

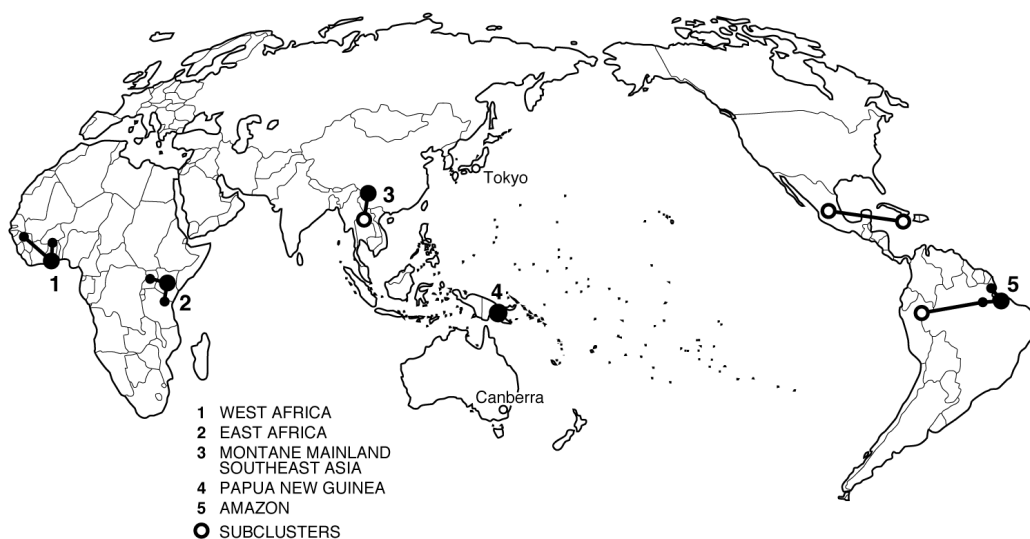


THE UNITED NATIONS UNIVERSITY Project
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PLEC NEWS AND VIEWS

SPECIAL ISSUE ON METHODOLOGY

No. 13 April 1999



The Clusters of PLEC



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PLEC NEWS AND VIEWS

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No. 13 APRIL 1999

GUIDELINES FOR PLEC

Harold Brookfield
Principal Scientific Coordinator

What this issue is about, and why

This special issue of PLEC News and Views addresses project methodology in the areas of biodiversity, agrodiversity, and demonstration sites. In the GEF proposal and the Project Document, we stated that a major task for the project's first year should be the harmonization of methodologies that had developed in different ways during the long 'preparatory period'. We do not seek uniformity, because PLEC is about a diversity of methodologies. But harmonization is essential.

By early 1998, it became apparent that the earlier guidelines for collection of information on diversity (Zarin 1995) were only partially being followed. The problem was that many of our participants found it very difficult to make operational the insistence in those guidelines on randomization. The initial guidelines by Zarin were quickly followed by a paper by members of the Yunnan Cluster in China (Guo, Dao and Brookfield 1996), proposing some enriching variants in the original methodology. Their 'agro-biodiversity assessment (ABA)' method, since followed in China, has influenced the revised guidelines that are printed here.

Experience in PLEC has shown that transects, very suitable for initial reconnaissance, were inadequate for demonstration site work, and unable to yield detailed analysis of either agrodiversity or biodiversity. As a first step once we had GEF funding available, it was decided at the commencement workshop at Mbarara in Uganda in March-April 1998 that the Scientific Coordinators should prepare guidelines on the study and analysis of agrodiversity. A first draft of such guidelines was produced in time to be tabled at the Management Group meeting in Tokyo in July 1998. After revision by Brookfield and Stocking, the guidelines were sent immediately to Clusters, but without discussion of method regarding agro-biodiversity. It had become apparent that collection of information on biodiversity was, quite widely, not being done in ways that would readily lead to the database we are required to provide, and did not meet international ecological standards. Christine Padoch, the Scientific Coordinator working most closely to the international biodiversity community, proposed at Tokyo that we organize a Biodiversity Advisory Group (BAG), to examine what PLEC had done and was doing, and propose a practical methodology for general adoption.

The Biodiversity Advisory Group (BAG)

A convenor (Dr Daniel Zarin) was appointed in the following month (August), and later BAG was completed by invitations to Professor Guo Huijun and Hon. Dr Lewis Enu-Kwesi. We took the opportunity of an already-planned set of meetings in China to organize a largely-field meeting of BAG in Yunnan in January 1999. In addition to visiting all four of the field sites of the China Cluster, the Group met informally several times before presenting its conclusions at the Baoshan meeting of the China Cluster on 28 January. A first draft of their final paper was available in the first week of February, and comments on it were quickly gathered by e-mail communication between the members and the Scientific Coordinators. After further drafts, a 'provisional' document was sent by e-mail attachment to all Cluster leaders and sub-Cluster leaders on 15 March. The final version, containing some subsequent editorial changes made by BAG members, is now printed in this issue.

Agrodiversity, biodiversity, and demonstration site work

The July 1998 agrodiversity guidelines were, meanwhile, being used, but these guidelines lacked relationship to the biodiversity work. The BAG meetings made it clear that such a relationship could arise directly from work that would classify resource use and management on the one hand, and would provide a sampling frame for biodiversity inventory on the other. That is, the same basic task would feed into both parts of the job. Once the BAG paper had reached an advanced stage, it became possible quickly to revise the agrodiversity paper in order to bring the two sets of guidelines together, and an agreed revision was sent to Clusters on 22 March. The revised agrodiversity paper appears in this issue as a companion to the biodiversity paper.

Collection and analysis of data are a part of the job, but the data really become useful by illuminating work with the farmers at our demonstration sites. The revised agrodiversity paper leads strongly in this direction. In order to emphasize the connection, we also reprint in this issue a paper on demonstration site work, by Christine Padoch and Miguel Pinedo-Vásquez, that appeared in *PLEC News and Views* 11, in November 1998. Three main elements of PLEC methodology are therefore discussed together in this issue.

References

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1996 Agrodiversity and biodiversity on the ground and among the people: methodology from Yunnan. *PLEC News and Views* 6: 14–22.
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METHODS FOR THE ASSESSMENT OF PLANT SPECIES DIVERSITY IN COMPLEX AGRICULTURAL LANDSCAPES: GUIDELINES FOR DATA COLLECTION AND ANALYSIS FROM THE PLEC BIODIVERSITY ADVISORY GROUP (PLEC-BAG)

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EXECUTIVE SUMMARY

This paper provides definitions of essential agro-biodiversity terminology (Table 1), a set of fundamental principles (Table 2) and practical guidelines (Tables 3 and 4) for the collection of core PLEC plant species diversity data, and instructions for the analysis and reporting of that data (Figures 1-4). The tables and figures may be used in the field as a 'recipe' for collection and analysis of that core data, which will ultimately be included in a PLEC biodiversity database. The text provides supplementary information and explanations.

Cluster personnel must acquire significant familiarity with the demonstration site prior to the collection of the core data, which require stratification of sampling based on Field Types (Tables 1 and 2). Methods for acquiring that familiarity are discussed by Brookfield, Stocking and Brookfield (1999), and analysis of biodiversity data collected during the familiarization process (e.g. along transects) will be discussed in a separate manuscript from the BAG members; those data do not constitute core data as defined here.

In addition to stratification, the fundamental principles emphasize prioritizing sampling toward Field Types with high species richness, replication of sample areas, and collection of data within fixed sample plots which are remeasured at appropriate intervals in order to capture the critical temporal component of agro-biodiversity (Table 2). The practical guidelines emphasize criteria for sample area selection, numbers of replicates, plot sizes, kinds of data to record, and sampling frequency (Table 4). The instructions for analysis include simple metrics for calculating the similarity in species composition among sample areas (Figure 2), and the development and uses of species-area and abundance-diversity curves (Figures 3 and 4 respectively).

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We thank Harold Brookfield, Mark Ducey and Christine Padoch for insightful comments on earlier versions of this paper.

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Table 1 Definitions of agro-biodiversity terminology recognized by the PLEC Biodiversity Advisory Group (BAG)

Term	Definition	Example	Source
Land-use Stage	A general land-use category based on vegetation structure and requiring a plant species-diversity sampling strategy distinct from that of other such categories	House gardens	This paper
Field Type	A specific land-use category which corresponds to the finest-scale land-use division made by farmers and researchers	Monocultural cultivation of <i>Cassia siamea</i> in coppiced fuelwood groves in Yunnan, China	Brookfield, Stocking and Brookfield (1999)
Sample area	A contiguous parcel occupied by one Field Type and selected for data collection	One selected <i>Cassia siamea</i> fuelwood grove	Avery and Burkhardt (1983)
Sample plot	The portion of a sample area from which data are collected	A 20 x 20 m section of the sample area described above within which tree species abundance data (see below) are collected	Avery and Burkhardt (1983)
Nested plot/sub-plot	A smaller sample plot located within a larger sample plot	A 1 x 1 m section of the sample plot described above, within which herbaceous species abundance data (see below) are collected	Avery and Burkhardt (1983)
Sampling frequency	The number of times a sample plot is measured	Annual sampling of citrus plantations in Ghana	Avery and Burkhardt (1983)
Species abundance	The number of individuals of a species present within a sample plot	112 <i>Euterpe oleracea</i> stems in a house garden plot in a PLEC demonstration site in Brazil	Gove et al. (1996)
Species richness	The number of species present within a sample plot or a larger unit of analysis	90 species present within all of the sampled house gardens in a PLEC demonstration site in Brazil	Gove et al. (1996)
Evenness	The equitability of species abundances within a sample plot or larger unit of analysis	High evenness is where numbers of individuals are equitably distributed among the species present	Gove et al. (1996)
Species diversity (<i>sensu stricto</i>)	Any of a number of statistical properties which describe the relationship between species richness and evenness within a sample plot or a larger unit of analysis	The Shannon-Wiener Index	Gove et al. (1996)
Sorenson's Similarity Index (S_s)	$S_s = 2T_{C_{i \& j}} / (T_i + T_j)$ where: T_i and T_j = the number of species in sample units i and j , respectively and $T_{C_{i \& j}}$ = the number of species common to sample units i and j	41 per cent similarity between 2 house gardens from a PLEC demonstration site in Amapá, Brazil	Jongman et al. (1995)

1. Introduction

The PLEC Biodiversity Advisory Group (PLEC-BAG) is a committee of Cluster personnel with expertise in the collection and analysis of agro-biodiversity data. Established by the PLEC management group in July 1998, the primary purpose of PLEC-BAG is to insure that the quality of core PLEC agro-biodiversity data collection, analysis and organization is sufficient to meet international scientific standards. Meeting such standards is essential if the results of our work are to be accepted as valid and considered to have wider applicability both within and outside of the PLEC network. A major objective of PLEC-BAG is to make each Cluster's conformance to those standards as effective and efficient as possible.

Specific responsibilities of PLEC-BAG include: 1) recommendation of common guidelines for the collection and analysis of core PLEC agro-biodiversity data across Clusters; 2) recommendation and development of a database system for the organization of core PLEC agro-biodiversity data; and 3) advising individual Clusters on agro-biodiversity issues on an as-needed basis. This paper is concerned with the first of those tasks, and is an outcome of the first full meeting of PLEC-BAG, which was hosted by the China Cluster in January 1999. A subsequent report on the second task is anticipated later this year (following the May 1999 management group meeting in Mexico, PLEC-BAG will reconvene in New Hampshire, USA to work on the database issue). The third task is ongoing, and is being undertaken via electronic mail and site visits.

A number of individual Clusters have already conducted a significant amount of agro-biodiversity data collection and analysis. This paper is not intended to comment directly on the work done to date; that process was initiated by Zarin in August 1998 and remains ongoing. Our intention here is to provide guidelines for future work, which will necessarily build on the variety of fieldwork and the methodological frameworks that have been developed within PLEC thus far (e.g. Brookfield and Stocking 1999; Brookfield, Stocking and Brookfield 1999; Guo, Dao and Brookfield 1996; Zarin 1995). Inevitably, our guidelines draw heavily on the varied experiences of the Amazonian, Chinese and West African Clusters represented by the BAG members.

Definitions of agro-biodiversity terminology recognized by PLEC-BAG and used throughout this paper are presented in Table 1. Those terms most directly relevant to the collection of core PLEC species diversity data include Land-use Stage, Field Type, sample area, sample plot, nested plot/subplot, species abundance, species richness and sampling frequency. Additional terms most directly relevant to analysis of those data include evenness, species diversity (*sensu stricto*), and Sorenson's Similarity Index.

2. Fundamental principles

We have developed a set of fundamental principles for the collection of core PLEC plant species diversity data (Table 2). The 'core' data refer to data which we anticipate including in the PLEC biodiversity database. A significant degree of familiarity with the demonstration site is required prior to the classification of Field Types and the collection of the core data. Methods for acquiring that familiarity, including farmer interviews, meetings, and farmer-assisted transect surveys, are discussed by Brookfield, Stocking and Brookfield (1999). Plant species diversity data collected during that familiarization process are extremely valuable and have a variety of uses; however, those data do not constitute core data as defined here. The fundamental principles for the collection of the core data emphasize the following points:

Table 2 Fundamental principles for the collection and analysis of core PLEC plant species diversity data
Refer to Table 1 for definitions of terminology used (first use in bold below)

- 1 Selection of **sample areas** for data collection must be stratified by **Field Types** identified by farmers and researchers
- 2 Selection of Field Types for sampling should prioritize those with high **species richness**
- 3 For each selected Field Type, sample plots must be surveyed in multiple sample areas (i.e. replication)
- 4 Data collection must occur within **sample plots** of fixed or measured dimensions
- 5 To capture the temporal component of agro-biodiversity, sample plots must be remeasured at appropriate intervals

First, at each demonstration site, selection of sample areas for data collection must be stratified based on Field Type. Table 3 gives examples of Field Types we have encountered within seven reasonably distinct Land-use Stages.

Second, selection of Field Types for sampling should prioritize those which appear to contain the greatest variety of species (i.e. high species richness). Researchers should pay particular attention to edges and other transitional areas which often contain high species richness but are generally ignored in sampling schemes because they do not fit neatly into any predetermined category.

Third, for each selected Field Type, sample plots must be surveyed in multiple sample areas. Table 4 includes guidelines for the minimum number of replicate sample areas needed for Field Types within each of our seven Land-use Stages.

Fourth, data collection must occur within sample plots of fixed or measured dimensions. Table 4 also includes guidelines for appropriate plot sizes and for the use of nested sub-plots to facilitate the sampling of understorey vegetation.

Fifth, sample plots must be remeasured at appropriate intervals. Table 4 also includes guidelines for sampling frequency.

3. Land-use Stages and Field Types

On the basis of vegetation structure, Land-use Stages are defined as distinct categories requiring different sampling strategies. At present, PLEC-BAG has identified seven Land-use Stages: annual cropping, agroforests, fallows, orchards, native forests, house gardens and edges. We further divide fallows into grass-dominated, shrub-dominated and tree-dominated sub-groups. Table 3 provides examples of these Land-use Stages from Amazônia, China and West Africa. We note that there may be additional Land-use Stages not included in Table 3, particularly at Cluster sites not represented by the members of PLEC-BAG; these will be added to the list as necessary. Also, we recognize that the Land-use Stages are not as discrete as their separate listing suggests. We are aware of overlap among several stages, particularly between fallows, agroforests, orchards and native forests. We do not believe that overlap will have a significant influence on the practical utility of the Land-use Stages for distinguishing species diversity data collection strategies. We also emphasize here that the inclusion of edges as a separate category is intended to encourage their sampling as a discrete unit.

Table 3 Land-use Stages currently identified by the PLEC Biodiversity Advisory Group (PLEC-BAG)

<i>Land-use Stage</i>		<i>Examples</i>		
		<i>Amazônia</i>	<i>China</i>	<i>West Africa</i>
Annual cropping		Sugar cane	Paddy rice field	Corn, millet and cassava monocrops
Agroforests		Banana and corn intercrop	Rubber, passion-fruit, upland rice intercrop	Mixture of annual crop species above with trees in old traditional small peasant farms
Fallows	Grass-dominated	Recent abandoned pasture	<i>Chromolaena</i> spp.	Along the Sekesua transect
	Shrub-dominated	Early regrowth following agricultural abandonment	8 years after sugar cane abandonment at Baihualing	On the Accra plains
	Tree-dominated	<i>Calycophyllum spruceanum</i> stands	Rare due to fuelwood harvest	Abandoned small-peasant agroforest
Orchards		Banana plantations	<i>Quercus acutissima</i> coppice fuelwood stands	Oil palm and coconut plantations
Native forests		<i>Várzea</i> forest	Nature reserve forest	Sacred grove forest
House gardens		<i>Euterpe oleracea</i> dominated garden	Extremely varied, often high in endemic species	Common around homes in villages and small towns
Edges		Banana–annual crop boundary	Community forest–sugar cane boundary	Not yet surveyed

In ecological terms, a Land-use Stage is analogous to a successional stage. We chose the term to reflect the dynamism we have seen in our Cluster-regions, where some stages can be rapidly converted into others, through very active or sometimes relatively passive management. In Yunnan, China we have seen the conversion of centuries-old paddy terrace land to house gardens as a response to changes in markets, tenure and governmental policies. In Ghana, the conversion and abandonment of a number of traditional and industrial planting systems have led to frequent Land-use Stage alterations in managed landscapes. In Amapá, Brazil, we have documented very rapid transitions among virtually all Land-use Stages.

The definition of Field Types at PLEC demonstration sites is necessarily an iterative process. Researchers should expect that the number of Field Types will grow as familiarity with farming systems and with the landscape increases and new Field Types are added and others divided. In a few cases, a particular Land-use Stage may contain only one Field Type; house gardens are sometimes (but not always) an example of this phenomenon, particularly where house garden production is focused on one major cash crop (e.g. açai fruit at the Amapá demonstration sites in Amazônia).

We view the relationship of Land-use Stages to Field Types as analogous to that between an ecological community and the niches contained within it. Modern ecological theory conceives of the niche as an n-dimensional space (Whittaker 1975), defined by a very large number of biotic and abiotic variables and their interactions; given the multivariate determinants of Field Type discussed by Brookfield and Stocking (1999) and Brookfield, Stocking and Brookfield (1999) it seems appropriate to view it similarly. Further description of the relationships among Land-use Stages, Field Types and management diversity is provided in the accompanying paper by Brookfield, Stocking and Brookfield (1999).

4. Data collection

Table 4 presents our recommendations for 1) sample area selection, 2) the minimum number of sample areas required, 3) appropriate plot sizes, 4) recording of species richness, abundance and utility data, and 5) sampling frequency. Each of those five issues is discussed below (sections 4.1–4.5).

4.1 Selection of sample areas

Selection of sample areas within a Field Type may be either random or biased, depending upon Cluster goals, and it is important to realize that opting for random or biased sample area selection has important consequences for the interpretation of results. Random selection of sample areas within a Field Type may be accomplished following the development of a detailed land-use map of the demonstration site, which would necessarily include Field Types as mapping units. Random sample area selection is appropriate if the Cluster wants to collect data representative of the Field Type within the demonstration site as a whole. Biased sample area selection is appropriate if the Cluster wants to collect data representative of the most productive or the most species-diverse examples within a Field Type. Biased sampling can often be accomplished through a combination of farmer interviews and selective visits to sample areas identified as unusual by the farmers themselves. Biased samples are not representative of the average for the demonstration site as a whole, but may be useful representations of the unusual or the exceptional.

Within any PLEC demonstration site, it may be appropriate to select sample areas randomly for some Field Types and to bias sample area selection for others. We recommend random

Table 4 Data collection guidelines for core PLEC species diversity data recommended by PLEC-BAG

			Fallows						
Land-use Stage	Annual cropping	Agroforest	Grass-dominated	Shrub-dominated	Tree-dominated	Orchards	Native forest	House gardens	Edges
Sample area selection	Random or biased	Biased	Random or biased	Random or biased	Random or biased	Random or biased	Random	Biased	Biased
Minimum number of sample areas	3 within each Field Type	3 within each Field Type	3 within each Field Type	3 within each Field Type	3 within each Field Type	3 within each Field Type	5 within each Field Type	10	10
Plot size	1 x 1 m or 5 x 5 m	5 x 5 m or 20 x 20 m with nested 1 x 1 m subplots	Mark 20 x 20 m frame, sample nested subplots	Mark 20 x 20 m frame, sample nested subplots	20 x 20 m with nested subplots	20 x 20 m with nested subplots	20 x 20 m with nested subplots	Entire sample area with nested subplots	Sample in 1 m ² increments
Minimum data to record	Presence, abundance & utility	Presence, abundance & utility	Presence, abundance & utility	Presence, abundance & utility	Presence, abundance & utility	Presence, abundance & utility	Presence, abundance & utility	Presence, abundance & utility	Presence, abundance & utility
Sampling frequency	Seasonal in year 1; once in each of the following 2 years	Seasonal in year 1; once in each of the following 2 years	Seasonal in year 1; once in year 3 only	Seasonal in year 1; once in year 3 only	Seasonal in year 1; once in year 3 only	Seasonal in year 1; once in year 3 only	Seasonal in year 1; once in year 3 only	Seasonal in year 1; once in each of the following 2 years	Seasonal in year 1; once in each of the following 2 years

selection of sample areas for native forest Field Types, and biased selection of sample areas for Field Types within the agroforest, house garden and edge Land-use Stages. Where highly managed fallow Field Types are present, biased selection is recommended; otherwise, fallow Field Types may be sampled randomly.

4.2 Minimum number of sample areas

Replication of sample areas is distinct from replication of plots within a sample area; the latter, which has been characterized as 'pseudo-replication' by Hurlbert (1984), may not be used as a substitute for the former. We recommend a minimum of 3 replicate sample areas for Field Types within annual cropping, agroforest, fallow and tree-crop stand Land-use Stages. A minimum of 5 replicates is recommended for native forest Field Types, and at least 10 replicates should be used for house garden and edge Field Types. These are minimum guidelines only, and were selected, based on the experience of BAG members, to reflect the amount of replication generally needed to adequately represent within-Field-Type variation in species diversity. Species-area curves, discussed below (section 5.3), are useful guides for estimating when sufficient replication has occurred.

4.3 Plot size

Three plot sizes have been selected by PLEC-BAG as standard frames for the collection of core PLEC species diversity data: 1 x 1 m, 5 x 5 m, and 20 x 20 m. The 1 x 1 m frame may be appropriate for sampling some Field Types within the annual cropping stage and as a nested sub-plot for sampling the herbaceous layer of Field Types within the agroforest, fallow, orchard, native forest and house garden stages. As appropriate, the 5 x 5 m frame may substitute for, or be used in conjunction with, the 1 x 1 m frame; the 5 x 5 m frame may also be sufficient as the basic unit for sampling some Field Types within the agroforest stage. The 20 x 20 m frame is appropriate for use in agroforest Field Types characterized by wider spacing, and as the basic frame for sampling Field Types within fallow, orchard and native forest stages. Within the grass- and shrub-dominated fallow sub-stages, we recommend establishment of the 20 x 20 m frame even if only nested 1 x 1 m and 5 x 5 m plots are sampled. Marking the corners of the 20 x 20 m frame, and sampling nested 1 x 1 m and 5 x 5 m plots within it, establishes the basis for representative repeated measurement of the same fallow plots even if they make a sub-stage transition as they age.

When the 1 x 1 m frame is used for nested subplots, employing several of them within a plot is generally advisable; these should be randomly distributed within the large frame. Use of the species-area curve method described below (section 5.3) should be a helpful guide to determining the number of nested subplots required. The China Cluster has used five 1 x 1 m nested subplots within each 20 x 20 m plot for various Field Types within the native forests and orchards Land-use Stages. At the Amapá demonstration sites, the Amazonian Cluster has used 5 x 5 m nested subplots to characterize understory regeneration in native forest plots.

House gardens and edges present special sampling problems which prevent the use of the standard frame sizes. Because of the high spatial variability present within most house gardens, PLEC-BAG recommends that the entire house garden area be considered the sample plot. Under these circumstances, it is also necessary to measure the area occupied by the house garden. Nested 1 x 1 m and 5 x 5 m sub-plots may be used within house gardens for herbaceous and other understory sampling. Edges tend to be linear in shape, and we recommend sampling in 1 m² increments, with the shape and number of increments to be adjusted according to the shape and size of the edges themselves.

4.4 Data recording

We emphasize two kinds of basic species diversity data: presence and abundance. Recording of presence requires simple listing of species observed in sample plots. Recording of abundance requires additionally listing the number of individuals of each species.

We also recommend collection of data to describe the utility of species surveyed. We suggest that, at a minimum, utility of an individual species be assigned to general categories, such as food, construction, crafts, medicine, commerce and others; this usage follows earlier ethnobotanical literature (e.g. Pinedo-Vásquez, Zarin and Jipp 1990; Prance et al. 1987). A single species may be assigned a 'use-value' in as many categories as appropriate. For some purposes, it may be important to distinguish between known 'potential' uses and actual 'intended' uses stated by the farmer of a particular sample area.

Collection of additional data including size and productivity and more detailed ethnobotanical uses of individual plant species may be accomplished at the same time as presence, abundance and utility data are gathered. Detailed information on harvesting and productivity of useful species is generally important. For tree species, diameter and height measurements are also desirable. We encourage Cluster personnel to maximize the efficiency of fieldwork by conducting species diversity data collection in concert with other related tasks. At present, while PLEC-BAG is evaluating biodiversity database software, Cluster personnel may wish to enter data into a spreadsheet software program, such as Excel, for ease of storage and dissemination within the Cluster.

4.5 Sampling frequency

Some of the variation in plant species diversity present in complex agricultural landscapes is associated with temporal rather than spatial variation. Capturing the temporal component of agro-biodiversity requires repeated sampling of the same plots at appropriate intervals. At a minimum, we recommend a combination of seasonal sampling in year 1 followed by annual resampling in subsequent years as a means of capturing both inter-seasonal and inter-annual change. Farmers should be consulted to determine the timing of resampling needed to capture changes in plant species diversity.

5. Data analysis

The data collection methods outlined above (section 4) were designed to permit many kinds of meaningful statistical analyses. Here, we focus on those analyses which can be done by Cluster personnel at each demonstration site with a minimum of expertise and computational capacity. The following sections discuss: 1) species richness; 2) analysis of similarity within and between Field Types; 3) species-area curves; and 4) abundance-diversity curves. These constitute the core PLEC species diversity analyses and should be reported using a format similar to that illustrated here (Figures 1–4). Note that at present none of the 'species diversity' indices traditionally used by ecologists (e.g. Shannon-Wiener, Simpson's) are included as core PLEC analyses. The reasons for this omission will be discussed in a forthcoming manuscript by the BAG members.

5.1 Species richness and utility

There are four levels at which calculation of species richness is appropriate: 1) within each plot; 2) within each Field Type; 3) within each Land-use Stage; and 4) within each demonstration site. Species richness within a plot is simply the number of species recorded as present. Within a Field

PLEC-BAG species richness and utility sample reporting form

A separate form should be used for each sample area surveyed. Forms for sample areas representing the same Field Type should be submitted together.

(1) DEMONSTRATION SITE: _____

(2) FIELD TYPE: _____ (3) LAND-USE STAGE: _____

(4) Field Type species richness: ____ (4a) Field Type utility index¹: _____

(4b) Number of 'useful' species²:
 food _____ construction ____ crafts _____
 medicine _____ commerce ____ other _____

(5) SAMPLE AREA number (and location)³: _____

(6) Sample area species richness: _____ (6a) Sample area utility index¹: ____

(6b) Useful spp.²:
 food _____ construction ____ crafts _____
 medicine _____ commerce ____ other _____

(7) PLOT number: _____ (8) Plot size: _____ (in metres)

(9) Date sampled: _____ (10) Plot data include⁴: _____

(11) Plot species richness: _____ (11a) Plot utility index¹: _____

(11b) Useful spp.²:
 food _____ construction ____ crafts _____
 medicine _____ commerce ____ other _____

(12) Number and size of NESTED SUB-PLOTS: _____

(13) Sub-plot data include⁴: _____ (14) Sub-plot species richness: _____

(14a) Sub-plot utility index¹: _____

(14b) Useful spp.²:
 food _____ construction ____ crafts _____
 medicine _____ commerce ____ other _____

¹ (4a), (6a), (11a), and (14a) refer to the percentage of total species identified as 'useful' (see text, section 5.1).

² (4b), (6b), (11b), and (14b) refer to the number of individual species identified as 'useful' within each category listed (see text, section 4.4).

³ Location information for (5) must be retained by the Cluster but need not be submitted.

⁴ (10) and (13) refer to the kind of vegetation tallied with the plot or sub-plot (e.g. woody stems > 1 cm diameter, or herbaceous plants, etc.)

Figure 1 PLEC-BAG species richness and utility sample reporting form

Type, species richness is the number of species present across all of the replicate plots. Within a Land-use Stage, species richness is the number of species present across all of the Field Types which the Land-use Stage contains. And for the demonstration site as a whole, species richness is simply the cumulative number of species across all Land-use Stages; in most cases this will be difficult to estimate because it is unlikely that Clusters will be able to comprehensively sample all Field Types within all Land-use Stages.

At each scale of analysis, the species utility index is simply defined as the percentage of species identified as 'useful.' Figure 1 is an example reporting form for species richness and utility statistics within a priority Field Type.

5.2 Similarity analysis

There are a number of 'similarity indices' used in the ecological literature. We have selected Sorenson's as the core similarity analysis for PLEC species diversity data within and among Field Types and Land-use Stages. We recommend using Sorenson's Similarity Index (on page 14) in three different ways:

- 1) to compare species composition data taken at different times in the same plot;
- 2) to compare species composition among replicate sample areas within a single Field Type;
- 3) to compare species composition among Field Types within a single Land-use Stage.

(A) Number of species in common among five house gardens at a Macapá demonstration site					
Sample area	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>
<u>1</u>	37	22	23	19	3
<u>2</u>		38	31	23	2
<u>3</u>			33	21	3
<u>4</u>				31	3
<u>5</u>					4
(B) Sorenson's Similarity Index for all pairwise comparisons among the five house gardens					
Sample area	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>
<u>1</u>	-	59%	66%	56%	15%
<u>2</u>		-	87%	65%	9%
<u>3</u>			-	66%	16%
<u>4</u>				-	17%
<u>5</u>					-
mean ± standard error = 46 ± 9%					

Figure 2 Example analysis of species similarity among sample areas within a single Field Type

- (A) Matrix illustrating the number of common species in all pairwise comparisons (bold values are total number of species within each sample area);
- (B) Matrix illustrating values of Sorenson's Index (S_s) for all pairwise comparisons calculated from data given in (A). Mean and standard error of Sorenson's Index for the set of ten pairwise comparisons are also provided.

The formula for Sorenson's Similarity Index (S_s) is as follows:

$$S_s = 2T_{c_{i&j}} / (T_i + T_j)$$

where: T_i and T_j = the number of species in sample units i and j , respectively,
and $T_{c_{i&j}}$ = the number of species common to sample units i and j

The result of the formula should be multiplied by 100 and reported as a per cent similarity value. For within-Field-Type analyses, all pairwise comparisons should be made, resulting in a similarity matrix and a mean similarity value (plus or minus a standard error) as illustrated in Figure 2. For between-Field-Type analyses, presence data from all replicates should be pooled for each Field Type prior to calculating the index.

5.3 Species-area curves

Species-area curves may be constructed for each Field Type by a stepwise calculation of cumulative species richness as data from each replicate plot are added to the total Field Type species richness (Figure 3). There are two reasons for using species-area curves: 1) to obtain information about the sufficiency of replication within a Field Type, and 2) to compare the species-area relationships of different Field Types, providing they were sampled using the same plot sizes. The species-area curve will 'flatten-out' when the number of replicate plots are sufficient to represent within-Field Type variation. Differences in the slope and inflection point of species-area curves can reflect differences in both total species richness between Field Types and in the distribution of species richness within them.

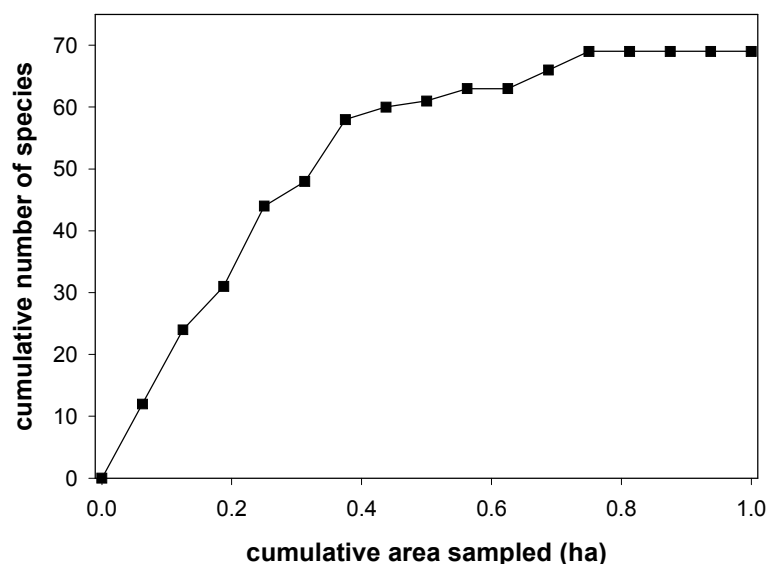


Figure 3 An example species area curve

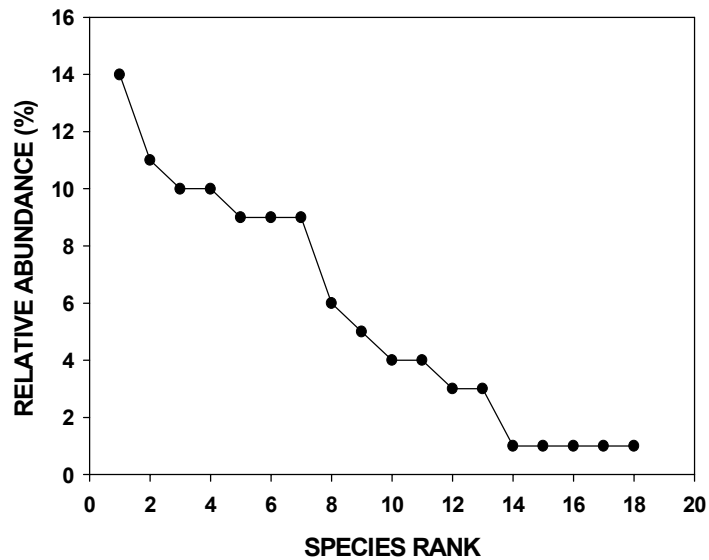
Based on data from sixteen 25 x 25 m plots sampled in an agricultural landscape in Ghana's southern forest-savanna ecotone. Each point represents one plot.

5.4 Abundance-diversity curves

Abundance-diversity curves are a means of graphically representing the relationship between species evenness and species richness in plots and Field Types. There are several steps involved in producing an abundance-diversity curve; these include:

- 1) ranking of species by their abundance values,
- 2) calculation of relative abundance values for each species, and
- 1) plotting the relative abundance values against the species ranks (Figure 4).

Differences in the slope and shape of the curve reflect differences in species richness and species evenness, and their relationship to one another.



sp. R.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	total	
Ab.	16	13	12	12	10	10	10	7	6	5	5	3	3	1	1	1	1	1	1	117
r. Ab.	14%	11%	10%	10%	9%	9%	9%	6%	5%	4%	4%	3%	3%	1%	1%	1%	1%	1%	1%	100%

Note: sp. R. = species rank (in order of abundance);
 Ab. = abundance of each species;
 r. Ab. = relative abundance of each species (Ab./total abundance)

Figure 4 An example abundance-diversity curve

Based on data from a 20 x 20 m native forest plot in a nature reserve forest at a Yunnan demonstration site (Guo et al. 1998)

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GUIDELINES ON AGRODIVERSITY ASSESSMENT IN DEMONSTRATION SITE AREAS (REVISED TO FORM A COMPANION PAPER TO THE BAG GUIDELINES)

Harold Brookfield¹, Michael Stocking² and Muriel Brookfield¹

GENERAL ISSUES

PLEC has to provide basic data on both agrodiversity and agro-biodiversity by December 1999. But this is not the end of the job. As with agro-biodiversity, recording agrodiversity is not something that can be done once, and then set aside. PLEC works with farmers who practise agrodiversity. Recording is our means of acquiring a thorough knowledge of practices in the demonstration sites, and identifying innovative practices and innovative farmers. Information on agrodiversity will continuously be refined and revised. The effect of seasonal and inter-annual changes will only become fully apparent over the whole project period. Partly through PLEC activities, practices may change. Thus the whole four years' work on both agrodiversity and plant-species diversity will have a place in the final Cluster and Project reports, and in the planning of follow-up work.

A document on this topic was first circulated in July 1998.³ This revision follows completion of the guidelines on Plant Species Diversity by Zarin, Guo and Enu-Kwesi.⁴ The purpose is to bring work on agro-biodiversity and agrodiversity into one context. **The two jobs are best thought of as two dimensions of the one job.** There is one central task that is common to both: the determination by observation and in-field collaboration with farmers of (a) the larger '**Land-use Stages**' or types at landscape level and (b) the finer detail of '**Field Types**' at site level. In this revision, we first define 'agrodiversity', then begin with the basic task that is common to analysis of both agrodiversity and agro-biodiversity.

Acknowledgement

We are grateful to Christine Padoch for a large number of suggestions on drafts at each stage; these are taken into account in this presentation.

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³ H. Brookfield and M. Stocking 1998. 'Agrodiversity in demonstration site areas: guidelines for description, analysis and the making of a database'. Tokyo, United Nations University, Ms.

⁴ D.J. Zarin, Guo Huijun, L. Enu-Kwesi, 1999 'Methods for the assessment of plant species diversity in complex agricultural landscapes: guidelines for data collection and analysis from the PLEC Biodiversity Advisory Group (PLEC-BAG). *PLEC News and Views* 13: 3–16.

AGRODIVERSITY

1. DEFINITION OF AGRODIVERSITY

Although sometimes used interchangeably, the words 'agrodiversity' and 'agro-biodiversity' have distinct meanings. 'Agro-biodiversity', much the older term, has generally been a shorthand for biological diversity on lands used for agricultural purposes. From within PLEC, Brookfield and Padoch (1994: 9) defined agrodiversity as *'the many ways in which farmers use the natural diversity of the environment for production, including not only their choice of crops but also their management of land, water, and biota as a whole'*. Independently, agricultural scientists Almekinders, Fresco and Struik (1995:128) wrote of agrodiversity in arable systems as resulting from *the interaction between plant genetic resources, the abiotic and biotic environments, and management practices*. They define it as *'the variation resulting from the interaction between the factors that determine the agro-ecosystems'*. Both definitions are applicable to work in PLEC. Resource management in detail is central to both.⁵

For PLEC, agro-biodiversity is a subset of agrodiversity. The relationship is set out below. Agro-biodiversity recording and measurement is currently the most sensitive area in terms of international scientific visibility, but it is closely related to diversity in resource management. Both are related to the natural bio-physical diversity stressed by Almekinders, Fresco and Struik, and to the manner in which farming operations are organized by the people.

THE COMMON CENTRAL TASK

2. LAND-USE STAGES (OR TYPES) AND FIELD TYPES

It is next important to define the two principal terms used, both in this paper and in the companion plant-diversity paper, as the elements of managed and unmanaged landscape that are basic to sampling and description. In the companion paper the task of definition, especially of 'Field Types', is left to us. Field Types are therefore discussed in greater detail.

2.1 Land-use Stages

Land-use Stages are areas of broadly common ecology, land-use (or its absence), and especially recent land-use history. Without detailed inventory, they look like one class of land use, with one class of land cover. They may be large, or small. We use the term Land-use Stages from the companion biodiversity paper, but they are roughly comparable with the land-utilization 'types' discussed in the FAO Land Evaluation literature.⁶ The FAO methodology does

⁵ H. Brookfield and C. Padoch 1994 'Appreciating agrodiversity: a look at the dynamics and diversity of indigenous farming systems', *Environment* 36(5): 6-11; 36-45. Almekinders C. J. M., L.O. Fresco and P.C. Struik 1995 'The need to study and manage variation in agro-ecosystems', *Netherlands Journal of Agricultural Science* 43: 127-142.

⁶ FAO 1976 *A framework for land evaluation*. Soils Bulletin 32. Rome: FAO. FAO 1983 *Guidelines: land evaluation for rainfed agriculture*. Soils Bulletin 52. FAO: Rome. FAO (1983: 26) sets out a useful table of headings for describing Land-utilization Types broadly comparable with our 'Land-use Stages', plus some suggestions for descriptive and semi-analytical quantification.

not have the same purpose as ours, but it is an attempt to grapple with the same order of complexity. Some parts of PLEC may find it useful.

Even where a land-use map is available, or can be generated from remote sensing imagery or photographs, transects in the company of farmers are an essential early step in the identification of Land-use Stages. Whether large or small, they should be recognized at a landscape scale, broadly at a map scale of about 1:25,000-50,000. In the companion paper by Zarin, Guo and Enu-Kwesi, examples given are fields under annual [or semi-annual or longer-than-annual] crops, agroforests, fallows, orchards [including fuel-wood plots and cash-crop plantations], native forests, house gardens, and the 'edges' between different types.

They are the primary sampling units for inventory of plant species, and they are the basic 'landscape level' units for the analysis of agrodiversity. The Biodiversity Advisory Group uses the term 'stages' so as to emphasize how one land-use type can become converted into another, both by successional processes and by farmers' own action. Over the four years of PLEC, stage transitions will probably be observed in all study areas.

2.2 Field Types

The distinction between Land-use Stages and the usually smaller **Field Types** is that the latter are specifically defined by farmers' practices, and not just by observation. This is the level of detail which farmers themselves recognize. **Field Types are assemblages of individual fields, managed sections of fallow or forest, agroforests and orchards, in which a similar characteristic set of useful plants is encountered, and in which resource management methods have strong similarity.**

PLEC's recording should follow the farmers' own categories for management of diversity. Although each individual field is different, there is often considerable similarity over quite a large area. Commonly, farmers develop specific sets of Field Types, in each of which they use similar management methods, and grow similar sets or combinations of crops.⁷ There may be only one, or a large number, of Field Types within each Land-use Stage.

In some systems, these Field Types shift across the landscape from year to year. At a village in Amazonian Peru, Christine Padoch and Wil de Jong identified what they described as 12 distinct farming systems in one small community in the Peruvian Amazon, and 39 ways of combining the twelve production types were found among 46 households in 1985. Many had changed these combinations in the following year. These farmers were using the dynamic environment of a shifting flood plain, as well as the dry land above it.⁸ The 12 distinct farming systems would seem to correspond with what BAG and the authors of this paper would describe as 'Field Types'.

Where land rotation is practised, formerly cropped fields leave behind them successional ('fallow') management types from which crop plants are still taken, and which may themselves be

⁷ In a pioneer study of an African system, still of value despite its age, de Schlippe (1956 *Shifting cultivation in Africa: the Zande system of agriculture*, pp. 117-18) speculated as follows on how such Field Types arose: 'Theoretically, one could think of thousands of different ways in which the great number of crops and varieties and the astonishing mosaic of soil-vegetation types could be combined into field types. In practice one discovers, however, that field types are few and that it is always the same field types that are repeated by all members of the group'.

⁸ C. Padoch and W. de Jong 1992 'Diversity, variation, and change in ribereño agriculture'. In K.H. Redford and C. Padoch (eds) *Conservation of neotropical forests: working from traditional resource use*, pp. 158-174. New York: Columbia University Press.

planted, and in which the succession may be managed. They constitute a further set of 'Field Types'.⁹

In systems where stage transitions take place infrequently, the Field Types are more permanent, and are often grouped within areas of broadly similar ecology. An illustration is the intensively cultivated and manured infield, versus the more extensively used outfield, common in the savanna regions of Africa and most sharply represented within PLEC in the Fouta Djallon of Guinea.

Another example is the division of land between:

- seasonally irrigated terraced or ponded fields;
- wet fields fed only by rainfall;
- dry fields which are alternately cropped and fallowed;
- planted and managed agro-forests;
- very mixed home gardens.

This repeated pattern of just five main types is commonly found in Yunnan, and widely across southeastern Asia.

Fields also have 'edges', whether separating fields of different type or of the same type. At the field level, the edges may have a specific management role, as well as a distinctive plant ecology. Thus live hedgerows and the risers separating terraces are 'edges'. They may have a role in soil and water management as well as being used to provide or grow distinctive useful plants; some of these have the additional functions of fertility management or soil stabilization. At the most micro-level, 'edges' also include trash lines, small stone walls or small wooden fences. While not all these smaller features are significant from the point of view of plant biodiversity, they are significant from the point of view of resource management.

Field Types, bringing together crop selection and resource management in distinctive ways, often arise in response to specific ecological conditions. While specific ecological niches may be used in specialized ways, these ways tend to be repeated over a large area. Field Types are also the means by which farmers most effectively mobilize their labour and allocate their resources. In many areas of the world, the basic reason why repeated patterns of Field Types come into existence would seem to be that they simplify work routines, and the problems of daily decision-making.

Notwithstanding the enormous internal diversity of cropping patterns, it is quite common to find the land used under only a small number of basic management systems, even across significantly different ecological zones. To recognize them necessitates not only repeated observation, but also the cooperation of the best and most alert farmers. It is easy for observers not trained to look for micro-features in the managed landscape to miss a great deal of relevant detail.

⁹ The February 1999 progress report from the Amazonia Cluster contains a classification of fallows at Amapá, where they are of major importance as production spaces. Five types are distinguished: (1) fallows in which vegetation is dominated by bananas, planted during the field stage and then managed in an agroforestry pattern to control losses from disease; (2) fallows dominated by açai palms, planted, broadcast or naturally regenerated, and managed by protection for commercially-valuable fruits and palm hearts; (3) fallows in which the plant community is dominated by timber species that were protected or planted during the field stage, and are harvested as timber; (4) fallows in which the vegetation is dominated by fruit species that were planted or protected during the field stage; (5) fallows in which vegetation was not managed or enriched during the field stage, dominated by vines, shrubs and trees, and destined to become new field sites.

STEPS TOWARD ANALYSIS

3. THE ELEMENTS OF AGRODIVERSITY¹⁰

Field Type classification is only the beginning. In order to understand and analyse agrodiversity, PLEC has to find ways of codifying enormous complexity. The start we propose is to codify agrodiversity itself, and among several possible ways we suggest first classifying it into just four main elements, all of which overlap and are interrelated.

3.1 The main elements

Focusing on what we find at Field Type level, there are two core elements:

3.1.1 *Management diversity*

This includes all methods of managing the land, water and biota for crop production and the maintenance of soil fertility and structure. Biological, chemical and physical methods of management are included, but they overlap. Some biological management, such as the reservation of forest for watershed protection, or the planting of live hedges, has direct physical consequences. Local knowledge, constantly modified by new information, is the foundation of this management diversity;

3.1.2 *Agro-biodiversity*

This has been defined within PLEC as '*management and direct use of biological species, including all crops, semi-domesticates and wild species*'.¹¹ It embraces all crops and other plants used by or useful to people and, by also involving biota having only indirect value to people, it cannot be sharply distinguished from total plant biodiversity. Particularly important is the diversity of crop combinations, and the manner in which these are used to sustain or increase production, reduce risk, and enhance conservation. Agro-biodiversity is not discussed in this paper, and reference should be made to the companion paper by Zarin, Guo and Enu-Kwesi.

Around these are two elements that explain how and why agro-biodiversity and management diversity arise. These are:

3.1.3 *Bio-physical diversity*

This includes soil characteristics and their productivity, the biodiversity of natural (or spontaneous) plant life, and of the soil biota. It takes account of both physical and chemical aspects of the soil, surface and near surface physical and biological processes, hydrology and micro-climate, and also variability and variation in all these elements. Farmers select among this diversity and they often manipulate it quite substantially. Sometimes this

¹⁰ The better to serve our purpose of linking the two papers, the order of presentation of these elements differs from that given in our 1998 paper, and in H. Brookfield and M. Stocking 1999 'Agrodiversity: definition, description and design', *Global Environmental Change* 9 : 77-80.

¹¹ Guo Huijun, Dao Zhiling and H. Brookfield 1996 'Agrodiversity and biodiversity on the ground and among the people: methodology from Yunnan', *PLEC News and Views* 6 : 14-22, at p. 15.

management goes to the extent of 'manufacturing' soils, and remodelling the landscape, as through terracing;

3.1.4 Organizational diversity

Often called the 'socio-economic aspects', this category includes diversity in the manner in which farms are owned and operated, and in the use of resource endowments. It underpins and helps explain how and why agro-biodiversity and management diversity vary between particular farms. Explanatory elements include labour, household size, the differing resource endowment of households, and reliance on off-farm employment. Also included are age-group and gender relations in farm work, dependence on the farm as against external sources of support, the spatial distribution of the farm, and differentials between farmers in access to land. Land tenure, and whatever rules or arrangements the community has to manage land tenure, and disputes, are therefore important elements.

Beyond all these are regional demographic trends, the market economy, and the political system. These frame the conditions under which farmers take decisions.

These categories are used throughout this document. Running through all of them is the dynamism of the **systems through time**. For the purposes of field observation by PLEC, we can crudely distinguish two main time scales:

- (A) *Short-term (inter- and intra-seasonal) sequential diversity* in farmers' decision-making on use of land, labour, capital and other farming resources, and in the security or risk of the harvest. The time scale is from months to a short sequence of years;
- (B) *Longer-term change in cropping and management practices*, in response to environmental, demographic, social, economic or political change. This includes shifts through time in cropping patterns, land-use allocation, and reliance on different income sources. These changes occur as soils and biota are modified by use and natural processes, as self-provisioning gives way to commercial production, new crops are adopted and others discarded, new practices are taken into the system and others neglected. The time scale is from a few years to many decades.

The shorter-term changes can be observed within the three remaining years of PLEC, and for this reason (and others) it is essential that work be done in different seasons through the year, in order that 'short-term sequential diversity' can be established. The same sort of observation and recording schedule is required as for plant diversity. It will usually only be possible to record longer-term change through investigation into land-use history, but farmers often make changes in their systems 'incrementally', cultivating the land while introducing new practices over a period of years.¹² While in progress, incremental change is hard to observe, but farmers can usefully be asked their intentions, as well as the history of their land.

3.2 Interrelation of the elements

No part of the scheme described above is separate from the others. This interrelationship of the different elements is centrally important for understanding, and for derivation of principles of diversity management. Bio-physical diversity can be viewed at almost any meaningful scale. At a

¹² W.E. Doolittle 1984 'Agricultural change as an incremental process', *Annals of the Association of American Geographers* 74: 124-137.

'landscape' scale, it is a major element in the widely-repeated manner in which farms are structured to allocate land of different intrinsic qualities so that all or most households have access to each. This is one way in which organizational diversity is directly related to bio-physical diversity. At a finer degree of resolution, bio-physical diversity can arise within a single field, where a crop will yield differently in separate parts of the field, whether in all years, or in years with drier or wetter climatic conditions better suiting one or other part of the field. The association of crops in an intercropped field may often show subtle differences related to natural conditions. Here there is a relationship between agro-biodiversity and bio-physical diversity.

In another frame of analysis, crop choice often differs between better-off and poorer farmers. There are many other differences, for example in use of livestock and their manure, and of purchased inputs. The type of conservation practices adopted is strongly influenced by the resources available to different groups of farmers, thus affecting the pattern of management diversity, and feeding back to enlarge the differentials in natural land quality. Thus all elements of agrodiversity, agro-biodiversity included, are indeed interrelated, and none can be considered without taking each of the others also into account. This becomes of major importance in writing up the results of observation and description.

RECORDING

4. RECORDING DIVERSITY WITHIN THE ELEMENTS

Once the sampling or selection frame, in the form of identification of 'Land-use Stages' and especially of 'Field Types', is done sufficiently for detailed work to begin, PLEC needs to seek a range of information. Discussion of what is needed can best be classified within the four elements of agrodiversity discussed above. This review is followed by a brief discussion of analysis and presentation, and then by a check list to assist recording of data in selected or sampled fields (the 'site'), and on the organizational diversity of the farming households which operate these fields. The most important elements in using whatever recording design is most appropriate to the area are (1) to be logical and consistent, and (2) to be able to relate detailed work in the fields to the characteristics of Field Types and Land-use Stages at the landscape level.¹³

Ultimately, sketch maps for Cluster use, at different scales according to the amount of detail investigated, might show:

- topography, drainage; areas having similar vegetation;
- all farmed land and, where feasible, Land-use Stages and Field Types characterized by similar forms of management and cropping patterns;
- settlements and roads;
- the outline of any area (or areas) studied and mapped in greater detail;
- the position of biodiversity-inventory sample quadrats, and soil-sample sites.

This needs to be complemented by description, and by the background material discussed above, for the population of the whole landscape area. Site maps, covering a much smaller area or

¹³ When we write of landscape level, we are writing of an area usually occupying several square kilometres; site level means a much smaller area. Appropriate map scales would vary greatly from area to area, but for the landscape may be in the range of 1:25,000-50,000, and for the site from 1:5,000-7,500. Particular areas within the site may need to be sketch-mapped at a larger scale.

areas, need to carry greater detail, but we advise that for publication purposes beyond the project, the actual location of the sites be shown only in an imprecise manner.

4.1 Selection of sample fields; looking for the unusual

The parallel biodiversity paper distinguishes between random sampling, on which it insists only for 'native forest', and biased sampling. The latter is appropriate in all other Land-use Stages if PLEC seeks data representative of the most productive or species-rich examples within a Field Type. With 'management diversity' as well as 'agro-biodiversity' in mind, we introduce a further reason for biased sampling. PLEC seeks 'expert farmers' with whom to work in its demonstration sites. These are 'farmers who put their expertise into patterns that combine superior production with preservation or even enhancement of biological diversity in their fields'.¹⁴ It is not easy to identify such farmers, but a good place to do so is in the fields themselves. We are certainly concerned with what the generality of farmers do, but PLEC also needs to look for the unusual and innovative in resource-management techniques, to sample such fields where they are found, and get to know the expert farmers. Searching for the unusual needs sharp eyes, and good guidance.

One way of selecting sample fields within a Land-use Stage or Field Type could be walking and briefly recording diversity along intersecting short transects designed to take different Field Types into account. Field workers need frequently to stop if important detail is not to be missed. Neither biodiversity nor management diversity should ever be studied from a moving vehicle, and neither task can be hurried. A lot of information arises from careful observation, and from in-field discussion with farmers. It is important also to ensure that fields are chosen to be representative of each Field Type. It is in this process that Field Types are likely to be subdivided, as described in the companion biodiversity paper.

Recording of management diversity in sample fields can accompany the recording of biodiversity within the cultivated and fallow areas. Especially if two or more field workers are present together, work on management diversity of selected fields can be combined with biodiversity inventory in the quadrats. **The whole field and its edges, not the quadrat, is the appropriate unit for recording management methods**, but the tasks can nevertheless be conducted at the same time, thus minimizing interference with the normal activities of cooperating farmers. The owner or tenant of the field should always be present, and his/her name recorded in order to cross-check with the data obtained on organizational diversity.

4.2 Recording organizational diversity

Organizational diversity differs from the other elements in that it cannot be recorded except at the level of whole farms, compared with one another. Farm layout is an element potentially capable of being mapped, but recording of other aspects calls for repeated discussion with farmers; so far as is possible we advise against formal interviews with farmers whom PLEC grows to know well. Investigations of the variable resource endowment among farm households need to begin at community level. If the Amazonian model of selecting 'expert farmers' as primary partners in

¹⁴ C. Padoch and M. Pinedo-Vásquez 1998 'Demonstrating PLEC: a diversity of approaches', *PLEC News and Views* 11: 7-9, quotation at p.8.

demonstration site work is not followed, sample (or 'contact') farmers should only be selected after classes of farmers having different resource endowments have been determined.¹⁵

Land tenure can be a particularly important variable, as it can have important consequences for land management and agro-biodiversity. The conditions of land tenure should be carefully recorded.

These data should be complemented by information on the population of the landscape area, including its demography, migration history, form of social organization, and arrangements for marketing of produce. In turn, this nests into wider-area information on the regional and national economies, policies and political forces. In most parts of PLEC this background work has already been done.

4.3 Recording findings: different ways

One basic way of recording diversity would be to prepare a matrix in which different sampled fields within Field Types are each treated as units within each of which particular methods, and crops, can be simply recorded by their presence or absence. Such a matrix can be prepared in note form in the field then transferred to a data-organizing system among which the simplest to use is probably an Excel Workbook. This could directly yield statistically measurable input into a database.¹⁶ An additional valuable way would be to use a roughly surveyed map, where areas can be measured and data on one aspect can be compared with another using GIS. Both methods have problems of which the field workers need to be aware.

Tabulated data can readily over-simplify complexity. Data tabulated or presented on maps have to be divided into classes, creating a false impression of uniformity over tracts of land sharply distinguished from other tracts of land. The sample quadrats used for biodiversity inventory are free from these problems, but they are not appropriate for analysis of management diversity, where the unit should be the field. Data obtained only from within or close to quadrats may omit important features which lie outside their limits, but have a role in relation to what is observed within them.

Data on organizational diversity need to be related to the observation and recording in the fields. Fields therefore need to be given numbers, related to the numbers given to the farms. We do not suggest that all the fields of any farm need to be sampled, but it may be important to record the number of Field Types that are represented within a selection of farms. Such a selection should include farms of the 'expert farmers' who are identified, but it should also include farms of both well-to-do and poorer farmers. One constraint to diffusion of good practices would thus be identified. Any 'wealth ranking' of farmers is therefore a job that needs to be done at an early stage in the work.

¹⁵ Methods of evaluating the resource endowment of farm households, and of differentiating farm households by their resource endowment, have a large literature, surrounded by some controversy. The topic is one for separate discussion. PLEC advocates the Amazonian model in which selection focuses on 'expert farmers' who farm and conserve best, are the most imaginatively experimental and innovative, and can teach others. Although all PLEC's farmers are small farmers, not all are equal. Where there are large differences between richer and poorer farmers, some ranking is desirable. Suitable reference material can be made available from the Canberra office of PLEC.

¹⁶ The 37 diagnostic variables among the management practices of mainly root-crop farmers, used by one PLEC group, provide an example of the type of descriptive data that can be recorded in this way, though their recording was at a small map scale (1:500,000). See B. J. Allen, R. M. Bourke and R. Hide 1995 'Agricultural systems in the Papua New Guinea project: approaches and methods', *PLEC News and Views* 5: 16-25.

A database can only be a partial product of the whole work, and a range of ways of presenting agrodiversity is necessary. It is probable that different combinations of methods will best suit the several Cluster areas and their demonstration sites. What is presented here is only one way of going forward. The information discussed below is needed for work at the site level of particular fields and farms. It is simplest to present it below in check-list form.

ANALYSIS

5. ANALYSIS AND DISCUSSION OF FINDINGS

The different elements of agrodiversity (agro-biodiversity included) need to be explained in relation to one another, and used in relation to one another in further work with the farmers. Statistical measures of diversity are an end-product of biodiversity analysis, but have few parallels in dealing with agrodiversity. It will certainly be valuable to obtain measures of crop-plant diversity, and it will be of particular significance to obtain these at the level of local (or 'landrace') varieties.¹⁷ Elements of the bio-physical environment such as soil fertility, and of the comparative status of farming households, can be reduced to simple statistics.¹⁸ But the core of agrodiversity lies in management, and no statistical indices yet exist for the analysis of resource management practices. Here we are dealing with what is technically called 'non-numerical unstructured data'. There is a range of computer routines for dealing with data of this nature, indexing them and finding structure within them, but some are very consuming of computer space.¹⁹

For reporting, the results of agrodiversity analysis need to be presented in such a way as to exhibit the depth of variation present, but without overwhelming the reader with detail. It will usually be best to determine, before writing, what are the main organizing principles in the situation described. This means usually placing the results in a regional or national context, and in the context of the driving forces of change in the recent history of the area.

For example, an area might only have been settled by its present people, after moves from elsewhere, within the past 50 years; PLEC has few demonstration sites in which there is a continuous record of occupation of the same site by the same people, extending over two or more centuries. There may have been major changes in economy and politics during the lifetime of people still active, impacting the nature of decision-making, and very importantly the conditions of land tenure. Whether by natural growth or by immigration, or both, there may have been a major increase in population. Cash production, and other forms of commerce, may have become dominant only in recent years. There may have been important environmental changes due to

¹⁷ A good example, although not one in which data are stratified by field type, appears in *PLEC News and Views* 12, in a paper by Fu Yongneng and Chen Aiguo (1999) entitled 'Diversity of upland rice, and of wild vegetables, in Baka, Xishuangbanna, Yunnan'.

¹⁸ An example, in which data were collected and analysed by members of the East Africa Cluster, is set out in Tengberg, A., J. Ellis-Jones, R. Kiome and M. Stocking 1998 'Applying the concept of agrodiversity to indigenous soil and water conservation practices in eastern Kenya', *Agriculture, Ecosystems and Environment* 70: 259-272.

¹⁹ We will be investigating some of these routines as applied to resource management, and if one or more seem sufficiently promising, and sufficiently user-friendly, Clusters will be informed by distribution of information and through *PLEC News and Views*. At this stage, we are not likely to be recommending them for wide adoption in PLEC's Clusters; the use of any such methods would require that all data be entered into computers at the time of collection.

shifting rivers, soil degradation or rapid recent deforestation. Whatever is most relevant should be the 'peg' on which discussion hangs, and around which data presentation can be focused.

The same considerations which affect land use also affect agro-biodiversity. The 'explanatory' elements of agrodiversity discussed in this paper are also explanatory elements of agro-biodiversity. There is no one single formula for all areas. We suggest that, in reporting before final writing, Clusters 'try out' various ideas on the best ways in which to organize presentation of their data on agrodiversity. Scientific coordinators will be ready to comment, and offer advice. The job of reporting is an iterative one. It begins with the presentation of data. As work goes forward, and as the researchers and the farmers gain increased familiarity with the aims and interests of one another, the data will improve. It will then become easier to interpret the data, both for presentation and most importantly in order to design further work with farmers.

* * * * *

AN AGRODIVERSITY CHECK-LIST

What follows is a suggested check-list only, for use in sampled or studied fields within Field Types, and for recording the organizational diversity of the farms operating these fields. Its purpose is to help ensure that comparable data are collected. Not all of it will be applicable in all areas, and other items will need to be recorded in some areas. The main common requirement is that information should be collected and recorded under each heading (**bolded**) within each category of agrodiversity, to enable early identification of what is important and identification of aspects that are worth investigating further. We suggest that if you are creating a presence/absence matrix you use these categories. The list outlined below is presented in smaller type, to stress its indicative nature.

PART A. MANAGEMENT DIVERSITY

The unit is the whole field and its edges, not any agro-biodiversity quadrat within it. Because chosen fields are representative of Field Types, it is important to look also at the environs of the selected fields in order to ensure that nothing of importance has been missed. Similar, but not identical, lists would apply to information needed for sampled agroforests and home gardens, and their edges.

Site preparation

Includes: tree-felling, slashing, burning (whole field, patches, debris only), clearance of preceding crop, ploughing of whole site ahead of any planting.

Methods of field-surface preparation

Includes: holing, tilling, mounding, ridging, and all other ways of preparing the ground for planting. Tools used. If mounding, ditching, burying of compost or of cut or uncut grass are practised, measurement of mound height, ditch depth, and cover depth. N.B. observations need to be made at the time land is being prepared for the crop.

Major land management

Includes: construction of terraces, walls, with details of height, construction material and method, slope of terraced land. This also includes drainage and irrigation extending over substantial areas. It overlaps with bio-physical diversity in that the 'manufactured soils' that are produced are products of major land management. (*Diagrams can be an important method of additional record*).

Minor land management and soil/ water retention

Small slope retention devices, of wood, stone or earth, within the field or on edges. The planting of soil-retention crops on steep patches. Soil drains are a feature of minor land management. Barriers such as grass strips, soil/ trash lines, log lines, stone lines, contour ridging, live barriers along the contour, soil-retention fences, etc. Important: dimensions, spacing, length of life, and replacement. Note whether they are traditional (meaning not recent introductions) or modern.

Planting material

For seed: source (own farm, other farmers, bought or supplied). For non-seed plants: nature of planting material, source as above. Planting methods: (dibbled, sown in rows, inserted in holes, broadcast, transplanted). Note any volunteer crops that arise spontaneously without planting. Crop varieties where relevant: note local names for varieties, and list distinguishing characteristics.

Cropping patterns and rotations (to supplement information obtained in agro-biodiversity quadrats)

Monocrop or intercrop (note main crops and their planting schedules – all together, early, late). In order to supply an indication of crop rotations/sequences, record the previous season's crops and intended next season's crops. Crop-plant spacing (along and between rows); densities. Distinguish planting around or on field edges, and plot edges.

Weeds and weeding

Weeds: severity of infestation, effect on yield, recent/invasive. Most serious weeds. Frequency of weeding, method (manual, hoes, chemical, other), time taken to weed one field. Proportion of weeds not removed (if any). (Note separately weeding methods in agroforest plots and in home gardens).

Pests and diseases, predators

Principal pests, within soil, on surface, birds. Severity of pest infestation. Farmer's methods of control. Disease problems: nature, recency, severity, farmers' methods of control, if any. Predators: if a problem, methods of protection.

Harvest, processing and storage

Time of harvesting of different crops, both those harvested at one time, and those taken as needed. Methods of harvest. Labour requirement. For grains, note if threshed in field or at home. For any crop, post-harvest processing, place and method of storage.

Livestock (see also under *Organizational Diversity*)

Note if livestock are tethered in the field or on edges, or if allowed freely into the field at any stage.

Soil fertility maintenance (important to note farmer's assessment of fertility of local soils, and effect of different crops in depleting soils)

Methods include: Fertilizers: type, quantity, method, timing. Compost: content, how made, quantity, timing. Mulch: sources, quantity, timing (note effect on pests). Use of nitrogen fixing plants in intercrops, rotations, quasi-rotations, agroforestry patterns (overlaps with recording of agro-biodiversity, but needs separate note where it is a conscious management practice).

Woodlot management

Includes: species grown; management (weeding, coppicing, felling), frequency of harvest. Presence or absence of any intercropped useful plants (See also under *Organizational Diversity*).

Fallow management (agronomic aspects)

Farmer's management of fallow: enrichment planting, weeding, slashing, elimination of unwanted species, harvesting of useful products, trapping and hunting wildlife (*This aspect of management is very important in some of PLEC's areas*).

Management aspects of otherwise unused land ('native forest')

Includes: reservation of forest for watershed protection, sacred groves, burial places, use for trapping and hunting wildlife and harvesting of useful products, including wild vegetables and wood.

PART B: BIO-PHYSICAL DIVERSITY

The unit where measurement is required is the whole sampled or selected field and its edges, but it is important also to obtain observational data (only) from the whole landscape area within which Field Types are identified.

Physical features (whole landscape-level area)

Includes: the whole area of the studied tract of land; altitudinal range; types of landforms (plateau, scarp, valley floor, rock outcrops, etc). Slope: % steep, medium, low, flat. Note any flood-prone areas (normal/exceptional), swamp.

Physical features (sampled field)

Note area, dimensions, altitude, slope, degree of modification by farmers (*from Management Diversity*).

Soils – Samples to be taken in sampled or selected fields within each Field Type, best at points used for biodiversity inventory. Should extend down to at least the base of the topsoil. For each sample site:

Assessment in field: Soil type – local name [correlate with FAO/ UNESCO, Soil Taxonomy and/ or national survey classification later]; soil texture - local descriptors; soil depth: both topsoil and subsoil; physical properties - e.g. hard when dry; stony; drainage and infiltration - poor, imperfect, good (note seasonal differences); workability - good, poor (note seasonal differences); colour - description, correlate with Mansell Colour chart; local assessment of relative fertility and associated indicators; other definable field characteristics (e.g. micro- and macro- fauna). Test infiltration rate.

For later laboratory assessment, a minimum list: Soil texture; soil chemical fertility status: cations Ca, K, Mg, Na - total N and available P; pH; base saturation; cation exchange capacity; organic matter status: per cent; C/N ratio; soil physical status: bulk density; available water storage capacity.

Erosion, degradation: Note evidence of sheet erosion: micro-pedestals; tree mounds and plant root exposure; in-field bare patches; poor crop growth; soil accumulations against trees, fences, other barriers; armour layer (small surface stones); rills and gullies - dimensions, spacing; evidence of recent soil losses; other *in situ* soil degradation: surface crusting, waterlogging, salinity, sodicity etc. Landslips, landslides and major earth movement.

Manufactured soils: Within the above, some soils are greatly modified by human use. They include soils that have been heavily manured or composted over a long time, with deeper surface horizons, usually higher pH and more available P, and soils created behind terrace walls. The fact of human modification emerges from information and observation. The characteristics to be examined for each sample taken are the same as above.

Micro-climates

Check whether farmers are aware of specific contrasts in micro-climate between different parts of their land, or of the whole landscape-level area.

PART C ORGANIZATIONAL DIVERSITY

The unit is each whole farm within which PLEC work is undertaken. Organizational aspects at community level are also important, for example in arrangements for resolving land tenure disputes, or managing incursions into the land of others, for fuel-wood or useful plants. The nature of these arrangements differs greatly between areas, and no check-list is offered.

The list is to help ensure that information obtained on farms is comparable and complete. **This is not a design for any sort of formal questionnaire.**

A few **census-type questions** need to be asked. For the farmer, male or female, and for other adults present they include: name; age; sex, born here or elsewhere. For the farmer, is he/she head of household. If a migrant, from where, when. Years of education. Number of children, age and sex, present/absent.

(This basic information can be enlarged. Those with appropriate social science training may find it valuable to set out the relationships of household members in diagrammatic form).

Other topics for record have more to do with the farm

Land tenure: Farmer (M/F). ownership history of the farm. If the land has been subdivided, when, and approximate area of subdivisions.

Tenancy, formal and informal: If the farmer is a tenant, note if a share of crop is used for rent. Note use by any other household of part of this farm, with details of any crop share received. Check whether farmer/farmer's household uses any part of another household's land, with details.

Crop and tree ownership: Any allocations to particular household members for their use (note particularly M/F allocations). Note if any trees belong to someone who is not a member of the household, and if this farm household, or its members, own trees that are not on their land, with details.

Land-use history (note that information on this topic is unlikely to emerge in a single conversation, and is likely only to come forth over long time). Topics for investigation: Length of time the farm has been in existence; the earlier history of the land; the main changes in land use/crops during the farmer's lifetime; land degradation, if any, during this time.

Land-use intentions (as with the previous question this is not a topic on which information is likely to emerge in a single conversation). The farmer's intentions for the future use of his/her land, both in the short term of the coming two years, and over a longer period.

Livestock Details of livestock, large and small, that the household owns. How the livestock are fed. The products that the livestock contribute, and where they are housed at night (*This question has cross-cutting relevance also to Management Diversity*).

Off-farm employment (*This is important in relation to farmers' commitment*). Check what members of the household have worked elsewhere during the last year and how much time they have spent away. From this follow questions of how much the farm household depends on off-farm income. (*Specific topics are not listed, as this is a very open-ended area*).

Food security Ascertain whether the farm provides most (say, two-thirds or more) of the household food supply during the year, and if not, how much. Check if there is a part of the year during which the farm does not provide sufficient food. If there is a bad season, and a crop fails, what does the household do?

Water Note if there is an adequate supply of water within easy reach and, if not, how far away is the collection point. The source of water: piped supply, wells, streams, tanks, other. Reliability of the water supply, and if it ever gets polluted or contaminated.

Fuel-wood (see also *Management Diversity*). Ascertain if the household has access to adequate supplies of fuel-wood from its own land or community land. Ascertain if a part of fuel-wood needs has to be met from 'native forest' including reserved forest areas.

Labour supply (*This important aspect needs to be explored over time*). Contributions of the family to labour on the farm; age-group and sex of the contributors. Tasks done only by adult men; done only by women; also done by children. Details of any hired labour, and the season and work entailed. Check whether there is cooperation between farms for specific tasks.

Transport Note any transport used to get to/from the fields, and of what type (include animals). Time taken to get to the furthest fields; distance from the farm to the nearest road. Record if the household owns its own pack animals, any bicycles, carts, motor cycles, wheeled vehicles.

Marketing The distance to the nearest (or most used) market; availability of transport to get produce to the market. Details of what is sold in the market, who does the marketing, and how often. Note if anything is sold directly from the farm.

To assist in interpretation, it may be useful to have a final check-list of farmers' views on constraints to their farm productivity which are outside their control. Many will have views on these topics. Perceived problems may include: lack of capital; need to borrow money at high cost; lack of security of land tenure; too little land; not enough good land; declining quality of land; lack of sufficient water; lack of sufficient livestock; inadequate supply of labour; poor marketing facilities; too many people (overpopulation); lack of community support, poor community spirit; too much intervention from the authorities; insufficient support from the authorities; pricing policies to the disadvantage of farmers.

Final note

The above is not an exhaustive list. Much else could be added. But these are aspects on which PLEC needs to be informed in order to work with the demonstration site people, both the identified experts and other farmers who cooperate in PLEC work.

DEMONSTRATING PLEC: A DIVERSITY OF APPROACHES¹

Christine Padoch and Miguel Pinedo-Vásquez
Amazonia Cluster

PLEC is not just a project about diversity; it is a project that thrives on the diversity of its participants and its constituent Clusters. The work of all PLEC groups focuses on the goal of helping farmers develop and conserve productive, sustainable, and biodiversity-rich agricultural, agroforestry, and forest management systems. We have each mapped a somewhat different path to that goal, and have advanced at different rates toward our common objective.

Several PLEC groups, including the Amazonia, China and West Africa Clusters, have long concentrated on demonstration activities. They have facilitated farmers' visits to regions, households, and plots where particularly expert villagers presented and explained their successful practices; they have promoted meetings among farmers and technicians; they have arranged conversations between policymakers and producers where the latter were not just listeners but teachers too; they have set up community nurseries; and they have aided farmers to form groups through which they may increase their knowledge and realize other production goals. Meanwhile, some other PLEC Clusters have concentrated on doing the research necessary to identify the practices and the practitioners that will be important to their demonstration activities in the future.

Funds from the GEF have enhanced greatly what PLEC can accomplish. These funds also obligate all the Clusters to move in the direction of a common timetable and set of activities. All Clusters will be setting up demonstration activities in the coming months. The directive to synchronize our schedules and adjust some of our work does not, however, put an end to the flexibility and diversity that our project has fostered and benefited from. It would be foolish not to use the experience of some of our PLEC colleagues and apply many of their successful practices. But there is still the expectation that Cluster work will continue to be diverse, dynamic, flexible, and site-specific.

No one correct approach

There are ways of setting up demonstrations that would be wrong for any Cluster and in any setting, but there is **no one correct way** for all PLEC groups to engage in demonstrations. Limiting demonstration activities to an experimental plot set up at a research station, that is remote to villages and fenced against the intrusion of farmers, is not the PLEC way. But establishing any number of experimental plots in villages, on household lands, on community property, on nearby land owned by some entity that welcomes farmers' visits—these all might well be integrated into a demonstration programme.

A formal meeting where PLEC personnel present an agenda that farmers must follow is not an acceptable demonstration activity. Meetings large or small, of men, of women, of children, of landholders and labourers, or all-inclusive meetings held in the village, in the field, or at an

¹ Reprinted from *PLEC News and Views* 11, 1998

accessible research station, all can be acceptable PLEC activities as long as they allow and encourage two-way exchange of information, learning, and benefits.

Many options are available to most PLEC Clusters in choosing what to feature in demonstration sites or demonstration activities, and whom to involve in making those choices and in carrying out the program. Based on our own experiences in PLEC work with the Macapá (Brazil)-based sub-Cluster of the Amazonia group, we can offer a few suggestions that other Clusters might consider.

Demonstrating PLEC in Amazonia

Our first major tasks in setting up our demonstration work were to identify the farmers with whom we wished to work closely, as well as the good practices we wanted to promote in the area. This work was begun during the research phase. As already discussed in an earlier article by Pinedo-Vásquez in *PLEC News and Views* (1996) we looked (and continue to look) for 'local experts': those farmers and forest managers who are exceptionally innovative, insightful, curious, observant, analytical, and successful. We looked especially for those farmers who put their expertise into patterns that combine superior production with preservation or even enhancement of biological diversity in their fields. These experts were often difficult to identify. They are not the same farmers who usually participate in development projects. They are not often those who are eager to try any 'modern' technology that is offered to them. They are frequently reluctant to discuss or even disclose their own methods. They are not the 'good, compliant' farmers other projects seek out. For our demonstration activities we need good teachers, not just good listeners.

The local experts and their insights and experience are our most important assets. They are the teachers and demonstrators; we are facilitators. We chose several experts at each of our sites in the floodplain villages, including some women. We also selected some specialized management practices that we had observed and felt are important to make better known to local farmers. Prior to beginning any demonstration and dissemination activities, however, we consulted with both the particular farmers who had developed or were using these techniques, as well as with the group of experts.

One of our important and ongoing demonstration foci is the production of bananas using the *banana emcapoeirada* agroforestry system. This is a system that we identified several years ago as a very effective way of maintaining production of bananas in the face of a devastating epidemic of mokko disease. A husband and wife team who live in the small village of Igarape da Lontra in the PLEC Ipixuna site had been working successfully with this system. We first turned to them to inquire whether they would be willing to share their knowledge, insights and experience with other small farmers. After getting a positive response, we brought together ten of our experts from various villages to the Ipixuna site for three days. The local expert agroforesters invited the expert group to stay in their house. Each day the group accompanied the farmers to their fields, worked with them, and spent each evening in their house discussing their observations, experiences and any doubts.

As facilitators we accompanied the whole process; we also arranged for all transport, supplied all food and refreshments and paid our experts a modest stipend. Upon return to their villages, the experts disseminated their new knowledge well. In the three years since we carried out this demonstration the *banana emcapoeirada* agroforestry system has become widespread, and banana production has increased substantially in the region.

Another successful demonstration activity we carried out involved technologies and cassava varieties appropriate for low-lying areas prone to tidal inundation. Working closely with a farmer noted for his success in producing crops on these difficult lands, we again helped make locally-developed specialized knowledge more widely appreciated. In this case, we first called together a meeting of experts to evaluate the technology and the unusual varieties the farmer employed. When the assembled experts had expressed their enthusiasm, we arranged a demonstration meeting in a local church that was attended by hundreds of local farmers as well as agricultural research technicians. The techniques and varieties that were demonstrated at that meeting and subsequent discussions are now much more widely known and the technicians are working to improve the varieties further.

The above are just a few of the approaches to furthering PLEC goals that we have used. Certainly not all of our planned activities have proved successful, but relying on our 'local experts' for advice and teaching continues to be central to our activities. We are still working on new ideas and new plans. As we spend more time getting to know the farmers, the experts, and the region, we expect greater success. The key has been working as closely as possible with the farmers and forest managers on their properties. We believe that each Cluster should select at least one person to dedicate his/her time to interacting very closely with farmers. As we stated before there is **no one correct way** to conduct successful demonstration activities. We have found that it is simply not possible to carry out any successful demonstration from a comfortable research station, office, or home in the city.

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