PD-ABS-577
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Sustainable Agriculture

Un Enfoque de Agricultura

Focus in the San Carlos

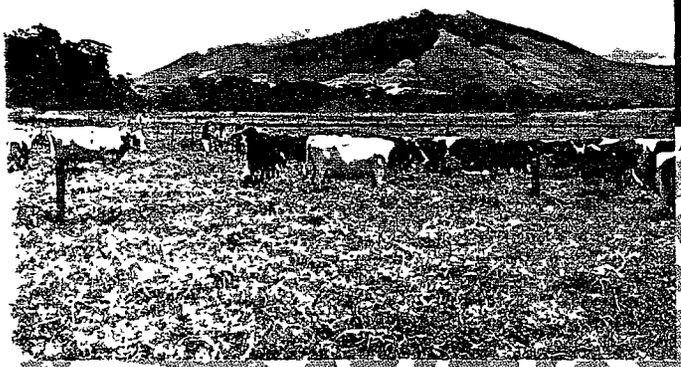
Sostenible en la Región

Region of Costa Rica

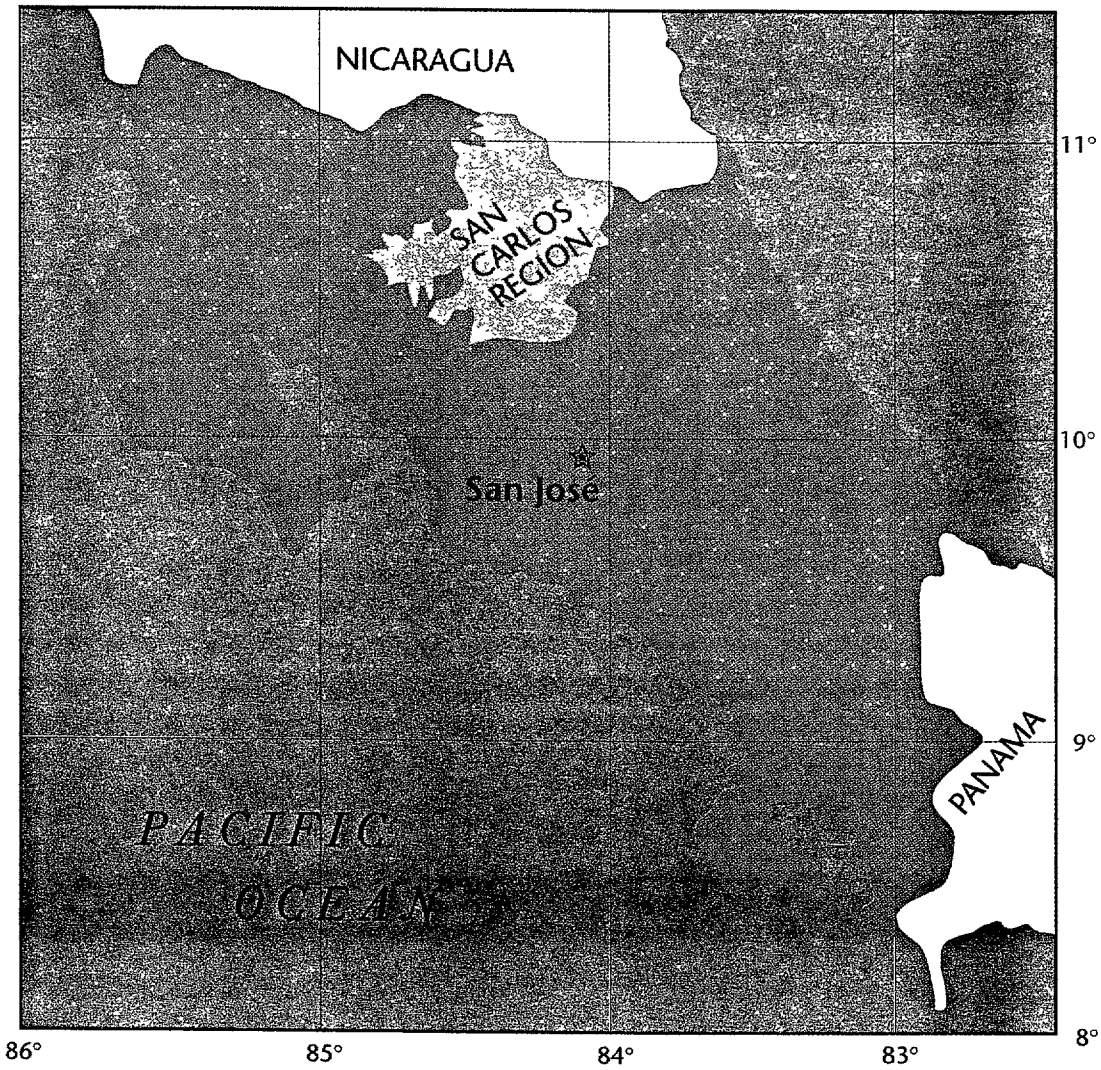
San Carlos de Costa Rica

A collaborative linkage between:
North Carolina State University,
Universidad de Costa Rica, and Universidad Nacional

Acuerdo de colaboración entre:
la Universidad del Estado de Carolina del Norte,
la Universidad de Costa Rica y la Universidad Nacional



Costa Rica



Location of Costa Rica in Central America. The San Carlos region is located from just north of San José to the Nicaraguan border.

La ubicación de Costa Rica en Centroamérica. La región de San Carlos está ubicada al norte de San José y se extiende hasta el borde con Nicaragua.

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Sustainable Agriculture Focus in the San Carlos Region

Un Enfoque de Agricultura Sostenible en la Región San Carlos de

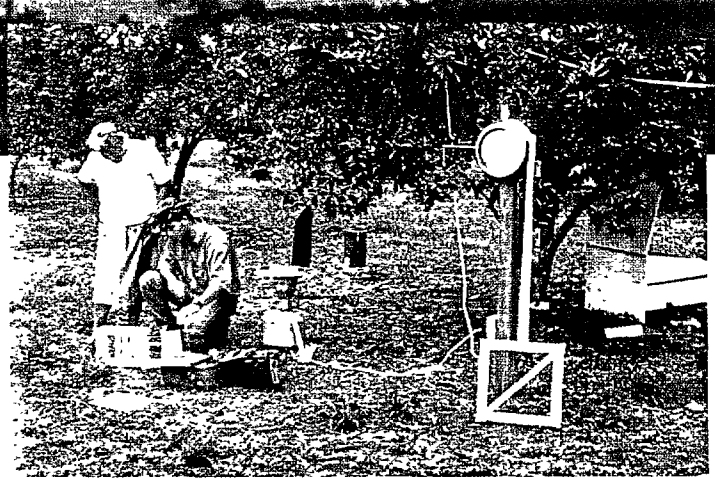
A collaborative linkage between North Carolina State University, Universidad de Costa Rica, and Universidad Nacional

Acuerdo de colaboración entre la Universidad del Estado de Carolina del Norte, la Universidad de Costa Rica y la Universidad Nacional

Introduction

Tropical agroecosystems are especially complex and sensitive to environmental disturbance. These agroecosystems are characterized by a diversity of plant and animal species, parasites, pathogens, weeds and other pests. In order to develop more sustainable agriculture systems, multidisciplinary and inter-institutional approaches are necessary. Our project focuses on the development of sustainable agricultural practices in the San Carlos region, a major agricultural area of Costa Rica.

The project has been funded by the University Development Linkages Program (UDLP) of the United States Agency for International Development (USAID). Collaborative linkages have been established between North Carolina State University (NCSU) and two Costa Rican universities, the National University at Heredia (Universidad Nacional, UNA) and the University of Costa Rica at San Jose (Universidad de Costa Rica, UCR). All are major universities with programs in agriculture and related sciences. The Technological Institute of Costa Rica (ITCR), San Carlos, has also played an important role in this collaborative effort.



UDLP scientists have studied methods of pesticide use reduction on citrus plantations. Científicos de UDPL han estudiado métodos para reducir el uso de plagucidas en plantaciones de cítricos.

Introducción

Los agroecosistemas tropicales son especialmente complejos y sensibles a cambios ambientales. Estos sistemas se caracterizan por una diversidad de plantas y especies animales, parásitos, patógenos, malezas y otras plagas. Se necesitan equipos multidisciplinarios y propuestas de actividades entre instituciones para desarrollar sistemas de agricultura sostenible. El enfoque de nuestro proyecto es en el desarrollo de prácticas de agricultura sostenible en la región de San Carlos, una área de importancia en la agricultura de Costa Rica.

Para la realización de este proyecto, fondos de investigación han sido provistos por el Programa de Desarrollo de Enlaces Universitarios (ULDP) de la Agencia Internacional para el Desarrollo (USAID). En este proyecto se han establecido programas de colaboración entre la Universidad del Estado de Carolina del Norte (NCSU) y dos universidades en Costa Rica, la Universidad Nacional (UNA) y la Universidad de Costa Rica (UCR). Todas éstas son importantes universidades con programas en agricultura y ciencias relacionadas. El Instituto Tecnológico de Costa Rica (ITCR) también ha jugado un rol importante en este programa.

San Carlos is an important region for dairy production. San Carlos es una

The San Carlos Region

Costa Rica is the second smallest Central American country and has more than a dozen tropical climatic zones. The San Carlos region consists of lush farmland with a warm, humid climate. The region was selected for this project because of its diversity of agriculture, variation in topography and for the increasing demands that agriculture is placing on the environment.

Prior to the 1940s, the economy of San Carlos was based on subsistence farming. In the 1950s, production of pasture raised dairy and beef cattle started to expand. San Carlos is currently considered the most important area for dairy production in the country. Dairy and beef cattle have been influential in the economic and cultural development of San Carlos.

In the 1980's, citrus and other nontraditional products, such as ornamental plants and spices, were planted in response to a national policy promoting diversification. These changes have contributed to the decline of traditional family agriculture. New strategies encourage the growth of exotic and native tree species in response to the disappearance of natural forests.

Research

Our UDLP project has applied the combined efforts of multiple disciplines and institutions toward the solution of broad problem areas. We believe that the linkages formed during this project will be lasting.

The sustainability of dairy, citrus and forest resources in the San Carlos region has been the focus of our project. Participating scientists have studied ways to reduce pesticide use in citrus and use of citrus processing wastes as dairy feed, identified dairy sustainability factors, initiated monitoring on farms by working with farmers through local producer organizations, and have promoted the use of a promising new pasture legume and the development of new heifer raising systems. Another project has focused on the establishment of native timber species on the boundaries of dairy pastures.

Public and animal health are also key areas of study. Electrical conductivity has been used to assess mastitis, an economically important disease of dairy cattle, and related work focuses on microbiological assessment of subclinical mastitis and the susceptibility of pathogens to antibiotics. Other projects include causes of lameness in dairy cattle and public health issues related to milk and milk products.

The UDLP research efforts have involved integration of other higher education institutions like the Technological Institute of Costa Rica (Instituto Tecnológico de Costa Rica), which promotes the technological development of San Carlos, and will be involved in future work of this program.

Scientists from many disciplines collaborate on various projects. Científicos de varias displinas colaboran en diferentes proyectos.

Post-graduate Programs and Short Term Training

Post-graduate programs and short term training projects have provided opportunities to enrich research programs and increase international awareness. Most importantly, they have provided vital links which will promote future collaboration.

Graduate students at NCSU, UNA, and UCR, although not supported directly by the UDLP, have been actively involved in research. Ongoing graduate programs include a diversity of topics pertinent to the San Carlos region. As these students obtain employment they will carry with them the philosophy of the need for sustainable development.

Costa Rican scientists have participated in molecular biology courses at NCSU, in a hands-on laboratory setting which provides skills for biotechnology. As an outgrowth of our participation in this course, a component of it will be taught at UNA by NCSU and Costa Rican instructors. Other short-term activities target English language improvement, participation in research projects, and workshops offered to scientists and agricultural technicians.

Arachis pintoi *is a promising new pasture legume.* Arachis pintoi *es una leguminosa con mucho futuro en la región.*

La Región de San Carlos

Costa Rica es un país pequeño en América Central con más de doce zonas climáticas. La región de San Carlos consiste en áreas con fincas de abundante vegetación y con un clima húmedo y caliente. Esta región ha sido seleccionada para el proyecto debido a la diversidad en la agricultura, la variación en la topografía y por las demandas crecientes que la agricultura ha estado poniendo en el medio ambiente.

Antes de 1940, la economía de San Carlos se basaba en producción de subsistencia. En los 50, la producción de ganado de leche y carne en pastura comenzó a expandirse. San Carlos es hoy día considerada una de las áreas de producción lechera más importantes del país. El ganado de leche y de carne han influído en el desarrollo económico y cultural de San Carlos.

En la década de los 1980, los cítricos y otros productos no tradicionales como plantas ornamentales y especias fueron cultivadas en respuesta a una política nacional para promover la diversificación. Estos cambios contribuyeron a la reducción de la agricultura familiar tradicional. El establecimiento de especies exóticas y nativas de árboles se plantea como estrategia en repuesta a la desaparición de los bosques naturales.

Investigación

Se han combinado los esfuerzos de varias disciplinas para resolver una gama de problemas en áreas diferentes en nuestro proyecto, proporcionando soluciones de impacto en varias áreas.

El enfoque de nuestro proyecto ha sido la sostenibilidad de los recursos lecheros, cítricos y forestales en la región de San Carlos. Los científicos participantes han evaluado la reducción del uso de pesticidas y el aprovechamiento de desechos generados durante el procesamiento de cítricos como alimento para ganado de leche; identificación de factores de sostenibilidad para la industria lechera; inicio de programa de seguimiento de fincas trabajando con los finqueros por medio de las organizaciones locales de productores; se ha promovido el uso de pasturas y leguminosas prometedoras y el desarrollo de sistemas alternativos para la crianza de terneras. Otro proyecto se ha concentrado en el uso de especies nativas forestales en los bordes de las áreas de pastura.

La Salud Animal y la Salud Pública son otras áreas importantes del proyecto. La conductividad eléctrica ha sido usada para determinar mastitis, una enfermedad de importancia económica en el ganado lechero; otros trabajos con enfoque en el análisis microbiológico de la mastitis subclínica y de la susceptibilidad de patógenos a antibióticos se están desarrollando. Otros proyectos incluyen las causas de laminitis en el ganado de leche y la salud pública en relación a la leche y los productos lácteos.

Estos esfuerzos en investigación han promovido la integración de otras instituciones de educación superior como el Instituto Tecnológico de Costa Rica (ITCR), institución promotora del desarrollo tecnológico de la región, que participará también en el trabajo futuro de este programa.

Animal health is a key area of study. La Salud Animal es una parte importante del estudio.

Programas de Post-grado y Entrenamiento a Corto Plazo

Programas de post-grado y proyectos de entrenamiento a corto plazo han provisto oportunidades para enriquecer e incrementar el interés en programas internacionales. Pero, aún más importante, éstos han facilitado enlaces vitales para promover colaboraciones futuras.

Estudiantes de post-grado en NCSU, UNA y UCR, aunque sin recibir fondos de investigación directos del ULDP, han participado activamente en investigación. Programas de post-grado que se están llevando a cabo incluyen una diversidad de temas pertinentes a la Región de San Carlos. Estos estudiantes llevan consigo la filosofía de la importancia del desarrollo sotenible a sus trabajos futuros.

Científicos de Costa Rica han participado en cursos de biología molecular dictados en NCSU, cursos que ofrecen entrenamiento práctico en el laboratorio y técnicas modernas de biotecnología. Debido a nuestra participación en estos cursos se ha creado el interés en dictar un componente del curso mencionado en UNA en 1997 con profesores de NCSU y Costa Rica. Otras actividades a corto plazo incluyen cursos de perfeccionamiento del idioma inglés y participación en proyectos de investigación y talleres ofrecidos a científicos y técnicos agropecuarios.

Training for agricultural professionals and technicians has been offered through workshops. Técnicos y profesionales en agricultura han recibido entrenamiento en diferentes talleres.

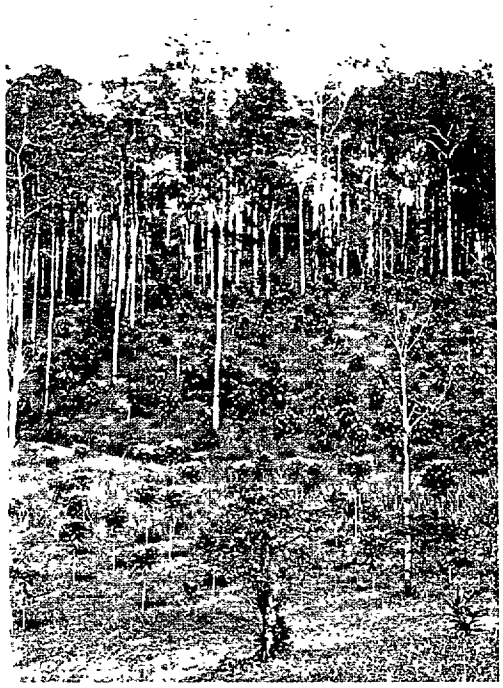
Native timber species have been introduced on dairy pasture boundaries. Especies nativas han sido introducidas en los bordes de pastizales de lecherias.

Future Direction

Building on the success of inter-institutional and multidisciplinary projects, future collaborative efforts are anticipated to design and validate alternative production systems. Short-term objectives focus on delineation of goals through strong interaction with producers and the private sector. These include pasture management and improvement, agroforestry, herd health, the interfaces of agriculture and public health, management of crop disease, reduction of pesticide use, and the processing of agricultural wastes for cattle feeds. A major goal is to increase the number of beneficiaries of the project, by promoting the interests of small and mid size farmers through field work, workshops, bulletins and stewardship. The project will focus on designing alternative production systems through research teams and extension participation. Inclusion of producer groups will be an important aspect of the program. The complete approach will require emphasis on the effects of socio-economic aspects of production, including gender, production-public health interface, and development groups.

Technical training will be provided through activities such as workshops, bulletins, field trips, and the collaboration of producers to disseminate information to fellow producers. Targeted audiences include: independent technicians, local producer groups, and undergraduate/graduate students.

Public health and food safety issues related to milk are other project focuses. La salud pública y la higiene de productos lácteos son otros temas abordados por el proyecto.



Secondary forest regeneration utilizing native tropical hardwood species is an important issue for the project. La recuperación del bosque secundario con especies nativas es un aspecto relevante para el proyecto.

Planes Futuros

Esfuerzos de colaboración futura se preveen para el diseño de experimentos y la validación de sistemas de producción alternativa basados en el éxito de los proyectos conducidos entre las instituciones y los equipos multidisciplinarios. Los objetivos a corto plazo consisten en la delineación de planes para fortalecer interacciones con productores y el sector privado. Estas interacciones incluyen temas como: manejo y mejoramiento de pasturas, proyectos agro-forestales, salud del hato y proyectos en la inter-fase entre agricultura y salud pública, manejo de enfermedades de cultivos, reducción del uso de pesticidas y procesamiento de productos de desecho de la agricultura para alimentación de ganado.

Uno de los objetivos principales del proyecto es el de aumentar el número de beneficiarios, la promoción de los intereses de productores de pequeño y mediano tamaño mediante el trabajo de campo, talleres, boletines y diferentes promociones. El proyecto se concentrará en el diseño de sistemas de producción alternativos por medio de la participación de equipos de investigación y extensión. La selección de grupos de productores será un aspecto importante de esta fase. Este plan de trabajo global enfatizará el efecto de factores socio-económicos en la producción, incluyendo el género, la interfase producción-salud pública y el trabajo con de grupos de desarrollo.

El entrenamiento técnico será provisto mediante actividades tales como talleres, publicaciones, días de campo y la colaboración de los finqueros en la diseminación de la información. El público de interés incluye: técnicos independientes, grupos locales de productores y estudiantes universitarios.

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SUSTAINABLE AGRICULTURE FOCUS IN THE SAN CARLOS REGION OF COSTA RICA

Collaborative Linkage Between North Carolina State University, the University of Costa Rica and the National University (Heredia, Costa Rica)

KL Anderson, JP Mueller, TB Sutton, MT Correa, F Arauz, M Caballero, E Muller, E Perez, A Rojas-Bourrillón, L Villalobos, M Villarreal

University Development Linkage Program (UDLP)
United States Agency for International Development (USAID)

North Carolina State University (NCSU)
Raleigh, North Carolina, USA

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San Jose, Costa Rica, Central America

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Heredia, Costa Rica, Central America

Report prepared with the assistance of Melanie Hord, Derrick Frazier and Vicki Grantham

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FINAL REPORT
EXECUTIVE SUMMARY
June 30, 2000

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EXECUTIVE SUMMARY

"Sustainable Agriculture Focus in the San Carlos Region of Costa Rica"

"Collaborative Linkage Between North Carolina State University, the University of Costa Rica and the National University (Heredia, Costa Rica)"

University Development Linkages Program (UDLP)
United States Agency for International Development (USAID)

1993–1998
Cooperative Agreement #PCE-5063-A-00-3012-00

North Carolina State University (NCSU)
The National University (UNA)
University of Costa Rica (UCR)

This project linked North Carolina State University (NCSU) with 2 Costa Rican institutions of higher education, the National University (UNA) at Heredia and the University of Costa Rica (UCR) at San Jose. Additionally, the Instituto Tecnológico de Costa Rica, San Carlos, participated in the project. The combined efforts of multiple disciplines and institutions were directed toward the investigation of broad problem areas. The sustainability of dairy, citrus and forest resources in the San Carlos region of Costa Rica has been the main focus of the project. Areas of emphasis were animal production and health, public health and plant protection.

UDLP Objectives, Accomplishments and Impact:

Objective 1: Initiate collaborative research projects on sustainable agricultural systems, deforestation associated with the cattle industry, and ecologically sound production systems that minimize pesticide use:

Accomplishments

- Many collaborative research projects were initiated and completed between US and Costa Rican researchers, as well as among Costa Rican researchers. One of the major accomplishments of the project was to strengthen and foster collaborative research projects of mutual interest among scientists in the 3 Costa Rican institutions.
- Completed projects involved at least the following:

  Animal production – 22
  Animal health – 5
  Public health – 4
  Plant protection – 9
- Sixteen papers were published or submitted to scientific journals, 46 abstracts of papers presented at scientific meetings were published and 11 graduate theses were published based on research supported by the project.
- Research focused on pasture improvement, use of alternative feed supplements as dairy feeds, agroforestry, animal health, human health and plant protection.
- Long-term studies were initiated on agroforestry, looking at methods to integrate native hardwoods with dairy pasture swards.
- Research in animal health investigated major dairy cattle diseases such as lameness and mastitis.

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- Public health research focused on emerging pathogens such as *Salmonella* spp., *Escherichia coli* 0157:H7, etc.
- Plant protection research focused on epidemiology and control of fungal diseases of citrus.

Impact

➢ A comprehensive approach to monitoring sustainability of dairy farms was developed that will contribute fundamentally to assessment of sustainability of dairy enterprises and will advance both research and application of sustainability. The approach is based on a model of analysis including both the above and below ground components of the system.

➢ Research on *Arachis pintoi* (perennial peanut) assessed its impact on economic and biological factors:

- Establishment of a grass-perennial peanut association was found to reduce the need for nitrogen chemical fertilizer use.
- A 50% reduction in concentrate use was found when perennial peanut was used for feeding small dairy heifers.
- Herbicide use on sorghum crops was eliminated when perennial peanut was used as a cover crop, reducing both cost and potential negative impact of herbicides.

➢ An agroforestry trial was conducted in which native timber species were established in association with pastures. This has led to a long-term project to combine timber species with several herbaceous forages. The goal is to develop a model to be applied to commercial farms in the humid tropics. This could address deforestation issues and be a component of sustainable systems.

➢ Research on alternate feedstuffs for cattle resulted in:

- The elimination of the dumping of 270,000 tons of citrus waste per year in rivers and surrounding areas.
- A reduction in concentrate cost by 16.5% in the San Carlos dairies studied and reduced grain use.
- Utilization of other agroindustrial by-products such as pineapple waste, effectively reducing environmental pollution.

➢ Research on fungal diseases of oranges:

- Found that by proper timing of oil sprays for greasy spot, 1 to 2 sprays per year could be eliminated, saving $450,000 / spray. It was also demonstrated that well-timed oil sprays could replace the use of copper sprays and the potentially negative environmental impact of copper use.
- Identified a management program for blossom end rot of citrus, caused by *Alternaria citri*, which has caused losses of 20% in some orange groves.
- Demonstrated that applications of lime and manganese could control corky root disease and significantly increase yield in badly affected orange groves.
- Identified methods to manage postbloom fruit drop of citrus, with the potential to significantly increase yield in years favorable for disease development.

➢ Public health research addressed methods to improve food safety and led to new research avenues. Data were collected on culture and health using a method blending anthropology and epidemiology. The desired endpoint was development of educational materials on zoonoses for subsistence dairy farmers (women in particular) in Costa Rica.

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Objective 2: Initiate short-term exchange of faculty, staff and students to participate in training and goal-oriented short courses

Accomplishments

- 35 faculty, staff and student exchanges
- Seven project-sponsored courses and workshops with over 250 participants
- Enhanced biotechnology use, with a course conducted in Costa Rica on use of polymerase chain reaction (PCR) technology
- Focus on forage research methods

Impact

➢ Biotechnology training expanded the capabilities of multiple Costa Rican investigators and research laboratories. Laboratory techniques were enhanced, including PCR and other tests such as rapid detection methods.

➢ Expanded forage research capability was applied to many research projects and approaches to monitor sustainability.

➢ Exchanges promoted participation of additional U.S. universities.

➢ The Sub-Program of Organic Animal Production was facilitated in the Organic Agricultural Program at the University of Costa Rica.

➢ Programs were developed to provide training in organic dairy production.

Objective 3: Enhance regional postgraduate training programs in the fields of sustainable agriculture and environmental protection

Accomplishments

- Two new postgraduate programs were initiated
  - Licenciatura Program on Ecological Agriculture initiated at Escuela de Ciencias Agrarias, Universidad Nacional
  - Masters Program in Alternative Agriculture with emphasis on Ecological Agriculture has been developed and approved and will be initiated in August of 2000 at the Escuela de Ciencias Agrarias, Universidad Nacional. The Program is coordinated by Dr. Leo Villalobos at UNA. For details, see the web site: www.una.ac.cr/agra/agrieco.html
- Research (not stipend) support was provided for students in 24 existing graduate programs (some cross-listed under graduate theses)

Impact

➢ The Graduate Program in Ecological Agriculture has the potential for tremendous impact both from training of future scientists for Central America as well as developing a strong research effort

➢ The impact of graduate students trained during the program is expected to be large, as they fill positions in the region and carry with them the philosophy of sustainable agricultural development

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- Students trained in graduate programs related to ecological agriculture have the potential to significantly influence the direction of agricultural programs in many sectors in Central and Latin American countries

Problems or Barriers to Program

The uncertainty of funding during the project, communication among project scientists, and turnover of key personnel were the three largest problems. The uncertainty in the availability and amount of funds was a serious impediment to the research component of the project. Many of the projects proposed were multi-year and we were unable to make long-term commitments to students and producers/growers. The research component would have undoubtedly been more productive had the funding been more certain. Maintaining communication in the first few years of the project was especially difficult because our Costa Rican colleagues had limited access to fax machines and e-mail service. This was partially addressed by frequent meetings and telephone calls. However, as e-mail became readily available to collaborators in Costa Rica, communication was greatly improved. The turnover of certain key personnel and the lack of fit between some cooperators was a major problem and negatively affected the continuity of some projects.

Assessment of Linkage on Internationalization at NCSU

A significant number of students and faculty gained experience in collaborative research / development during the course of the project. For example, one NCSU Crop Science student, Azur Moulaert, completed and published his research based on an agroforestry project. He currently works for an organization in Washington, D.C., doing international development. Dr. Jeffrey Musser, graduate student, College of Veterinary Medicine, was able to use his UDLP Costa Rican research experience as part of the foundation for a successful application for an American Advancement of Science Public Policy Fellowship at USAID. Experience and audiovisual materials garnered during the project have enriched material presented to NCSU students in classes such as Veterinary Public Health, Plant Disease Management, Sustainable Agriculture, etc. Costa Rican collaborators have presented seminars and lectures for courses at NCSU.

Assessment of Input of Linkage on Strengthening Developing Institution's Capability to Meet Societal Development Needs

The linkage had marked success in development of institutional / individual scientist capabilities. Most profound was stimulation of collaborative activities among the Costa Rican researchers. Costa Rican citizens and the government have a tremendous interest in environmental protection and sustainability. Research and training conducted during the UDLP have directly addressed these issues. These activities and Costa Rican scientists trained during the project will augment the country's ability to respond to these issues. The strong collaborations developed during the project will continue well beyond the end of the project.

QUANTITATIVE MEASURES OF OUTPUT

Collaborative Research Projects

Animal production – 22 projects
Animal health – 5 projects
Public health – 4 projects
Plant protection – 9 projects

Publications

Published in scientific journals – 10
Manuscripts submitted for publication
in scientific journals – 6
Invited lectures, scientific meetings – 2
Abstracts presented in scientific meetings – 46
Books – 1
Presentations in seminars
and workshops – 20
Graduate theses – 11
Other publications – 6

Extension Activities

Symposia – 1 (35 participants)
Seminars – 7 (687 participants)
Training / Workshops – 3 (40 participants)
Field Trips / Field Days – 6 (284 participants)

Research Proposals Generated / Additional Funding – 8

Training

Faculty, staff and student exchanges – 35
Project-sponsored courses and workshops – 7 (250 participants)
Participation in scientific meetings and workshops – 6

Education

Post-graduate programs initiated – 2
UDLP support for research in existing
graduate programs – 24 (some cross-listed under theses)
Courses taught – 3 (34 participants)
Undergraduate training and teaching support – 8

Project Administration

Project management and coordination meetings – 9
UDLP Scientists – 11
Collaborating scientists – 57

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FINAL REPORT

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Sustainable Agriculture Focus in the San Carlos Region of Costa Rica

Collaborative Linkage Between North Carolina State University, the University of Costa Rica and the National University (Heredia, Costa Rica)

University Development Linkage Program

North Carolina State University • Universidad de Costa Rica • Universidad Nacional

UDLP Objectives

- Initiate collaborative research projects on sustainable agricultural systems, deforestation associated with the cattle industry, and ecologically sound production systems that minimize pesticide use
- Initiate short-term exchange of faculty, staff and students to participate in training and goal-oriented short courses
- Enhance regional postgraduate training programs in the fields of sustainable agriculture and environmental protection

Research

Collaborative Research

The UDLP project has applied the combined efforts of multiple disciplines and institutions toward the solution of broad problem areas. The sustainability of dairy, citrus and forest resources in the San Carlos region has been the main focus of the project, with research in the key areas of animal health and production, public health and plant protection.

Animal Production

Research efforts were concentrated on the sustainability of dairy and beef production in the San Carlos region. Limiting factors for beef production were identified and indicators of sustainability on dairy farms were defined. UDLP researchers worked with farmers through local producer organizations to initiate monitoring on farms. Much of the research was focused on pasture improvement and the use of alternative feed supplements in an integrated sustainable system. New crops were evaluated as forage for beef and dairy cattle, a long-term study involving the integration of two native hardwood species with dairy pasture swards was initiated, and the feasibility of using locally produced citrus processing wastes and other by-products as cattle feed was analyzed. Factors related to first calving age and milk production in dairy cattle were also studied. Individual research projects in animal production are listed in Table 1.

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Table 1. Research in Animal Production.

Title	Researchers	Duration
Diagnostic on dairy production in the San Carlos Region	L. Villalobos, A. Rojas-Bourrillón	1994
A silvopastoral system in the north Atlantic zone of Costa Rica: Combining indigenous timber species with dairy pasture swards	P. Mueller, A. Moulaert-Quiros, J. Laarman, L. Villalobos, M. Villarreal, R. Piedra	1994–1996
Monitoring bioeconomic parameters for the definition of sustainability on dairy farms of San Carlos	L. Villalobos, M. Villarreal, R. Rodríguez, E. Araya	1994–1999
Identification of factors increasing age at first calving of dairy heifers	A. Quan, A. Rojas-Bourrillón, E. Eduarte	1995
Nutritive value and composition of citrus pulp produced in the San Carlos region	A. Rojas-Bourillón, H. Dormond	1995
Pasture forage studies and sustainability of dairies	L. Villalobos	1995
Indicators of existence and sustainable use of secondary forest in conjunction with livestock	R. Ortiz	1995–1996
Technological development of the beef industry in San Carlos	R. Rosales, C. Martinelli, C. Arroyo	1996–1997
Validation of a heifer feeding system using *Arachis pintoi* as a protein bank	A. Quan, A. Rojas-Bourrillón, M. Villarreal	1996–1997
Arachis pintoi and organic fertilizer as an alternative system for black sorghum production in San Carlos	A. Quan, A. Rojas-Bourrillón	1997–1999
Characterization of the nutritive value of three accessions of *Arachis pintoi* at different cutting frequencies	M. Villarreal, L. Villalobos, R. Cochran, A. Rojas, J. Sánchez, M. Poore	1997–2000
Econômic analysis of farms located in the highland area of San Carlos	M. Salazar, A. Rojas-Bourrillón	1998
Comparison of energy sources on steers grazing perennial peanuts	A. Rojas-Bourrillón, A. Chavez	1998–1999
Utilization of urea or poultry litter as protein supplements for bulls fed pejibaye pulp silage	C. Arroyo, A. Rojas-Bourrillón, R. Rosales	1998–1999

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Table 1. Research in Animal Production (cont.)

Title	Researchers	Duration
Competency of San Carlos dairy enterprise under GATT policies	M. Salazar, A. Rojas-Bourrillón	1998–1999
Monitoring of pineapple waste in cattle feeding in San Carlos	H. Dormond, A. Rojas-Bourrillón, M. Poore, M. Villarreal	1998–1999
Economics of heifer raising programs in San Carlos	M.A. Aguilar, M. Salazar, A. Rojas-Bourrillón, J. Heinrichs	1998–1999
Monitoring of citrus pulp quality: pathogenic microorganisms	G. Bonilla, L. Villalobos, A. Rojas-Bourrillón	1998–1999
Graded levels of non-protein nitrogen for steers fed pejibaye pulp silage	A. Rojas-Bourrillón	1998–1999
Development of silvopastoral systems for the humid tropics using indigenous timber species and herbaceous forage	M. Villarreal, L. Villalobos, P. Mueller, L. Rodríguez, R. Rodríguez, C. Hidalgo	1999–2005
Hay made of perennial peanut forage: Biomass production and chemical composition	A. Rojas-Bourrillón, A. Chavez	2000
Nutritive value and fermentation pattern of perennial peanut silages	A. Rojas-Bourrillón, H. Soto, M. Villarreal	2000

Animal Health

An epidemiological study on the relationship between pathogens and management practices on dairy farms in San Carlos was conducted. Electrical conductivity was used to assess mastitis, an economically important disease of dairy cattle. Related work focused on the microbiological assessment of subclinical mastitis and the susceptibility of pathogens to antibiotics. In a study on lameness in dairy cattle, factors that may help reduce the prevalence of this important problem affecting production were identified. Individual research projects in animal health are listed in Table 2.

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Table 2. Research in Animal Health

Title	Researchers	Duration
Diagnostic of dairy health in San Carlos	C. Eilers, E. Muller	1993
Lameness in dairy cattle	D. Montero, E. Muller, E. Perez	1995–1996
Electrical conductivity in assessment of economic loss from mastitis	J. Musser, K. Anderson, M. Caballero, D. Amaya, J. Marota-Ruga	1995–1997
Pulsed-field gel electrophoresis and antibiotic profiles of 192 strains of *Staphylococcus aureus* from bovine mastitis in Costa Rica	M. Caballero	1997
Mastitis survey in farms located in the high and midland areas of San Carlos	A. Rojas-Bourrillón, E. March	1998

Public Health

Public health issues related to meat, milk and milk products have been addressed. Modern techniques for detection of pathogens and antibiotic residues were used to monitor the presence of these agents in beef, poultry, milk, and cheeses from the San Carlos region. In another public health project, case studies of women in subsistence farming in Costa Rica led to a better understanding of the transmission and prevention of zoonotic diseases. Data on culture and health were gathered and educational materials on zoonoses were developed for subsistence dairy farmers in Costa Rica. A project combining public health issues of zoonosis, food safety, and regulatory medicine was initiated. This project includes research, outreach and technology transfer programs for issues related to drug use, residues and antimicrobial resistance in dairy products. Individual research projects in public health are listed in Table 3.

Table 3. Research in Public Health

Title	Researchers	Duration
Women in subsistence dairy farming: understanding zoonotic disease transmission and prevention	M. Correa, E. March	1995–1996
Evaluation of contamination of *Salmonella* spp. in broilers in Costa Rica	M. Caballero, A. Arosemena, E. Perez, F. Garcia, K. Anderson	1998–1999
Prevalence of *Escherichia coli* O157:H7 in dairy calves in the San Carlos region	M. Caballero, S. Telles, E. Perez, K. Anderson	1999
Prevalence of *Escherichia coli* O157:H7 in beef carcasses from San Carlos	M. Caballero, S. Telles, E. Perez, K. Anderson	1999

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Plant Protection

The epidemiology and control of fungal diseases of citrus were the principal areas of research in crop protection. The epidemiology of citrus greasy spot, the most prevalent foliar disease of citrus in the San Carlos region, was studied and alternatives to chemical control were evaluated. In related studies, resistance to the fungicide benomyl was found in isolates of the greasy spot pathogen from San Carlos. Other research on citrus health included the evaluation of methods for field control of black rot of orange and studies to determine the etiology of the citrus corky root syndrome. A survey of plant protection problems and pesticide use in citrus orchards in the San Carlos region was also conducted. In addition to research on citrus diseases, studies were conducted to identify sources of resistance to the anthracnose disease in chile pepper and to determine the etiology of the root rot disease of cocoyam, an important root crop in the San Carlos region. Individual research projects in plant protection are listed in Table 4.

Table 4. Research in plant protection

Title	Researchers	Duration
Spore discharge patterns of citrus greasy spot pathogen in orange groves and control strategies through cultural practices and timing of oil sprays	H. Hidalgo, L. Brenes, T. Sutton, L.F. Arauz	1993–1996
Cultural control of citrus greasy spot by means of primary inoculum management	L. Brenes, L. F. Arauz, T. Sutton	1993–1997
Survey of crop protection problems and pesticide use in citrus orchards in the Northern Region of Costa Rica	L. Brenes, L.F. Arauz, T. Sutton	1994
Benomyl resistance in the citrus greasy spot pathogen, *M. citri*, in Costa Rica	H. Hidalgo, T. Sutton, L.F. Arauz	1994–1995
Field control of black rot of orange (*Alternaria citri*)	R. Astua, L.F. Arauz, E. Vargas, F. Morales	1995–1996
Etiology of the citrus corky root syndrome	E. Vargas, G. Abarca	1996–1999
Influence of orchard floor vegetation management on some aspects of the health of a citrus agroecosystem in San Carlos, Costa Rica	L.F. Arauz, F. Mora	1996–1999
Identification of sources of resistance to anthracnose (*Colletotrichum* spp.) in chile pepper (*Capsicum* spp.)	L.F. Arauz, M. Saborío	1998–1999
Distribution, economic impact and control of postbloom fruit drop in citrus in Costa Rica	L.F. Arauz, E. Arce	1999–2001

Publications

Publications in Scientific Journals

Anderson, K.L. 1996. New considerations in disease control and food safety. Ciencias Veterinarias Volumen Especial: 97–100.

Baynes, R.E., Lyman, R., Anderson, K.L., Brownie, C.F. 1999. A preliminary survey of antibiotic residues and viable bacteria in milk from three Caribbean Basin countries. J. Food Prot. 62(2): 177–180.

Correa, M. 1999. Gathering data on culture and health to develop educational materials on zoonoses for subsistence dairy farmers in Costa Rica. J. Agromedicine 6(1):33–42.

Hidalgo, H., Sutton, T.B., Arauz, L.F. 1997. Epidemiology and control of citrus greasy spot on Valencia orange in the humid tropics of Costa Rica. Plant Disease 81:1015–1022.

Hidalgo, H., Sutton, T.B., Arauz, L.F. 1998. Resistencia de *Mycosphaerella citri* a benomil en plantaciones de cítricos de Costa Rica. Agronomía Mesoamericana 9(1):86–89.

Montero, D., Perez, E. 1996. Diseño del estudio y epidemiología descriptiva de las lesiones podales del ganado lechero en el trópico húmedo de Costa Rica. Ciencias Veterinarias 19:19–32.

Montero, D., Perez, E. 1996. Prevalencia por tipo de lesión podal del ganado de leche en el trópico húmedo de Costa Rica. Ciencias Veterinarias 19: 33–50.

Musser, J.M.B., Anderson, K., Caballero, M., Amaya, D., Maroto-Puga, J. 1998. Evaluation of a hand-held electrical conductivity meter for detection of subclinical mastitis in cattle. Amer. J. Vet. Res. 59:1087–1091.

Rojas-Bourillon, A., Villarreal, M., Hidalgo, E., Quan, A. 1999. Validation of the use of *Arachis pintoi* for dairy heifers. I. Reduction of concentrate and use of *Arachis* as sole forage for Jersey heifers. Agronomía Costarricense 23(1):7–11.

Rojas-Bourillon, A., Villarreal, M., Rojas, M., Quan, A. 1999. Validation of the use of *Arachis pintoi* for dairy heifers. II. Utilization as long-term forage. Agronomía Costarricense 23(1):13–19.

Manuscripts Submitted for Publication in Scientific Journals

Moulaert, A.Q., Mueller, J.P., Villarreal, M., Piedra, R., Villalobos, L. Establishment of two indigenous timber species in dairy pastures in Costa Rica. Under revision, Agroforestry Systems, 2000.

Rodríguez, R., Villalobos, L., Villarreal, M. BNF of *Arachis pintoi* in greenhouse conditions. Submitted to Pasturas Tropicales.

Rodríguez, R., Villalobos, L., Villarreal, M. BNF of *Arachis pintoi* CIAT – 17434 associated with star grass in field conditions. Submitted to Pasturas Tropicales.

Rodríguez, R., Villalobos, L., Villarreal, M. Mineralization of different plant parts of *Arachis pintoi*. Submitted to Pasturas Tropicales.

Rojas-Bourrillón, A., Gamboa, H., Villarreal, M., Víquez, E., Castro, R., Poore, M. Sustitución de maíz por pulpa de cítricos deshidratada sobre la producción y composición láctea de vacas encastadas Holstein en el trópico húmedo. Submitted to Agronomía Costarricense, February 2000.

Tobías, C., Vargas, E., Rojas-Bourrillón, A., Soto, H. Uso de excretas de pollos de engorde en la alimentación animal. III. Rendimientos productivos de toretes suplementados con pollinaza. Submitted to Agronomía Costarricense, October 1999.

Invited Lectures in Scientific Meetings

Abarca, G. 1996. Los sinfilidos, el complejo de jobotos y sus relaciones con la raíz corchosa en suelos de Costa Rica. X Congreso Nacional Agronómico y de Recursos Naturales, III Congreso Nacional de Fitopatología y II Congreso Nacional de Suelos. San José, Costa Rica. Vol. III:63–65.

Vargas, E. 1996. Hongos y bacterias aislados de raices corchosas de cafeto y citricos en suelos con diferentes caracteristicas. X Congreso Nacional Agronómico y de Recursos Naturales, III Congreso Nacional de Fitopatología y II Congreso Nacional de Suelos. San José, Costa Rica. Vol III:67–68.

Abstracts Presented in Scientific Meetings

Acuna, A.L., Rosales, R. 1996. Slaughter processing analysis of Coopemontecillos plant. X Congreso Nacional Agronómico y de Recursos Naturales, III Congreso Nacional de Fitopatología y II Congreso Nacional de Suelos. San José, Costa Rica. Abstr. 124. Vol. I:395.

Arauz, L.F., Hord, M.J. 1994. Prueba de fungicidas para el combate de la mancha grasienta (*Mycosphaerella citri*) en naranja (*Citrus sinensis*). XL Reunión Anual PCCMCA. San José, Costa Rica. Abstr. 86.

Araya, E., Elizondo, J., Jiménez, C., Quan, A. 1996. Evaluation of four chemical treatments and manual control of weeds in a perennial peanut. 1. Qualitative characteristics. X Congreso Nacional Agronómico y de Recursos Naturales, III Congreso Nacional de Fitopatología y II Congreso Nacional de Suelos. San José, Costa Rica. Abstr. 84, Vol. I:354.

Araya, E., Elizando, J., Jiménez, C., Quan, A. 1996. Evaluation of four chemical treatments and manual control of weeds in a perennial peanut crop. 2. Quantitative characteristics. X Congreso Nacional Agronómico y de Recursos Naturales, III Congreso Nacional de Fitopatología y II Congreso Nacional de Suelos. San José, Costa Rica. Abstr. 83, Vol. I:353.

Astúa, R., Arauz, L.F., Vargas, E., Morales, F. 1996. Combate de campo de la pudrición negra de la naranja con fungicidas y micronutrientes. X Congreso Nacional Agronómico y de Recursos Naturales, III Congreso Nacional de Fitopatología y II Congreso Nacional de Suelos. San José, Costa Rica.Abstr. 145. Vol. II:83.

Baynes, R., Lyman, R., Goss, K., Steelman-Szymeczek, S., Caballero, M., Corpening, C., Brownie, C., Anderson, K. 1998. Antimicrobial residue and milk quality concerns in Caribbean Basin Countries. Abstract. 1998 Society of Toxicology Annual Meeting. 42(1–5) J. Soc. Toxicology (Supplement), March 1998, p. 286.

Baynes, R., Lyman, R., Goss, K., Steelman-Szymeczek, S., Caballero, M., Corpening, C., Brownie, C., Anderson, K. 1998. Drug residue concerns in Caribbean Basin Countries. Proceedings: Congreso Panamericano de Control de Mastitis y Calidad de la Leche. Merida, Yucatán, Mexico. pp. 189–192.

Brenes, L. Arauz, L.F., Sutton, T.B. 1997. Combate de la mancha grasienta del naranjo mediante el manejo de inóculo. XXXVII Annual Meeting of the American Phytopathological Society, Caribbean Division. San José, Costa Rica. Abstr. 58.

Brenes, L.E., Arauz, L.F. 1994. Diagnóstico del manejo fitosanitario de los cítricos en la Región Huetar Norte de Costa Rica. V Congreso Internacional de Manejo Integrado de Plagas. Heredia, Costa Rica. Abstr. 097, p. 124.

Correa, M. 1998. Multidisciplinary efforts and educational programs for zoonotic-disease education. 2nd Argentinean Conference on Zoonosis and 1st Latin American Conference on Emerging Zoonosis. April 14–17, 1998. Buenos Aires, Argentina.

Correa, M., March, E. 1997. Zoonotic disease transmission and prevention: a case study of women in subsistence farming in Costa Rica. XIII Congress of the International Association of Agricultural Medicine and Rural Health. Iowa City, Iowa. Abstr. 030-5.

Hidalgo, H., Sutton, T.B., Arauz, L.F. 1996. Liberación de ascosporas de *Mycosphaerella citri*, agente casual de la mancha grasienta y resistencia de *M. citri* a benomil en Costa Rica. X Congreso Nacional Agronómico y de Recursos Naturales, III Congreso Nacional de Fitopatología y II Congreso Nacional de Suelos. San José, Costa Rica. Abstr. 144, Vol. II:82.

Moulaert, A.Q., Mueller, J.P., Villarreal, M., Piedra, R., Villalobos, L. 1997. A silvopastoral system in the north Atlantic zone of Costa Rica: Combining indigenous timber species with dairy pasture swards. ID 1399. In: Proc. XVIII Int. Grassland Congress. Winnipeg, Manitoba, Canada.

Quan, A., Amador, L., Rojas, A., Villalobos, L. 1996. Rumen dynamics in animals with and without access to a protein bank of perennial peanut. X Congreso Nacional Agronómico y de Recursos Naturales, III Congreso Nacional de Fitopatología y II Congreso Nacional de Suelos. San José, Costa Rica. Abstr. 112, Vol. I:383.

Quan, A., Rojas, A. 1996. Effect of three levels of starter on growth rate of Jersey heifers grazing Star grass and perennial peanut as protein bank. X Congreso Nacional Agronómico y de Recursos Naturales, III Congreso Nacional de Fitopatología y II Congreso Nacional de Suelos. San José, Costa Rica. Abstr. 110, Vol. I:381.

Rodríguez, R., Villalobos, L., Villareal, M. 1999. Diversidad de lombrices en sistemas de pasturas asociadas y no asociadas con *Arachis pintoi* en la región de San Carlos, Costa Rica. I Congreso Interuniversitario de Biodiversidad. Ciudad de la Investigación, UCR. San José, Costa Rica.

Rodríguez, R., Villalobos, L., Villarreal, M. 1999. Biodiversidad de organismos presentes en el follaje de pasturas asociadas y no asociadas en *Arachis pintoi*, San Carlos, Costa Rica. I Congreso Interuniversitario de Biodiversidad. Ciudad de la Investigación, UCR. San José, Costa Rica.

Rodríguez, R., Villalobos, L., Villarreal, M. 1999. Composición de la biomasa subterránea en pasturas asociadas y no asociadas con *Arachis pintoi* en la región de San Carlos, Costa Rica. XI Congreso Nacional Agronómico y de Recursos Naturales, V Congreso Nacional de Entomología, IV Congreso Nacional de Fitopatología, III Congreso Nacional de Suelos y I Congreso Nacional de Extensión Agrícola y Forestal. San José, Costa Rica. Abstr. 322, Vol. III:59.

Rodríguez, R., Villalobos, L., Villarreal, M. 1999. Densidad y biomasa de lombrices presentes en pasturas asociadas y no asociadas con *Arachis pintoi*, en diferentes localidades de San Carlos. XI Congreso Nacional Agronómico y de Recursos Naturales, V Congreso Nacional de Entomología, IV Congreso Nacional de Fitopatología, III Congreso Nacional de Suelos y I Congreso Nacional de Extensión Agrícola y Forestal. San José, Costa Rica. Abstr. 319, Vol. III:53.

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Rodríguez, R., Villalobos, L., Villarreal, M., Cervantes, C. 1999. Absorción de Nitrógeno proveniente de *Arachis pintoi* por el pasto *Cynodon nlemfuensis* mediante la metodología isotópica del ^{15}N. Segundo Congreso Internacional Agropecuario y Forestal de la Región Tropical Húmeda. EARTH, Las Mercedes, Guácimo, Costa Rica. p.68.

Rodríguez, R., Villalobos, L., Villarreal, M., Cervantes, C. 1999. Fijación de Nitrógeno de *Arachis pintoi* asociado con pasto êstrella. Segundo Congreso Internacional Agropecuario y Forestal de la Región Tropical Húmeda. EARTH, Las Mercedes, Guácimo, Costa Rica. p.69.

Rodríguez, R., Villalobos, L., Villarreal, M., Cervantes, C. 1999. Absorción del Nitrógeno proveniente del *Arachis pintoi* por el pasto *Cynodon nlemfuensis* bajo condiciones controladas mediante la metodología ísotópica de ^{15}N. XI Congreso Nacional Agronómico y de Recursos Naturales, V Congreso Nacional de Entomología, IV Congreso Nacional de Fitopatología, III Congreso Nacional de Suelos y I Congreso Nacional de Extensión Agrícola y Forestal. San José, Costa Rica. Abstr. 348, Vol. III:116.

Rodríguez, R., Villalobos, L., Villarreal, M., Cervantes, C. 1999. Fijación de nitrogeno del mani forrajero CIAT 17434 (*Arachis pintoi*) asociado con pasto estrella (*Cynodon nlemfuensis*) en condiciones de campo. XI Congreso Nacional Agronómico y de Recursos Naturales, V Congreso Nacional de Entomología, IV Congreso Nacional de Fitopatología, III Congreso Nacional de Suelos y I Congreso Nacional de Extensión Agrícola y Forestal. San José, Costa Rica. Abstr. 314, Vol. III:47.

Rodríguez, R., Villalobos, L., Villarreal, M., Cervantes, C. 1999. Fijación de nitrogeno de cuatro accesiones de mani forrajero (*Arachis pintoi*) bajo condiciones controladas. XI Congreso Nacional Agronómico y de Recursos Naturales, V Congreso Nacional de Entomología, IV Congreso Nacional de Fitopatología, III Congreso Nacional de Suelos y I Congreso Nacional de Extensión Agrícola y Forestal. San José, Costa Rica. Abstr. 350, Vol. III:119.

Rodríguez, R., Villalobos, L., Villarreal, M., Cervantes, C., Urquiaga, S. 1998. Absorción de nitrógeno proveniente del *Arachis pintoi* por el pasto *Cynodon nlemfuensis* bajo condiciones controladas mediante la metodología isotópica de ^{15}N. Memoria de la XIX Reunión Latinoamericana de Rhizobiología. Venezuela. p. 133.

Rodríguez, R., Villalobos, L., Villarreal, M., Cervantes, C., Urquiaga, S. 2000. Fijación de Nitrógeno de cuatro accesiones de Maní Forrajero (*Arachis pintoi*) bajo condiciones controladas. Primer Congreso de Investigación: Los retos y propuestas de la Investigación en el III milenio. San José, Costa Rica. p. 138.

Rodríguez, R., Villalobos, L., Villarreal, M., Cervantes, C., Urquiaga, S. 2000. Fijación de Nitrógeno del Maní Forrajero (*Arachis pintoi* CIAT 17434) asociado con pasto Estrella (*Cynodon nlemfuensis*) en condiciones de campo. Primer Congreso de Investigación: Los retos y propuestas de la investigación en el III milenio. San José, Costa Rica. p. 137.

Rojas-Bourillón, A., Gamboa, L.H., Villarreal, M., Víquez, E., Castro, R., Poore, M. 1999. Maíz o pulpa de cítricos peletizada en concentrados para la producción de leche en vacas mestizas Holstein. Segundo Congreso Internacional Agropecuario y Forestal de la Región Tropical Húmeda. EARTH, Las Mercedes, Guácimo, Costa Rica. p. 73.

Rojas-Bourillón, A., Quan, A., Rojas, M., Villarreal, M. 1999. Utilización de *Arachis pintoi* como forraje de corte para la crianza de terneras de lechería. Segundo Congreso Internacional Agropecuario y Forestal de la Región Tropical Húmeda. EARTH, Las Mercedes, Guácimo, Costa Rica. p. 77.

Rojas-Bourillón, A., Villarreal, M., Hidalgo, E., Quan, A. 1999. Pastoreo de *Arachis pintoi* y suministro de concentrado en terneras de lechería. Segundo Congreso Internacional Agropecuario y Forestal de la Región Tropical Húmeda. EARTH, Las Mercedes, Guácimo, Costa Rica. p. 75.

23

Saborío, M., Mora, L.F., Arauz, L.F., Grant, F., Vargas, E. 1999. Identificación de fuentes de resistencia a antracnosis (*Colletotrichum* spp.) en chile picante (*Capsicum* spp.) XI Congreso Nacional Agronómico y de Recursos Naturales, V Congreso Nacional de Entomología, IV Congreso Nacional de Fitopatología, III Congreso Nacional de Suelos y I Congreso Nacional de Extensión Agrícola y Forestal. San José, Costa Rica. 1999. p. 46.

Villalobos, L., Rodríguez, R., Villarreal, M. 1999. Diversidad de invertebrados presentes en pasturas bajo diferentes condiciones de manejo. XI Congreso Nacional Agronómico y de Recursos Naturales, V Congreso Nacional de Entomología, IV Congreso Nacional de Fitopatología, III Congreso Nacional de Suelos y I Congreso Nacional de Extensión Agrícola y Forestal. San José, Costa Rica. Abstr. 316, Vol III:49.

Villalobos, L., Rodríguez, R., Villarreal, M. 1999. Indicadores potenciales de sostenibilidad en la introducción de *Arachis pintoi* en potreros de fincas lecheras de San Carlos, Costa Rica. XI Congreso Nacional Agronómico y de Recursos Naturales, V Congreso Nacional de Entomología, IV Congreso Nacional de Fitopatología, III Congreso Nacional de Suelos y I Congreso Nacional de Extensión Agrícola y Forestal. San José, Costa Rica. Abstr. 321, Vol. III:57.

Villalobos, L., Rodríguez, R., Villarreal, M. 1999. Poblaciones de artrópodos en sistemas pasturas asociadas y no asociadas con *Arachis pintoi*. San Carlos, Costa Rica. XI Congreso Nacional Agronómico y de Recursos Naturales, V Congreso Nacional de Entomología, IV Congreso Nacional de Fitopatología, III Congreso Nacional de Suelos y I Congreso Nacional de Extensión Agrícola y Forestal. San José, Costa Rica. Abstr. 320, Vol. III:55.

Villalobos, L., Rodríguez, R., Villarreal, M. 2000. Indicadores potenciales de sostenibilidad en la introducción de *Arachis pintoi* en potreros de fincas lecheras de San Carlos, Costa Rica. Primer Congreso de Investigación: Los retos y propuestas de la investigación en el III milenio. San José, Costa Rica. p. 136.

Villalobos, L., Villarreal, M., Araya, E., Rodríguez, R. 1996. Asociación de *Arachis pintoi* en siete fincas lecheras del trópico húmedo. San Carlos. X Congreso Nacional Agronómico y de Recursos Naturales, III Congreso Nacional de Fitopatología y II Congreso Nacional de Suelos. San José, Costa Rica. Abstr. 111, Vol. 1:382.

Villarreal, M., Naranjo, G., Villalobos, L., Rodríguez, R., Morera, P. 1999. Evaluación preliminar de poblaciones de babosas (*Sarasinula plebeia*) en la leguminosa *Arachis pintoi*. I Congreso Interuniversitario de Biodiversidad. Ciudad de la Investigación, UCR. San José, Costa Rica.

Villarreal, M., Naranjo, G., Villalobos, L., Rodríguez, R., Morera, P. 2000. Evaluación preliminar de poblaciones de babosas (*Sarasinula plebeia*) en la leguminosa *Arachis pintoi*. Primer Congreso de Investigación: Los retos y propuestas de la investigación en el III milenio. San José, Costa Rica. p. 132.

Villarreal, M., Rodríguez, R., Villalobos, L. 1999. Poblaciones microbiales presentes en suelos de pasturas bajo diferentes condiciones de manejo en la región de San Carlos, Costa Rica. XI Congreso Nacional Agronómico y de Recursos Naturales, V Congreso Nacional de Entomología, IV Congreso Nacional de Fitopatología, III Congreso Nacional de Suelos y I Congreso Nacional de Extensión Agrícola y Forestal. San José, Costa Rica. Abstr. 317, Vol. III:51.

Villarreal, M., Ugalde, M., Paniagua, W., Rojas, A., Rojas, Y. 2000. Efecto de la alimentación suplementaria con banano verde y maní forrajero (*Arachis pintoi*) en la producción y calidad de la leche de un hato en San Carlos. Primer Congreso de Investigación: Los retos y propuestas de la investigación en el III milenio. San José, Costa Rica. p. 134.

Villarreal, M., Ugalde, M., Paniagua, W., Rojas-Bourillón, A., Rojas, Y. 1999. Efecto de la alimentación suplementaria con banano verde y maní forrajero (*Arachis pintoi*) en la producción y calidad de la leche de un hato en San Carlos. XI Congreso Nacional Agronómico y de Recursos Naturales, V Congreso Nacional de Entomología, IV Congreso Nacional de Fitopatología, III Congreso Nacional de Suelos y I Congreso Nacional de Extensión Agrícola y Forestal. San José, Costa Rica. Vol. III:579.

Villarreal, M., Ugalde, M., Paniagua, W., Rojas-Bourillón, A., Rojas, Y. 1999. Efecto de la alimentación suplementaria con banano verde y maní forrajero (*Arachis pintoi*) en la producción y calidad de la leche de un hato en San Carlos. Segundo Congreso Internacional Agropecuario y Forestal de la Región Tropical Húmeda. EARTH, Las Mercedes, Guácimo, Costa Rica. p.76

Villarreal, M., Villalobos, L., Rodríguez, R. 1999. Comportamiento de la leguminosa forrajera *Arachis pintoi* en fincas lecheras de la region de San Carlos, Costa Rica. XI Congreso Nacional Agronómico y de Recursos Naturales, V Congreso Nacional de Entomología, IV Congreso Nacional de Fitopatología, III Congreso Nacional de Suelos y I Congreso Nacional de Extensión Agrícola y Forestal. San José, Costa Rica. Abstr. 418, Vol. III:556.

Villarreal, M., Villalobos, L., Rodríguez, R. 2000. Comportamiento de la leguminosa forrajera *Arachis pintoi* en fincas lecheras en la Región de San Carlos, Costa Rica. Primer Congreso de Investigación: Los retos y propuestas de la investigación en el III milenio. San José, Costa Rica. p. 121.

Villarreal, M., Zúñiga, R., Zumbado, E. 1999. Potencial de producción de biomasa aérea y semilla de tres accesiones de *Arachis pintoi* sometidas a diferentes frecuencias de corte. Segundo Congreso Internacional Agropecuario y Forestal de la Región Tropical Húmeda. EARTH, Las Mercedes, Guácimo, Costa Rica. p. 67.

Villarreal, M., Zúñiga, R., Zumbado, R. 2000. Potencial de producción de biomasa aérea y semilla de tres accesiones de *Arachis pintoi* sometidas a diferentes frecuencias de corte. Primer Congreso de Investigación: Los retos y propuestas de la Investigación en el III milenio. San José, Costa Rica., p. 135.

Books

Vargas, E., Mata, R.A:, Abarca, G., Quesada, M. Opciones al combate del síndrome de la raíz corchosa, en naranja (*Citrus sinensis*). In: Opciones al uso unilateral de plaguicidas en Costa Rica: pasado, presente y futuro. Vol III. J.E. García, G. Fuentes, J. Nájera (Eds.). Editorial Universidad Estatal a la Distancia (EUNED), San José, Costa Rica. In press, 2000.

Presentations in Seminars and Workshops

Anderson, K.L., Mueller, P., Sutton, T., Correa, M.T., Laarman, J., Arauz, L. F, Rojas, A., Mueller, E., Villalobos, L., Perez, E. 1995. Sustainable agricultural focus in the San Carlos Region of Costa Rica: A collaborative linkage between North Carolina State University (NCSU), Universidad de Costa Rica (UCR) and Universidad Nacional (UNA). Poster presentation. Partnership for Development, USAID, UDLP International Workshop, Arlington, VA. October 15–18, 1995.

Anderson, K.L., Mueller, P., Sutton, T., Correa, M., Villalobos, L., Caballero, M., Perez, E., Arauz, L.F, Rojas, A., Villarreal, M. 1999. Sustainable agricultural focus in the San Carlos region of Costa Rica. Poster presentation. USAID/Higher Education Partnership in Development: Latin American and Caribbean Conference. Tegucigalpa, Honduras. January 20–23, 1999.

Caballero, M. 1996. The Veterinary School at Heredia, Costa Rica: Views of a Costa Rican microbiologist. NCSU College of Veterinary Medicine, Raleigh, NC. November 20, 1996.

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Camacho, J., Villalobos, L., Villarreal, M., Rodríguez, R. 1998. Monitoring bio-economic parameters for the definition of sustainability on dairy farms in San Carlos, Costa Rica: A case study. Workshop on rural and peri-urban farming systems to improve agricultural productivity. Rothamsted, United Kingdom. June 3–6, 1998.

Correa, M. 1993. Women in development. Case study in rural Costa Rica. Sustainable development: Agenda for the future. Colloquium at North Carolina Central University, Durham, NC. October 20, 1993.

Correa, M, Anderson, K. 2000. History and regulations of organic dairy production in the US. First National Meeting on Organic Dairy: Options and Limitations ("Primer Encuentro Nacional sobre Ganaderia Organica: Opciones y Limitaciones"). San Jose, UNED. May 29, 2000.

Martin, T. 2000. Residue avoidance policies in the US and globalization of the FARAD program. Seminar at College of Veterinary Medicine, Universidad Nacional, Heredia, Costa Rica. March 22, 2000.

Musser, J.M.B. 1995. Subclinical mastitis in Costa Rican dairies. Presentation to NCSU–College of Veterinary Medicine Student International Club. Raleigh, NC. March 1995.

Rodríguez, R., Villalobos, L., Villarreal, M. 1999. Densidad y biomasa de lombrices presentes en pasturas asociadas y no asociadas con *Arachis pintoi*, en diferentes localidades de San Carlos. In: Technical working group, Ministry of Agriculture. Cartago, Costa Rica. August 20, 1999.

Rojas-Bourrillón, A. 1996. Utilization of wet tropical by-products in dairy cattle. International Course in Dairy Nutrition. University of Costa Rica, September 9–14, 1996.

Rojas-Bourrillón, A., Quan, A. 1998. *Arachis pintoi*: una alternativa para la producción orgánica de forrajes de corte para la alimentación animal. In: I Taller de Agricultura Orgánica. Facultad de Agronomía, Universidad de Costa Rica. April 23, 1998.

Vassey, M. 2000. Pura vida: Veterinary perspectives in Costa Rica. Population Medicine Program Seminar, NC State University, College of Veterinary Medicine, April 13, 2000.

Villalobos, L., Rodríguez, R., Villarreal, M. 1999. Experiencias en la introducción de *Arachis pintoi* en fincas lecheras de la Región de San Carlos, Costa Rica. Instituto Nacional de Aprendizaje 30th Anniversary. June 1, 1999.

Villalobos, L., Rodríguez, R., Villarreal, M. 1999. Indicadores potenciales de sostenibilidad en la introduccion de *Arachis pintoi* en potreros de fincas lecheras de San Carlos, Costa Rica. In: Technical working group, Ministry of Agriculture. Cartago, Costa Rica. August 20, 1999.

Villalobos, L., Rodríguez, R., Villarreal, M. 1999. Sustainability indicators as a tool for monitoring introduction of forage germplasm in dairy farms. In: Unification of indicator quality for assessment of impact of multidisciplinary systems. Workshop on Ecosystems Converted to Agricultural Use. Heredia, Costa Rica. April 27–May 1, 1999. 9 pp.

Villalobos, L., Villarreal, M., Araya, E. 1995. Establishment of *Arachis pintoi* on dairy farms in San Carlos. Preliminary information. In: Workshop on regional experiences with *Arachis pintoi* and future plans for research and promotion of the species in Mexico, Central America and the Caribbean (Experiencias Regionales con *Arachis pintoi* y Planes Futuros de Investigación y Promoción de la Especie en México, Centroamerica y el Caribe). Estación Experimental Alfredo Volio Mata, Universidad de Costa Rica. RIEPT—MCAC/CIAT. October 9–13, 1995. pp. 113–188.

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Villalobos, L., Villarreal, M., Rodríguez, R. 1997. Establishment of *Arachis pintoi* in dairy farms of San Carlos. Lecture in National Congress of County Development Boards. Moravia, Costa Rica. November 1997.

Villarreal, M. 1998. Aspectos de manejo de forrajes en el trópico. Workshop: Ganadería Intensiva en el Trópico Húmedo. CENAP/CIPRES/ITCR/MAG. Florencia de San Carlos, Costa Rica.. February 24–26, 1998. 20p.

Villarreal, M. 1999. Algunas consideraciones sobre el uso de semillas forrajeras como recurso agropecuario para el mejoramiento de pasturas. Seminar: Perspectivas para el Mejoramiento de la Ganadería Bovina en Costa Rica. Escuela de Agronomía, ITCR, Sede San Carlos. December 2, 1999. 12 p.

Villarreal, M. 1999. Alternativas forrajeras para intensificar la producción de carne. Seminar: Mejoramiento de la Producción de Carne en el Trópico. Escuela de Agronomía, ITCR, Sede San Carlos. December 1, 1999. 16 p.

Graduate Theses

Abarca, R., Madríz, A. 1999. Determinar la competitividad económica de la explotación lechera especializada de las zonas altas del Valle Central y San Carlos ante convenio marco del Gatt. Licenciatura Thesis. Escuela de Economía Agrícola, Universidad de Costa Rica. 162 pp.

Brenes, Luis. 1999. Manejo fitosanitario de la naranja: bases para un uso racional de plaguicidas con especial énfasis en el control de la mancha grasienta. Magister Scientiae Thesis. Posgrado en Ciencias Agrícolas y Recursos Naturales, Universidad de Costa Rica. 106 pp.

Hidalgo-Alvarez, Herman. 1996. Epidemiology and control of citrus greasy spot on Valencia orange and resistance of *Mycosphaerella citri* to benomyl in San Carlos, Costa Rica. Master of Science Thesis. North Carolina State University, Department of Plant Pathology, College of Agricultural and Life Sciences, Raleigh, NC. 42 pp.

Hidalgo, Jorge Luis. 1998. El efecto del encalado y la fertilización con sulfato de manganeso sobre la población de sinfilidos (*Symphyla*) en un suelo bajo cultivo de naranja (*Citrus sinensia* var. *Valencia*) en San Carlos, Alajuela. Licenciatura Thesis. Facultad de Agronomía, Universidad de Costa Rica. 48 pp.

Montero Caballero, Danilo. 1996. Estudio epidemiológico de las lesiones podales del ganado de leche en el trópico húmedo de Costa Rica. Magister Scientiae Thesis. Posgrado en Ciencias Veterinarias Tropicales, Universidad Nacional, Heredia, Costa Rica.

Moulaert, A. Q. 1996. A silvopastoral system in the North Atlantic zone of Costa Rica: Combining indigenous timber species with dairy pasture swards. Master of Science Thesis. North Carolina State University, Department of Crop Science, College of Agricultural and Life Sciences. Raleigh, NC. 72 pp.

Naranjo U., Gustavo. 2000. Evaluación preliminar de poblaciones de babosas (*Sarasinula plebeia*) en la leguminosa *Arachis pintoi* y otros cultivos de interés agrícola. Licenciatura Thesis. Escuela de Agronomía, ITCR, Sede San Carlos. 36 p.

Ortíz, R. 1996. Bosque secundario por abandono de pastizales en la Región Huetar Norte de Costa Rica: Análisis de algunos criterios económicos y ambientales. Magister Scientiae Thesis. Posgrado en Política Económica con mención en Economía Ecológica y Desarrollo Sostenible. Universidad Nacional, Heredia, Costa Rica. 112 pp.

Rodríguez Flores, Ruth. 1998. Determinación de la fijación biológica de nitrógeno del *Arachis pintoi* y absorción por el *Cynodon nlemfuènsis* con la metodología de ^{15}N. Licenciatura Thesis. Escuela de Ciencias Agrarias, Universidad Nacional, Heredia, Costa Rica. 116 pp.

Tobias, C. 1999. Uso de excretas de pollos de engorde en la alimentación animal. Magister Scientiae Thesis. Posgrado en Ciencias Agrícolas y Recursos Naturales, Universidad de Costa Rica. 114 pp.

Ugalde, M. 1998. Uso del banano verde de desecho y maní forrajero (*Arachis pintoi*) como sustitutos parciales del concentrado en la alimentación de vacas en la lechería del Instituto Tecnológico de Costa Rica, Santa Clara, San Carlos. Licenciatura Thesis, Escuela de Agronomía, Instituto Tecnológico de Costa Rica. 43 pp.

Other Publications

Anderson, K.L., Mueller, J.P., Sutton, T.B., Correa, M.T., Villalobos, L., Caballero, M., Arauz, L.F, Rojas, A., Villareal, M. 1998. Sustainable agriculture focus in the San Carlos region of Costa Rica, NCSU-UNA-UCR University Linkages Development Program Linkages Project Brochure.

Brenes, L.E., Arauz, L.F. 1994. Crop protection in citrus production – Pesticide use in Costa Rican northern region orchards. Preliminary report for NCSU-UCR-UNA UDLP Project. Pesticide program, UNA and Phytopathology Department, UCR.

Rodríguez, J. D. 1999. Estudio de siete fincas lecheras en la Región Huetar Norte de Costa Rica: Evaluación de la introducción de una leguminosa (*Arachis pintoi* CIAT 18744) y descripción tecnológica de las unidades de producción. Graduation project. B.Sc. Program in Agronomy, Escuela de Agronomía, Instituto Tecnológico de Costa Rica, Sede San Carlos. 50 p.

Rodríguez, R., Villalobos, L., Villarreal, M. 1998. Fijación Biológica del Nitrógeno del Maní Forrajero (*Arachis pintoi*). Document prepared for dairy producers in the project "Monitoring bioeconomic parameters for the definition of sustainability on dairy farms of San Carlos". UNA/ITCR Cooperative program UNA-NSCU-UCR. 9 p.

Villalobos, L., Rojas-Bourrillón, A. 1994. Diagnostic on dairy production in the San Carlos region. Report prepared for UDLP Coordination Meeting, Raleigh, NC.

Villalobos, L., Villarreal, M., Rodríguez, R., Araya, E. 1997. Monitoreo de parametros bioeconómicos para la definición de la sostenibilidad en fincas lecheras de la Región de San Carlos. First written report to the farmers.

Extension Activities (Related to Research Conducted During the Project)

Symposia

Advances in Research on Fungal Diseases in Citrus in the Northern Zone of Costa Rica. San Carlos, Costa Rica. November 12, 1996. Citrus orchard managers were updated on epidemiology and control of citrus greasy spot and methods for control of black rot of citrus. Organized by UCR and the Costa Rican Association of Plant Pathologists. UDLP scientists: L.F. Arauz, L. Brenes, H. Hidalgo, R. Astúa. 35 participants.

Seminars

Utilization of Citrus Pulp in Dairy Rations. Conference given by UDLP scientist A. Rojas-Bourrillón to farmers from the Dos Pinos Cooperative. San Carlos, Costa Rica. Feb 17–21, 1996. Organized by UCR and Coop Dos Pinos. 103 farmers from five counties participated.

Mastitis, An Everyday Problem in Dairy. Conference given by UDLP scientist M. Caballero in San Carlos, Costa Rica. October 1, 1997. Dairy farmers from San Carlos were informed about mastitis and results of a study on the prevalence of antibiotics in milk samples from the San Carlos region were presented and discussed. Organized by UNA and the Dos Pinos Cooperative. Approx. 30 dairy farmers attended.

Advances in Dairy Calf Nutrition. Conference given by UDLP scientist A. Rojas-Bourrillón to dairy producers from 12 counties. The conference was given in six counties of San Carlos and in six other locations in the country. February 3–April 6, 1998. Organized by Coop Dos Pinos. 254 producers attended.

Feeding Dairy Cows with Waste Products. Conference given by UDLP scientist A. Rojas-Bourrillón to dairy cattle farmers. San José, Costa Rica. August 3, 1998. Organized by the National Dairy Board of Costa Rica. 35 producers attended.

Citrus Greasy Spot. Conference given by UDLP scientist L.F. Arauz to citrus growers in the San Carlos region. San Carlos, Costa Rica. June 23, 1999. Organized by UCR and Tico Frut. 30 growers attended.

Body Condition Management. Conference given by UDLP scientist A. Rojas-Bourrillón to cattle producers. Pital, San Carlos, Costa Rica. August 7, 1999. Organized by the Jersey Breed Association. 135 producers attended.

First National Meeting on Organic Dairy: Options and Limitations ("Primer Encuentro Nacional sobre Ganaderia Organica: Opciones y Limitaciones.") Organized by IICA, CORFOGA, AMBIO, UNED, CADEXCO, UNA–CVM, and NCSU–CVM. San Jose, UNED, May 29, 2000. 100 producers, academicians, and government personnel attended (maximum attendance allowed).

Training and Workshops

Planning and program development for the project, "Drug Use, Residues and Antimicrobial Resistance in Three Central American Countries: Costa Rica, Panama and Nicaragua." August 8, 2000. San Jose, Costa Rica. UDLP Scientists: M. Correa and M. Caballero.

Forage *Arachis* in Dairy Farms of San Carlos. San Carlos. August 23, 1997. Workshop organized by UNA, UCR and ITCR to promote farmer-to-farmer transfer of information and experiences. UDLP scientists: L. Villalobos, M. Villarreal, R. Rodríguez, and A. Rojas. 15 participants.

Body Condition Score for Dairy Cows. Rio Cuarto, Grecia, Costa Rica. September 6, 1997. Training given to farmers with information on health, milk production and reproductive performance associated with body condition score. Organized by UCR and Penn State. UDLP scientists: Dr. Jud Heinrichs (invited) and A. Rojas-Bourrillón. 25 participants.

Field Trips / Field Days

Production and Use of Pastures for Milk Production. INA, Naranjo, Alajuela, Costa Rica. November 9, 1996. Jersey Association Field Day sponsored by Concentrados Aguilar & Solis. UDLP scientist: M. Villarreal. Approximately 50 participants.

Animal Production Under the Criteria of Sustainability for Small Livestock Farmers. San Carlos Region. October 7, 1997. Field trip organized by D. Montero (SIDESA) and "Bread for the World". UDLP scientists and Costa Rican farmers shared experiences with visiting technicians, producers and scientists from Nicaragua, Honduras and Costa Rica. UDLP scientist: L. Villalobos. 22 participants.

Use of *Arachis pintoi* as Forage for Beef and Dairy Cattle in the Humid Tropics. Pital, Costa Rica. November 15, 1997. Field day for cattle farmers. UDLP scientists: M. Villarreal, A. Rojas and L. Villalobos. Approximately 50 farmers attended.

Experiences in the Use of Wet By-products on Feedlot Operations. ITCR, San Carlos. April 15, 1998. Conference given at the Cattle Field Day. UDLP scientists: C. Tobias and A. Rojas-Bourrillón. 52 participants.

Validation of a Heifer Feeding System Using *Arachis pintoi*. Venecia, Costa Rica. August 22, 1998. Conference given during Dairy Cattle Field Day – Advances in Dairy Calf Nutrition. UDLP scientist: A. Rojas-Bourrillón. 68 farmers attended.

Advances in Heifer Replacement Management. Monteverde, Costa Rica. September 5, 1998. Dairy Cattle Field Day. UDLP scientist: A. Rojas-Bourrillón. Attended by 42 farmers.

Research Proposals Generated/Additional Funding

Spanish Language Training for Health Professionals. Preproposal submitted to the National Security Education Program. July 1, 1994. UDLP scientists: K. Anderson and E. Muller, with Dr. Gwen Griffith (USAID).

Outreach Program for Nicaragua and the Northern Region of Costa Rica: An Approach to Sustainable Production Systems. Preproposal submitted to the Association Liaison Office of University Cooperation in Development, Washington, D.C. May 10, 1998. UDLP scientists: K. Anderson, P. Mueller, T. B. Sutton, L. Villalobos, M. Caballero, M. Villarreal, A. Rojas, L.F. Arauz.

Development of Silvopastoral Systems for the Humid Tropic Using Indigenous Timber Species and Herbaceous Forages. Submitted to the Environmental Defense Fund, October 1998. Amount requested: $15,000. UDLP scientists: P. Mueller, M. Villarreal and L. Villalobos.

Integrated Management of the Citrus Agro-ecosystem Health. Submitted to the Costa Rican Ministry of Agriculture in 1998 and partially funded in the amount of $4000. UDLP scientist: L.F. Arauz.

Development of Alternative Systems for Sustainable Milk Production in the San Carlos Region of Costa Rica. Submitted to Fundación CR-USA, June 1999. Amount requested: $100,000. UDLP scientists: L. Villalobos and M. Villarreal.

Public Health Issues Related to Meat, Milk and Milk Products. Submitted to Fundación CR-USA, 1999. Amount requested: $10,000. UDLP scientists: M. Caballero, K.L. Anderson, et al.

Distribution, Economic Impact and Control of Postbloom Fruit Drop in Citrus in the San Carlos Region. UDLP project funds have been complemented by a $7,000 grant for research in 2000 from TicoFrut, the major citrus processing company in Costa Rica. UDLP scientist: L.F. Arauz.

Drug Use, Residues, and Antimicrobial Resistance in Three Central American Countries: Costa Rica, Panama and Nicaragua. ULDP project funds were used to conduct a rapid assessment in these 3 countries. ULDP scientists: M. Correa, M. Caballero, and K. Anderson.

As of the writing of this report, efforts to gain additional funding are being actively pursued.

Training

Faculty, Staff and Student Exchanges

C.H.A.M. Eilers, student at Wageningen Agricultural University, conducted a survey of dairy health in San Carlos under the direction of Dr. Muller (UNA). September–October, 1993.

M. Correa (NCSU) received training in rural anthropology at UCR and conducted fieldwork in Buena Vista de Guatuzo, San Carlos. May 1993 and January 1994.

E. Eduarte (UNA) and H. Dormond (UCR) participated in field trials in forage research at NCSU. Summer, 1994.

A. Ortuño (UNA) received training in biotechnology at NCSU. Summer, 1994.

M. Vito (NCSU–CVM), veterinary student at NCSU worked with Drs. Correa and Perez on the project "Veterinary Extension Service in Costa Rica and Its Role in Tropical Disease Field Research". October 1994, VMM 879, Clinical Epidemiology.

K. Flammer (NCSU–CVM) visited Costa Rica and met with Dr. Eduard Muller (Director, University for International Cooperation) and Dr. Ana Ortuño (Director of Graduate Programs, School of Veterinary Medicine, UNA) to discuss linkages between programs regarding preservation and production of wildlife as a sustainable alternative for Costa Rican farmers. November 28 – December 2, 1994.

M. Vargas (UCR) attended a six-week course on biotechnology at NCSU. May–June, 1994.

L. Villalobos (UNA) attended a training course in Vienna on isotopic and radiologic techniques relevant to studies on soil/plant relationships. The course was the base for future trials on nitrogen fixation by *Arachis pintoi*. Sponsored by the International Atomic Energy Commission. May 29–July 7, 1995.

J.M.B. Musser (NCSU) and D. Amaya (NCSU) received field research training in Costa Rica during 1995–1997.

A. Quan (UCR) and M. Villarreal (ITCR) participated in forage research at NCSU. Summer 1995.

Sandra Strong, senior veterinary student at NCSU College of Veterinary Medicine, conducted field and laboratory research in Costa Rica with Drs. Caballero and Perez (UNA) in a project entitled "*Listeria monocytogenes* in milk samples collected from the San Carlos Region". January 15–February 5, 1996.

E. Araya (UCR) worked collaboratively with Dr. Paul Mueller at NCSU. July–August, 1996. Also attended the Forage and Pasture Crop Training at the Southern States Cooperative, Raleigh, NC. August 6–7, 1996.

A. Rojas (UCR), M. Villarreal (ITCR) and L. Villalobos (UNA), attended the Grazing School for Beef Producers, NCSU Beef Educational Unit, Lake Wheeler Road Field Laboratory, Raleigh, NC. November 21–22, 1996.

M. Caballero (UNA), received training in Polymerase Chain Reaction (PCR) in Mycoplasmology and Pulsed-field Gel Electrophoresis at NCSU. May 1997.

M. Poore (NCSU) provided training in Costa Rica on collaborative forage research and forage research training techniques and gave two lectures at UCR on the use of agroindustrial wastes as cattle feed. June 1997.

I. Camacho (UNA), R. Rodríguez (UNA) and R. Rosales (UCR) visited laboratories at NCSU to exchange experiences and discuss pasture management and the use of by-products as animal feeds. July – August 1997.

Drs. Niki Robertson and Sarah Wyatt, NCSU – College of Agricultural and Life Sciences, participated in a course in polymerase chain reaction technology in Costa Rica in February, 1998.

Derrick Frazier (NCSU), Master's of International Studies student, participated in project evaluation as a component of PS 543, Latin American and Caribbean Politics, Spring Semester, 1999.

M. Vassey (NCSU–CVM) conducted fieldwork for project on drug use, residues and antimicrobial resistance at UNA–College of Veterinary Medicine. March 20–27, 2000.

The following Costa Rican scientists visited NC State and selected faculty and participated in activities relevant to mutual collaboration:

H. Dormond (UCR). 1994.

A. Quan (UCR). Summer 1995.

M. Vargas (UCR). March–April 1995.

M. Villarreal (ITCR). Summer 1995.

E. Araya (UCR). July–August 1996. Also worked collaboratively with Dr. Mueller.

I. Camacho (UNA). July–August 1997.

R. Rodríguez (UNA). July–August 1997.

R. Rosales (UCR). July–August 1997.

C. Arroyo (UCR). 1998.

Project-sponsored Courses and Workshops

Workshop on laboratory methods for forage fiber analysis. Escuela de Ciencias Agrarias, Universidad Nacional. January 16–21, 1995. Organized by NCSU, UCR and UNA. UDLP scientists: M. Poore, J. Moore, A. Rojas-Bourrillón and E. Eduarte. 18 participants.

Pasture Sampling Techniques. ITCR, San Carlos. January 17–18, 1995. Technicians and scientists from the Costa Rican Ministry of Agriculture and Costa Rican Universities learned methods for pasture sampling and analysis of canopy structure. Organized by UNA and NCSU. UDLP scientists: P. Mueller, J. Green, and L. Villalobos. 14 participants.

Animal Production in Central America: Conservation and Sustainable Development. San José, Costa Rica. August 8–12, 1995. Workshop organized by UNA with objective of improving the curriculum of the graduate program in Veterinary Medicine at the Universidad Nacional. The workshop was possible due to joint efforts of UDLP and other projects at UNA with Dutch funding. UDLP scientists: E. Muller and E. Perez. Approximately 20 participants.

International Course in Dairy Nutrition. University of Costa Rica, September 9–14, 1996. Organized by UCR with logistical support provided by UDLP. UDLP scientist A. Rojas-Bourrillón gave a conference entitled "Utilization of wet tropical by-products in dairy cattle". The course was attended by 48 Latin American technicians from 10 countries in the region.

Collaborative Forage Research and Forage Research Training Techniques in Costa Rica. Universidad Nacional, Heredia, Costa Rica. June, 1997. Costa Rican scientists and technicians were updated on methods of forage fiber analyses. Organized by UNA and UCR. UDLP scientists: E. Eduarte, A. Rojas-Bourrillón, M. Poore, J. Moore. 18 participants.

Polymerase Chain Reaction (PCR) Technology. School of Veterinary Medicine, Universidad Nacional, Heredia, Costa Rica. February 2–13, 1998. This two week course was offered to Costa Rican scientists and technicians and included 20 hours of theory and 60 hours of laboratory practice in PCR technology. Organized by UNA, UCR and NCSU. UDLP scientists: M. Caballero, F. García, and invited professors Dr. Niki Robertson and Dr. S. Wyatt from NCSU. 12 participants from UNA and UCR.

Seminar Series: Alternatives for the Improvement of Cattle Production in Costa Rica: 1. Alternatives for the Improvement of Dual Purpose Cattle Production. 2. Improvement of Beef Production in the Tropics. 3. Perspectives for the Improvement of Cattle Production in Costa Rica. Instituto Tecnológico de Costa Rica, School of Agronomy, San Carlos. November 30–December 2, 1999. Organized by ITCR and Asociación Nacional de Universidades e Instituciones de Educación Superior (Mexico). UDLP scientists: Milton Villarreal and Augusto Rojas. 120 participants.

Participation in Scientific Meetings and Workshops

World Sustainable Development: An Agenda for the Twenty-first Century. Symposium at the North Carolina Central University Center for International Studies and the North Carolina Triangle Chapter of the Society for International Development. October 20, 1993. UDLP scientists: M.T. Correa. and E. March.

Seminar on Sustained Agroforestry and Animal Production Systems. ITCR-ODA-MAG. San Carlos, Costa Rica. April 12–16, 1996. UDLP scientists: A. Quan and E. Araya.

International Conference on Emerging Technologies in IPM. Raleigh, NC. March 8–10, 1999. UDLP scientist: L.F. Arauz.

International Course on Designing Experiments in Forest Species and Perennial Crops. Comité Nacional REDCA, Universidad Nacional, CATIE and the International Biometrics Society. Universidad Nacional, Heredia, Costa Rica. March 30–April 3, 1998. UDLP scientist: Milton Villarreal.

Primer Congreso Latinoamericano de Agroforestería para la Producción Animal Sostenible. FAO – CIPAV. Cali, Colombia. October 25–27, 1999. UDLP scientist: Milton Villarreal.

Sexto Seminario Internacional sobre Sistemas Agropecuarios Sostenibles. FAO – CIPAV. Cali Colombia. October 28–30, 1999. UDLP scientist: Milton Villarreal.

Education

Post-graduate Programs Initiated

Ecological Agriculture (Licenciatura). Escuela de Ciencias Agrarias, Universidad Nacional. In 1998, with the partial support of our UDLP, a new Licenciatura Program on Ecological Agriculture was initiated at Escuela de Ciencias Agrarias, Universidad Nacional. This program became the embryo for the new Masters Degree on Alternative Agriculture, with emphasis on Ecological Agriculture, which will start in August 2000.

Masters Program in Alternative Agriculture with emphasis on Ecological Agriculture. Escuela de Ciencias Agrarias, Universidad Nacional. This program, which will begin in August 2000, is an outgrowth of the Licenciatura Program in Ecological Agriculture. The Program is coordinated by Dr. L. Villalobos, UNA and involves faculty from other Costa Rican and USA institutions, including NCSU. It is expected that the program will recruit not only Costa Rican students, but also students from Central America and the Caribbean. Some of the modules offered by the Program could be of interest to some US graduate students. Details are provided in the program web site: www.una.ac.cr/agra/agrieco.html.

Collaboration with Existing Graduate Programs (Note: Some programs are also cross-listed with graduate theses, p. 15)

UDLP support for research in existing graduate programs *(Note: No student was specifically supported by the UDLP Project. Students participated in projects or research associated with the UDLP)*

Licenciatura Program, School of Veterinary Medicine, Universidad Nacional.

Cristian Sánchez. 2000. Antibiotic residues and presence of *Listeria monocytogenes* in fresh cheese in the San Carlos region.

Regional Graduate Program in Veterinary Sciences (PCVET), Universidad Nacional.

Aixa Arosemena. 1996–2000. Contamination of *Salmonella* spp. in poultry in Costa Rica.

Danilo Montero Caballero. 1993–1996. Epidemiology of dairy cattle lameness in the San Carlos region.

Sacha Telles. 1996–2000. Epidemiological aspects of *Escherichia coli* O157H7 in dairy farms in San Carlos, Costa Rica: Prevalence and management practices associated with its dispersal.

Licenciatura Program in Agricultural Sciences, Universidad Nacional.

Ruth Rodríguez Flores. 1998. Estimation of Biological Nitrogen Fixation of *Arachis pintoi* and uptake by *Cynodon nlemfuensis* using ^{15}N methodology.

M.Sc. Program in Economic Policy, School of Economics, Universidad Nacional.

Rosalba Ortíz Valverde. 1995–1996. Indicators of existence and sustainable use of secondary forest in conjunction with livestock.

Licenciatura Program in Plant Science, Universidad de Costa Rica.

Ricardo Astúa. 1995–1996. Field control of black rot of orange (*Alternaria citri*).

Jorge L. Hidalgo. 1996–1998. Population dynamics of symphyla associated with the corky root syndrome in citrus.

Licenciatura Program in Animal Science, Universidad de Costa Rica.

Randall Abarca. 1998–1999. Determination of the economic competitiveness under GATT policies of the specialized dairy operations of the highland areas of the Central Valley and San Carlos.

Agustin Madriz. 1998–1999. Determination of the economic competitiveness under GATT policies of the specialized dairy operations of the highland areas of the Central Valley and San Carlos.

Anthony Rivera. 1999–2000. Production costs of Holstein heifers in the highland areas of San Carlos.

Ingrid Aguilar. 1999–2000. Production costs of Holstein heifers in the midland areas of San Carlos.

Andrés Marín. 2000. Economic competitiveness of dairies in the midlands of San Carlos.

Francisco Gutiérrez. 1999–2000. Effect of the addition of poultry litter on the nutritive quality of pineapple waste silage.

M.Sc. Program in Plant Protection, Graduate Program in Agricultural Science and Natural Resources, Universidad de Costa Rica.

Luis Brenes. 1994–1996. Control of citrus greasy spot through primary inoculum management.

Eric Arce. 1999–2001. Distribution, economic impact and control of postbloom fruit drop in citrus in Costa Rica.

M.Sc. Program in Animal Science, Graduate Program in Agricultural Science and Natural Resources, Universidad de Costa Rica.

Carlos Tobias. 1996–1999. Utilization of poultry litter in animal feeding.

Rodolfo Wing Ching Jones. 1999–2001. Nutritive value and chemical composition of silages made of perennial peanuts.

Ph.D. Program in Sustainable Agricultural Systems, Universidad de Costa Rica.

Floribeth Mora. 1996–2000. Influence of orchard floor vegetation management on some aspects of the health of a citrus agroecosystem in San Carlos, Costa Rica.

Licenciatura Program in Agronomy, Instituto Tecnológico de Costa Rica.

Maricela Ugalde R. 1998. Use of rejected green bananas and *Arachis pintoi* as partial substitutes for concentrate for dairy cows.

Gustavo Naranjo U. 2000. Preliminary evaluation of slug populations (*Sarasinula plebeia*) in *Arachis pintoi* and other agricultural crops.

M.S. Program in Crop Science, North Carolina State University.

A. Moulaert. 1994–1995. A silvopastoral system in the north Atlantic zone of Costa Rica.

M.S. Plant Pathology, North Carolina State University.

Herman Hidalgo. 1994–1995. Epidemiology and control of citrus greasy spot on Valencia orange and resistance of *Mycosphaerella citri* to benomyl in San Carlos, Costa Rica.

College of Veterinary Medicine, North Carolina State University.

J.M.B. Musser. 1994–1999. PhD student, Comparative Biomedical Sciences. Electrical conductivity for diagnosis of mastitis.

Daniel Amaya. 1995. Post-DVM residency training.

Courses taught

Development of Small and Medium Size Agroindustrial Enterprises. Masters Program in Rural Development, Universidad Nacional. 1995. The course used farms within the UDLP to host case studies. Coordinator: C. Ramírez. Collaborator: L. Villalobos. 10 students. The following case studies were completed as requirements for the course:

Flores, R. 1995. Case study: Production systems on dairy farms in Rio Cuarto de Grecia.
Hernandez, C.M., Miranda, F., Villalobos, L. 1995. Case study: Analysis of two dairy farms in the San Carlos Region.
Ramirez, German. 1995. Case study: Luis A. Alfaro Farm.
Rojas, C. and Aguilar, O. 1995. Case study: Dairy farms located in El Centro de San Carlos and Rio Cuarto de Grecia.

Ecology and Sustainability. Licenciatura Program on Ecological Agriculture. Universidad Nacional. 1998. Coordinator: V. Cartín. Collaborator: L. Villalobos. 12 students.

Designing Environmentally Friendly Agricultural Systems. Licenciatura Program on Ecological Agriculture. Universidad Nacional. 1998. Coordinator: L. Villalobos. 12 students. Case studies conducted in Talamanca (Indian Reserve), San Carlos and Zarcero.

Undergraduate Training and Teaching Support

Teaching material support was provided by UDLP scientist A. Rojas-Bourrillón for courses in Nutrition (AZ4105 and AZ 32101) and Genetics Management (AZ 4103) in the B.Sc. program in Animal Science, UCR. Reprints of "Basic Concepts in Ruminant Nutrition" were provided for 18 students in course AZ4105.

Slides from visits to Costa Rica and case studies were provided by UDLP scientist Dr. M. Correa in the sophomore course in Epidemiology and Public Health (VMM 944) at the College of Veterinary Medicine, NCSU.

Beef Management Training. October 16, 1996. Twelve students from the Beef Course (UCR Animal Science Course AZ 42101) were trained on a farm that participates in the UDLP project in the lowland area of San Carlos. The students were trained in a) determination of stocking potential rate of the farm b) prediction of calving rate, c) soil analysis interpretation, d) establishment of perennial peanut plots, e) analysis of the present reproductive management at the farm. Professores R. Rosales, H. Soto, A. Rojas-Bourrillón.

Training of 24 students from the B.Sc. Program at ITCR, San Carlos (Course 3108). October 17, 1996. The students attended a Dairy Calf Nutrition and Management Course. Professors in charge: A. Rojas-Bourrillón and Olger Murillo.

Students from ITCR, San Carlos, attended a lecture on "Alternative tropical feed stuffs for dairy nutrition". October 27, 1997. Speaker: A. Rojas-Bourrillón.

Undergraduate project in B.Sc. Program in Agronomy, Instituto Tecnológico de Costa Rica. 1999. Undergraduate José David Rodríguez evaluated the introduction of *Arachis pintoi* CIAT 18744 on seven dairy farms in the North Atlantic region of Costa Rica.

Project Administration

Project Management and Coordination Meetings

UDLP coordination meeting, San José, Costa Rica. August 7–12, 1993.

UDLP coordination meeting, Raleigh, NC. March 7–11, 1994.

UDLP coordination meeting, San José, Costa Rica. October 15–19, 1994.

UDLP coordination meeting, Raleigh, NC. October, 1995.

UDLP coordination meeting, Raleigh, NC. November 18–19, 1996.

UDLP coordination meeting, San Carlos, Costa Rica. July 27–31, 1997.

Project Management meeting, Raleigh, NC. February 18–20, 1998.

Project Management meeting, Costa Rica. July 25–28, 1998.

UDLP coordination meeting, Raleigh, NC. June 7–9, 1999.

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