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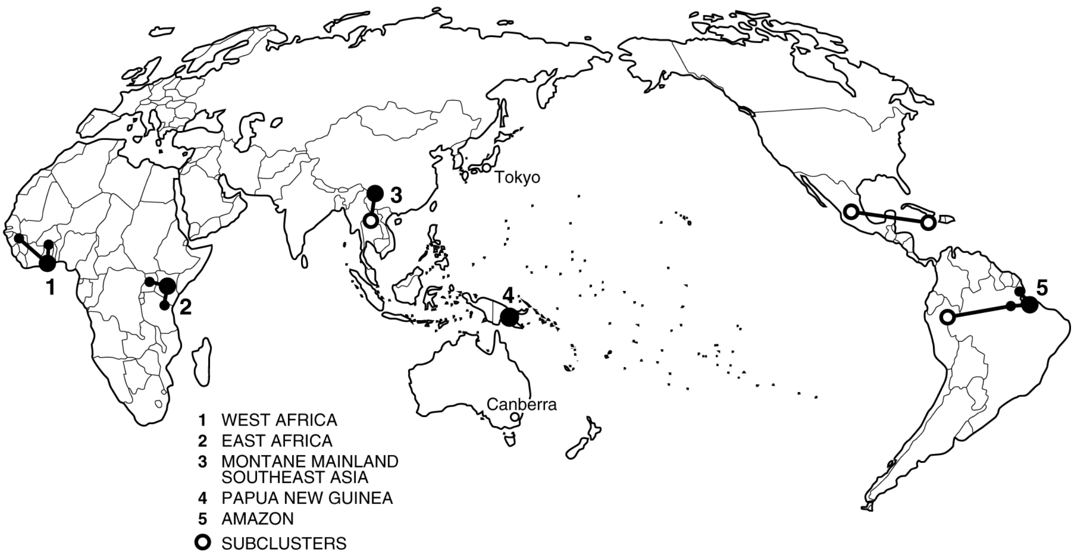

The Clusters of PLEC

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PRINCIPAL SCIENTIFIC COORDINATOR'S REPORT

PLEC AT MID-TERM: NOVEMBER 1999 TO MAY 2000

Harold Brookfield

Preparation for the mid-term review of our GEF-funded project has dominated all PLEC activities during the past few months. This issue of *PLEC News and Views* has been delayed so that material concerning the review, and some of the papers submitted in preparation, could be included in this issue. The review was held in the month of April 2000. The reviewer was Professor Stephen Brush of the University of California at Davis. His report will be summarized in the next issue of *PLEC News and Views,* with a commentary, after it has been discussed at the general meeting of the project, and the management group meeting, at Macapá and Belém in Brazilian Amazonia between 26 May and 2 June, 2000.

Dr Brush visited Tokyo at the beginning of his mission, where he met the Tokyo staff and Brookfield. He also met the Rector and Vice-Rector of the UNU. He then visited three Cluster areas selected for on-the-ground inspection. In China he was accompanied by Christine Padoch and Liang Luohui, then continued to Ghana accompanied by Harold Brookfield and (for part of the time) Michael Stocking. Finally, he visited Brazilian Amazonia, where he was accompanied by Miguel Pinedo-Vásquez, a member both of the Cluster and of the Development Activities Advisory Team (DAT). Dr Brush's report was sent to UNEP on 5 May, and subsequently distributed to all Cluster and sub-Cluster leaders and other participants in the Brazil meeting.

Some important substantive reports

During the last few months PLEC Clusters have prepared for the review by writing substantive reports on their surveys of biodiversity and agro-biodiversity, land management regimes, organization and society at the demonstration sites, and on the causes of local land degradation. These were in addition to the regular progress reports. The substantive reports were due in December, and have been supplied between December and April. A few are still outstanding, or incomplete, in May, but all Clusters provided a substantial body of material in time to be seen by Dr Brush before or during the review.

Clusters interpreted their task in different ways, demonstrating character-istic PLEC diversity. Some reported only in summary form, while others provided collections of papers on specific aspects written as for publication. A number of the reports are provisional, with data or analysis to be added. Large statistical appendices accompany most of the biodiversity papers, making these inappropriate for general publication. Further, it is PLEC policy that detailed biodiversity data should, for the most part, remain in-country and not be published internationally, or put into an internationally-accessible data base.

Cluster papers in this issue and the next

A number of the biodiversity, agrodiversity and other papers provided for the review are certainly suitable for publication, especially if the appendices are reduced or deleted. A small selection of the papers appears in this issue of *PLEC News and Views*, and more will appear in the following issue (mostly after authors have had an opportunity to complete unfinished work). This issue is the largest yet to appear, and we expect the next issue to be of similar size. Other papers may be found suitable for inclusion in one of the two planned PLEC publications described below. Some of the detailed material from China is already appearing during 2000 in a special issue of *Acta Botanica Yunnanica*. A wealth of data and interpretation is now arising from PLEC work, some of it very original and innovative, and a policy for its dissemination will be discussed by the meeting in Brazil.

Other general papers

Two general papers were prepared in advance of the review. One of these, on 'Biological diversity, land degradation and sustainable rural livelihoods' by Michael Stocking, has already been presented at PLEC and international meetings. A version will appear in Chinese in the special issue of *Acta Botanica Yunnanica*. Another, a briefing paper on the project as a whole, was prepared for the reviewer by Harold Brookfield. Because this is in large part confidential, it will not be published as such, but substantial non-confidential extracts are already incorporated in the Consolidated Progress Report on work in fiscal 1999 submitted by UNU to UNEP.

PLEC has also been reported to the international community in several places in recent months. Fidelis Kaihura, Michael Stocking and Niamh Murnaghan have writtten a paper on 'Agrodiversity as a means of sustaining small-scale dryland farming systems in Tanzania'. This was presented by Fidelis Kaihura to a Global Biodiversity Forum organized during the fourth meeting of the Conference of Parties to the Convention on Biological Diversity held in Nairobi on 12–24 May 2000. Earlier, Toby McGrath made a presentation on PLEC at the third meeting of the Conference of Parties to the Convention to Combat Desertification held at Recife in Brazil, 15–26 November 1999. Edwin Gyasi offered a presentation on PLEC at a special session on Agricultural Biodiversity held by the Scientific and Technical Advisory Panel to the GEF (STAP) at its meeting in Barbados in February 2000. Information on publication plans for these papers is not yet available.

Progress at the demonstration sites

With concentration of work into the areas where it is most advanced, the number of effective demonstration sites in the whole project has been reduced from the 37 listed in *PLEC News and Views* No. 14 (pages 38–40) to about 32. Most of those reduced to subsidiary status, or eliminated, were late additions. At the same time, PLEC activities have spread significantly around some of the more strongly-established older sites, as neighbouring communities and farmers have become keen to participate in the farmer-to-farmer training in innovative methods that is sponsored by PLEC scientists.

At its more mature sites, PLEC is increasingly concerned with agricultural change both as observed, and as enhanced by the activities of PLEC. In one area in Brazil there is fairly rapid increase in agroforestry and forest-enhancement practices in response to shifting relative prices of field-crops, tree-crops and timber. The result is to sustain and even increase biodiversity. Management practices enhanced through farmer-to-farmer training have brought about significant changes in Brazil, southern Ghana, Tanzania and one area in China.

Not all changes encountered by PLEC are positive; for example, continuing loss of upland rice varieties in China. Planting of trees among crops still receives a mixed reception. In China there is active conversion of natural forest growth to cash-tree plantations, not without some problems.

Exchange of germplasm as well as ideas between the people of different sites, on the other hand, has been of positive benefit in several areas. Improvement or introduction of indigenous composting techniques has been important in Guinea and Ghana. In Ghana, a group of farmers from the most active sites has received training at the University farm in propagation techniques including grafting, and corm-splitting of plantains. The farmers are enthusiastically putting the new knowledge into practice. Training in grafting has also been given in China.

The impact of BAG and DAT

The Biodiversity Advisory Group (BAG) recommendations have now been in the hands of all PLEC groups for more than a year, and they have been used in all areas. A lot of earlier work that yielded only indicative results has been re-done. This takes time and it is likely to be well into 2000 before all areas subject to inventory have been surveyed finally. This delay is unfortunate, because in several sites that have been observed over a period of time there have already been changes in land-use stages, and it is desirable to measure the biodiversity impact of these changes. To accelerate progress, BAG members have visited areas in northern Ghana, all three countries in East Africa and Papua New Guinea.

One aspect of biodiversity that has been only incompletely surveyed by PLEC is within-species diversity at the genetic level, although note has generally been taken where there are varieties distinct both in morphology and end-use. A stronger emphasis on within-species diversity is a likely outcome of Dr Brush's review. It needs to be stressed that the agrodiversity that we advocate is the ecological and social environment within which biodiversity can persist and thrive. PLEC is not yet a part of the emerging agro-biodiversity 'mainstream', but it works in the context of all agro-biodiversity. '**What is important to preserve is not the genetic material in and of itself, but the processes that create and preserve genetic diversity**' (Louette 1999: 138). That is the central role of PLEC in relation to the important new scientific developments that are growing up around us.

Problems of data analysis and presentation have arisen in several Clusters, despite the guidelines prepared by the BAG meeting in New Hampshire in June 1999. Early in 2000, Mr Kevin Coffey of the New York Botanical Garden was contracted to act as a consultant to BAG on this aspect. He is presenting guidance on data-base construction at the meeting in Brazil.

The Development Activities Advisory Team (DAT) is a newer creation, but it has already been very active in the inter-Cluster exchange of ideas, carrying the experience of West Africa and Amazonia into East Africa and Papua New Guinea. Its first major statement to the whole project will be at the Brazil meeting. DAT has encountered rather more resistance than has BAG, for there remains an element of misunderstanding within parts of PLEC regarding the true role of the scientist in a demonstration site. The very term ‘demonstration site’, which we were given by the GEF Secretariat, may be partly responsible. It might seem to imply ‘demonstration’ to the people by the scientists, not **by the people to the people**. Some scientists find it hard to accept this important distinction, or to bear it in mind at all times.

The distinctive feature of BAG and DAT is that all five members draw on expertise from within the project, all being selected from PLEC Clusters, and four of them from within the developing countries. Their creation and rising importance in the project reflect a transition in project guidance from external to internal direction of activity.

PLEC PUBLICATION PLANS

Now that a group of papers is available from among Cluster reports submitted between December 1999 and April 2000, publication plans can be discussed in more positive terms. At its meeting in Xishuangbanna in January 2000, the Coordination Team decided that there should be two substantial publications. The first of these will take the form of a ‘manual’ on the study, analysis and promotion of biodiversity in an agrodiversity context. After general introductory statements, it will include reprints or revised versions of several papers that have been published in the un-refereed *PLEC News and Views*. These will include those in the ‘guidelines’ special issue *PLEC News and Views* No. 13 (1999), and the statement on demonstration site work by the two members of DAT presented in Brazil on 28 May, which will appear in *PLEC News and Views* No. 16 later in 2000. The ‘manual’ will also include case studies demonstrating successful practice, some of which will be commissioned at a modest fee. Contributions will be peer-reviewed. A draft proposal will be presented and discussed at the Management Group meeting on 1 June, after which a firm proposal will be made to publishers and a set of early deadlines established.

For the second publication, we propose a set of scientific papers which will be offered to an appropriate journal as the content of a special issue. Most of these will be based on work already partly reported by Cluster members, but often incomplete. Some authors have already been alerted. A list of candidate papers will be discussed and enlarged by the Coordination Team on 2 June, and there will then be correspondence with authors. We expect this set of papers to be complete by very early in 2001. All will be peer-reviewed within the project before a final set of edited papers is offered to the journal. Principal authors of the accepted papers, Scientific Coordinators excluded, will receive a modest honorarium. A set of deadlines will be established as soon as possible.

Third, and not yet discussed in detail, PLEC has to consider the production of a book consolidating the results of its work. This will be finalized only after the completion of the GEF-funded project in February 2002, but should be completed as soon as possible after that date. This book will be offered to the United Nations University Press for publication. There will be both general and Cluster chapters. Year Four (2001–2) contracts will call on GEF-funded Clusters to prepare drafts for such consolidated publication of their results by the end of the reporting year.

The non-GEF Clusters will be invited to do the same.

Not all publication by PLEC members will be embraced in these proposals. Several Cluster members are planning papers for scientific journals, and this is strongly encouraged. It was also agreed in January 2000 that a prize, or prizes, be offered for the best of these papers. They should be made available for review in final pre-publication form during the first half of 2001, so that decisions can be taken and reported before the end of project life. Papers by Scientific Coordinators will not be eligible for this competition. Details will be elaborated in *PLEC News and Views* No. 16, due before the end of the calendar year 2000.

NEW HOMEPAGE

The PLEC homepage has been re-designed and re-written. It contains information on the project as a whole, on its Clusters and on publications. Current news is regularly updated. Contact addresses are listed in detail. In future *PLEC News and Views*, from No. 11 onward, will be accessible through the Homepage. The address is **http://www.unu.edu/env/plec/**

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Other matters for report

The China Cluster held its annual meeting in January 2000, attended by the Managing Coordinator, the Senior Academic Programme Officer and Stocking. Brookfield and Padoch joined on the last day of this meeting, which was followed by a meeting of the Coordination Team, also attended by Audrey Yuse. At the latter meeting, plans were discussed for a training workshop in China to be led by Christine Padoch, in about July. Plans were also discussed for a proposed UNU/PLEC Forum, in China, on 'Working with farmers in agrodiversity conservation', provisionally in October 2000.

Most of the rest of the meeting was concerned with preparation for the mid-term review, and with plans for ensuring the sustainability of PLEC outcomes beyond the end of GEF funding. Harold Brookfield said that he could not be involved in any such follow-up work, and Christine Padoch agreed to convene a working group to examine the prospects.

Related to PLEC, but not part of it, is the decision by UNEP in January 2000 to support preparation of *Guidelines on field assessment of land degradation* by Michael Stocking, Geoff Humphreys, Anna Tengberg and Niamh Murnaghan. The guidelines will be completed during the calendar year 2000. While land degradation work is not central to PLEC, and further work within PLEC on land degradation is discouraged in the review report, it remains a topic of major concern to many project members, and has significant relationship with biodiversity.

Reference

Louette, D.
1999 Traditional management of seed and genetic diversity: what is a landrace? In Brush, S.B. (ed.) *Genes in the field: on-farm conservation of crop diversity*, pp. 109–142. Boca Raton: Lewis Publishers.

NEW BOOKS

Helen Parsons

PLEC Project, Australian National University, Canberra

Four new books published toward the end of 1999 may be of particular interest to readers of PLEC News and Views.

Wood, D. and J. M. Lenné (eds) 1999 *Agrobiodiversity: characterization, utilization and management*. New York: CABI. 464 pp. ISBN 0 85199 337 0 (Hb) £65/$120

This book looks at agricultural biodiversity on a wide scale, inclusive of issues relating to traditional and modern intensive agriculture. The book provides a broad review of agro-biodiversity—what it is, the history, and how it is managed and conserved. It highlights the need for effective farming practices to incorporate biodiversity into sustainable agricultural development.

Agro-biodiversity (based on Qualset et al. 1997) includes not only the crops and livestock and their wild relatives, but also interacting species of pollinators, symbionts, pests, predators, parasites and competitors, above ground and in the soil. The chapters follow this structure looking at each of these aspects of agro-biodiversity. It brings together contributions from a wide geographical and disciplinary background. Emphasis is placed on functional interactions between components of agro-biodiversity in a range of farming systems, illustrated by case studies. Traditional management, the effects of agricultural practices and the influences of new technologies on diversity are examined.

Agro-biodiversity is a relatively new term and this book is an excellent and wide ranging introduction to an emerging and different way of looking at biodiversity and its conservation as it relates to agricultural production and agroecosystems. As Lenné and Wood point out, '…study, increased understanding, and the sustainable management of agro-biodiversity…may well be critical not just to agricultural production, but also to the future of biodiversity globally' (p. 448).

**Brush, S. B. (ed.) 1999 *Genes in the field: conserving plant diversity on farms*. Rome; Ottawa; Boca Raton: IDRC/IPGRI/Lewis. 304 pp.
ISBN: 1566704057 (Pb) $29.95**

This second book is concerned more with the conservation of genetic resources. Genetic diversity is valued by individual farmers, farming communities, and by agriculture in general, for a myriad of reasons, and this comprehensive collection of papers deals with the dynamic conservation, management and improvement of crop diversity on farms.

The pressure of increased population, agricultural science and technology, and the economic integration of the world's many diverse cultures forces farmers to adopt modern crop varieties, bred for broad adaptation, resistance to disease, and their ability to better use water, fertilizer, and higher yields. The modern varieties have come to threaten regional and local varieties. While the concern of farmers is to maintain production levels and income, this is often incompatible with the maintenance of genetic diversity. However, a great deal of diversity continues to be maintained on farms. *In situ* conservation is complementary to *ex situ* conservation, and neither alone is sufficient to conserve the total range of genetic resources. This book looks at why, what, where, and how to maintain and promote genetic diversity.

Brown in Chapter 3 examines on-farm conservation from the perspective of the population. It identifies the factors influencing dynamic change in the population, investigating genetic structure of landraces, and including research methodologies.

The case studies give fascinating insights into the complexity of factors that have led to the diversity generated and maintained by farmers. Traditional practices combined with modern scientific research can benefit both the farmers and modern agriculture.

The study from the Fertile Crescent describes the great variability within landraces of barley, and how conventional breeding techniques using selected material from farmers fields can generate improved lines for local conditions and needs. Mixtures of selected lines give yield improvement with the stability required in a variable climate. In Ethiopia, an important centre of diversity of barley, farmers are active in conservation, selecting for combinations of characteristics in barley. While the selected seed displays morphological uniformity, it is not genetically uniform. Traditional management and cultural practices ensure continued diversity.

Louette researched the dynamic process that preserves the genetic diversity of maize in Cuzalapa in Mexico. Through surveys and analysis of genetic diversity, the study unravelled the seed selection and exchange systems that conserve a high level of regional diversity through landraces that are genetically variable over time. It is not just what happens in the field, but cultural and societal interactions that influence the generation and conservation of diversity. The conditions under which crops are grown and managed have to be preserved.

The final section of the book deals with policy, institutional issues and intellectual property rights. Ways to support and promote the conservation of diversity of crops through culture, and ways to give economic incentive to farmers to conserve traditional varieties are examined.

Exploring and understanding the different strategies for conservation, and farmers concerns is an essential starting point for answering some of the key questions about the implementation of ‘on farm’ conservation and the role of local cultivators and research institutions in sustainable agricultural development.

Scoones, I. and C. Toulmin 1999
***Policies for soil fertility management in Africa*. London: DFID. 128 pp. ISBN 189982541X (Pb) £10**

Improving soil fertility management in African farming systems is a major issue on the development policy agenda. A number of international initiatives and donor programmes have been established that aim to address the problems of soil fertility decline. The authors looked systematically at key documents to assess the stated causes and assumed consequences, and the solutions proposed to the perceived crisis in soil fertility.

Fifteen case studies from twelve countries are used to examine the nature of soil fertility—identifying what it is, the complexity of measuring decline over time, the interacting limiting factors, and what farmers do to maintain soil fertility. The problem is complex and diverse, reflecting the diversity in farming systems, and one that cannot be attributed solely to increasing population pressure and land mismanagement.

Soil fertility management is interpreted from the perspective of nutrient budgets, looking at nutrient inputs and flows in various scenarios. The book discusses interventions that can be used to improve soil fertility within a broad context of how best to support rural livelihoods, emphasizing the need to involve farmers in the process. It discusses whether there is a case for public intervention, and assesses the range of strategies available for encouraging more sustainable soil management practices.

This book is a well-written and very sensible analysis of a complex issue. While it is about soil fertility in Africa, the methods of analysis and assessment could be applied to other development policy issues, and for that reason deserves a wider audience.

Almekinders, C. and N. Louwaars
1999 *Farmers' seed production: new approaches and practices.* London: Intermediate Technology Publications. 240 pp. ISBN 1853394661 (Pb) £14.95/$29.95

Where farmers rely on their own or locally produced seed, limitations exist in seed quality or access to good seed. Seed technology can provide a valuable input into small-scale farmers' seed production. This handbook covers a range of topics relating to local seed supply systems, offering new approaches and methods to support on-farm seed production by small-scale farmers in developing countries.

The first part of the book describes the nature of seed selection and improvement, and introduces issues and background information relating to local seed supply systems. The second part of the book deals with the technical issues of seed selection, improvement and production, both in conventional systems and participatory plant breeding. Practical guidelines on how local seed systems can be analysed and improved are outlined in the third part of the book. Crop specific information is presented in the final section.

This book will be a useful and interesting reference for those working directly with farmers. It is written in an accessible style for a wide-ranging audience.

Reference

Qualset, C. O., A. B. Damania, A. C. A. Zanatta and S. B. Brush
1997 Locally based crop plant conservation. In Maxted, N., B. Ford-Lloyd and J. G. Hawkes (eds) *Plant genetic conservation: the in situ approach*, pp. 160–75. London: Chapman and Hall.

PAPERS BY PROJECT MEMBERS

BIODIVERSITY AS A PRODUCT OF SMALLHOLDERS' STRATEGIES FOR OVERCOMING CHANGES IN THEIR NATURAL AND SOCIAL LANDSCAPES: A REPORT PREPARED BY THE AMAZONIA CLUSTER

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Editorial Note

This paper is the text only of a larger paper which includes tables, diagrams and calculations. An edited text is printed here because of its value as a demonstration of methodology.

Background

The PLEC objective to measure biodiversity levels within the landholdings of smallholders emerges as an opportunity to look beyond the superficial environmental ideologies that impel many biodiversity researchers to ignore land 'tarnished' by humans and to search for 'pristine' ecosystems. In contrast, reporting the biodiversity that is produced, managed or conserved by smallholders, we aim to illustrate the valuable role of smallholders in the formation and transformation of biodiversity within the estuarine varzea floodplain. We argue that a considerable number of land-use systems in Amazonia enhance rather than reduce levels of biodiversity. We favour the promotion of smallholder agriculture, agroforestry and forest management practices within varzea floodplain environments as an alternative to cattle ranching, selective logging and other modern land-use practices currently threatening biodiversity in the region.

PLEC Amazonia aims to contribute the needed technical and scientific information for identifying alternatives to biodiversity destruction on regional and global scales. The biodiversity crisis, as a global event, is forcing countries to employ experts to measure and suggest actions that conserve, restore or improve species, ecosystem and landscape diversity (UNEP 1995). Results from biodiversity inventories are helping to identify regions and countries where levels of species and ecosystem extinction are critical (Vogt et al. 2000). Although species and ecosystem extinction are both biological problems, the solutions to these problems are also dependent on social components (Kalliola and Flores 1999). Experts recommend a thorough examination of the processes that change biodiversity levels over time and space (Brondizio 1996).

Research conducted in Amazonia provides two distinct opinions on the processes that control biodiversity levels. Ecologists suggest that biodiversity is the result of natural processes (Terborgh 1999). In contrast, the anthropocentric point of view, proposed by many social scientists, argues that biodiversity in Amazonia is the result of long-term human intervention and manipulation of natural processes (Raffles 1998). Both arguments limit our understanding of the combination of natural and anthropogenic processes that create high or low levels of biodiversity. As part of the PLEC project, the Amazonia Cluster tested the hypothesis that biodiversity is the result of complex interactions of natural and anthropogenic processes. We measured and monitored the levels of biodiversity produced, managed, maintained or conserved by smallholders within their landholdings in varzea environments. These residents take advantage of fluvio-dynamic and other natural processes to produce and conserve agro-biodiversity and biological diversity in their landholdings.

Several authors have reported that the landholdings of Amazonian smallholders contain high levels of species and ecosystem diversity (Brondizio and Siqueira 1997; Pinedo-Vasquez 1995). Studies that focus on swidden-fallow or shifting cultivation practices suggest that agroforestry and agricultural fields as well as forests managed by smallholders contain much more biodiversity than do more ‘modern’ land-use systems such as cattle ranches, industrial plantations and others that are part of the current development models promoted in Amazonia (Brondizio 1997; Anderson 1992). These studies help to distinguish between the land-use systems that conserve and those that destroy Amazonian biodiversity.

While most experts agree on the ecological value of biodiversity found in the landholdings of smallholders, they also argue that biological diversity does not help farmers improve their living conditions (Smith 1996). In contrast, the conversion of forest land into pastures and the subsequent reduction of biodiversity produces high economic returns for cattle ranchers (Rabelo personal communication). The low economic value of biodiversity explains why in some tropical regions that are rich in biodiversity the majority of people are poor (Peluso 1995). Similarly, some researchers argue that Amazonian smallholders have little appreciation for biodiversity (Smith 1996). Experts continue to argue these points largely because: 1) what information exists on biodiversity managed by smallholders in Amazonia is incomplete and has yet to be presented in a consistent and accessible form and 2) most researchers do no understand the role of biodiversity in the livelihood of peasants.

Most of the studies that measure species diversity managed by smallholders in the Amazon estuary actually measure only a small fraction of the total diversity found in these landholdings. They often only evaluate house gardens and not the many other land-use stages or field types that are found in the landholdings (Anderson 1997). Here we report the existing biodiversity used and maintained by smallholders in all fields, fallows, house gardens and forests that contribute to economic activities in peasant landholdings or within community territories.

The inclusion of smallholders as principal stewards of biodiversity raises new questions and requires a detailed understanding of the factors that influence species diversity. Research must avoid the tendency to reduce studies to the simple quantification of biodiversity. To observe existing biodiversity beyond a simple summation of numbers, we incorporated both social and ecological methodologies and techniques into the design of our surveys. We included some ecological parameters to quantify biodiversity in different land uses and to calculate the standard indices recommended by members of the PLEC Biodiversity Advisory Group (BAG). We combined these methods with participant observation and other techniques used by social scientists to identify the technologies and local knowledge that maintain biodiversity in this dynamic social and natural environment.

Agro-biodiversity and other forms of biological diversity were measured within each land-use stage (LUS) and field type (FT) found within the landholdings of sampled smallholders located in the PLEC sites at Santarém-Ituqui and Mazagão-Ipixuna (Macapá). Data collected show that the two sites differ greatly in the number and kinds of plant species that are planted, managed or conserved by their inhabitants. Landscape analysis using historical and geographic information shows that the differences in levels of biodiversity between the two sites are due to the fact that each landscape is affected and controlled by different natural and social processes. Similarly, agrodiversity levels and other forms of production and management technologies differ between the two sites. Because the two sites are more different than they are similar in terms of the amount of biodiversity, the technologies used by farmers, and the processes they are subject to, were analysed and discussed in two separate documents. In this report we include data collected in the Mazagão-Ipixuna site and in a future report we will include data from Santarém-Ituqui.

The information collected from the Mazagão-Ipixuna site is reported in four separate sections. A brief discussion about the design and techniques used for gathering data on agro-biodiversity, biological diversity, production and management technologies, as well as conservation practices, is included in the methodology section. Methods used for collecting geographic and historical data on natural and social process are also described in this section. Data collected from biodiversity surveys, interviews and archival documents are included in the results section, which also gives data on agrodiversity and other forms of production and management technologies. Descriptive information about local conservation practices is also analysed and discussed in this part of the report. Biodiversity levels found in the site, the methodologies used in the surveys and the value of biodiversity indexes are also part of this final section. We end the report by stressing the need for re-constructing and interpreting biodiversity analyses in order to propose sound alternatives that can help to minimize the loss of biological diversity.

Methods

The physical changes in the landscape (including vegetation cover) are reported in a Master's thesis by a Brazilian student (Pereira 1998). Results from the interpretation of aerial photos and Landsat images, and information collected from land surveys, were used to identify important natural and social events that influenced the landscape in both sites. Data about the natural and anthropogenic origins of water bodies, land formations and type of vegetation cover were analysed by Raffles (1998), and used to help understand the role of people in modifying the landscape. Records on economic booms and busts, changes in land tenure and use over time were collected through interviews and by reviewing documents in archives located in Macapá and Belém.

The identification, quantification and classification of the existing land-use stages (LUS) and field types (FTs) used information collected from a sample of 60 landholdings; 36 were in Mazagão and 24 in Ipixuna. Data from each landholding were gathered during an average of two visits per year (at the beginning and the end of the agriculture season) for the last five years. We recorded the following information: the number, area and location of LUSs and FTs in relation to the river and house. With members of the families (men, women and children) we drafted maps for each landholding representing its location within the landscape.

The existing agro-biodiversity and other forms of plant diversity in the LUS and FTs were inventoried following the PLEC-BAG recommended methods and design. Plant diversity in forest areas was measured in 10 randomly selected samples (five in each site) from 27 ha of forest found in the 60 selected landholdings. All selected forests were managed at varying intensities for the harvest of timber and several other marketable resources. All trees greater than or equal to 5 cm DBH (diameter at breast height) were inventoried in 4 randomly selected plots of 25 m x 25 m in each of the sample forests. Individuals with a DBH less than 5 cm were inventoried in a sample of 80 (4 in each 25 m x 25 m plot) randomly selected sub-plots of 5 m x 5 m. In each inventoried plot and sub-plot we recorded the common name, height, DBH and location of each species. Because of the heterogeneity of the landscape we estimate ß-diversity in addition to the species richness and Shannon index recommended by BAG. Rank abundance per species was also calculated. Importance values for species and families were also estimated for all sample forests. The majority of the results and the estimated floristic and structural parameters of the inventoried forests are included in the Master's thesis of a Brazilian student and member of the Amazonia team (Rabelo 2000).

Plant diversity in fallows was quantified in a sample of 18 ha (10 in Mazagão and 8 in Ipixuna) that was randomly selected from a total 52 ha of fallows. The selected 18 ha included fallows ranging from 5 to 8 years old that were managed to produce several products with market value, including the fruit of the açai (*Euterpe oleraceae*) palm. Inventories were carried out in a total of 90 plots (5 in each selected fallow) of 20 m x 20 m that were randomly selected from the selected fallows. Natural regeneration was also inventoried in each fallow plot using sub-plots of 2.5 m x 2.5 m. Data recorded for each inventoried species were the same as those used to record in the forest plots. All calculated biodiversity indices including ß-diversity paralleled the ones estimated for the forest samples.

The team selected a sample of 36 house gardens (20 in Mazagão and 16 in Ipixuna) to quantify plant diversity. The sample house gardens cover a total area of 94 ha. The average size of each garden was 2.3 ha. Each plant in these gardens was inventoried. Data recorded included common name and life form (tree, shrubs, vine, grass and herb). Species diversity was estimated using the indices recommended by BAG. We quantified species and varieties of planted or protected crops in 10 fields in Mazagão and 10 in Ipixuna, randomly selected from an average of 72 fields made by farmers at the beginning of the wet and dry seasons. Crop inventories were conducted twice a year (before harvesting in the wet and dry seasons). The average size of the selected fields was 1000 m^2 (50 m long x 20 m wide). The fields were then divided into sub-plots of 10 m x 10 m. Plant inventories were conducted in a sample of 90 (5 in each of the 18 sampled fields) randomly selected plots. For all planted or protected species and varieties found, we recorded common name, life form and uses. The levels of agro-biodiversity found in each sampled field, as well as variations from one season to the other, are discussed based on absolute and relative abundance.

Agrodiversity and other production and management technologies, as well as conservation practices, were recorded using participant observation techniques. Team members followed the members of the selected households to their daily activities and observed and recorded production and management techniques used in the fields, house gardens, fallows and forests. Information collected from each household was cross-checked during group discussions and dialogue with the most knowledgeable members of each household and community.

Results

Dynamics of the natural environment

The Mazagão and Ipixuna sites are part of the estuarine varzea floodplain and are tidally-influenced environments. Both sites are composed of very heterogeneous landscapes that include a great diversity of human settlements, land formations, water bodies and vegetation cover. The biological and social components are subject to complex and dynamic natural and anthropogenic processes. Although these processes are highly variable and unpredictable in their frequency, intensity and spatial characteristics, the historical and landscape data show that the residents of both sites have developed technologies and strategies for managing and maintaining these processes.

Major changes in the direction of the river have taken place at both sites in the last fifty years. One of the major changes in landscape and river dynamics during this period was the formation of an island near of the city of Macapá. The residents of Mazagão reported an increase in sedimentation leading to the formation of new lands and an increase in the height of their levees. The residents of Ipixuna reported major changes in the size and number of streams, landforms and vegetation cover since the appearance of the island.

Our informants, as well as data collected from air photographs and Landsat images, record that three main fluvio-dynamic events have produced major changes in the social and natural landscape of Ipixuna. First, since the formation of the island, the river current is stronger and navigation is increasingly dangerous. Second, as the current of the Amazon river has become stronger, most of the sediments and other materials transported by the small and neighbouring Pedreira river are deposited at the mouth of the river. Third, since the current became stronger, the removal of vegetation along the stream has greatly increased lateral erosion by tidal pulse.

People from Ipixuna are managing these fluvio-dynamic and other natural processes to open new stream channels using water buffalo, to gain access to new land and resources (Raffles 1998). They have developed intricate technologies for raising planting surfaces above the level of tidal floods (Padoch and Pinedo-Vasquez 1999). These types of interventions exemplify how the mechanisms influencing landscape, ecosystem and species diversity cannot be identified by the study of either natural or social processes alone.

Social processes

Based on oral, historical and geographic information collected, the social processes characteristic of the two sites appear to be as complex and dynamic as the natural processes. The Ipixuna and Mazagão varzea floodplains were subject to different intensities and degrees of land and resource use, and of outside intervention, through the implementation of development and conservation projects. Resources have been commercially produced and extracted for varying periods encompassing several booms and busts. In Mazagão, commercial production of crops, such as rice, began in the middle of the 17th century. By contrast, commercial agricultural production in Pedreira-Ipixuna did not begin until the end of the 1940s (Raffles 1998).

Despite decades of political and economic pressures to adapt modern production systems and reduce crop diversity, most of the production systems and techniques used by smallholders in both sites are based on indigenous technologies. Swidden fallows are the predominant production system practised, which allows smallholders to maintain high levels of agro-biodiversity and other forms of biological diversity in their fields, fallows, house gardens and forests. This in turn helps farmers in both sites to access cash income by harvesting or extracting several resources.

Commercial extraction from both sites has followed patterns similar to other areas of the estuarine varzea. Commercial logging started in both locations at the beginning of this century (Pinedo-Vasquez 1999). Extraction of seeds of *murumuru* (*Astrocaryum murumuru*), *andiroba* (*Carapa guianensis*) and *pracaxi* (*Parkia* spp.) was carried out commercially from 1940 until about 1970. Commercial fishing of catfish and shrimp became an important cash source for the inhabitants in both regions after 1950 (Raffles 1998). Extraction of the fruits and the heart of the açai palm (*Euterpe oleraceae*) has had a significant economic impact in both sites since 1960. Currently, heart of palm, fruits of açai, several species of timber and shrimp are the most important products extracted for sale.

The increase in demand for açai fruit and timber in the market, and the decline in prices for agricultural products, have changed the role of agriculture, agroforestry and forest extraction in the household economy. In the past, crop production was mainly for the market and was the main source of cash income for smallholders in both sites, and agroforestry and forest products were mainly for their subsistence. Currently, agricultural activities are mainly for the production of subsistence products while agroforestry and forest management have become the main activities for income generation. Emphasis on agroforestry and forest products explains why smallholders are reducing the size and number of agricultural fields.

Agricultural fields

Although quantitative data were collected for only two years, we can clearly see a trend in the number and size of land-use stages in both sites. In 1998 within the landholdings from Ipixuna and Mazagão there were 25 and 23 fields respectively. The data from 1999 show the number of fields declined to 12 and 18. In both cases fields were left to become fallows for the production of several agroforestry and forest products such as açai fruit and *pau mulato* (*Calycophyllum spruceanum*), a valuable fast growing timber species.

While the number of fields declined, the average field size remained at 0.6 ha for both years. Results show that the decline in the number of fields did not affect the levels of agro-biodiversity in fields at both sites. Farmers are not only planting crops, but are also protecting the seedlings and saplings of several forest and agroforest species. While a similar number of species and varieties were planted at both sites, smallholders from Mazagão protected more than twice the number of species and varieties than did the farmers of Ipixuna. Numbers of species and varieties planted or protected by smallholders in their fields, including the naturally regenerated seedlings of forest and agroforest species, were very high.

There were important differences between the two sites. Farmers in Mazagão tend to focus on protecting rather than planting species: in Ipixuna the converse is true. Species and their varieties observed in fields included grains, tubers, fruit, medicinal and timber species. The average number of species and varieties of crops found in the sampled fields was higher than those reported in fields owned by smallholders within colonization projects and areas owned by cattle ranchers (Anderson 1992). A considerable number of species inventoried are perennials. The farming of tree, shrub and other perennial seedlings shows how smallholders are responding to the drop in prices and market instability of the typical annuals.

Agricultural products are produced in large industrial plantations in the south of

Brazil and are generally cheap and of high quality. As markets in urban Amazonia are flooded with staple crops from southern Brazil, smallholders find they cannot compete with the falling prices for rice, beans and other crops. Based on these and other socio-economic pressures, we found that household income in both sites is in a transitional phase, shifting from a dependence on agricultural products to agroforestry and forest products.

The protection or planting of timber, fruit and other forest or agroforestry species in the fields is changing agrodiversity and other farming technologies used by smallholders. Although fields are still made using swidden techniques, we observed that most farmers are opting not to burn the slash. They believe that seeds of valuable agroforestry species such as *maracuja do mato* and forest species such as tropical cedar are destroyed by fire, preventing natural regeneration. Similarly, weeding operations tend to be more selective and less intensive. For instance, when growing corn, beans and other annual crops the majority of farmers do not weed their fields.

Fallows

Changes in farming operations and technologies are helping smallholders to manage seedlings and saplings of tree and shrub species in their fields. In agricultural fields it is common to find protected agroforestry and forest species naturally regenerating both randomly and in clusters. Most farmers explain that they are protecting the seedlings of timber species, açai palm and other valuable species to enrich their future fallows and forests. Based on the performance of the protected seedlings in fields, farmers have two main fallow types: 1) wild fallows (*capoeiras com mato*), where vegetation is low in valuable species and 2) enriched fallows (*capoeiras contaminadas*), where vegetation is dominated by valuable species. Smallholders use the wild fallows for making fields and manage the enriched fallows for the production of agroforestry and forest products.

Despite the assumption that human intervention in fallows lowers the species richness (Anderson 1992), we found that the enriched fallows contained levels of plant diversity similar to the wild fallows. The general trend is that smallholders tend to maintain or in some cases increase levels of biodiversity as part of a strategy to increase the number of outputs available in the fallows. Of the eight sampled households, six maintained more species in their enriched fallows than in their wild fallows and only two had less.

While the difference in the average species richness between enriched (25) and wild (22) fallows was just 3 species, differences in species composition among enriched fallows are greater than among wild fallows. Biodiversity levels vary considerably with the intensity and frequency of the owners' interventions. For instance, Alvino maintained more than twice the number of species (39) than did Juracy in the same size (0.3 ha) of fallow, while in their wild fallows they maintained similar numbers of species.

There was a difference in the density of individual plants per area and species richness. Smallholders maintained more individuals of species in enriched fallows (average 557 in 0.26 ha) than in wild fallows (average 347 in 0.26 ha). Differences among the sampled enriched fallows were greater than among the sampled wild fallows. For instance, Alvino maintained more than three times more individuals (1120) per species than Juracy in the same size (0.3 ha) of fallow. Such differences are present also in fallows owned by a single family. For example Tomé maintained varying densities of individuals in his three sampled enriched fallows.

Plant diversity and density of individuals and species were clearly influenced by the intensity and frequency of management operations as well as the way in which the seedlings and saplings of valuable species were managed in the field stage. Results from the floristic and structural analysis were consistent with field observations. Vegetation of wild fallows that were not managed was clearly dominated by individuals of *imbauba* (*Cecropia membraneaceae*) and other early colonizing pioneer species. The majority of enriched fallows contained several agroforestry species including bananas and several species and varieties of citrus. This report focuses on enriched fallows because they are under intensive management and they have considerable economic and ecological importance.

Field observations showed that farmers maintained individuals of economic species at different stages of growth in the same fallows and fields. There were adult *pau mulato* trees near other individuals of the same species in the sapling and seedling stages. These uneven-aged stands created a multiplicity of habitats for other species in the landscape.

Of the eight sampled enriched fallows only two (Tomé 2 and Tomé 3) had an estimated species richness index (Dmn = 0.93 and 0.89) of less than one, while only one fallow (Nonato) showed an estimated Shannon's index (H' = 0.84) of less than one. The proximity of the estimated indices to one indicates that there was a correlation (r = 0.94) between the distribution of individuals and species in the enriched fallows.

The rates of abundance and dominance of species in fallows reflects the smallholders' intensive use and management of fallows. Species richness in the enriched fallows showed a strong correlation (r = 0.88) between number of species and number of individuals. The number of trees per area increased when the number of species increased in the fallows.

Although thinning and removal of vines are the main management operations applied to fallows, smallholders are adapting or developing new management techniques. This transformation and innovation is facilitated by the increased value of forest and fallow products in the markets. In both sites farmers are making small openings (*clareras*) in their fallows for planting semi-annual species such as bananas, and for transplanting seedlings of desirable species. They collect seeds of several species, such as tropical cedar and açai palm, to broadcast in their fallows. The frequency and intensity of termite nest removal and other operations to control pests are also increasing as a result of farmers' economic dependence on fallow products. Decisions to convert fallows into fields or forests are based on several factors, including how well production of agroforestry products, such as bananas, is faring, and on whether forest species, such as açai palm, are dominating the vegetation.

Forests

In both sites we found that the forest areas of smallholders were the results of successive management operations that began in the field stage and continued into the fallow and forest stages. Inventories conducted in a sample of 10 hectares (5 in Mazagão and 5 in Ipixuna) showed a great diversity of species.

In both sites the forests contained high levels of species richness and evenness. The average number of species (51) found in the Mazagão forests was higher than the average (36) found in Ipixuna. In contrast, the sampled forests of Ipixuna had more trees (average 1117) than those sampled (average 1041) in Mazagão. These results reflect the histories of management and resource. extraction. In Mazagão people are more dedicated to forest activities and they tend to continually enrich their forest with desirable species of timber, medicinal plants, and fruits. Farmers in Ipixuna practise more agroforestry and the collection of fruits and medicinal products, with some timber extraction.

Despite the differences in forest uses and management practised by the two groups, forests in both sites showed very high diversity on Shannon's Index. Based on the estimated diversity indices, forests in Mazagão had higher values (average H' = 2.59) than do forests in Ipixuna (average H' = 1.77). These results were very similar to the reported estimated Shannon's Index for forest areas in other regions of the estuarine varzea floodplain (Anderson 1992).

While forests in Mazagão were richer in species than are those in Ipixuna, the two most commercially valued species (*Euterpe oleraceae* and *Calycophyllum spruceanum*) were some of most dominant and abundant species in both sites. This abundance indicates that people are encouraging the establishment and growth of these and other valuable species. Similarly, the presence of a high number of timber, fruit and medicinal species suggests the intensity of management by local people in both sites. Data show that the people also maintain low numbers of individuals of several non-commercial species. Among these are pioneer species such as *C. palmata* and *Croton* spp. that play an important role in attracting game animals.

The estimated Importance Value Index (IVI) shows that eight of the ten most important species found in the forests of Mazagão and Ipixuna produced commercial products.

As in the case of managing fallows, people are adapting and developing innovative management technologies that correspond to specific environmental and economic conditions. The abundance and dominance of economically important species is maintained through management that promotes the regeneration of species under different light and environmental conditions. For instance, the majority of farmers conduct pre-harvest operations to avoid excessive damage to the forests, thus optimizing production. Some innovative farmers broadcast seeds or plant seedlings of valuable species before cutting timber. Most seedlings are collected from other parts of the forests, but the seedlings of *andiroba* (*Carapa guianensis*) are mainly produced in house gardens.

House gardens

Within their house gardens the inhabitants of Mazagão and Ipixuna include orchards, nurseries, medicinal plants, vegetables, ornamentals, spices, grasses and vines, and areas for raising domestic animals. The sampled house gardens include most of these categories and all vegetation in them was inventoried. The species and varieties of domestic and semi-domestic animals are currently being recorded and will be included in a later report.

House gardens in Mazagão and Ipixuna were rich in species and produced a large variety of products. There was little variation between sites in numbers of species and individuals maintained. Variation becomes apparent when individual house gardens are compared. Based on these observations, the biodiversity analysis of the sampled house gardens from both sites was pooled.

Although results showed that house gardens contain high biodiversity, there was a significant difference (CV = -0.02) in the number of species and individuals found in each sampled house garden. The average number of species found among the 16 sample house gardens was 17; the maximum, 26, belonged to Nicolau da Silva and the minimum, 11, to Rudinaldo. Similarly, results show that the number of individuals found in the house gardens varied from 136 (Pedro D) to 815 (Alziro). Most of the species found in Alziro's house gardens were herbs, grasses or vines that he planted for medicinal, ornamental, spice and food uses. The majority of species inventoried in Pedro D's house garden were palms and trees.

The estimated species richness index shows that people are maintaining high levels of biodiversity in their house gardens. Among the 16 sampled areas only one house garden had a low species richness index (Dmn = 0.45). However, the estimated diversity and Shannon indices indicate that all sampled house gardens featured high species diversity. Two house gardens, Nicolau (H' = 2.83) and Hernandes (H' = 2.05) contained the highest diversity of species.

While the levels of biodiversity in fields, fallows and forests are strongly dependent on the intensity and frequency of production and management technologies, the number of species in house gardens depends more on their uses. House gardens that are composed of orchards, nurseries and gardens have a greater number of species than those with only one field type.

Conclusion

We expect to continue collecting more data on the biological composition of the different land-use stages and field types found in the landholdings on the PLEC sites. Results from the biodiversity surveys conducted in Mazagão and Ipixuna discussed in this report are only a fraction of the data collected by the Amazonia Cluster. Upcoming reports from the sub-Clusters in Santarém-Ituqui and Iquitos-Peru will add useful biological data that can help to clarify further the complex and diverse operations and technologies used by smallholders who produce and maintain Amazonian biodiversity.

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Amazonian farmer
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INVESTIGATION INTO TREES THAT COMBINE EFFECTIVELY WITH FIELD CROPS

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Introduction

An investigation carried out among local farmers at the two PLEC demonstration sites Gyamfiase-Adenya and Amanase-Whanabenya, in the southern coastal savannah-forest transition zone of Ghana, revealed that some indigenous trees are reputed to combine effectively with some food crops while others are known to be antagonistic. The basis for this observation by the local farmers has not hitherto been examined critically. Such indigenous knowledge or observation is important for the conservation of agro-biodiversity and the incorporation of trees into indigenous farming systems.

The objective of the project was to catalogue all those trees which have been observed by the local farmers to combine effectively with food crops at the two demonstration sites and to investigate experimentally the underlying cause or causes.

The survey

A survey involving PLEC scientists was carried out at both Gyamfiase and Whanabenya. An interview following field observation was the main methodology adopted for the survey. About 20 farmers were interviewed at each site during the survey.

Information gathered from the survey was cross-checked during PLEC scientists' frequent visits to the various demonstration sites and group discussions with the farmers' associations in the two areas.

Survey results

The survey gave the following list of trees which combine well with food crops such as cassava (*Manihot esculenta Crantz*), cocoyam (*Colocasia esculenta*), plantain (*Musa paradisiaca*), white yam (*Discorea alata*) and maize (*Zea mays*).

Local Name	Botanical Name
1. Onyamedua	*Alstonia boonei*
2. Odoma	*Ficus surr*
3. Duabo	*Bussea occidentalis*
4. Ankye	*Blighia spp*
5. Awonwe	*Vernonia amygdalina*
6. Osese	*Holarrhena floribunda*
7. Afrafraha	*Milletia thoningii*
8. Emere	*Terminalia ivorensis*
9. Ofuntum	*Funtumia elastica*
10. Odwen	*Baphia nitida*
11. Abrewa Nyansin (Kumanni)	*Lannea welwitschii*
12. Cida	*Petersiathus macrocarpus*
13. Opron	*Mansonia altissima*
14. Kakapenpen	*Rauvolfia vomitoria*
15. Odum	*Milicia excelsa*

The following trees were said to not combine effectively with food crops:

1. Wawa (*Triplochiton scleroxylon*)
2. Waterku (*Cola gigantea*)
3. Odanwoma (*Piptadeniastrum africanum*)
4. Santewaa (*Melatia spp*.)

Materials and methods

A preliminary on-farm farmer-managed trial was initiated during the main rainy season of 1999. The aim was to obtain growth and yield data to investigate the observation that some plants combine effectively with food crops while others do not. The trials were conducted within the PLEC demonstration site at Gyamfiase. With the help of the local farmers two tree species, *Cola gigantea* and *Ficus surr*, were selected for the study. According to the local farmers, the former tree is reputed not to combine effectively with food crops while the latter does combine with food crops.

Three *Cola gigantea* (*CG*) trees of different sizes, based on the circumference of the trunk 2.0 m from the base, were selected for the study. The circumference of CG_1 was 4.0 m, CG_2 was 2.5 m and CG_3 was 1.5 m. The circumference of the *Ficus* tree was 1.0 m.

The vegetation underneath the trees was predominantly *Chromalaena odorata*. The shrub was slashed and completely removed. Soil samples of the top layer (0–15 cm) were randomly collected around each tree and transported to the laboratory. The samples were air-dried, ground to pass through a 2.0 mm mesh screen and kept dry prior to analysis.

Maize variety 'Dobidi' was sown in concentric circles around each tree. The first concentric circle was 2.0 m away from the base of each tree. Twelve other circles 1.0 m apart followed this. The total area planted around each tree was 616 m^2. Maize seeds were sown in twos, 90 cm apart in concentric circles. Six weeks after planting (WAP) cassava sticks were inter-planted among the maize plants. No chemical fertilizer was applied to the crops. Weeding was done manually by the farmers. The maize plants were harvested 15 WAP. The plant height of the cassava was also taken 12 WAP.

Field observation

Field observation indicated that the test crops grew poorly within 7.0 m away from the *C. gigantea* while the contrary was observed in the case of the *Ficus* tree. Outside the 7.0 m perimeter both maize and cassava grew very well.

Table 1 shows the grain yield of the maize after harvest. The results showed that the yield obtained within the radius of 7.0 m of the *C. gigantea* plants, irrespective of the size of the tree, was very negligible. By contrast yield obtained 5.0 m outside the 7.0 m perimeter was very significant. In the case of the *Ficus* tree there was no yield difference with distance away from the base of the tree.

Table 1 Effect of varying distances from some selected trees on the crop yield of maize 12 weeks after planting

Distance from the tree (m)	Grain yield (kg)			
	Tree species			
	Ficus	CG_1	CG_2	CG_3
0-4	3.5	-	-	-
4-7	4.0	0.3	0.4	0.4
7-12	3.5	2.7	2.6	2.5
>12	3.8	3.0	3.5	3.9

CG = *Cola gigantea*

The effect of varying distances from the selected trees on the growth of cassava is shown in Table 2. The results showed increasing growth of the cassava away from the *C. gigantea* plants. Plants growing close to the trees were spindly and very poor, while those growing outside the 7.0 m perimeter were quite normal. Under the *Ficus* tree the cassava plants showed no sign of stunted growth either within or beyond the 7.0 m perimeter. The plants grew normally and were very healthy.

Table 2 Effect of varying distances from some selected trees on plant height of cassava 12 weeks after planting

Distance from the tree (m)	Plant height (cm)			
	Tree species			
	Ficus	*CG_1*	*CG_2*	*CG_3*
0-4	172.7	58.4	25.4	20.3
4-7	170.4	114.3	71.1	78.7
7-12	172.4	172.7	116.8	144.8
>12	173.4	172.7	116.8	128.2

Discussion

The poor growth observed under the *C. gigantea*, irrespective of size, age and height appears to support the observation by the indigenous farmers that some food crops do not combine effectively with the tree. Even though shade may be a factor affecting the growth of maize and cassava which both prefer full sun, the results seem to suggest that there may be some other factors contributing to the adverse effect on the growth of the test crops. The allelopathic effect of the roots cannot be discounted. The particularly good growth obtained under *Ficus* may be attributed to the copious exudates associated with the tree.

It may be concluded from the present preliminary study that *C. gigantea* may not be a useful plant to be incorporated into food-crop fields. The study and experimental work are continuing.

GENDER AND AGRODIVERSITY IN SOUTHERN GHANA: PRELIMINARY FINDINGS

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Introduction

Earlier work has brought into focus the important role of women in the management and use of environmental resources including soils, crops, water, forests and the indigenous plants on which local communities depend. Women's central role in agrodiversity therefore cannot be over-emphasized. Agro-diversity often varies between different farms; and gender roles and relations in farm work, household dynamics, land tenure and differential access to productive resources often contribute to these variations.

Work under this phase of the PLEC Project therefore sought to:

- examine gender roles and relations in ownership and management of homegardens and other field types;
- record management strategies in specific female homegardens and other farm types;
- examine the role of homegardens and community livelihood programmes in enhancing household food security;
- record women's indigenous knowledge and perceptions of endangered plants including food and medicinal plants.

Methodology

The study used data from a homegarden survey of plants in three demonstration sites undertaken in 1999 and a household survey on organizational and management aspects of agrodiversity using a sample of 31 'expert' and 'innovative' farmers, identified over the years of PLEC work in demonstration sites. The selection of farmers included males, females, land-owners and tenants across each of the three demonstration sites. In-depth interviews were also carried out with female 'expert' farmers.

Gender and land tenure

Sustainable resource use depends partly on local people's ownership and control of land and other resources and on the sense of security this provides. Usufruct right to land is both matrilineal and patrilineal in the Gyamfiase-Adenya and Amanase areas. Women can own land from their families or can obtain land through husbands who are landowners. Male and female migrants, however, acquire land from owners on share-cropping arrangements which often favour the land owner.

In Sekesua-Osonson and Whanabenya, inheritance is through a patrilinial system and devolves only to male children, except where there are no males in the family. Accessibility to land for women, be they indigenous or migrant women, is limited. Women in these areas depend on their husbands or other male relatives for access to land, but do not own or control such land and cannot pass it on to their children. They may also obtain land from owners through share-cropping arrangements. Lack of access and control over land affects women's freedom and choices to practise land conservation and vary management strategies. This was a critical area of concern for migrant women in particular.

In homegardens, women obtain plots from their husbands and cultivate a variety of food crops and medicinal plants. Table 1 indicates that although owners of homegardens are also the operators/caretakers of the gardens, there are gender differences in ownership. Three-quarters of the homegardens surveyed are owned and operated or managed by the males in Gyamfiase-Adenya and Amanase-Whanabenya areas, with females owning/operating about a quarter of the homegardens. In Sekesua-Osonson, female ownership is even lower (6%): the women are heavily involved in off-farm activities. Although women may not be listed as the principal caretakers of the gardens, they contribute significantly in the form of labour and management of soil fertility. This needs to be recognized in developing strategies for biodiversity conservation.

Table 1 Ownership and management of homegardens by gender in demonstration sites

Demonstration Site	Owner				Principal operator/manager				Total	
	Male		Female		Male		Female			
Gyamfiase-Adenya	288	(77.8%)	82	(22.2%)	298	(80.5%)	72	(19.5%)	370	(100%)
Sekesua-Osonson	60	(93.8%)	4	(6.2%)	60	(93.8%)	4	(6.2%)	64	(100%)
Amanase-Whanabenya	69	(77.5%)	20	(22.5%)	66	(74.1%)	23	(25.9%)	89	(100%)
TOTAL	417	(79.7%)	106	(20.3%)	424	(81.1%)	99	(18.9%)	523	(100%)

Source: Homegarden Survey, 1999

Gender division of labour

Gender division of labour is not rigid in the demonstration sites. The heavier tasks of land preparation (clearing, felling trees, burning vegetation and preparation of soil for farming) are done predominantly by men. Both men and women are involved in planting, weeding, harvesting and transportation of crops home. In all three sites these tasks may be subject to local variation and some tasks are performed by both sexes. Gender divisions of labour are flexible.

As well as their own and family labour, hired labour is also used, particularly for initial land clearing and clearing weeds beneath grown crops. But, with little capital, labour hire is difficult for many women. As a result women have smaller farm sizes, with many of them moving into other economic activities.

Land management

Land and crop rotation are practised by female as well as by male respondents.

Traditional methods of management such as mulching with cleared weeds and maize stalks to conserve soil moisture, fallows ranging from 2–8 years, and deliberate leaving of weeds and trees to check soil erosion, are practised as well.

Several management and conservation practices are used by women in the homegardens, including the application of manure using household refuse, and other strategies. One 'expert' farmer, Madam Florence Akoto, in Gyamfiase-Adenya, had cut a water channel to redirect stream water from flooding her farm during the rainy season.

Women farmers have a high level of awareness of environmental management. Their direct contact with the natural environment as providers of water, fuel, food and fodder and their high level of awareness of environmental practices in the face of resource constraints, need to be more widely utilized for sustainable management of farming systems.

Fuelwood availability

With deforestation, fuelwood is becoming scarce in the demonstration sites, especially in Amanase-Whanabenya. Women's central role in food preparation means that they have direct responsibility for fuelwood supply and are therefore worst affected by fuelwood scarcity.

Accessibility to fuelwood is easier for landowners than for tenant farmers. Tenant farmers often have to share their fuelwood stocks with landowners depending on the share-cropping arrangement between tenant and farmer. After depletion of fuelwood stocks on their land, women experience difficulties as many have limited funds to purchase fuelwood. Some households use corncobs, twigs from burnt plots, and palm fronds as fuelwood supplements. Not only is the quantity of fuelwood declining, but women in Amanase-Whanabenya reported a decline in the quality and variety of species.

Homegardens

Both men and women in demonstration sites have homegardens where a variety of food crops and medicinal plants are cultivated. Household refuse is often dumped on homegardens as manure. Homegardens serve as a source of food supply for household needs especially in emergency situations. Some women, mostly in monogamous families, manage their gardens jointly with their husbands. In polygamous families, each wife may operate a homegarden separately.

Further analysis is being undertaken on homegardens with regard to the following:

- gender differences in crop/tree ownership;
- allocations of produce to male/female household members for use;
- gender differences in management strategies in homegardens;
- role of homegardens/farms in providing household food security, since women have the major responsibility for household food provision.

Economic opportunities

The sustainability of rural livelihoods is often critically dependent on livelihood diversification supported by a variety of natural resource endowments. Off-farm employment is gradually assuming importance in the demonstration areas in supplementing household income and requirements. Secondary economic activities undertaken by many women are gari processing, palm oil extraction and petty trading. All are predominantly female activities. In Amanase-Whanabenya especially, women are gradually giving up active farming in favour of gari and cassava-dough processing.

Other land-based activities are gaining importance as income generating sources, including snail harvesting, mushroom cultivation, bee-keeping and livestock rearing (piggeries).

Women's associations

To enhance their accessibility to capital, credit and other inputs, the women have formed associations in each demonstration site. In Bewase, the women's association has a community farm and a plant nursery, and is diversifying into off-farm activities. The potential of these groups for overcoming environmental problems and diversifying income sources, and as a channel for the expression of women's concerns and for building women's opportunities is great, and needs to be encouraged. Given economic opportunities, women can help develop the community and improve environmental resource management.

The forward plan is to:

- Continue to record gender differences in crop/tree ownership on farm types;
- record women's indigenous knowledge and uses of endangered plants including medicinal plants;
- continue to investigate the role of homegardens and community livelihood programmes in enhancing household food security;
- investigate the role of off-farm employment and other strategies in sustaining rural livelihoods;
- evaluate and seek to enhance the role of women's associations in over-coming environmental problems.

Summary and conclusion

Preliminary findings indicate that women have vital and changing roles as environmental resource managers. Yet they face significant constraints in access to resources including land, labour, credit and other economic opportunities. Gender differences and gender relations in household dynamics, resource organization and other socio-economic factors can play a part in explaining and impacting on bio-physical conditions. This needs to be recognized for sustainble environmental management.

COLLECTION OF YAM TYPES AT BONGNAYILI-DUGU-SONG MAIN DEMONSTRATION SITE IN NORTHERN GHANA

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Introduction

Yam (*Dioscorea spp.)* provides one of the staple foods in Northern Region of Ghana, which is entirely within the so-called West African yam zone (an area extending from about 4° N to about 10° N). In addition, the yam has high social and cultural value for rural communities.

The high regard in which the yam crop is held is justified by its nutritional value. Research carried out by Ayensu and Coursey (1972) revealed that in the yam-consuming areas of West Africa it supplied about one-third of the protein requirement for adult males. It contains substantial amounts of minerals and vitamin C, and a small but important quantity of B group vitamins.

In West Africa, the following species of yam are widely cultivated:

- *Dioscorea alata* or Water Yam,
- *Dioscorea cayenensis* or Guinea Yam,
- *Dioscorea esculenta*, or Lesser Yam,
- *Dioscorea rotundata*, or White Yam
- *Dioscorea bulbifera,* or Potato Yam
- many others, wild, but edible species.

Blench (1997) describes the yam species cultivated in West Africa as being at the dynamic frontier between wild and domestic. There is much that is not yet known about yams, but Blench argues that this crop has much to offer in terms of food security.

Yams are normally grown as the first crop in rotation, after land has been cleared. Usually, little or no fertilizer is used, even though the crop responds favorably to an application of phosphorus and potassium, as with other root and tuber crops. Yam performs best on deep well drained loamy soils. Yam is frequently grown with other crops, such as millet, sorghum, maize, rice, cowpea and other crops of the savanna and transition ecological zone. However, a clear relationship exists between cultivation of yams as a sole crop and high yield (Kowal and Kassam 1978).

Former research on yams in Ghana has been oriented towards establishing miniset techniques for rapid seed yam multiplication, along research lines developed by the International Institute for Tropical Agriculture (IITA). Yam germplasm collection by Nyankpala Agricultural Experimental Station resulted in about 55 accession lines in 1989. Most of them have been sent to IITA for storage and preservation.

Yam types collection at PLEC main demonstration site at Bongnayili-Dugu-Song

PLEC methodology requires conservation of species *in situ*, at locations where they are usually grown. The plant species are identified and their abundance and various uses by the rural community is recorded. Formal research in terms of fertilizer requirements, or yield-crop spacing relationships, does not provide answers to all the various socio-cultural and economic values that the particular crop may have for the demonstration site community.

Collection of yam types was carried out during the 1999 cultivation season. The locations where yam was grown were noted and photographs of the vines taken, along with agronomic and other characteristics. The majority of yam types observed during the season were of the *D. cayenensis* and *D. rotundata* varieties. However, there are several differences among the types observed in the field including the length of the vine, the length and weight of tuber, and the socio-cultural and economic value. These differences are well known to the farmers. They identify yam types in the field using the following criteria:

- nature of the vines (whether staked or cripping, i.e. spreading on the mounds and intervening ground);
- Leaf characteristics:
  - leaf colour
  - leaf size
  - roughness etc.
- tuber characteristics (size, skin roughness etc. used for identification during the 'pricking' season, 5–6 months after planting, when farmers cut tubers off the vine, leaving the vines and root to produce seed yams. Only some yam types tolerate this practice.

These observations are presented in Table 1 on pp. 29–30. Length and weight of tuber are the average of several replicated measurements.

Observations and recommendations

- Farmers at the PLEC Demonstration site in Northern Region grow many types of yam. About 24 different types were distinguished and described during the 1999 growing season.
- Farmers clearly differentiate the types of yam grown, by their various characteristics.
- All types have specific uses, which vary from commercial to the hunger crop, eaten only during the lean season, and for use at ceremonies and festivals.
- Socio-cultural values of the yam and its specific types need further analysis. Previous research was mostly oriented towards researcher-managed types of investigation.

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Table 1 Yam types observed during the 1999 growing season at Bognayili-Dugu-Song PLEC Demonstration Site, Northern Region, Ghana

Yam type	**Origin*** (according to farmers)	**Main use**	**Agronomic characteristics** (see text)	**Other remarks**	**Length of tuber** (cm)	**Weight of tuber** (kg)
1. Laabako	Dagbon	Consumed locally (as fufu, sliced yam) Also sold as cash crop	Normally grown staked	Women prefer this type, since it is easier to cook It is also used to perform yam sacrifices, due to its early maturing qualities	28	1.8
2. Kpuno	Dagbon	Consumed locally (as fufu, sliced yam) Also sold as cash crop	Normally grown staked		27	1.7
3. Chenchito	Dagbon	Consumed locally (as fufu) Also sold as cash crop	Staked late in the season	This type of yam is eaten at funerals and festivals	30	1.9
4. Fugla / Fugra	Dagbon	Consumed locally (sliced and roasted)	Cripping plant	Rarely sold for cash	29	1.9
5. Kpuringa	Dagbon	Consumed locally (sliced and roasted)	Staked plant	Eaten mostly by children (small size tubers)	21	0.8
6. Goonyeni/ Zuglangbo	Dagbon	Consumed locally (sliced and roasted)	Cripping plant		28	3.1
7. Nyuwogu	Dagbon	Consumed locally (sliced and roasted)	Staked plant		25	2.7
8. Liiliya	Yendi Area	Cash crop, sometimes eaten at home	Staked plant		19	0.6
9. Chamba	Yendi Area	Used for fufu	Late staked		36	0.8
10. Kpurinjo	Yendi Area	Consumed locally (sliced and roasted), also used as cash crop	Staked, not prickable		NA	NA
11. Kiki	Yendi Area	Consumed locally (sliced and roasted), also used as cash crop	Staked, not prickable		NA	NA
12. Mogni-nyuga	Yendi Area	Consumed locally (sliced and roasted, as fufu), also used as cash crop	Staked, not prickable		NA	NA
13. Dakpauni	Yendi Area	Consumed locally (sliced and roasted, as fufu), also used as cash crop	Staked, not prickable		15	0.3

Table 1 continued

Yam type	Origin* (according to farmers)	Main use	Agronomic characteristics (see text)	Other remarks	Length of tuber (cm)	Weight of tuber (kg)
14. Zong	Dagbon	Consumed locally (sliced and roasted, as fufu), also used as cash crop	Staked, not prickable		NA	NA
15. Friginle	Dagbon	Consumed cooked and roasted, also cash crop	Staked	Aerial yam	10	0.1
16. Kukulga	Dagbon	Consumed cooked and roasted, also cash crop	Staked		37	1.4
17. Kan-gbaringa	Dagbon	Consumed locally as fufu, or sliced yam	Staked and prickable		25	1.3
18. Nyanfu	S. Ghana	Consumed locally as sliced yam	Staked	Due to bitter taste it is cooked, and left overnight to be eaten the following morning	6	0.1
19. Manchisi	S. Ghana	Consumed locally as sliced or roasted yam, also sold as cash crop	Staked		15	0.7
20. Kpagahi	Dagbon	Consumed locally as sliced yam, good for fufu or roasted Not sold	Cripping plant	Used to feed family during 'lean' season	NA	NA
21. Baayeri	Dagbon	Consumed locally as sliced yam, and fufu Sold as cash crop	Staked, also pricked		19	0.2
22. Gun-gon Kpella	Dagbon	Consumed locally as sliced yam, good for fufu or roasted Not sold	Cripping plant		14	0.9
23. Bonbe-tingye	Dagbon	Consumed locally Sold as cash crop	Staked, not pricked		45	1.65
24. Baamyegu	Dagbon	Consumed locally	Cripping plant		20	0.1

* Dagbon are the people of the Bongnayili-Dugu-Song demonstration site, and the surrounding region. Yendi is the core area of Dagbon, a main source of new yam varieties.

CHANGES IN THE NATURAL AND SOCIAL LANDSCAPES PRODUCED BY THE 1999 HIGH FLOOD NEAR IQUITOS, AMAZONIA

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A major flood occurred in the upper Amazon in 1999 during a La Niña event. The Iquitos sub-Cluster team examined some of the effects on the local communities.

Several important changes in the landscape of the Sector Muyuy occurred after the 1999 flood. Two small islands were formed in the left channel of the Amazon River and an island near the end of Panguana Island was totally eroded. As a result of its disappearance, all the families in the village of Jose Carlos Mareategui had to move to other villages on other islands. In addition, the small channel that separated the islands of San Lorenzo and Santana de Muyuy villages was blocked by sediments, thus connecting the two islands. To the west of San Lorenzo Island a long and narrow sand bar formed, while at the end of Santana Island new silt bars were deposited. Figure 1 shows the area before these events occurred.

Perhaps the most dramatic change in the landscape during the 1999 high flood was the lateral migration of the river between the villages of El Aguajal and Yarina. This migration produced landslides (*desbarrancamientos*) and subsidence (*sochomamiento*), eliminating large sections of the levee. Erosion of the levee exposed the inland swamp forests (*aguajal*), dominated by aguaje palm (*Mauritia flexuosa*): large sections of this natural forest are currently at the margin of the river. Because of the process of lateral migration, the river current in this section became stronger than in the neighboring parts of the river, and carried heavy coarse sand sediments (*arena blanca*) into the swamp forest. After the floods, large sections of the swamp forest were covered with white sand deposits, forming sand bars (*emplayados*) in the forest. The abundant and dominant aguaje palm and associated tree species on all sand bars died, and giant grass species such as *Gynerium sagittatum*, pioneer tree species such as *Cecropia membranaceae,* and other early successional species are becoming the dominant vegetation.

While changes in area and vegetation of the swamp are some of the most visible effects of the 1999 flood, changes in area and relief of levees are the most significant in relation to household income, agro-biodiversity and agrodiversity. For instance, all residents of Muyuy Island identified erosion or sedimentation of fields, fallows or house gardens located in levees (*restingas*) as the most important changes left by the La Niña flood. Based on observations made during the flood, all levees were under water for at least 45 days.

Several levees were exposed to strong river currents and suffered landslides. Small discharge channels (*caños*) were formed that cut the levees and connected river channels (main or secondary) with the back slopes of levees (*bajeales*) and back swamps (*tahuampas*) or oxbow lakes (*cochas*). In most cases, the new small discharge channels became important routes for moving products from inland

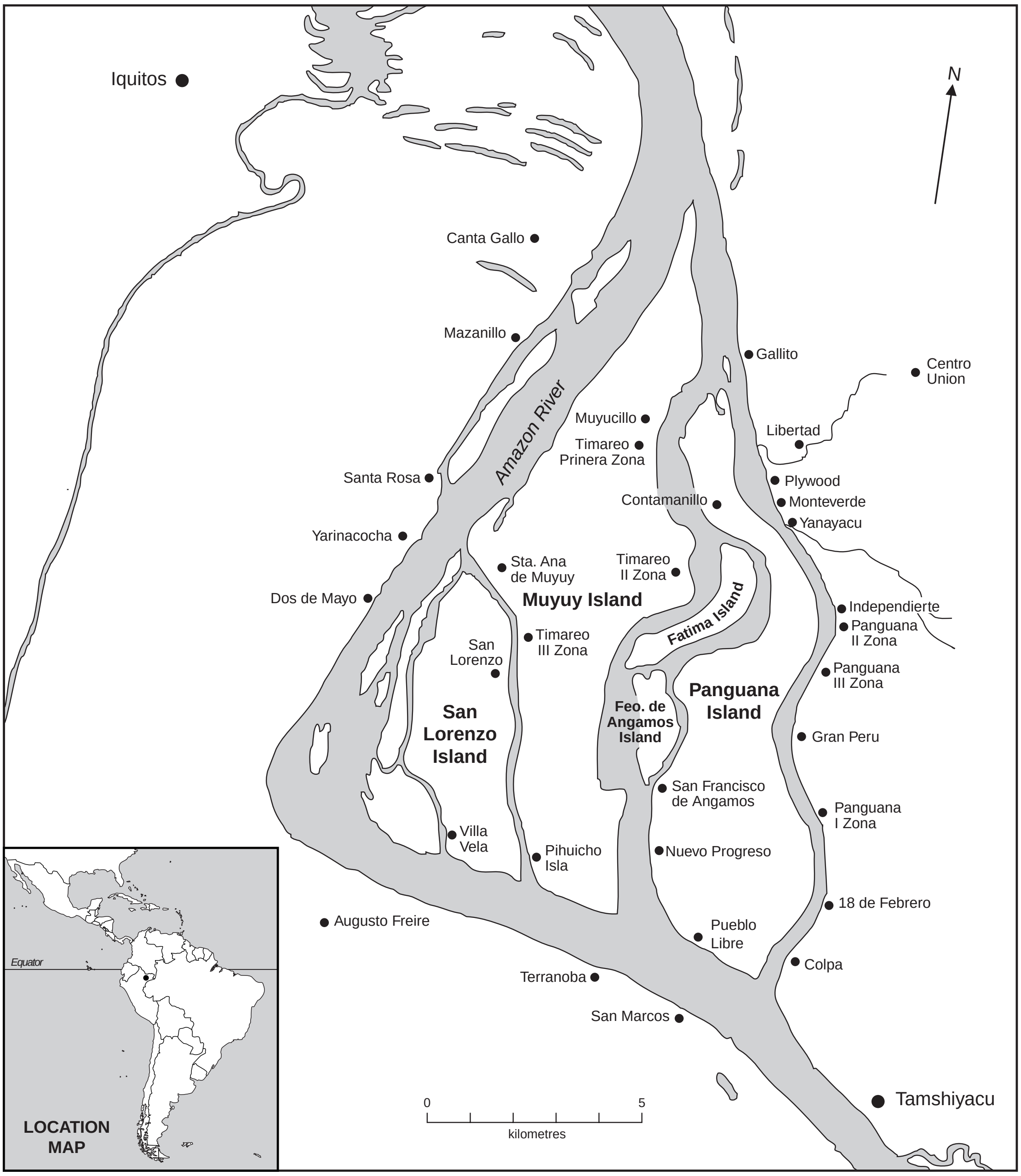

Figure 1 Amazon River before the 1999 high flood

levees that previously had been far from the river and river communities. Formation of these small channels also facilitated the movement of water and sediments that in turn modified the area and configuration of land forms and bodies of water that form the Muyuy varzea floodplain.

The number and area of silt and sand bars formed along the river channels following the 1999 flood were greater than those formed by the 1998 flood. Based on land surveys conducted during the period of lowest river levels, a total of 26 sand and 18 silt bars were formed along approximately 90 km of the river channel. The total area of sand bars was 364 ha and the largest sand bar was 27 ha (9000 m long by 30 m wide); the smallest was 1.2 ha (600 m long by 20 m wide) in size. More sand than silt bars were formed, but the total area of silt bars (468 ha) was higher than that of sand bars. A silt bar of 48 ha (8000 m long by 60 m wide) was the largest and the one of 18 ha (6000 m long by 30 m wide) was the smallest. The majority of silt bars (11) were formed along small islands, while most sand bars (16) were formed within river channels.

The formation of new silt bars modified the depth of the river channels and changed the main route of navigation. Since the 1999 high flood, boats navigate closer to the left bank where Dos de Mayo village is located rather than to the far bank where San Lorenzo is situated. The formation of a silt bar in the middle of the river channel was the main cause for the new route. The change favours residents of Dos de Mayo, but the people of San Lorenzo were severely affected and became isolated from the main river channel. Because of this, San Lorenzo lost a quarter of its population. Nine families (with an average of seven members each) moved to Dos de Mayo. The 1999 high flood greatly helped people from Dos de Mayo to transport their products to the Iquitos markets, while the people of San Lorenzo were left with major difficulties in reaching urban markets.

Their proximity to the main river channel exposes the residents of Dos de Mayo to landslides and land subsidence produced by the lateral migration of the river. Landslides are reducing the territory of the village and forcing them to move. Most residents have had to move their houses a significant distance from the river. Farmers are now choosing levees that are distant from the river or not at risk of being eroded, to make their fields. This use of new levees has produced conflicts between them and families from neighboring communities who own most of the inland levees. One of the main questions explored by the team was how this and other conflicts that emerged from the landscape changes produced by the 1999 high floods have influenced household income and resource use patterns in Muyuy. Data were collected from a sample of 12 (of a total 42) randomly selected villages (Table 1).

Table 1 Name and location of the 12 sample communities in Muyuy

Villages	Location
San José	Right bank, Itaya river
Centro Mazana	Right bank, Itaya river
Mazanillo	Right bank, Itaya river
Moenacaño	Left bank, Amazon river
Ullpacaño	Left bank, Amazon river
Dos de Mayo	Left bank, Amazon river
Cantagallo	Left bank, Amazon river
Cañaveral	Left bank, Amazon river
Yarinacocha	Left bank, Amazon river
Santana de Muyuy	Left bank, Amazon river
San Lorenzo	Left bank, Amazon river
Santa Rosa.	Left bank, Amazon river

The activities of each one of the sample families were monitored during and after the floods. While the village lands were under water the team recorded techniques used by members of the sample families to protect trees, shrubs and other crops from floodwaters. We recorded the ways in which people obtained resources for their consumption and cash income during floods. Their landholdings were measured and the component land-use stages identified and classified as soon as the water receded. The area and type of sediments deposited on each land-use stage were evaluated in each selected landholding. A month after the river level went down and the levees were dry, plant species and varieties that had survived the La Niña flood were inventoried. Plant inventories in randomly selected fields, fallows, forests and house gardens were also conducted during the planting and harvesting seasons. Crop production was monitored over the whole year as were consumption and marketing patterns.

Although most of the data are still being processed, the few results analysed and discussed in this section help to identify the impact of floods on the landholdings.

Most farmers can clearly identify the factors associated with floods that produced changes to the relief of their landholdings and damages to their planted or managed crops. The sample farmers most commonly mentioned the following six:

- the exposure to strong currents and waves usually results in their fields being covered with sand, or eroded;
- daily changes in water temperature from cold to warm when the river is receding tend to kill most fruit and other tree crops;
- the number of trees and other plants that die during floods depend on how deep the waters are and how long the plants remain under water;
- most fruit and medicinal trees and shrubs die during floods when people climb or touch them;
- the mortality of trees is high when sand sediments accumulate around the stems of plants or trunks of trees;
- if the plant is not covered with mulch during the first 20 days after the river level recedes, trees are sure to die.

We found that in the majority of fields, fallows and house gardens of the sample households, the 1999 flood deposited more silt than sand. On average, twice as many fields in our sample villages received silt rather than sand sediments (Table 2).

Table 2 Number of fields where silt or sand sediments were deposited during the 1999 high flood

Sample	**Fields**		**Fallows**		**House gardens**	
Villages	Silt	Sand	Silt	Sand	Silt	Sand
San José	22	0	41	2	6	19
Centro Mazana	10	0	32	0	16	10
Mazanillo	13	0	41	0	10	14
Moenacaño	26	6	22	6	8	15
Ullpacaño	12	7	14	11	13	11
Dos de Mayo	19	11	26	14	18	10
Cantagallo	23	14	16	9	15	16
Cañaveral	27	17	21	6	7	18
Yarinacocha	24	13	12	10	13	10
Santana de Muyuy	18	12	24	14	12	19
San Lorenzo	32	8	21	17	10	16
Santa Rosa	26	11	19	15	14	21

Silt sediments also accumulated in more fallows (average 24 per village) compared with sand sediments (average nine). In contrast, the number of house gardens where sand sediments accumulated was greater (15 per village) than the average number where silt sediments (11) were deposited. Farmers explained that house gardens are located near homes that stand near the river, and the movement of canoes and other boats are constantly producing added waves and stronger currents. In addition, people clean the grasses from in front of their houses, leaving house gardens without protection from strong currents and waves during floods.

Despite the exposure of their house and house gardens to floods, the majority of farmers from the selected villages did not perceive the 1999 high flood as a catastrophic event. They mentioned that the flood brought benefits such as an abundance of fish, a decline in the population of field mice and other pests, and the deposition of new fertile sediments in their fields. During interviews farmers reported that they tend to lose their agricultural crops more to pests than to floods. Although most bananas, plantains, papayas and other semi-annual plants were lost, most of these crops had been harvested before the floods came, and seeds and other planting materials had been stored away in houses or elsewhere.

The seeds of some species of flowers that are grown commercially were protected in the fields. Before the flood reached the field or garden, people buried the seeds 10 to 20 cm deep and covered them with mulch, leaving them underwater for the duration of the flood. After the waters receded they removed the mulch for use in seed germination and the production of the seedlings that were later transplanted to other parts of the fields. The majority of farmers also protected cassava stalks and plantain and banana suckers in their fields. Cassava stems were stored around the old stumps of trees, and banana and plantain suckers were protected on suspended platforms or in branches of trees. The seeds of beans, rice, corn, watermelon and vegetables were stored at home. Despite protecting these seeds in bottles and other containers, the majority of families lost them to insect infestation. Farmers who succeeded in protecting their seeds, mixed them with dried chili peppers and in some cases covered the seed containers with burned diesel oil.

Various techniques were used for protecting tree and other agroforestry species. They made fences around trees or areas with valuable trees to protect them from river currents, from physical contact with people, and to control sedimentation of sand. In addition, they used clumps of floating grasses as barriers to protect trees from strong currents and to limit the access of people to the field. Clumps of grasses were also used for attracting animals, particularly rodents that were captured during the flood. Farmers protected individual tree species that are known to be less tolerant of floods by accumulating plant materials around the bottom of the trunks. These and other techniques explain the observation that individuals of fruit species, such as avocado (*Persea americana*), peach palm (*Batris gassipaes*) and caimito (*Pouroma caimito*) that are not resistant to floods, survived.

Protecting their plants is just one of many activities of the residents of Muyuy during high floods. Other common activities were:

- the collection of forest and agroforestry products;
- fishing;
- working in the city in temporary or seasonal jobs; and
- providing transportation services in canoes.

Most of the transportation services were for the recreation of the middle-class people from Iquitos and were mainly performed by children and women. In addition to the adventure of navigating in canoes within the flooded forests, some families offered fishing as part of the entertainment.

Fish was one of the most important sources of income for the inhabitants of Muyuy during the flood. One or two members of each household participated in fishing expeditions during flood time. The majority of people went to places where they knew that during high floods it would be easy to capture paiche (*Arapaima gigas*), gamitana (*Colossoma macropomum*) and other fish species in high demand in the urban markets. Some residents of Muyuy went to places (particularly oxbow lakes) where their relatives in the city told them that fish were abundant. Farmers fished a total of 72 species of fish during the time the high flood lasted. The most common species caught for consumption and sale are shown in Table 3.

While fishing was mainly conducted in places distant from Muyuy, the harvesting of forest products and hunting were done in forests areas located in or near the communities. The collection of forest products was done mainly by women, and the capture of animals by children. Most families obtained a considerable part of their cash income from selling these when agriculture and agroforestry products were not available. Forest products include barks for medicinal use, timber, and animals such as field rats, doves and caimans (Table 4).

Table 3 Fish species caught during the 1999 high flood

Species	Uses	
Sardina	Few were consumed	Mostly sold
Sábalo huayero		All were sold
Boquichico		All were sold
Palometa		All were sold
Paña blanca	Mostly consumed	Few were sold
Paña colorada	Mostly consumed	Few were sold
Llambina	Mostly consumed	Few were sold
Shiruye	Few were consumed	Mostly sold
Fasaco	Mostly consumed	Few were sold
liza negra		All were sold
Liza pintada		All were sold
Liza muri		All were sold
Yahuarachi	Mostly consumed	Few were sold
Corvina		All were sold
Manitoa		All were sold
Carachama	Few were consumed	Mostly sold
Shuyo	Mostly consumed	Few were sold

The majority of the captured animals and birds are known as *purmeros* (inhabitants of fallows) that were either protected or managed in the landholdings (Table 4). Most of these species are captured throughout the year, but the majority of them were sold in the market only during high floods: during the rest of the year they were captured mainly for local consumption. The number and amount of collected forest products increased during the flood. Although timber was extracted, fruits and medicinal products constitute the most important products that were collected and sold during the 1999 high flood.

Table 4 List of forest products and animals that were collected or captured for consumption or sale during the 1999 high flood.

1) Species hunted	
a) Mammals	*b) Birds*
Pelejo	Paloma
Uculla	Torcaza
Sampoña	Panguana
Sachacuy	Manacaraco
Añuje	Garza ceniza
Majaz	Loro cabeza amarillo
Ronsoco	Loro ojetero
Carachupa	Unchala
Pichico	
Coto	
Zorro	
Conocono	
Lagarto blanco	
Lagarto negro	

2) Forest and agroforestry products	**Sold as**
Capirona (*Callycophyllum spruceanum*)	Timber, construction, fire wood and bark as medicine
Catahua (*Ura crepitants*)	Timber and as support of floating houses
Remocaspi	To make pattels and kitchen utensils
Capinuri (*Maquirea coraceae*)	Timber, latex and bark as medicine
Cedro (*Cedrela odorata*)	Timber
Topa (*Ochromus lagopus*)	As support of floating houses and fences
Moena amarilla (*Aniba amazonica*)	Timber
Pan del árbol	Fruit and resin as medicine
Ayauma (*Curupita sp.*)	Fruit for chicken feed and bark as medicine
Oje (*Ficus anthelmitic*)	Latex as medicine
Ipururo	Bark and leaves as medicine
Toronja	Fruits
Guayaba	Fruits
Shimbillo carapa doble (*Inga sp.*)	Fruits and timber
Shimbillo rabo de mono (*Inga ulei*)	Fruits and timber
Shimbillo pairajo (*Inga cinamonum*)	Fruits and timber
Aguaje (*Mauritia flexuosa*)	Fruits
Huasai (*Euterpe precatoria*)	Heart of palm
Ungurahui (*Jesenia batua*)	Fruits
Camu-camu (Myrciaria sp.)	Fruits

HOUSEHOLD STRUCTURE, AGRODIVERSITY AND AGRO-BIODIVERSITY ON SMALL FARMS IN THE RIO GRANDE VALLEY, JAMAICA

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Introduction

Preserving genetic diversity on small farms and the knowledge about uses of local plants are among the pressing challenges facing agricultural policy-makers in Jamaica and other parts of the Caribbean. Traditionally, small farms in these countries have functioned as repositories for a large variety of useful plants. Much of the genetic diversity found on them is intentional, and represents hundreds of years of farmers' experimentation with local plants in a variety of micro-habitats, to provide food, spices, medicines, ornaments, and timber. In recent years diversity appears to be declining as monoculture is increasingly practised by small-scale farmers producing for the export market. As specialized varieties replace the large number of traditional varieties, efforts to identify and preserve plant genetic resources and local knowledge of their use have intensified. It is imperative that the plant genetic resource base of Caribbean countries not be compromised with changing global economic circumstances.

As part of the effort to preserve agrodiversity in Jamaica, researchers at the University of the West Indies are collaborating with the PLEC programme to study and promote agrodiversity in remote Jamaican small farming communities. To date, research efforts have been directed towards testing the methodology of agrodiversity assessment on small farms in the selected study area and compiling a database of the different plant species found, their natural history, and their use value. Data have also been collected on farmers' socio-economic status, production methods, management strategies with respect to soil conservation, use of pesticides and fertilizers, and the impact of landslides. These management strategies are being studied in relation to the patterns and levels of species diversity encountered on farms.

Initial findings regarding crop diversity on small farms in one part of the Fellowship area in the Rio Grande Valley, Jamaica were highlighted in a previous paper (Thomas-Hope, Spence and Semple 1999). This paper presents a more detailed assessment of crop diversity in several other communities in the Fellowship area at the farm level. The methodology follows recent PLEC guidelines (Zarin, Guo and Enu-Kwesi 1999).

There has been much written about the relationship between species richness and biophysical factors such as soil type, climate, elevation, drought, and pests. A number of socio-economic factors may also affect the range of plants encountered on farms. These include:

- the demographic profile;
- subsistence and cash needs of rural households;
- their resource endowment;
- nutritional needs;
- labour availability;
- influence of the extension officer;
- religious concerns; and
- security of crops.

This paper examines the extent to which household structure is related to crop diversity on small farms in the study area. Analysis of the effects of other socio-economic factors will be examined in the future. The research hypothesis is that farm household characteristics play a significant role in the range of plant species found on small farms.

Study area and methodology

The study was based in Fellowship and surrounding communities in the Lower Rio Grande Valley in the Parish of Portland, Jamaica. The Parish of Portland is a high rainfall area with a rich flora and fauna. The terrain is hilly to near mountainous. Heavy rainfall and steep slopes increase the amount of erosion and threaten the sustainability of agriculture in the area. At the same time farmers are increasingly attracted to the lucrative banana export market.

Based on the land-use classification system set out by Zarin, Guo and Enu-Kwesi (1999), the dominant land-use stages in Fellowship and surrounding communities were identified as agroforestry, house gardens, secondary and primary forests, and tree, shrub, and grass-dominant fallow lands. Within these land-use stages, several broad fields types were identified. Firstly, there were the export-banana fields. These fields have intricate drainage networks, and the banana plants require intensive care and highly specific harvesting practices set down by the Banana Exportation Company (BECO), the agency controlling the export-banana industry in Jamaica. Fields used for non-export banana were different from export-banana fields. Although the basic drainage patterns remained the same, far less labour and time were spent caring for both the plants and the drainage systems. Plantain dominant fields were similar to the non-export banana fields.

Another broad category of fields was devoted to the cultivation of fruit, ornamental plants, and timber trees. These fields have little or no drainage works. Minimal tilling was performed and tending of trees was not labour intensive. For these reasons, these fields were popular among older farmers. Fields devoted to the cultivation of vegetables constituted another category. These fields depend on irrigation, either rain-fed or man-made systems. They also have well-established drainage systems and plants are usually cultivated on well-tilled soil arranged in 'beds'. A great deal of time was spent caring for the plants, and extensive use was made of fertilizers and pesticides to enhance plant growth. Another field type was used to grow yams. Yams are grown on mounds called 'yam hills'. As the yam plants mature, the vines are sustained by 'yam sticks' about three metres in height. The yam hills, with their tall, erect sticks give these fields a distinctive appearance. Other types of field were identified based on how fallow lands were managed or on how ornamental plants were managed.

As the various field types were well distributed among farm units in the study area, vegetation sampling was conducted at the level of individual farm units. Farm units refer to the actual land owned or managed by farmers. Typically, they consist of a house garden and one or more plots located some distance from the farmers' place of residence. Using the farm units allowed for the correlation of biodiversity data with social and economic data at the household level. The sample consisted of 40 households from a total of 1250 households, or 3% of the households in the study area.

For each farm unit, vegetation sampling was carried out on the house garden and on each additional plot. On each plot, different field types were sampled. One square metre quadrats were placed at varying intervals along transects depending on the size of the area being sampled. The presence and abundance of different species within each quadrat were recorded. Farmers were asked to assist in the identification of species and their uses. This applied to both cultivated and naturally growing plants.

Definition of household

A household was defined as a unit comprising either one person living alone or a group of people, whether related or not, living at the same address. Household members share housekeeping duties and have at least one meal together each day, or share common living accommodation (i.e., a living room or a sitting room). Anyone who was away from home continuously for a period of more than six months was excluded from the total household.

Crop diversity in the study area

A total of 235 different species of plants were identified on the farms in the study area. These plants included roots and tubers, vegetables, legumes, cereals, fruits, condiments, ornamental and medicinal plants, and timber trees. Table 1 gives a breakdown of the food and spice plants according to major categories and specific use value. Usage includes food, building material, erosion control, mulch, medicine, spices and stimulants. This varied usage highlights the important role that plant resources play in the livelihood practices and culture of people in the various villages. A reduction in crop diversity threatens not just food supply, but lifestyles and the viability of the economic base of the community.

The most frequently encountered economic crop was banana, found on 85% of the farms. The prevalence of banana reflects its status as the most important export crop. In addition, green banana is an important staple for residents in the area. The next six economic crops, in terms of proportion of farms where they were recorded, were coconuts (73%), dasheen (55%), plantain (53%), breadfruit (48%), oranges (47%) and yams (43%). Dasheen, plantain, breadfruit and yams are staple crops.

Maize was the only cereal crop grown by sampled farmers, but it was not widely cultivated as only 12% of farms had maize. Legumes on the other hand were widely grown. Six different types of legumes were cultivated, namely gungo peas, cowpea, overlook bean, kidney bean, and French peanut. A large number of vegetables were also grown including several fruits, the ackee, cho-cho and susumber, that are used as vegetables. Except for lumber trees, all of the use categories had a large variety of types of plants.

Crop diversity by plot type

House gardens

House gardens ranged in size from 0.1 hectare to 4.4 hectares with a mean of 0.8 hectares. These gardens had a variety of annual and perennial trees, shrubs and herbs, and were multi-storied as were the other field types. A total of 110 different food crops were identified in the house gardens. The number of cultivated food crops in individual gardens ranged from two to 58, with a mean value of 14. A number of plants were identified as main crops based on their importance for food and income. The five most frequently reported main crops were banana, plantain, dasheen, coconut, and yams. A considerable number of medicinal plants were also found. These included cerasee, peppermint, colic mint, fever grass, aloe vera, garlic, and ganja. Ornamental plants were found mostly in house gardens, although a few were found on second and third plots. Similar to other islands in the

Caribbean, house gardens in the study area perform a range of functions: they are a source of full-time and part-time employment, and provide a significant proportion of the household food supply. They are also a place for crop experimentation, and a training ground for young people in horticulture.

Farm plots

The majority of farmers cultivate one plot in addition to their house gardens. Only five of the farmers cultivated a third plot. Both the second and third plots were dominated by crops destined either for the domestic or export markets. The second plots were more intensely utilized than the third plots because of their closeness to the farmers' place of residence and tenure was often more secure. The size of the second plot ranged from 0.2 hectares to six hectares with a modal size of two hectares. The mean number of cultivated crops on them was nine with a maximum of 30. The mean number of cultivated species on the third plot was three with a maximum of eight. The five main crops encountered on second plots were plantain, found on 50% of the farms, banana (31%), coconut (23%), yellow yam (23%), and renta yam (19%). On the third plot, banana, breadfruit, coco, dasheen, yellow yam and sugarcane dominated.

When the farming units in the study area were categorized according to their market orientation, it was found that farms producing for the domestic market had the highest level of cultivated plant species with an average of 25 species. Those producing jointly for subsistence, the domestic, and export, markets had an average of 17 different plant species. Those producing only for the export market had an average of only four cultivated plant species on their plots, reflecting the impact of export agriculture on agrodiversity. Growing bananas at the expense of other crops contributes significantly to a reduction in species richness. Farmers whose interest was solely in export agriculture had little interest in encouraging the growth of medicinal, ornamental plants or trees on their farms. These farmers were in the minority. The more typical situation was where farmers who specialized in export agriculture also cultivated a small amount of other crops for food.

Household size and crop diversity

Household size in the study area ranged from one to 15 persons. The mean household size was 4.0 with a standard deviation of 2.27. Households consisting of four or less persons (small households) accounted for 56% of the sample. Overall, no statistically significant relationship was found to exist between crop diversity and household size. A chi-square test returned a probability value of 0.21. The hypothesis that large households had greater crop diversity on their farms than small households was not substantiated.

The data showed that crop diversity did not vary according to the amount of farm labour available to the household. One reason is that there is little variation in the amount of labour available to different farmers. Approximately 72% of farmers reported that they did not receive additional help from any member of the household, nor did they hire additional labour due to its high cost. Most farmers work their land single-handedly. Farmers who received help from household members or who hired labour were mostly those devoted to the cultivation of export crops. In this case, the farmer was already committed to the cultivation of a reduced number of crops before the decision to hire labour was made.

Gender of household head and crop diversity

There was no difference between the gender of the head of household and the number of different plant species cultivated. Female farmers in the study area cultivated as many different crops as male farmers. This finding corroborates the conclusion of Davis-Morrison (1999) who noted that for Millbanks, in the Upper Rio Grande area of Jamaica, there were no major differences in the range of crops grown by male and female farmers. One reason is that women are involved in all aspects of farming—weeding, planting, harvesting, and marketing—and are equally knowledgeable about the usefulness of different plant species. Also, women are as likely as male farmers to be engaged in export agriculture.

Age of head of household and crop diversity

The mean age of farmers in the Fellowship area was 43 years with a standard deviation of 12 years. The age of farmers ranged from 18 to 70 years. Male farmers in the upper age groups tended to cultivate fewer varieties of crops than younger, male farmers. This pattern is consistent with findings by Spence (1996) for the Parish of Clarendon in Jamaica. The conventional view that younger farmers concentrate more on root crops while older farmers concentrate on tree crops was not borne out: all age groups responded to the demands of the export market to grow banana. The great emphasis on banana by all age groups shows the pervasiveness as well as the strength of the influence of the export market in shaping crop patterns on farms.

Conclusion

This study has shown that a wide variety of plants characterize small farms in the Rio Grande Valley. Due to the lack of baseline data it was not possible to determine whether there has been significant loss in the crop diversity on these farms within recent years or whether the number of export-oriented farms has increased. Further monitoring is necessary to establish the nature of these changes. It can, however, be concluded that crop diversity on export-oriented farms was considerably less than on farms devoted to domestic agriculture or joint domestic/export-oriented agriculture.

At the household level, the household demographic characteristics did not have a significant influence on crop diversity on the farms studied. In particular, household size, and age or gender of the head of household did not significantly affect crop diversity.

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Table 1 Crop and forage plant species found in the the Lower Rio Grande Valley and their uses

This forms part of a list which includes also 46 medicinals and stimulants, 34 ornamentals, and 19 other plants, as supplied by the authors

Common name	Botanical name	Uses*	Common name	Botanical name	Uses*
Cereals			**Vegetables**		
Rice	*Oryza sativa*	fo	Ackee	*Blighia sapida*	fr
Maize	*Zea mays*	af, fo	Avocado	*Persea americana*	fr
			Broccoli	*Brassica oleracea var. italica*	fo
Starchy Fruits			Cabbage	*Brassica oleracea var. capita*	fo
Banana	*Musa sapientum*	fr	Cauliflower	*Brassica oleracea var. botrytis*	fo
Plantain	*Musa paradisiaca*	fr	Pak Choi	*Brassica chinensis*	fo
Breadfruit	*Artocarpus altilis*	fr,ot	Callaloo	*Amaranthus sp.*	fo
			Carrot	*Daucas carota*	fo
Roots /Tubers			Cho-cho	*Sechium edule*	fr
Arrowroot	*Maranta arundinacea*	fo	Cucumber	*Cucumis sativus*	fr
Cassava	*Manihot esculenta*	fo,ot	Lettuce	*Lactuca sativa*	fo
Dasheen	*Colocasia esculenta*	fo	Okra	*Abelmoschus esculentus*	fo
Coco	*Xanthosoma sagittifolium*	fo	Pumpkin	*Cucurbita maxima*	fr
Lucea Yam	*Dioscorea rotunda*	fo	Susumber	*Solanum torvum*	fr
Negro Yam	*Dioscorea rotunda*	fo	Tomato	*Lycopersicon esculentum*	fr
Sweet Yam	*Dioscorea esculenta*	fo			
Yampie	*Dioscorea trifida*	fo	**Fruits**		
Yellow Yam	*Dioscorea cayenensis*	fo	Black mango	*Mangifera indica*	fr
Senvenson Yam	*Dioscorea sp.*	fo	Bombay mango	*Mangifera indica*	fr
Renta Yam	*Dioscorea sp.*	fo	Cherry Creek mango	*Mangifera indica*	fr
White Afu Yam	*Dioscorea sp.*	fo	East Indian mango	*Mangifera indica*	fr
Sweet Potato	*Ipomoea batatas*	fo	Long mango	*Mangifera indica*	fr
			Number Eleven mango	*Mangifera indica*	fr
Sugar Plants			St. Julian mango	*Mangifera indica*	fr
Sugarcane	*Sacharrum officinarum*	fo,be	Stringy mango	*Mangifera indica*	fr
			Sweetie mango	*Mangifera indica*	fr
Legume/Pulses/ Nuts			Tommy Atkins mango	*Mangifera indica*	fr
Almond	*Terminalia catappa*	fr	Granadilla	*Passiflora quandrangularis*	fr
Cashew	*Anacardium occidentale*	fr	Passion Fruit	*Passiflora edulis*	fr
Broad Bean	*Vicia faba*	fo (pods)	Sweetcup	*Passiflora maliformis*	fr
Cowpea	*Vigna unguiculata*	fo (pods)	Honeysuckle	*Passiflora sp.*	fr
French Peanut	*Sterculia apetala*	fo	Grapefruit	*Citrus paradisi sepium*	fr
Gungo Pea	*Cajanus cajan*	fo (pods)	Lemon	*Citrus limon*	fr
Kidney Bean	*Phaseolus vulgaris*	fo (pods)	Lime	*Citrus aurantofolia*	fr
String Bean	*Phaseolus vulgaris*	fo (pods)	Navel Orange	*Citrus sinensis*	fr
Overlook Bean	*Canavalia ensiformis*	c	Ortanique	*Citrus 'Putative X'*	fr

Table 1 continued

Common name	Botanical name	Uses*
Fruits cont'd		
Shaddock	*Citrus grandis*	fr
Sweet Orange	*Citrus sinensis*	fr
Sour Orange	*Citrus aurantium*	fr
Tangerine	*Citrus reticula*	
Cherry, West Indian	*Malphigia pucifolia*	fr
Carambola	*Averrhoa carambola*	fr
Chocolate\Cocoa	*Theobroma cacao*	fr,be
Coconut	*Cocus nucifera*	fr,be,oi
Coffee	*Coffea sp.*	be, mu
Coolie Plum	*Ziziphus mauritiana*	fr
Custard Apple	*Annona reticulata*	fr
Soursop	*Annona muricata*	fr, me
Sweetsop	*Annona squamosa*	fr
Guava	*Psidium guajava*	fr
Guinep	*Melicocca bijuga*	fr
Hog Plum	*Spondias mombin*	fr
June Plum	*Spondias dulcis*	fr
Jackfruit	*Artocarpus heterophyllus*	fr
Jimbelin	*Phyllanthus acidus*	fr
Loquat	*Eribotyra japonica*	fr
Lychee	*Litchi chinenesis*	fr
Mammee Apple	*Mammea americana*	fr
Naseberry	*Manilkara zapota*	fr
Otaheite Apple	*Syzgium malaccense*	fr
Rose Apple	*Syzygium jambos*	fr
Palm Door/Conks Nut	*Taxonomic name unknown*	fr
Papaya	*Carica papaya*	fr
Pear		fr
Pineapple	*Ananas comosus*	fr
Sorrel	*Hibiscus sabdariffa*	be
Star Apple	*Chrysohyllum cainito*	fr
Stinking Toe	*Hymenaea courbaril*	fr
Tamarind	*Tamarindus indica*	fr
Watermelon	*Citrullus lanatus*	fr

Common name	Botanical name	Uses*
Spices/Condiments		
Bird Pepper	*Capsicum frutescens*	sp,me
Brown Hot Pepper	*Capsicum sp.*	sp
Cinnamon	*Cinnamomum zeylanicum*	
Escallion	*Allium fistulosum*	sp,me
French Thyme	*Plectranthus amboinicus*	sp
Garlic	*Allium sativum*	sp, me
Ginger	*Zingiber officinale*	sp, me
Nutmeg	*Myristica fragans*	sp
Onion	*Allium cepa*	sp,me
Pimento	*Pimenta dioica*	sp
Red Scotch Bonnet	*Capsicum sp.*	sp
Sweet Pepper	*Capsicum annuum*	fo, sp
Thyme	*Thymus vulgaris*	sp, me
Vanilla	*Vanilla planifolia*	sp
Yellow Scotch Bonnet	*Capsicum sp.*	sp
Forage		
Corn Grass	*Setaria barbata*	af
Crab Grass	*Stenotaphrum secundatum*	af,er
Fatten Barrow	*Synedrella nodiflora*	af
Guinea Grass	*Panicum maximum*	af,er
Nut Grass	*Cyperus rotundus*	
Pasture Grass	*Taxonomic name unknown*	af,er
Water Grass	*Commelina diffusa*	af,me

***Uses**
af = animal food
be = beverage
c = ceremonial/sacred
er = erosion control
fo = food
fe = fence
fr = fruit
sp = spice
me = medicinal
nu = no use
oi = oil
ot = other trees

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