ECU 005/99

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

PROGRESS REPORT #6

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Project title: Regional scaling of field-level economic-biophysical models (DME-Nor)
Organization: CIP
Duration of the project: October 1996 – September 1999
Reporting period: May, 1999- October, 1999
Date of reporting: September 30, 1999

Progress report #5 provided extensive narrative descriptions of most activities of the project. This progress report focuses on developments and results in the last six month period.

This penultimate report to the ISAC of the Ecoregional Fund highlights the ongoing nature of the research program established around the Tradeoffs concept. The DME funds were the second source of funding for this program and the only funds to provide explicitly for methodology development. The support provided by the Fund has significantly contributed to the development of this program and provided for major advances in resolving important methodological hurdles. This is the penultimate report since we requested a six month no-cost extension of the financing from the Fund to complete certain field activities in Ecuador and Peru.

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.

Specific objectives of the project are to:

1. Link soil processes (erosion and fertility) with the tradeoffs model of Crissman, Antle and Capalbo, 1997.
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 (the Tradeoff 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 Tradeoff 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 Tradeoff Model to extrapolate results to a regional basis.
6. Based on the Tradeoff 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 Tradeoff Model and the use and interpretation of integrated economic and bio-physical modeling.
8. To communicate the empirical results of the Ecuadorian and Peruvian studies to the appropriate sets of users in the Andean region.

2. PLANNED AND COMPLETED ACTIVITIES

For planned activities please refer to the Logframe attached in Appendix 4. For a narrative review of completed activities please see section four below.

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

New Projects and Collaboration

Team members proposed four new allied projects during the last year. Two were funded while the others are still pending. Two new significant collaborations were added and one is pending. Below are brief summaries. Abstracts of the projects are found in the appendices.

Funded Research Proposals:

- "New Methods in Presenting Research: Hypertext Compact Disks and Andean Watersheds": This is a CIP-IDRC-U. British Colombia collaboration. The funding for CIP-Ecuador participation comes from the DME-Nor project and helps the project comply with its specific objectives numbers 7 and 8. The objective of this new collaboration is to introduce hypertext concepts in the presentation of research programs and research results. With the guidance of the Institute for Resources and Environment of the University of British Colombia, research groups working in five Andean watersheds, including the Tradeoffs Project's research sites in Carchi and Cajamarca, will cooperate in a series of workshops in Peru and Ecuador to produce hypertext CDs that present the research program and research results relevant to the watershed. This new proposal

- "Eco-soils: Investigation for the ecological management and productivity of soils in the Ecuadorian Andean Eco-region": This is a CIP-INIAP-U. Guelph collaboration financed by the Competitive Grants for Research fund of the Agricultural Services Modernization Program (PROMSA) of the Ecuadorian Government. The objective of this three year project is to screen various agricultural practices for their impact on the regenerative capacity of soils with a special emphasis on the biological component. This project adds an important component of soil husbandry as a new scenario for application to the Tradeoffs Model. This proposal was awarded and will receive initial financing in December.

Pending Proposals:

- "Climatic variability and its relationship with agriculture in the Ecuadorian sierra: Impact of El Niño and the Southern Oscillation (ENSO)": This is a CIP-INIAP-INAHMI (National Meterological Institute) – Florida Consortium (U. Miami, U. Florida, Fla. State U.) collaboration financed by the Strategic Alliance fund of the Agricultural Services Modernization Program (PROMSA) of the Ecuadorian Government. The objective of this three year project is to develop and implement methodologies to evaluate the climatic variability associated with ENSO events and screen various agricultural practices for their impact on Sierra agriculture. This project provides for specific links to the Tradeoffs Model program to provide decision support for the use of climate predictions and the impact of alternative policies given those predictions. This project is still pending approval.

- "Strengthening research capacity for productivity improvement and sustainability of mixed livestock-crop systems in the Andean eco-region." This is a CIP-INIAP collaboration financed by the Strategic Alliance fund of the Agricultural Services Modernization Program (PROMSA) of the Ecuadorian Government. The objective of this three year project is to introduce capabilities in systems analysis to improve productivity and sustainability in the important small holder crop-livestock sector found on the valley walls of the sierra. This project provides the opportunity to extend the analysis of the potato pasture system of Carchi to other regions of the country. This project is still pending approval.

Collaborations:

- "Relations between Rural Poverty and Environmental Degradation in Latin America." An Interamerican Development Bank FONTAGRO fund project coordinated by RIMISP of Santiago, Chile and CIP. An Ecuador case study (one of ten in the project) is being implemented by CIP in collaboration with the MANRECUR Project of the Foundation for Agricultural Development (FUNDAGRO). The case study will regress erosion status of fields against measures of farm household poverty and access to technology. The project combines the soil map downscaling and erosion mapping work from DME-Nor and a large poverty-demography survey conducted by the MANRECUR team.

- "Mechanical erosion on hillside farms in Ecuador." The Program for the Management of Water and Soil (PROMAS) is a cooperative research program between the Catholic University of Leuven-Belgium and the Universidad de Cuenca. The Flamencan Inter-university Council funds the program through the Belgian Cooperation Administration. PROMAS has pioneered in Ecuador research methods to measure mechanical erosion caused by tractors, oxen, and hand tillage during land preparation. We are implementing trials in Carchi with tractor tillage that are part of a national set of trails. Combined with our existing water erosion work, this collaboration gives us valuable insights into the relative importance of the types of erosion in fields of different slope angles and length and soil type.

- Proposed collaboration: "The nature of change: people and land use in the Northern Andes." WOTRO Multidisciplinary Program Grant presented by the Department of Environmental Sciences WAU with collaboration of CIP, Universidad de los Andes of Merida, Venezuela, and Gottingen University, Germany. Early meetings of the DME-Nor research team included WAU faculty with expertise in land use change and pioneers in the use of the CLUE methodology. However, these members eventually moved out of the university and dropped off the team. There are many similar conceptual elements between the CLUE and Tradeoffs methodologies. Both approaches utilize similar spatial data and include as a key element an examination of land use. The CLUE methodology bases land use changes on observed trends and when projected to the future, limited by a combination of biophysical characteristics, technology and policy. The Tradeoffs methodology passes these characteristics through the filter of an econometric optimization model. This collaboration will provide an opportunity to explore commonalties and differences between the two approaches.

Dissemination of Project Accomplishments

In the tradeoffs program we define three types of stakeholders. First are the Tradeoffs Program research collaborators. These individuals are either fully trained professionals or professionals qualified for further degree training. Participation in the Tradeoffs Program brings new experiences in systems analysis and agricultural research based on modeling and the use of other new tools.

The second group of stakeholders are those individuals that constitute the analyst users of the Tradeoff Model. This group of stakeholders provides the perspective of the utility of the model

and the functionality of its components. This group of stakeholders are typically trained analysts working in government ministries or other agencies, universities, or in research oriented NGOs.

The final group of stakeholders are those end product users of Tradeoffs Model results. These users are engaged in both priority setting for Tradeoffs Model applications, provide feedback on interim results and utilize final results. This group of stakeholders involves individuals with responsibilities for national, regional or local decision making about agricultural, environmental, health or other policy. This group is also concerned about agricultural, environmental and health technology development and implementation.

Montana State University hired Dr. David Yanggen as a post doctoral agricultural economist to work in Quito with the Tradeoffs Program team starting in January 2000. Part of his job assignment will be to develop a program of stakeholder engagement in the Andean region during 2000 and 2001. This will include events to introduce the Tradeoffs Model and concepts to the second and third stakeholder groups and to provide training in its use. This will also include collaborative exercises with the second stakeholder group to engage the opinions of the third stakeholder group.

A number of activities were completed in 1999 to disseminate project work.

- In September, 1999, some of the project's findings were presented by John Antle at a workshop on "Integrating Ecological and Economic Models" at the GCTE conference held at Reading University, England.

- The project was selected as one of four Eco-regional Fund projects to present during a plenary session at the Third International Symposium on Systems Approaches for Agricultural Development (SAAD3) in Lima, Peru on November 8, 1999.

- In October 1998, Jetse Stoorvogel presented "A Decision support system to quantify trade-offs in sustainable agriculture and the environment in the Andes" to the *Workshop on Ecoregional Research* at the International Livestock Research Center in Addis Ababa.

- John Antle presented an invited seminar on the project at the Washington DC offices of USAID in June, 1999. The presentation is available on the web at www.trc.montana.edu/crsp/crsp.html.

- Presentations given during the project workshop held in March, 1999 in Quito, are also available on the web at www.trc.montana.edu/crsp/crsp.html.

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

Narrative of Accomplishments

MODEL DEVELOPMENT and DATA COLLECTION

- Version 2.1 of the Tradeoff Model, a decision support system for policy makers, was completed. This software integrates field-scale GIS-based soils and climate data with the DSSAT suite of crop growth simulation models, econometric-based economic simulation models of land use and management decisions, and environmental process models (leaching, runoff and erosion). The software provides the basis to draw a statistically representative sample of fields in a region such as a watershed, conduct integrated analysis, and statistically aggregate the results to a scale relevant to policy decision making. The software displays tradeoffs between competing or complementary policy objectives in simple two-dimensional graphs, and shows how these tradeoffs change under alternative policy and technology scenarios. The software was documented in a report that has been submitted to the Quantitative Approaches to System Analysis Series.

- An analytical framework was developed for analysis of soil quality and related long-term sustainability issues within the Tradeoff Model in a paper by Antle and Stoorvogel (1999).

- Farm-level survey data collection continued at the Cajamarca site in Peru. The first three crop cycles of data from 810 fields was completed. Data were computerized and prepared for analysis. On going data collection from the fourth and fifth crop cycles have added an additional 258 fields. Data collection will finish in February, 2000 when the last parcels from the fifth cycle are harvested. Dynamic monitoring of the cow herds of those farmers with cows was started.

ECONOMIC RESEARCH and DATA COLLECTION

- A methodological framework was developed for integration of crop models (such as the DSSAT models) into econometric and economic simulation models (see Antle and Capalbo, 1999). This framework is being incorporated into the Tradeoff Model software.

- Procedures for simplifying the econometric productions models were developed and applied to the pesticide application model for Carchi. A simpler static version of the model was developed to compare to a more complex and data-intensive dynamic model. Results showed that the simpler model did not accurately reproduce the health-output tradeoffs generated by the dynamic mode. This finding suggests that attempts to simplify the pesticide data collection process may lead to a significant loss of information relative to analysis of health-output tradeoffs. This work is being written-up for publication.

- Relationship of poverty and environment. A new research collaboration (see section 3 above) finances a case study relating farmer wealth and erosion status of farmer parcels. We are using

an existing survey designed to establish poverty indices and demographic and migratory trends among a sample of farm and non-farm households in El Angel. This survey is being combined with Tradeoff Project developed methods to evaluate the effects of poverty and associated household characteristics on land use and its consequent effect on erosion. Analysis of land use history using methods previously developed in this project (Veen 1999) are being applied in El Angel to develop a parcel-level map for linking with the existing farm household survey in El Angel.

- Household food consumption in Ecuador. During the 1990's Ecuador has conducted regular national surveys on Household economic conditions called Encuestas de Condiciones de Vida. The surveys are conducted by the National Statistical and Census Institute (INEC) of more than 6000 households are statistically representative of urban and rural areas in distinct ecoregions of the country. The survey data has only recently become available for use by third parties. In this thesis research, we are utilizing the 1995 survey to estimate household demand for food items, the income and nutritional impact of changing incomes and prices for those food items and the distributive effects of these changes in different sectors of Ecuadorian society. This is the first household food demand research done in Ecuador since the 1970's and will provide us with relatively current estimates of price and income elasticities of demand for individual foods and food groups. These demand elasticities are a key element to establish market level distribution effects of different scenarios imposed on the Tradeoffs Model. This activity is a collaboration of the Tradeoffs Program with the IPM CRSP.

SOIL and EROSION RESEARCH and MODELING

- A major issue in the bio-physical modeling is the lack of appropriate quantitative soil data. Traditional soil surveys often only describe soils in a qualitative model and the mapping units are simply too large. Typically, representative profiles are described and analyzed. The data from one profile are simply used for the mapping units. The variability within mapping units is simply disregarded. With the thesis research of Van Soest (1998) and Meyles and Kooistra (1998) an appropriate database was created for the Carchi site. A digital elevation model and the concept of functional horizons provided the basis for downscaling the existing explorative soil survey. The same methodology has now been applied to the Cajamarca study site. The results published in a thesis report (Overmars 1999) provide the quantitative descriptions of the soils necessary for bio-physical modeling.

Meyles , E., and Kooistra, L., 1998. A novel method to describe spatial soil variability: a case study for a potato-pasture area in the northern Andes of Ecuador. MSc Thesis, Wageningen Agricultural University.

Van Soest, F., 1998. A method for downscaling Soil Information from regional to catena level. MSc Thesis, Wageningen Agricultural University.

- Soil variability within soil mapping units can have different origins. Topography plays an important role and if a detailed digital elevation model is available this can be used to reveal this variability. However, only part of the variability can be explained. Other sources of variation are micro-climate (currently under study by Baigorria) and the influence of

management. In Carchi, especially mechanical erosion as a result of soil tilling seems to play an important role. Frequently, it is observed that the topsoil has been removed completely in fields. We investigated in detail this mechanical erosion and related it to land use history, soil type and slope. The results from the field survey were used to successfully develop simple statistical models to extrapolate the results to the entire study area. The results were published in the research report of Veen (1999).

- Cooperation with Catholic U. of Leuven of Belgium and U. of Cuenca in southern Ecuador in national trials for measuring erosion effects of land preparation on sloping fields with tractor, oxen and hand tillage. The trials being conducted by the Tradeoffs Program team are in Carchi. Similar trials are being conducted in Chimborazo and Azuay provinces for oxen and hand tillage. These trials complement the above mentioned work on erosion and land use history and will provide experimental data which measure the downward flow of soil due to tillage. The Carchi trials, being conducted by INIAP collaborators, will focus on tractor tillage and sample approximately 20 fields with distinct soils and slopes.

- In the previous report we documented a field experiment that was carried out to monitor two-dimensional water flow with bromide on two farmers' fields in Carchi. The research showed that lateral movement of water is important in the sloping fields of the area. This makes the usage of one-dimensional models (like LeachP) rather cumbersome. Recently a two-dimensional model denominated Hydrus-2D (suitable for the simulation of water movement and solute transport) was published by Simunek *et al* (1996). With the soil database available for Carchi and Hydrus-2D we were unable to reproduce the observed bromide movement in the soil. The extreme topography may be one reason why the model does not work properly. Another reason may be an-isotropy in the hydrological characteristics of the soils. Preliminary results were published in the report of Meerbach (1999).

Simunek, J., Sejna, M., and van Genuchten, M.Th., 1996. The HYDRUS-2D software package for simulating water flow and solute transport in tow-dimensional variably saturated media, version 1. U.S. Salinity Laboratory, USDA, Riverside, USA.

- The project works at two, relatively small study sites. It is important to check whether these sites are representative and whether the results also apply to a larger area. In Ecuador, the main study area includes two watersheds just north of San Gabriel. The potato pasture production area continues to the east in the direction of Tulcan and to the west in the direction of El Angel. Veen (1999) and De Vries (1999) have studied soil variation in both areas. Soils were rather different in the different areas and also the risk for pesticide leaching. However, since models are being used to describe the processes we are able to capture these new conditions if basic data are available. In other words, it is likely that we will find different tradeoffs in those area but the situation is not that different that we need other models or tools.

- A M.Sc. thesis was started to investigate the spatial variability in soil fertility within the San Gabriel area. This thesis will develop methodologies to review the spatial variability in soil fertility using existing data and information. It will describe the spatial distribution of soil fertility at field and regional levels and compare costs of different methods.

- Toxicological studies of carbofuran adsorption/desorption, half-life, percolation, and movement were completed. The study shows the importance of local calibration of these important pesticide characteristics. Although many studies make use of standard databases provided by, for example, the United Stated Environmental Protection Agency, local conditions may have an enormous impact on the variables. Subsequently using the new toxicological information, field validation of LEACHM in Carchi was started as a thesis project.

- Topographic variables for slope, aspect, and altitude derived from a digital elevation model (DEM) have been combined with equations for interpolating maximum and minimum temperatures and solar radiation values in the La Encañada watershed in Cajamarca, Peru (Baigorria and Bowen, 1999). Continued collection of climatic data in the La Encañada watershed in collaboration with ADEFOR.

- A new cost-effective methodology for multi-scale data collection to estimate soil erosion is under investigation. A special three-stage methodology was developed for data collection and model validation. This is being tested at the La Encañada watershed in Cajamarca, Peru. Step one consists of a broad investigation of all WEPP input parameters at the watershed scale followed by an uncertainty analysis. This analysis provides the decision support for the second step that consists of the validation of the hillslope version of WEPP. Finally, in a third step the watershed version is validated using the knowledge and experience gained in the previous steps. The WEPP is then used to recommend appropriate conservation strategies for the region. (Romero and Strosnijder, 1999)

- Data collection in collaboration with the Fundación Pastaza continues from the three rehabilitated erosion runoff plots in Ecuador.

MILK-PASTURE MODELING

- In collaboration with ILRI, the pasture/milk simulation model was converted from Quickbasic Extended V7.1 to FORTRAN. The model was validated in the Parish of La Libertad in Carchi in the canton adjacent to the San Gabriel work site. To give a larger functional range to the model, the project has financed a thesis at ESPOCH in the central Andean province of Chimborazo. This thesis is done with the rangelands group at ESPOCH that have a large paramo pastures database and cattle are grazed at generally higher altitudes in dryer conditions compared to Carchi. A second model validation activity is underway in Cajamarca where two professors in the graduate school of the National University of Cajarmarca are validating the model in two agro-ecozones, one in the La Encañada watershed and the other on the valley floor of Cajamarca.

- We have viewed with concern the lack of available data on pastures in Peru and Ecuador and have initiated an effort to collect and systematize this data for use by the Tradeoffs Program and others.

CROP MODELING

- A soil organic module from the CENTURY model has been incorporated into the DSSAT crop models to better simulate C and N dynamics in low-input systems (Gijsman and Bowen, 1999). Collaborators at INIA and the University of Cajamarca harvested a potato experiment in early May 1999 that was designed to obtain detailed growth analysis data and soil water and inorganic N measurements with time for validating the potato models.

- The potential production model LINTUL-potato (Kooman et al, 1995) was extended with soil water and soil nitrogen models. The effects of water and nitrogen limitation on potato growth and development were included. The soil moisture content affects via Relative Water Content (RWC) of the leaves:
    1) the leaf expansion rate
    2) the Light Use Efficiency (LUE)
    3) the partitioning of assimilates between root and shoot by an assimilate balance method of the different plant organs.

  The nitrogen availability in the soil affects via the shoot-N concentration the:
    1) shoot (leaf) growth rate
    2) the Light Use Efficiency (LUE)
    3) the partitioning of assimilates between root and shoot by an assimilate balance method of the different plant organs.

  The Late Blight model developed by van Oijen (1993) was extended with the Active Leaf Layer Model. The LINTUL Late Blight model simulates:
    1) the resistance and virulence components of crop and pathogen respectively,
    2) the crop damage and
    3) the effects of different spraying regimes on pathogen development and crop damage.

  The resistance and virulence components of the host/pathogen interaction are taken from human epidemiology. Five components are distinguished:
    1) infection efficiency
    2) latency period
    3) lesion growth
    4) infective period
    5) sporulation rate

  These five components characterize the host/pathogen interaction during the cropping season.

  The effects of spraying are simulated with the leaf cohort model. The leaf cohort model allows for leaf position specific infection rates. The leaf position determines the duration of leaf wetness, which affects the Late Blight infection probability. The leaf cohort model also allows for the incorporation of spraying regimes. Each time step the ratio between fungicide protected and non-protected leaves is calculated. The probability of Late Blight infections decrease with increasing protection. A site specific optimal spraying schedule can be determined which allows for different leaf growth rates due to environmental conditions, fungicide characteristics for denaturation and wash-off and if necessary weather predictions.

The pesticide Trade Off model developed several years ago and applied successfully in a range of policy studies. The Pesticide Trade Off model essentially calculates the trade off between several environmental and human health characteristics and potato production by applying several potato production strategies involving different Late Blight management strategies. The Late Blight management strategies are based upon application of either (partially) resistant cultivars or spraying of preventive and curative fungicides. The LINTUL Late Blight Active Layer model is within the DME-NOR project incorporated within the Trade-off decision support system.

- Thesis studies completed in Ecuador provided validation of genetic coefficients of the DSSAT maize and bean models (Tapia 1999, Flores 1999). These studies provide the basis for an eventual application of the Tradeoffs Model in the agro-ecozone immediately below the potato-pasture zone where we are presently working.

HEALTH

- Several activities relevant to the Tradeoffs Model and research program were initiated within the Eco-Salud project. First, three communities were identified and approximately 60 farm family volunteers recruited for collaboration in project data collection and training activities. In these three communities, base line surveys were completed of farmer and wife knowledge, attitude and practice concerning pesticides. WHO-type neuro-psychological batteries were administered to two of the communities with the third community now in progress. Farmer field school training in IPM and pesticide safe handling were started in the three communities. Parcel-level monitoring of production and expenses was started on a sample of fields from the farmer participants in the FFS. The data collected will be consistent the previously collected Carchi data and the Cajamarca data being collected.

PROJECT ADMINISTRATION and MANAGEMENT

- Project research reports were prepared, and presentations were made at international scientific conferences.

- A proposal to the Competitive Grants for Research component of the Agricultural Services Modernization Program of Ecuador (PROMSA) was awarded. A funding proposal for Hypertext presentation of the Carchi research program was developed and approved. Two proposals for the Strategic Alliances component of PROMSA were prepared and are pending.

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.

See the logframe for the period 1999-2000 in Annex 5 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.

PUBLICATIONS, REPORTS AND PRESENTATIONS

Note: Project publications and reports can be found on the project web page at www.trc.montana.edu/crsp/crsp.html.

Antle, J.M. and S.M. Capalbo, "Econometric-Process Models for Integrated Assessment of Agricultural Production Systems." Paper presented at Department of Agricultural and Resource Economics, UC Davis, May 1999. Manuscript submitted for publication to *American Journal of Agricultural Economics*.

Antle, J.M. and J. Stoorvogel, "Integrated Assessment of Sustainable Land Use and Soil Quality." Paper presented at the conference on Sustainable Land Use in Developing Countries, Wageningen, June 1999. Submitted for publication in a volume based on the conference.

Antle, J. and C. Crissman, "Temporal Input Aggregation in Production Models: The Case of Pesticides." Research report in preparation.

Antle, J., S. Capalbo and C. Crissman, "Econometrics-Based, Stochastic Simulation Models of Production for Analysis of Economic and Environmental Tradeoffs in Agriculture." Research report in preparation.

Baigorria, G.A. and W.T. Bowen. 1999. A process-based model for spatial interpolation of extreme temperatures and solar radiation. Paper accepted for presentation at the Third Systems Analysis for Agricultural Development Conference in Lima Peru Nov 7-11, 1999.

Bowen, W.T., H. Cabrera, V. Barrera, and G. Baigorria. 1999. Simulating the response of potato to applied nitrogen. p. 381-386. CIP Program Report 1997-1998.

Bowen, W.T., G. Baigorria, V. Barrera, J. Cordova, P. Muck, and R. Pastor. 1999. A process-based model (WEPP) for simulating soil erosion in the Andes. p. 403-408. CIP Program Report 1997-1998.

De Vries, G., 1999. Andean soils and pesticides: determination of the risk for pesticide leaching in the potato production area of Northern Ecuador. MSc Thesis, Wageningen Agricultural University.

Flores, M. 1999. Validación del Modelo CROPGRO DSSAT para el cultivo frejol arbustivo en el Canton Mira, Provincia de Carchi. Tesis de Grado para la obtencion del titulo Ing. Agr. del Escuela Politenica de Chimborazo, Riobamba, Ecuador.

Gijsman, A.J. and W.T. Bowen. 1999. Simulating crop production in low-input agricultural systems with DSSAT linked to the CENTURY soil organic matter module. Paper accepted for presentation at the Third Systems Analysis for Agricultural Development Conference in Lima Peru Nov 7-11, 1999.

Meerbach, D., 1999. Water flow and solute transport in soils in the region of San Gabriel, Ecuador. MSc Thesis, Wageningen Agricultural University.

Overmars, K.P., 1999. Developing a method for downscaling soil information from regional to catena level. MSc Thesis, Wageningen Agricultural University.

Romero, C.C. and L. Stroosnijder. 1999. A multi-scale approach for erosion impact assessment in the Andes. Paper accepted for presentation at the Third Systems Analysis for Agricultural Development Conference in Lima Peru Nov 7-11, 1999.

Stoorvogel, U. C. Crissman, J. Antle and W. Bowen. "A Decision support system to quantify trade-offs in sustainable agriculture and the environment in the Andes." In P.K. Thornton and AnN. Odero (eds.) *Proceedings: Workshop on Ecoregional Research at ILRI*. ILRI, Addis Ababa, 5-8 October 1998. Pp 123-134.

Stoorvogel, J.J., J. Antle, C. Crissman, and W. Bowen, 1999. *The tradeoff model: A Policy Decision Support System for Agriculture*. Quantitative Approaches to Systems Analysis, Graduate School of Production Ecology, Wageningen, The Netherlands. (Submitted)

Tapia, R. 1999. Validación del modelo de simulación DSSAT – Cultivo de Maiz en los condiciones climaticos y de suelo de la sección oriental de la Estación Experimental INIAP Santa Catalina. Tesis de Grado. U. Central, Quito, Ecuador.

Veen, M. "The development of Land Use and land management, and their effects upon soils in processes of erosion and compaction. M.Sc. Thesis Wageningen Agricultural University.

STUDENTS SUPPORTED BY THE SM-CRSP/DME-NOR PROJECTS

Note: the following students are supported by the SM-CRSP project in collaboration with CIP and WAU :

Name	Degree	Institution	Home Country	Date Expected
Roberto Valdivia	M.Sc.	Montana State U.	Peru	2001
Mykel Mathews	B.S.	Montana State U.	USA	2000
Cecilia Ortíz	Ph.D.	Utah State University	Ecuador	1999
José Negrete	Ing. Agr.	Esc. Pol. de Chimborazo	Ecuador	1999

Hernán Uvidia	Ing. Agr.	Esc. Pol. de Chimborazo	Ecuador	2000
Neidy Clavijo	Ing. Agr.	Esc. Pol. De Chimorazo	Ecuador	1998
Miguel Flores	Ing. Agr.	Esc. Pol. De Chimorazo	Ecuador	1999
Roque Tapia	Ing. Agr.	Univ. Central, Quito	Ecuador	1999
Fabian Muñoz	Ing.Estadistico	Univ. Central, Quito	Ecuador	2000
Genaro Carrión	M.Sc.	U. Nac. de Cajamarca	Peru	1999
Sara García	M.Sc.	U. Nac. de Cajamarca	Peru	1999
Ernesto Rodriguez	M.Sc.	U. Nac. de Cajamarca	Peru	1999
Mario Cáceres	M.Sc.	U. Nac. de Cajamarca	Peru	1999

Note: the following students are supported jointly by the SM-CRSP and DME-Nor projects in collaboration with CIP and WAU :

Ramiro Merino	Ph.D.	Wageningen Ag. U.	Ecuador	2001
Guillermo Baigorría	Ph.D.	Wageningen Ag. U.	Peru	2001
Consuelo Romero	Ph.D.	Wageningen Ag. U.	Peru	2001
Raul Jarrimillo	M.S.	Wageningen Ag. U.	Ecuador	2000
Magedelena Lopez	M.S.	Wageningen Ag. U.	Ecuador	2000

Note: the following Dutch students were supported primarily by the DME-Nor grant in collaboration with the SM-CRSP project and CIP in Ecuador and Peru.

David Meerbach,	M.Sc.	Wageningen Ag. U.	Netherlands	1997
Francien van Soest	M.Sc.	Wageningen Ag. U.	Netherlands	1997
Erik Meyles	M.Sc.	Wageningen Ag. U.	Netherlands	1998
Lammert Kooistra	M.Sc.	Wageningen Ag. U.	Netherlands	1998
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Abbreviations and Acronyms

AB-DLO	Research Institute for Agrobiology and Soil Fertility, the Netherlands
CIP	International Potato Center
ESPOCH	Escuela Politenica de Chimborazo, Ecuador
IDRC	International Development Research Council, Canada
IFPRI	International Food Policy Research Institute, United States
INIA	National Institute for Agricultural Research, Peru
INIAP	National Institute for Agricultural and Livestock Research, Ecuador
PROMAS	Program for the Management of Water and Soil of the U. of Cuenca
PATH	Program for Appropriate Technology in Health

Annex 1:
New Methods in Presenting Research: Hypertext Compact Disks and Andean Watersheds

Participating Institutions:

- CIP/CONDESAN
- University of British Columbia – Institute of Resources and Environment
- Universidad de Caldas – Facultad Post-Grado
- University of Cuenca – Programa de Manejo de Agua y Suelos (PROMAS)
- Universidad Nacional de Puno –
- IDRC – Proyecto MANRECUR 2

General Objective: To introduce to Latin American researchers the use of hypertext media for presenting agricultural/environmental research problems and research results.

Specific Objectives:

- Through a series of workshops, train five research teams working in five different research sites in the high tropical Andes in the design and preparation of hypertext compact disks for presentation of the nature of agriculture and environment in highland tropical watersheds.
- The research teams produce five compact disks which profile their work in the five different sites.
- Present this work in fora during the UNEP Year of the Mountain.

Justification:
The incorporation of sustainability criteria in agricultural research and development agendas has brought an increasing level of complexity in the problems to be confronted. What was a commodity oriented approach was broadened to a farming systems approach and is now an approach that is concerned with the environmental setting and impacts (among other things) of farming systems. All this is to be done preferably within a setting where stakeholders are consulted and advised. Identifying, relating and communicating all the complimentary and conflictive elements of an agenda to promote the sustainable development of a given region is a difficult and time consuming task.

The development of modern computer-based multimedia systems offers new opportunities to consult and communicate with stakeholders during consultation and results sharing exchanges. The Institute for Resources and the Environment of the University of British Columbia has developed expertise in the use of hypertext-based presentation in both compact disks and in web sites in the internet. Their expertise comes from cases of working in the problems of watershed development and management in both Canada and developing countries. Hypertext-based presentations allow an unprecedented flexibility in structuring the many biophysical, agricultural, economic, and cultural interrelationships found in these settings. Hypertext allows users to move in a non-linear fashion among the various elements. It further allows information presentation to by layered. A first layer can be for users simply wanting to familiarize themselves with what is happening. A second layer can present analysis and additional layers can go deeper into analysis, theory and data presentation. Further, the media can be continually updated. As new research

or development results are achieved, the compact disk or web site can be updated. This supercedes the traditional problem of deciding when to cut off research for presentation in a book or research paper.

CONDESAN has promoted the concept of pilot sites as a basis for fundamental research and extrapolation and horizontal sharing of research results among the collaborators in the consortium. These pilot sites are generally watershed based. Lessons learned in these pilot sites highlight the extreme biophysical and agricultural heterogeneity found in the watersheds. This project will bring teams from the CONDESAN sites in La Miel, Colombia, Carchi, Ecuador, Cajamarca, Peru, and Puno, Peru along with the non-CONDESAN site in Cuenca, Ecuador to a series of workshops conducted by the Institute for Resources and the Environment of UBC. In these workshops representatives of the research teams will learn principles of problem statement and information presentation appropriate for hypertext media are taught in a hands-on environment. These representatives will take these principles back to their research teams where the hypertext "stories" will be developed and produced. Followup workshops will critique interim efforts and compare lessons across research sites. After 12 months, the final product will be a compact disk with hypertext presentation of the watersheds or research sites and the research programs and results relevant to that watershed or research site.

The United Nations General Assembly designated 2002 as the "International Year of Mountains". There are and will be many significant regional and international events organized around this theme. To have the complex problems and ongoing work to solve those problems of a selection of watersheds or research sites from the tropical Andes captured on compact disks can reach a wide and influential audience .

Annex 2:
Eco-soils: Investigation for the ecological management and productivity of soils in the Ecuadorian Andean Eco-region

(original title in Spanish: Eco-suelos: Eco-Suelos: Investigación para el manejo ecológico y productivo de suelos en la ecoregión andina del Ecuador)

This is a three year project financed by the Competitive Grants for Research fund of the Agricultural Services Modernization Program (PROMSA) of the Ecuadorian Government, a World Bank financed program.

Participating Institutions:

- Instituto Nacional Autónomo de Investigaciones Agropecuarias (INIAP), Quito, EC
- Centro Internacional de la Papa (CIP), Quito, EC
- Land Resource Sciences, Guelph University, Guelph, Ontario, CA
- Fondo Ecuatoriano Populorum Progressio (FEEP)-Regional Bolívar, Guaranda, EC
- Universidad Estatal de Bolívar-Facultad de Ciencias Agropecuarias, Guaranda, EC

Objectives:

- Develop research methods to evaluate the impact of agricultural practices in the regenerative capacity of soil, with an emphasis on the biological component.
- Identify useful practices to improve productive management and sustainability of soils.
- Diffuse these new alternatives and methodologies.

Justification:

Farmers and agricultural researchers in Ecuador have long noted productivity loss in soils used in potato cultivation. According to farmers, soils become 'tired' and take longer rotations to recuperate originally observed productivity. This has led in their opinion to greater presence of pathogens and pests in the soil and in turn has led to ever increasing amounts of pesticide use. It is well known that living organisms in the soil play a crucial role in the management and maintenance of physical aspects (porosity, areation, drainage, and infiltration), chemical aspects (pH, nutrient cycling and availability) and in biological aspects (antagonism, nitrification) of soils. However, in Ecuador almost the entire effort in research in and promotion of soil conservation has been in chemical and physical aspects. The impact of agricultural practices in the biological component of soils has been ignored.

tt is known that practices such as mixed cropping, rotations and the use of organic amendments tend to favor diversity and abundance of soil organisms. At the same time, modern monoculture with its associated use of agri-chemicals is known to reduce the capacity of soils as a buffer and thus its productivity. Thus in Ecuador there is a clear need to imporve the management of abiotic and biotic factors to improve the sustainability of soil management. This project will complement existing projects in INAIP and CIP that promote integrated potato management and evaluation of the costs in productivity, environment and human health of the agricultural technologies and policies. This project will integrate knowledge from entomology, extension, microbiology, phyto-pathology and soil sciences to promote improved awareness and

understanding about the principles and practices required to optimize the management of soil. The project participants will develop new tools for analyzing alternative practices and identifying new more appropriate management regimes for the present and future of agriculture in the region.

Annex 3:
Climatic variability and its relationship with agriculture in the Ecuadorian sierra: Impact of El Niño and the Southern Oscillation (ENSO)

(original title in Spanish: Variabilidad Climatica Y Su Relacion Con La Agricultura En La Sierra Ecuatoriana: Impacto Del Fenomeno El Niño - Oscilación Del Sur (ENSO))

This is a proposal pending before the competitive grants committee of the Strategic Alliance fund of the Agricultural Services Modernization Program (PROMSA) of the Ecuadorian Government.

Participating Institutions:

- Instituto Nacional de Meteorología e Hidrología, INAMHI, Quito, EC (the national meterological institute)
- Instituto Nacional Autónomo de Investigaciones Agropecuarias (INIAP), Quito, EC
- Centro Internacional de la Papa (CIP), Quito, EC
- The Florida Consortium (U. Miami, U. Florida, Florida State U.)

General Objective:

Establish a strategic alliance in order to study, develop and implement methods that permit the evaluation of the climatic variability associates with El Niño Southern Oscillation events and the impact of their prediction en the agriculture of the Ecuadorian sierra.

Specific Objectives:

- Quantify the impact of climatic variability associated with ENSO events in agriculture of the Ecuadorian sierra.
- Adapt, develop and evaluate tools and methodologies that permit the translation of global climate forecasts to daily climate forecasts at local and regional levels.
- Adapt, develop and evaluate tools and methods that use climate forecasts in order to help decision making in the agriculture sector of the Ecuadorian sierra.
- Continously train multidisciplinary teams in Ecuador that can provide useful and on time information to reduce the risks from climatic variability in the agriculture sector.

Justification:

The Declaration of Guayaquil, produced at the first Intergovernmental Meeting of Experts of El Niño held in Guayaquil in November 1998, emphasizes the urgent need to invest in research to understand the connections between climate variability and El Niño. With this knowledge climate forecasts are possible that can help one of the most vulnerable sectors of Ecuadorian society. With the capacity to anticipate favorable or unfavorable climatic conditions the agricultural sector can take steps to minimize the impact.

Statistical and numerical models developed to predict ENSO events relate anomalies in ocean surface temperature and its effects on regional climate behavior. Some models can predict

ENSO events up to a year in advance. Thus with ENSO event prediction, regional climate prediction can be developed using 1) statistical analysis that measures the historic assciation among ENSO measurements and relevant climatic variables or 2) numerical modesl of the interaction of ocean/atmosphere. Using these techniques an ENSO forecast can provide useful climatic information in many regions several months in advance.

Various scientific investigations have demonstrated a relation between the phases of ENSO and agricultural production in different parts of the world. The Florida Consortium has made an application of this type of climatic forecasts in the USA, Argentina, Uruguay, Costa Rica and Mexico (see their web site at www.coaps.fsu.edu/lib/Florida_Consortium).

This project will specifically link with an ongoing INIAP-CIP research program in Ecuador that examines the linkages between agriculture, the environment and human health and the impacts of agricultural technologies and policies. With CIP as the principal collaborating external institution and INIAP as the principal Ecuadorian institution, and the Florida Consortium, NOAA and the International Institute for Research in Global Climate Change, INIAMHI seeks to form a strategic alliance with the objective to study, develop and implement methods to predict climate variability associated with ENSO events in the Ecuadorian sierra.

Annex 4:
Strengthening research capacity for productivity improvement and sustainability of mixed livestock-crop systems in the Andean eco-region

(original title in Spanish: Fortalecimiento de las capacidades de investigación para el mejoramiento de la productividad y sostenibilidad de los sistemas de producción mixtos, cultivos-ganadería, en la ecoregión andina del Ecuador)

This is a proposal pending before the competitive grants committee of the Strategic Alliance fund of the Agricultural Services Modernization Program (PROMSA) of the Ecuadorian Government.

Participating Institutions:

- Instituto Nacional Autónomo de Investigaciones Agropecuarias (INIAP), Quito, EC
- Centro Internacional de la Papa (CIP), Quito, EC

General Objective

Strengthen research capacity for the improvement of the productivity and sustainability of mixed crop-livestock systems in the Andean eco-region of Ecuador.

Specific Objectives

- Characterize the mixed crop-livestock systems found in the Andean eco-region.
- Identify and implement technological, political and economic options in order to improve the productivity and sustainability of the mixed crop-livestock systems.
- Train professionals in order to develop research capacity in production systems with a focus on Systems Analysis.
- Promote the research results to different agricultural development actors in Ecuador.

Justification:

Small holder mixed crop-livestock systems in the Ecuadorian sierra exist in a wide range of agro-ecological conditions, ranging from very well adapted zones of adequate rainfall and good soils to very marginal conditions where conditions are droughty, soils are poor and organic matter management is a problem. Systems can range from potatoes and naturally established unimproved pasture to systems where crops are planted in the rainy months and there is insufficient moisture to establish pastures in the dry months and crops such as barley are grown for human consumption and fodder. INIAP has developed numerous technologies for individual components of a wide range of systems but has never had the capacity to look at the interrelationships of these systems to identify potential bottlenecks or complementarities to relieve constraints in these systems. This project will introduce systems analysis to INIAP through collaboration with CIP and the Tradeoffs Program.