeting.

3. MAY TO OCTOBER 1998 ACTIVITIES COMPLETED OR CONTINUING (numbers refer to the corresponding numbers in section 2 above)

Objective 1

1. Field work for leaching studies completed and documented in WAU student thesis.
2. Institutional conflicts between the Ecuadorian Atomic Energy Commission (which owns the pesticide analysis equipment) and the Universidad Católica (where the equipment is located) has delayed the completion of the pesticide studies. We are working on solutions to this delay.
3. A first draft of one M.S. thesis study, "Bio-economic characteristics of slow-forming terraces in La Encañada" by Genaro Carrión, was completed September 1998. This study is helping to define the cost-benefit relationships for slow-forming terraces so that scenarios related to their use can be realistically incorporated into the DSS. The other thesis activities related to growth analysis of forages and soil erosion model (WEPP) evaluation have continued; thesis drafts describing these activities will be ready by the end of the year. To further reinforce erosion studies, plans for establishing erosion plot trials in Ecuador are being developed (see point 3 below).
4. Climate data from the Cajamarca watershed—including the La Encañada watershed—were digitized with ADEFOR collaborators. These data include daily values for precipitation, maximum and minimum air temperatures, and relative humidity from 45 stations with varying recording periods since 1977. Monthly interpolated climatic maps have been generated using the ANUSPLIN software. To generate interpolated daily values for running with the models, we have begun to adapt the MTCLIM model from the University of Montana.

Objective 2

1. The pasture-milk model developed by Victor Barrera in Carchi and a dual-purpose animal production model developed by Blanca Arce and Roberto Quiroz are being combined into one model for incorporation in the Tradeoffs Model.

Objective 3

1. Potato yield data from historical field experiments in Ecuador and Peru (the Clavijo Ing. Agr. thesis in Ecuador and the Cabrera study in Peru) were used to estimate genetic coefficients for the more commonly grown clones. These coefficient estimates were then used to test the performance of the SUBSTOR-potato model by comparing simulated yields against measured data from other historical experiments. A thesis and at least one other publication that describe this process are being prepared. The van Haren study of the LINTUL model using Bolivia historical data was completed.
2. Potato trials for LINTUL and SUBSTOR for potential, water and nitrogen limited production and late blight limited production were planned for Peru and Ecuador. In Peru, these studies are being planned and conducted jointly with INIA and the University of La Molina. Planting dates are October and November.
3. Maize and bean trials for DSSAT crop growth model calibration in Ecuador were planted.
4. Historical wheat and barley experimental data in Peru were collected and systematized using the GCTE and ICASA data formats.

Objective 4

1. The GIS data base for Carchi was finalized and incorporates data on soils, field size, climate, and infrastructure. A WAU student arrived in Ecuador to further elaborate the relation between land use and soil processes. This relation will be used to improve the quality of the soils information and to incorporate possible soil degradation as a result of land management as a scenario. In addition, the relation will be used as the basis to extrapolate the soil data to the 'larger' potato-pasture zone. As a first step to creat a similar GIS database for La Encañada, a digital elevation model was created on the basis of existing maps with contours and rivers.
2. A WAU student arrived in Peru to establish basis for downscaling the La Encañada soil map.
3. A K3-type economic model is in development (see discussion in point 4 below).

Objective 5

1. A second version of the user shell was developed in which the GIS model linkage has been formalized and in which a linkage to the crop growth simulation model and the pesticide leaching models is established. The economic simulation model has been adapted to deal with the results of the crop growth simulation model. (see point 4 below).
2. The original SAS program combining the econometric estimation models and the parcel simulation model was separated and made generically compatible with the user shell.
3. Methods were developed to integrate the econometric production model and crop growth models both for estimation of the econometric model's parameters and for its simulation.
4. An econometric dairy model was developed and estimated using Carchi data and was incorporated into the economic simulation model.
5. Parcel-level data collection continues in La Encañada. The 38 farmers are currently managing 178 fields in which there are 518 plantings. This number exceeded our expectations and additional field staff were hired to keep data collection on schedule.

Objective 6

1. The invited paper was presented (see the citation below).

Objective 7

1. The Ecuadorian MS students are enrolled at WAU.
2. The Peruvian MS student delayed enrollment at MSU until the winter semester due to a leg injury.
3. The Peru Ph.D. student will start his sandwich program at WAU in October.
4. Only one of the Peru MS students at U. Cajamarca has presented a first draft oftheir theses, with the others due to be finished before the end of the year.
5. The Ecuadorian Ing. Agr. Students at INIAP are continuing their programs as planned. No major delays are anticipated.

Objective 8

1. Progress report #3 was presented for the ISAC meeting in Brazilia. The audited financial report for the period was sent to ISNAR by the CIP CFO.
2. The annual project meeting, originally planned for November was postponed to March, 1999. This meeting, six months before this project terminates, will be a major reporting and review meeting of project activities and assignment of written reports for the timely completion of the Regional Scaling project in October.

3. ORGANIZATIONAL CHANGES AND INSTITUTIONAL DEVELOPMENTS INCLUDING STAFF TRAINING, EXTERNAL CONTACTS, ETC.

During the period, a three-way collaborative research agreement was signed with the Fundación Pastaza of Ambato, Ecuador, CIP, and INIAP. The objective of the research agreement is to provide information for the calibration of erosion models that will facilitate our completion of objectives 1 and 5. The Fundación owns three four-year old erosion trials with complete weather stations but was without funds to maintain or collect data from them. In the following period, the project team, in collaboration with the Fundación, will design trials useful for scenario analysis and model calibration and will rehabilitate the trials, re-train data collectors and standardize sample collection, management and analysis.

During the period a contract was signed between CIP and the Ecuadorian Atomic Energy Commission to finance the toxicological studies of carbofuran leaching. Professor R. Merino of the Catholic University is responsible for conducting the analyses. The services purchased with this contract are now overdue due to the conflict mentioned above. Merino is very concerned and we are working with him seeking possible solutions.

During the period conversations among John Antle, Charles Crissman and George Norton of the IPM CRSP led to the development of a joint activity between the projects. The description of that activity taken from the IPM CRSP Work Plan for Ecuador is found in Annex 5

The conversion of the pasture-milk model is being done with the technical and financial collaboration of Carlos Leon Velarde, South America Representative of the International Livestock Research Institute (ILRI).

During the period additional field staff were hired for the La Encañada parcel level data collection activity. The new staff include the replacement for the student departing for Montana State, a data entry person and a second field physical measurement assistant.

4. SELECTED RESULTS OF PROJECT ACTIVITIES COMPLETED DURING THE REPORTING PERIOD

Most advances during the period were on *methodological work* on model development. Significant revisions in the tradeoffs model structure provides an innovative linkage between crop growth models and econometric decision making models. Work continued on the development of a simplified economic model, labeled a k3-type model in project jargon. We will apply the simulation model using both the more data intensive k5-type model and the k3-type model to evaluate the loss in estimation and predictive ability for evaluating tradeoffs. A simplified economic model will permit application of the model in a larger region, outside of where sample economic data collection occurred. This will facilitate extrapolating model results over larger geographic regions.

- To develop methods that allow linkages between statistical economic decision making models and process-based crop simulation models to facilitate analysis of economic, agricultural and environmental impacts of policy or technology change.

For this project objective, we made links between the crop growth models and the economic models. The figures in Appendix 3 illustrate the present structure of the tradeoffs model and show the specific linkages for incorporating the crop growth models into the integrated assessment. The original supply functions in the economic model estimated agricultural production on the basis of a vector of environmental characteristics (soils, altitude and climate) and prices of inputs and labor. The supply functions (estimated in a statistical manner) are specific to a particular region. To allow for extrapolation, mechanistic simulation models are used to transfer the vector of environmental characteristics into an inherent productivity. The supply functions were re-estimated as a function of this inherent productivity and again prices and wages. During extrapolation, the mechanistic simulation model will consider the proper processes to estimate the inherent productivity in areas where no farm survey took place.
Figure 1 shows a summary of the model structure. In the upper northwest portion of the figure are the processes to establish the inherent productivity of the survey fields. A set of location specific parcel level bio-physical data are processed through the crop growth and milk and pasture models to produce a measure of inherent productivity of the survey field which in the case of crop growth is potential yield, limited only by average fertilization levels and water availability. Conceptually, this is a summary measure of the various pieces of bio-physical information that the farmer faces. Computationally, the measure is included as additional information in the estimation

of the economic models, adding providing a means to efficiently incorporate bio-physical information into them.

In the southwestern quadrant are similar processed to establish the inherent productivity of randomly sampled fields. On the east side of the figure are the processes to establish the economic parameters. These three sets of processes feed into the land use and land management decision models contained in the oval in the center of the figure. The impacts of these land use and land management decisions are captured in the processes illustrated southern quadrant. This impacts quadrant is currently developed for pesticide leaching. Future work will add erosion and health impacts.

The economic model was improved in several aspects. Net returns from milk production were explicitly modeled using sample data from Carchi for inclusion in the land use decision stage of the model. The model was linked with the output of the bio-physical models as detailed above. Finally, the economic model was modularized. The modularization involved the development of SAS programs to estimate all economic simulation model parameters that can then be input into the simulation model. This design permits more efficient manipulation of the models by users.

- To develop methods for scaling integrated economic-biophysical modeling results from field to regional levels.

- To develop methods to link geo-referenced databases to the integrated biophysical-economic models for importing data to run the models and for display of simulated results.

For these two project objectives, Figures 2 and 3 illustrate our method for linking geo-referenced databases to the tradeoffs models. Figure 2 is our method for linking information from *survey* fields (those from which information was gathered during our data collection exercises). Fields are selected with a latitude and longitude measurement. The coordinates are then used to select characteristics from farm management and geo-referenced biophysical databases. These characteristics are then supplied to a crop growth simulation model which produces a soil, climate and average management (nitrogen levels) limited yield.

A similar logic is used in figure 3 for the selection of *sample* fields to be used in the simulation. Sample fields are selected from the GIS datasets that contain bio-physical information from all possible fields in the larger region. This is the portion of the model in which extrapolation beyond the survey watersheds. The model randomly draws a set of coordinates. The GIS database is invoked to determine the bio-physical characteristics (i.e. soil and climate) corresponding to that specific location. The shells checks whether the coordinates fall within the study area and within an agricultural area, after which the inherent productivity is determined.

Figure 4 shows the processes where leaching impacts are calculated and then aggregated from a field to a measure useful for regional analysis. The economic model produces sequences of timing and quantities of pesticide applications based on the land use (potato or pasture) and land management decisions (when and how much pesticides to apply to potatoes). These are combined with *sample* field characteristics to produce leaching for a distribution of fields in the region. The leaching outcomes are then calculated for scenario changes in relative prices or technology changes. These results are aggregated for the regional tradeoff determination.

Considerable project resources have gone to the assembly of the geo-referenced databases. One advance is the inexpensive method for downscaling soils maps. The method was established inside the survey watersheds in Carchi and reported on in the previous progress report. During this period, this work will be replicated in the Cajamarca site. Inexpensive, effective downscaling of soil maps provides a more solid base for using CGM and extrapolating their results. Work also planned for the period involves the interpolation of climatic data in the two sites.

5. FINANCIAL REPORT : BALANCE INCOME AND EXPENDITURES [EXPENDITURES PER BUDGET ITEM, ACTIVITY, SUBPROGRAM]

See financial report from CIP accounting office.

6. MAIN ACTIVITIES FOR COMING PERIOD - CHANGES OR ADJUSTMENT COMPARED WITH ORIGINAL WORKPLAN- RELATED BUDGET FOR THE NEXT HALF-YEAR PERIOD.

See the logframe for the period October 1998 to October 1999 in Annex 4 for project activities and associated budget. For activities to be completed in the upcoming period refer to the dates in the Measurable Indicators column in the Activities rows. Main changes from the previous period are: (1) the inclusion of the health scenario and the associated Carchi-based data collection, (2) the postponement of work on the climate change scenario until word is received on funding for the IAI CRN project proposal, (3) inclusion of the erosion trial management activities in Ecuador, (4) establishment of a new water sampling activity in Carchi, and (5) the shifting of the annual project meeting to March, 1999.

7. LIST OF PUBLICATIONS PRODUCED

Antle, J., C. Crissman, J. Stoorvogel and W. Bowen. "Integrating GIS Data, Crop Growth Models, and Econometric Models for Spatial Analysis of Agricultural Production." Research Discussion Paper, in preparation.

Antle, J., J. Stoorvogel and C. Crissman. "TRADEOFF: A Decision Support System for Policy Decision Makers." Version 1, September 1997. Version 2, September 1998.

Antle, J., J. Stoorvogel and C. Crissman. "User Documentation for TRADEOFF: A Decision Support System for Policy Decision Makers." In preparation.

Crissman, C.C., J. M. Antle and J. J. Stoorvogel. "Tradeoffs in Agriculture, the Environment and Human Health: Decision Support for Policy and Technology Managers." AAEA International Conference on "Agricultural Intensification, Economic Development and the Environment" July 31-August 1, 1998 Salt Lake City, Utah, USA

APPENDICES:

Appendix 1: IDRC Health Project excerpts
Appendix 2: IAI ENSO and Climate Change Proposal Executive Summary
Appendix 3: Figures:
    Summary of Tradeoffs Model
    Calcualtion of Inherent Productivity on Survey Fields
    Calculation of Inherent Productivity on Sample Fields
    Calculation of Leaching Impacts
Appendix 4: Logframe of October 1998 to October 1999 activities
Appendix 5: Excerpt from IPM-CRSP Work Plan for Latin American Site in Ecuador

Appendix 1:
Human Health and Changes in Potato Production Technology in the Highland Ecuadorian Agro-Ecosystem

A research project funded by the Canadian-CGIAR Collaborative Research Grants in Agro-Ecosystem Management for Human Health (see the RFP at http://idrc.ca/ecohealth/rfp_en.html). Below are excerpts from the project proposal.

General Objectives: To improve the health and welfare of rural residents through improving the sustainability of the potato-dairy farming system in highland Ecuador; to promote safe pesticide management practices as part of a program of integrated pest and disease management (IPM/IDM); and to demonstrate to policy makers and other stakeholders the beneficial linkages between changes in agricultural management and improved human health.

Specific Objectives:

1. In collaboration with farm women and men, *to understand* the relative importance of household practices potentially related to pesticide contamination and dietary/nutritional factors in explaining poorer neurobehavioural function between different genders in farm households.

2. In collaboration with farm men and women, *to evaluate* the health impacts for each gender of training/demonstration programs on safer pesticide use and IPM/IDM.

3. In collaboration with local and regional stakeholders, *to integrate* the above findings into tradeoffs/synergy models which relate agricultural management strategies, environmental factors, household factors, farm productivity and human health for use in policy decisions which affect agro-ecosystem management.

Abstract:

In the Andes, potatoes are a dietary staple and an important agricultural crop in the potato-and-dairy farming system; pesticides are an essential part of current production technology. Previous research in Ecuador showed that pesticide use was associated with adverse health impacts on farm families. Ecuador's sustainable agriculture program seeks to reduce farm health risks by encouraging integrated pest/disease management (IP/DM), safe field use of pesticides and improved farm household practices, without adversely affecting production. The proposed project will help achieve this development priority.

This research will extend previous studies and build on an ongoing program of eco-regional research. The latter includes an IPM implementation program of the national agricultural research institute (INIAP), national non-governmental organizations (NGO) and a CIP-INIAP-Montana State University project on measuring *tradeoffs* between the environment and agricultural output. The proposed project will support the CIP-INIAP-NGO participatory farmer-to-farmer training under FORTIPAPA by introducing IPM and safe pesticide use practices at pilot sites to farm families and women=s groups in particular.

A cluster sample of farm households in Carchi Province, Ecuador, will participate in an assessment of household practices and dietary factors and then be monitored for improvement in neuro-behavioural

function due to changes in potato production technology and safer pesticide-use practices. Selection of equivalent numbers of women and men, linkage with other agro-ecological data from sister projects and gender stratified analyses will permit clarification of differential factors and effects across genders and ecological zones. Through statistical health-effects and economic-production models, observed changes will be related to changes in production efficiency, likely environmental impacts and synergies/tradeoffs between health and productivity in the potato-and-dairy farming system. Addition of human health to the ongoing eco-regional research program will both improve benefits to farm families and strengthen the policy relevance of the program's findings.

Proponent IARC: The International Potato Center - CIP, Lima, Peru.
Project Leader: Charles Crissman
Collaborating Research Institutions:

- Instituto National Autonomo de Investigaciones Agropecuarias (INIAP)
- McMaster Institute of Environment & Health (MIEH), McMaster University
- Program for Appropriate Technology in Health (PATH Canada)

Principal Investigators:

Charles Crissman, Ph.D., The International Potato Center
Donald Cole, MD, MSc, FRCPC, McMaster Institute of Environment & Health (MIEH), McMaster U.
Victor Barrera, Ing. Agr., Instituto National Aut\nomo de Investigaciones Agropecuarias (INIAP)
Peter Berti, Ph. D., Programme for Appropriate Technology in Health (PATH Canada)

Collaborating NGO's:

Agricultural extension NGO's in Ecuador, including the Centro Educativo de Servicios Agricolas (CESA), the Fondo Ecuatoriano de Progresum Populorm (FEPP), and CARE-International.

Appendix 2:
An Integrated Assessment of ENSO and Climate Change Impacts on Andean Agriculture

A research proposal to the Collaborative Research Network program of the Inter-American Institute for Global Change Research (IAI CRN) (See the RFP at http://geoserver.geo.nsf.gov/adgeo/international/iai/crnfina.htm). Below is the executive summary from the proposal.

Principal Investigator: Charles Crissman, International Potato Center (CIP), Quito, Ecuador

Institutions: Instituto Geofísico del Perú (IGP), Lima, PERU
Consortium for the Sustainable Development of the Andean Ecoregion (CONDESAN)
Centro Internacional de la Papa (CIP), Lima, PERU
Universidad Nacional de Cajamarca, Cajamarca, PERU
Servicio Nacional de Meterología y Hidrología (SENAMHI), Lima, PERU
Universidad de Los Andes, Merida, VENEZUELA
Instituto Nacional de Meterología y Hidrología, (INAMHI), Quito, ECUADOR
Universidad de Caldas, Manizales, COLOMBIA
International Fertilizer Development Center (IFDC), Muscle Shoals, Alabama, USA
University of Florida, Gainesville, Florida, USA
Montana State University, Bozeman, Montana, USA
University of Montana, Missoula, Montana, USA

The inclusion of institutions and individual researchers with experience in atmospheric sciences will strengthen an existing network dedicated to the sustainable development of the Andean ecoregion called CONDESAN. The proposed research will develop the scientific basis to conduct an integrated assessment of the human dimension of ENSO and climate change impacts in the Andes. The research will do this by integrating research on ENSO-related climate variability and climate change with research developing a Decision Support System (DSS) of integrated economic, biophysicial and crop growth models. The basis for the integrated assessment is the quantification of tradeoffs between agricultural production, the environment, and human health. An important hypothesis to be investigated is that ENSO and climate change effects will lead to unfavorable shifts in these tradeoffs, such that present agricultural production systems will be characterized by greater risk and increased vulnerability to soil loss, with these characteristics being greatest in marginal hillside agriculture. Researchers will develop ENSO effects and forecasting models for selected major agricultural environments of the tropical Andes mountains. CONDESAN is devoted to the development of integrated assessment tools, but lacks sufficient funding and expertise to include ENSO-related climate variability and climate change in scenario analyses. This unique team of atmospheric and soil scientists, remote sensing, systems, and livestock specialists, economists, and agronomists will pursue the following objectives. (1) To strengthen the capacity of Andean scientists and institutions to provide integrated assessments of the likely impact of ENSO-related climate variability and global climate change on Andean agriculture. (2) To characterize the relationship between ENSO signals and climate variability in major Andean agricultural environments. (3) To quantify the adaptability, sustainability and vulnerability of Andean agriculture to ENSO events and projected climate change by augmenting ongoing data collection and model integration activities. (4) To identify policy and technology options that may take advantage of positive opportunities or reduce the negative impact of extreme weather events and projected climate change; and (5) to communicate to decision-makers the implications of ENSO-based climate forecasts and climate change projections. The policy relevant impacts of this project will be felt through better-informed decision making in a variety of political and research settings. By combining ENSO and climate change scenarios with policy and technology scenarios, it will be possible to assess how the potential impacts of ENSO and climate change may be aggravated or mitigated by these policy interventions.

Annex 5:
Excerpt from IPM-CRSP Work Plan for Latin American Site in Ecuador

III. Training and Socioeconomic Activities

III.1 Modeling impacts of changes in pest management technologies (joint research activity with the SOILS CRSP)

a. **Scientists:** C. Crissman, P. Espinosa – CIP; R. Jacome – INIAP; J. Antle – Montana State (SOILS CRSP); P. Pardey and S. Wood – IFPRI; G. Norton, S. Hamilton – Virginia Tech.

b. **Status:** New activity

c. **Objectives:** To (1) assess the impacts of IPM technologies on land use and management, farmer income, and pesticide use, (2) assess the aggregate economic impacts of the IPM technologies developed on the IPM CRSP, including spillovers across regional and national boundaries, (3) assess the health and economic impacts of IPM CRSP technologies by gender .

d. **Hypotheses:** (1) Land use and management, farmer income, and pesticide use will not be affected by IPM technologies generated on the IPM CRSP, (2) IPM CRSP technologies do not have economic impacts or spillovers, (3) IPM CRSP technologies do not have differential health and economic impacts by gender

e. **Description of research activity:** A bio-economic simulation model will be used to address objective one. This model is currently being developed on the SOILS CRSP to explore the effects of factors such as changes in technologies and prices on land use and management, revenues, income stability, erosion, contamination of water tables, etc. This model is being developed for the same geographic region where the potato IPM work is underway on the IPM CRSP. It is proposed that reductions in pesticide use be measured or projected due to generation and adoption of IPM technologies on potatoes and that these pesticide use changes be fed into the bio-economic model as a scenario, with modifications made to the model as needed. To address objective two, it is proposed that the per unit cost reductions measured or projected due to IPM CRSP technologies be combined with measured or projected information on adoption and included in an economic surplus model to generate aggregate benefits. All changes in input use, outputs, and prices are being measured for each of the CRSP experiments. This information will be used to help generate per unit cost changes. Information on agro-ecological zones assembled by IFPRI and included in a GIS model will be used in the economic surplus model to help define the potential spillovers of the technologies. For objective three, survey information on household labor allocation and income distribution within the household will be used to project gross gender-differentiated economic impacts. Health impacts by gender will be examined by collecting information on activities by gender that might directly (e.g. applying pesticides) or indirectly (e.g. washing clothes of pesticide applicators) lead to pesticide exposure.

f. **Justification:** Knowledge of farm, regional, and aggregate level impacts of IPM is essential for designing IPM programs and pest management recommendations, for justifying programs and research activities, and for designing environmental policies and programs. These impacts often spill over across regions and have differential effects within the household. The Ecuador potato site provides an excellent opportunity to join together modeling efforts and data generated on two CRSPs and by two international agricultural research centers to produce unique impact assessment information. Application of the models developed at this site may provide a template for subsequent joint research activities in other sites as well.

g. **Relation to other research activities at the site:** This project directly complements other research activities underway on the SOILS CRSP on bio-economic modeling and at CIP and INIAP in general and on the IPM CRSP in particular to control late blight, Andean potato weevil, and potato tuber moth. It uses the results of those other research activities to generate the raw material needed to conduct the impact assessments.

h. **Projected outputs:** The activity will produce both models and reports that describe impacts of the IPM research on potatoes in Ecuador.

i. **Projected impacts:** The results should generate information on which technologies to promote in training programs, on which IPM alternatives might justify further research, and on the benefits of pest management policies or regulations that influence pesticide use. It should provide information to help in justifying IPM programs.

j. **Start:** September 1998

k. **Projected completion:** September 2003

l. **Projected person-months of scientist time per year:** 6

m. **Budget:** INIAP/CIP: $8,360, Montana State: (covered by Soils CRSP), Virginia Tech: $19,050 (including $10,000 for graduate student support), IFPRI: $15,400