PN-ABE-044

# Professional Education in Agroforestry

## Proceedings of an International Workshop

Edited by ESTER ZULBERTI

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# Professional Education in Agroforestry

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Ester Zulberti

ICRAF

*Published by the*

INTERNATIONAL COUNCIL FOR RESEARCH IN AGROFORESTRY
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# INTERNATIONAL WORKSHOP

# ON

# PROFESSIONAL EDUCATION IN AGROFORESTRY

| | |
|---|---|
| Date: | From 5 to 10 December 1982 |
| Venue: | ICIPE Training Centre<br>Duduville<br><br>Nairobi, Kenya |
| Participants and Contributors: | Seventy-three (73) from Africa, America, Europe, Indian Subcontinent, Southeast Asia and South Pacific. |
| Workshop Organizers: | Dr. Peter Huxley, ICRAF<br><br>Dr. Ester Zulberti, ICRAF<br><br>Dr. Olaf Anders, DSE |

# FOREWORD

Agroforestry, whether as a science or practice, is an approach to more balanced land management based on the idea that woody perennials in the landscape can enhance both the productivity and sustainability of land-use systems. This can be achieved by introducing "trees" to farmers' fields, or by allowing farmers to utilize forest lands in a controlled and ecologically sound fashion. We know well that in many tropical and sub-tropical regions widespread devastation of land resources is being caused through the increase in numbers of both man and his animals, and through methods of soil management which promote ecological degradation in fragile ecosystems. Furthermore, although conventional forestry practices designed to produce timber and wood products can certainly conserve the environment, they provide little food for the human settlements residing in or near them. Where some form of shifting agriculture is practiced in such forested regions, the "forest fallow" period has now, perforce, often been dangerously shortened, with consequent land deterioration. Even on many of the more productive arable soils in the tropics we know that continued cultivation and cropping will result in an insidious loss of soil fertility.

In all of these situations, well-planned agroforestry should be considered as a potentially more productive and land conserving alternative. Indeed, in many parts of the tropics and sub-tropics indigenous rural inhabitants have, themselves, worked out systems in which the production of agricultural crops (or grasses) are combined with woody perennial species on the same unit of land. Animals may or may not be part of such systems. This approach to land use offers a chance to halt, or even reverse, the detrimental trends imposed on the environment by many current systems of production. However, if we are to set about improving existing agroforestry systems, we must survey and study them critically in order to mould existing knowledge and technologies into suitable tools with which to manage agroforestry systems more effectively, or to help design new ones.

If such opportunities to manage land appropriately in the tropics are to be grasped, where are the people to come from who can integrate the several disciplines and skills which together must be combined and reformed into this "new" approach? Are we to take existing foresters, agriculturists and others experienced in specific areas of land utilization and land management, and "retrain" them? Should agroforestry be introduced alongside conventional courses or programmes? Do we have a need to raise a new generation specifically taught agroforestry *per se*? If we do, then have we enough practical information to train agroforesters at the technical and management level, or are we better able just to elaborate and inculcate the principles and scientific concepts?

All these, and other questions, needed clarification if appropriately-educated personnel were to begin to be available in sufficient numbers to deal with the developing thrust towards agroforestry which is now emerging throughout the world. In organising this Workshop I feel that ICRAF and DSE grasped a particularly timely initiative. Even though the preparation and publication of these proceedings has been delayed, the topics presented are not likely to be any the less relevant. The hope is that they will usefully contribute to the rapidly developing agroforestry educational scene.

Bjorn Lundgren
Director
July, 1987

# PREFACE

ICRAF's contributions to and involvements with training and education have been an integral part of its activities from its inception in 1978. In the early days these took the form of preparing a range of training materials (mostly for others to use), guiding in-house trainees, giving agroforestry lectures, and contributing to seminars and world literature on the place of agroforestry in the educational process. Born among these early efforts was an appreciation that there would shortly be an exploding interest in establishing university and college courses in the "new" subject of agroforestry.

The first moves to plan and obtain donor support for this conference were made in 1979; this was followed by a long period of planning and communication with potential participants who established the structure and content of this Workshop and set to work those who were to attend it later. With the enthusiastic help of Dr. H.J. von Maydell (then an ICRAF Board Member, who interceded on our behalf with the donor agency, DSE) this long period of preparation was brought to fruition in 1982.

Less than five years later the subject of "Agroforestry" is, in one way or another, incorporated in the curricula and examination structures of educational institutes in both developing and developed countries to a degree and extent that even those of us involved at the time would not have predicted. Indeed, a major need at present is for the provision of enough suitably-prepared educational materials to satisfy the demand of those teaching agroforestry.

Fortunately, the ideas and information from which to prepare textbooks and teaching aids in the component parts of the subject are becoming available in an ever-increasing volume. Numerous agroforestry field projects generate reports and case studies, and more and more research scientists and applied foresters and agriculturalists direct their efforts to this exciting

discipline. We now need the help and involvement of experienced educationists to select, re-structure and suitably re-formulate this growing mass of information, concepts and data. Future generations can then be educated to understand better than the last the scientific basis for sustainable and productive land use, especially in the tropical and sub-tropical regions of our oft misused globe.

P.A. Huxley
Principal Workshop
Organizer

ACKNOWLEDGEMENTS

ICRAF is grateful to the German Foundation for International Development (DSE) for assisting with the organization of this conference and for providing a major funding contribution. We also wish to thank the Ford Foundation, the Beijer Institute and the Dutch Government for providing additional funds.

Appreciation is extended to all who contributed to the Workshop, particularly Regional Coordinators, authors of position papers, and Working-Group Chairmen and Rapporteurs/Rapporteuse.

Sincere gratitude is also extended to the ICRAF scientific staff who undertook the reviews with dedication amidst other ICRAF programme obligations.

Finally, thanks go to the ICIPE Training Centre at Duduville for the hospitality accorded to the participants, and to all the participants who contributed to the success of the Workshop.

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## SUMMARY

The International Council for Research in Agroforestry, together with the German Foundation for International Development, undertook the organization of an International Workshop on Professional Education in Agroforestry, in Nairobi, to address the problems and to assess possible courses of action and priorities in agroforestry professional education.

Seventy-three participants and contributors from national as well as international organizations attended the meeting from 5 to 10 December 1982 and represented the main geographical regions of the world. The professional expertise represented appropriate academic levels in teaching, curriculum development, planning and implementation of educational programmes and also included agroforestry, agriculture, forestry, ecology/biology, land planning, land-resource management and education specialists. The list of participants and contributions is given in Annex 1.

The Workshop objectives were to debate and establish priorities, plans and procedures for future action in agroforestry professional education, in order to:

- assess manpower needs and review requirements for professional agroforestry education;
- review appropriate forms of teaching and particular institutional requirements for adopting agroforestry; and
- examine the details of how best to achieve the education required by reviewing teaching material as well as existing outlines of the contents of programmes/courses on a regional basis.

Participants' contributions were received in the form of regional submissions, position papers, reviews of source materials to teach agroforestry, and working-groups' recommendations.

Regional Coordinators were appointed for seven geographical areas of the world: Africa, America, Europe, the Middle East, Southeast Asia, the South Pacific and the Indian Subcontinent. Each was to

conduct a survey on the state of the art in agroforestry education. Results of the worldwide study were presented to the Workshop audience during the first plenary session on 6 December (see the Workshop Programme of Activities in Table 1). Summaries of the regional submissions are contained in Section 1.

Position papers were submitted by invited contributors on subjects related to the main objectives of the Workshop. The papers aimed to focus discussions and stimulate ideas. Hence, no formal presentation of position papers took place. Abstracts of all contributions are presented in Section 2 together with the full, edited text of selected papers.

The reviews of source materials were prepared with a strong contribution from ICRAF staff and describe the scope and merit of existing information for teaching agroforestry. Edited versions of the reviews are presented in Section 3.

Six working groups were convened to discuss topics related to the main objectives of the meeting. Chairmen were nominated in advance for each group and invited to arrive in Nairobi a day ahead in order to draw a plan of action and discuss the general scope and expected outcomes of the groups. A summary of the work accomplished is presented in Section 4.

A two-day display of available publications in agroforestry and related fields was prepared by the organizers. Forty-six commercial publishers and institutions were invited to display brochures, booklets, books, handouts, posters, etcetera of potential use for teaching agroforestry. Exhibitions of different materials were arranged for morning sessions of December 7 and 8. Participants were very enthusiastic about this innovative gathering that provided them with an update on literature available from publishing houses as well as from the institutions represented by participants. A great deal of interaction and exchange of information among participants occurred during these very pleasant and lively sessions. The list of publishers who were invited to submit display material appears in Annex 2.

TABLE 1

## PROGRAMME OF ACTIVITIES

Plenaries at Safari Park Hotel

Working Group Sessions at Duduville

| | SUN. 5 DEC. | MON. 6 DEC. | TUES. 7 DEC. | WED. 8 DEC. | THUR. 9 DEC. | FRI. 10 DEC. | SAT. 11 DEC. |
|---|---|---|---|---|---|---|---|
| MORNING | Participants Arrival and Registration<br><br>Working Group Chairmen's Meeting | Complete Registration<br>———<br>Workshop Objectives (Plenary)<br>Summaries of Regional Coordinators' Work | Display<br>———<br>Working Group Sessions<br>———<br>Introduction to Resource Documents | Display<br>———<br>Working Group Sessions | Plenary<br>———<br>Working Group Sessions | Final Meeting of Working Groups & Typing of Reports | AGRO-FORESTRY |
| AFTERNOON | Working Group Chairmen's Meeting | Identification of Working Groups<br>———<br>Display | Working Group Sessions<br>———<br>Plenary | Working Group Chairmen & Rapporteurs Meeting<br>——— | Final Drafts of Resource Documentation & Recommendations | (Plenary) Summary of Resource Documents and Recommendations<br>———<br>Field Trip Information<br><br>Workshop Evaluation | FIELD<br><br>DAY<br><br>(optional) |
| EVENING | Reception and Opening Ceremony | Meeting with Working Group Chairmen & Rapporteurs | Meetings with Working Group Chairmen & Rapporteurs | Social Gathering | Meetings with Working Group Chairmen & Rapporteurs<br>———<br>Slide Show | Social Gathering | Participants Depart |

# PRINCIPAL CONCLUSIONS AND RECOMMENDATIONS

During the ICRAF/DSE International Workshop on Professional Education in Agroforestry rich sources of information were uncovered about where and how professional agroforestry is being taught at present. Although the list is still far from complete, it provides a basis for further enquiry. The Workshop also generated many ideas concerning current needs for agroforestry education, and a surprising level of agreement emerged regarding priority issues. These are summarised below:

- Agroforestry is highly interdisciplinary; it is not just a branch of forestry. The development of agroforestry into an experimental science which can be taught, and which will result in the provision of adequate numbers of competent, professionally trained personnel, must be done in a way that recognizes existing professional links and existing professional standards and requirements.

- One practical way to assist the development of agroforestry as a subject may be to encourage the "twinning" of appropriate institutions, for example those of forestry, agriculture, applied ecology, etcetera, and to do this either in the "north-south" or the "south-south" context.

- There is a need to ascertain the degree to which agroforestry is (or is not) <u>institutionalized</u>, and to see to what extent agroforesters are becoming key personnel in creating integrative links between separate national organizations. The questionnaire designed by the Workshop's network of regional coordinators could, perhaps, be reformulated and redesigned to obtain this kind of information. (see Appendix IA)

- Where land use is already being taught in an integrative way, there may be no need to initiate any new and separate educational programme in "agroforestry." Having said this, at present probably very few institutes or faculties actually achieve the breadth or the degree of interdisciplinary approach needed, although a number are moving in this direction.

Some countries have undertaken, or at present are undertaking, a critical reappraisal of the structure and relevance of the ways in which their education, training and extension in land use is fitted to new emerging national needs (environmental conservation, the energy crisis, etcetera). Much can be done to introduce the agroforestry approach with immediate effect and without any costly or drastic restructuring of national educational or training resources, through short courses of various kinds. Some effort will have to be made, however, to provide in-service or retraining facilities in order to train the teachers, if this immediate short-term expedient is to be effective. These efforts will each be tackled on a national basis, but there are implications for appropriate back-stopping and support.

Where a whole programme on agroforestry education is considered desirable, or essential, then the first place to start is probably at the postgraduate level in the form of 1- or 2-year master's degree which combines course and field work. By far the greatest development of agroforestry is occurring in the tropics and sub-tropics; therefore, most such postgraduate courses will be best situated in faculties or institutes in developing countries. Agroforestry technology is highly regionally oriented, both in terms of the species used and in the detailed design and management of actual operations systems. Therefore practical course work should be carried out in relation to site-specific and problem-oriented situations if it is to be fully relevant. Institutes and faculties in developing countries will need additional support in this effort if they are to satisfy national needs. ICRAF is perhaps particularly well placed to cooperate and help develop the structure and content of such a master's programme.

Short courses of various kinds are needed and there is a wide range of organizations and institutions that are available now to help in different ways to support, prepare, organize and/or disseminate these. Widespread types of training in the form of short courses in agroforestry are considered essential to

acquaint a broad range of professionals from many disciplines (scientists of different kinds, planners, resource managers) with the basic ideas of agroforestry. ICRAF has already advocated the "modular" approach to teaching agroforestry and the construction of course "packages," complete with texts, references, visual aids and other teaching materials (including guidelines for the lecturers). Such course "packages" could be prepared at selected institutions that have the interdisciplinary capacity at this time. These would be provided to those institutions that wish to introduce agroforestry as a subject in their present teaching programmes. The scope for such "packages" is rather wide and these could be an efficient and cost-effective way of helping many institutions that at present do not have full resources to plan such courses or provide fully experienced staff to run them. Another relatively low-cost approach would be the 10-12 week course, a movable feature (i.e. held in a different country each year) run by a number of agroforestry experts and supported by, in each case, available local educators and scientists. This would be similar to many of the courses already mounted by FAO or by UNESCO.

The training materials needed for teaching agroforestry must cover both principles and practices. As the reviewers indicated, there is absolutely no lack of written material; this ranges from all the important scientific subject areas to the theoretical foundations for understanding and evaluating agroforestry land-use systems and practices. However, the tasks of interpretation and selection are more difficult in some areas (for example, socio-economics, crop eco-physiology) than in others (soil science, meteorology/climatology) and qualified specialists, or groups of specialists, are needed to select and work-up the available information within each discipline.

There is an urgent need to <u>inventory existing agroforestry systems</u> but, because the teaching of agroforestry has to be more than just a descriptive exercise, this must also entail collecting actual data for comparison and

evaluation. FAO's Shifting Cultivation Programme and ICRAF's project to inventory agroforestry systems world-wide are just two current activities which will help to initiate such a process.

All the information required for teaching must be regularly updated, collated and disseminated. Accounts of existing or newly devised research methodology, or of applicable technology, will no doubt become generally available through the usual sources - scientific publications, text books (ultimately), and other training materials - and the information and data from inventories, case studies and the like will need to be more positively and centrally handled. This is a matter requiring immediate decision and action from both national and international organizations.

The account given above of some of the main recommendations arising from the Workshop indicates that many questions of implementation still need to be firmly addressed. The need to get agrofrestry education moving, a need which is becoming increasingly apparent, will, however, require a concerted effort by international and national organizations. Fortunately, there are a number of such organizations that are well placed to help, where past experience and current initiatives can be joined so as to provide the necessary assistance in formulating, organizing or supporting (with staff and/or finance) effective national programmes of agroforestry education.

The outcome of the Workshop was a clear appreciation of the amount of teaching material which is now becoming available. The challenge is to establish the means for collecting, collating and disseminating this information, and then to structure it into courses or even whole programmes in a cost-effective manner, recognizing existing priorities. These proceedings, present some guidelines which we believe will aid in meeting this challenge.

## CONCLUSIONS ET RECOMMANDATIONS PRINCIPALES

Lors de l'Atelier International sur l'Enseignement Professionnel en Agro-foresterie organisé par ICRAF/DSE, on a pu avoir beaucoup d'informations trés fournies sur les lieux et sur la façon dont l'enseignement professionnel en agroforesterie est effectué à présent. Bien que la liste soit encore très incomplète, elle peut servir de base à une enquéte plus poussée. L'Atelier a également permis d'exposer de nombreuses idées concernant les besoins actuels et on s'est mis d'accord de manière surprenante sur les priorités de l'enseignement agro-forestier. En voici un résumé:

L'approche agroforestière est largement interdisciplinaire: elle n'est pas une simple branche de la foresterie. Le développement de l'agroforestrie en une science expérimentale susceptible d'être enseignée, avec pour conséquence la formation d'un nombre adéquat de personnel professionnellement compétent, doit s'effectuer de façon à tenir compte des liens qui existent entre les professions ainsi que des niveaux professionnels et des besoins.

Pour aider de manière pratique au développement de l'agroforestrie en une "matière" distincte, on pourrait encourager le "jumelage" d'institutions appropriées, par exemple celles specialisées en foresterie, en agriculture, en écologie appliquée, et d'autres encore, et de le faire dans un contexte "nord-sud" ou "sud-sud."

Il serait utile d'établir à quel point le domaine agro-forestier est -- ou n'est pas -- institutionnalisé et de voir dans quelle mesure les agroforestiers sont en passe de devenir un personnel clé dans la création de liens complémentaires entre des organisations nationales séparées. Il serait peut être bon

de remodeler et reformuler le questionnaire conçu par le Réseau des Coordinateurs Régionaux lors de l'Atelier, dans le but d'obtenir ces renseignements (voir Appendice A).

Là où l'utilisation des terres est déjà intégrée à l'enseignement, il n'est peut-être pas nécessaire d'entreprendre un nouveau programme d'enseignement séparé en "Etudes agroforestières." Ceci étant dit, il y a probablement

> peu d'instituts et de facultés qui atteignent effectivement une ampleur ou un degré d'approche interdisciplinaire suffisants. Cependant un certain nombre de ces instituts sont en bonne voie.

Certains pays ont entrepris ou sont en train d'entreprendre une réévaluation critique de la structure et de la validité de leurs méthodes d'enseignement, de formation et de vulgarisation dans le domaine de l'utilisation des terres et de la manière dont celles-ci sont adaptées aux tous nouveaux besoins nationaux (conservation de l'environnement, crise de l'énergie, etc.) Pour pallier à l'urgence de l'approche agroforestière et sans entrainer une restructuration coûteuse ou fondamentale des ressources nationales en matière d'éducation ou de formation, on pourrait organiser divertes sortes de cours de courte durée. Il faudra néanmoins faciliter l'accès des professeurs à des stages de formation professionnelle et de "mises à jour", si l'on vise à ce que cette solution à court terme soit efficace. Tous ces efforts devront être démarrer au plan national, ceci impliquant toutefois des épaulements et des appuis là oú ils sont nécessaires.

Si l'on considère souhaitable -- voire même indispensable -- un programme complet en agroforesterie, alors, on devra commencer dès le

niveau post-licence sous la forme d'une maîtrise en un ou deux ans, combinant des cours et du travail sur le terrain. Le développement majeur de l'agroforesterie a actuellement lieu dans les régions tropicales et sub-tropicalesé c'est pourquoi il serait préférable de situer la majorité de ces cours universitaires au niveau de la maîtrise dans des facultés et instituts de pays en voie de développement. La technologie agroforestière est très orientée régionalement tant pour ce qui est des espèces utilisées que pour la mise au point et la gestion des systèmes opérationnels eux-mêmes. Il faudrait donc que les travaux pratiques pour être le plus utiles possible se fassent en conditions réeles, dans des sites déterminées et pour résoudre de vrais problèmes. Dans cet effort, les instituts et facultés des pays en voie de développement auront besoin d'appuis supplémentaires, si elles doivent satisfaire aux besoins nationaux. L'ICRAF est peut-être particulièrement bien placé pour coopérer et aider au développement de la structure et du contenu d'un tel programme de maîtrise.

Différents cours de courte durée sont nécessaires et il existe un grand nombre d'organisations et d'institutions actuellement prêtes à aider de différentes manières, en soutenant, préparant, organisant et/ou diffusant ces cours. On considère comme essentiels quelques types de formation sous la forme de cours brèfs en agroforesterie pour familiariser avec l'idée de base d'agroforesterie un large éventail de professionnels de disciplines variées (chercheurs de spécialités différentes, planificateurs et gestionnaires de ressources). L'ICRAF a déjà préconisé l'approche "modulaire" pour l'enseignement de l'agroforesterie et l'édification de cours entiers "prêts à l'emploi" comprenant textes, références, aides visuelles et autres documents utiles (ainsi que des lignes directrices destinées à l'enseignant). Des nécessaires de cours de cette nature pourraient

être préparés par des institutions sélectionnées qui ont déjà un haut degré d'interdisciplinarité. Ces cours seraient fournis aux établissements qui souhaitent introduire l'agroforesterie comme matière enseignée dans leurs programmes actuels. L'envergure de tels cours "tous faits" est très large et ils pourraient se révéler un moyen efficace et peu coûteux d'aider de nombreux établissements qui ne possèdent pas à présent de ressources suffisantes pour organiser de tels cours, ou pour fournir un personnel qualifié pour donner ces cours. Une autre approche relativement peu coûteuse serait une formation de 10 à 12 semaines, à caractère mobile (c'est-à-dire ayant lieu chaque année dans un pays différent), dirigée par des experts agroforestiers et soutenue dans chaque cas par des éducateurs et chercheurs locaux disponibles. Cette solution se rapprocherait des nombreux cours déjà mis sur pied par la F.A.O. ou par l'UNESCO.

Les matériaux utilisés pour l'enseignement de l'agroforesterie doivent couvrir aussi bien la théorie que la pratique. Comme l'ont indiqué les experts, la documentation écrite ne manque pas: celle-ci s'étend depuis tous les domaines scientifiques d'importance jusqu'aux bases théoriques de la compréhension et de l'évaluation des systèmes d'utilisation des terres en agroforesterie et aux pratiques agroforestières. Cependant, la tâche d'interprétation et de sélection sera plus ardue dans certains domaines (par exemple la socio-économie, l'écophysiologie des cultures), que dans d'autres (etude des sols, météorologie/climatologie). De plus, il faudra faire appel à des spécialistes qualifiés ou à des groupes spécialisés pour sélectionner et traiter les données disponibles dans chaque discipline.

Il y a un besoin urgent d'inventorier les systèmes agroforestiers mais, puisque nous voulons que l'enseignement de l'agroforesterie

soit davantage qu'un simple exercice descriptif, il faut y inclure la masse des données réelles permettant leur comparaison et leur évaluation. Le Programme de la F.A.O. sur les cultures itinérantes et le projet ICRAF d'inventaire des systèmes agroforestiers sur le plan mondial ne représentent que deux activités en cours qui aideront à mettre en route une telle démarche.

Toutes les données requises pour l'enseignement doivent être régulièrement remises à jour, collationnées et disséminées. On pourra toujours avoir recours par les sources habituelles - publications scientifiques, manuels (un des buts ultimes), et autres matériaux éducatifs aux rapports sur la méthodologie existante ou récemment expérimentée de la recherche, ou aux rapports souples technologies applicables. Les renseignements et les données que les inventaires et les études de cas procureront devront être traités d'une manière plus complète et plus centrale. Cette question réclame une décision et une action immédiates de la part des organisations nationales et internationales.

Le rapport que nous venons de donner, concerne les recommandations principales émergeant de l'Atelier International ICRAF/DSE sur l'Enseignement Professionnel en Agroforesterie et indique que de nombreux problèmes de réalisation se posent encore. Le besoin, visiblement croissant, de développer l'agroforesterie va nécessiter un effort concerté des organisations internationales et nationales. Heureusement, un certain nombre de ces organisations sont bien placées pour apporter une aide par leur expérience acquise et par leurs initiatives présentes: celles-ci peuvent être réunies, afin de fournir l'assistance nécessaire à la formulation, à l'organisation et au support (en personnel et/ou en fonds) de programmes nationaux efficaces pour l'enseignement de l'agroforesterie.

L'Atelier de travail a abouti à une estimation lucide de la quantité de matériaux disponibles utilisables pour l'enseignement. La difficulté est de collecter, collationner et disséminer cette masse de renseignments et ensuite à la structurer en cours ou même en programmes complets d'une manière rentable et prioritaire. Le présent compte-rendu propose quelques lignes directrices qui -- nous voulons le croire -- aideront à aplanir les difficultés.

## PRINCIPALES CONCLUSIONES Y RECOMENDACIONES

Durante el Taller Internacional de Trabajo sobre Educación Agroforestal organizado por ICRAF/DSE, se presentó información sobre la enseñanza de la agroforestería (donde y como se enseña) en las principales regiones del mundo. A pesar de que la lista de programas identificados dista mucho de ser completa, ésta puede ser utilizada como elemento de referencia y consulta en el desarrollo de futuras actividades en el área. El Taller de Trabajo generó también numerosas ideas sobre necesidades y prioridades de educación y capacitación agroforestal, las que se resumen a continuación:

.La agroforestería es interdisciplinaria por naturaleza, no es sólo una rama de la silvicultura. Esta disciplina debe ser enseñada como una ciencia experimental en donde se tomen en cuenta los vínculos, normas y requerimientos técnicos existentes.

.Una forma de promover el establecimiento de programas de educación agroforestal es a través de convenios entre "instituciones hermanas" (facultades ó institutos de silvicultura, agricultura ó ecología aplicada) en el contexto de convenios "norte-sur" ó "sur-sur".

.Es necesario evaluar el grado actual de institucionalización de la agroforestería y determinar cual es el papel que juega el personal técnico agroforestal existente, especialmente en lo que se refiere a la coordinación entre instituciones nacionales, tradicionalmente separadas. El cuestionario originalmente diseñado para la red de coordinadores regionales del Taller de Trabajo podría ser utilizado para tal fin, previa revisión y/ó adaptación.

.En aquellas instituciones de educación formal ó informal donde los temas relacionados con el uso de la tierra ya se enseñan con un enfoque de sistema integrado, no se considera imprescindible/necesaria la creación de nuevos programas de educación agroforestal.
.La introducción de la enseñanza agroforestal en programas de capacitación y extensión no requiere necesariamente de reestructuras institucionales drásticas y/ó costosas. Se puede comenzar con la organización de cursos cortos de "capacitación en servicio" dirigidos al personal docente (profesores, instructores) para que éstos incorporen gradualmente el tema en los planes de estudio.

.Cuando el establecimiento de un programa completo de educación agroforestal es necesario o deseable, es probable que el nivel más apropiado para comenzar sea el de post-grado, en cursos de 1 ó 2 años de duración para la obtención del título de master (M.Sc.). El programa debe combinar el trabajo académico con el de campo. Dado que la tecnología agroforestal se encuentra más desarrollada en los trópicos y sub-trópicos, es en instituciones de estas zonas donde idealmente deberían establecerse los programas de educación agroforestal. Los institutos y facultades de países en desarrollo que comiencen este tipo de programas necesitarán apoyo en lo que se relaciona a diseño curricular y de materiales de enseñanza. ICRAF es, quizás, una de las instituciones mejor dotadas para brindar este apoyo.

.Existe la necesidad de organizar diferentes tipos de cursos de capacitación agroforestal dirigidos a técnicos y profesionales de las ramas agrícola, forestal y de desarrollo ganadero. Simultáneamente a los cursos, se deben diseñar materiales didácticos que incluyan: ayudas visuales, listas de referen-

cia, apuntes, guías didácticas para los instructores, etc. ICRAF ha venido advocando el uso de sistemas modulares para la enseñanza agroforestal similar a los cursos montados por FAO ó UNESCO.

.Los materiales didácticos deben cubrir tanto los principios como las aplicaciones agroforestales. Tal como lo indicara el grupo de revisores de materiales de enseñanza del Taller, no es que exista una carencia de literatura sobre estos temas. Más bien la dificultad radica en la selección e interpretación de la información, que en algunas áreas (por ejemplo, socio-economía, ecofisiología vegetal) resulta más difícil que en otras (suelos, meteorología ó climatología). Se recomienda que en esta labor participen técnicos altamente calificados ó grupos de especialistas en las diferentes áreas.

.Se estima urgente la necesidad de realizar un inventario de sistemas agroforestales cuya información sea utilizada en programas de educación agroforestal. Dado que la enseñanza agroforestal comprende mucho más que la mera descripción de sistemas es importante que el inventario incluya la recolección de datos para fines de comparación y evaluación. El programa de la FAO sobre "rotación de cultivos" y el proyecto de ICRAF sobre "inventario de sistemas agroforestales" contribuirán a iniciar este proceso.

.La información a ser utilizada en la enseñanza agroforestal necesita ser revisada, ordenada y diseminada periódicamente. Los desarrollos metodológicos y/ó tecnológicos son usualmente publicados en fuentes de comunicación tales como revistas científicas, boletines técnicos, libros, etc. Es necesario establecer mecanismos de centralización de esta información para su posterior

diseminación a instituciones educativas.

Esta síntesis de conclusiones y recomendaciones surgidas del Taller de Trabajo claramente indica que los problemas relacionados con la enseñanza de la agroforestería deben aún ser abordados con firmeza. La necesidad de poner en marcha programas educativos en este área requiere de un esfuerzo mancomunado de instituciones nacionales e internacionales. Afortunadamente, existe un buen número de organizaciones que debido a su experiencia previa y actividades presentes estarían en buenas condiciones de prestar apoyo (recursos humanos o financieros) a los programas nacionales para la formulación, organización y ejecución de planes de estudio en este área. Además, durante el desarrollo del Taller se puso de manifiesto que al momento ya existe una gran cantidad de información que puede ser utilizada en la enseñanza agroforestal. El gran reto consiste en establecer mecanismos que permitan, primero, la identificación de las fuentes de información y recopilación de literatura existente, segundo, la clasificación/selección y difusión de la misma; y, tercero, la transformación de la información en materiales de enseñanza, cursos o programas educativos completos.

Confiamos en que las ideas y/o sugerencias que surgieron del Taller de Trabajo contribuirán positivamente al proceso.

# SECTION 1 - REGIONAL SUBMISSIONS

A survey of existing activities and plans in educational institutions concerning the teaching of agroforestry at the professional level was carried out six months prior to the Workshop. The aim of the study was to collect such information as there is about the need for professionally educated agroforestry personnel, and to determine the present level and possible development of agroforestry education.

Eleven Regional Coordinators were appointed throughout the world to undertake such a task (see Table 2). The guidelines for a questionnaire were provided by ICRAF to all Regional Coordinators in an effort to ensure that similar, as well as comparable, information would be collected in all regions (see Appendix A). The questionnaire was translated and adapted as required according to the educational system prevailing in each region. Questionnaires were mailed to universities and other institutions of higher education, government departments and appropriate research institutions in one hundred and four countries.

The study faced the well-known limitations of postal surveys; replies were scarce and delayed. Nevertheless, as Dr. El-Hadji Sene, Regional Coordinator of Francophone Africa, pointed out "it seems only those people interested in and dedicated to promoting agroforestry care to reply, and thus their replies are most informative and pertinent".

Results of the regional surveys were presented to the Workshop audience during the first plenary session on Monday, 6 December.

There was concern among some Workshop participants as to whether the institutions contacted in each region truly represented the body of existing educational/ research institutions. For some regions, the list was thought to be far from complete and additions were recommended to complement the study. Nonetheless, the list of institutions as compiled and presented by Regional Coordinators is believed to constitute in itself valuable information; hence it is presented by region in Appendix B of this section.

TABLE 2

REGIONS AND REGIONAL COORDINATORS

| REGIONS | REGIONAL COORDINATORS |
|---|---|
| 1. AFRICA (Anglophone) | Martin Kyomo, Tanzania |
| 2. AFRICA (Francophone) | El-Hadji Sene, Senegal |
| 3. AFRICA (North) MIDDLE EAST | Marwan Kamal, Jordan |
| 4. SOUTH EAST ASIA | Abdul M. Ahmad, Malaysia |
| 5. SOUTH PACIFIC | Stanley Richardson, New Zealand |
| 6. INDIAN SUB-CONTINENT | N.J. Joshi, India |
| 7. EUROPE (West) | Francis Halle, France |
| 8. EUROPE (East) | Marjan Kotar, Yugoslavia |
| 9. AMERICA (North) | Francois Mergen, United States |
| 10. AMERICA (Central) | Gerardo Budowski, Costa Rica |
| 11. AMERICA (South) | Jean Dubois, Brazil |

The summary of the edited findings of Regional Coordinators is organized according to those aspects directly related to the objectives of the survey: the need for professionally educated agroforestry personnel, the present level of agroforestry education, and the possible development of agroforestry education.

| | |
|---|---|
| . REGION: | Anglophone Africa |
| . COORDINATOR: | Martin L. Kyomo |
| . COUNTRIES COVERED: | Botswana, Ethiopia, Ghana, Kenya, Lesotho, Liberia, Malawi, Mauritius, Nigeria, Seychelles, Sierra Leone, Somalia, Sudan, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe. |
| . INSTITUTIONS CONTACTED: | 41 |
| . RETURNED QUESTIONNAIRES: | 16 |

Need for professionally educated agroforestry personnel

Professional personnel educated in agroforestry will be required in the region in all disciplines including land-resource management, extension, research and teaching/training. However, priority lies in teaching agroforestry courses to the staff already engaged in research, extension or teaching agriculture and allied sciences.

The number of personnel required varies from country to country depending on its area, climate, potential for agroforestry, available natural resources and socio-cultural aspects of populations. The proposed manpower requirements for countries in the region are summarized in Table 3.

Teaching and research staff should be trained to the MSc level, or better still to the PhD level in one of the disciplines of agroforestry. A BSc degree in agroforestry, forestry or agriculture may suffice in the case of extension staff.

Once the importance of agroforestry has been recognized by policy makers and planners in areas of land-use planning, it should then be easier to introduce certificate and diploma-level courses in agriculture and forestry in order to produce middle-level agroforestry extension staff.

TABLE 3

PROPOSED MANPOWER REQUIREMENTS IN AGROFORESTRY FROM VARIOUS ANGLOPHONE AFRICAN COUNTRIES SOUTH OF THE SAHARA

| COUNTRY | HIGH LEVEL RESEARCH | HIGH LEVEL TEACHING | MIDDLE LEVEL EXTENSION | MIDDLE LEVEL OTHERS | TOTAL |
|---|---|---|---|---|---|
| Botswana | - | - | - | - | |
| Ethiopia | - | - | - | - | |
| Ghana (Kumasi) Univ. | 2 | 2 | 4 | 6 | 14 |
| Ghana (Kumasi) Govt. | x | x | x | x | |
| Kenya | 0 | x | 4 | - | 4 |
| Lesotho | x | x | x | x | |
| Liberia | - | - | - | - | |
| Malawi Univ. | 3 | 2 | 3 | 3 | 11 |
| Malawi Govt. | 2 | 2 | 4 | 6 | 14 |
| Mauritius | - | - | - | - | |
| Nigeria, Ibadan | 30 | 8 | 22 | 6 | 66 |
| Nsukka | x | x | x | x | |
| Ile-Ife | x | x | x | x | |
| Seychelles | - | - | - | - | |
| Sierra Leone | x | x | x | x | |
| Somalia | x | x | x | x | |
| Sudan | - | - | - | - | |
| Swaziland xx | x | x | x | x | |
| Tanzania xx | 5 | 4 | x | x | 9 |
| Uganda Govt. | x | x | x | x | |
| Uganda xx | 5 | 2 | 32 | 10 | 49 |
| Zambia | - | - | - | - | |
| Zimbabwe | - | - | - | - | |
| SUBTOTALS | 47 | 20 | 69 | 31 | 167 |

- Did not respond
x Responded but did not mention numbers
xx Universities' responses; they were voting for the country concerned.

## Present level of agroforestry education

Among the various educational institutions surveyed in anglophone Africa, none at present offer a certificate, diploma, degree or postgraduate degree exclusively in agroforestry. This is mainly due to the lack of staff trained in agroforestry and rigid institutional structures. In order to offer a full-fledged diploma, an undergraduate or a postgraduate degree in agroforestry, there will be a need to teach subjects which cut across various disciplines in physical, natural and biological sciences.

The Department of Forestry Resource Management at the University of Ibadan in Nigeria offers courses in basic sciences in agriculture and forestry during the first two years and specialization in one of the disciplines of agroforestry during the last one or two years, depending on the length of the course.

Most Departments/Faculties of Forestry at various universities in Lesotho, Tanzania, Ghana, Sierra Leone, Somalia, Uganda and others include lectures on agroforestry in their silviculture courses.

In colleges/universities where a department or faculty of forestry does not exist, for example at Bunda College in Malawi, some aspects of agroforestry have been introduced in the crop production course.

## Possible development of agroforestry education

Most institutions in the region involved in teaching agriculture and/or forestry have the physical facilities and infrastructure to teach agroforestry as a subject or course (see Table 4). However, in order to establish agroforestry education and research on its proper footing additional manpower and physical resources will be required, including experimental areas/demonstration plots, etc.

The present agriculture and forestry undergraduate and postgraduate curricula will have to undergo revision. The student timetable is always full. Therefore, the introduction of additional courses in agroforestry may not receive a sympathetic ear. This should be the task of specialized curricula review panels.

TABLE 4

AGROFORESTRY EDUCATION IN VARIOUS ANGLOPHONE AFRICAN COUNTRIES SOUTH OF THE SAHARA

| | RESPONDENT | EXISTING PROGRAMMES | PLANNED PROGRAMMES | FACILITIES AVAILABLE |
|---|---|---|---|---|
| 1. | Ghana Forestry Commission Kumasi, Ghana | No | No | Yes |
| 2. | University of Science & Technology, Kumasi Ghana | No | Yes | Yes |
| 3. | Ministry of Environment & Natural Resources Nairobi, Kenya | No | Yes | Yes |
| 4. | Lesotho Agricultural College, Maseru, Lesotho | No | No | Yes |
| 5. | Bunda College of Agriculture, Univ. of Malawi, Lilongwe, Malawi | No | No | Yes |
| 6. | Department of Forestry Lilongwe, Malawi | No | No | Yes |
| 7. | University of Nigeria Nsukka, Nigeria | No | No | Yes |
| 8. | University of Ibadan Ibadan, Nigeria | No | Yes | Yes |
| 9. | University of Ibadan Ibadan, Nigeria | Yes | Yes | Yes |
| 10. | University of Iile-Ife Nigeria | No | No | Yes |
| 11. | Division of Forestry Freetown, Sierra Leone | No | No | Yes |
| 12. | Somalia National Univ. of Mogadishu, Somalia | No | No | Yes |
| 13. | University of Swaziland Luyengo, Swaziland | No | No | Yes |
| 14. | University of Dar-es-Salam Morogoro, Tanzania | No | Yes | Yes |
| 15. | Makerere University Kampala, Uganda | No | No | Yes |
| 16. | Department of Forestry Entebbe, Uganda | No | Yes | Yes |

## Final remarks

Agroforestry has an important role to play in the development of future land use in most of the tropical and sub-tropical countries.

It is clear that old methods (similar to how nature works) which do not disturb existing ecosystems to a large extent, ensure the endurance of the delicate balance of soil, water, vegetation and fauna. What has been called a disturbed natural environment, has in later years been replaced by more unnatural farming systems, often imported from regions with entirely different conditions. It is time that this trend be reversed. What we may consider is the development of a highly productive farming system. This should be based on all the innovations that science and technology have to offer within the reach and capacity of ordinary man. This is fundamental for long-term ecological stability: no mean task at present, but through education and training it is definitely possible.

## Institutions Contacted in the Region

See list in Appendix B.

| | |
|---|---|
| . REGION: | Francophone Africa |
| . COORDINATOR: | El-Hadji Sene |
| . COUNTRIES COVERED: | Benin, Burkina Faso, Burundi, Cameroun, Guinea, Ivory Coast, Mali, Niger, Senegal, Togo, Zaire |
| . INSTITUTIONS CONTACTED: | 17* |
| . RETURNED QUESTIONNAIRES: | 13 |

Need for professionally educated agroforestry personnel

Even though people experienced difficulties in assessing the number of educated people needed there was a general agreement in that the most urgent needs are; a) to provide existing educational institutions with adequately trained teaching staff in agroforestry; b) to train, along a yet to be defined curriculum, engineers and technicians (francophone connotation); and c) to provide developing agencies in rural areas with sociologists in order to improve field surveys to identify people's needs and how agroforestry can best help them.

Present level of agroforestry education

Information on this section was very scarce and poor, probably reflecting the real situation in the training institutions in the region. There are no institutions offering diploma or degree courses. A list of institutions that could start some kind of agroforestry education or training in the near future is presented in Table 5. The majority are considering arrangements for more integrated training in agriculture and forestry.

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* Information was also collected on a direct contact basis. The Regional Coordinator attended the conference on the Senegal Forestry Development Plan of Action which gathered Sahelian country representatives, funding and consulting agencies as well. The conference took place from 2 to 5 June 1982.

TABLE 5

INSTITUTIONS IN FRANCOPHONE AFRICA WITH POSSIBILITIES TO START AGROFORESTRY EDUCATION PROGRAMMES

| COUNTRY | LEVEL(*) U | G | PG | INSTITUTION | OUTPUTS |
|---|---|---|---|---|---|
| Burkina Faso | | X | | Institut Supérieur Polytechnique | Agronomists Foresters |
| Cameroon | | X | X | École Nationale Supérieur Agronomique (with a forestry and an agric. branch or dept.) | Agronomists Foresters |
| Gabon | (not specified) | | | École Nationale des Eaux et Forêts | (not specified) |
| Ivory Coast | X | | | École Forestière de Bouaké | Extension Workers (food produce & husbandry) |
| | X | | | École Forestière du Banco | Technical Assistants |
| | | X | X | École Nationale Supérieure Agronomique | Agronomists, Professional Foresters |
| Mali | | X | | Institut Polytechnique Rural de Katibougou | Agronomists, Foresters, Husbandry specialists |
| Senegal | X | | | Écoles des agents Techniques | |
| | | | | . agriculture | Technical Assistants |
| | | | | . forestry | Technical Assistants |
| | | | | . animal husbandry | Technical Assistants |
| | | X | X | École Nationale des Cadres Ruraux | Technical Engineers (agriculture, forestry husbandry) |
| | | X | X | Institut des Sciences de l'Environnement | Environmentalists Land Resource Managers |
| | | X | X | École Nationale d'Economie Appliquée | Land Managers |
| | | X | X | Cours Post-Universitaire Sahel | Land Resource Managers (integrated approach) |
| | | X | X | Institut Nationale de Dévelopment Rural (INDR) | Agronomists Foresters |

(*)U = undergraduate G = graduate PG = postgraduate

## Possible development of agroforestry education

The possible development of agroforestry education and training is to be sought not only in the training institutions but in real life and in the field. It is very important in this context to realize that many countries in the region have created development agencies responsible for promoting rural development; extension workers and specialists, at the grass-roots level, have to deal with all activities that contribute to the general welfare of the farmers e.g. food crops, animal husbandry, tree planting, land use, and others. Thus, the demand for agroforestry "training" of this personnel is very high and should be given priority.

An important pre-requisite to any kind of action leading to the firm establishment of "agroforestry education" is to sensitize universities and schools about the need to coordinate the various disciplines related to agroforestry. All institutions listed in the table above could do a good job but they must receive help to build experience and teaching materials which are meagre at present. In a first move, short-term courses for professors and practitioners could be organized. Facilities exist everywhere, for example in Senegal, the Ecole Nationale d'Economie Appliquée, Institut des Sciences de l'Environnement; in Dakar the Institut National de Développement Rural; and in Mali the Institut Polytechnique Rural of Katibougou.

In addition, agroforestry - either traditional or new - in practice is far more advanced than training, education and scientific study and research. Field personnel working in on-going projects should be associated with these courses, for example, in Burkina Faso the Project de Reboisements Viollageois; in Senegal the Project de Reboisement et d'Aménagement du Bassin Arachidier; and in Ivory Coast the Programme d'Installation des Jeunses.

Of course ICRAF should be the key institution to promote these activities. It could be suggested that regional organizations such as CILSS (Comité Inter-états de lutte contre la sécheresse dans le Sahel), Institut du Sahel, CEAO, Conseil de l'Entente, be approached to support these activities. CILSS and CEAO could be key targets in this process; CILSS has

advocated integration in the projects it helps formulate and fund, and CEAO proclaimed 1983-1993 the Afforestation Decade.

## Final remarks

The curricula of most of the institutions training rural development "agents" have a set of common courses that convey the understanding of natural systems and basic agronomy. This tronc commun is mainly delivered at the beginning of the studies. Another set of commun courses could be added at the end of the training to include agroforestry.

There is no support for the idea of training agroforesters at the graduate level. Rather, complementary education in agroforestry should be given to agronomists, foresters and animal husbandry specialists in the form of a special course leading to a certificate.

Institutions such as Institut National de Dévelopment Rural, Institut Agricole de Bouake (at a somewhat lower level), Institut Polytechnique Rural de Katibougou in Mali, Ecole Nationale Superieure Agronomique in Cameroun, among many others, could be approached to investigate the possibility of these arrangements.

In any case, and as the last concluding remark, agroforestry is being practiced and the world of learning has to quickly catch up to give new momentum to it. Improved productivity and welfare are the stakes.

## Institutions Contacted in the Region

See list in Appendix B.

| | |
|---|---|
| . REGION: | Middle East and North Africa |
| . COORDINATOR: | Marwan R. Kamal |
| . COUNTRIES COVERED: | Abu Dhabi, Algeria, Egypt, Iraq, Jordan, Lebanon, Libya, Morocco, Saudi Arabia, Somalia, South Yemen, Sudan, Syria and Tunis |
| . INSTITUTIONS CONTACTED: | 44 |
| . RETURNED QUESTIONNAIRES: | 11 |

Need for professionally educated agroforestry personnel

Respondent countries indicated that agroforestry is a well-known practice in the region. Conditions cited as the main obstacles to improving existing agroforestry practices are: a) unfavourable weather conditions (e.g. Arab Gulf States); b) scarcity of adequate water resources for irrigation (e.g. Arab Gulf States, Saudi Arabia and parts of North Africa; and c) lack of knowledge and absence of significant research in agroforestry. It was emphasized that in order to improve existing agroforestry there is a need for professionally educated agroforestry personnel.

Present level of agroforestry education

No country offers educational programmes in agroforestry. However, there are a number of institutions with already established programmes or courses where agroforestry could easily be introduced at different levels (Iraq, Saudi Arabia, Egypt, Jordan, Libya and Morocco. See Table 6).

Possible development of agroforestry education

Seven agricultural faculties in the region have forestry departments established, either separate or coupled with range or natural resources. Two of these faculties have academic programmes leading to the MSc and PhD degrees in forestry; they are Alexandria University in Egypt and IAVH II in Morocco.

TABLE 6

INSTITUTIONS IN THE MIDDLE EAST AND NORTH AFRICA WITH POSSIBILITIES TO START AGROFORESTRY EDUCATION PROGRAMMES

| COUNTRY/UNIVERSITY | TYPE OF PROGRAMME OFFERED AT PRESENT | DURATION (YEARS) | DEGREE | OUTPUT PER YEAR |
|---|---|---|---|---|
| IRAQ | | | | |
| - Mosul | undergraduate | 4 | B.Sc Forestry | 20 |
| - Saleh El-Din | undergraduate | 4 | B.Sc | 40-50 |
| SAUDI ARABIA | | | | |
| - King Saud | course in forestry at B.Sc & M.Sc level | | | |
| - King Faisal | courses in agriculture | | | |
| EGYPT | | | | |
| - Alexandria | undergraduate | 4 | B.Sc Forestry | |
| | graduate | 2 & 3 | M.Sc Forestry | 3 |
| | | | Ph.D Forestry | 3 |
| JORDAN | courses in forestry together with production programme | | | |
| LIBYA | undergraduate | 4 | B.Sc Range & Forestry | 100 |
| MOROCCO | | | | |
| - E.N.F.I. | undergraduate | 4 | B.Sc Forestry | 15-20 |
| - I.A.V.H. II | graduate | 2 | M.Sc Forestry | 10-15 |

Universities without forestry departments have expressed the need to start by establishing them within their agricultural faculties. Others have pertinent courses which could easily accommodate agroforestry, such as tree physiology, sociology, land use, soil conservation, land reclamation and cultivation, social forestry and others. The lack of adequate facilities in general, was stressed by all countries especially in terms of equipment and demonstration materials.

## Final remarks

Middle East countries vary in their climate, ranging from arid and semi-arid to humid. In most of these countries, water is scarce and thus not much agroforestry is expected. This is the case in the Arab Gulf states except in the southern parts of Iraq. Thus, if any agroforestry is to be developed in those areas, it will depend on the introduction of drought resistant and salt tolerant trees.

The remainder of the Middle East can have and has agroforestry. However, much training and research is still needed to develop new systems in agroforestry. The establishment of agroforestry departments in universities of the region would help in the achievement of these goals.

In North Africa, agroforestry education needs to be given more emphasis by introducing it at various levels of education. Also, research needs to be done in order to develop systems which best fit the local conditions. This type of research needs to be done by specialized institutes with qualified personnel. The graduate programs at universities in Egypt and Morocco could certainly help in the development of new systems.

## Institutions Contacted in the Region

The list is not available.

| | |
|---|---|
| . **REGION:** | Southeast Asia |
| . **COORDINATOR:** | Abdul Manap Ahmad |
| . **COUNTRIES COVERED:** | Indonesia, Malaysia, Philippines and Thailand |
| . **INSTITUTIONS CONTACTED:** | 6 |
| . **RETURNED QUESTIONNAIRES:** | 6 |

Need for professionally educated agroforestry personnel

Agroforestry systems have been quite well established in the region with the support of governments and international agencies. But to be really effective such an approach has to be properly supervised, managed and technically organized. A cross-section of trained manpower is felt to be needed in order to successfully implement such programmes. A summary of the estimated professional personnel required by country in the region is shown in Table 7.

Present level of agroforestry education

Recognising the need for trained manpower, a few institutions in the region have started to introduce agroforestry subjects in existing programmes. For example, in Indonesia, agroforestry courses are being offered at Gadjah Mada University in Jagjakarta and at the Institute Pertanian Bogor in Bogor. In addition, research in agroforestry is being conducted at the Institute of Ecology, Padjadjaran University in Bandung.

In Malaysia, the Universiti Pertanian Malaysia offers agroforestry specializations in the BSc programmes of several faculties e.g. Forestry, Agriculture, Veterinary Medicine and Animal Science, and Fisheries and Marine Science. Students in their final year are required to undertake a one-year agroforestry project.

At the University of the Philippines in Los Banos (UPLB) agroforestry is taught in several courses at the BSc level in Forestry. Preparations are underway to start a one-year diploma programme in forestry*

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*Ed's note. This programme was started in 1984.

TABLE 7

NEED FOR TRAINED MANPOWER IN SOUTHEAST ASIA

| AREA OF TRAINING | INDONESIA | MALAYSIA | PHILIPPINES | THAILAND |
|---|---|---|---|---|
| | NUMBER OF PROFESSIONALS | | | |
| Extension | * | 10 | 1000 | 10-30 |
| Land management | - | 10 | 600 | 10-30 |
| Land resource planning | - | 10 | 150 | 10-30 |
| Research | - | 10 | 150 | 10-30 |
| Social Sciences | - | 10 | 50 | - |
| Training-Teaching | - | - | 30 | - |

* Institutions in Indonesia did not indicate estimated numbers.

that includes the following courses:

| First Semester | Units |
|---|---|
| Agroforestry systems | 4 |
| Community analysis & planning for social forestry | 3 |
| Communication-extension education in forestry | 3 |
| Feasibility studies for social forestry projects | 4 |
| Management of social forestry systems | 3 |
| **Second Semester** | |
| Forest-Based Cottage Industries | 3 |
| Infrastructures for Social Forestry | 4 |
| Soil Conservation | 3 |
| Crop Production and Protection | 3 |
| Product Utilization & Preservation | 3 |
| **Summer** | |
| Practicum | - |

Short training courses, seminars and workshops in agroforestry are also conducted in the Philippines by the Bureau of Forest Development and the Southeast Asia Regional Center for Graduate Study and Research in Agriculture (SEARCA).

The Faculty of Forestry at Kaesetsart University in Bangkok, Thailand, has been offering agroforestry as an elective subject since 1980. The components being taught under this subject are forestry, agriculture and socio-economics. A proposal is under discussion to establish a BSc degree in agroforestry that will include the following:

| Courses | Credits | Content |
|---|---|---|
| 1. Natural Science | 40 | Chemistry, biology, physics mathematics, etc. |
| 2. Social Science & Humanity | 18 | Sociology, humanity, English, rural development etc. |

| | | |
|---|---|---|
| 3. Forestry | 30 | Introduction to forestry, silviculture, forest management, etc. |
| 4. Agriculture | 30 | Soils, agronomy, horticulture, plant science, animal science, etc. |
| 5. Environmental Conservation | 6 | Introduction to environent, concept of conservation, resources utilization, waste treatment, recycling, rehabilitation, etc. |
| 6. Human Ecology | 3 | Human settlement, human basic needs, man & environment, migration, etc. |
| 7. Plant & Animal Ecology | 6 | Structure, function, ecosystems analysis, etc. |
| 8. Agroforestry | 12 | concept, scope, analysis, interdisciplinary, land management, human optimum requirement of land, etc. |
| Total | 145 | |

Possible development of agroforestry education

Possibilities to add/expand agroforestry education programmes in the region look very promising. There are already established courses and programmes where agroforestry can easily be taught e.g. land management, ecology, biology, farming systems, and others. In all countries of Southeast Asia there are well-equipped facilities.

Institutions Contacted in the Region

See the list in Appendix B.

. REGION: South Pacific

. COORDINATOR: Stanley D. Richardson

. COUNTRIES COVERED: Autralia, Fiji, Kiribati, New Zealand, Papua New Guinea, Solomon Islands, Tonga, Vanuatu, Western Samoa

.INSTITUTIONS CONTACTED: 80

.RETURNED QUESTIONNAIRES: 33

Need for professionally educated agroforestry personnel

The most important perceived need is in "research and extension" and it is generally considered that the necessary expertise can be developed by additions to existing agriculture or forestry curricula. Most replies reflect a conviction that agriculturalists stand in greater need of forestry training than foresters of agriculture.

An exception is provided by New Zealand: one respondent argued strongly that the average forester's knowledge of livestock is very poor; another, that the expertise needed to further agroforestry is legal and economic rather than technical - legal to cope with problems of land tenure and integration of uses, and economic to handle problems of co-operative marketing of produce. In smaller islands, the importance of land tenure is also recognised but the approach is quite different. New Zealand is concerned that security of tenure be assured to companies and private individuals for whole forest rotations, thus enabling the provision of loan finance, long-term marketing agreements, etc. In the small islands, traditional rights of usufruct preclude the alienation of land and consequently the aim is to involve the multiple landowners themselves in what is closer to subsistence agroforestry than commercial practice.

Present level of agroforestry education

Professional training appropriate to agroforestry development is varied but generally regarded by respondents as inadequate. In the university forestry departments in the region (at the Australian National

University (ANU) and the University of Melbourne in Australia, the University of Canterbury in New Zealand, and the University of Technology in Papua New Guinea), plantation management for wood and grazing is discussed in the context of "silvicultural practice," while various courses impinge upon land use. In New Zealand universities, agroforestry receives more attention in departments of horticulture plant science, agriculture and environment though, again, it is a peripheral subject based largely on visits to field trials and operative systems. In Papua New Guinea, biology students are given short field courses in agroforestry at the Wau Ecology Institute. The University of the South Pacific (USP), at the main campus in Fiji, teaches courses in land management and rural technology while courses given at the School of Agriculture (Western Samoa) and other USP centres (e.g. Kiribati, Solomon Islands, Tonga and Vanuatu), provide extension courses which may impinge upon plantation management.

Research institutes, tree crop and farm forestry associations and other special interest agencies appear to play the most important role in agroforestry training in the region. In Australia, research is carried out by the Division of Forest Research, CSIRO, and by State Departments of Forestry - notably in Victoria, Western Australia, Tasmania and New South Wales. All are active in extension and demonstration. Tasmania is attempting to integrate nut tree cultivation (hazel and walnuts) with pastoral agriculture, while the Australian Forest Development Institute sponsors, through the McMillan Rural Studies Centre, correspondence courses on tree growing on farms. The ANU is involved in a joint project with ICRAF on computer analysis of agroforestry systems. All these activities have an outreach component.

In New Zealand, the Forest Research Institute (FRI) entertains some 600 to 800 visitors annually at its agroforestry research trials -- mostly students of the university agriculture and forestry schools. The Department of Scientific and Industrial Research (DSIR) Crop Research Division is evaluating fodder and forage trees as well as nut crops and is considering providing courses in tree crop management; the New Zealand Technical Correspondence Institute (NZTCI) mounts a 10-part "Introduction to Tree Crops" course sponsored by New Zealand Tree Crops Association. Farm Forestry Associations are active and contribute to

courses mounted at Flock House (North Island) and Telford (South Island) -- technical training institutions under the control of the Ministry of Agriculture.

In Papau New Guinea, the Wau Ecology Institute is testing legumes in the context of subsistence agriculture and is demonstrating conservation farming techniques and community agroforestry; the Institute also has research programmes on intercropping, food tree species, etc, while the National Government, through the Department of Minerals and Energy, is involved with village agroforestry ventures including food staples, fuelwood, charcoal and compost for sale in urban centres. These activities serve as demonstration foci, though it would not be claimed that they are aimed at professional-level personnel.

The smaller island supports Government departments involved in agricultural extension including demonstrations of intercropping of coconuts, taungya systems and multiple purpose, shade-tree cultivation. Of the countries responding to the questionnaire, Kiribati, Vanuatu and Western Samoa show particular enthusiasm for agroforestry on the part of both agriculturalists and foresters.

Possible development of agroforestry education

Agroforestry systems in the South Pacific operate at two distinct levels. First, there are the indigenous self-reliance systems of the small islands, which exemplify the adage that necessity is the mother of invention, and which depend on communal land holdings, rights of usufruct and co-operative living. Secondly, there are the high technology systems involving intensive tree crop, pasture management as practiced in Australia and New Zealand and, under the influence of the latter country, in foreign aid projects in the islands.

Men from the small islands have much to teach and little to learn from the rest of us. Opportunities lie in the transfer of the technology of biological self-sufficiency and, more importantly, of the attitudes which enable the acceptance of a zero-growth philosophy. The technological lessons are, notably, the innovative utilization of coconuts and, if we are open-minded enough to learn, the benefits of root-crop

cultures over junk-food economies based on polished rice and tinned fish!

In this context the development of agroforestry education at the professional level should instil an awareness of the traditional crops and technologies of self-reliance in administrators, politicians and their advisors. It is too easy for Islanders educated overseas to reject what is appropriate to local needs in favour of imported methods which will not work, or which work only with expensive infrastructural support. To provide the training bases, the collation and dissemination of technical and cultural information are needed. Moreover, the regional institutions of higher education must be persuaded to incorporate these into courses.

The second kind of agroforestry, the high-technology systems, can more readily be accommodated within traditional teaching disciplines. The danger here is that they may be prescribed for situations in which they are inappropriate. In Papua New Guinea, for example, literally hundreds of cattle-grazing projects have failed, not because of any failure to transfer the technology of animal husbandry, but because the infrastructure (available in Australia and New Zealand) for such things as veterinary assistance, slaughtering, cool storage and marketing, has not been made available in areas where small-holder developments have been attempted. Again, the land tenure system in most of the Pacific Islands, cannot adapt to demands for undisputed title -- or long-term leases -- which the high technology agroforestry systems (whether tree crop or pasture-based) make.

Other important components of infrastructure requirements for agroforestry are financial. Major deficiencies in present forestry curricula in the region relate to such areas as the provision of finance, taxation, and marketing. Frequently there are discrepancies in the treatment of forestry and agriculture, of which the universities are unaware. The preparation of projects in a form suitable for bank (including international) financing is a complex art that is seldom taught at universities (as a result, the financing agencies rely heavily on expensive consultants who, all too often, are reluctant to depart from precedent or to offer the innovation which agroforestry needs).

## Final remarks

In all areas of agroforestry, it is important that the teaching approach be holistic. One regrettable consequence of specialization in all fields is a tendency to teach as if knowledge were kept in discrete packets, filed away in pigeon-holes (the compartments often so restrictive that no self-respecting pigeon would tolerate them). We leave it to the student to integrate these packets of information -- and we express surprise that he or she often neglects to do what we as teachers have conspicously failed to do. This is dangerous in any field; it is particularly so in an area which sets out *ab initio* to be integrative.

## Institutions Contacted in the Region

The list is not available.

. REGION: Indian Sub-Continent

. COORDINATOR: N.J. Joshi

. COUNTRIES COVERED: India, Pakistan, Afghanistan, Nepal, Bangladesh, Burma and Sri Lanka

. INSTITUTIONS CONTACTED: (not specified)

*The present report mainly deals with the status and needs of agroforestry education in India. No replies were received by the Regional Coordinator from other countries and institutions contacted in the region.

Need for professionally educated agroforestry personnel

The success of the Agroforestry/Social Forestry programmes, particularly of farm forestry, depends on the active involvement of the people. Farmers and villagers have to plant trees on their farms and community lands. They must, therefore, have some knowledge regarding how to plant and grow trees, why to plant trees, when to plant, which trees to plant, how to tend them etc. This knowledge will have to be given by Forest Extension workers at the village level. These extension workers themselves must be given training in agroforestry and extension methodology. To supervise the work of the extension workers at the block level and also to conduct courses to train them, a cadre of middle-level workers will be necessary. Higher education in agroforestry will be required for those who will be in charge of this programme at the district level and above, and for those who will be conducting research. Thus there is a necessity of having a three-tier agroforestry educational system comprising higher-level, middle-level and village-level education.

As per the Fuelwood Study Committee (1982) appointed by the Planning Commission, it would be necessary to have fuelwood plantations of over 1.5 million hectares and plant about 800 million trees under farm forestry, each year, if the fuelwood needs of the people are to

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*Ed's note.

be met. This brings the need for trained manpower to about 4500-5000 workers at village level, 1200 at the middle level, and 300 at the professional level.

Present level of agroforestry education

India has a well-developed system of imparting education in forestry through the various forestry schools and colleges and in agriculture through the agricultural universities. At present, however, no where in India does any institute offer a training course exclusively for agroforestry. But social forestry is now included as one of the subjects in forestry schools and colleges, while many universities have included forestry as one of the optional subjects for degree courses. Some agricultural universities have also started degree and postgraduate courses in forestry.

The Central Soil and Water Conservation Research and Training Institute at Dehra Dun (Uttar Pradesh) which has eight Regional Centres, offers 5 1/2-month long courses in soil and water conservation techniques in which forestry, including agroforestry, is taught. The Indian Grassland and Fodder Research Institute at Jhansi (Madhya Pradesh) also teaches agroforestry as one of the subjects in its 9-month course on forage development.

Possible development of agroforestry education

For the higher level, a National Institute of Agroforestry Education will have to be created for graduates in forestry and/or agriculture to undertake a one-year postgraduate course. The course content could include: silviculture, agronomy, sociology, social psychology, extension methodology, resource ecology and, of course, agroforestry systems.

For middle-level personnel, a six-to nine-month course at the regional level can be organized in existing forestry and agricultural institutes (see Tables 8 and 9). The training of forest rangers and students from agricultural schools should emphasize agroforestry extension methods. The syllabus of a six-month course on Social Forestry prepared by the Forestry Research Institute in Dehra Dun may serve as a model (see Appendix C).

TABLE 8

LIST OF FORESTRY COLLEGES IN INDIA AND PROGRAMME DURATION

| | | |
|---|---|---|
| 1. | Indian Forest College, Dehra Dun | 2-year course |
| 2. | State Forest Service College, Dehra Dun | 2-year course |
| 3. | State Forest Service College, Coimbatore | 2-year course |
| 4. | State Forest Service College, Burnihar | 2-year course |
| 5. | Northern Forest Rangers College, Dehra Dun | 1-year course |
| 6. | Southern Forest Rangers College, Coimbatore | 1-year course |
| 7. | Eastern Forest Rangers College, Kurseong | 2-year course |
| 8. | Central Forest Rangers College, Chandrapur | 1-year course |
| 9. | Forest Rangers College, Balaghat | 2-year course |
| 10. | Forest Rangers College, Rajpipla, Gujarat | 1-year course |
| 11. | Forest Rangers College, Angul, Orissa | 1-year course |
| 12. | Forest Rangers College, Jabalpur, M.P. | 1-year course |
| 13. | Forest Rangers College, Haldwani, U.P. | 1-year course |
| 14. | Forest Rangers College, Chikalda, Maharashtra | 1-year course |

TABLE 9

LIST OF STATE FORESTERS TRAINING SCHOOLS

1. Foresters' Training School, Chattarnag, Jammu & Kashmir.

2. Foresters & Training Class, Chota-Udeyapur, Baroda Circle, Gujarati

3. Foresters' Training School, Dandeli Kanara, North Division, Belagaum Circle, Mysore.

4. Forest Sruveyor Training School, Dandeli, Working Plan Division Plant Development Circle, Mysore.

5. Nicholson Forest School, Champua, Keonjhar Division, Angul Circle Orrissa.

6. Foresters' Training Division, Nainital, Working Plan Circle, Uttar Pradesh.

7. Lower Subordinate Forest Training School, Solan, Simla Circle, Himachal Pradesh.

8. Soil Conservation School, Solan, Chamba Forest Division, Chamba Circle, H.P.

9. Bihar Foresters' Training School, Chaibassa, District Singhbhum, Bihar.

10. West Bengal Forest School, Dow-Hill, District Darjeeling, West Benga.

11. Tamil Nadu Forestry Training School, Viagal Dam- 656512, Tamil Nadu.

12. Foresters School, Balaghat, Madhya Pradesh.

13. Assam Forest School, Jalukbari, Gauhati - 14, Assam.

14. Foresters Training School, Chandrapur, Maharashtra.

15. Dadashab Chaudhari Van Prashikshan Vidyalaya, Pal, District Jalagaon, Maharashtra.

16. Forest Training School, Pinjore, District Ambala, Harayana.

17. Andhra Pradesh Forest School, Yellandu, District Khamam - 507123, Andhra Pradesh.

18. Forest Training School, Alwar, Narain Villa, Rajasthan.

19. Kerala Forest School, Walayar Dam, District Palghat, Kerala State.

20. Foresters Training School, Haldwani, District Nainital, Uttar Prades

21. Forest School, Amarkantak, Madhya Pradesh.

22. Forestry Training School, Kakrapur, Madhi, District Surat, Pin - 394360.

23. Tripura Forest School, Golaghati, District West Tripura, Tripura.

For the village level workers, a short course -- four to six months -- can be organized at the state level. Subjects could include basic knowledge about silviculture and agronomy related to important local tree species and crops, nursery techniques, pest control, and others. The number of village workers to be trained is going to be so large that it would be necessary to create agroforestry schools in each state.

Several institutions are at present undertaking agroforestry research projects that could be linked to agroforestry education and training programmes. Among them, the Forest Research Institute (FRI) in Dehra Dun has a coordinated research project on growing cash crops in conjunction with forest species, in newly felled forest areas, with centres at Ranchi, Kurseong and Chandrapur. The FRI is also funding research on wind breaks and shelterbelts, carried out by the Punjab Agricultural University, Ludhiana and the Andhra Pradesh Agricultural University, Hyderabad. The FRI has also prepared a scheme on agroforestry research in different climatic zones for implementation during the Sixth Five Year Plan.

The Indian Grassland and Fodder Research Institute at Jhansi (Uttar Pradesh), The Central Soil Salinity Research Institute at Karnal (Haryana) and the Central Arid Zone Research Institute, Jodhpur (Rajasthan), all under the Indian Council for Agricultural Research (ICAR) also conduct research on agroforestry. The ICAR has also prepared a project for coordinated research on agroforestry for implementation during the Sixth Five Year Plan.*

It will not be possible to develop at once, the infrastructure necessary to train such a large number of personnel in India. Until this can be done, the present institutions will have to be taken advantage of for imparting training to existing forestry and agricultural personnel.

In the long run, however, there will have to be a separate cadre of agroforestry workers at all levels. In fact in Maharashtra a separate department of Social

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*Ed's note. The plan is in implementation.

Forestry has been created and in other states like Uttar Pradesh, Gujarati, etc. where social forestry projects with foreign assistance are under implementation, district social forestry or forestry extension wings have been set up in the forestry departments. In some states, forestry extension workers have been appointed for each development block.

Final remarks

In addition to the agroforestry education and training proposed, it will be necessary to organize frequent seminars and workshops for personnel at different levels, including field workers, social workers, research scientists, administrators and education specialists etc. The message of agroforestry will also have to be spread amongst the common people as well as school and college students through demonstration plots, exhibition films, slide shows, lectures and the press, radio and television. Celebrations like World Forestry Day, Vanmahotsava, etc., may also be established for agroforestry.

Institutions Contacted in the Region

The list is not available.

## REFERENCES


1. Anon. (1980). Task Force report on taking Forestry to people; Ministry of Agriculture, Government of India, New Delhi.

2. Anon. (1981). Proceedings of the Summer Institute on Agroforesry in Arid and Semi-arid Zones, Jodhpur.

3. Anon. (1976). National Commission on Agriculture; Report, Part IX, Forestry, Ministry of Agriculture & Irrigation, Government of India, New Delhi.

4. Anon. (1979). DSE/ ICRAF Seminar on International Cooperation in Agroforestry, Nairobi.

5. Anon. (1982). Report of the Fuelwood Study Committee - Planning Commission, Government of India, New Delhi.

6. Borthakur, D.N. (1979). Agroforestry based farming system as an alternative to jhuming; I.C.A.R., Agroforestry Seminar, Imphal.

7. FAO. (1981). Forestry and Rural Development, FAO Forestry Paper No. 26.

8. FAO. (1978). Forestry for local community development; FAO Forestry Paper No. 7.

9. Jagjit Singh & Rander, H.S. (1976). Workshop cum Seminar on Social & Forestry, Gandhinagar, Gujarat.

10. J. Sholto Douglas & Robert A. de J. Hart. (1982). Forest Farming.

11. Joshi N.J. (1982). Social forestry, Bhagirath, January 1982, Volume XXIX.

12. King, K.F.S. (1979). Some principles of Agroforestry (Key note address), I.C.A.R. & Agroforestry Seminar, Imphal.

13. Lahiri, A.K. & Ghosh D.(1976.) Workshop cum Seminar on Social Forestry, Gandhinagar, Gujarat.

14. Nair, K.K. (1979). Agroforestry as applicable to Southern hills; I.C.A.R. Agroforestry Seminar, Imphal.

15. Pande, D.C. (1973). Some thoughts on Forestry in relation to Agriculture; Indian Forester. Vol. 99 January - 73.

16. Paroda, S.S. and Muthana, K.D. (1978). Agroforestry practices in arid zone; I.C.A.R., Agroforestry Seminar, Imphal.

17. Rao, M. Sitaram (1980). Introduction to Social Forestry; Oxford and IBH Publishing Co. Bombay.

18. Sangal, P.M. (1981). Scope and implementation of Agroforestry in India, Indian Forester May, 1981.

19. Seth, S.K. (1981). India and Sri Lanka - Agroforestry; FAO publication.

20. Singh, G.P. (1979). Agroforestry as an alternative to shifting cultivation; Sixty Seventh Session of the Indian Science Congress, Gauhati, Assam.

- REGION: Western Europe
- COORDINATOR: Francis Halle
- COUNTRIES COVERED: Belgium, Denmark, England, Federal Republic of Germany, France, Italy, Luxembourg, Netherlands, Norway, Portugal, Scotland, Spain, Sweden and Switzerland.
- INSTITUTIONS CONTACTED: 29
- RETURNED QUESTIONNAIRES: 18

* The present report was submitted as a draft document as many answers were still missing at the time of presentation. The Regional Coordinator was unable to find adequate addresses of institutions in Italy, Spain, Portugal, Sweden and Norway. He also felt that the questionnaire was not well adapted to the European educational system, and this may have deterred some institutions from responding to it.

Need for professionally educated agroforestry personnel

Agroforestry research personnel and training/teaching staff are required in the United Kingdom, Germany, the Netherlands, Denmark and France, during the coming five years.

In West Germany, land resource planners and land resource management experts will also be required during the said period, together with environmental engineers, biotechnologists, landscape architects and landscape ecologists.

As for the general orientation of this personnel, it is very clear that they would be working in the tropics conducting either research projects, or practical field projects (planning, management extension). In general, the feeling is that agroforestry is of interest for tropical experts, not for local ones.

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*Ed's note.

As for the number of agroforestry-educated people needed in the region during the next five years, it varies from 10 to 20 in France, and from 5 to 25 in the Netherlands. A respondent from the United Kingdom said that "the need for agroforestry-educated people (in the UK) seems infinite, but to get things started the most important people to educate are the politicians."

Present level of agroforestry education

Agroforestry is at present almost negligible in Western Europe, as far as local land-use systems are concerned. Ancient and declining agroforestry traces are still visible in Scotland, in the Netherlands, in France (Britany, Cevennes) and in Northern Germany; most of it seems to be "hedgerow landscapes," and it is generally not classified nor understood as agroforestry. However, if awareness could be instilled that integration has advantages as compared with separating, one could expect more agroforestry in land use during the coming years in many marginal underpopulated places in Europe. For the Federal Republic of Germany alone, the scope of this possible extension is 0.3 to 0.6 million ha.

From the survey, one gets the impression that agroforestry might be of interest to ecology departments or some private ecological institutions or projects in the region, but it will not have significant importance either in Europe or in temperate countries. In general, the feeling is that agroforestry as a land-use system is likely to take place only in the tropics.

Agroforestry education is mostly included as part of graduate and/or postgraduate courses in forestry, land-use planning or ecology. An incomplete list of institutions in the region teaching agroforestry together with some information on their programmes is shown in Table 10.

Possible development of agroforestry education

In Denmark, a new course in tropical silviculture is planned to include agroforesty. No further details are available at the moment.

In England, agroforestry could easily be included in

TABLE 10

SOME INSTITUTIONS TEACHING AGROFORESTRY IN WESTERN EUROPE

| | |
|---|---|
| **Denmark** | |
| . Faculty of Forestry Kobenhavn | - AF is included in M.Sc. programme in Silviculture for one term (= 6 months) Prof. H.A. Henricksen and Dr. K. Sanojca, lecturers |
| . Federal Republic of Germany | |
| . Institut für Landespflege der Universität Freiburg | - Special seminar in AF is included in courses on Tropical Forestry and Forestry for Local Community Development |
| | - AF is part of International Forestry, Forest Development Policy, and Land-Use Planning courses at M.Sc. and Ph.D levels. Prof. Dr. H. Steinlin, lecturer |
| . Institut für Weltforstwirtschaft Hamburg | - Includes AF in lectures and seminars on Tropical Forestry Resources Prof. Dr. H.J. von Maydell, lecturer |
| . Forstwissenschaftliche Fakultat der Ludwing Maximilian Universität München | - AF lectures are included in Tropical Forestry courses |
| . Forstwissenschaftlicher Fachbereich der Universität Göttingen | - Same as above |
| **France** | |
| . Ecole Nationale de Génie rural et des Eaux et Forets Montpellier | - AF is included in a 2-year programme in Forestry |
| . Université de Montpellier Montpellier | - AF lectures are included in Tropical Ecology and Forestry programmes |
| . Centre National d'Etudes Agronomiques des Régions Chaudes Montpellier | - Same as above |
| . Ecole Nationale due Génie Rural et des Eaux et Forêts Paris | - Same as above |
| **The Netherlands** | |
| . Wageningen Agricultural University Wageningen | - Offers a short postgraduate course in AF during one semester at M.Sc. level, in Silviculture. The course is taught by staff from forestry, tropical agriculture and husbandry Prof. R.A. Olderman, K.F. Wiersum and C. Veer, lecturers |
| . International Institute The Haag | - AF is taught in Diploma (1 year) and M.Sc. (2 years) programmes |

the MSc programme at Bangor University.*

In the Netherlands, the Forestry Institute "Hinkeloord" will continue to integrate agroforestry aspects in all relevant disciplinary courses; but an interdisciplinary course is being planned.

In the Federal Republic of Germany, the Hamburg Institut für Weltforstwirtschaft is going to add agroforestry aspects in the lectures, and is also ready to provide facilities (although limited) for a seminar or short-term courses.

In France, the GERDAT project mentioned above and Montpellier University are ready to integrate more agroforestry in courses and research projects; possibly also Montpellier School of Agriculture.

## Final remarks

Responses from institutions in the region were diverse. While some people doubt that agroforestry training and education will become of real interest in the near future - except among agronomists, ecologists and biologists working in the tropics - others see agroforestry taking an increasingly important place in existing educational programmes.

Forestry and Agricultural Departments are seen to be too tied to traditional structures. Thus the progress is more likely to come from Ecology Departments or the like, which have broader views. No cumulative programme of existing subjects in other disciplines is expected to be successful because as Prof. R.A. Oldeman from Wageningen Agricultural University said "agriculture plus forestry does not equal agroforestry." In the meantime, as institutional changes take place, we should remember that: "Presently to give a talk on agroforestry is the best way to keep the students awake."[1]

## Institutions Contacted in the Region

See list in Appendix B.

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*Ed's note. The University College of North Wales in Bangor is at present offering a MSc degree in Environmental Forestry with a specific topic on "agroforestry and community forestry."

[1] Prof. F. Halle's remark

. REGION: Eastern Europe

. COORDINATOR: Marjan Kotar

. COUNTRIES COVERED: Yugoslavia and East Germany

. INSTITUTIONS CONTACTED: (not specified)

*Responses from institutions in this region were very poor. Information presented in this report covers only Yugoslavia and East Germany. The Regional Coordinator was unable to attend the Workshop. M. Kotar is a professor at the Univerza Edvarda Kardelja, VDO Biotehnisha Fakulteta, VTOZD za Gozdarstvo, 6100 Ljubljana, Vecna pot 83, Yugoslavia.

Need for professionally educated agroforestry personnel

Education in agroforestry is mostly related to forestry and to a lesser degree agriculture and, most probably, it is going to remain so. Within these two branches the demand for trained manpower is in the areas of land-resource planning, land-resource management, research and training/teaching.

Present level of agroforestry education

In Yugoslavia, agroforestry is included in several technical subjects such as silviculture, forest management, landscape tending, forest ecosystem management and others. Faculties offer graduate (Engineer) and postgraduate (M.A. and Doctor) degrees; an average of 200 students per year graduate from the forestry faculties.

In East Germany, agroforestry is a lecture topic mainly for students coming from developing countries attending courses at the Faculty of Forestry, Technical University of Dresden.

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*Ed's note.

## Possible development of agroforestry education

Agroforestry can successfully be expanded in existing forestry courses but greater emphasis should be given to the management systems aspect.

## Institutions Contacted in the Region

See list in Appendix B.

| | |
|---|---|
| . REGION: | North America |
| . COORDINATOR: | Francois Mergen |
| . COUNTRIES COVERED: | Canada, Hawaii, Puerto Rico and the continental United States |
| . INSTITUTIONS CONTACTED: | 100 |
| . RETURNED QUESTIONNAIRES: | 59 |

* Although the survey was intended to cover North American countries only, full consideration was also given to the educational needs of native and foreign students in North America who are interested in agroforestry of developing countries. The regional paper was presented by F. Mergen (who attended the Workshop) and Chun K. Lai, research assistant (who did not). F. Mergen thanked, in writing, the respondents for their cooperation and Mrs. Debbie Sterling who handled the correspondence and questionnaires. Financial support for this study was granted by the General Service Foundation to Yale University for work on "Resource - Population - Environment."

Need for professionally educated agroforestry personnel

There was a wide range of responses to the questions on the needs for professionally educated agroforestry personnel. Although the estimated number of agroforesters required in the next five years deviated from zero to hundreds, there was, in general, concensus on two points: 1) the greatest immediate need is for research and extension personnel, and 2) there is a need for agroforestry personnel to serve in developing countries.

a) North America

Two reasons that agroforestry practices are unlikely to be widely adopted in North America in the short-term future are, first, the high labour intensity of management involved and, second, the perceived incompatibility of many agroforestry systems with mechanization.

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*Ed's note.

However, the potential for agroforestry applications should increase in the areas of: integrated farm forestry; biomass energy production, multicropping schemes with valuable timber species; reclamation of mining, and planting of marginal sites with fast-growing, multiple-use trees, shrubs and plants; and small organic or mixed-farming systems.

Most of the work will be in the experimental or pilot stages. Therefore, continued support and funding is needed for the research efforts, as well as for the comparative analysis of research results. Extension work, and communication of appropriate agroforestry information needs to be provided to potential practitioners. One respondent speculated that about 500 extension persons could benefit from some agroforestry training in the U.S. alone. The training of existing agricultural extension workers, vis-a-vis short-term agroforest courses, is viewed as "the major action for quick results...in the U.S."

b) Developing Countries

There is much truth to the statement that: Agroforestry as a discipline is inextricably tied to the needs of developing nations because of the technical skills and education provided by foresters. The recent emphasis on agroforestry as an approach to dealing with some of the pressing problems in developing countries - deforestation, increased population and land-use pressures, and declining agricultural yields due to environmental degradation (Vergara, 1981) - has resulted in the increased demand for expatriate "experts" in aid projects. One respondent estimated that 100 professional personnel educated in agroforestry would be required for overseas assignments in the next five years.

Given the dearth of qualified and experienced "experts" in agroforestry, one cannot overstate the importance of relevant professional education for North Americans and foreign nationals destined for agroforestry work in developing countries. The revision of certain university curricula to allow for a tropical or international forestry option is a prerequisite for furthering the development of agroforestry education in North America (Kunkle, 1981).

Present level of agroforestry education

Presently in North America, there are no formal programs of education which deal specifically with agroforestry. The agroforestry teaching that occurs is summarized below, based on personal previous knowledge and on questionnaire responses, by province (Canada) or state (U.S.). As one can readily observe, agroforestry education occurs mostly in forestry schools rather than in agricultural colleges. At the undergraduate (B.Sc.) degree level, it exists mainly as just one component of introductory courses in tropical forestry or agriculture. At the graduate (M.Sc. and Ph.D) level, there are some extended opportunities to explore various aspects of agroforestry through thesis or special project work, seminars, and participation in related research.

c) Canada

The Department of Forest Science at the University of Alberta is unique in Canada (and probably in all of North America) in that there is an integrated faculty of Agriculture and Forestry. Although there are no specific courses devoted to agroforestry, this faculty framework allows the undergraduate student to pursue an integrated program leading to B.Sc degree in either Forestry or Agriculture.

This is done through the inclusion of courses relevant to agroforestry such as: soils, natural resource economics, plantation forestry, wildlife and animal productivity, horticulture, range management, remote sensing, entomology and pathology, linear programming, and decision systems.

The Forestry Department of the University of British Columbia has recently restructured its undergraduate program to include a new option in International Forestry. The student can choose a concentration in agroforestry by utilizing the framework of "elective" courses to develop competence in the areas of International Forestry and Range Management. At the graduate level, flexible programs may be designed in close cooperation with other faculties, especially in the Agricultural Sciences, to meet the individual needs of students interested in agroforestry. There is a strong "overseas component" in the graduate student body.

At the University of Toronto, the faculty of Forestry offers a one-year Diploma in Resource Management which is intended for experienced graduates who wish to upgrade their education or further their specialization. Agroforestry is one of the appropriate topics within the Diploma structure, which averages about six students per year for all disciplines, including agroforestry. Agroforestry principles are included as part of several undergraduate and graduate courses. The two graduate courses that deal most directly with agroforestry are "Forestry in the Developing World" and "The Tropical Moist Forest."

At Laval University, the faculty of Forestry and Surveying is in the process of developing a graduate (M.Sc) degree program in International Forestry. Some members of the faculty have done research and education work in the past decade in Zaire and Morocco. The Hassan II Institute of Agronomy and Veterinary Sciences (Morocco) has entered into a cooperative agreement with Laval for a new International Forestry program. This should help to pave the way for exchange programs, especially from francophone Africa, involving faculty and students with mutual research interests. In addition, it will create new opportunities for students wishing to study agroforestry.

d) Hawaii

At the University of Hawaii at Honolulu, agroforestry is dealt with indirectly through courses in tropical agronomy, tropical soils, range management and resource economics, but an "Interdepartmental Program in Tropical Forestry" has recently been proposed to the University administration. As a first step, an undergraduate course in "Tropical Forestry" will be jointly offered by the Botany and Horticulture Departments in 1983; a seminar on the subject was also under discussion. Both will have an agroforestry component.

About one-half of the graduate students are foreign and many American students have or will work abroad - often in developing countries. Therefore, the educational and research emphasis "aims at the small farmer...where trees are often part of the mixed-crop system."

A number of graduate students are involved in "farm forestry" -- primarily through the Departments of Agronomy and Soils -- studying tree use in farming systems. This requires an interdepartmental base of studies in economics, pest management, animal science, engineering, and other disciplines, as well as core studies in agronomy, soils, botany and horticulture.

The East-West Center has been described as the leading institution for agroforestry training in Hawaii. The Center conducts, in cooperation with relevant government agencies, training seminars on agroforestry for extension agents in the South Pacific and the Southeast Asia Regions. Seminars have been coordinated in the past on legume tree based agroforestry for forestry extension and rural development officers in the Philippines. The basic training material is a packet -- based on a Workshop on Agroforestry in Hawaii conducted in November of 1981 -- entitled "New Directions in Agroforestry: The Potential of Tropical Legume Trees" (EWC, 1982).

e) Puerto Rico

The responses from Puerto Rico indicated that no agroforestry education exists there. There is some potential for integrating agroforestry principles into existing courses in ecology and biology at institutions such as the University of Puerto Rico at Mayaguez, Rio Piedras, and Cayey, the Inter-American University, and the Catholic University. Currently there is no forestry program at the University of Puerto Rico.

f) United States (Continental)

It is obvious that U.S. forestry schools, in general, have a weak international component. One survey of 41 accredited forestry schools revealed that less than one-quarter of the schools offered courses in world forestry, tropical forestry, or international resource management (Neff, 1982). Because most of the limited agroforestry teaching occurs at forestry schools, it becomes evident that until the international forestry component is strengthened, the prospects for institutionalizing agroforestry education in the U.S. will remain dim. The main exception to this generalization is in the area of biomass energy and farm forestry. Education extension, and research programs on integrating tree biofuel production into

farming systems can be expected to expand.

The University of California at Berkeley has an active program in agroforestry education in the U.S. today. Although no formal degree program exists, graduate courses are offered in agroforestry, land management in agrarian countries, social analysis of local resource management systems, and community management of resources. Faculty are jointly presenting seminars on the agroforestry concept; two were presented in 1981-82, and more seminars may be offered in 1982-83. For students focussing on agroforestry as their area of emphasis, the planned annual output is one Ph.D. and three M.Sc. degrees. These are being done in various aspects of agroforestry.

Opportunities for studying agroforestry are present at the Yale University School of Forestry and Environmental Studies. Agroforestry concepts and applications are covered in three graduate courses: "International Natural Resource Problems" (Fall and Spring terms) and "Tropical Forest Ecosystems." In addition, graduate students are involved in research on various aspects of the subject -- biological, political-economic, and socio-cultural -- by taking Special Projects courses offered by faculty with interest in agroforestry. In the past, the school sponsored field trips to the tropics which allowed examination of agroforestry activities, and students are also working in tropical forests on their Ph.D research. An "International Symposium on Tropical Forests" was held at the school during April 15-16, 1980 which discussed among other issues, the potential for applying agroforestry systems in developing countries (Mergen, 1981). The school is anxious to develop a master's program in Tropical Studies which when implemented, will undoubtedly expand the scope of agroforestry teaching at the graduate level.

The University of Florida at Gainesville houses both Forestry and Agronomy Departments where programs are tied to intensely managed forest ecosystems related to agroforestry. Program support from government funding is around US $2 million per annum. Graduate output per year is estimated at 40 students for the B.Sc. degree, 15 for the M.Sc. and 3 for the Ph.D. degree. The Department of Forestry at the University of Kentucky offers several courses which include some

agroforestry, especially with regard to its potential applications in the reclamation of surface mining spoils.

The College of Forest Resources at the University of Maine at Orono is increasing its involvement in tropical forestry. A "Tropical Timber Seminar" was planned to be offered during the 1983 spring term. Courses in "Foreign Wood Properties" and "Woodlot Management" are under discussion. All three courses are amenable to the inclusion of agroforestry principles. An International Forestry Symposium was organized by the College in February of 1981. In addition, the College of Agriculture currently offers a two-semester course on "Tropical Soils and Crops." There have been suggestions to expand the course to four semesters to include coverage of domestic animals and forestry in the tropics.

Agroforestry receives limited attention at the University of Massachusetts Department of Forestry. One graduate course, "Advanced Forest Economics," does cover the economic analysis of agroforestry projects. Other courses cover arboriculture and shade tree.

The Department of Forestry, Michigan State University offers courses in tree physiology and tree improvement which include agroforestr in the context of agronomic intercropping in tree sc -chards. Special lectures are given occasionally on agroforestry subjects; related special topic courses are jointly presented by the Forestry, and Crop and Soil Science faculties.

The school of Forestry at Oregon State University is initiating extension and research programs related to agroforestry. A short-term course was being planned for April-May, 1983.

There is little interest in agroforestry at the Pennsylvania State University Department of Forestry. However the Faculty of Agriculture presents a course on "Problems in Agriculture in Tropical Areas" which addresses agroforestry and includes a two-week field trip to Puerto Rico.

The College of Forestry at the University of Washington has an established center for International Studies. However, agroforestry education is limited

to one undergraduate course in range management, and one (expanding to two in 1983) graduate course in tropical forestry. Because of the importance of research in this area in the U.S. and the potential implications for widespread adoption of tree crops by farmers, the details of two biomass energy research programs are given.

The Department of Forestry at the University of Illinois at Urbana has promoted the agroforestry concept since the early 1970s. However, even indirect funding for agroforestry work via biomass energy research did not materialize until the end of the decade. In 1982 direct pilot funding was available for two projects: "Farming and Forestry -- an integrated approach" and "Bio-energy Conversion Systems: an on-the-farm study for converting local biofuel to heat energy for grain drying and space heating." These two programs have already made significant progress, including the following achievements: a) establishment of over 100 acres (40 ha) of agroforestry research plots including black walnut (*Juglans nigra* L.), and *Paulownia* spp. in forage/hay settings with trees at variable spacings from 10 by 10 feet (3 x 3 m) up to 65 by 65 feet (20 x 20 m); b) establishment of 4 acres (1.6 ha) of various nut producing trees; and planting of 10,000 seedlings of species with potential for strip biomass production -- autumn olive (*Elaeagnus umbellata* Thunb.), sycamore (*Plantanus occidentalis* L.), black locust (*Robinia pseudoacacia* L.), and black alder (*Alnus glutinosa* L. Gaertn.) -- to test the compatability of biomass strips with conventional zero-till herbicides used for corn (*Zea mays*), soybean (*Glycine soja*) and grain sorghum (*Sorghum vulgare*). Further plot work is planned with white pine, black walnut, yellow poplar (*Liriodendron tulipifera* L.), and possibly thornless honey locust (*Gleditsia triacanthos* L.).

Agroforestry research is conducted by the Caesar Kleberg Wildlife Research Institute at Texas University. It is primarily focused on agroforestry systems which employ *Leucaena* spp. for multiple purposes: fodder, agricultural intercropping, and biofuel for conversion to ethanol.

Government funding is approximately US $120,000 per year. About one graduate (M.Sc. in Agriculture) per

year receives informal agroforestry training through participation in research and review of scientific literature.

Possible development of agroforestry education

Perhaps the largest obstacle to the development of education programs in agroforestry is the separatist view of many North American educators of agriculture and forestry as distinct disciplines and professions. Recognition of this immense problem is reflected in respondents' observations:

- "The integration of two major disciplines (agriculture and forestry) in the U.S. because of the extreme range of conditions, will be a complicated one."

- "Our educational process has become so highly specialized that very little interaction is encouraged between the forester, the range scientist and the agronomist.... We need both closer cooperation between the disciplines and individuals with broader training."

- "Frankly, the competition for land between forestry and agriculture is one which impedes progress in many, if not all, developing countries. If we can build a bridge between forestry professionals and agriculturalists, we may be able to break down the barriers often encountered in overall land-use policy and planning in these countries."

Theoretical Knowlege

A broad interdisciplinary base of knowledge is required for the agroforester. The following types of university courses have been suggested as building blocks for a strong, theoretical foundation:

1. An introductory course which defines agroforestry: its objective, methodology, practical experience, and gaps that exist at present.

2. Courses on technical, economic, and social design and analysis of agroforestry systems including: a) tropical agriculture and forestry crops; appropriate establishment and crop husbandry techniques; range of expected yields;

role of fertilizers, pesticides and mulches, and common pests and disease; b) economic analysis techniques relevant to agroforestry projects: shadow pricing, quantification of costs, benefits and externality considerations; c) sociological aspects of agroforestry development: importance of local participation in project design (World Bank, 1980a); d) applied sociology and anthropology in preparation for assignments in developing countries.

3. Courses on the management and use of agroforestry systems as components of diversified patterns of land use (World Bank, 1980b).

4. Courses on agroforestry as a developmental intervention at local levels (FAO, 1978a, 1979b).

5. Courses on the administration and management of farmer-oriented forestry programmes with emphasis on: a) small-scale institution building and technical assistance activities as pre-requisites to large-scale development programs; b) the need for relevant public administration experts who are sensitive to local conditions; c) analysis of policies affecting levels of agroforestry investment.

6. Courses on effective extension programs, including the use of mass media, training packets, and demonstration plots.

Practical experience.

While a solid, theoretical background is necessary, it must be combined with extensive day to day, practical experience in field work. Because little is known about agroforestry species,... "it is essential that agroforestry specialists be very well grounded and experienced in experimental problem-solving techniques."

For the agroforester to be proficient as a problem-solver, practical experience and research are needed in the following areas:

1. Propagation requirements and techniques for agroforestry species. For example, it is not known whether Acacia albida del. is

self-fertile, if it can outcross, or if it obligately outcrosses. This must be determined to decide whether to propagate asexually or by seed.

2. Seed collection, cataloging and storage of seeds. We need the creation of seed banks for certain species and an exchange of germplasm.

3. Nursery techniques such as: a) seed separation and germination, and b) rhizobial and mycorrhizal inoculation.

4. Outplanting techniqies including: a) manual and machine planting of bare-root and containerized seedlings, and b) the determination of optimal outplanting time based on soil moisture and rainfall criteria.

5. Experimental design considerations for field plots:
   a) border effects
   b) randomized, complete block design
   c) latin-square, and
   d) statistical analysis

6. Basic agricultural fungicides, insecticides, and herbicides and calibration procedures for their proper application.

7. Determination of total above and below ground biomass:
   a) harvesting techniques
   b) dry matter determination, and
   c) allometric methods for non-destructive biomass determination.

Teaching Materials.

The lack of teaching materials (and expertise) is a major constraint to the development of agroforestry education. As one respondent pointed out: "At present, the best training and education would be built into investigative processes that generate eventually teachable material."

The development of quality "training packages" has been advocated by some respondents as an alternative to short courses or seminars which suffer from logistical complexities, high cost and time

constraints. These "packages" may consist of textbooks, anthologies for independent reading, practical exercises, individual materials and instructors' guides. The main advantage is that high quality teaching materials, relevant to agroforestry, should be easily available to institutions and individuals for formal courses and independent study (Tschnikel, 1982). It is desirable that regional depositories of training materials (e.g. - CATIE, ICRAF) be identified.

Further along these lines, a new program structure has been proposed for agroforestry at the degree-level which would utilize a "degree-program package" that contains a program outline as well as much of the basic teaching material. Such a "package" could be formulated by an international team of experienced curriculum developers, agroforestry educators, and researchers. This approach should be flexible enough to accommodate local or regional conditions while still maintaining the basic integrity of the "program package" (Huxley, 1980).

Examples of materials which could be potentially used with little or no modification for agroforestry teaching include, e.g.:

- Agroforestry Species, A Crop Sheets Manual (ICRAF, 1980a)
- A Study of Tree Crop Farming Systems in the Lowland Humid Tropics (World Bank, 1980b)
- Firewood Crops: Shrub and Tree Species for Energy Production (NAS, 1980)
- International Cooperation in Agroforestry (ICRAF, 1980b)
- Leucaena: Promising Forage and Tree Crop for the Tropics (NAS, 1977)
- New Direction in Agroforestry: The Potential of Tropical Legume Trees (East-West Center, 1982)
- Plant Research in Agroforestry (ICRAF, 1982)
- Proceedings of Workshop on Agroforestry Systems in Latin America (CATIE, 1979)

- Reforestation in Arid Lands (VITA, 1977)

- Tree Crops for Energy Co-production on Farms (SERI, 1980)

- Tropical Agroforestry -- A Bibliography (CATIE, 1981)

- Tropical Legumes: Resources for the Future (NAS, 1979)

- Underexploited Tropical Plants with Promising Economic Value (NAS, 1975)

- Viewpoints on Agroforestry (Wiersum, 1981).

In addition, the ICRAF Newsletter and the Agroforestry Bulletin (CATIE, UNU and IUFRO) are sources of information on new agroforestry research activities.

Recommendations

While the gestation of agroforestry as a discipline is underway in North America, its birth appears to be neither immiment nor easy. From the many veiwpoints represented in this survey, it is obvious that considerable discussion is required before agroforestry education can be institutionalized. As a first step, there is a great need to obtain a concensus of what agroforestry is, and can or cannot provide. It is important that the interested parties have a "common ground" for reference so that semantic bickering can cease.

The following recommendations are made in the hope that some tangible, short-term progress is realizable while the ground work is laid to ensure that the long-term needs of agroforestry education are met:

1. Facilitate the integration of agriculture and forestry. Because agroforestry is a new field in North America, its "birth" is dependent on the "marriage" of the two major disciplines it is based on:

   a) facilitate the establishment of "interdepartmental" university programs at institutions which already have programs in forestry, agriculture and animal sciences, especially those with tropical components.

The proposed program at the University of Hawaii may, with modification, serve as a prototype.

b) encourage the formation of "integrated" faculties. The combined expertise of an integrated Faculty of Agriculture and Forestry (University of Alberta) would place them in the best position to offer relevant courses in agroforestry and to work toward the development of a full program (Contant, 1980).

c) provide agroforestry training to both agronomic and forestry extension agents.

2. Concurrent support and development of research and operational programmes along with educational programs. The basic lack of research to support the development of agroforestry courses is well recognized. One respondent wrote: "Most literature is discursive, advocative and generally unscientific. Scientific efforts are primarily inductive and very limited in general value.... If training and education are treated apart from operational research needs, we will get poorly trained people and too many operational failures to withstand the normal impatience of governments. It is necessary to construct operational research along with educational programmes."

3. Development, production and dissemination of suitable materials for agroforestry teaching. This will require the coordination of efforts by international and regional organizations active in agroforestry: e.g. ICRAF, IUFRO, UNU, CATIE, FAO, AID, IITA. Innovative approaches to agroforestry education such as "modular teaching packages" (Contant, 1980; Huxley, 1980) should be explored.

4. "Twinning" arrangements between institutions in developing countries and comparable ones in North America. The twinning of research and educational agencies in developing countries with agencies in developed nations has been advocated by the World Bank and FAO (1981) as a means of strengthening research institutions. This concept could and should be applied to educational institutions as well. The twinning of universities with mutual interests in agroforestry would not only serve an "institution

building" function, but would also greatly benefit both North American and foreign students. The North American institutions would be able to provide the proper theoretical coursework, while universities in developing countries would make available opportunities for practical field experience. The existing joint programs between North America and foreign institutions should be strengthened.

Institutions Contacted in the Region

See the list in Appendix B.

## REFERENCES


CATIE. (1979). Proceedings of a Workshop on Agroforestry Systems in Latin America. CATIE, Turrialba, Costa Rica, 220p.

CATIE (1981). Bibliography on Tropical Agroforestry. CATIE, Turrialba, Costa Rica, 67pp.

Contant, R.B. (1980). "Training and education in agroforestry." In: International Cooperation in Agroforestry, Chandler, T. and D. Spurgeon, eds. ICRAF, Nairobi, 469pp.

FAO. (1978a). Forestry for Local Community Development. FAO Forestry Paper. No. 7, Rome, 144pp.

FAO. (1979b). Forestry for Rural communities. FAO., Rome, 56 pp.

Huxley, P.A. (1980). "Agroforestry at degree-level: new program structure." In: International Cooperation in Agroforestry, Chandler, T. and D. Spurgeon, eds. ICRAF, Nairobi, 569pp.

ICRAF. (1979). Soils Research in Agroforestry, Proc. of Expert Consultation, Mongo, H.O. and P.A. Huxley, eds., ICRAF, Nairobi, 584 pp.

ICRAF. (1980a). Agroforestry Species, A Crop Sheets Manual. In: Nair, P.K.R., ed. ICRAF, Nairobi, 335pp.

ICRAF. (1980b). International Cooperation in Agroforestry. In: Proc. of Intl. Conf., July 16-21, 1979, Nairobi, Chandler, T. and D. Spurgeon, eds. ICRAF, Nairobi, 469pp.

ICRAF. (1982). Plant Research in Agroforestry, Proc. of Consultative Meeting. Huxley, P.A., ed. ICRAF, Nairobi, 2 vols. (in press).

Kunkle, S.H. (1981). Improving linkages of forestry professionals with USAID forestry programs - the US connection. Discussion paper presented at Joint Intl. For. Working Group/World For. Comm. of SAT/ISTF Technical session, 1981 SAF Natl. Convention, Orlando, FL, USA, 8pp.

Mergen, Francois. (1981). ed. Tropical Forests: Utilization and Conservation. Yale University, New Haven, CT, USA, 199pp.

NAS. (1977). Leucaena: Promising Forage and Tree Crop for the Tropics. NAS, Wash. D.C., USA, 118 pp.

NAS. (1979). Tropical Legumes: Resources for the Future. NAS. Wash. D.C., USA, 331pp.

NAS. (1980). Firewood Crops: Shrub and Tree Species for Energy Production. NAS. Wash. D.C., USA, 237pp.

Neff, J.W. (1982). Forestry curricula: the missing international perspective. J. of For. 80:12-13.

SERI. (1980). Tree Crops for Energy Co-production on Farms. Proc. of Conf. Nov. 12-14, 1980, Estes Park, Colorado, sponsored by US Dept. of Energy. 260pp.

Tschinkel, H. (1982). The production and distribution of training packages for natural resources management in developing countries. USAID/ROCAP, San Jose, Costa Rica, 7pp.

Vergara, N.T. (1981). Integral agroforestry: a potential strategy for stabilizing cultivation and sustaining productivity of the natural environment. Working Paper, East-West Center, Honolulu, HI, USA, 33pp.

VITA. (1979). Reforestration in Arid Lands. VITA, Mt, Ranier, MD, USA, 248pp.

Wiersum, K.F. (1981). Viewpoints on Agroforestry. Editor Agric. Univ. Wageningen, The Netherlands, 185pp.

World Bank. (1980a). Sociological aspects of forestry project design. AGR Techn. Note No. 3, World Bank, Wash. D.C., 100pp.

World Bank. (1980b). A Study of Tree Crop Farming in the Lowland Humid Tropics. World Bank, Wash DC, vol. 1, 191pp +Tables.

World Bank/FAO. (1981) Forestry research needs in developing countries; time for a re-appraisal? Paper presented at 17th IUFRO Congress, Sept.6-17, 1981, Kyoto, Japan, 56pp.

| | |
|---|---|
| . REGION: | Central America |
| . COORDINATOR: | Gerardo Budowski |
| . COUNTRIES COVERED: | Costa Rica, Cuba, Dominican Republic, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua and Panama |
| . INSTITUTIONS CONTACTED: | (not specified) |

*The present appraisal is based on questionnaires and personal knowledge of the Regional Coordinator who has been actively involved in agroforestry training in the region since 1976. In general, the response to questionnaires was low.

Present level of agroforestry education

At the postgraduate level, only Chapingo in Mexico and Centro Agronómico Tropical de Investigación y Ensenañza (CATIE) in Costa Rica offer agrofrestry. CATIE as an international center receives students from many Latin American countries while Chapingo is organized to fulfill Mexican needs. CATIE also accepts a small number of candidates from other universities working towards a degree, to undertake field research in agroforestry. Over 50 scientists, more than half of them at the Ph.D. level, are involved in agroforestry at CATIE.

At the graduate level (B.Sc. equivalent) several schools of forestry as well as agriculture include agroforestry aspects in the academic programmes. The following list is probably incomplete:

| | |
|---|---|
| Costa Rica | Escuela de Ciencias Ambientales, Universidad Nacional, Heredia, Instituto Tecnológico, Cartago; Escuela de Biología, Universidad de Costa Rica. |
| El Salvador | Facultad de Agronomía |

*Ed's note.

| | |
|---|---|
| Guatamala | Universidad de San Carlos, Facultad de Agronomía, Universidad Saldivar, Facultad de Ciencias Ambientales. |
| Honduras | Facultad de Agronomía y de Ciencias Forestales, la Ceiba. |
| Jamaica | University of the West Indies |
| Mexico | Universidad Autónoma, Chapingo; Colegio Superior de Agricultura Tropical, Cárdenas; Escuela Superior de Agricultura Antonio Narro, Saltillo. |
| Nicaragua | Universidad Centro-americana, Escuela de Biología; Facultad de Agronomía. |

No data came from other agricultural and forestry schools in Mexico and Cuba, nor from the faculties of agriculture in Dominican Republic and Port au Prince (Damien) in Haiti, although there is possibly some agroforestry being taught.

At the undergraduate level, training in agroforestry has largely rested with the forestry schools. The Central American Forestry School, located in Siguatepeque (Honduras), deserves to be mentioned because of its international status, staffed with high quality teachers (several of them seconded by FAO and other international cooperation agencies) and a three-year curriculum.

In terms of short courses, conferences, symposia, workshops, etc. in agroforestry CATIE, on a regional scale, has organized the following:

a) Three courses lasting 11-12 days each were held, two at CATIE and one in Mexico, the latter covering a wide area and being eminently practical. For each course an average of 25 students from many countries were involved as well as 5-10 professors. The courses were very intensive but did not go in depth. The amount of well prepared practicals and the exposure to a relatively large number of agroforestry systems was a distinct advantage - the Mexican course was partly called "research methods in agroforestry." In all three courses it was possible to

obtain sponsorship from international organizations (UNU, DSE and AID respectively). CATIE foresees three more courses in the next two years.

b) A Latin American workshop was held in 1979 with emphasis on the humid tropics; two international seminars and a Latin American Conference on forestry with a large input from agroforestry, also were held during 1981-1982.

c) Study tours for selected groups interested in agroforestry have become quite common at CATIE. They last from a few days to several weeks and are sponsored by national, bilateral (AID, DDA) and UN organizations (FAO, UNU).

d) In-service training has been provided since 1978 with the sponsorship of the United National University (UNU). UNU "fellows" come to CATIE for about six months. Whenever necessary they take a six week crash course in Spanish. They spend most of their time in carrying out research projects and attending courses. As of 1982 twelve fellows have qualified: 5 from Thailand, 2 from Tanzania, 2 from Indonesia, 1 from Nigeria, 1 from Peru and 1 from Venezuela. The evaluations show this "south-south" flow to be highly satisfactory.

One tangible result of all these activities has been the projection of a large number of publications and teaching materials that have been very much in demand in the region.

There are abundant examples of agroforestry in the region with a few that can provide demonstrations and/or research material for teaching agroforestry. (Budowski 1981). To mention a few: a) coffee with low kept shade trees with or without a third high canopy of timber or other useful trees; b) cocoa with shade trees and a third canopy; c) pasture for dairy farms and planted trees in the highlands; d) trees in lowlands with pastures; e) pine (various *Pinus* spp.) and pasture; f) browsing, mostly by goats in dry or semi-desert areas (Mexico and some Caribbean islands); g) shelterbelts around cotton fields (Nicaragua); h) *taungya* with teak (Trinidad) and pines (Belize and Mexico) and others. Research conducted at CATIE and Jalapa in Mexico also includes quantification of

benefits from mulch, nutrients (particularly N) and fodder from leguminous trees used in coffee-farms or cutgrass. There are also trials with Leucaena, Erythrina and Gliricidia for alley cropping.

Some training material has been produced at CATIE. A list of publications including over 150 references dating from 1976 onwards is available (CATIE 1982), and many are available from CATIE free of charge.

Possible development of agroforestry education

In order to improve the conditions that would lead to stronger agroforestry programmes in the region -- whether at undergraduate, graduate or postgraduate levels -- there is an imperative necessity to:

- undertake quality research on existing agroforestry practices with data on biologic, economic and social parametres including, whenever possible, comparisons with alternative land-use schemes.

- strengthen funding schemes to establish regular training programmes.

- promote channels of communication and interaction among all disciplines related to land use.

- develop teaching aids adapted to different conditions and improve the distribution mechanisms of such training materials.

Final remarks

There is the strong feeling that the ill-defined scope and boundaries of agroforestry have prevented a better understanding of an integrated approach to training programmes. This may be compounded by rigid local administrative structures (Budowski 1982), even those of international funding organizations where agroforestry does not "fit" into traditional divisions.

Institutions Contacted in the Region

The list is not available.

## REFERENCES


Budowski. (1981). Quantification of current agroforestry practices and controlled research plots in Costa Rica. A paper submitted to the Consultative Meeting on Plant Research and Agroforestry, ICRAF, Nairobi, 24 p. 1982.

Budowski. (1982). Applicability of agroforestry systems. In: Agroforestry in the African Humid Tropics. Proceedings of a Workshop held in Ibadan, Nigeria, 27 April - 1st May, 1981. L.H. MacDonald Ed. United Nations University, Tokyo, 163p, pp. 13-16.

CATIE. (Nov., 1982). Lista de documentos mimeografiados del Departamento de Recursos Naturales Renovables (Lista No. 2). CATIE Turrialba 41 p.

Combe. J., Jimenez, J.H. and Monge C. Comps. (1981). Bibliography on Tropical Agroforestry. CATIE, Costa Rica. Serie Bibliotecología y Documentación No. 6. 67 p., 680 refs.

FAO/SIDA. (no date) Informe del Seminario FAO/SIDA sobre el fomento de la educación forestal en America Latina, FAO, ROMA. 78 p.

- REGION: South America
- COORDINATOR: Jean Dubois
- COUNTRIES COVERED: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Perú, Suriname, Trinidad, Tobago, Uruguay and Venezuela.
- INSTITUTIONS CONTACTED: 130
- RETURNED QUESTIONNARIES: 18

Need for professionally educated agroforestry personnel

Awareness of the importance of agroforestry land use in the region in general is non-existant or incipient and agroforestry research and development, so far, very limited. Thus the need for professionally educated agroforestry personnel is seen in the area of research. Well-trained research officers should be produced in adequate numbers and allowed to use part of their time to lecture on agroforestry in faculties and technical schools, and to train extension personnel. The required number of agroforestry research personnel for South America can only be estimated: Argentina (8), Bolivia (4), Brazil (28), Chile (6), Colombia (12), Ecuador (6), Guyana (1), Paraguay (2), Perú (8), Suriname (2), making a total of 90 professionals.

In Colombia, where agroforestry development is more substantial, training of personnel may also include land resource planners (3), land resource managers (5), extensionists at graduate level (6) and at middle level (30).

Present level of agroforestry education

Argentina - No specialized courses in agroforestry are offered or so far being planned. Some aspects of agroforestry are included in agronomy, forestry and cattle farming courses at the Universidad Nacional de Cuyo in Mendoza province.

Brazil - A specific agroforestry course (10 hours) was officially included in the curriculum of the Forestry Department, Faculty of Agrarian Sciences in Para, Belem. A course in agroforestry (20 hours) including field work was taught in 1982 at the same Faculty to postgraduate students in forestry (see description in Appendix D)

The Agronomy Department at the Federal Rural University in Pernambuco, Recife offers a 5-hour course on agroforestry as part of the graduate programme on "Regional Forestry."

Chile - A section on silvopastoral systems (3 hours per week during one semester) is being taught as part of a graduate course on forest management for arid regions in the Department of Forestry, University of Chile in Santiago. The course content covers the following: i) problems of arid zones, ii) production and productivity in arid zones, iii) silvopastoral systems in use in Chile: management, plant-soil relationships and present status of silvopastoral systems in semi-arid zones.

Colombia - No specialized courses in agroforestry are being taught. However, a section of a graduate course on "Agroforestry" at the Faculty of Agronomy in Caldas University is devoted to agroforestry.

Perú - Some agroforestry lectures are included in graduate courses on topics such as Forestry and Economic Development, Ecology and Development and Natural Resources Policies at the National Agrarian University, La Molina in Lima.

No information is available from other countries in the region, probably as there is no agroforestry included in existing programmes.

Possible development of agroforestry education

At the postgraduate level, a short course (2 hours duration plus one session of practice) is being planned to start in 1983 at the Forestry Department of La Molina in Peru. M.Sc. level students will have the opportunity to present their theses on agroforestry topics. At the Faculty of Forestry Sciences in Curitiba, Brazil, M.Sc. theses on agroforestry are beginning to be accepted.

At the graduate level, the Faculty of Agronomy in Pelotas, southern Brazil, is contemplating the introduction of agroforestry aspects in "silviculture" courses and the Faculty of Forestry Sciences in Curitiba; also Brazil, is planning to include a 60-hour course in agroforest y.

The main restriction to the effective development of agroforestry education in the region is linked to the present lack of adequately trained and experienced professional personnel.

Interestingly, some respondents stressed the need to elaborate education programmes in agroforestry based on local/regional conditions and think, therefore, that agroforestry teaching will be consolidated only when enough knowledge has been generated. Surveys of existing land uses and research implementation are seen as a priority.

Only one respondent felt that fellowships are necessary to training personnel abroad. This may indicate a general conviction that professional personnel should be trained locally, amongst local conditions and traditions.

Institutions Contacted in the Region

See the list in Appendix B

# APPENDIX A

## QUESTIONNAIRE ON PROFESSIONAL EDUCATION IN AGROFORESTRY

Please give answers on extra sheets as necessary

NAME AND ADDRESS OF PERSON RETURNING QUESTIONNAIRE INCLUDING ORGANISATION AND POSITION.

BACKGROUND QUESTIONS - Please answer from your general knowledge of the situation if you are unable to give specific data, and elaborate as much as possible.

1. To what extent are agroforestry land-use systems being practiced in your country? Indicate what kinds of systems. Are they successful?

2. Are there opportunities to introduce new systems of agroforestry? If so, of what kind?

QUESTION ON THE NEED FOR PROFESSIONALLY EDUCATED AGROFORESTY PERSONNEL - Please answer as fully as possible

3. What types of professional personnel educated in agroforestry may be required in your country in the next five years?

   Land resource planners
   Land resource management experts
   Extension personnel
   Research personnel
   Training/teaching staff
   Others (designate)

   (Also add estimates of numbers (and level of speculation about these) for the next five years for the above categories if at all possible.)

QUESTIONS ON THE PRESENT LEVEL OF AGROFORESTRY EDUCATION - (Please provide any documentation providing further information, if this is available)

4. Indicate, with complete addresses, the institutes in your country (including your own) which are now teaching professional personnel in agroforestry (certificate, diploma, degree or higher degree levels). If such education is actively being planned at this time please indicate this separately.

   Briefly describe for each Institute/Faculty

   a) Type of programme or course
   b) Duration
   c) Professional qualification obtained
   d) Approximate output (by year)
   e) Approximate level of government or other financial support for agroforestry education and the staff and material inputs allocated to these courses/programmes.

## QUESTIONS ON THE POSSIBLE DEVELOPMENT OF AGROFORESTRY EDUCATION

5. What existing activities (or plans) may effectively increase the scope of existing professional teaching of agroforestry? For example:

   a) Are there existing courses in land use/land management subjects, ecology, biology, etc. which could easily include agroforestry.

   b) Are there facilities for establishing short-term courses or seminars on agroforestry, if this is considered necessary.

## CONCLUSIONS

6. What other pertinent information can you contribute regarding the needs for professional education in agroforestry in your country over the next decade.

7. Please add any other comments or views if you wish.

Section 1 APPENDIX B*

## INSTITUTIONS CONTACTED BY REGIONAL COORDINATORS

### ANGLOPHONE AFRICA

1. The Head, Forestry Department, Ministry of Agriculture, Private Bag, 34 Gaborone, Botswana

2. African Timber Organization, P.O. Box 1077, Libreville, Gabon

3. The Head, Forestry Division, Department of Agriculture, Yundum, W.E. Gambia

4. The Dean, Faculty of Agriculture, University of Ghana, P.O. Box 68, Legon-Accra, Ghana

5. The Dean, School of Agriculture, University of Cape-Coast, Cape Coast, Ghana

6. Forest Products Research Institute, University P.O. Box 63, Kumasi, Ghana

7. Forestry Department, P.O. Box 527, Accra, Ghana

8. The Dean, Faculty of Agriculture, University of Science & Technology, Private Bag, Kumasi, Ghana

9. State Forest Development Agency, P.O. Box 1034, Addis Ababa, Ethiopia

10. The Dean, Faculty of Agriculture, University of Nairobi, P.O. Box 29053, Kabete, Kenya

11. Forest Department, P.O. Box 30513, Nairobi, Kenya

12. The Dean, College of Agriculture & Forestry, University of Liberia, P.O. Box 9020, Monrovia, Liberia

13. The Dean, Faculty of Agriculture, National University of Lesotho, Roma, Lesotho

---

*Ed's note. Addresses and titles were current as of the date of the Workshop.

14. The Principal, Bunda College of Agriculture, University of Malawi, P.O. Box 219, Lilongwe, Malawi

15. The Head, Department of Forestry P.O. Box 30048, Capital City, Lilongwe 3, Malawi

16. The Head, Malawi College of Forestry, Private Bag, 6, Dedza, Malawi

17. The Head, Forestry Research Institute of Malawi, P.O. Box 270, Zomba, Malawi

18. The Dean, School of Agriculture, University of Mauritius, Reduit, Mauritius

19. The Head, Department of Forestry, Faculty of Agriculture & Silviculture, University of Eduardo Mondlane, Caixa Postale 257, Maputo, Mozambique

20. Forest Research Institute of Nigeria, PMB 5054, Ibadan, Nigeria

21. The Head, Federal Department of MB 12613, Lagos, Nigeria

22. The Head, Department of Forest Resources Management, University of Ibadan, Ibadan, Nigeria

23. The Dean, Faculty of Agriculture, University of Ife, Lee, Nigeria

24. The Dean, Faculty of Agriculture, Ahmadu Bello University, P.O. Box 1044, Zaria, Nigeria

25. The Dean, Faculty of Agriculture, University of Ibadan, Ibadan, Nigeria

26. The Dean, University of Nigeria, Nsukka, Nigeria

27. The Dean, Faculty of Agriculture, Njala University, Freetown, Sierra Leone

28. The Head, Division of Forestry, Ministry of Agriculture & Resources, Freetown, Sierra Leone

29. The Dean, Faculty of Agriculture, Somalia National University, P.O. Box 801, Mogadishu, Somalia

30. The Dean, College of Natural Resources & Environmental Studies, University of Juba, Juba, Sudan

31. The Head, Department of Forestry, Faculty of Agriculture, University of Khartoum, Khartoum, Sudan

32. Director of Forestry, P.O. Box 658, Khartoum, Sudan

33. The Dean, Faculty of Agriculture, University of Botswana & Swaziland, P.O. Luyengo, Swaziland

34. The Dean, Faculty of Agriculture Forestry & Veterinary Science, Sub-Post Office, University Morogoro, Tanzania

35. Chief Conservator of Forests, P.O. Box 31, Entebbe, Uganda

36. The Dean, Faculty of Agriculture & Forestry, Makerere University, P.O. Box 7062, Kampala, Uganda

37. The Head, Department of Forestry, P.O. Box 228, Ndola, Zambia

38. The Head, Division of Forest Research P.O. Box 2099, Kitwe, Zambia

39. The Principal, Zambia Forest College, P/B Mwekera, Kitwe, Zambia

40. Division of Forest Research, P.O. Box 22099, Kitwe, Zambia

41. The Dean, School of Agricultural Sciences, University of Zambia, P.O. Box 2379, Lusaka, Zambia

FRANCOPHONE AFRICA

42. Burkina Faso, Institut Supérieur Polytechinique, Ougadougou, Burkina Faso

43. École Nationale Supérieure Agronomique, POB 138, Yaoundé, Cameroun

44. École Nationale des Eaux et Forêts, c/o IRAF-BP 2246, Libreville, Gabon

45. École Forestière de Bouaké, BP 654, Bouaké, Ivory Coast

46. École Forestière de Banco, Abidjan, Ivory Coast

47. Institut Polytechnique, Rural de Katibougou, Katibougou, Mali

48. École des Agents Techniques Agriculture, Ziguinchor, Senegal

49. Écoles des Agents Techniques, Forestry, Ziguinchor, Senegal

50. Écoles des Agents Technique, Animal Husbandry, St. Louis, Senegal

51. École Nationale des Cadres, Ruraux, Bambey, Senegal

52. Institut des Sciences de l'Environnement, Dakar University, Faculty of Science, Dakar-FANN, Senegal

53. École Nationale d'Economie Appliqué, Dakar, Route to Ouakam, Senegal

54. Cours Post Universitaire du Sahel, BP 5077, Dakar, Senegal

55. Institut National de Dévelopment Rural (INDR), Route de Khombole à Thiès, Senegal

56. École Nationale d'Economie Appliqué, Dakar, Route to Ouakam, Senegal

57. Cours Post-Universitaire de Sahel, BP 5077, Dakar, Senegal

58. Institut Nationale de Dévelopment Rural (INDR), Route de Khombole à Thiès, Senegal

SOUTHEAST ASIA

59. Institut Pertanian Bogor, Bogor, Indonesia

60. Gadjah Mada University, Jogjakarta, Indonesia

61. Universiti Pertanian Malaysia, Serdang, Selangor, Malaysia

62. College of Forestry, University of the Philippines, Los Banos, Philippines

63. Don Mariano Marcos State University, Bacnotan, La Union, Philippines

64. University of Kesetsart, Bangkok, Thailand

WESTERN EUROPE

65. Faculty of Forestry, Thorvaldsensvej 57 DK-1871 Kobenhavn V, Denmark

66. Institut für Landespflege der Universitat Freiburg, Bertholdstrasse 17, D 7800 Freiburg I.BR, Federal Republic of Germany

67. Institut für Weltforstwirtschaft, Leuschnerstrasse 91, Postfach 80 02 01, D-2050 Hamburg 80, Federal Republic of Germany

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69. Forestwissenschaftlicher Fachbereich der Universität, Göttingen, Busgenweg 5 D. 34 Göttingen-Weende, Federal Republic of Germany

70. Ecole National du Genié Rural et des Eaux et Forêts, Antenne de Montpellier de l'ENGREF, Val de Montferrand, Domaine de Lavalette, F 34000, Montpellier, France

71. Université de Montpellier, Place E. Bataillon, F 34060 Montpellier Cedex, France

72. Centre National d'Etudes Agronomiques des Régions Chaudes, 3191, Route de Mende, F 34060 Montpellier Cedex, France

73. Ecole Nationale du Génie Rural et des Eaux et Forêts, 19 Avenue de Maine, F 75732 Paris Cedex 15, France

74. GERDAT - Groupement d'Études et de Recherches pour le Dévelopment de l'Agronomie Tropicale, BP 5035, F 34032 Montpellier Cedex, France

75. Wageningen Agricultural University, Forestry Institute "HINKELOORD", P.O. Box 342, 6700 AH Wageningen, The Netherlands

EASTERN EUROPE

76. Technischen Universitat Dresden, Sektion Forstwirtschaft Tharandt, Dresden, East Germany

77. Biotehniska Fakultet, VTOZD za Gozdarstvo, 61000 Ljubljana, Vecna pot 83, Yugoslavia

78. Sumarski Fakultet, 71000 Sarajevo, Zegrebacka 20, Yugoslavia

79. Sumarski Fakultet, 11000 Beograd, Kneza Viseslava 1, Yugoslavia

80. Sumarski Fakultet, 41000 Zagreb, Simunska 25, Yugoslavia

81. Sumarski Fakultet, 91000 Skopje, Avtokomanda, Yugoslavia

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83. Yvan Hardy, Dean, Faculty of Forestry and Surveying, Laval University, Quebec GIK 7P4

84. A.J. Kayll, Director, School of Forestry, Lakehead University, Thunder Bay, Ontario P7B 5E1

85. Peter J. Murphy, Associate Dean - Forestry, Faculty of Agriculture and Forestry, University of Alberta, Edmonton, Alberta T6G 2H1

86. Vidar, J. Nordin, Dean, Faculty of Forestry, University of Toronto, Toronto, Ontario M5S 1A1

87. J.V. Thirgood, Professor, International Forestry Program, University of British Columbia, Vancouver, British Columbia V6T 1W5

Hawaii

88. James L. Brewbaker, Professor of Horticulture, University of Hawaii, 3190 Maile Way, Honolulu 96822

89. Napoleon T. Vergara, Research Associate, East-West Center, 1777 East-West Road, Honolulu 96848

Puerto Rico

90. Ralph C. Schmidt, Chief, Forest Service, Department of Natural Resources, San Juan 00906

91, 92. Frank H. Wadsworth, and Peter L. Weaver, Research Foresters, Institute of Tropical Forestry, Rio Piedras 00928

United States

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Universities

93. R.W. Behan, Dea, School of Forestry, Northern Arizona University, Flagstaff, Arizona 86011

94, 95. D.E. Teeguarden, Head of Department, Jeff Romm, Assistant Professor, Forestry and Resource Management, University of California, Berkely, California 94720

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97. William H. Smith, Acting Dean, School of Forestry and Environmental Studies, Yale University, New Haven, Connecticut 06511

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99, 100. George M. Guess, Assistant Professor, Department of Politics and Public Affairs, and Samuel C. Snedaker, Professor and Acting Chairman Division of Marine Affairs, University of Florida, Miami, Florida 33149

101. Gary L. Rolfe, Head, Department of Forestry, University of Illinois, Urbana, Illinois 61801

102. Mason C. Carter, Professor and Head, Department of Forestry and Natural Resources, Purdue University, West Lafayette, Indiana 47907

103. Frederick S. Hopkins, Jr., Professor, Department of Forestry, Iowa State University, Ames, Iowa 50011

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106, 107. Fred B. Knight, Dean, and Timothy G. O'Keefe, Associate Professor, College of Forest Resources, University of Maine, Orono, Maine 04469

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129. J.L. Whitmore, USDA-FS-International Forestry, Box 2417, Washington, D.C. 20013

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131. Thomas E. Greathouse, Forestry Advisor, USAID Agroforestry Outreach Project, B.P. 1634, Port-au-Prince, Haiti.

132. Henry Tschinkel, Regional Forestry Advisor, USAID/ROCAP, A.P. 10053, San Jose, Costa Rica.

133, 134. Donald L. Plucknett, Scientific Advisor, and John S. Spears, Forestry Advisor, The World Bank, 1818 H Street, N.W., Washington, D.C. 20433.

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136. Edward J. Finegan, Consultant, USAID/RENARE, Apartado 25, Paraiso, Ancon, Panama.

137. Pieter E. Hoekstra, Bio-Energy Project, USDA-FS, P.O. Box 2417, Washington, D.C. 20013.

138. Robert D. Kirmse, Research Scientist, Brazil-Small Ruminant CRSP., c/o Department of Range Science, Utah State University, Logan, Utah 84322.

139. Robert Peck, Forestry Consultant, Carrera 56 1A-10, Cali, Colombia.

140. Fred R. Weber, Forestry Consultant, IRDCS, 5797 Bogart Lane, Boise, Idaho 83703.

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### Argentina

141. Facultad de Agronomía, Universidad de Buenos Aires Av. San Martín 4453, Buenos Aires

142. Facultad de Ciencias Agrarias, Universidad Nacional del Comahue, Ruta 151, Cinco Saltos, Provincia de Río Negro

143. Facultad de Ciencias Agrarias, Universidad Nacional del Comahue Moreno s/n, San Martín de los Andes, Provincial del Neuquén

144. Facultad de Ciencias Agrarias, Universidad Nacional de Cuyo, Almirante Brown 500, Chacra de Coria, Provincia de Mendoza

145. Facultad de Ciencias Agropecuarias, Universidad Nacional de Entre Ríos Casilla de Correo 24, Paraná, Provincia de Entre Ríos

146. Faculted de Ciencias Agrarias, Universidad Nacional de Catamarca, República 350, Catamarca

147. Facultad Ciencias Agrarias, Universidad Nacional de Córdoba Obispo Trejo y Sanabria, Córdoba

148. Facultad de Agronomía y Veterinaria, Universidad Nacional del Litoral Casilla Correo 3, Esperanza, Provincia de Santa Fé

149. Escuela de Ingeniería Forestal, Universidad Nacional de Misiones Km 3 - 3382 El Dorado, Provincia de Misiones

150. Facultad de Ingeniería Industrial Agropecuaria, Universidad Nacional del Nordeste, San Martín 1315, Resistencia, Provincia de Chaco

151. Facultad de Agronomía, Universidad Nacional de Rio Cuarto Campo Universitario, Ruta 8 y 36, Km 603, Provincia de Córdoba

152. Facultad de Ciencias Agrarias, Universidad Nacional de Rosario Ruta 33 y Ovidio Lagos, Casilla 166, Provincia de Santa Fé

153. Facultad de Ciencias Agrarias, Universidad Nacional de Salta, Buenos Aires 177, Salta

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# APPENDIX C

## SYLLABUS OF COURSES IN SOCIAL FORESTRY IN INDIA

SOCIAL FORESTRY: Introduction - definition, scope, history and (SCFI) necessity, special significance in the context of energy and small timber requirements of India, environmental pollution and recreation; place of Social Forestry in the National Forest Policy of India. Psychology of change, behavioural sciences etc. Gandhi - a concept.

FARM FORESTRY: Its need and scope on and around agricultural lands; role in rural economy and its effect on agricultural practices; establishment of farm forests, choice of species, planting techniques, maintenance; organization of the programme, role of the Forest Department; protection.

EXTENSION FORESTRY: Objectives and scope viz-a-viz Farm Forestry; raising of trees for fodder, timber, firewood, creation of pasture lands; avenue plantation, canal bank plantations, plantations along railway lines; choice of species, techniques, maintenance, extension approach, organisation of the programme, role of the Forest Department; protection.

RECREATION FORESTRY: Needs of the urban population; scope of its application in forests, city forests and concept of integrated town planning and forestry; creation of forest parks in natural forests close to urban centres. Improvement of slum areas by planting suitable trees.

WINDBREAKS, SHELTERBELTS AND CATCHMENT FORESTS: Scope of creation of windbreaks, shelterbelts; choice of species, techniques, maintenance; scope in the catchment forest of water works etc.; protection.

ORGANISATION, LEGISLATION AND PUBLICITY: Extension, organisation, training and demonstration, public participation and public; need for a defined policy, suitable legislation to support the programme. Obtaining people's cooperation.

Various projects running in States with regard to Social Forestry. Their salient features, availability of land, financial involvements and returns. Impact of these projects.

Writing a project with a view to bring villagers above the poverty line, keeping in view -

a) unit of operation
b) availability of land
c) unit of administration, staff
d) returns thereof
e) financial viability
f) long-term impact.

Visit to certain States e.g. Gujarat, Madhya Pradesh and Utter Pradesh to study the Social Forestry schemes and to evaluate their success etc.

Special schemes like Tasar cultivation, Babool gum tapping, Bidi leaf, Minor Forest Products (Mahua, Kanji, Neem etc.) Their potentialities and financial returns.

Generation of employment in various plantation works and the extent of income generated directly from the sale of the forest produce and also in terms of wages earned by the workers. Institutional and organisational support for implementation.

# APPENDIX D

## SYLLABUS OF AN AGROFORESTRY COURSE OFFERED AT THE POSTGRADUATE LEVEL AT THE FACULTY OF AGRARIAN SCIENCES, BELEM, PARA, BRAZIL

### I. GENERAL CONCEPTS

1. Agroforestry - Review of existing definitions. Analysis of objectives.

2. Classification of agroforestry systems - Analysis of Combe - Budowski classification (1978). Types of combined crops. Function of trees used in the combinations. Distribution of the tree component in space and time. Use of agroforestry at subsistence level. Ecological affinity between agroforestry production systems and purely agricultural perennial polycropping systems.

3. Advantages and limitations of agroforestry systems - Discussions with students.

### II. AGROFORESTRY SYSTEMS AND PRACTICES IN USE OR OF POTENTIAL INTEREST FOR THE SOUTH-AMERICAN HUMID TROPICS

1. Home-garden and home-garden type agroforestry systems - (basically used at subsistance level, sometimes, in part, for cash-crops).

1.1 Amazonian home-gardens (species used, socio-economic importance, diversification and potential improvement of Amazonian home-gardens).

1.2 Home-garden traditions in the South-Pacific Islands (general description, animal and plant species used).

1.3 The Indonesian home-gardens (functions, structure and composition, canopy closure indexes, diversity of models, ecological impact on environment conservation, socio-economic importance).

2. Taungya and "pseudo-taungya"

2.1 True taungya (historical background, economical and social importance, species used in Asia and Africa, basic requirements and characteristics).

2.2 Pseudo-taungya: temporary combination of food and/or short-cycle cash crops in young man-made forests (cf. large-scale reforestration programmes in Brazil, and to a lesser extent in Colombia).

3. The silvo-banana system (mayumbe) (historical background, description of the system, species used, results obtained, economic importance, potential value for South America).

4. Sequential agroforestry based on the manipulation and improvement of tree-fallow (basic notions on shifting-cultivation, the traditional "nkunku" system of the bakongo, concepts and description of improved tree-fallow including research made in the field, socio-economic and ecological importance, species used so far).

5. The "coffee (and/or cacao) - Erythrina-Cordia" combination (general description, examples from Central America and South America, socio-economic importance, examples of other equivalent combinations with Inga spp. and other tree species, soil-plant relations prevailing in that combination).

6. Agricultural crops combined with natural regeneration of desirable timber-species of fast growth (full description of examples given from Colombia e.g. Atrato and Bajo Calima, how to improve that practice in terms of quality-production and returns).

7. Permanent or semi-permanent combination of agricultural short rotation crops with tree line-planting (examples given from Bajo Calime/Colombia and from Missiones/Argentina).

8. The Limoncocha system: swine and other small animal husbandry combined with agroforestry (description of the system, results obtained at experimental level, perspectives for its application in small farms in the Amazon).

9. Life-fences (objectives, establishment techniques, species used, examples given from Central and South America).

10. Silvo-pastoral systems

10.1 Grazing in forest areas (natural forests)
10.2 Temporary grazing in young man-made forests
10.3 Fodder trees and shrubs more or less evenly distributed in grazing lands
10.4 Protein-banks
10.5 Shelter-belts

III. SILVICULTURAL TREATMENTS AND TECHINIQUES FOR AGROFORESTRY SYSTEMS

1. Criteria for the choice of tree species (growth habits, possible competition on agricultural crops, biological and economic value of tree species).

2. Criteria for the choice of planting stock

3. The "mafuku" technique (direct sowing on burned heaps)

4. Traditonal dense versus Anderson method

5. Thinning and pruning

IV. PRESENT SITUATION OF AGROFORESTRY REASEARCH IN THE BRAZILIAN AMAZON

Situation and first results of agroforestry research implemented by EMBRAPA in the Brazilian Amazon.

## V. SOCIO-ECONOMIC ASPECTS RELATED TO THE USE OF AGROFORESTRY IN SMALL FARMS (HUMID TROPICS)

1. The management of the tree component should not affect negatively agricultural activities (examples given).

2. Necessity to develop agroforestry systems in the larger frame of farming systems, examples given:

- small farms in the region of Lloro (El Choco, Colombia)
- small farms in Bajo Calima (Colombia)
- small farms in San Jose del Guaviare (Colombian Amazon)

3. Promotion of associative work and production groups

- for the use of silvo-pastoral systems
- as regard post-harvest problems, industrial conversion and marketing of products.

4. Supportive services: credit, education and training.

## VI. TREE SPECIES OF INTEREST FOR AGROFORESTRY SYSTEMS

1. Species native to Latin America (humid tropics)

1.1 Mainly for timber production: *Cordia* spp., *Vochysia* spp., *Pithecellobium saman* var, acutfolium, *Cedrela* spp. (limiting factor: shoot-borer), *Swietenia macrophylla* (shoot-borer!), *Tabebuia rosea*, *Zanthoxylum* spp., *Bagassa guianensis*, *Simarouba* spp., *Didymopanax morototoni*, *Centrolobium paraense*.

1.2 Native species providing quality timber and edible fruits (locally industrialized): *Bertholletia excelsa*, *Platonia insignis*, *Caryocar* spp.

1.3 Native forage trees and shrubs: *Leucaena leucocephala*, *Leucaena* (other species), *Pithecellobium saman*, *Parmentiera* spp., *Desmodium* spp.

1.4 Native species providing other services (firewood, shade, maintenance of soil fertility): Inga spp., Calliandra calothyrsus, Erythrina spp., Glyricidia sepium, etc.

2. Exotics: Artocarpus spp., Acacia mangium, Sesbania grandiflora, Desmodium gyroides, Desmanthus virgatus, Acacia auriculiformis, Albizia falcataria, Albizia lebbek, other species of the genus Albizia, Terminalia spp., Acrocarpus fraxinifolius.

## VII. DOCUMENTATION AND INSTITUTIONAL ASPECTS

(presenting to the students publications and periodical newsletters or reviews on agroforestry, plus general information on ICRAF and institutions developing studies and/or research in the field).

## VIII. FINAL DISCUSSION

At the end of each chapter the students have the opportunity to ask questions on the matter of the chapter. At this final session, free questions are accepted and used to promote discussions with equal participation of professors and students.

## SECTION TWO - POSITION PAPERS

Position papers dealt with some of the specific issues encompassed under the Workshop objectives. They were intended not to necessarily pre-empt the conclusions of the Workshop on those issues, but rather to express the different views of particular contributors and to focus the discussions.

Position papers were invited on the following and/or related subjects:

| | |
|---|---|
| Professional requirements | What will be expected of professional agroforesters? (the employers' viewpoints) |
| Types of personnel needed | Agroforestry as a profession - the possibilities? (an overall assessment of the types of professional agroforestry personnel who will be needed) |
| Educational programmes and AF | Do we really need to teach agroforestry? (agroforestry's relation to other types of educational programmes) |
| Courses, etc. and institutional capabilities | What infrastructural and resource changes may be needed to teach agroforestry? (programme/courses in AF in relation to current institute/faculty capabilities) |
| Teaching methods | Is there a case for developing a new angle on teaching agroforestry (an appraisal of teaching methods most suited to agroforestry programmes and courses) |
| Institutional adoption | Where is it most useful and easiest to start? (an evaluation of the capabilities of different types of institutional arrangements at all the concerned levels e.g. certificate, diploma, graduate, postgraduate) |

| | |
|---|---|
| Teaching materials | What is available to use now? (content, presentation, proposals for new teaching aids) |

Twenty-four position papers were submitted to the Workshop. They were not formally presented to the audience but remained available during the Working Groups' deliberations. Abstracts of all position papers are presented in alphabetical order by author's last name (Part A). These are followed by the full text of edited, selected papers (Part B).

Copies of the full text of position papers not included in this section can be made available by ICRAF upon request.

## PART A. ABSTRACTS

1. Title: Need for an agroforestry curriculum in the Philippines

Author: Emiliana Bernardo

Recognition that agroforestry should be an area of concern is already worldwide as best evidenced by the establishment of ICRAF. The problems and circumstances leading to the development of great interest in agroforestry have been clearly identified. In response to these problems, a number of institutions all over the world are now implementing research activities or projects in agroforestry and more are expected to follow. Thus, the need for the services of trained manpower in this area of specialization will be increasing. To be able to meet the demand for this group of workers not only in quantity but also in quality, there is a need to consider the manner in which they should be trained.

This position paper focuses specifically on: (1) whether modification of the existing BS Forestry curriculum by making agroforestry an area of specialization will be sufficient; or (2) if re-training in agroforestry of the B.Sc. Forestry or B.Sc. Agriculture graduates would be a better approach; or, (3) if there is a need to develop a separate curriculum or degree in agroforestry.

After a discussion of the main points above, it is concluded that a separate curriculum should be developed for the training of manpower in agroforestry. In designing curriculum, emphasis is recommended on a holistic orientation to problem solving, integration of knowledge and understanding of human relations. Inclusion of new problem-oriented agroforestry courses which cut across disciplines in agriculture and forestry is seen as a must.

2. Title: The Network and "Twinning" Concepts of Research and Training

Author: Eberhard F. Brunig

Several international organisations and institutions have developed a concept of cooperation and coordination by means of networks within regions which are supplemented by inter-regional "twinning" arrangements between centers of excellence. The Unesco program, "Man and Biosphere," emphasizes system-orientation. The World Bank and FAO are jointly sponsoring a programme which includes a strong element of "twinning." IUFRO is looking into ways to strengthen research networks in the tropics. It is argued that these schemes are highly relevant to agroforestry education.

3. Title: Constraints on teaching agroforestry at the professional level

Author: J.F. Burley

Although agroforestry practices are old, formal education is new. Many academic institutions are rushing to provide undergraduate and postgraduate courses, and this paper indicates some constraints on their preparation, operation and value:

i) The historical separation of agriculture and forestry in government administration and in professional education, their competition for land and finance, and the lack of awareness of each other's scientific discipline.

ii) the lack of a tradition of teaching the subject and hence of a syllabus.

iii) Lack of teaching staff with agroforestry experience.

iv) Lack of relevant field facilities and agroforestry experiments, especially in temperate countries.

v) The site-specificity of agroforestry practices and hence of the literature.

vi) The lack of objective and quantitative models for describing agroforestry systems.

vii) The lack of awareness of the sociological components.

viii) Uncertain employment prospects for graduates.

ix) The difficulty of choosing relevant research topics and appropriate techniques for postgraduate research.

An overall conclusion is that agroforestry education will benefit from the establishment of collaborative links ("twinning") between universities in temperate and tropical countries for the exchange of students and staff and for the sharing of laboratory and field facilities.

4. Title: Concepts and constraints of agroforestry education

Author: Peter G. von Carlowitz

The paper outlines some of the problems related to formal agroforestry education. A brief summary of the state of the art in agroforestry education in developing regions is presented.

Based on a description of knowledge and methods available at present, four hypothetical educational models for university/college level are outlined. These are then critically discussed and the problems and constraints of each of them exposed.

The paper concludes with the author's personal views on what is needed and what should be done to start agroforestry educational programmes.

5. Title: From research to communication in agroforestry: some insights from the MAB Programme

Author: Francisco di Castri

Attempts within the "Man and Biosphere" (MAB) programme of Unesco to produce research findings and materials useful for education and training in agroforestry are outlined. Three different field projects -- one in the humid tropics of Mexico, another in an urban situation in Papua New Guinea, the third in the arid zones of northern Kenya -- provide examples of the types of educational materials and training activities that can be integrated within field research projects. Lessons learned in the preparation of the poster-exhibit "Ecology in Action" and their possible relevance to the development of programmes in agroforestry education are described.

6. Title: Traditional agroforestry in West Java, Indonesia

Author: Linda Christanty

Two traditional agroforestry systems in West Java, the pekarangan (home garden) and talun kebun (shifting cultivation), are described in this paper. As man-made agro-ecosystems developed over the centuries, these dynamic systems have been adapted to environmental, social, cultural, and economic factors in order to fulfill the various needs of people.

The descriptions of the general features of the systems and management practices are accompanied by detailed profile-diagrams to illustrate vertical stratification of plant species.

The paper can be used, in its present form, as training material. It also constitutes a source of information and reference for scholars with an interest in agroforestry in Indonesia.

7. Title: Agroforestry programmes and education in agroforestry in Malawi

Author: O.T. Edje

The author presents a review of the traditional agroforestry systems as practiced by farmers in Malawi. A description is provided of existing development programmes with agroforestry components in Malawi, including the National Tree Planting Day, the National Rural Development Programme, and the Wood Energy Project. Research in agroforestry is being carried out at Bunda College of Agriculture (taungya systems, fast growing, nitrogen-fixing trees) and the Tobacco Research Authority (inter-planting tobacco with Eucalyptus).

No agroforestry programme as such is being offered by educational institutions at present. However, agroforestry is taught as a component of diploma courses at Bunda College of Agriculture where students can undertake research (dissertation) projects in agriculture. At the Malawi College of Forestry some aspects of land and forest management are related to agroforestry.

8. Title: Guidelines for an agroforestry educational programme in Venezuela

Author: Eduardo Escalante

In Venezuela, as in other tropical countries, educational schemes developed for temperate regions are applied to train professionals in tropical agriculture. Moreover, the social, historical and cultural characteristics of the small farmer -- whether from the tropics or the temperate zones -- are rarely taken into consideration.

Tropical ecosystems -- including components such as animals, crops and trees in the same unit of land -- are very complex. Professionals with specific backgrounds in forestry, agriculture or animal sciences are not well prepared to deal with existing farming systems. Agroforestry-trained personnel at the

professional and middle level are seen as a potential solution to handle development programmes in the tropics.

Guidelines for the establishment of agroforestry educational programmes at undergraduate and graduate levels are recommended. Emphasis on curriculum design which focuses on problem-oriented processes is supported.

9. Title: Economics for agroforestry

Authors: Dan M. Etherington and Peter J. Matthews

Economics is concerned with choice between competing alternatives. Most tree-crop research institutes are responsible for single crops. Within-crop resource allocation problems need only a few of the tools of the economist. However, agroforestry is a multi-crop discipline in which choices have to be made. If the acceptance of a technology is dependant on the farmers assessment of its costs and benefits, then an understanding of economics is important for agroforesters. Economics has a contribution to make in at least three areas of decision: (1) in the relative proportions of the components in an agroforestry land-use system; (2) in the temporal placement of the components, and (3) in the assessment of the reduction in risk.

The paper concludes with a brief description of the MULBUD computer package designed as a practical tool for the economic analysis of complex agroforestry land-use systems.

10. Title: A combined system/case study approach for agroforestry

Author: Peter A. Huxley

This contribution is a shorter version of four previously published papers on the combined system/case study approach to teaching agriculture and, more recently, agroforestry.

Agroforestry is about land-use systems. Furthermore, students undertaking agroforestry programmes will have to go on to fill a wide range of national tasks, and to be essentially problem-oriented. We therefore need to start by teaching agroforestry from a holistic point of view and progress from the general to the particular.

In order to narrow down the very wide scope of agroforestry as a "new" discipline we need to:

a) concentrate on <u>principles</u> -- an enormous amount of material from other disciplines (agriculture, forestry, ecology etc.) is available and awaits only suitable modification; and

b) adopt a highly <u>selective</u> approach to descriptive agroforestry.

Selectivity, relevance and a strong directive towards a systems/problem-orientation approach are essential. Therefore a programme in agroforestry is best based on a series of progressive and carefully interlinked practical "cases" (including field experiments). These would start with systems as a whole, and work towards the particular. Courses, as we know them (e.g. on soil science, plant science etc), would not be taught as separate entities, but their elements would occur in relation to the various sets of "cases" or field studies. Thus their value would be made obvious in practical terms without losing any academic virtue. In such a scheme the important issue would be not "how to cram it in" but "what can be left out"; training the mind, especially to be highly integrative, would be more important than just filling it.

11. Title: Building in-country capabilities for the development of efficient agroforestry systems in Southern Asia

Author: Joseph C. Madamba

Agroforestry has been practiced for centuries by the small farmers of Southern Asia as a

major component of traditional agricultural systems. At the present time, the developing countries of Southeast Asia are beginning to seriously consider agroforestry systems as a possible appropriate, alternative form of land management which can improve production in a sustainable way.

By 1982, many exciting developments had taken place in Southeast Asia which led to the emergence and evolution of a Southeast Asia Network for Agroforestry Research and Development.

In order to rapidly build up the necessary initial critical mass of in-country capability for the development of efficient agroforestry systems, this paper proposes a three-phase Agroforestry Training Programme package. It includes (1) a Regional Agroforestry Seminar-Workshop for Policy Makers and Planners (one week); (2) in-country Training Courses for University Faculty and Research Scientists working in agroforestry (two weeks per course); and (3) a regional course for Agroforestry Project Implementation Managers and Farm Cooperators (three weeks).

12. Title: The need for, and level of agroforestry education

Author: J. Maghembe and E. Kariuki

The problems of multicropping systems are reviewed at the farm level, and possible reasons for the lack of information on systems involving woody perennials are suggested. It is suggested further that a key to solving these problems may lie in the acceptance of agroforestry land-use systems by decision-makers in agriculture, animal husbandry and allied sciences. This should then be followed up by revisions in the current syllabi at professional and technical levels in agriculture, forestry and animal science to include agroforestry components. A broad M.Sc. degree in agroforestry aimed at a diverse professionals is preferred over other programmes to produce agroforestry scientists.

13. Title: The scope of using the existing forestry programme structures in agroforestry education

Author: B. K. Maiyo

The Forest Estate of Kenya today covers approximately 3% of the country's land surface, and there is no prospect of any substantial increase in this percentage except by afforestation (both in the Forest Estate and in the rural areas) on a very considerable scale. Not much has been achieved by way of afforestation in the rural areas mainly due to inappropriate budgets and lack of suitable land. Approximately two-thirds of the country is either arid or semi-arid with very little potential for wood production. In areas of high rainfall, land is rarely devoted to wood production. There is stiff competition for forestry and agricultural lands and the latter seems to have been winning the battle.

In 1971 the Forest Department introduced a Forest Extension Scheme in an attempt to expand forest activities in the rural areas. And to date Forest Extension Officers have been posted to most of the 41 Administrative Districts. To meet the staff requirement for this exercise, a Forest Extension Course was added to the Kenya Forestry College Syllabus in 1975. A description of the syllabi for certificate and diploma courses in forestry is included in the paper.

14. Title: What will be expected of professional agroforesters?

Author: H. J. von Maydell

Forestry in many tropical countries is gradually moving away from being dominated by commercial or protective concepts and towards appreciating integrated land-use strategies in the forest and outside, which aim at socio-economic development in rural areas and give priority to people's demands. At the same time, agriculture is becoming increasingly aware of the multiple benefits of forestry, of

forest trees and shrubs on crop and pasture lands. Both concepts converge to a certain extent on agroforestry land-use systems, demanding a new type of expert, the "professional agroforester" (PA).

The PA is expected to play a significant role as a mediator between conflicting interests of forestry, agriculture and animal husbandry. He/She will act as catalyst in fostering mutual understanding and encouraging ecologically balanced, multiple land-use practices. On the administrative level, he/she will coordinate functions of the various professional services. In the field, he/she will provide practical advice to communities or individual landowners.

The PA may be a forester with a solid background in agriculture and/or livestock management, specialized in integrated land-use and natural resources management. He/She may also be an agriculturalist with extensive knowledge of forestry and of growing and using trees. The agroforester's main qualification, at all levels, will be his/her ability to identify and solve problems of rural development by optimizing interdisciplinary activities and by promoting cooperation.

15. Title: An agro-system: ecosystem and farming system framework for professional agroforestry education

Author: G. L. McClymont

Recommended in this paper is the development of teaching which provides all agricultural and forestry graduates with a common core of knowledge which helps them to see land use as potentially involving crops, pastures, trees and animals, and gives them a conceptual framework for this. Essentially, it is recommending a formal approach to re-creating the types of productive and sustainable 'agricultures' from which modern land use evolved, based on intimate interactions between soils, water, crops, trees, pasture, animals and man.

Agriculture is conceptualized as a system (the agro-system) including components and sub-systems classifiable as ecological (interacting physical and biological components of soils, climate, water and organisms), technological (the tools, machines structures, materials, new cultivars etc., used to manipulate the ecological components), economic (costs, prices, markets, credit etc.) and social (values, goals, knowledge, beliefs, organisations etc.) at farm, local/regional, national and global levels, with continuous interactions within and between all components and levels. Farming systems (the total pattern of land and other resourse use and technologies involved on a land area managed as a unit) are considered in terms of inputs and economic, ecological and social outputs. Ecological concepts of organism -- environment interaction and limiting factors, and population and agro-ecosystem structure and dynamics are defined; their use in the potential role and management of trees in agro-ecosystems and farming systems is considered.

The organizational basis of teaching directed at developing an 'agro-system' approach to land use, including agroforestry, is examined.

It is concluded that the most valid measure of success in developing agroforestry education will be the extent to which the term is no longer required, i.e. by the extent to which all agriculturalists automatically consider the potential for inclusion of trees in farming systems and foresters similarly consider the potential for integrating crop and/or animal production with timber production.

16. Title: Agroforestry education in contemporary and future forest development in Kenya

Author: Jeff. A. Odera

The paper emphasises the need for producing a force of change-agents who are capable of working harmoniously among themselves and with the farmer on rural development and integrated

land use. It is suggested that the agriculture and forestry curricula developed some years back are still extant and must be restructured to help revamp the presently cramped and constrained services.

It is strongly suggested that the agricultural and forestry students should be given a general course on forestry and agricultural practises respectively during the first year, and agroforestry configurations during the final year, with the forestry students getting a more in-depth course in social forestry and agroforestry. It is recommended that agroforestry and social forestry be introduced in the specialist courses, and be provided as course electives in favour of initiating a B.Sc. course in agroforestry. Specialization in agroforestry should be delayed to the M.Sc. and Ph.D. levels to enable the graduates to fit within the existing schemes of service and to acquire a solid professional foundation.

The paper notes good employment openings for graduates with good training in social forestry and agroforestry both in the formal and in the private sectors.

17. Title: Elements of agroforestry in existing forestry educational programmes in Nigeria

Author: David V. Okali

The ultimate objective of professional education in agroforestry is to stimulate wide-scale adoption of the concept as a modern instrument for improving land management. To achieve this end, advantage can be taken of existing educational programmes for immediate propagation of agroforestry ideas. The major challenges to be overcome by professional agroforesters include demonstrating that existing agroforestry practices, that have failed to meet present-day demands on land, can be modernized and improved to enhance productivity and stability of land while supporting more than subsistence levels of living. Sound understanding of the biological

and socio-economic bases of existing practices will facilitate the designing of improved agroforestry practices. The ability to analyse agroforestry systems, to study the nature and interactions of their components, and to improve and identify appropriate recombinations of agroforestry components for optimum benefit are the main attributes to be inculcated in the professional agroforester. They will need to become familiar with varied principles in the natural and social sciences.

Existing university forestry programmes in Nigeria are described, pointing out areas that can be profitably strengthened or modified to enhance agroforestry education.

18. Title: Logic of agroforestry curriculum development: The case of the University of the Philippines at Los Banos (UPLB), Philippines

Author: Lucrecio L. Rebugio

The paper presents the results of an opinion poll of twenty-nine senior staff members of thirteen departments in five colleges at UPLB. The survey was conducted to determine staff views about the relevance, objectives, competing/complementary programmes, and options/alternatives for a curriculum leading to a B.Sc. in Agroforestry.

The survey showed that senior staff at UPLB consider the agroforestry curriculum to be highly relevant. They suggested that the objectives for such a programme be based on the following: (1) knowledge of agricultural and forestry production technologies and distribution systems, as well as of bio-physical and social structures; (2) an anthropocentric (man/social-oriented) attitude and ecological orientation/sensitivity; and (3) decision-making and managerial skills.

Options are suggested to improve UPLB's capability to produce agroforestry professionals by establishing: (1) specific agroforestry courses in existing agriculture and forestry

programmes; (2) an agroforestry curriculum within the present B.Sc. programmes in agriculture and forestry; and (3) learning laboratories to develop adaptive agroforestry skills.

Recommendations are made for non-formal training programmes aimed to develop skill-specific personnel to be offered by development agencies responsible for the implementation of agroforestry programmes.

19. Title: Agroforestry in land management education programmes

Author: Mandivamba Rukuni

Deforestation of Zimbabwe's communal lands already poses severe limitations to agricultural productivity. Wood is still the major source of fuel and construction material in these areas. There are no viable alternatives to wood. Cultivated area is expanding while grazing and forest land is diminishing.

The Government has already started programmes to incorporate forestry in the communal lands' production. However, no agroforestry programmes are yet underway.

The University of Zimbabwe and other training institutions have not yet considered the possibility of including agroforestry teaching. The Faculty of Agriculture offers four honours degrees with options in Agricultural Economics, Animal Science, Crop Science and Soil Science. There are some common courses taught across these options and there are specialised courses in each option. A list is provided of those courses common to the four options where agroforestry could easily be included.

Major points of discussion in the paper are centered around questions such as "should agroforestry be incorporated in some, or only one of these courses, or should it be taught as an entirely different subject? Should agroforestry be taught as a service course

available to all degree options or should it be a specialization in itself?"

20. Title: Education and training on the rural community development

Author: A. Soekiman

The concept of agroforestry is relatively new in the academic world. There is a need to teach agroforestry particularly to those involved in forest management and education and training. They in turn, will have to develop a farmer's awareness towards the importance of the forests to the people's lives, particularly the forest farmers and shifting cultivators who live around the forests.

It is recommended that agroforestry be introduced in formal as well as informal education and training programmes at all levels. Seminars on rural community development and agroforestry are to be organized for policy makers. Guidelines on possible content and audience for each type of training are provided. Special emphasis is given to the organization of a 3-6 month course on what the author defines as "coordinated training" aimed at bringing together the theory and the practice of land use and forest management for community development.

21. Title: Agroforestry education for rural development

Author: Michael Stocking

In both its research and utilization, agroforestry's roots lie firmly but metaphorically in rural development. This is because rural development concerns the problems of poor societies and degraded environments, and the improvement in welfare by better conservation, increased incomes and more sensitive planning all of which are in accord with ICRAF's rationale for agroforestry. Therefore, agroforestry has to be seen in the context of the way in which agricultural and

rural development schemes are planned and implemented to ensure that agroforestry is at least considered as a possible option. Professional education should address how and why agroforestry can meet human needs and be integrated into existing farming systems. The educational challenge is far more than a straightforward transference of technical knowledge.

A project planning cycle, as presented in the paper, is an ideal starting point for the training of middle- to high-level planners. It ensures a logical and sequential approach to the recognition and solution of rural development problems, objectively evaluating development options which may include elements of agroforestry. At a professional level, training in rural development is an essential component, so that technical aspects of agroforestry are integrated into broad aims and objectives of development.

22. Title: Staff specialization and teaching of forestry and agriculture courses in faculties of agriculture in Africa

Author: Abd-El-Azim O. Tantawy

The paper presents the results of a comparative study of institutions of higher education in Africa conducted in 1980 by the Association of Faculties of Agriculture in Africa (AFAA) . Even though not directly related to agroforestry education, the results provide useful information on existing forestry and agricultural programmes where agroforestry teaching may be considered in the future.

There are seventy faculties of agriculture in Africa out of which sixteen have departments of forestry or wood technology. There are 2977 specialized personnel with only 94 specialized in forestry.

Twenty-one countries in Africa offer an introductory course in forestry for third-year B.Sc. students in general agriculture while nine countries offer B.Sc. courses with a

specialization in forestry.

M.Sc. and Ph.D. programmes in forestry are offered in Nigeria (Ibadan), Egypt (Alexandria), Uganda (Kampala), Ghana (Cape Coast) and Morocco (Rabat).

Courses offered at the B.Sc., M.Sc. and Ph.D. levels at the Department of Wood Technology in Alexandria University are presented as an example.

It is recommended that M.Sc. programmes in Agroforestry be developed in the region, along with the creation of an African agroforestry journal and the establishment of an agroforestry society in Africa. AFAA can actively cooperate in the implementation of all recommendations.

23. Title: Person power in agroforestry

Author: Khubchand Tejwani

The types of person power needed in any field is determined by the job which is to be accomplished. To promote agroforestry as a land-use system there is the need to 1) develop technological packages, 2) extend the practices of agroforestry and 3) develop professional personnel. Therefore, there is a need for researchers, extension personnel, teachers and trainers.

Training of different types of agroforesters will require different approaches. For researchers, it is essential that agroforestry be incorporated as a component in land-use management syllabi of agricultural and forestry colleges. If a full-fledged course can be offered, all the better. For extension staff, agroforestry packages should be identified to help in the development activities. At the same time short, intensive training courses should be organized to help them integrate the various disciplines involved in land use. Teachers and trainers need to participate in training programmes designed to provide not only the technical content related to

agroforestry but also teaching methodologies and communication skills.

Agricultural and forestry colleges, research and training institutes, and field projects are the best places to train person power in agroforestry.

The institutionalization of incentive mechanisms, e.g. prizes, improved status, etc., is recommended for the newly developed personnel.

24. Title: The need for agroforestry in short courses

Author: Peter J. Wood

Training in short courses as opposed to formal education is identified for three main groups: planners and administrators, professional officers, and field or technical officers. It is suggested that short orientation courses emphasising land-use planning are most needed for the former. Professionals need longer courses covering the widest range of subjects, and technical grade officers may find short, site-specific courses best. Brief suggestions for topics, course structure, location and numbers of participants are given.

# ECONOMICS FOR AGROFORESTRY

by

Dan M. Etherington and Peter J. Matthews

Agroforestry is an exciting, new and eclectic discipline. As the very name suggests, it expects to borrow heavily from agriculture and forestry. In this paper we explain why economics has been of limited value to tree-crop research institutes but is of great significance to this new discipline. Our thesis is that agroforestry land-use systems are concerned with cropping systems containing many components. Choices will have to be made as to the relative weights to be attached to each component. Economics is particularly concerned about choice between competing alternatives and as such should feature significantly in the training of agroforesters.

## Production Possibilities

The typical starting point for any discussion of the economics of choice between alternative outputs is a production possibility frontier (PPF) such as that in Figure 1. The PPF shows the maximum amount of two products (maize and beans) that can be produced with given resources. This curve is analogous to the replacement series diagram of the agronomist. Textbooks of economics conventionally show two possible extremes among the set of rational PPFs, the linear relationship represented by the line segment AC and, a concave curve, from below, with segments showing complementary (AB), competitive (BC) and supplementary (CD) relationships. Economists, with their concern for the optimum use of scarce resources give but scant attention to complementary and supplementary relationships because the rational manager of resources would always exploit such situations fully before getting to the more interesting problem of allocating resources in the competitive range. For this reason all subsequent illustrations in a chapter on "Multiple Products" will usually only

Figure 1. Production Possibility Frontier

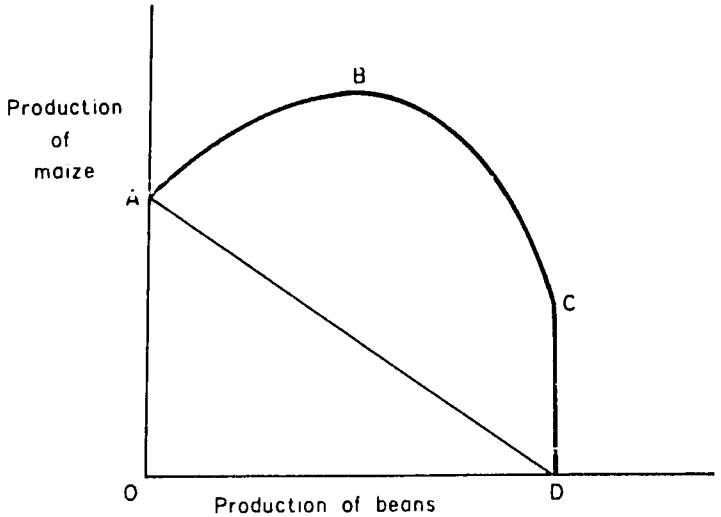
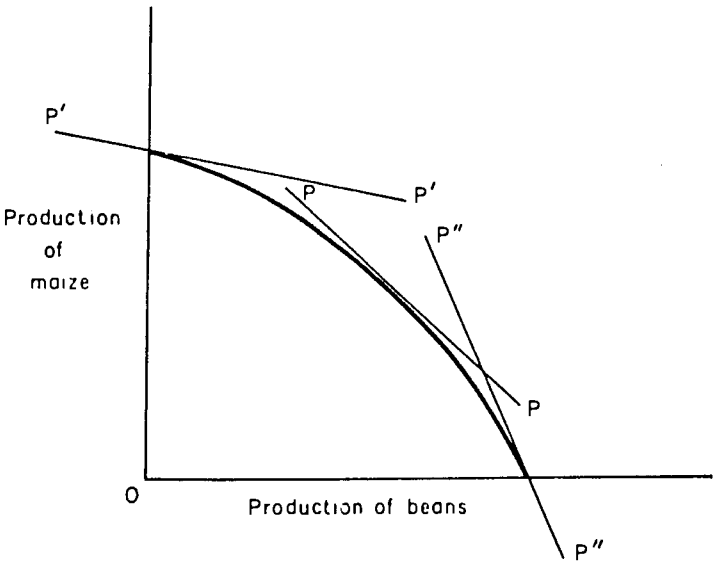



Figure 2. Conventional Production Possibility Frontier



show the competitive situation as in Figure 2. This is not meant to under-rate the significance of the "mutual externalities" that complementary relationships imply. In agroforestry there are some good examples: cattle-under-coconuts (Carrad 1977), cocoa-under-coconuts (Nair et al. 1978), and the classic example given in economics text books, bees in an orchard (Mead 1955).

For agroforestry the distinction between the concave curves of Figures 1 and 2 is significant because Figure 2 (and the line segment AD in Figure 1) allows for the complete specialization in either crop if the relative price is sufficiently favourable. Such a "counter-point" solution is illustrated by the price-line P'P' which leads to the sole crop production of maize while if the relative price shifted to P'P', only beans would be produced. Any intermediate set of prices would lead to some of both crops being produced from the limited resources (e.g. the line PP).

Tree Crop Research

This distinction is important because it serves to explain an historical legacy that agroforestry is going to have to live with and yet try to compensate for: the specialization of most of the tree crop research institutes in the tropics. Historic boom prices in rubber, coffee, tea, cocoa, quinine and so on down the list led to corner point solutions of complete specialization. Commercial interests soon demanded improvements in technology to increase production and/or combat the disease problems that soon became evident in areas concentrating on sole crops. The resulting specialist research institutes made notable advances in plant breeding, plant nutrition and disease control. However, by their very constitutions and terms of reference such institutions are biased towards their specific crop (Barlow 1978). (This is often reflected in the professional literature for example, see Alvim et. al 1978). Thus a specialist Tea Research Institute has as its primary objective the maximization of the output of tea. Its simple objective function conforms to that of the estate sector that sponsored it in the first place. In this typical situation, economic decisions are limited to "within crop" allocations and monocrop investments, so it is not too surprising that such institutions felt little

need for the specific skills of the economist. Indeed even today it is the exception rather than the rule for such institutes to have effective economics divisions unless there is specific involvement with smallholder farmers. If there is such an involvement then the institute comes up against a very different and often conflicting set of objectives. Here the product of concern to the Institute is but one argument in the complex objective function of the smallholder. It is therefore hardly surprising that the technologies that have been designed specifically for a monocropping estate have few customers among small-holders because what is best for tea (rubber, or coffee, or sisal, etc.) is not necessarily best for a farmer interested in the crop primarily as a source of supplementary cash income. Here there are trade-offs to be made in the allocation of resources between crops (and livestock) producing more cash income and more subsistence production. Choices do have to be made in the allocation of limited family labour and/or limited land.

Added Complications

If this was the end of the story then the disciples of agroforestry might have been able to escape with little more than a smattering of training in sociology and economics. Unfortunately there are added complications that suggest that training in these fields will have to be thorough. Three complications in particular should be noted: first is the fact that choice in many agroforestry situations will not be limited to simply the choice between a number of alternative competing crops but also alternative spatial arrangements of those crops (Willey 1979, Flinn 1979). In one arrangement two crops may be competitive, in another they may have some complementary relationships. For example, our maize and beans may compete for the same land and if the relative prices were those given by the price line PP in Figure 2, then resources would be allocated so as to produce X* maize and Y* beans. The picture that then comes to mind is of one field devoted to maize cropping trials; and the practice of many smallholders suggests that output can be varied if the same quantity of seed and the same amounts of land are allocated to these crops but in different spatial arrangements (Willey 1979, Trenbath 1976, Belshaw 1979). Thus the very shape

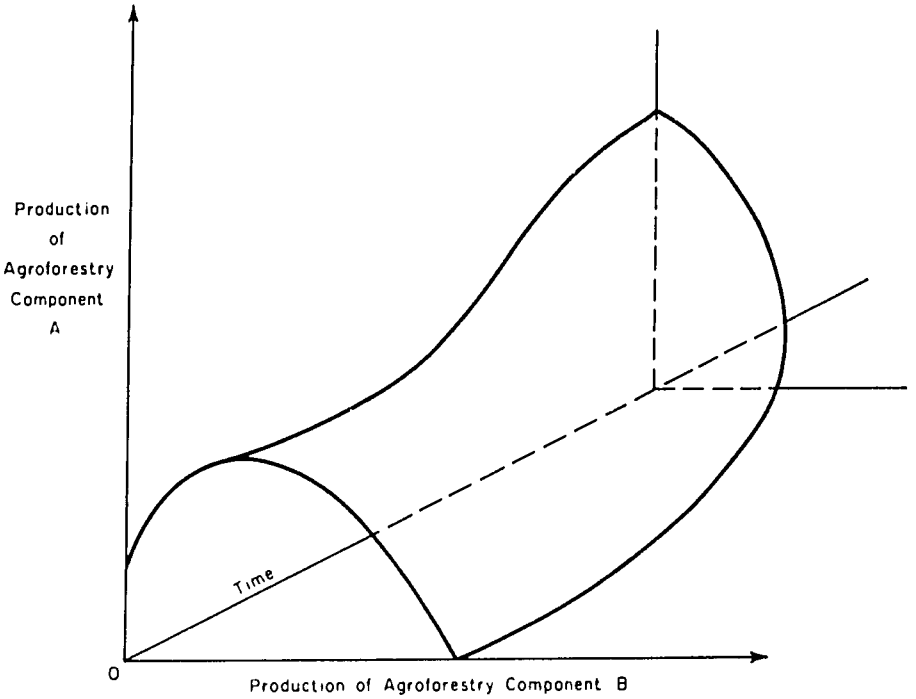
of the PPF can be altered by changing the 'technology' and it may not be the case that one technology dominates over the whole range of crop combinations.

The second complication compounds the first: the tree crop component of agroforestry land-use systems immediately raises temporal issues (Burgess 1977). As trees grow so they change the micro environment they inhabit. There may be complementary relationships over one period and competitive effects later or vice versa. Thus, for example, the agricultural catch crops that are typically grown among young rubber or forest plantations thrive until the maturing trees intercept more of the available light and 'crowd out' crops of shorter stature. Such effects could be summarised by giving the time dimension to our PPF as in Figure 3. This follows the dynamic replacement series suggested by Huxley (Huxley 1981). Although we are not aware of this diagram being used elsewhere, economists have been very interested in the questions raised by production and consumption taking place over long periods of time. There is a vast literature in the general area of "capital theory" that seeks to understand the implications for decision making of the passage of time. The literature on "cost-benefit analysis" originates from these considerations of time.

While bearing in mind the warning that agroforestry is unlikely to be the miracle solution to many of the land-use problems of the world (Lundgren 1979), agroforestry in the semi-arid areas of the tropics is believed to have important potential for reducing the risks and uncertainties of those attempting to eke out a living in such marginal conditions. Farmers the world over are familiar with risk and uncertainty so it is not surprising that this is a field in which there is now a substantial agricultural economics literature (Anderson, Dillon & Hardaker 1979). In this third area particularly the economics profession recognises the importance of collaborative "farming systems" research (Collinson 1979, Norman 1978).

In the last analysis, whether a technology is or is not adopted will depend on the individual farmer's assessment of its benefits as against its costs. Appropriate economic analysis must take account of

Figure 3. Multi-period Production Possibility Surface



the long-term and multiple-component nature of agroforestry land-use systems since the objective is ".... to get higher productivity, more economic returns, and better social benefits on a sustained basis, than are obtainable from monoculture on the same unit of land." (Nair 1979). We have said enough to suggest that such analysis is sufficiently complex for training in economics to be an important component in any professional education programme in agroforestry.

## A Practical Tool

We conclude by bringing to the attention of the participants a practical tool that has been designed to assist in the economic analysis of these complex, long-term, land-use systems. The tool is a computer package called MULBUD which has been designed to operate on inexpensive microcomputers (Etherington *et al*. 1982). The name is an acronym for multi-period, multi-crop budgeting. It was designed to provide a simple, straight-forward, partial budgeting tool for researchers and planners working on tree (perennial) crops in developing countries who had had no previous experience of computers and probably minimal training in economics. The programme is extremely "user-friendly", "fail-safe" and as "obvious" as possible. The fundamental building block is the individual (monocrop) *minimum consistent crop data set* which the user specifies by responding to a series of questions. MULBUD can then build multicrop budgets with temporal and area options. Monocrop or multicrop budgets are displayed in "final report" format with appropriate economic indicators and flexible, user defined, sensitivity analysis. For the technically minded, the package comprises ten modules which total 258K 8-bit bytes in size. It operates on 288 microcomputers running the CP/M operating system with 64K bytes of RAM memory. *MULBUD does not give solutions, it gives alternatives.* It is a user driven simulation tool rather than an optimising algorithm. It is as positive as a slide-rule so provides no normative answers. Development of MULBUD has been a joint Australian National University (ANU)/ICRAF Project, funded by the ANU and the International Development and Research Centre (IDRC) of Canada.

## REFERENCES

Anderson, J.R., Dillon, J., Hardaker. J.B. (1978). Agricultural Decision Analysis. Iowa State University Press.

Alvim P. DE T., and Kozlowski (1977). Ecophysiology of Tropical Crops, Academic Press. New York.

Barlow, C. (1978). The Natural Rubber Industry. Its Development, Technology and Economy in Malaysia Oxford University Press, Kuala Lumpur.

Belshaw, D. (1979). "Taking Indigenous Technology Seriously: The Case of Intercropping Technologies in East Africa." I.D.S. Bulletin Vol. 18, No.12, January.

Burgess, R.J. (1977). The intercropping of Smallholder Coconuts in Western Samoa: An Analysis using Multi-Period Linear Programming. (M.A.D.E.), Australian National University, August.

Carrad, B. (1977). "Cattle and Coconuts: A Study of Copra Estates in the Solomon Islands." Confidential Report, Development Studies Centre, The Australian National University.

Collinson, M.P. (1979). "Micro-level accomplishment and challenges for the less developed world." International Association of Agricultural Economists 17th Conference, Banff, Canada, September.

Etherington, D.M., Matthews, P.J. (1982). MULBUD User's Manual. Development Studies Centre, The Australian National University.

Huxley, P.A. (1981). "The Role of Trees in Agroforestry - Some Comments" Proceedings of the Consultative Meeting on Plant Research for Agroforestry. April (forthcoming 1982).

Flinn, J.C. (1979). "Agroeconomic considerations in cassava intercropping systems." In Weber et al. Eds. Intercropping with Cassava. IDRC, Ottawa.

Lundgren, B. (1979). "Research Strategy for Soils in Agroforestry." In Monoi, H.O. and Huxley, P.A. Eds, Soils Research in Agroforestry, ICRAF.

Meade, J.E. (1955). Trade and Welfare. O.U.P. London.

Mollison, B.C. and Holmgren, D., (1978). Permaculture 1: A Perennial Agricultural System for Human Settlements, Corgi Books (Transworld Publishers), Melbourne.

Nair, P.K.R., Ram Varma, Nelliat, E.V. and Bavappa, K.V.A. (1975). "Beneficial Effects of Crop Combination of Coconut and Cocoa. Indian Journal of Agricultural Science 45, (4), pp.165-71.

NAIR, P.K.R., (1979). "Definition of agroforestry." ICRAF Newsletter Vol. 1, No.1.

Norman, D.W. (1978). "Farming Systems Research to Improve the Livelihood of Small Farmers." American Journal of Economics, 60:5, December.

Trenbath, B.R. (1976). "Plant Interactions in Mixed Crop Communities" Multiple Cropping (American Society of Agronomy) pp.129-169.

Weber, E. Nestel, B. and Campbell M., Eds. (1979). Intercropping with Cassava Proceedings of an international workshop held at Trivandrun, India, 27 November-1 December 1978 (I.D.R.C., Ottawa).

Willey, R.W. (1979). "Intercropping - Its Importance and Research Needs". Part 1. Competition and Yield Advantages." Field Crop Abstracts 32, 1, January 1979, Part 2, Agronomy and Research Approaches F.C.A. 32, 2, February 1979.

# A COMBINED SYSTEMS/CASE STUDY APPROACH FOR AGROFORESTRY TEACHING

by

Peter A. Huxley

Agroforestry may be taught as a defined programme, or it may be just a component course or subject in a programme with quite a different label (forestry, agriculture, applied ecology, geography, resource-planning etc.). This short paper addresses the first requirement: and it summarizes what has been said elsewhere (Huxley, 1976a, 1976b, 1980, 1982, Bawden et al. 1984). The needs for the second might best be satisfied by preparing a flexible course 'package' (complete with references, text extracts, visual aids etc.) for use in a wide range of different faculties and institutions (ICRAF, 1980).

## Agroforestry is about land-use systems

It goes without saying that the objectives in teaching an agroforestry programme will be not merely to satisfy academic development alone but, without disregarding this, to provide trained professionals to fill a wide range of relevant national tasks in an essentially problem-oriented way. There may, therefore, be a number of specialized approaches to be catered for -- for example to educate those who are to take up posts as development managers, or economic planners, or research personnel, and so on.

This situation is no different, of course, should we be teaching agriculture (in its broadest sense), or commercial forestry. The kinds of ideas, expertise and information required/contained in agroforestry are certainly similar to those. However, the difference with agroforestry is that the approach to land use, its development, and the resolution of problems which arise in maintaining or promoting agroforestry land-use systems, has to cover an even wider set of issues; and these have to be understood

and interpreted through a strictly well-integrated and ordered pathway of methodologies which, as yet, are just being thought about. We, therefore, have to address two issues:

> are we to deal with educating generalists or "semi-specialists", or both; and
>
> what is it that we are going to teach if we are to develop the methodological approaches which are required?

Agroforestry, however you care to define it, is basically concerned with making land more productive in a sustainable way. It is therefore concerned with the analysis, understanding and development of land-use systems. And it is from this standpoint that we should first consider our questions. The ability to intervene for the better in an existing system, or to design a new one, implies that we understand the system as a whole, or, at least, sufficiently about its component parts and processes (or those of its subsystems) to appreciate the likely effects of changes or manipulations.

Perhaps we have already answered the first question then, because we have to teach enough about the situation for the recipient to adopt a holistic approach. Particularly in evaluation and problem-orientation, an agroforester will have to work from the general to the particular, and back again to the general. In doing this, narrow disciplinary 'blinkers' will not help. And an ability to understand, and even develop, new methods as one goes along will be vital.

An agroforestry programme will thus essentially contain instruction and information on how to look at agroforestry land-use systems. Only by doing this will the complexity and integration needed in considering even the simplest agroforestry situation be containable, and problem-solving be feasible in a practical and meaningful way.

How do we narrow it down?

Because agroforestry covers such a broad scope, and because there are so many types of agroforestry land-use systems involved, two sets of reductions may be needed:

a concentration on the principles; and

a highly selective approach to the description of agroforestry systems and situations.

A few examples may suffice to illustrate the first point. Productivity in agroforestry systems is concerned with the outcome of biological interactions between plant associations. The successful design and management of such a system must, therefore, depend on an adequate knowledge of plant-to-plant interactions and of how these can best fit into particular economic and social contexts. There is now a huge and growing literature on agricultural intercropping from which we can draw in order to at least start teaching the principles relevant to agroforestry situations. Then again, the sustainability of a land-use system is only predictable if we know enough about the changes which plants, man, and animals can bring about with regard to the soil. Indeed, because agroforestry is so location-specific the extrapolibility of any successful system is only possible if there is some basic understanding of its environmental interactions. Hence we need to draw on the large body of literature relating to soil/plant/climate interactions, but re-interpret it in the light of what we know about the characteristics of agroforestry land-use systems. Research literature from agriculture, horticulture, forestry and general ecology contains much that is relevant which can be put together in a suitable form for teaching agroforestry.

Thus one vital difference between teaching agroforestry and agriculture or forestry at present is that, in many instances in agroforestry, detailed data and descriptions are just not available. Nevertheless, it will often be possible to create a synthesis of available information from different sources (Huxley, 1980; Lundgren, 1980), and to elaborate principles.

However, we can do better than that because there are many situations where woody perennials play an obvious role in the landscape. These can readily form the basis for teaching about agroforestry and serve to introduce practical examples. Such a "case-study" approach to teaching agroforestry is

quite feasible now, and it can be used to concentrate teaching selectively on practical and relevant issues.

In the long run agroforestry must not remain purely descriptive; it has to become experimental and in a cost-effective way. A resolution of what basic information is needed is rapidly coming about, together with a burgeoning interest in describing what is actually in existence. Any satisfactory teaching programme for agroforestry will, undoubtedly, combine these two approaches and go on, further, to elaborate the research methodologies which are now being promulgated (Huxley, 1983).

Achieving the right synthesis

Major educational changes proceed reiteratively. We do not at present have a cadre of lecturers/teachers who have themselves been through agroforestry educational programmes, and have then gone on to gain experience in practical agroforestry. Those of us who have arrived at agroforestry from other disciplines have to do the best we can to put together what we, as individuals with vastly different backgrounds, see as appropriate, at this particular stage. There is an excitement in belonging to such a multi-disciplinary effort, but also a danger. Enthusiam has to be tempered with an appreciation that we are not trying just to fill a pot with all the necessary ingredients from every available discipline, but to work out a new recipe which will not boil over! The critical issue here is not so much what to put into an agroforestry programme but what to leave out! And, in the process, to ensure that we are training the mind and not just filling it. Here again the "case-study" approach is one which, if based on appropriately selected material, can introduce a considerable level of selectivity and relevance. A whole programme (which itself can be divided into parallel "streams") can be based on a sequence of practical "cases" which enable biological, environmental and socio-economic concepts to be adequately exposed and understood. And the principles involved can be very closely linked to practical situations and not taught just as a set of self-contained entities.

In the previous papers I suggested an outline scheme for teaching subject courses (for example, soil science and soil management, various aspects of

plant and environmental sciences, and so on,) not in virtual isolation from one another, to be integrated only if possible at the end of the teaching programme, but taught throughout in relation to a well-devised sequence of practical situations. These would start with examples which dealt with the system or systems as a whole -- the general -- and work towards more and more details, in terms of management or research -- the particular.

The amount of logistical and infrastructual support for an agroforestry programme based on this method is necessarily large. Any programme which depends so consistently on field practicals and field case studies can be vulnerable. Nevertheless, the advantages of completely integrating the physical, biological and social sciences to directly relevant field examples throughout, would be considerable not just in terms of educational value, but in the practical and operational capacity of the outgoing students. The highly integrative nature of agroforestry demands that we avoid, as far as is reasonable, a devisive approach to teaching it, and do not fall into the trap which has generally ensnared agricultural and forestry educators.

For example, many existing professional educational programmes in agriculture and forestry present a confusing array of subjects to the student. To some extent this has come about because of the confusion of linking the structure of analytical research, which is devisive too directly to land-use education, which is (or should be) integrative. In agriculture and forestry 'New' subjects are constantly being added to an already overburdened programme, and students soon "lose sight of the wood for the tree." Bearing in mind the very wide scope of agroforestry the "separate course" approach could be both inefficient and far too burdensome for students. Agroforestry educational programmes will demand that we be both practical and integrative to a high degree if we are to be successful. We have the opportunity to approach this in the right way, let us not lose it!

## REFERENCES

Bawden, R.J. Macadam, R.D., Packham, Y.J., and I. Valentine. (1984). "Systems thinking and practices in the education of agriculturists." Agric. Systems. 13, 205-225.

Huxley, P.A. (1976a). "Agricultural re-education," Span, 19, 80.

Huxley, P.A., (1976b). Addendum to "Agricultural re-education" In: Keswani, C.L. et al. (eds). Proc. Workshop on Agricultural Curricula for Undergraduate Students. Fac. Agric. For and Vet. Sci. Univ. Dar-es-Salaam, Morogoro, Tanzania, pp.335-345.

Huxley, P.A. (1979). "Agroforestry at degree level: a new programme structure, in T. Chandler and D. Spurgeon (eds). - International Co-operation in Agroforestry - Proc. of an International Conference. DSE/ICRAF Nairobi, pp. 219-229 .

Huxley, P.A. (1980). "Agroforestry research: the value of existing data appraisal," In: T. Chandler and D. Spurgeon (eds). pp.275-315.

Huxley, P.A. (1982). "Education for agroforestry," In: Proceedings of the UNU/Albert Ludwigs University Workshop on Agroforestry, May, 31 - June 5, Freiburg. United Nations University, Tokyo, (in press)

Huxley, P.A. (ed). (1983). "Research Methodology for the Exploration and Assessment of Multipurpose Trees." (Source meterials and guidelines, compiled by P.A. Huxley, J. Burley, P.J. Wood, and P.J Robinson), ICRAF, Nairobi.

ICRAF. (1980). Programme of Work, ICRAF, Nairobi.

Lundgren, B. (1980). "Research strategy for soils in agroforestry." In: Soils Research in Agroforestry, Proc. of an Expert Consultation. H.O. Mongi and P.A. Huxley (eds) ICRAF, Nairobi. pp. 523-538 .

# AGROFORESTRY EDUCATION FOR RURAL DEVELOPMENT

by

Michael Stocking

## Introduction

The primary rationale for agroforestry (AF) is to utilize the many interactions between trees and crops to obtain greater or more diversified or more sustainable production from existing resources than is possible with other forms of land use under the prevailing ecological, technological and socio-economic conditions (ICRAF's Programme of Work for 1982, unpublished). In short, AF attempts to use a set of technical solutions involving trees and crops in order to answer a range of technical and non-technical rural problems: e.g.

- maintain and improve soil fertility
- reduce soil erosion potential;
- increase agricultural productivity;
- enhance rural incomes;
- provide a viable alternative land use under commercial and subsistence farming systems.

It is this multi-purpose role of AF that is both a challenge to education and an opportunity to make a real advance in development.

## Agroforestry and rural development

### A Two-way Interaction

AF potentially has a great contribution to make to rural development, and, in turn, development planners have an important guiding role in AF. Therefore, when considering the form and structure of AF education, the following contexts should be taken into account:

(i) the whole spectrum of problems in rural development, such as poverty, malnutrition, lack of access to resources etc. Not only could AF assist in solving such problems, but the problems themselves will often provide key opportunities for the successful implementation of AF where other solutions might have failed;

(ii) the way in which agricultural and rural development projects are planned, so that AF is included. Because AF is not a narrow professional discipline but an amalgam of the technical aspects of ecology and land-use planning, there is a reluctance on the part of planners and administrators to include AF as it does not fit neatly into the standard professional disciplines normally recruited for projects;

(iii) the way in which rural development specialists, land-use planners, resource assessors and the like are trained. These are the people we hope would include an option or an element of AF in solving rural development problems. If the option is never provided, the possible opportunity of sustained development may be missed.

The interaction between development planners and professionals is mutually supportive: neither group can be seen in isolation from the other, for to do so would invite failure of a development scheme and the rejection of an agroforestry technique.

## The Educational Challenge

There are many important technical aspects of AF which need investigation. For example, many of the crop, tree and soil interactions are poorly understood; agriculture and forestry research stations rarely provide the right data for a proper evaluation of the productivity and performance of AF systems. Despite these gaps in knowledge, however, AF has many more intractable social, political and institutional hurdles to jump than it has technical problems to solve. To many professionals it is blindingly obvious that AF could solve soil erosion problems and provide viable soil conservation systems in East Africa (Ecosystems, 1982). The natural adoption of AF by traditional cultivators in many ecological zones is

further proof of the appropriateness of AF to modern development problems. Yet it is the incapacity of scientific and administrative institutions, the lack of social awareness and political apathy that limit the adoption of AF as a rural development solution.

For these reasons our education and training in AF must address how and why AF can meet human needs and can be integrated into existing farming systems. The technical frontier in AF is way ahead of the operational frontier. The educational challenge is to increase awareness of the opportunities of AF in rural development, and establish an interchange between researchers and the planners/implementers of AF. Equally wrong would be the sole pursuit of AF to the exclusion of other development solutions. AF could usefully learn from the lessons of 'The Green Revolution' with its introduction of high-yielding varieties which is causing at least as many development problems as it is solving. The lessons will involve such questions as 'How can we apply a technical solution to a human problem?'; or 'What are the benefits and disbenefits of implementing systems of agroforestry on a society?' or 'Is there a sufficient institutional framework to support AF?'

## The Project Planning Cycle [1/]

Rural development deals with complex problems. For example, rural areas throughout Africa fail to produce sufficient food, not necessarily because people do not want to produce crops but because, for a variety of reasons, it is not in their individual interests to grow more. In dealing with the complexities of cause and effect in rural development, it is essential to adopt a balanced consideration of the problems and an orderly approach to possible solutions.

The planning model or project planning cycle (Figure 4) is especially suited to a rational incorporation of AF as a development tool. The cycle comprises nine identifiable areas of planning activity, each separable from the others by particular activities, methods and problems. It is a sad fact that most

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[1/] Material for this section is taken from 'Agriplan Training System: A Summary.' -- ODG (1981).

**PROJECT PLANNING CYCLE: The nine steps in the Agriplan Planning Model as used in training for Zambian middle-level professionals**

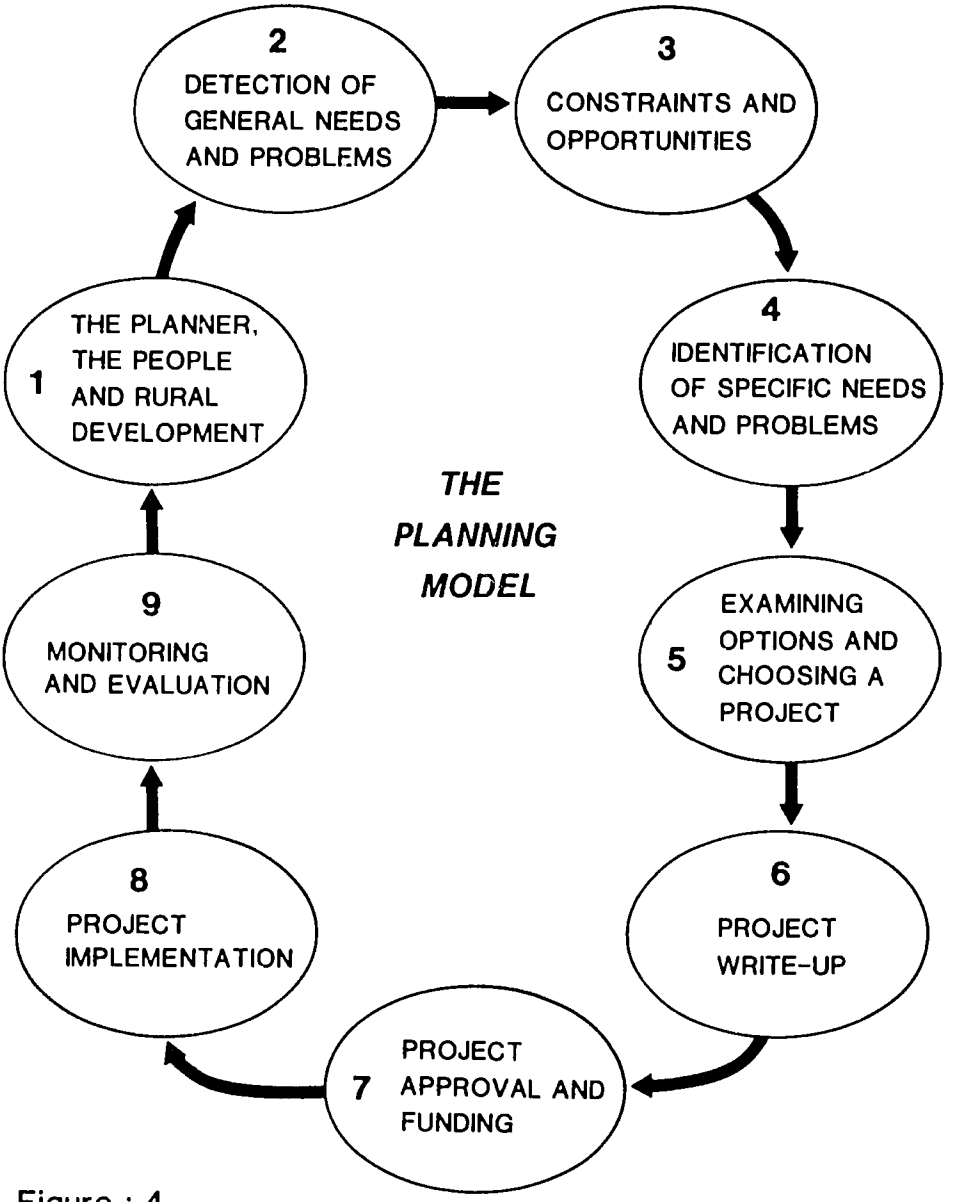



Figure : 4

rural development projects start at Step 4 in the Planning Model, jump quickly to Steps 6 and 7, and finish at Step 8. The short-circuiting of a planning approach has led to many rural development failures where, for example an inappropriate choice has been forced on an unwilling people by well-meaning professionals and planners: a solution that is technically the best need not necessarily be the best. One of the main arguments for AF is that it provides an efficient and productive activity that will often have greater chances of acceptance because of its overwhelming environmental and social advantages. On the other hand AF may be inappropriate under some circumstances. It would be essential for planners to identify those situations to ensure that failure of AF does not occur. Failure nurtures disillusionment which would be doubly critical for the fledgling science.

The planning model, known by its original project name of 'Agriplan', has already formed the basis for the training of middle-level (i.e. provincial agriculturalists, district officers etc.) in Zambia, and it is currently also being operated in Nepal, both programmes having been funded by UNDP and implemented by FAO with teams from the Overseas Development Group in the U.K. Table 11 gives a breakdown of the Steps in the Zambian 'Agriplan'. The Agriplan approach uses a systematic analysis of the reasons for rural poverty which, in the Zambian case, included an economy excessively reliant on copper production, a strong urban bias, dependence for agricultural production on a few commercial farms, and lack of investment in the rural areas. In bringing these problems to the fore, the Agriplan approach requires trainees to adopt a holistic approach, urging in so far as is possible an unbiased evaluation of separate development strategies. At various stages of the planning cycle, political, economic, social and ecological dimensions are each given appropriate but flexible emphasis. In such a millieu AF should receive objective consideration, its advantages carefully weighed both against its own disadvantages and against other options. Merely to promote AF is to court failure and rejection.

## Training Methods

The Agriplan system is intended for in-service training. The structure, rationale and sequence of

TABLE 11. SESSIONS IN THE AGRIPLAN TRAINING SYSTEM AND THEIR RELEVANCE TO AGROFORESTRY (AF)

| Step | Session | Possible AF-related input |
|---|---|---|
| STEP 1. THE PLANNER, THE PEOPLE AND RURAL DEVELOPMENT | | |
| | 1. Development: Which Way? | Rural sector aims to include AF. Who benefits by AF? |
| | 2. Getting To Know Them: Socio-Economic Groups | AF appropriate/ different to which socio-economic group? (subsistence, small-scale, emergent producers, etc.) |
| | 3. Planned Development: Conflict and Change | Use of scarce resources. Difficulties of the rural planner. |
| STEP 2. DETECTION OF GENERAL NEEDS AND PROBLEMS | | |
| | 4. Detecting General Needs and Problems | Rapid rural appraisal techniques for AF. |
| | 5. Designing Rapid Rural Appraisal | - " - |
| | 6. Analysis of RRA Results | - " - |
| | 7. Identifying Themes | - " - |
| STEP 3. CONSTRAINTS AND OPPORTUNITIES | | |
| | 8. Types of Constraints and Opportunities. | Introduce AF as an opportunity, but its practice limited by constraints: |
| | 9. Constraints and Opportunities: Human and Institutional | Constraints such as prejudice, self-interest, bias, etc. |

Table 11 con't

| | |
|---|---|
| 10. Constraints and Opportunities: the Physical Environment | *Environmental opportunities and constraints |
| **STEP 4. IDENTIFICATION OF SPECIFIC NEEDS AND PROBLEMS** | |
| 11. Approach and Bias in a Field Survey | *Field surveys for AF |
| 12. Designing Questions and Organizing a Survey | Survey checklists related to AF |
| 13. Analysing Field Survey Data | Organization of data into summaries |
| 14. Data Presentation: Bar Charts and Graphs | - " - |
| 15. Defining Objectives | Local objectives and relationship to AF |
| **STEP 5. EXAMINING OPTIONS AND CHOOSING A PROJECT** | |
| 16. Making and Examining Options | Inclusion of AF options |
| 17. Criteria for Comparing Options | *Acceptability/feasibility criteria for AF |
| 18. Appraisal of Options | Objective appraisal between 'best' options |
| 19. Choosing a Project | *Cost estimates of AF |
| **STEP 6. PROJECT WRITE-UP** | |
| 20. Project Write-up | Presentation of AF arguments |
| 21. Project Pro-Forms | Economic impacts, benefits of AF through shadow-pricing, rates of return, etc. |

Table 11 con't.

| | |
|---|---|
| STEP 7. PROJECT APPRAISAL AND FUNDING | |
| 22. Approval and Funding: the Setting | |
| 23. Approval and Funding: How it Happens | |
| STEP 8. PROJECT IMPLEMENTATION | |
| 24. Introduction | Organization of AF responsibilities |
| 25. Programming Exercise | *Timing and planning of AF |
| 26. Budget Control and Monitoring | *Management of AF progress |
| STEP 9. MONITORING AND EVALUATION | |
| 27. Meaning and Uses of M & E | M & E in AF |
| 28. Monitoring Projects | *How to monitor an AF programme |
| 29. Evaluating Projects | Evaluation and incremental change in project design |
| 30. Guidelines for Monitoring and Evaluation of Rural Development | M & E in action |

*These AF inputs are essential, and in any training system for AF professionals they would need emphasis and possible expansion.

the training programme is based upon the planning model (Figure 4) with the nine steps broken down into some 30 sessions (Table 11). Each session corresponds to a single contact period of teaching, usually of three or four hours duration. Examples of the sessions are to be found in Project Planning Handbook (ODG, 1981b). In a training system designed for projects and personnel where AF would be a possible strong element, a change of emphasis and restructuring would be appropriate, but the planning principles would remain the same.

The steps in the planning cycle are linked to the Case Studies (ODG, 1981c). These provide concrete illustrations of planning problems and methods. The case studies are accounts of real events or projects, although it may be useful to have a fictitious but realistic 'Central Case Study' to emphasise the major points.

The training sessions are based upon group discussion, role play, practical fieldwork, data analysis, games and self-testing. The contact periods are reinforced by homework, often based upon the case studies. Participants may identify, appraise and write up real development schemes as part of their training programme.

An Agriplan training programme might be conducted in one of three ways. First, an entire course may be covered intensively in six weeks, with follow-up visits by the trainers. Secondly, a course may be spread over seven or eight months, with sessions held once a week. A third possibility is a combination of the first and second with intensive training at the beginning and end of the course and once-weekly sessions in between. Using this combination, a full programme could be covered in three to five months.

The programme is designed for a maximum of twenty participants with a minimum of two full-time trainers possessing complementary areas of expertise. At least one should be an experienced educator. Additional short-term inputs may be required to cover specialist areas. The system can be adapted to a range of educational standards from extension workers and agricultural assistants to graduate officers. The aim

is to train teams of planners collectively able to effect rural planning, rather than a few individuals fully competent in all aspects of development planning. Successful implementation depends upon the spread of knowledge through training the trainers, and emphasizing the transfer of the system to local personnel.

## Applying the Agriplan System to Agroforestry

The Agriplan experience is particularly relevant and appropriate to AF because of its emphasis on participatory planning and sensitive ecological and human solutions (Table 11), it is not a technique of passive instruction but includes active participation in the range of decisions surrounding the acceptance or rejection of an AF option, the final decision resting on technical aspects of AF and human needs. In this it is vital that AF specialists are trained in how their knowledge contributes to development, and how development in turn assists the progress of AF. The Agriplan approach through a Project Planning Cycle adapted for emphasis on AF is therefore suited to those middle-level personnel in existing ministries of agriculture, forestry and natural resources (or their equivalents) who are expected to initiate and supervise small-scale projects designed for small farmers and poor rural communities.

In addition the approach stresses the need to learn from rural people about the nature and causes of rural problems, and about opportunities that currently exist within the cultural and agricultural environment that are AF-oriented. Agriplan attempts to encourage professionals to learn from the local situation and to create information appropriate to local problems. Table 11 identifies those parts of Agriplan particularly relevant to AF.

## REFERENCES

Ecosystems. (1982). Southeast Shinyanga Land Use Study. Volume 3: Planning for soil Conservation. Report to Shinyanga Regional Integrated Development Programme, Tanzania and the World Bank. Ecosystems Ltd., Nairobi.

ODG. (1981a). Agriplan Training System: A Summary. Assistance for National In-Service Training for Agricultural and Rural Development. Overseas Development Group for FAO/UNDP, Rome (Project ZAM/77/004).

ODG. (1981b). Agriplan Training System: Project Planning Handbook. *op. cit.*

ODG. (1981c). Agriplan Training System: Case Studies. *Op. cit.*

# THE NETWORK AND TWINNING CONCEPTS OF RESEARCH AND TRAINING: WHAT DO THEY MEAN TO EDUCATION IN AGROFORESTRY?

by

Eberhard F. Brunig

## The Network and Twinning Concepts

The Unesco programme "Man and Biosphere" (MAB) has been successfully promoting inter-regional networks of cooperation in research and training since its inception in 1971. The network for the MAB (see Figure 5) is characterized by:

- close coordination in methodology, cooperation by personnel, information exchange and between-projects training assistance;
- coordinating activities and leading role played by regional centres of excellence in the tropical zone;
- strengthening of research by international cooperation in all phases of research planning, development of methodology, project implementation, evaluation and transfer of new knowledge by training and public education, with centres of excellence in the developed countries taking a lead in the process.

The scientific strategies for promoting endogenous development by external stimuli aim at breaking the major bottle-necks which are:

- existing information is scattered, not applied, insufficient;
- lack of capacity and capability of endogenous manpower;
- obstacles in the institutional, social and political marginal conditions.

The action includes problem-oriented, interdisciplinary efforts by a combination of research, demonstration, training and education with a basic philosophy of systemic and biocybernetic thinking.

# International Unesco Network "MAB1"

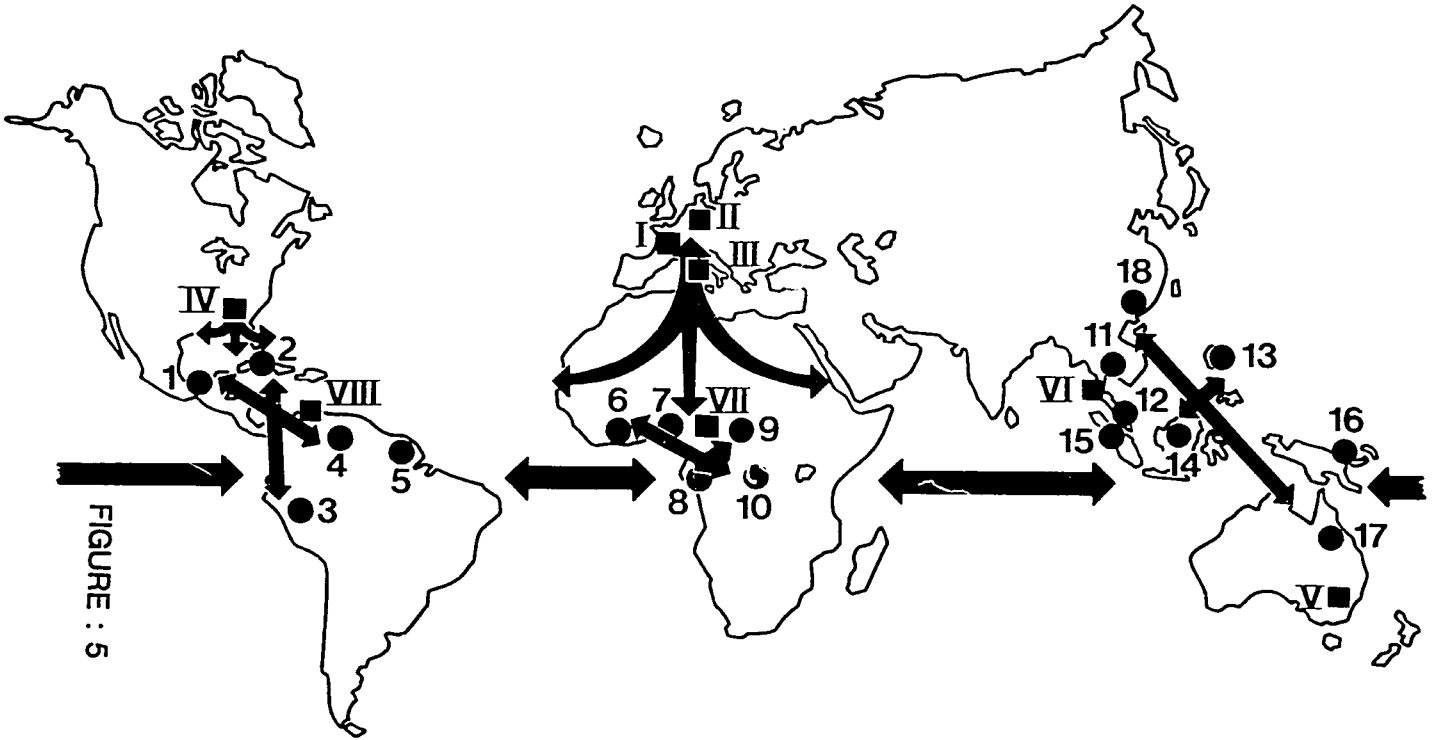



FIGURE : 5

Figure 5. Legend

The Unesco Program "Man and Biosphere" (MAB), Project Area 1 "Ecological Effects of Increasing Human Activities on Tropical and Subtropical Forest Ecosytems": the international network of cooperation between regional centres and pilot projects.

Coordinating Regional Centres

I MAB Secretariate of Unesco Headquarters, Paris; ORSTROM, France
II Institute for World Forestry, Hamburg, FRG
III Dept. of Microbiology, University of Rome, Italy
IV Institute of Ecology, Athens, Georgia, USA
V National University, Canberra, Australia
VI University of Malaya, Kuala Lumpur, and Universiti Pertanian, Malaysia, Serdang
VII Centre Reg. de Documentation, Yaounde, Cameroun
VIII Centro Internacional de Ecologia Tropical (CIET) and Centro Ecologia, IVIC, Caracas, Venezuela

Cooperating MAB Pilot Projects

1. Jalapa and other sites (Mexico)
2. Sierra del Rosario (Cuba)
3. Loreto (Peru)
4. San Carlos de Rio Negro (Venezuela)
5. Oyapok (French Guyana)
6. Tai Forest (Ivory Coast)
7. Omo and other sites (Nigeria)
8. Makoku (Gabon)
9. Basse Lobaye (Central African Republic)
10. Yangambi (Zaire)
11. Sakaerat (Thailand)
12. Pasoh and other sites (Malaysia)
13. Puerto Galera-Agno River Basin (Philippines)
14. East Kalimantan (Indonesia)
15. Leuser National Park (Indonesia)
16. Gogol (Papua New Guinea)
17. North Queensland (Australia)
18. Dinghu Mountains (China)

The objective is to provide scientific knowledge and expertise needed to advise planners, managers, politicians and the people involved in the management and conservation of the ecosystems on which their existence depends. Flow of information is indicated in Figure 6. The MAB 1 projects include a strong element of multiple production and utilization of vegetation crop systems with the aim of combining adequate utility with high stability. This includes agroforestry crops and systems.

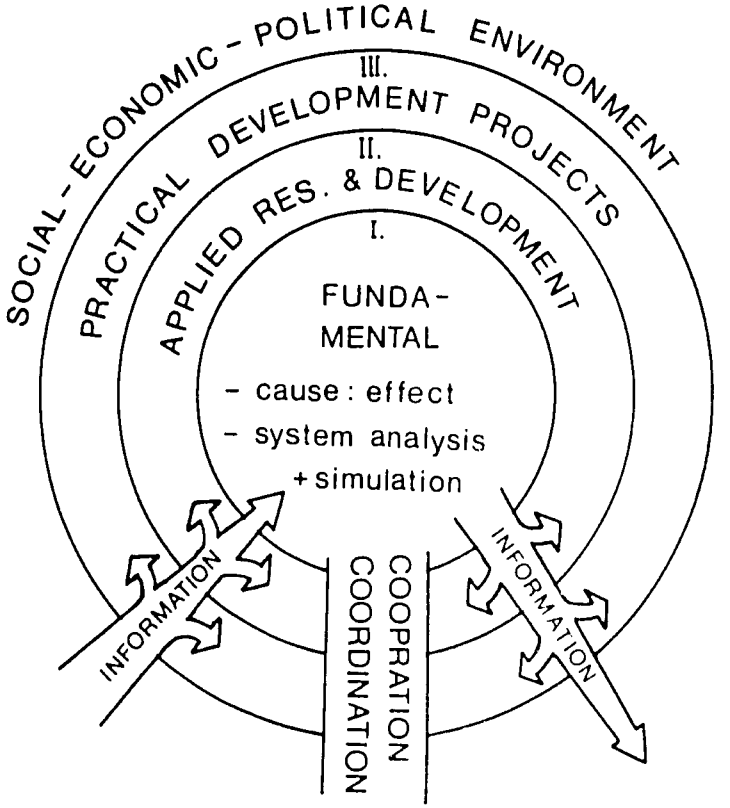
The World Bank jointly with FAO has launched the development of a programme of twinning between centres of excellence in forestry research during the XVII IUFRO World Congress in Kyoto, 1981. The idea is to establish a research network or "twinning" of national institutions in developing countries with overseas research centres to strengthen research programming and achieve greater efficiency and balance of research.

Priority areas of the programme proposal include use- and system-oriented conservation of humid tropical forest ecosystems and agroforestry. The proposal was backed by the 2nd FAO Tropical Forest Expert Meeting in January, 1982, and the FAO committee of Forestry Meeting in May, 1982. A conference of Forest Research Directors of the Asian-Pacific Region at the Environment and Policy Institute, held in Honolulu in August 1982, strongly endorsed the proposal and urged IUFRO to take action. The report and recommendations of that conference include a plea for more emphasis and better research on the natural and ecological bases of forestry and the application of systems approaches to research, training and implementation of research results.

## Relevance to Agroforestry Education

Complex dynamic, natural and cultural ecosystems have continued to puzzle the manager because:

- their very nature makes them indeterministic and their future stages are unpredictable;
- intervention into processes and modification of system structure produce predictable reactions only at very short ranges of time, long-term effects become increasingly unpredictable as the time horizon widens;
- complex interactions within the system and external linkages with other systems cause




INTER
- disciplinary
- agencies
- national

I. BASIC, SCIENTIFIC RESEARCH

II. APPLIED RESEARCH, TECHNOLOGY DEVELOPMENT

III. PRACTICAL PROJECTS OF IMPLEMENTATION

Figure 6. Relationship between the various levels of research, testing and implementation, with corresponding flows of information and levels of training and education in agroforestry.

unexpected side-effects with strong tendencies to a build-up of instability as a result of positive feed-back, which creates high risk levels and possibilities for partial failure and final collapse.

Empirical results and practical experience are of very limited usefulness to the manager of such systems because they are derived under specific constellations of endogenous and exogenous conditions and influences which have a low probability to persist or be repeated. Changes of socio-economic, technological or natural conditions over-tax the resources of the empirical practitioner (e.g. the experienced traditional farmer) and often leave him helpless. An example of failure of a well-established agroforestry scheme has been described by Sambas Wirakusumah (1979) from Java. In this case the trend to failure was initiated by unexpected technological developments outside the range of immediate system interactions, to which the traditional system could not adapt.

Generally, experience and traditional expertise are no substitutes for scientific knowledge. In the case of agroforestry, this knowledge includes knowledge of the cause-effect interactions at plant and crop ecosystem levels and of the structure, regulatory mechanisms and dynamics at the level of the crop, and of the socio-economic (business unit or regional and national) ecosystem levels. The provision of such knowledge and the holistic approach needed for the study and modelling of large, complex systems (for a discussion of the specific problems with large systems see Grossmann 1982) exceeds by far national capacities and requires international and interdisciplinary cooperation. To be efficient and effective, education in agroforestry must be accordingly organized. This means:

- a hierarchic structure of training and educational programmes according to the ecosystem levels <u>and</u> the target groups (e.g. scientific researcher, applied researcher and developer, planner, politician, practioner);
- regional network cooperation in educational programmes with regional centres of excellence providing leadership;
- "twinning" between educational centres of excellence.

## REFERENCES

Grossman, W.D. (1982). Modelling of Large Scale System. In: Brunig, E.F. (ed.). Transactions of the Third International MAB IUFRO Workshop on Ecosystems Research Deutsches Nationalkomitee MAB, MAB-Mitt. Nr 10, 1982, pp. 130-138.

Wirakusumah, S. (1979). Diversified silvicultural and agrosilvicultural crops. In: Adisoemarto, S. and Brunig, E.F. (eds.). Transactions of the Second International MAB IUFRO Workshop on Tropical Rainforest Ecosystems Research. Chair of World Forestry, Hamburg-Reinbek, Special Report No. 2, 1979, pp. 124-127.

# AGROFORESTRY EDUCATION FOR CONTEMPORARY AND FUTURE FOREST DEVELOPMENT IN KENYA

by

J.A. Odera

The smallholder or peasant farmer, our most important target group in rural development, operates like an enterprise manager of a commercial undertaking who is concerned with producing the basic needs of food and wood for family consumption and surpluses for sales, etc. Approaches to the farmer especially by extension staff of multiple land-use agents of agriculture, livestock and forestry must therefore be integrated within the goal of improving his performance rather than going for a radical change.

Unfortunately today there is considerable conflict and competition between agriculture and forestry. While the forester is preaching tree planting messages for energy, building materials and environmental stabilization, the agriculturalist is primarily concerned with food production. The discrepancies between agriculture and forestry can be seen and one can say that there is a strong competition between the two sub-sectors, resulting in considerable confusion among the farmers.

Lack of effective co-ordination between the extension agencies is also costing the farmer considerable time, with a high opportunity cost. It is estimated that up to 60 per cent of a progressive farmer's working time may be spent with extension agents and visits by organizations and parties.

Professional biases in the extension programmes are a consequence of historical educational isolation between the agriculture and forestry disciplines, consistent with sectoral or subsectoral government structures. The current subject-patronized educational approach leads to an output of trained personnel who find it very difficult to appreciate the concept of wise land use, with concomittant needs for resource conservation, and environmental stabilization. Both the agricultural and forestry graduates are today inadequately trained for an integrated approach to rural development and

multisectoral planning both of which are important for smallholder agriculture.

A revised and a more imaginative educational and training programme is therefore needed for the extension agents to help mobilize the presently cramped and constrained service. According to Mburu (1980) although community forestry is gaining ground in leaps and bounds, it is being promoted by foresters who have been trained to raise forest plantations as cheaply as possible in large plantations. He therefore, stresses the need for a re-appraisal both by agriculturalists and foresters. Traditional forestry training concentrates on conservation and industrial production of wood while the agricultural education is heavily oriented toward large-scale commercial farming. Contant (1979) urged institutions of higher education and technical colleges to insert a course in farming systems and agroforestry into their curricula.

Admittedly the traditional forestry and agricultural courses cannot continue to be stretched further without diluting professionalism. But some adjustments can be made to produce an output of trained personnel capable of conceptualizing and appreciating multi-disciplinary delivery service and the dynamics of the multiple land-use systems.

It is recommended that the service courses currently provided in agricultural and forestry education be reviewed and the curricula be reorganized to accommodate new courses on agroforestry and social forestry to reflect the growing importance in these areas. Indeed, several universities have recently introduced agroforestry topics and aspects of community forestry in such courses as silviculture, soils, and economics, or as part of the course in tropical forestry, with emphasis in forestry and land use particularly in peasant agriculture. In this context, the University of Nairobi introduced in 1982 new courses of three units each in agroforestry and rural forestry programmes. But the Kenyan young university department is still inadequately staffed and the curriculum is short of desirable adjustments in agroforestry and social forestry. The first year of the B.Sc. F. is still spent on basic courses which could well be covered in the higher school certificate syllabi. Dropping some of these courses would

provide time for utility courses on social forestry and agroforestry.

While the curricula developed many years ago are still extant and call for revision, such revision must be geared toward meeting felt national development needs. Admittedly opinion on the latter is bound to vary. But perhaps the most important need today is developing forests for the people. This along with earlier discussions show that in the future the role of forestry in our national development will be evaluated in the farming sector.

Consequently the proposed training should be directed to agricultural and forestry change agents in the field, students in schools, teacher training colleges, technical institutions and those at the university. Utility courses on agroforestry should be given at the foundation level -- the primary and secondary schools. Adjustments for agroforestry education should be promoted together with those designed to cater for social forestry to facilitate effective focus on forestry needs of our times and for tomorrow's generation.

Informal Education

Informal courses, workshops and seminars should be arranged for in-service agricultural and forestry change agents, at the district level. Such courses should concentrate on social forestry including introduction to agroforestry technologies, principles and practices. About 25 per cent of the session should be spent on special sessions during which the agriculturalists would concentrate in introductory forestry, nursery and silvicultural practices. The foresters would concentrate on introductory agriculture and animal husbandry.

Technical Education

Technical education aims at producing grassroots and mid-level extension agents. Both the certificate and the diploma curricula should generally be restructured to give a practical balance between resource sciences, social sciences and management sciences, to enable the graduates to communicate with the farmers.

More importantly the agricultural institutions should introduce new courses on forestry practices to be

taught during the first year and agroforestry technologies on social forestry to be taught in the final year. The forestry institutions on their part should teach regional agriculture during the first year and agroforestry and social forestry during the final year. A common syllabus on agroforestry should be taught in the agricultural and forestry institutions. While an elementary course on social forestry should be given to the agricultural students, the forestry students should take an in-depth course on social forestry to be consistent with the changing emphasis in forest development.

Professional Education

Although agricultural and forestry graduates have hitherto tended to work as supervisors, and adminstrators or researchers, they should have first-hand information on multiple land-use. To achieve this, the B.Sc. students studying agriculture and forestry should be taught introductory courses in forestry and agriculture respectively during the first year. The agriculturalists should be familiar with forestry practices, and silvicultural methods while the forester should be given basic information on agronomy and animal husbandry. Joint courses in agroforestry and social forestry should be introduced during the third year, for both the agriculture and forestry students, with the forestry students taking a more in-depth course in social forestry.

The undergraduate programme should aim at providing the graduates with a working knowledge of integrated land-use systems without narrowing employment openings for the graduates through premature specialization in these areas. Specialization in agroforestry configuration, social forestry, various aspects of agriculture and forestry should therefore be delayed and be offered to those pursuing M.Sc. and Ph.D. programmes. But existing provisions for study options allowed in the final year in the present forestry curriculum should include agroforestry and social forestry as additional approved electives. Course development for the new topics should be undertaken jointly by the user Ministries and the University Department to ensure a realistic focus on the National needs.

The proposed training should aim at reinforcing and

upgrading the competence of the graduates implementing the development of social forestry within the context of wise land use. In a country pervaded by strong feelings of professionalism, many Kenyan agriculturalists today look at agroforestry with caution. This is to be expected because agroforestry was conceived of and begun by foresters. Foresters must therefore continue to pave the way into the future in an attempt at providing graduates who are competently trained in handling integrated rural development programmes and the hitherto neglected extension service. The response from agriculturalists is bound to improve when the future becomes more certain.

Although Huxley (1979) proposed the introduction of a degree programme in agroforestry, discussions with Kenyan agriculturists and foresters (headquarters and field-based) indicate that such a programme at the undergraduate level would deny the graduates a chance of acquiring a sound forestry base desirable for specialization and subsequent career opportunities. Specialization at the M.Sc. level on agroforestry, social forestry and allied aspects of integrated land-use should be promoted in favour of a basic agroforestry degree. Indeed parallel well-thought-out research programmes at the M.Sc. and Ph.D. levels, and post-doctoral fellowships by nationals and researchers attached to international institutions should be advanced as an important avenue for fostering the development in the state of the art of agroforestry and social forestry. This would ensure an unimpeded flow of new field-tested technical knowledge to the farmer for enhanced rural development.

Odera

## REFERENCES


1. Contant, R.B. (1979). "Training education in agroforestry." Conference on Internat. Co-operation in Agroforestry. Nairobi, pp. 191-218.

2. Huxley, P.A. (1979). "Agroforestry at degree-level." Ibid - pp 219-227.

3. Mburu, O.M. (1980). "Agroforestry in forest management in Kenya." Proceedings of the Kenya Nat. Seminar on Agroforestry, Nairobi, pp. 1922.

# CONSTRAINTS ON AGROFORESTRY TEACHING AT THE PROFESSIONAL LEVEL

by

J. Burley

## Introduction

Spatial and temporal mixtures of agricultural crops, domestic animals and trees have been practiced on small, individual land holdings for centuries in many temperate and tropical countries. Nevertheless, it is only relatively recently that agroforestry, however it is defined (see ICRAF, 1979; Stewart, 1981), has become recognized by governments, development agencies and educational institutions as a concept of land use that has great potential for meeting the multiple needs of rural populations. These needs include environmental amelioration (soil and water conservation, soil improvement, protection from wind and climatic extremes) and subsistence or cash crops (production of food, fodder, poles, saw timber, fuel, fibres, chemical derivatives, such as essential oils, herbs, cultural and religious necessities). Agroforestry has the added advantage of retaining some tree cover under conditions in which complete removal would be unwise.

Growing populations of humans and animals place increasing pressure on available land and require further removal of forest and the rehabilitation of degraded and abandoned lands. It is thus urgent to develop systems of multiple cropping that can be practised in perpetuity on individual holdings or on larger, communally owned areas. Such development requires professional staff and these require university training. The object of this Workshop is to review available teaching material and to assist in the preparation of agroforestry courses. While many countries and universities are rushing to meet our needs by offering professional training courses, this paper indicates some of the constraints that may inhibit the preparation, operation or value of such courses.

## Historical Antagonisms Between Agriculture and Forestry

In most countries agriculture and forestry are controlled by different departments or organisations,

often in different ministries. They frequently compete for use of the same land unless clear government land-use policies exist. This separation is reflected in the organisation of university teaching (wherein the two disciplines are taught in different departments) and in the structure of their courses (wherein the scientific content of each is maintained distinct with little awareness of the other discipline's course content). It is essential to overcome such entrenched attitudes in developing worthwhile courses in agriculture, forestry and agroforestry.

Combined courses are rare but one excellent example is the undergraduate course at Oxford in which the social, economic, biological and technical components of both agriculture and forestry are taught, together with some contributions on "agroforestry." It is ironic that, under government financial pressure, this course will be terminated as of 1985; however, it is encouraging that not two but four departments (Agriculture, Botany, Forestry and Zoology) are combining teaching resources to produce a new course in Pure and Applied Biology. Such inter-departmental collaboration is rare in academic institutions. Fortunately many of the components of the original course in Agricultural and Forest Sciences will be included in the new course and evidence is already accumulating that it will be popular among the new intake of students.

Lack of a Teaching Syllabus

Since the informed interest in agroforestry is a recent explosion, there are few formal courses either totally devoted to an agroforestry degree or a part of an agriculture or forestry degree; CATIE (Costa Rica) and the Universities of Nairobi, Oxford and Philippines (among others) do offer courses that contain agroforestry components at first or second degree level. At present there is no background of educational experience in agroforestry as there is in classical agriculture and forestry. A major topic should be the general scientific principles underlying agroforestry processes, e.g. light profiles, root profiles, competition and complementarity. These should be covered in a sufficiently critical manner to facilitate extrapolation from research results to practical application.

## Lack of Experienced Staff

Since most existing academic staff have come up through traditional agricultural or forestry routes of education and experience, there are few with field experience in designing or managing agroforestry systems. Thus much of their teaching is from a conceptual viewpoint or from reviews of other people's published experience. Such secondary sources are always better teaching aids when interpreted in the light of practical experience. As more young graduates join field projects (as volunteers, expatriate or national employees), gain experience and then join university faculties, they will improve the level of teaching. However, this depends on a commitment by government or university authorities to expand faculties or change the direction of teaching.

## Lack of Field Facilities

Many universities that teach agriculture or forestry in temperate regions either own or have access to good farms or forests for practical teaching but they are situated in countries that do not themselves practice or need agroforestry combinations; however, those universities are the sources of graduates who will work on assistance projects in tropical countries. Conversely the universities located in the tropics, where the demands and potential value of agroforestry are greatest, often have few field facilities of their own, although clearly they are situated close to real problems and potential demonstration areas.

It is difficult to conceive of an effective undergraduate course in such a practical subject as agroforestry without access to field demonstrations. In the case of research degrees, field facilities are also desirable (see below).

## Site Specificity of Agroforestry Systems

Despite the newness of our concern, a large literature exists (some 7,000 references relating to agroforestry are held by ICRAF) and new specialist journals have appeared (e.g. Agroforestry Systems). However, the design, management and results of combinations of agricultural and tree crops are highly dependent on local climatic, edaphic and sociological conditions. Thus, although principles can be taught, practice or demonstration, if they can be offered at all, are

effective mainly in the location of the teaching establishment. This has always been true to some extent for pure agriculture or pure forestry but the problems are intensified by the complex interactions between crops and by the local variations of social structure, land tenure and personal farming methods. Where practical examples can not be demonstrated, teaching is perhaps best done by studies of well documented cases illustrating both good and bad examples, although at Oxford we have found these better for short, intensive, specialist courses.

## Lack of Descriptive Models

Because of this site specificity it is difficult to compare the information provided in the many published reports or to interpret its extrapolation to other sites. Objective and quantitative methods are needed to describe the complex combinations of species and management treatments and to evaluate their products in terms of quantity and value of the multiple products. Benefits to the soil, water and climate of the farm or district are particularly difficult to estimate. This forms the subject of one of the major programmes of ICRAF.

## Lack of Awareness of Sociological Components

Previously both agriculture and forestry have been taught with large scale government or commercial enterprises in mind. Only very recently have governments and development agencies realised the importance of combining the two disciplines in field projects and the necessity of involving local communities and individuals in the decision-making and managerial processes. The World Bank (1978) revised its investment policy for the forestry sector to favour rural development rather than industrial projects. In a review of forestry research priorities in developing countries prepared by J. Burley and J. Spears (World Bank) and J.E.M. Arnold (FAO), the highest priority was given to research on the place of trees in support of agriculture and, within this major field, the top priority was for sociological studies (World Bank and FAO, 1981).

These needs for research and development imply that our agroforestry courses must include a fair proportion of sociological theory and practice, with particular attention to extension methods.

## Uncertain Employment Prospects

Bearing in mind the urgent demands for agroforestry in many countries, it might be expected that employment opportunities should be great in national and international organisations. However, uncertainty exists in the former because in many countries it is not clear whether the Departments of Agriculture or Forestry are responsible for the planning, management and staffing of agroforestry activities; in the latter, although staff are needed at headquarters and in the field, a high level of experience is required and often a nationality quota system operates.

In countries with government-financed universities in which new courses are based on an estimated demand for graduates, this uncertainty of employment adds to the natural resistance of the authorities to anything that may even vaguely threaten the existence of current courses. In contrast, where universities rush to jump on the bandwagon of agroforestry, they and their graduates may be disillusioned at the lack of ultimate, relevant employment.

Burley

## REFERENCES

ICRAF. (1979). Newsletter, Vol. 1, No. 1. International Council for Research in Agroforestry, Nairobi, Kenya, 4p.

Stewart, P.J. (1981). "Forestry agriculture and land husbandry." Commonw. For Rev. 60(1): 29-34.

World Bank. (1978). Forestry sector policy paper. World Bank, Washington D.C., USA. 65p.

World Bank and FAO. (1981). "Forestry research needs in developing countries - time for a reappraisal?" Spec. Pap 17th IUFRO, Congr. Kyoto, Japan. 56p.

# WHAT WILL BE EXPECTED OF PROFESSIONAL AGROFORESTERS?

by

H.J. von Maydell

## Introduction

Agroforestry, comprising a wide range of integrated land-use systems, is not new. During the last 10 years, however, due to increasing problems of rural development in many tropical countries, it has gained attention at various levels by different groups. Foresters have discovered that working with and for local people is more rewarding and more likely to be successful than keeping them out of "reserved" forest lands, and agriculturists as well as range specialists are increasingly aware of the multiple benefits to be gained from trees and shrubs.

A great many expectations have been created; if rightfully or not is yet to be seen. Agroforestry is expected to solve problems, many problems, heterogeneous problems, to reconcile conflicts between target groups with frequently competing objectives. "The agroforester" is expected to be the professional able to teach and bring about multidisciplinary, i.e. ecological, economic, social ...etc., land use. What, really (or realistically?) is he expected to do and to be?

## What is the Professional Agroforester Expected to Do?

About 30 per cent of the earth's land surface is covered by forest vegetation of all types, some 20 per cent by closed forests. Looking at all the various problems of rural development, today and tomorrow, it is well justified to ask what the contribution of those vast areas to human welfare should be and how the forest's contribution could be increased. It is for these reasons that the recent World Forestry Congresses, in choosing their themes, gradually adopted the ruling principle of serving man, especially rural societies in the Third World. At many conferences, in many publications and recently formulated guidelines for land-use policies, it has been outlined that "the necessary efforts should be made to enable people in the rural areas to benefit from trees and forestry" (Saouma, 1978). The FAO Advisory Committee on Forestry

Education at its Eleventh Session in September, 1981, "noted that in contrast with such definitions forestry education in many developing countries still placed emphasis on commercial forestry for export, and that most servicing officers in forest services were brought up to believe that this was in fact professional forestry. They would need to undergo a re-education process so that they could accept community forestry as part of their responsibilities. This would demand quite different end-product, and hence new ways of measuring what one was about.*

The Committee felt that there was evidence in many countries that forest services were not well structured to attain the aims of social forestry. It was also obvious that if social forestry was to be carried out by local groups on land owned by local communities, the forest officer could not have the same authoritarian role. He would need to be an adviser." Agroforestry is expected to play an important role, but if agroforestry is different from "traditional" forestry who then is to develop and to implement agroforestry? And does that person need a more specialized or a much broader education to meet the requirements and practical challenges in the field?

There are visiting cards, indicating that their holders are "agroforesters." A great number of traditional and modern farmers, foresters and range managers have been practicing agroforestry for a long time. But are they agroforesters by profession? ICRAF's staff members are doing agroforestry research work in the front line. Are they "agroforesters?"

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*) The Seventh World Forestry Congress had as its theme "The forest and socio-economic development", the Eighth Congress "Forests for people."

The following is taken from the official declaration of the Eighth World Forestry Congress in Djakarta, 1978: "Moreover, foresters should look beyond their forest reserves to areas where the planting of trees can be of major benefit to people and to agriculture other than for the direct harvesting of timber."

Suppose some one--an international or national organization or any other employer--were looking for an agroforester. What would they expect him (or her*) to do? We could suggest the following announcement for a senior agroforestry consultant: "Under the direction of the Chief, Rural Development Unit, and in close cooperation with the forest, agricultural, livestock and socio-economic development branches, the incumbent will be responsible for:

a) Developing a strategy for multidisciplinary land resources management with special emphasis on sustainability of the region's productive potential.

b) Coordinating programmes and activities of the various rural development services.

c) Optimizing resource allocation and primary production structures by using modern planning methods.

d) Ensuring that the Unit's basic studies and forward planning are consistent with the land use policy of the country and with studies and resolutions of ICRAF, the organizations of the UN, the institutes of the CGIAR** and other relevant organizations.

e) Assisting in:

   i) the analysis of the economic and social validity and implications of proposals for integrated land-use development;

   ii) identification, formulation, backstopping and evaluation of field projects;

   iii) the conducting of seminars and training courses on agroforestry development and land-use planning.

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*) The future role of women in agroforestry will deserve special attention since, depending on the region and social structures, women often do the practical field work applying agroforestry.

**) Consultative Group on International Agricultural Research.

f) Assisting and participating in missions for the review, identification, formulation or appraisal of projects and prospects in agroforestry and rural development.

g) Such other relevant duties as required."

This example could easily be modified and even more easily expanded. In summing up, the agroforester would be expected to develop a strategy rather than specific technologies; to plan, coordinate, monitor and evaluate rather than to implement; to advise and inform rather than to test and apply. In other words, he would be a man of the head office rather than of the field staff.

Is this the "agroforester" we are looking for in the majority of cases, or do we also need someone to solve such problems as how to improve nutrition, energy supplies, raw material availability, environment and rural ecology, and the socio-economic development by applying forestry practices or just using trees and shrubs on a project or enterprise level? Will he be responsible for integrating agroforestry into community forestry programmes.

Poschen (1982) has called for a "barefoot agroforester." "These barefoot agroforesters would serve as catalysts, undertaking field research and publication and extension work, using local knowledge and experience, and applying the most elementary scientific methods like observation, comparison, and systematization. Although there are problems in agroforestry that call for sophisticated research instruments, in many cases small-scale science may be more efficient."

What, then, is the new type of professional agroforester expected to do (what others have not done or could not be doing?) He is obviously expected to deal professionally with farming and/or grazing activities <u>on forest lands</u>, i.e. with those agricultural activities that are already there and quite often detrimental to the forest (shifting cultivation, excessive grazing practices). In addition he will be involved with improving the forest land's overall sustained yields by, for example, adding farm and/or range management to former exclusively forestry-oriented management. He will be expected to open up the forest for profitable agricultural land use, compatible with intensive forestry, in order

to "enable people in rural areas to benefit from trees and forestry." And, last but not least, by doing this he will be saving vanishing forest resources in densely populated areas of many tropical countries from being cut and burnt down in order to secure food supplies.

The agroforester, moreover, will be expected to be the tree and shrub specialist who knows how to improve agriculture and range management outside the forest by maintaining or newly offering these "forest components" to non-forest lands. He will have to know precisely the possible advantages and disadvantages of single woody plants (or groups of them) on crop and/or pasture lands, and he will have to "sell" the idea of improving the farm and range land's productivity and sustained carrying capacity by proper use of trees and shrubs. In doing so, the agroforester will have to communicate and cooperate with people on different levels -- international, governmental, regional, local and sectorial, but most important, with the local farmer and herdsman. He will have to understand their rules and concerns. He will have to speak "their language" and be an interpreter between society and individual; between modern, scientifically advantageous technology and old, adapted and approved traditional land use; between forestry and agriculture in its broadest sense. This is subsummarized under g above as "such other relevant duties as required." And this, in turn, makes clear that the professional agroforester would rightfully be expected to be essentially more than a "coordinator" at a rural development unit's head office, that he will have to work at very different levels, which, in turn, will require different qualifications.

What is the professional agroforester expected to be?

From the "job description" one may be inclined to ask, whether "the professional agroforester" should be an individual or a team. In fact, it would be dangerous to expect the agroforester, a single person, to replace a tea[illegible] f experts. But he should be the one who initi[illegible] teams or consultancy of short-term experts where applicable. Employers who are short of funds for rural development programmes may be inclined to save personnel by looking for the "all round specialist."

Those propagating agroforestry should be well aware of the expectations they themselves may be creating in

this respect. Is the agroforester a person who knows everything about very little or almost nothing about everything?

Less polemical, is he still a forester by profession? If so, does he have a more comprehensive educational background than the "ordinary" forester? Does he need at least basic knowledge of agriculture and/or range management, sociology, etc. (as may be required) in addition? Will he gain such "superqualifications" (by postgraduate studies, special training, practical experience), that he will be more than just a forester?

The other option would be, that he is a forester, specialized in the various subjects of natural resources management within a normal qualification programme, that his education comprises agriculture and range management rather than, for example, forest products and wood science or logging. He would then know less about some of the traditional forestry subjects but more about integrated land use, etc. He would be a specialized (in agroforestry) forester.*

If agroforestry implies an interdisciplinary approach to land use, then, in principle, the professional agroforester could as well be a non-forester, that is an agriculturalist or rangeland manager, a "generalist" with additional knowledge in forestry, or a specialist in forestry within his own normal curriculum.

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*) FAO (1982). "The Committee pointed out that education for social forestry would require the re-education of many serving professional foresters whose own education had an overwhelming predominance in forestry of a commercial or protective nature. The curriculum for such an educational programme at university level would need to be more widely drawn than was traditional in many forestry courses. Unless such a curriculum could instill into the undergraduate courses an appropriate breadth of vision of the sociological and political issues involved in community forestry, the graduate was unlikely to be very adaptable to as yet ill-perceived procedures for implementing community forestry. Depending on local circumstances, such a curriculum could consist of half forestry and half sociology, politics and agriculture. In such a curriculum great weighting would need to be given to rural sociology."

Following the example of a vacancy announcement for a senior agroforestry consultant as scheduled above, we could suggest: "Qualifications-essential: Either a degree in agroforestry; or in forestry with specialization in agroforestry, agriculture or natural resources management; or in agriculture/range management with specialization in agroforestry or forestry, supplemented by either postgraduate studies encompassing the agroforestry sector or by sufficient postgraduate experience in applying agroforestry principles to the problems of integrated land use. X-years of experience in planning and conducting strategies for multidisciplinary land resources management planning and/or applied research. Part of this experience must have been acquired through work in developing countries. Ability to work in harmony with staff members of various professional backgrounds and with rural people. Qualifications-desirable: Acquaintance with research and/or field programmes of ICRAF, the UNDP, FAO or similar agencies. Field experience in the relevant climatic zone, special knowledge (e.g. in watershed management, marketing, erosion control, ecology, community development, etc.)."

Agroforestry in itself is such a broad subject that one can easily assume further specialization such as towards a silvo-pastoral branch, a mixed cropping branch, a soil protection and improvement branch, etc. Moreover, qualifications for different climatic zones may gain importance.

From all the above suggestions one may draw the conclusion that "the" professional agroforester does not exist, but rather a heterogeneous group of agroforesters. However, for every one of them the question will have to be answered, whether their education should follow a general trend towards specialization, i.e. knowledge in ("vertical") depth, making allowance for less width, or knowledge in ("horizontal") width, tolerating less disciplinary depth. The latter appears to deserve preference. The agroforester will certainly not be expected to be a "walking dictionary or data bank" but he will be expected to be the one who, based on solid knowledge of forestry and agriculture, thinks and works with a profound understanding of rural systems and the people concerned and who has gained practical experience in the field, or as a consultant, or in research.

## REFERENCES

Combe, J. and Budowski, G. (1979). "Classification of Agroforestry Techniques." Workshop Agroforestry Systems in Latin America. Proceedings. Turrialba/Costa Rica. pp.17-47.

FAO. (1982). Report of the Eleventh Session of the FAO Advisory Committee on Forestry Education. FAO, Rome.

Griffin, D.M. (1982). "Education in forestry for local community development," In: FAO Report of the Eleventh Session of the FAO Advisory Committee on Forestry Education, FAO, Rome. pp.28-32.

Poschen, P. (1982)."Barefoot agroforesters: a suggested catalyst." In: Agroforestry in the African Humid Tropics, ed. by L.H. MacDonald. The United Nations University. 140 p.

Saouma, E. (1978). Foreword. FAO Forestry Department: Forestry for rural communities. FAO, Rome.

Soedjarwo. (1978). The Eighth World Forestry Congress. The Djakarta Declaration. Unasylva, Rome. 30, 121, pp. 35-38.

## SECTION 3 - REVIEWS OF SOURCE MATERIALS FOR TEACHING AGROFORESTRY

The main objective of the Workshop reviews was to evaluate the scope and merits of existing books, journals, documents, articles, visual aids and other materials in different disciplines to see which would be suitable for teaching agroforestry.

Nine reviews were prepared for the Workshop, six by ICRAF scientific staff and three by invited contributors, covering materials related to both the science and technology of plants, animals, soil and soil management, climate and agrometeorology, socio-economics, information and management. One of the reviews is a survey of non-governmental organisations with a possible interest in agroforestry. It was undertaken by the Environment Liaison Centre (ELC) in Nairobi to identify sources of educational material currently in use. Even though the report does not have the same characteristics of other Workshop reviews, the content falls within the scope of this section.

Reviewers were faced with several difficulties in accomplishing their tasks: scattered and confused literature in their fields as related to agroforestry; a shortage of authoritative, refereed, sound scientific papers; too much material either not relevant or not directly applicable to agroforestry even from fairly extensive and well-researched fields such as "soil science." As one reviewer pointed out "...references were listed in books and journals including everything from plants and soil to the Louisiana cattlemen..." Thus, the reviews have different scopes. While some present the compilation and collation of highly selective key literature to be used as references/information in preparing appropriate teaching materials in agroforestry, others examine the state of knowledge in a particular discipline identifying salient features particularly relevant for teaching agroforestry.

A vast number of articles, books, documents, etc. had been produced in most of the above disciplines as of 1982. Thus the present reviews may be seen as an early and perhaps first attempt to collate such sources of information and references as they relate to agroforestry. Asterisks in the reference list of each review denote key material. The full, edited texts of the reviews are presented in alphabetical order by author's last name.

## R1. REVIEW OF KEY LITERATURE MATERIALS RELEVANT TO PLANT ASPECTS OF AGROFORESTRY - by M.G.R. Cannell

### Introduction

Agroforestry bibliographies prepared by Richards (1982, CAB) and Combe *et al*. (1981, CARE) were compared. Conclusions on the discussions that took place at ICRAF's conference on Plant Research in Agroforestry in 1983 were considered. From those discussions, and the bibliographies, it is apparent that the agroforestry literature provides useful *descriptions* of species and site specific agroforestry land-use practices, but it contains very little analysis and insight into the biological, sociological and economic principles of agroforestry.

A need is seen for: a manual of agroforestry crop associations with analyses of the crop inter-relationships in space and time; an account of the principles of crop physiology and plant community ecology relevant to agroforestry, and; further information on the biology and management (pruning responses, etc.) of trees of value in agroforestry

The review consists of a highly selective list of references arranged into six groups: species information, agroforestry crop combinations, crop physiology, tree biology, plant-plant interactions, and methodology.

### Species Information

When designing or modifying agroforestry systems, information is needed on the biology and management of both indigenous and exotic species of potential value. Information on the tree species of value for firewood, soil improvement and multiple uses can be found in manuals by the National Academy of Sciences (4), (5), (6) and Nair (7). Further information can be found in reviews on particular species, such as *Leucaena* and *Prosopis* (see references listed by Rachie, in *Plant Research in Agroforestry* and in ICRAF newsletters), on underexploited tropical plants of

promising value (NAS, No. 16, 187 pp) and species investigations in particular geographic regions such as the work of Okafor in Nigeria (e.g. 1980 Forest Ecol. Manage. 3, 45-55) and Maydell's work in the Sahel, (e.g. 1978, Plant Research and Development Tubingen, 7, 44-59).

Information on the search for species, their collection, introduction and evaluation may be found in Whyte (11), in Burley and Wood (2) in particular reference to species and provenance research in the tropics, and in Webb (9).

There are numerous books on individual major crops, such as coffee, cocoa, rubber, coconut, oil palm (e.g. Longman's Tropical Agriculture Series) and the basic botany of all major crops species is explained in Tropical Crops, Vols. I and II, 1968 by J.W. Purseglove, Longman, London. However, the books by Williams (10) and Alvim (1) are recommended as introductory texts on agronomic and ecophysiological aspects of trees and other crops.

Two other authoritative multi-authored books dealing with floral biology, domestication and genetic improvement of tropical tree crops are those of Ferwerda (3) and Simmonds (8).

## Agroforestry Combinations

Four good general accounts of agroforestry land-use practices are given by Combe (12), Ruthenberg (13), Watson (14) and Wiersum (15).

There are numerous accounts of particular crop-combinations in systems of taungya, alley-cropping, home gardens, silvo-pastoral systems, fruit-tree intercropping and so on. These will be found in the two bibliographics mentioned above (both of which are suitably indexed) together with the proceedings of ICRAF's meeting on "Plant Research in Agroforestry" (34).

## Crop Physiology

In order to understand and interpret plant-plant interactions, it is important that students have a grasp of the relevant principles of crop physiology, some of which may not be taught in courses of

forestry. These principles are as relevant to agroforestry as to any other cropping system. For an agroforester lecturer the recommended literature in this area is Bunting (16), (17), Brouwer (18), and Cooper (19) particularly the papers by Loomis and Gerakis on "Productivity of agricultural ecosystems," by Kira on "Primary productivity of forests" and Cooper's review paper. Together with Monteith's paper (23), these will give an appreciation of potential biological production of cropping systems in the tropics. Other useful references are Evans (20), Fisher and Turner (21), Milthorpe and Moorby (22) (an introductory text for students), Trenbath and Angus (24) and de Wit (25) (a classic text that should be read before other papers on canopy architecture).

Tree Biology

Trees in agroforestry systems usually demand, or benefit from, individual management. Some instruction is therefore needed on the special features of woody perennials that influence the ways in which they are managed. Huxley, in 'Plant Research in Agroforesty' (34) listed some of the characteristics of trees that need to be examined before they are introduced into agroforestry systems. Much of the practical information needed is species specific (including pest and pathogen control) and will be found in texts on specific crops (coffee, cocoa, *Leucaena*, etc.) but there are papers that provide background on some general topics, such as vegetative propagation, the branching structure of tropical trees, pruning responses, phenology, pollination of fruit trees, and light interception of discontinuous canopies. Specifically, Garner (31) provides an illustrated practical guide on propagation techniques, with notes on individual species; the periodic shoot growth of tropical trees is explained in Borchert (27). Waring (40) suggests methods of diagnosing stress in forest trees. Other references of interest are listed under this heading at the end of the review.

Plant - Plant Interactions

Agroforestry systems involve complex interactions between trees and crop plants in the horizontal, vertical and temporal dimensions, in which different crops share and/or 'compete' for environmental resources of light, water and nutrients. In order to explain the processes involved one needs to draw on

the literature on the responses of crop plants to (a) shading, nutrient shortage and water stress (and the prospects of selecting plants tolerant to these conditions), (b) density stress in monocultures, and (c) intercropping in mixtures. This information could then be used to help predict or explain the biological success or failure of particular agroforestry systems. Most of the standard agroforestry literature describes the end results of such complex interactions, without analysing the processes.

Most of the key works were referred to by Cannell, Connors, Huxley, Raintree, Loomis and Jackson in "Plant Research in Agroforestry." A key general work is that of Harper (41) Chapters 6 to 11.

For plant responses to shading and water stress Christiansen and Lewis (42) provides excellent reviews on selecting crop plants tolerant to mineral nutrient deficiencies and to water stress. Further recommended readings in the area are Earley (43) Felker (44), Jackson and Palmer (47), Salter and Goode (52) Willey (54) and others.

As it relates to crop responses to density stress, the extensive literature on the effects of spacing in monocultures on yields and their components was reviewed by Cannell, in "Plant Research in Agroforestry" (34) covering forest trees, fruit trees and palms storage root crops, grain legumes, and cereals. See also Willey and Heath (55).

The overwhelming weakness of most of the literature on intercropping competition between species is that it deals with two species mixtures that share the same ground over the same cropping cycle. The theory of such simple systems, such as that proposed by C.T. de Wit (1960) "On Competition" (Versl. Landbouwk. Onderz No. 66, 82 pp) does not cope with the complexity of agroforestry systems and I do not recommend that it be taught to agroforestry students. However, it is important that students be aware of the concepts explained in papers by Watson and French (61) where edge effects were analysed and explained in a manner that could be applied to tree-crop interfaces; and in Willey (63). In Papendick (59) key papers on multiplecropping are those of Trenbath, Andrews, Kassam, Harwood and Price, Pinchimet et al and Okigbo and Greenland.

Other papers on the design of intercrop experiments, the concept of 'land equivalent ratio,' 'competition ration' and the results and interpretation of experiments using 2-crop mixtures (of herbaceous crops) can be found in issues of Experimental Agriculture since 1977, notably by Barker, Fisher, Huxley, Willey and Mead.

## Methodology

It is impossible to cover all the techniques that might be used to study agroforestry systems. However, some of the general texts that may be consulted are: Burley and Wood (64) for information on seed collection, site assessment, experimental design and field practices; Chapman (65) for methodologies on surveying, production ecology, nutrient budgeting, climate, soil and site assessment; and Jeffers (68) who provides a practical guide for those with little mathematical training. Other references of interest are Huxley (67) and Whittaker (69).

## R1-REFERENCES (Plant Aspects)

### Species Information


1. *Alvim, P. de T. and Kozlowski, T.T. (1977). Ecophysiology of tropical crops. Academic Press.

2. Burley J. and Wood P.J., eds. (1976). A Manual on Species and Provenance Research with Particular Reference to the Tropics. CFI, Oxford. 226 pp.

3. Ferwerda F.P. and Wit F. (1969). Outlines of perennial crop breeding in the tropics. Miscellaneous Papers, 4, Landbouwhogeschool, Wageningen, The Netherlands, 511 pp.

4. National Academy of Sciences (1979). Tropical Legumes: Resources for the future No. 25, 331, pp, Washington D.C.

5. National Academy of Sciences (1980). Firewood crops: shrub and tree species for energy production, No. 27. 237 pp. Washington D.C.

6. National Academy of Sciences (1977). Leucaena : promising forage and tree crop for the tropics, No. 26, 118 pp. Washington D.C.

7. *Nair, P.K.R. (1980). Agroforestry Species: a crop sheet manual. ICRAF, Nairobi, 336 pp.

8. Simmonds, N.W. (1976). Evolution of crop plants. Longman, London, 339 pp.

9. *Webb D.V., Wood P.J. and Smith, J. (1980). A guide to species selection for tropical and subtropical plantations. Tropical Forestry Paper 16, CFI, Oxford.

10. *Williams C. N. (1979). The Agronomy of the Major Tropical Crops. (2nd ed.). Oxford University Press, 228 pp.

11. Whyte P.O. (1957). FAO Agricultural Study 41.

Agroforestry Crop Combinations

12. *Combe, J. (1982). Agroforestry techniques in tropical countries: potential and limitations. Agroforestry Systems, 1:13-27.

13. *Ruthenburg, H. (1976). Farming Systems in the Tropics. (2nd ed.) Clarendon Press, Oxford, England. 366 pp.

14. *Watson, G.A. (1980). A study of tree crop farming systems in the lowland humid tropics. World Bank, Agricultural and Rural Development Dept., Technical Note 2, Vols. I & II, 191 & 108 pp.

15. *Wiersum, K.F. (1982). Tree gardening and taungya on Java: examples of agroforestry techniques in the humid tropics. Agroforestry Systems, 1:53-70.

Crop Physiology

16. *Bunting, A.H. (1976). Maximizing the product, or how to have it both ways. In: Tree Physiology and Yield Improvement M.G.R. Cannel and F.T. Last, eds. Academic Press.

17. Bunting, A.H. (1975). Time, phenology and the yield of crops. Weather 40:312-325.

18. Brouwer, R. (1962). Distribution of dry matter in the plant. Neth. J. Agri. Sci. 10: 361-376.

19. *Cooper, J.P. ed. (no date given). Photosynthesis and Productivity in Different Environments. Cambridge University Press.

20. *Evans, L.T. (1975). The physiological basis of crop yield. pp 327-355. In: Crop Physiology L.T. Evans, ed. Cambridge University Press 374 pp.

21. Fisher, R.A. and Turner, N.C. (1978). Plant productivity in the arid and semi-arid zones. Ann. Rev. Plant Physiol. 29: 277-317.

22. *Milthorpe, F.L. and Moorby, J. (1974). An introduction to crop physiology. Cambridge University Press, 202 pp.

23. *Monteith, J.L. (1972). Solar radiation and productivity in tropical ecosystems. J. Appl. Ecol. 9:747-766 (Also see Monteith's paper on 'Climate' in Alvim and Kozlowski (1977) Ecophysiology of Crops).

24. Trenbath, B.R. and Angus, J.F. (1975). Leaf inclination and crop production. Field Crop Abstracts, 28:231-244.

25. *Wit de C. T. (1965). Photosynthesis of leaf canopies. Centre for Agricultural Publication and Documentation (Versl. Landbouwk, Onderz, No. 663), Wageningen, The Netherlands, 57 pp.

Tree Biology

26. Bhimaya, C.P., Kaul, R.N. and Ganguti, B.N. (1964). Studies on lopping intensities of *Prosopis spicigera*. Indian Forester 90:19-23.

27. Borchert, R. (1973). Simulation of rhythmic tree growth under constant conditions. Physiol. Plant. 29:173-180.

28. Cannell, M.G.R. (1975). Crop physiological aspects of coffee bean yield, a review. J. Coffee Res. 5:7-10.

29. Chalmers, D.J. and van den Ende, B. (1975). Productivity of peach trees: factors affecting dry weight distribution during tree growth. Ann. Bot. 39:423-432.

30. *Chapman, G.P. (1964). Pollination and the yeilds of tropical crops: an appraisal. Euphytica 13:187-197.

31. *Garner, R.J. and Chandhri, S.A. (1976). The propagation of tropical fruit trees. Horticultural Review 4, Commonwealth Bureau of Horticulture and Plantation Crops, East Malling, Maidstone, Kent, 566 pp.

32. *Halle, F., Olderman, R.A.A. and Tomlinson, P.B. (1978). Tropical trees and forests, an architectural analysis. Springer-Verlag.

33. *Huxley, P.A. and van Eck, W.A. (1974). Seasonal changes in growth and development of some woody perennials near Kampala, Uganda. J. Ecol. 62:579-592.

34. *Huxley, P.A., ed. (1983). Plant Research and Agroforestry. ICRAF, Nairobi, Kenya. 617 pp.

35. *Jackson, J.E. (1970). Light interception and utlilization by orchard systems, pp. 208-267. In: Horticultural Review, J. Janick, ed. AUI Publishing Co. Inc., Westport, Connecticut.

36. Magambo, J.J.S. and Cannell, M.G.R. (1981). Dry matter production and partition in relation to yield of tea. Expl. Agric. 17:33-38.

37. Maggs, D.H. (1964). The distance from tree base to shoot origin as a factor in shoot and tree growth. J. Hort. Sci. 39:298-307.

38. Tomlinson, P.B. and Zimmermann, M.H., (1978). Tropical trees as living systems. Cambridge University Press.

39. Waring, P.F. (1968). The physiology of the whole tree, p.55-68. In: Ann. Rep. East Malling Research Station Maidstone, Kent, England.

40. Waring R.H. (1979). Vital signs of forest ecosystems, pp. 131-136. In: Forests: fresh perspective from ecosystem analysis. R.H. Waring. ed. Oregon State University Press, Corvallis, Oregon, 198 pp.

Plant-plant Interactions ·

41. *Harper, J. L. (no date given) Population biology of plant. Academic Press. 892 pp.

a) Plant responses to shading and water stress.

42. *Christiansen, M.N. and Lewis, C.F. (1982). Breeding Plants for Less Favourable Environments. John Wiley & Sons. 459 pp.

43. *Earley, E.B., McIlrath, W.O., Sief, R.D. and Hageman, R.H. (1967). Effects of shade applied at different stages of plant development on corn (Zea mays L.) production. Crop. Sci. 7:151-156.

44. *Felker, P., Clark, P.R., Osborn, J. and Cannell, G.H. (1980). Nitrogen cycling/water use efficiency interactions in semi-arid ecosystems in relation to management of tree legumes (Prosopis). Int. Symp. on Browse in Africa, Int. Livestock Centre for Africa, Addis Ababa.

45. Fisher, R.A. (1981). Optimizing the use of water and nitrogen through breeding of crops. Plant and Soil, 58:249-278.

46. Hanks, B.J. and Tanner, C.B. (1952). Water consumption by plants as influenced by soil fertility. Agric. J. 44:98-100.

47. *Jackson, J.E. and Palmer, J.W. (1977). Effects of shade on the growth and cropping of apple trees. II. Effects on components of yield. J. Hort. Sci. 52:253-266.

48. Kozlowski. T.T. (1981). Water deficits and plant growth. Vol. VI. Woody plant communities. Academic Press, 582 pp.

49. Maggs, D.H. (1961). Changes in the amount and distribution of increment induced by contrasting watering, nutrition and environmental regimes. Ann. Bot. 25: 353-362.

50. Monteith, J.L. (1981). Climatic variation and the growth of crops. Quart. J. Royal Met. Soc. 107:749-774.

51. Sale, P.J.M. (1976). Effect of shading at different times on the growth and yield of the potato. Aust. J. Agric. Res. 27: 557-566.

52. *Salter, P.J. and Goode, G.E. (1967). Crop responses to water at different stages of growth. Research Review No. 2. Commonwealth Bureau of Horticulture and Plantation Crops, East Malling, Maidstone, Kent, England.

53. Shubert, M.L. (1969). The nature and importance of competition between woody and herbaceous plants in grassland ecosystem, pp. 172-182. In: The Grassland Ecosystem: a preliminary synthesis. R.L. Dix and R.G. Biedleman. Eds. Range Sci. Dept. Sci. Series. 2. Colorado State University, Fort Collins.

54. *Willey, R.W. (1975). Use of shade in coffee, cocoa and tea. Hort. Abstracts 45:791-798.

b) Crop responses to density stress

55. *Willey, R.W. and Heath S.B. (1969). The quantitative relationships between plant population and crop yield. Advances in Agronomy, 21:231-281.

c) Intercropping competitions between species.

56. Cannell, M.G.R. (1978). Improving per hectare forest productivity. In: Proceedings of 5th North American Forest Biology Workshop, pp.

120-148. C.A. Hollis and A.E. Squillace, eds., University of Florida, Gainsville.

57. *Donald, C.M. (1963). Competition among crop and pasture plants. Advances in Agronomy 15: 1-118.

58. *Donald, C.M. and Hamblin, J. (1976). The biological yield and harvest index of cereals as agronomic and plant breeding criteria. Advances in Agronomy. 28:361-405.

59. *Papendick, R.I., Sanchez, P.A. and Triplett, G.B., eds. (1976). Multiple cropping. American Society of Agronomy Special Publication, Number 27, 378 pp. ASA, 677 South Segoe Road, Madison, Wisconsin 53711.

60. *Trenbath, B.R. (1974). Biomass productivity in mixtures. Advances in Agronomy. 26: 117-210.

61. Watson, D.J. and French, S.A.W. (1971). Interference between rows and between plants within rows of wheat crop, and its effects on growth and yield of differently spaced rows. J. Appl. Ecol. 8:421-445.

62. Willey, R.W. and Osiru, D.S.O. (1972). Studies on mixtures of maize and beans (Phaseolus vulgaris) with particular reference to plant population. J. Agric. Sci. Camb. 79: 527-529.

63. *Willey, R.W. (1979). Intercropping: its importance and research needs. Parts I and II. Field Crop Abstracts 32:1-10 and 73-85.

Methodology

64. *Burley, J. and Wood, P.J. (and 12 others) (1976). A manual on species and provenance research with particular reference to the tropics. Tropical Forestry Papers No. 70, Dept, Forestry, Commonwealth Forestry Institute, University of Oxford. 226. pp.

65. *Chapman, S.B., ed. (1976) Methods in plant ecology. Blackwells Scientific Publications, Oxford, Edinburgh and Melbourne, 536 pp.

66. Grossman, W.D. and Schneider, T.W. (1980). Die angewandte Systemtheorie als Mittel zur Untersuchung von Funktion und Dynamik agroforstwirtschaftlich geprägter Lebensräume. Mitt. Bundesforst. Anst. Forst-Holzwirtsch. 132:1-26.

67. *Huxley, P.A. (1979). Agroforestry research: the value of existing data appraisal. In: International Co-operation in Agroforestry T. Chandler and D. Spurgeon. eds. pp. 297-315. ICRAF, Nairobi.

68. *Jeffers, J.N.R. (1978). An introduction to systems analyses with ecological applications. Edward Arnold, London. 198 pp.

69. Whittaker, R.H. (1961). Estimation of net primary production of forest and shrub communities. Ecology 42:177-180.

## R2. AGRICULTURAL METEOROLOGY IN AGROFORESTRY: A REVIEW OF SOURCE MATERIALS AND LITERATURE

- by T. Darnhofer

### Introduction

Agriculture, in its widest sense, including horticulture, forestry and livestock, interacts with a complex system of natural conditions, among which meteorological factors hold a key position. Many agricultural processes, such as variety selection, crop yields, productivity, etc., depend considerably on the effect of these factors. It is for this reason that measurements of meteorological parameters and appropriate analysis of these measurements are required in order to understand many agricultural problems and to work out efficient solutions.

Agricultural meteorology, accordingly, is concerned with interactions between meteorological and hydrological factors and agriculture. Its field of interest is the "soil-plant-atmosphere" system, which includes the soil layer penetrated by roots, the air layer near the ground where plants grow and animals live, and higher levels of the atmosphere where biological particles (pollen, seeds) are transported and birds and insects fly. Within this system, agricultural meteorology is not only concerned with the natural climate at different scales and its variations, but also with the relevant aspects of environmental modifications initiated by man (wind breaks, irrigation, intensive land-use systems and others).

### Components of Agricultural Meteorology

The components of agricultural meteorology can be summarized -- in accordance with the respective World Meteorological Organization (WMO) guide -- as follows:

1. Agrometeorological monitoring

   Physical measurement of meteorological and relevant hydrological parameters (temperature, radiation, wind, precipitation, humidity, evaporation, soil moisture) appropriate data collection, design of networks and experiments.

2. Plant environment and crop production

Effect of meteorological element on growth and development of plants, quantity and quality of yields, climatic requirements of crop plants.

3. Plant injury and crop losses

Effects of weather hazards on crop, pests and diseases including weather effects on the biology of birds, insects, and disease organisms themselves. Impact of pest control measures. Bush and forest fires.

4. Livestock health and production

Environmental problems of livestock housing, health and production. Indirect effects on animals through fodder.

5. Animal diseases and parasites

Direct and indirect effects of weather on the various types of animal diseases.

6. Climatic resources

Climatological surveys, ecosystem assessment, climatic statistics agroclimatic resource analysis. For an agrometeorological assessment of an area, the following methodology has been suggested:

- determination of the bioclimatological plant requirements,
- classification of varieties into bioclimatic groups,
- identification of bioclimatic indices which characterise crop growth, development and yield,
- comparison of bioclimatic indices with the climatological data available for a region in order to determine agroclimatic types,
- agroclimatic zoning by fitting bioclimatic indices to agroclimatic types.

7. Soil resources

Soil classification, soil deterioration and erosion. Climate and weather affect the

chemical, physical and mechanical properties of the soil, thus having repercussions on cultivation, plant growth, pest control and harvesting. Soil erosion depends largely on weather factors.

8. Water resources

Agricultural water needs, water-use efficiency of crops, irrigation requirements, drainage, agricultural drought. The water balance of the soil and water availability to the plants is of predominant importance to most agricultural problems especially in semi-arid and arid regions.

9. Management operations

Weather climate analysis in relation to: field work day, crop harvest and drying conditions, pest control, machinery use, storage of agricultural products, weather forecasting requirements for agriculture.

10. Artificial modification of the meteorological and hydrological regimes

- Protection against adverse weather conditions, such as frost, wind, radiation, drought, either by selecting appropriate varieties or by improving the agricultural sites by irrigation, windbreaks and shelterbelts.
- Soil conservation practices
- Controlled climate facilities (greenhouses, growth chambers)
- Assessment of weather modification due to human activity.

11. Forest meteorology

Application of meteorological information can be of considerable benefit for the protection and conservation of forest resources.

12. Economic value of agrometeorological information and advice

Evaluation of the economic significance of

agrometeorological services by meaningful interpretation of the effect of weather and climate on agricultural activities and production. (Cost/benefit estimations of irrigation, frost protection, shelterbelts, weather integrated pest controls, and farm machinery operations).

## The Role of Agrometeorology in Agroforestry

By definition, an agroforestry land-use system grows tree and crops together and can contain a livestock component. It is meant to meet human requirements thus being "productive." It should have stabilising or even improving effects on the environment, thus making it sustainable. Furthermore it should be adopted by a significant number of users to have the desired impact on the area.

In order to meet the "production" and the "sustainability" criteria, trees, shrubs, and hedges, should provide fruit, fodder, mulch, fuel, shade and/or shelter in accordance with the needs of the user. Agricultural crops and livestock components are selected with the same requirements in view. The physical arrangement of these components on the available land is again subject to the basic criteria. Consequently an agroforestry land-use system has to be considered a highly complex agricultural system including many components.

Woody plants in agroforestry systems have new applications compared to their role in traditional forestry practices. The climatic implications of their use under these conditions are not well known.

The systematic intercropping of trees and shrubs with agricultural crops changes micro-climatic conditions, which are likely to have reciprocal consequences on productivity. Shelterbelts modify a number of meteorological variables such as wind speed, evaporation, temperature, air and soil humidity, and radiation, which are important for crop growth and animal development. Mulching affects soil moisture and temperature. Given the components of agricultural meteorology, the basic ideas of agroforestry and the few examples given above, it becomes evident that agrometeorology can help find solutions to agroforestry problems. However, efficient use of meteorological and climatological information depends

mainly on an understanding of the effects of weather and climate on soils, plants and animals by the personnel concerned with the evaluation, planning and implementation of agroforestry systems.

## Agrometeorological Training in Agroforestry

In order to achieve the objectives of agricultural meteorology in agroforestry, training at all levels should be considered to be a basic requirement. High-level agrometeorological knowledge is needed to assist in agroforestry systems and potential evaluations on the basis of agroclimatic information, and in the planning and execution of agrometeorological research connected with technology programmes. High/medium-level training is required by personnel in charge of designing and evaluating agroforestry land-use systems in order to recognise climatological effects and constraints as well as possible modifications of the micro-climatic conditions. Medium-level instruction for personnel in charge of stations management will assure appropriate application of agrometeorological component designs and information. Field assistants should have sufficient training in meteorology to enable them to observe and record meteorological phenomena accurately.

To make sure that there is an understanding of weather effects on the environment, courses in meteorology and climatology, in many countries, are not restricted to agrometeorologists but are, on the contrary, compulsory for many disciplines related to agricultural sciences. Reference should be made to WMO, which assumes a major responsibility for the international coordination of training in meteorology and agrometeorology.

Syllabi of instruction in agricultural meteorology exist for the different levels as well as a number of lecture note collections. To what extent these syllabi have to be modified and adopted will depend on the organisation and the level of the education programme in agroforestry.

However, emphasis will have to be placed on:

- agrometeorological monitoring: (measuring parameters carrying out phenological

observations, organizing appropriate data collections and presentation, designing agrometeorological experiments).

- assessment of agroclimatic resources: (determination of climatic requirements of crops and trees; interpretation of agroclimatic zones and regions with regard to their suitability for various plants; assessment of the recurrence and probability of climatic constraints to agriculture; estimation of relations between yields and meteorological regimes).

- artificial modification of microclimatic regimes: (assessment of the microclimatic changes related to the inter-cropping of trees, shrubs and agricultural plants in agroforestry systems; control of meteorological phenomena adverse to agriculture.

## R2 - SOURCE MATERIALS AND REFERENCES

Concerning the components of agricultural meteorology relevant to AF, there is much overlap. However with regard to the enormous amount of literature on agrometeorology and climatology, it is not possible to give a comprehensive bibliography of relevant references. Nevertheless a few of the most important ones, available at ICRAF, are listed below.

General

1. WMO Guide to Agricultural Meteorological Practices (1981). WMO No. 134, 2nd edition. An overall view of the scope of agricultural meteorology is given in 8 chapters under headings like: Agricultural meteorological elements and their observation, Agrometeorological forecasting, Application of Meteorology to Forestry, etc.

   Appendix I - Bibliography of literature on agricultural meteorology

   Appendix II - List of periodicals relevant to agricultural meteorology

   Appendix III - List of international organizations of interest to agricultural meteorologists.

2. Geiger R. (1965). The Climate Near the Ground 611 p. English translation, Harvard University Press. Textbook on basic microclimatology. It give an exhaustive analysis of physical laws and their consequences on various meteorological elements including descriptions of the influences of topography vegetation and artificial devices on weather.

3. Motheith J.L. (1976). Vegetation and the Atmosphere. N.Y., Academy Press. Summary of actual micrometeorological and ecological knowledge. Vol. 1. Summary of physical biological elements. Vol. 2. Case studies in agricultural, forestry and ecological fields.

4. Chiang, J. Hu. (1968). Climate and Agriculture - an Ecological Survey. Aldime Publishing Company 304 pp. Textbook on the general principles of agricultural climatology.

5. Seemann, Y., Y. Chirkov, J. Lomas, B. Primault (1979). Agrometeorology. Springer, Berlin. 324 pp. Introduction to the present day problems of agrometeorology; a series of accounts, each complete in itself, of agrometeorology problems.

6. Robertson,G.W. (1980). The Role of Agrometeorology in Agricultural Development and Investment Projects, WMO, No. 536, 85 p.

Meteorological Training

7. WMO. (1982). Compendium of training facilities for meteorology and operational hydrology. WMO No. 240, 6th edition, 590 p. Worldwide summary of training facilities in a wide variety of fields of applied meteorology including information on the content, dates and duration of courses.

8. Gloyne, R.W. and J. Lomas. (1980). Lecture notes for training class II and class III agricultural meteorological personnel. WMO No. 551, 260 p. Compendium of lecture notes, presenting the range of micrometeorological principles with particular respect to the applications in agriculture.

9. Lowry, W. (1972/76). Compendium of lecture notes in climatology for class III meteorological

personnel. WMO No. 335, 154 p. In 9 chapters including: theoretical fundamentals of physical climatology, applied and synoptic climatology, bioclimatology, climatic classifications, etc. these lecture notes correspond with the syllabi as outlined in the "Guidelines".

10. Proceedings of WMO/IAMAP Symposium on Education and Training in Meteorology and Meteorological Aspects of Environmental Problems (1975). WMO No. 432, 321 p. The contributions cover the class I and class II training in different fields of meteorology in different parts of the world. Contribution by J.J. Burgos includes proposals for agrometeorological training of agricultural and forestry engineers.

Climatology

11. Landsberg H.E. and others. (no date given). World Survey of Climatology. Elsevier Publishing Co.: Vol. 9, Climates of South and Western Asia, 248 p.
Vol. 10 Climates of Africa, 604 p.
Vol. 12 Climates of Central and South America. Summaries of the existing climatological knowledge for the area concerned with references to more detailed literature.

12. Bluethgen Allgemeine Klimageographie (1966). 2nd edition (German) 720 p. Walter De Gruyter and COM. BERLIN. Basic textbook on geographical climatology, covering the fields of analytical climatology, synoptical climate geography, general circulation, general types of climate modification by man.

13. Brown, L.H., J. Cocheme. (1973). A study of the agroclimatology of the highlands of East Africa. WMO No. 339, 197 p. Report on the FAO/UNESCO/WMO Project on the Agroclimatology covering the countries Ethiopia, Kenya, Tanzania and Uganda.

14. Agroclimatology of the highlands of Eastern Africa. (1973). Proceedings of the Technical Conference Nairobi. WMO No. 389, 242 pages. Follow-up of the agroclimatic survey carried out by FAO/UNESCO/WMO

15. Cocheme, J., P. Frauquin. (1967). Agrometeorological survey of a semiarid area in Africa south of the Sahara. WMO No. 210, 136 p. The subjects covered include rainfall, crop transpiration, availability of water during different periods of the year, heat and light and the correlation between crops and climate.

16. Agroclimatology in the Semi-arid areas South of the Sahara. (1973). Proceedings of the technical regional conference. Dakar, 1971. WMO No. 340, 253 p. FAO/UNESCO/WMO interagency project. Follow-up of the survey mentioned under reference 15.

17. Davy, E.G., F. Mattei, S.I. Solomon. (1976). An Evaluation of Climate and Water Resources for Development of Agriculture in the Sudano Sahelian Zone of West Africa. WMO No. 459, 289 p. General background information on agrometeorology and surface water resources in a large part of West Africa.

18. Frere, M., J.Q. Rijkz, J. Rea. (1978). Estudio agroclimatologico de la Zona andima. WMO No. 506, 297 p. (Spanish) Outcome of an agroclimatology project carried out jointly by FAO/WMO and UNESCO. The first part analyzes the agrometeorological factors; the second part studies the main crops in the area and their reaction to agroclimatic factors.

19. Amare-Getahun. (1980). Agro-climates and agricultural systems in Ethiopia. Agricultural Systems. 5:39-59.

20. Jackson, I.J. (1977). Climate, water and agriculture in the tropics. Longman Corp. 248 p. This book examines characteristics of tropical rainfall and evaporation together with their implications especially related to agriculture, land use, and aspects such as soil erosion and irrigation.

Agrometeorology of Crops

21. Agrometeorology of the Wheat Crop. (1974). Proceedings of the WMO Symposium in Brunswick 1973, WMO No. 396, 242 p.

22. Agrometeorology of the Maize Crop. (1977). WMO No. 48, 454 p. Proceedings of the Symposium on the Agrometeorology of the maize crop. WMO - Iowa State University, 1976.

23. Da Mota, F.S. (1978). Soya Bean and Weather. WMO No. 498, 64 p.

24. Robertson, G.W. (1975). Rice and Weather. WMO 423, 40 p.

25. Agrometeorology of the Rice Crop (1980). Proceedings of the WMO/IRRI Symposium WMO No. 541.

Agro-ecology

26. Report on the Agro-ecological zones project.
Vol. 1: Methodology and Results for Africa 1978
Vol. 2: Results for Southwest Asia 1978
Vol. 3: Results for Southeast Asia 1980
FAO World Soils Resources Report No.48

27. Holderidge, L.R. and others. (1971). Forest Environments in Tropical Life Zones. A pilot study, Pergamon Press, 747 p. Particular reference is made to chapter two on the Holdridge "life zone system" as proposed 1947.

Others

28. Crop Water Requirements. (1974). FAO Irrigation and Drainage papers, No. 24, 198 p.

29. Frere, M., F. Popov (1979). Agrometeorological Crop monitoring and forecasting. FAO Plant Production and Protection Paper No. 17, 64 p.

30. Windbreaks and Shelterbelts. (1964). WMO No. 59, 188 p. Established by a working group of the Commission of Agricultural Meteorology this publication summarised the results of reasearch on this subject. The bibliography lists about 550 references. (another approximately 300 references on shelterbelts for the period 1970 - 1980 are available through the National Agricultural Library, U.S. Department of Agriculture).

31. Drought and Agriculture. (1975). WMO No. 392, 127 p. This publication gives consideration to many meteorological factors of drought including its definition and early recognition, its effect on plants, animals and diseases as well as methods for alleviating its effects.

32. Davies, J.W. (1975). Mulching Effects on Plant Climate and Yield. WMO No. 388, 92 p. This publication deals with effect of mulching on the climate of the soil and the micro-climate near the ground. The effect of mulching on temperature and moisture regimes of the soil, soil erosion, soil physics, pests, diseases and the growth of weeds are given with the published experimental evidence.

33. Baier, W. (1977). Crop weather models and their use in yield assessments. WMO No. 458, 48 p. A review of the techniques currently available for simulating and analysis on the operational use of empirical statistical yield models for periodic assessment of regional production.

34. The effect of meteorological factors on crop yields and methods of forecasting the yield (1982). WMO No. 566, 54 p.

35. Dancette, C., J.F. Poulain. (1969). Influence de l'*acacia albida* sur les facteurs pedoclimatiques et les rendements de cultures Sols Africains 13(3):197-238.

36. Smith, H. (1982). Light Quality, Photo-perception and Plant Strategy. Ann. Rev. Plant Physiology 33:481-518.

37. Symposium on Forestry Meteorology. (1978). Proceedings of the Symposium on Forest Meteorology in Ottawa. WMO No. 527, 233 p.

Bibliography

38. Agrarmeteorologiosche Bibliographie des Deutschen Wetterdienstes. (1978, 1979, 1980). Annual bibliography on agricultural, meteorological publications which have become known to the Central Office of the "Deutscher Wetterdienst" in the course of the year. (1980; 2263 references including short abstracts).

## R3. REVIEW OF ECONOMICS LITERATURE RELEVANT FOR AGROFORESTRY - by D. Hoekstra

*The present review focusses on existing literature in the English language highlighting economic theories, principles and methods of particular importance to agroforestry.

### Multiple Output Theory

ICRAF's perception of agroforestry is one of multicomponent, multiperiod land-use systems and technologies in which woody perennials are deliberately used on the same land management unit as agricultural crops and/or animals, either in some form of spatial arrangement or temporal sequence.

The theory on the analyses and/or planning of multiple output systems was originally developed around 1920 by Edgeworth-Bowley using a box diagram. Since then, it has been further developed and is presently described in several agricultural economics textbooks, amongst others Henderson *et al*. (30) and Rae (48).

This theory has been elaborated in articles and publications dealing with intercropping and/or multiple cropping. Amongst the best known ones are Willey (58, 59), Hildebrand (31) and Flinn (21).

Reference to this theory has also been made in articles by Filius (20) and Raintree (49) dealing with economic aspects of agroforestry.

The graphical approach used to portray the optimisation of multiple output systems using iso revenue curves and iso production possibility frontiers is quite useful whenever the problem is limited to two outputs, however it is inadequate when more than two inputs and outputs have to be dealt with at the same time.

Linear programming was developed to deal with optimizing such systems e.g. multiple component, multiple input production systems. However, the underlying optimization principle of marginal cost equals marginal benefits is similar to the simple two output production system.

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*Ed's note.

Basic textbooks on linear programming explaining the theory as well as the construction of an l. p. matrix are Beneke et al. (5) and Heady et al. (29).

Applications of linear programming for agroforestry have been made by Raintree (49), Dykstra (15) and Verinumbe et al. (57).

Perhaps because of the complexity of l. p. and/or the lack of data, other non-optimizing methods such as budget comparisons are being used more often for analysis; see amongst others Dillon et al. (12) and Rae (48) for a detailed description. These methods have been used for analysing agroforestry land-use systems by Lagemann et al. (30), Grinnell (26) and Sain (51). Both methods, l. p. and budgeting, disregard the cost of time in their analyses which is a serious drawback to agroforestry applications since it is almost by definition multiperiod in nature.

Multiperiod Theory

The economic theory on the valuation of time has been developed by economists like Hirschleifer, Fisher, Hicks and Ferguson. However, their publications mainly deal with the mathematical side of the theory and need not be included as basic textbooks. The principles are explained in a more popular form in many economics textbooks e.g. Price-Gittenger (23).

The valuation of time (usually referred to as discounting) has been combined with linear programming, in what is called multi-stage linear programming (also called poly-periodic and dynamic programming). This method has been described by Agrawal et al. (1) and Hadley (27) and an agroforestry application was made by Burgess (7).

Due to the complexity of the matrix and the considerable amount of computer memory required, this method is not yet popular and most analysis and/or planning of multiperiod production systems is therefore based on the non-optimisation method of discounted budget comparison. Many textbooks have been produced on project analyses/planning describing this method including discounting procedures, valuation of inputs and outputs using the market price or opportunity cost principle, as well as a description and evaluation of the different measures used to compare the financial and economic

attractiveness of the alternative combinations considered. Amongst the most useful references in this wide field are Gregerson *et al*. (24), Squire (53), Little (41), UNIDO (55), Gregory (25).

Agroforestry Systems Analysis

Several articles are dedicated to the analysis and evaluation of agroforestry projects. Most of them advocate the use of the non-optimisation method of discounted budget comparison usually referred to as cost/benefit analyses. Some useful references are: Etherinton (17), Vergara (56), Hoekstra (32), Harou (28), Arnold (2), Mruthynjaya (45) and Mindajao (44). Other articles or publications deal with the evaluation of particular forms of agroforestry e.g. fuelwood production by Devres *et al*. (10), Hosier (34) and Earl (16); village woodlots or social forestry by Bromley (6) and Shapiro (52).

Cost/benefit analysis has been applied to numerous agroforestry land-use systems; unfortunately many of them were never identified as such and are therefore not easily available. Some of these studies are: Etherington *et al*. (18) on intercropping under coconuts; Vergara (56) on a multipurpose tree alley cropping system in crops; Hosier *et al*. (35) and Openshaw (46) on a fuelwood/crop production system; Bromley (6) on a multipurpose woodlot; Ball (3), Lowe (43) and Hofstad (33) on the evaluation of the *taungya* system; Srivastana *et al*. (54) on woodlot and boundary planting; ILCA (36) on silvopastoral land-use systems.

Given that these economic theories are of particular importance to agroforestry some basic economic knowledge of the three major agroforestry components e.g. crops, livestock and trees should be part of training programmes in agroforestry. Several references to basic textbooks on agricultural and forestry economics have been included already and these should be complemented by the following books/articles dealing with livestock economics: Dillon (11), Crotty (9), Koncracki (39), Jarvis (37) and Low (42).

Since the study of existing land-use systems is considered to be an essential part of ICRAF's diagnosis and design exercise for agroforestry, some of the recent literature on the farming systems approach on methods analysing and describing land-use systems should be included in an economic training programme for agroforestry e.g. Perrin et al. (47) CIMMYT (8) Banta (4) and Ruthenberg (50).

Data for Agroforestry Systems Analysis

Description of methods for data collection can be found in previously mentioned farming systems literature, for instance Friedrich (22) and Dixon (13). However most of these methods/systems are limited to collecting and recording data for annual production systems.

Little guidance is so far provided for collecting data sets for multiperiod production systems. The MULBUD (19) computer programme by the Australian National University and ICRAF is a first step in specifying minimum consistent data sets for multiperiod production systems, but further research will be required on the best possible methods of obtaining such data.

## R3 - REFERENCES (Economic Aspects)


1. Agrawal, and E.D. Heady. (1973). Quantitative methods for agricultural decisions, Iowa University Press.

2. Arnold, J.E.M. (1982). Economic constraints and incentives in agroforestry. United National University Workshop on Agroforestry, Freiburg.

3. Ball, J. (1977). Taungya in Southern Nigeria. FO: NIR/71/456 F.A.O.

4. Banta, G.R. (1982). Asian cropping systems research. Micro-economic evaluation procedures. I.D.R.C., Ottawa.

5. Beneke, R.R., R. Winterboer. (1978). Linear Programming Applications to Agriculture. Iowa State University Press, Ames.

6. Bromley, D.W. (1981). The economics of social forestry: An analysis of a proposed programme

in Madhya Pradesh, India. One section of a team report: Center for Resource Policy Studies. School of Natural Resources, University of Wisconsin, Madison.

7. Burgess, R.J. (1981). The intercropping of small holders coconuts in Western Samoa. An analysis using multi-stage linear programming. Australian National University, Development Studies Centre.

8. Centro Internacional De Mejoramiento De Maiz Y Trigo (1980). Planning technologies appropriate to farmers, concepts and procedures, CIMMYT.

9. Crotty, R. (1980). Cattle, economics and development. Commonwealth Agricultural Bureaux, London.

10. Devres, et al. (1980). The socio-economic context of fuelwood use in small rural communities. A.I.D. Evaluation Special Study No. 1.

11. Dillon, J.L. (1976). The analysis of response in crop and livestock production, 2nd ed. Oxford, Pergamon.

12. Dillon, J.L., J.B. Hardaker. (1980). Farm management research for small farmers development. F.A.O. Agricultural Service Bulletin No. 41.

13. Dixon, J. (1982). FARMAP, Users Manual, Computer print-out. F.A.O.

14. Doran, M.H., A.R.C. Low, L.R. Kemp. (1979). Cattle as store of wealth in Swaziland. Implications for livestock development and overgrazing in Eastern and Southern Africa. J. Amer. Agric. Econ. 61, No. 1.

15. Dykstra, D.P. (1980) Food and fuel: A preliminary mathematical programming analysis for an ujamaa village in Tanzania. In: Proceedings of the Kenya National Seminar on Agroforestry. L. Buck, ed. ICRAF and University of Nairobi.

16. Earl, P.E. (1975). Forest energy and economic development, Clarendon Press, Oxford.

17. Etherington, D.M. (1981). Multiperiod budgeting and the economic assessment of perennial crop intercropping system. Australian National University, Development Studies Centre.

18. Etherington, D.M., K. Karumanayaka. (1981). An economic analysis of some options for intercropping under coconuts in Sri Lanka. Sri Lanka Journal of Agrarian Studies, 2, No. 1.

19. Etherington, D.M., P.J. Matthews. (1982). MULBUD users manual. Australian University (Development Studies Centre), ICRAF, Nairobi.

20. Filius, A.M. (1981). Economic Aspects of Agroforestry; Viewpoints on Agroforestry K.F. Wiersum, ed. Agricultural University Wageningen, The Netherlands.

21. Flinn, J.C. (1979). Agroeconomic Considerations in Cassava Intercropping Research; intercropping with Cassava. E. Weber B. Nestel & M. Campbell, eds. International Development Research Centre, Ottawa.

22. Friedrich, K.H. (1977). Farm management data collection and analysis: An electronic data processing, storage and retrieval systems. F.A.O. Service Bulletin No. 34.

23. Gittinger, J., Price (1972). Economic analysis of agricultural projects. Baltimore, Johns Hopkins University Press for the World Bank.

24. Gregerson, H.M., A.H. Contreras. (1979). Economic Analysis of Forestry Projects, F.A.O. Forestry Paper No. 17.

25. Gregory, G.B. (1972). Forest resource economics. The Ronald Press Company, New York.

26. Grinnell, H.R. (1977). A study of agrosilviculture potential in West Africa. I.D.R.C.

27. Hadley, G. (1964). Non-linear and dynamic programming. Reading, Mass: Addison Wesley.

28. Harou, P.A. (1981). The economics of agroforestry projects. Proceedings XVII IUFRO World Congress Japan.

29. Heady, E.O., W. Candler. (1958). Linear programming methods. Iowa State Univesity Press.

30. Henderson J.M., R.E. Qiandt. (1971). Microeconomic Theory. A Mathematical Approach. 2nd edition. McGraw-Hill, New York.

31. Hildebrand, P.E. (1976). Multiple Cropping Systems are Dollars and "Sense" Agronomy. Multiple Cropping, American Society of Agronomy.

32. Hoekstra, D.A. (1982). The use of farms planning in agroforestry design and appraisal. ICRAF, Nairobi.

33. Hofstad, O. (1978). Preliminary evaluation of the taungya system for combined wood and food production in North-Eastern Tanzania Division of Forestry, Faculty of Agriculture, Forestry and Veterinary Science, University of Dar-es-Salaam. Record No. 2.

34. Hosier, R. (1982). Social benefit-cost analysis of fuelwood development projects. The Beijer Institute, Stockholm.

35. Hosier, R., B. van Gelder. (1982). The economics of optimal fuelwood production techniques. The Beijer Institute Stockholm.

36. International Livestock Centre for Africa (1980). Economic aspects of browse development, ILCA Bulletin No. 12. Addis Ababa.

37. Jarvis, L.S. (1980). Cattle as store of wealth in Swaziland - comment. J. Amer. Agric. Econ. 62, 3.

38. Jarvis, L.S. (1974). Cattle as capital and ranchers as portfolio managers - An application to Argentina's cattle sector. J. Political Economics 82, 3.

39. Koncracki, Z.A. (1978). The economics of pastoralism. A case study of Sub-Saharan African. Frank Cass and Co. Ltd., London.

40. Lageman, J., J. Heuveldop. (1982). Characterisation of agroforestry system: The case of Acosta-Puriscal, Costa Rica, CATIE.

41. Little, I.M.O., J.A. Mirlass. (1974). Project appraisal and planning for developing countries. New York, Basic Books.

42. Low, A.R.C., R.L. Kemp, M.H. Doran. (1980). Cattle as store of wealth in Swaziland - Reply J. Amer. Agric. Econ. 62, 3.

43. Lowe, R.G. (1977). Farm forestry in Nigeria. Federal Department of Forest Research, Ibadan.

44. Mindajao, N.M. (1979). The economics of agroforestry. Agroforestry Symposium/Workshop P.C.A.R.R. Philipinnes.

45. Mruthyunjaya. (1981). Benefit-cost considerations in agroforestry. In: Proceedings of the Summer Institute on Agroforestry in Arid and Semi-arid Zones. Vol. 4 CAZRI JODHPUR.

46. Openshaw, K. (1982). Costs and benefits of proposed tree planting programme for satisfying Kenya's wood energy requirements. Beijer Institute Stockholm.

47. Perrin, R.K., D.L. Winkelmann, E.R. Moscardi, J.R. Anderson. (1976). From agronomic data to farmers recommendations, An economics training mannual. CIMMYT.

48. Rae, A.N. (1977). Crop-management economics. Croby, Lockwood, Staples, London

49. Raintree, J.B. (1981). Bioeconomic Consideration in the Design of Agroforestry Intercropping Systems. ICRAF, Nairobi, Kenya.

50. Ruthenberg, H. (1980). Farming systems in the tropics, (3rd ed). Clarendon Press. Oxford.

51. Sain. R. (1973). Economic analysis of shifting cultivation. Indian Agri. Econ. 33, No. 4.

52. Shapiro, K. (1982). Agroforestry in Niger: Economic and social analysis. Research proposal, Centre for Research on Economic Development and School of Natural Resources. The University of Michigan. Special Publication No. 27.

53. Squire, L. and van der Tak, H.S. (1976). Economic analysis of projects, Baltimore, Johns Hopkins University Press for the World Bank.

54. Srivastana, B.P., Pant, M.M. (1979). Social forestry on a cost-benefit analysis framework. The Indian Forester, 105, No. 1.

55. UNIDO (1978). Guide to practical project appraisal. Social benefit-cost analysis in developing countries. New York, UN.

56. Vergara, N.T. (1982). Economic evaluation of agroforestry. Working group on agroforestry, Environment and Policy Institute. East-West Centre, Hawaii.

57. Verinumbe, I., Kripscheer, H.C., Enabor, E.E. (1981). The potential of leguminous tree crops in zero-tillage cropping in Nigeria. A linear programming model. International Institute of Tropical Agriculture, Ibadan.

58. Willey, R.W. (1979). Intercropping - Its Importance and Research Needs. Part 1 Competition and Yield Advantages. Field Crop Abstracts, 32, No.1.

59. Willey, R.W. (1979). Intercropping - Its Importance and Research Needs. Part 2 Agronomy and Research Approaches. Field Crop Abstracts, 32, No. 2

## R4. A QUALITATIVE OVERVIEW OF SOURCES OF AGROFORESTRY INFORMATION - by R. Labelle

In answering requests for agroforestry information there are a number of data files that can be computer accessed. Among the most relevant ones for agroforestry, there are:

AGRIS: The International Information System for the Agricultural Sciences and Technology, produced by FAO, Rome.

ATA : Abstracts of Tropical Agriculture (known as TROPAG under the host SDC, Inc.) produced by the Royal Tropical Institute, Amsterdam.

Bibliography of Agriculture: (known as AGRICOLA under the various host services) produced by the Technical Information Service, National Agricultural Library, USDA, Washington.

CAB Abstract: 25 abstract journals published by CAB, the Commonwealth Agricultural Bureaux.

Biological Abstracts and Bio Research Index: Biosciences Information Service. (known as BIOSIS under the various host services).

In most cases, files can be consulted for information originating as far back as the early 70's. Computer update searches, known as SDI services (for Selective Dissemination of Information) provide the current titles in selected areas of agroforestry information in the form of computer printouts of references. The Council has an SDI service using the AGRICOLA and CAB data bases for two topics: "Small Scale Farm Production Systems" and "Tropical Trees and Seeds."

An important source of information exists through what is known as the "invisible college" of agroforestry workers world-wide. Individuals placed throughout the world and sharing a common interest in agroforestry and specifically in the teaching or training aspects of agroforestry, communicate and exchange information on the subject. This source of information has not been investigated systematically.

ICRAF relies on a growing list of information centres, and in some cases individuals, to assist with information searches and in document provision. A

list of these centres is appended to the selected bibliography on agroforestry by Majisu and Labelle (18). Among these, the following are noteworthy.

In Kenya, the library of the Kenya Agricultural Research Institute (KARI) is located near Nairobi. A literature service, in essence a photocopied table of contents service of relevant journals, is mailed bi-weekly to the ICRAF library. Articles of interest are identified and returned to the Council for use by the staff requesting them. Most contemporary information can be identified in this fashion. For documents that are not available at the KARI library, requests for document provision are addressed elsewhere. In the case of documents requested from the conventional literature, the main sources are: The British Library Lending Division (BLLD), the National Agricultural Library (NAL) of the US Department of Agriculture and PUDOC (the Centre for Agricultural Publishing and Documentation) located at the Agricultural University of the Netherlands in Wageningen. In general, well-stocked libraries located in departments of forestry or agriculture will provide many if not most of the references sought from conventional sources.

However, the conventional literature does not necessarily reflect the agroforestry research and development work that is underway in developing countries. Non-conventional literature however may reflect this work. Before going any further, let us define non-conventional literature in relation to agroforestry interests. For this, we shall refer to Posnett's (26) definition of the term in relation to non-conventional literature of tropical agricultural resource assessment and development.

Accordingly, non-conventional literature is "that part of the literature which would present a non-specialist library, as opposed to a special library, with more than average difficulty in its acquisition. To be able to acquire this literature implies some knowledge of the infrastructure and 'invisible college' facilities within the special subject concerned." The bibliographic documents cited in the major data banks mentioned above, together form the conventional literature.

Regional Information Centres

CATIE is a regional agency supported by several

Central American countries. It promotes research, training and technical cooperation in agriculture, forestry and animal production. Several information activities exist at CATIE. A bibliography of agroforestry was produced in 1981 by Combe, J. et al. (7) and reflects the extensive contacts this institution has with others in Latin America. A substantial collection of documents, many of which have been used to produce the bibliography along with new acquisitions, are managed by INFORAT at CATIE.

Much of the information at CATIE is non-conventional and could only have been recovered as a result of the on-going work and contacts that CATIE staff have with countries in Latin America. But, the coverage is difficult to assess. The best source of this information should theoretically be the national agricultural or forestry institutions of Latin American countries. However very little information can be identified by correspondence, let alone recovered. This observation underlies the importance of personal contacts and of the role that gatherings such as this agroforestry education workshop can play in the process of acquiring information upon which plans to undertake agroforestry research or joint research projects or to set priorities in general, can be made. In fact, as a general rule, the information that is recovered from searching the literature on agroforestry invariably suggests more about what research needs to be done than it provides complete and reliable data on agroforestry.

The Orton Memorial Library at CATIE contains 60,000 books and receives or has received 11,000 journals, half of which are on-going subscriptions. Two special and unique collections on cacao and coffee are housed there as well as many other documents of primordial interest to agroforestry workers in the American Tropics.

A third source of agroforestry information at CATIE lies with the Plant Production division. Of interest here is the annotated bibliography on farming systems entitled "Sistemas de producción de plantas perennes".

Communications with CATIE should be sent to these three sources in order to have access to the greatest amount of knowledge and expertise available.

The Agricultural Information Bank for Asia (AIBA) is

part of the Southeast Asian Regional Centre for Graduate Study and Research in Agriculture (SEARCA). AIBA has recently produced a bibliography, with some annotations, of 467 references dealing with agroforestry in the region of Southeast Asia. As with the CATIE bibliography, it will be continuously updated. The references have been retrieved from the AGRIS and AGRIASIA data banks, for which SEARCA is the regional input centre. In both cases, many of the references cited are non-conventional and it is difficult to assess what information has been left out. For example, in Latin America 60,000 relevant documents in science, including in-house research reports, results and mimeo documents are produced each year yet only about one third are "seen." This information is crucial to all those interested in agroforestry as it describes agroforestry systems, practices and/or components.

The International Livestock Centre for Africa, (ILCA) has an active information and documentation service operating out of the headquarters in Addis Ababa. Considerable information on livestock production systems, in Africa, including those in which woody perennials play an important part are available there. The holdings maintained at the ILCA library are of particular interest for two reasons. Firstly, many documents have been acquired as the result of a systematic effort, funded by the International Development Research Centre of Canada, to identify and collect relevant documents in African countries. Local consultants have been hired to identify the documents or where they are deposited and a team of two people have been flown in to photograph the documents in question so they can be stored on microfiche. All the documents so acquired are then analysed and indexed. Several countries' bibliographies exist at present. The second reason is that a Hewlett Packard 3000 series minicomputer using the MINISIS bibliographic data base management software is used to afford rapid access to this important source of non-conventional literature. ILCA will respond to requests for searches of this data base and a computer printout of citations can be obtained.

With the exception of ILCA, ICRAF has not exchanged documentation in answer to specific requests for information, with other agricultural research centres of the Consultative Group for International Agricultural Research (CGIAR group). The following CG

centres however, carry out work that is pertinent to agroforestry, although most of this research effort is geared to commodity crops. The Annual Report for 1980 (13) of the International Institute for Tropical Agriculture (IITA), located in Nigeria, outlines, as part of the research activities, a research programme in which potential agroforestry technologies are discussed. The technologies in question are alley cropping and live mulch systems. The programme also mentions that agroforestry surveys are undertaken. Other CG centres also mention agroforestry technologies in their search reports or information brochures. These are the International Rice Research Institute (IRRI) located in the Philippines, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) headquartered in India.

National Information Sources: Developing Countries

Probably the best source of documentary information from the developing countries is available through the AGRIS system. AGRIS, International Information System for the Agricultural Sciences and Technology, has been created through the cooperation of the FAO (10), various governments and institutions, to provide "a data base which provides references to current literature, collected from world-wide sources, relevant to research and development in the food and agriculture sector and allied fields. Input is provided by cooperating centres, which identify scientific literature within the scope of the system and produced in their own country or region. The input received from participating centres is merged into a magnetic tape data base, from which is derived:

- AGRINDEX, a printed and categorized bibliography which is issued monthly;

- a magnetic tape service in which all references contained in the bibliography are available in machine readable form."

AGRINDEX is produced monthly and contains several thousand citations to the literature. Ninety-five national centres (of which fifty-seven are from developing countries), as well as five more multi-national centres, contribute input to the system. The author has found that manual searches reveal more citations of interest. Because the AGRIS network exists to identify the non-conventional literature,

especially in the developing countries, it would be worthwhile if educators and scientists involved in agroforestry training in these countries were to show their students the value of the AGRINDEX. They would indirectly contribute to reinforcing national research in Third World countries as well as cooperation in research among them.

Possibly the best way to use the AGRINDEX for agroforestry is to search by subject category. As with most abstract journals and especially with the computer data bases mentioned previously, searching using agroforestry as a descriptor is a virtual waste of time. Agroforestry in fact is not listed under the subject category of the AGRINDEX. However, this is expected to change in the future, if it has not already occurred, with the publication of AGROVOC, a multilingual thesaurus of agricultural terminology presently produced by the FAO and the Commission of the European Communities (CEC) (15).

The AGROVOC descriptors provide a rather general but nevertheless useful coverage of agroforestry-related concepts and it will facilitate searching the AGRIS magnetic data bases.

Apart from AGRIS, a few national documentation centres or national institutions are worth mentioning. In Sudan, the National Documentation Centre of the National Council for Research (P.O. Box 2404, Khartoum, Sudan) has produced a Bibliography of Agriculture and Veterinary Sciences in the Sudan (19) as well as Sudan Science Abstracts (1).

National Information Sources: Developed Countries

The bibliographic resources in these countries are many and they can be grouped in three main categories:

Firstly is the vast literature accumulated during the colonial experience of the British, the French, the Dutch and the Belgians. These collections have not been examined in any great detail by the author, but the preliminary investigations undertaken as well as a few visits to the repository libraries reveal that they have been systematically acquired and can be so retrieved. Unfortunately, there is a lot of work involved even if one were to simply try to inventory them for the information they contain that is relevant to agroforestry.

This is because they are all indexed for manual retrieval. The most efficient key to this information lies with review articles referring back to this literature and exposing its secrets in an organized way.

The British institutions of interest are the Tropical Products Institute (TPI) located in London, some of the Commonwealth Agricultural Bureaux and the libraries of the institutions where they are located such as the library of the Commonwealth Forestry Institute, that of the Rothamsted Experimental Station (Commonwealth Bureau of Soils), the East Malling Research Station (Commonwealth Bureau of Horticulture and Plantation Crops), and of course the libraries of the Royal Botanic Gardens at Kew, to name but a few.

The Tropical Products Institute for example, has accumulated a significant amount of information on plant and animal products from developing countries. The Technical Index of the Tropical Products Institute (9) is a manual index containing references to the literature on tropical commodities. A total of 675,000 entries deal with information running from the nineteenth century to the present time.

In the Netherlands, the Royal Tropical Institute documentation services have existed since 1916. Manual searches can be requested for this literature.

The "Centre d'Information Appliquee au Developpement et a l'Agriculture Tropicale" located in Belgium has compiled a three volume bibliography of documents on agriculture and land-use management in Zaire, Rwanda and Burundi (5). This bibliography is systematically indexed with many entries on woody plants and land-use practices relevant to agroforestry in the lowland humid tropics. More than 5000 documents are cited in Volumes 1 and 2 of the bibliography.

The "Centre de Documentation Economique et Sociale Africaire" (CEDESA) is another Belgian institution which has produced reviews on socio-cultural and socio-economic aspects of land use in the humid tropics of Africa with bibliographies containing several hundred references.

In France, three institutions of the (GERDAT) are of particular interest. The "Centre Technique Forestier Tropical" (CIFT), the "Institut de Recherches en

Agronomie Tropicale" (IRAT) and the "Institut d'Elevage et de Médecine Véterinaire des Pays Tropicaux" (IEMVT) contain in their separate libraries all of the literature from the French colonial period. Study, by hired consultants of the holdings of these libraries has revealed that a massive amount of research results have been assembled that are pertinent to agroforestry, in the broadest sense. As is usual, the older literature is not stored on magnetic tape so it must be retrieved manually. Only the Belgian bibliography mentioned above is systematically presented to the interested user.

Secondly, the current literature indexed by research institutions, some of which have been named above, is also of interest, in particular the French institutions of the GERDAT and of the Office de la Recherche Scientifique et Technique Outre Mer (ORSTOM). IRAT in fact has recently produced an excellent bibliography on agroforestry (12). Unfortunately, the contemporary holdings of these institutions still have to be searched manually although many articles are also added to the "Pascal" magnetic tape data base of French scientific literature.

Thirdly, the recently acquired holdings of a few key institutions are currently promoting interest in agroforestry systems and practices. A collection of documents assembled by J. Bene (the IDRC consultant who first proposed the creation of ICRAF to promote interest and research in agroforestry) is located at the library of the IDRC in Ottawa, Canada. This library contains many pertinent documents, some of which have been acquired or produced as a result of projects the IDRC has funded in agroforestry research.

The Board on Science and Technology for International Development (BOSTID), located in Washington, D.C. is a part of the National Academy of Sciences (NAS). Research Associates of the BOSTID have produced several important publications on underexploited trees, in particular nitrogen-fixing woody legumes. These plants are prime candidates to be investigated through research as components of agroforestry systems. The four publications of NAS (22, 23, 24, 25) on these species are the best single source of information for research scientists on this subject. Not only do they review the knowledge available on each species, but they also suggest research

priorities as well as listing research workers and seed sources. The amount of work associated with the production of these documents was only possible because of an extensive network of cooperants whose experience and practical knowledge was essential.

In order to properly determine the state of the art in regard to agroforestry knowledge, whether in the 'Agroforestry Systems Inventory' or the inventory of potential 'Agroforestry Tree Species' a similar approach will be necessary and a network of "qualified informants" will have to be created. For education in agroforestry these books will remain of prime importance, until updated versions are published.

Mention should also be made of the materials on agroforestry produced by the East West Centre in Hawaii (31, 32, 33, 34, 35). These documents summarize some of the knowledge on fast growing nitrogen fixing trees in the humid tropics of Southeast Asia.

Also noteworthy is the "Leucaena Research Reports" published by the Council for Agricultural Planning and Development, 37 Nanhai Road, Taipei, Taiwan, Republic of China and prepared by the Department of Horticulture at the University of Hawaii, 3190 Maile Way, Honolulu, Hawaii 96822, U.S.A.

## R4 - REFERENCES (Information Sources)


1. Abbadi, S. ed. (1980). Sudan Science Abstracts. National Council for Research, National Documentation Centre, Khartoum. 1(1). 115 refs. 49 pp.

2. Agroforestry Systems Journal (1982). What is Agroforestry? Editorial Agro. Syst. J. 1(1).

3. Buck, L. ed. (1982). Proceedings of the Kenya National Seminar on Agroforestry. 12 - 22 Nov., 1980, Nairobi, ICRAF. 638 pp.

4. Cannell, M. (1982). Plant Science. (See page 165 of these proceedings).

5. Centre d'Information Appliquée and Dévelopment et l'Agriculture Tropicale (1972, 1973, 1982). Bibliographie Analytique pour l'Agronomie Tropicale. Zaire, Rwanda, Burundi. Vol. I 1972, Vol. II, 1973, Vol. III, 1982.

6. Chandler, T. and D. Spurgeon, eds. (1980). International Cooperation in Agroforestry. Proceedings of an International Conference Nairobi, 16 - 21 July, 1979. ICRAF, Nairobi, 469 pp.

7. Combe, J. Jimenez-Saa, H. and Monge, C. (1981). Bibliography on Tropical Agroforestry. Turrialba, Costa Rica, Centro Agronomico Tropical de Investigacion y Emsenanza, Bibliografia No. 6. 680 refs. 67 pp.

8. Darnhoffer, T. (1982). AgroEco-Climatological Source References. (See page 177 of these proceedings).

9. Datta, V.K. (1974). The Technical Index of the Tropical Products Institute Trop. Sci. 16(4): 237-246

10. FAO. (1982). AGRINDEX. Vol. 8, No. 11 685 pp. Apimondia Publishers, Rome.

11. Huxley, P.A. ed. (1983). Plant Research and Agroforestry. Proceedings of a Consultative Meeting, 8 - 15 April, 1981, ICRAF, Nairobi.

12. Institut de Recherches en Agronomie Tropicale (1982). Bibliographie sur l'Agroforestrie. IRAT, Centre de Documentation 698 refs. 131 pp.

13. International Institute of Tropical Agriculture (1981). Annual Report for 1980. Ibadan, Nigeria.

14. Khan, M. (1982). Non-Government Organization Information Sources. (See page 209 of these proceedings).

15. Leatherdale, D., G.E. Tidbury and R. Mack. (1982). AGROVOC. A Multilingual Thesaurus of Agricultural Terminology. English Version. FAO and CEC. 530 pp. Apimondia Publishers, Rome.

16. Lundgren, B. (1982). ICRAF's Programme of Work for 1983. With Projections for 1984 to 1986. ICRAF, Nairobi.

17. Lundgren, B. (1982). The Use of Agroforestry to Improve the Productivity of Converted Tropical Land. Report to the Office of Technology Assessment of the U.S. Congress. ICRAF, Nairobi.

18. Majisu, L. and R. Labelle (1982). A Selected Bibliography on Agroforestry. ICRAF, Nairobi.

19. Mamoun, I.E. (1978). Bibliography of Agriculture and Veterinary Sciences in the Sudan. 2nd Edition up to 1974. National Council for Research Agricultural Research Council, Khartoum.

20. Mongi, H.O. and P.A. Huxley, eds. (1979). Soils Research in Agroforestry. Proceedings of an Expert Consultation, Nairobi, 26 - 30 March 1979. ICRAF, Nairobi. 581 pp.

21. Nair, P.K.R. (1982). Soils and Soil Management under Agroforestry. (See page 216 of these proceedings).

22. National Academy of Sciences (1975). Underexploited Tropical Plants with Promising Economic Value. NAS, Washington, D.C. 187 pp.

23. Ibid. (1977). Leucaena: Promising Forage and Tree Crop for the Tropics. NAS, Washington, D.C. 118 pp.

24. Ibid. (1979). Tropical Legumes: Resources for the Future. NAS, Washington, D.C. 331 pp.

25. Ibid. (1980). Firewood Crops, Shrub and Tree Species for Energy Production. NAS, Washington, D.C. 237 pp.

26. Posnett, N.W. (no date). The Value and Availability of Non-Conventional Literature in Tropical Agricultural Resource Assessment and Development. Land Resource Development Centre, Surbiton, Surrey, U.K. 18 pp.

27. Raintree, J. (1982). Readings for a Socially Relevant Agroforestry. (See page 235 of these proceedings).

28. Torres, F. (1982). Role of Woody Perennials in Animal Agroforestry. (See page 266 of these proceedings).

29. Trustees, ICRAF (1979). Charter of the International Council for Research in Agroforestry.

30. Veer, C. (1982). Management Theories and Strategies. (See page 317 of these proceedings).

31. Vergara, N.I. (1982). New Directions in Agroforestry: The Potentials of Tropical Legumes Trees. Improving Agroforestry in the Asia-Pacific Tropics. East West Centre, Honolulu, Hawaii, 52 pp.

32. Ibid. New Directions -- Legume Trees. Economic Evaluation of Agroforestry Projects. East West Centre, Honolulu, Hawaii, 23 pp.

33. Ibid. New Directions -- Legume Trees. Initial Tasks in Agroforestry Projects. East West Centre, Honolulu, Hawaii. 9 pp.

34. Ibid. New Directions -- Legume Trees. Selection of Legume Trees for Agroforestry. East West Centre, Honolulu, Hawaii, 28 pp.

35. Ibid. New Directions -- Legume Trees. Sustained Outputs from Legume Tree Based Agroforestry Systems. East West Centre, Honolulu, HA. 36 pp.

## R5. NGOs AND AGROFORESTRY - by M. Khan

### Introduction

NGO (non-governmental organization) activity in some environmental fields compares favourably with the action of governments, intergovernmental and international agencies. NGOs are unique in their ability to transcend (when necessary) politics and internal strife and appeal to people directly. This makes them particularly valuable. However, in the field of agroforestry NGOs have yet to make a noticeable impact. This does not reflect their potential; only their present lack of financial and technical resources. Undoubtedly, in only a short amount of time, NGOs will assume greater responsibility in organizing people to promote agroforestry practices in those areas where the need is strongly felt.

Agroforestry is a new field which is becoming more and more important as people at all levels begin to realize that land must be used more productively to ensure a continuing supply of food and fuel for an increasing world population. It is highly visible in academia but less so among lay environmentalists who at times work in an ad hoc manner rather than systematically. Many of those individuals and the NGOs that they make up are involved in agroforestry but have not labelled it as such. Their efforts in the field of formal education are minimal at best and in informal education only random. Consequently, their contribution to the fund of knowledge on agroforestry is not great.

It would be unfair, however, to conclude that there is no room for the NGO movement in the field of agroforestry. It will be the role of international agencies and university bodies to provide the impetus for NGO work by advising NGOs and supplying the necessary information and financial support. NGOs have the contacts, the commitment and the potential expertise to make a significant contribution.

The following small report summarizes the activities of NGOs who responded to a survey by the Environment Liaison Centre in Nairobi.

A total of 109 questionnaires were sent out to organizations all over the world. Addresses were gleaned from various sources of varying degrees of reliability. Some questionnaires were returned to the ELC unanswered; others were answered but appeared to be government organizations rather than NGOs. Twenty-two were received that were determined to be NGOs or universities (not already on ICRAF's lists).

The questionnaire's brevity was thought to encourage a high response but did not seem to have this result.

A regional breakdown reflects the number of questionnaires sent out rather than the amount of agroforestry activity in that particular region, although the disproportionate figures in India and Australia probably indicate a greater interest there than elsewhere.

| ASIA | | U.K. and IRELAND | |
|---|---|---|---|
| India | 6 | England | 3 |
| Philippines | 1 | N. Ireland | 1 |
| Malaysia | 1 | Ireland | 1 |
| **NORTH AMERICA** | | **AUSTRALIA** | |
| USA | 2 | Australia | 1 |
| **AFRICA** | | **SOUTH AMERICA** | |
| Nigeria | 1 | Brazil | 1 |
| Zimbabwe | 1 | | |

Survey Results

Activities of the various NGOs range from research to extension work in rural areas. Friends of Trees in India hold Eco-development camps and try to encourage students to help in rural development. In Northern Ireland, field trials have been undertaken to test the possibility of grazing sheep in young forestry plantations. Another group in India is intercropping agricultural crops with teak and bamboo. The Highwood Agroforestry Research Trust in England is establishing a research project to assess the potential of agroforestry under temperate conditions with special reference to symbiotic relationships between different plant species. The International Tree Crops Institute, USA branch, is also involved in research, education and nursery work related to temperate region multipurpose woody perennials. The work includes consultancy, workshops, slide shows, contracted research and mail-order nursery/seed sales.

In Brazil, the Instituto Nacional de Pesquisas da Amazonia, Department of Agroecology is carrying out research in the following areas:

a. the introduction of species for fruit, wood, fuel and shade production, shade tolerance and cover, replacement of bush fallow etc.,

b. the basic interactions between trees and other crops,

c. the production of animal products in natural forests and plantations,

d. the installation and potential for 'food forests' food producing perennials with associated crops and animals.

The Commonwealth Forestry Association in England publishes articles in its quarterly Community Forestry Review. The Agroforestry Research Centre in the Philippines is involved in many agroforestry projects including land-use classification, rehabilitation of denuded hilly land areas, protection of hilly lands and agroforestry farms, appropriate mix production systems, harvesting and processing methods.

NGOs have limited educational activities. Those few who indicated any kind of work in this field mentioned

extension work and general provision of information. Friends of the Trees in India organizes seminars, workshops, slide shows and other media events aimed at students and farmers in both rural and urban areas. Dasauli Gram Swarag Mandal, also in India, aims its work at rural people of all ages, from school children to the elderly. Its programme includes education in afforestation and teaching and supporting people in establishing cottage industries.

Other NGOs provide information for those who require it such as the Commonwealth Forestry Association. Its services reach over 1500 professionals in the teaching profession and in the forestry/agrofrestry fields. It also provides information to libraries.

The Department of Agriculture of the University of Queensland (not officially an NGO) is doing agroforestry work in the Solomon Islands. Postgraduate research involves large scale trials evaluating animal production from sown and naturalized pastures under perennial tree crops. Fifteen staff from the Solomon Islands have been trained in: pasture sampling for dry matter and species composition using direct and visual techniques; grazing animal management, weight recording; soil sampling, light recording, measurement of tree growth parameters.

One of the largest NGOs involved in agroforestry is the International Tree Crops Institute. Two of its offices are in the USA, one in California and one in Kentucky. Both are involved in workshops, consulting, and in general promoting the ideas of agroforestry especially to farmers. It acts as a clearinghouse for information on tree crops and agroforestry and maintains specialized libraries on agriculture, horticulture, forestry and conservation. It also publishes a quarterly newsletter, Agroforestry Review. (The headquarters for the ITCI in England publishes The International Tree Crops Journal). The ITCI office in California produced a slide show, "Windbreak Trees for California" and has organized several regional conferences on tree crops and is currently sponsoring a series of study tours outside the USA.

Perhaps part of the reason that NGO activities on agroforestry appear limited is because of the lack of available information that presently exists. Most NGOs reported that they use ICRAF publications or whatever they can uncover from local sources. The

availability of material demonstrates only the inaccessibility of reference works, not necessarily their non-existence. No NGO actually supplied the ELC with any texts, reports or other documents, nor did they annotate those they mentioned that they use. The following bibliography then, merely lists materials being used with no evaluation attached. It does not include those that NGOs have developed for their own use such as reports on their research, posters, charts, slides nor the various ICRAF materials that were, in fact, mentioned often.

NGOs were asked what kinds of resources they would need to help them in their activities. This elicited the greatest response. Requests ranged from the general, "all information provided by ICRAF" to the very specific, "quick maturing chestnuts and walnuts and perennial cereals suitable for British conditions." Other materials suggested include:

Complete bibliography on agroforestry;
Plastic models on different systems of agroforestry;
Literature on water-shed management, energy and rural development;
"How-to" slides;
Visual aids and equipment;
Seminar/Workshop proceedings;
Material regarding social factors;
Nursery aids;
Data on existing schemes concerning costs and problems of establishing the schemes and subsequent gains and losses; and
Research on agroforestry development in marginal rain-fed cultivation areas.

## R5 - REFERENCES


1. Arkcoll, D.B. (1978). Food Forests - An alternative to shifting cultivation. Abstracts of XI International Congress of Nutrition. Rio de Janeiro.

2. Arkcoll, D.B. (1979). Nutrient recycling as an alternative to shifting cultivation. Abstracts of Conference on Ecodevelopment and Econfarming. Berlin Science Foundation. Alemanha.

3. Arkcoll, D.B. (1981). Some studies on the variation in the composition of the fruit of Bactrisgasipaeas.

4. Arkcoll, D.B. (1981). The Production of Food from Trees and Forests.

5. Arkcoll, D.B. and Chauvel, A. (1981). Preliminary studies on nutrient reserves in some Brazilian Oxisols.

6. Bennett, Alice (1980). Agroforestry: Its Relation to Soil Conservation and World Food Production.

7. Bugg, R. (1980). Windbreak Trees of California.

8. Bugg, R. (1980). Wind Problems in California, and the Use of Windbreaks in their alleviation.

9. Dobereiner, Johanna, J.S. Araujo, D.B. Arkcoll. (1981). Energy Alternatives from Agriculture.

10. Douglas, Sholto J., Robert A. de J. Hart Walkins, Eng. and Rodale USA. Forest Farming.

11. Esbenshade, Henry W., H.J. von Maydell, (1978). Tree Crops in Africa: The case of the Carob, Honeylocusts, Mesquite, and Acacia.

12. Esbenshade, Henry W. (1977). The Kiawe in Hawaii: Perspectives and Potentials for Multiple-Use Management.

13. Esbenshade, Henry W. (1978). The Development of Tree Crops for Agroforestry Systems.

14. F.A.O. Forestry for Local Community Development.

15. Merwin, Miles L., H. Esbenshade. (1978). The Culture of Carob (Ceratonia siliqua L.) for Food, Fodder and Fuel in Semi-Arid Environments.

16. Merwin, Miles L., H. Esbenshade. (1978). Tree Crops for Food, Fiber, and Conservation of Rural Environments.

17. Mollison and Holmgren. (no date given). Permaculture One, Corgi.

18. Mongi, H.O., P.A. Huxley (1979). Soils Research in Agroforestry. ICRAF, Nairobi.

19. Nair, P.K.R. (1980). Agroforestry Crop Sheets Manual. ICRAF, Nairobi.

20. Penman, H.L. (1963). Vegetation and Hydrology CAB. Tec. Bul. No. 53. 124 p.

21. Pereira, H.C. (1973). Land Use and Water Resources. Cambridge University Press.

22. Plucknett, D.A. (1979). Managing Pastures and Cattle Under Coconuts. Westfield Press, Boulder, Colorado.

23. Sanchez, P.A. (1976). Properties and Managment of Soils in the Tropics. Wiley - Interscience.

24. Skerman, P.J. (1977). Tropical Forage Legumes. F.A.O. Rome.

25. 't Mannetje, L. ed. (1978). Measurement of Grassland Vegetation and Animal Production. C.A.B. Bull, 52. Hurley, Berks. England.

26. Tropical Legumes - Resources for the Future. (1979). National Academy of Sciences, Washington, D.C.

27. Williams, Gregory. (1979). Agrosilviculture for Appalachia: An Annotated Bibliography, Gregory Williams.

28. Williams, Gregory, M. L. Merwin. (1982). Energy and Soil Conserving Perennial Crops for Marginal Land in Temperate Climates.

29. Wilson, J.R., ed. (1978). Plant Relations in Pastures. CSIRO, Melbourne.

## R6. REVIEW OF SOURCE MATERIALS FOR TEACHING SOILS AND SOIL MANAGEMENT IN AGROFORESTRY - by P.K.R. Nair

### Introduction

In a fairly extensive and well-researched discipline such as soil science, it would appear that source materials are plentiful, but when we look at the attributes and characteristics of agroforestry (the tree-crop integration, multiple outputs, focus on applicability under low-input conditions and marginal lands, strong emphasis on resource-conserving and self-sustaining nature, etc.) we find that most available source materials are either not relevant or not directly applicable to agroforestry situations. The reason is that most of the existing information and research results have been obtained from studies based on monocrop stands, high-input conditions, and high-potential lands with focus on maximization of a single end-product. Therefore, while attempting to review the source materials, the logical first step is to put the subject matter itself in a proper perspective by a) examining briefly the state of knowledge on the soils aspects of agroforestry and b) elucidating some salient features of soil management in agroforestry.

### State of Knowledge on Soils Aspects of Agroforestry

Since the science of agroforestry is relatively new, there is no substantial body of knowledge on any of its operational aspects including soil. Nevertheless, there exists information from some other relevant and similar situations, which, when properly collated and synthesized with the available knowledge on the basic principles of soil management, could lead to developing sound scientific premises about agroforestry.

The author has made some efforts in this direction (Nair, 1982) and has arrived at the following postulations on the expected soil conditions and the anticipated additional advantages of agroforestry situations. While making these postulations, the emphasis has been on such systems where trees and other woody perennials do not form a discernible component of the existing land-use systems, but where such species could be integrated without unduly modifying the currently adopted land-use practices.

The inclusion of compatible and desirable species of woody perennials on farmlands can result in a marked improvement in soil fertility. There are several possible mechanisms for this, which include:

- increase in the organic matter content of soil through addition of leaf litter and other plant parts;
- an efficient nutrient cycling within the system and consequently more efficient utilization of nutrients that are inherently present in the soil or are externally applied;
- biological nitrogen fixation, especially by fast-growing trees;
- solubilization of difficultly-available nutrients, for example, phosphate, through the activity of mycorrhizae and phosphate-solubilizing bacteria;
- increase in the plant cycling fraction of nutrients and resultant reduction in the loss of nutrient beyond the nutrient absorbing zone of soil;
- complementary interaction between the component species of the system, resulting in a more efficient sharing of nutrient resources among the components;
- additional nutrient economy because of different nutrient absorbing zones of the root systems of the component species;
- moderating effect of soil organic matter on extreme soil reactions and consequent nutrient release/availability patterns.

The improvement in organic matter status of the soil can result in an increased activity of the favourable microorganisms in the root zone. In addition to the nutrient relations mentioned earlier, such microorganisms may also produce growth-promoting substances through desirable interaction and cause compensalistic effects on the growth of plant species.

Inclusion of trees and woody perennials on farmlands, in the long run, results in marked improvements. Physical conditions of soil-permeability, water-holding capacity, aggregate stability, soil temperature regimes, etc. are all improved, though slowly, with the net result that the soil is made a better medium for plant growth.

The soil-conserving and erosion-reducing role of trees is one of the most widely acclaimed and compelling reasons for including trees on farmlands that are prone to erosion hazards. The beneficial effect of trees in this regard are limited not only to protecting the immediate farmland in consideration, but also to imparting stability to the ecosystem and reducing the rate of siltation of dams and reservoirs.

The influence of trees on the hydrological characteristics and their relevance to agroforestry can extend from the micro-site level to the farm and regional levels. Although the effect of water use by the tree component on water availability to crop plants in different climatic conditions has not yet been clearly understood, there is evidence that the hydrological characteristics of catchment areas are favourably influenced by the presence of trees.

However, agroforestry is only a potential land-use system, which, if practised properly, might prove superior to existing systems in some situations; it is not aimed at replacing other profitable and stable production systems. Agroforestry is also not expected to do away with the need for nutritional input to soil through manures and fertilizers if sustained productivity at higher levels are to be achieved. The system, when practised appropriately, is likely to use the nutrients more cost-effectively and efficiently, and increase sustainability of production. Therefore these postulations on the advantages of agroforestry should not be interpreted to lead to exaggerated claims and conclusions. The magnitude of the benefit that can be derived will depend upon a number of factors including the environmental conditions, tree and crop characteristics and soil conditions, and above all, management practices; the results are therefore likely to be different from farm to farm.

## Soil Management Considerations in Agroforestry

In order to circumvent the difficulty of the considerable length of time that would be necessary to validate the above-mentioned postulations through well-conducted experiments, it seems justifiable to suggest some expedient measures however ad hoc they might appear to be. Research results on alley cropping, mainly from IITA, Nigeria are one example to show how technically feasible and socially acceptable farming systems involving trees can impart

sustainability of production from fragile and easily degradable Alfisols in the lowland humid tropics. Similarly, the evidence of the soil-improving qualities of some multi-purpose tree species, e.g. Acacia albida and Prosopis cineraria in the dry regions and their complementarity with the understorey agricultural species suggests the possibility of devising/improving soil management systems for other marginal areas and "wasted" lands in different ecological situations and involving a wide range of useful woody perennial species. Some technology components of low-input soil management systems can, therefore, be suggested for agroforestry situations.

First, incorporation of trees and other woody perennials can be made on some farmlands without causing significant changes in the conventional agricultural practices. These include alley planting, zonal system, contour strips, etc. Similarly intercropping of agricultural species can be undertaken in tree stands in a number of ways. Several approaches have also been proposed to increase crop production in shifting cultivation systems without substantially changing the structure of such systems: the corridor system, shortening of the length of fallows, planted fallows and other ways of improving the quality of fallows, etc.

Second, land clearing/preparation methods are of crucial importance because certain mechanical operations can result in serious damage to soil physical properties leading to compaction and degradation of soil structure, and removal of topsoil by erosion. Similarly conventional land preparation methods, especially for agricultural species, can aggravate soil erosion and impair soil physical conditions. The choice of land clearing/preparation methods depends on soil properties, species, and level of management. The magnitude of effort needed to control weeds decreases as the proportion of soil surface that is left unprotected by a plant canopy over a specified time span decreases.

Third, when relatively short-duration agricultural species are continuously cultivated in sole stands or in combination with perennial species, the fertility status of the soil will change, necessitating frequent external input of nutrients as manures and fertilizers in order to compensate such frequent "export" of nutrients from the soil through the harvests.

However, in many areas, the cost and/or availability of fertilizers make heavy fertilization uneconomical and impracticable. It is in this context that it becomes convenient and important to exploit the desirable soil enriching/restoring characteristics of perennial plants to the fullest extent. Biological nitrogen fixation, efficient nutrient cycling, maintenance of higher organic matter status through litter fall and addition of dead biomass, complementary sharing of nutrients, reduction of leaching loss of nutrients because of more root spread in soil profile, etc. are some of the phenomena that could be advantageously manipulated.

Finally, a combined stand of plants of different growth habits and phenotype can be of considerable advantage in soil protection. The presence of more plant cover on the soil, either live or as mulch, reduces the impact of raindrops on the soil and thus minimizes splash and sheet erosion. Moreover, higher organic matter content and more root volume in the soil impart better physical conditions causing increased infiltration and decreased runoff. These advantages of species diversity of plants in soil productivity and protection are little understood and hence are often ignored.

Considering the vastness and complexity of situations under which agroforestry could be adopted as a viable land-use system, it is inevitable that these soil management considerations have to be of a general and rather peripheral nature. The specific management practices for a given set of conditions will depend upon the prevailing soil conditions, climate, plant species, level of management and other local situations. It would therefore appear worthwhile to aim at a soil quality categorization for grouping soils and soil conditions according to the nature of problems they present, and suggest an agroforestry solution to the management of their physical and chemical properties. Thus the different categories could indicate the main soil-related constraints, and the ways of overcoming such constraints through forestry technology could be examined. When the necessary data become available, the method would be directly applicable to land evaluation exercises; the method would be directly applicable to land evaluation exercises, and it can serve as a useful tool for soil constraint analysis <u>vis-a-vis</u> agroforestry solutions/alternatives.

## Essential Elements of Teaching Soils in an Agroforestry Education Programme

The basic principles of soil science that are to be taught in an educational programme are the same irrespective of whether the course forms part of curricula in agriculture, forestry, agroforestry, ecology, etc. A basic knowledge of these principles is an essential prerequisite for studying a core course on soils in agroforestry. Depending upon the level at which the course is taught (diploma/first degree/second degree), the candidates may already have acquired such minimum knowledge. If not, it may be acquired from the good source materials that exist for teaching these basics.

From the concepts and considerations that have been outlined earlier, it is quite clear that a course on soils in an agroforestry education programme will have to be focussed on those aspects on which agroforestry practices may have a marked influence. Evidently the genesis, morphology, mineralogy and taxonomy of a soil are not expected to be influenced within a reasonable time span by agroforestry (and other) land-use practices, whereas nutrient relations, fertility, physical and biological characteristics, etc. will undergo marked changes under the influence of land-use practices. Areas on which the course should lay special emphasis should therefore include the following:

### Tropical soils and their characteristics

- the tropical environment - major soil types and their distribution in the tropics - soil physical properties - organic matter and fertility status - clay mineralogy and ion exchange properties - soil fertility evaluation - problem soils.

### General trends in soil productivity under major land-use systems of the tropics

- arable farming - plantation agriculture - multiple cropping - plantation forestry - shifting cultivation - tropical pastures - integrated production systems.

## Soil fertility

- soil fertility parameters - organic matter - addition and decomposition of organic matter - effects of cultivation - long-term effects of land use on soil fertility - soil enriching and depleting crops -soil fertility build-up under trees.

## Soil physical properties

- soil structure - soil water relations - soil air and temperature - leaching losses - plant adaptation to different conditions - detrimental effects of tillage and use of machine - reclamation of degraded soils by proper land-use techniques.

## Soil erosion and conservation

- erosion and runoff - erosivity and erodability - erosion index - physical soil conservation measures - biological soil conservation - role of trees in watershed management and soil conservation - agro-forestry approaches to soil conservation.

## Soil biology

- soil microflora and fauna - mycorrhizae and tropical soils - beneficial soil organisms - nitrogen fixation - nitrogen fixing trees - management of soil biology for agroforesty.

## Soil-plant system

- soil as a dynamic body- soil-plant ecosystem - boundaries and sub-systems - input, output and turnover of nutrients, water and other fluxes - soil-plant system in agroforestry - management considerations.

## Plant nutrients and nutrient cycling

- plant nutrients and their functions - nutrient dynamics in tropical soils - fertilizer use - nutrient efficiency with respect to land-use practices - long-term effects - nutrient cycling in the soil-plant system - agroforestry and nutrient cycling.

Long-term effects and sustained productivity

- soil management for long-term productivity - long-term effects of cultivation and arable cropping - soil productivity under perennial crops - sustained productivity and sustainability of production - criteria of sustainability.

Resource conservation

- soil resources of the tropics - resource use efficiency - conservation of resources - resource conservation aspects of agroforestry.

Soil testing and interpretation of results

- soil analysis for fertility rating - soil physical analysis - soil sampling from agroforestry fields - interpretation of laboratory test results - monitoring of long-term changes - criteria for evaluation.

## KEY SOURCE MATERIALS

As mentioned before, most --if not all -- of the existing materials that are relevant to the study of soils and soil management are not directly related to the subject matter in relation to agroforestry. Therefore, such materials have to be collated and synthesized to develop source materials for 'soils in agroforestry.' Some of the important materials (books and journal articles) that could be used as reference sources for such a synthesis are listed here. The major aspect(s) of soils and soil management in agroforestry that have been identified earlier, to which each of these source materials is most relevant is also indicated. Finally, a list of important scientific journals in which relevant, research results usually appear is also given. Needless to say, these lists are by no means exhaustive, nor is the objective of this review to prepare such a bibliography.

MAJOR TOPICS AND THEIR IMPORTANT SOURCE MATERIALS FOR A TEACHING PROGRAMME ON SOILS AND SOIL MANAGEMENT IN AGROFORESTRY

| Topics | Books * | Journal papers * |
|---|---|---|
| 1. Tropical soils and their characteristics | 4, 8, 11, 13, 20, 22, 24, 31, 33 34 | 2, 43, 57 |
| 2. General trends in soil productivity under major tropical land-use systems | 5, 8, 9, 11, 13, 14, 15, 23, 24. 26, 27, 29, 30, 31, 33, 34 | 1, 2, 4, 5, 12, 14, 17, 18, 22, 25, 29, 30, 43, 53 |
| 3. Soil fertility | 3, 4, 14, 15, 20, 23, 24, 25, 26, 27, 31, 33 | 3,4,5,11,15,20,22,23,24,25, 26,27,28,29,31,32,35,36,37, 43,45,46,47,48,49,55,57 |
| 4. Soil physical properties | 4, 6, 15, 22, 26, 31, 33, 34 | 22, 26, 40, 41, 55, 56 |
| 5. Soil erosion and conservation | 15, 17, 19, 22, 23, 26, 31, 33, 38 | 30, 39, 43 |
| 6. Soil biology | 1, 2, 5, 11, 12, 21, 26, 27, 28, 31, 32, 36, 37 | 9, 11, 15, 23, 33, 34, 54 |
| 7. Soil-plant system | 4, 9, 12, 14, 16, 20, 24, 26, 27, 28, 31, 32, 34, 36 | 5, 31, 35, 44, 46, 57 |
| 8. Plant nutrients and nutrient cycling | 10, 12, 15, 16, 23, 24, 25, 27, 30, 31, 34 | 3, 6, 7, 8, 10, 12, 13, 16, 19, 20, 29, 31, 42, 44, 47, 51, 52 |
| 9. Long-term effects and sustained productivity | 4, 8, 10, 14, 15, 20, 23, 24, 26, 27, 33, 34 | 4, 5, 21, 27, 33, 45, 46, 48, 50 |
| 10. Resource conservation | 10, 15, 20, 22, 23, 24, 29, 33, 34 | 14, 49 |
| 11. Soil testing and interpretation of results | 7, 18, 20, 25, 26, 29, 31, 32 | 35, 48, 50 |

* See separate lists of books and journal papers for details.

# R6 - REFERENCES

## Books


1. Alexander, M. (1961). Introduction to Soil Microbiology. Wiley, New York.

2. Alexander, M. ed. (1961). Advances in Microbial Ecology. Plenum Press, New York.

3. Allison, F.E. (1973). Soil Organic Matter and its Role in Crop Production. Elsevier, Amsterdam.

4. Armson, K.A. (1977). Forest Soils: Properties and Processes. Univ. Toronto Press, Toronto.

5. Ayanaba, A. and P.J. Dart, eds. (no date given). Biological Nitrogen Fixation in Farming Systems of the Tropics. Wiley, Chichester.

6. Baver, L.D., W.H. Gardner and W.R. Gardner. (1972). Soil Physics. Wiley, New York.

7. Black, C.A., ed. in chief. (1965). Methods of Soil Analysis, Parts 1 & 2. Am. Soc. Agron., Madison, Wisconsin.

8. Bornemisza, E., and A. Alvarado, ed. (no date given). Soil Management in Tropical America. North Carolina State Univ. Raleigh.

9. Conklin, H.C. (1963). The Study of Shifting Cultivation. Panamerican Union, Studies and Monograph 6. Washington, D.C.

10. CSIRO. (1981). Proceedings of the Australian Forest Nutrition Workshop. Productivity in Perpetuity. CSIRO, Canberra.

11. Debereiner, J., R.H. Burris and A. Hollaender eds. (1978). Limitations and Potentials for Biological Nitrogen Fixation in the Tropics. Plenum, N.Y.

12. Dommergues, Y.R. and S.V. Krupa eds. (1978). Interaction Between Non-Pathogenic Soil Microorganisms and Plants. Elsevier, Amsterdam.

13. Drosdoff, M. ED. (1972). Soils of the Humid Tropics. National Acad. Sci., Washington, D.C.

14. Felker, P. (1978). State of the Art: Acacia albida as a Complimentary Permanent Intercrop with Annual Crops. Univ. Calif., Riverside.

15. FAO. (1974). Shifting Cultivation and Soil Conservation in Africa. Soils Bulletin 24. FAO, Rome.

16. Golley, F.B., J.T. McGinnis, R.G. Clements, G.I. Child and M.J. Duever. (1975). Mineral Cycling in a Tropical Moist Forest Ecosystem. Univ. Georgia Press, Athens (U.S.A.).

17. Greenland, D.J. and R. Lal eds. (no date given). Soil Conservation and Management in the Humid Tropics. Wiley, Chichester.

18. Hesse, P.R., (1971). A Textbook of Soil Chemical Analysis. John Murray, London.

19. Hudson, N. (1976). Soil conservation. B.T. Batsford, U.K.

20. IAEA. (1978). Soil Organic Matter Studies. Vol. 1 & 2, Intern. Atomic Energy Agency, Vienna.

21. IFS. (1978). Proceedings of the International Workshop on Tropical Mycorrhiza Research, Kumasi, September 1978. IFS, Stockholm.

22. Lal, R. and D.J. Greenland eds. (1979). Soil Physical Properties and Crop Production in the Tropics. Wiley, London.

23. Lundgren, B. (1978). Soil Conditions and Nutrient Cycling under Natural and Plantation Forests in Tanzanian Highlands. Reports in Forest Ecol. and Forest Soils No. 31, Swedish Univ. Agric. Sci., Uppsala.

24. Mann, H.S. and S.K. Saxena eds. (1981). Khejri (Prosopis cineraria) in the Indian Desert. CAZRI Monograph No. 11, Central Arid Zone Res. Inst. Jodhpur, India.

25. Mengel, K. and E.A. Kirkby. (1982). Principles of Plant Nutrition. Intern. Potash Inst., Berne.

26. Mongi, H.O. and P.A. Huxley, eds. (1979). Soils Research in Agroforestry - Proceedings of an Expert Consultation. ICRAF, Nairobi.

27. Nye, P.H. and D.J. Greenland. (1960). The Soil under Shifting Cultivation. Tech. Comm. No. 51, Commonwealth Bureau of Soils, Harpenden, U.K.

28. Plant and Soil. (1971). Biological Nitrogen Fixation in Natural and Agricultural Habitats. Plant and Soil, Special Vol.

29. Qureshi, A.H. (1978). Sustained Yield from Tropical Forest: a practical policy for resource and environmental management. EAPI, East-West Centre, Honolulu.

30. Rodin, L.E. and N.I. Basilevich. 1967. Production and Mineral Cycling in Terrestial Vegetation. Oliver & Boyd, Edinburgh.

31. Russell, E.W. (1973). Soil Conditions and Plant Growth. 10th ed. Longmans, London.

32. Russell, R.S. (1977). Plant Root Systems: Their Function and Interaction with the Soil. McGraw-Hill, London.

33. Sanchez, P.A. (1976). Properties and Management of Soils in the Tropics. Wiley, New York.

34. Sanchez, P.A. and L.E. Tergas, ed. Pasture Production in Acid Soils of the Tropics. CIAT, Cali, Colombia.

35. Vincent, J.M., A.S. Whitney and J. Bose, eds. (1977). Exploiting the Legume-Rhizabium Symbiosis in Tropical Agriculture Univ. Hawaii, Niftal Project.

36. Walker, N., ed. (1975). Soil Microbiology. Butterworths, London.

37. Wenner, C.G. (1980). Soil Conservation in Kenya. Ministry of Agriculture, Nairobi.

Scientific Papers and Articles


1. Abu-Zeid, M.O. (1973). Continuous cropping in areas of shifting cultivation in Southern Sudan. Trop. Agri. (Trinidad) 50:285-290.

2. Borthakur, N.B., R.N. Prasad, S.P. Ghosh, A. Singh, R.P. Awasthi, R.N. Rai, A. Varma, H.H. Datta, J.N. Sachan, and M.D. Singh. (1981). Agroforestry based farming system as an alternative to Jhuming. In: Proceedings of the Agroforestry Seminar, May 1979, pp. 109-131. ICAR, New Delhi.

3. Broughton, W.J. (1977). Effect of various covers on soil fertility under Hevea brasiliensis and on growth of the tree. Agro-Ecosystems 3:147-170.

4. Charreau, C. and P. Vidal (1965). Influence de l'Acacia albida Del sur le sol, nutrition minerale et rendements des mils Pennisetum au Senegal.

5. Chijioke, E.O. (1980). Impact on Soils of Fast-growing Species in Lowland Humid Tropics. FAO Forestry Paper 21. FAO, Rome. 111 p.

6. Clark, F.E., C.V. Cole, and R.A. Bowman. (1980). Nutrient cycling. In: Bryemeyer, A.J. and G.M. Van Dyne eds. Grasslands, Systems Analysis and Man, Chapter 8, pp. 659-712. Inter. Biol. Prog. 19, Vol. 2, Cambridge Univ. Press, London.

7. Clarkson, D.T. and J.B. Hanson. (1980). The mineral nutrition of higher plants. Ann. Rev. Plant Physoil. 31:239-98.

8. Cornforth, J.S. (1970). Leaf-fall in a tropical forest. J. Appl. Ecol. 7:602-608.

9. Dobereiner, J., J.M. Day, and P.J. Dart. (1972). Nitrogenase activity and oxygen sensitivity of the Paspalum notatum-Azotobacter paspali association. J. Gen. Microbiol. 71:103-116.

10. Edwards, P.J. (1977). Studies of mineral cycling in a Montane Rain Forest in New Guinea. II. The production and disappearance of litter. J. Ecology. 65:1971-992.

11. Eskew, D.L. and I.P. Ting. (1978). Nitrogen fixation by legumes and blue-green algal lichen crusts in a Colorado desert environment. Amer. J. Bot. 65:850-856.

12. Fassbander, H.W. (1977). Ciclos de elementos nutritivos en ecosistemas forestales tropicales y su transformación con la agricultura rotativa. In: Reunión-Taller sobre Ordenación y Conservación de Suelos en America Latina. Lima, Perú.

13. Felker, P. and R.S. Bandurski. (1977). Protein and amino acid composition of tree legume seeds. J. Sci. Fd. Agric. 28:791-797.

14. Felker, P. and R.S. Bandurski, (1979). Uses and potential uses of leguminous trees for minimal energy input agriculture. Econ. Bot. 33:172-184.

15. Felker, P. and P.C. Clark, (1980). Nitrogen fixation (acetylene reduction) and cross inoculation in 12 Prosopis (mesquite) Species. Plant and Soil 57:177-186.

16. Felker, P., P.C. Clark, J. Osborn, and G.H. Cannell. (1980). Nitrogen cycling water use efficiency interactions in semi-arid ecosystems in relation to management of tree legumes (Prosopis). Paper presented at International Symposium on Browse in Africa. ILCA. Addis Ababa.

17. Florence, R.G. (1967). Factors that may have a bearing upon the decline of productivity under forest monoculture. Austr. For. 31:50-71.

18. Foelster, H., G. de las Salas, and P.K. Khanna. (1976). A tropical ever-green forest site with perched water table, Magdalena valley, Colombia: Biomass and bioelement inventory of primary and secondary vegetation. Oecologia Plantarum. 11: 297-320.

19. Frissel, M.J. ed. (1977). Cycling of Mineral Nutrients in Agricultural Ecosystems. Agro-Ecosystems 4:i-viii + 1-354.

20. Greenland, D.J. and J.M.L. Kowal. (1960). Nutrient content of moist tropical forest of Ghana. Plant and Soil 12:154-174.

21. Greenland, D.J. and P.H. Nye. (1959). Increase in the carbon and nitrogen contents of tropical soils under natural fallows. J. Soil Sci. 9:284-299.

22. Hartmans, E.H. (1981). Land development and management in Tropical Africa. IITA, Ibadan, Nigeria. 21 p.

23. Heogberg, P. and M. Kvarnastroem. (1982). Nitrogen fixation by the woody legume Leucaena leucocephala in Tanzania. Plant and Soil 66: 21-28.

24. Hutton, E.M. and I.A. Bonner. (1960). Dry matter and protein yields in four strains of Leucaena glauca (Benth.). J. Austr. Inst. Agric. Sci. 26: 276-277.

25. Jenik, J. (1977). Roots and root system in tropical trees in morphological and ecological aspects. In: Tomlinson, P.B. and M.H. Zimmermann eds. Tropical Trees as Living Systems, Ch. 14. Cambridge Univ. Press, New York.

26. Jha, M.N., P. Pande, and T.C. Pathak. (1979). Studies on the change in the physico-chemical properties of Tripura soils as a result Jhuming. India Forester, 105:436-441.

27. Jung, G. (1966). Etude d l'influence de l'Acacia albida (Del.) sur les processus microbiologiques dans le sol et sur leurs variations saisonnieres. Centre ORSTOM-Dakar, Senegal. Mimeo. 49 p.

28. Kang, B.T., L. Sipkens, G.F. Wilson and D. Nangju. (1981). Leucaena prunings as nitrogen source for maize. Fert. Res. 2:279-287.

29. Kang, B.T., G.F. Wilson, and L. Sipkens. (1981). Alley cropping maize (Zea mays L.) and Leucaena (Leucaena leucocephala LAM) in southern Nigeria. Plant and Soil 63:165-179.

30. Kellman, M.C. (1969). Some environmental components of shifting cultivation in upland Hindano. J. Trop. Geography 28:40-56.

31. Kellman, M.C. (1979). Soil enrichment by neotropical savanna trees. J. Ecology 67: 565-577.

32. Kerfoot, O. (1963). The root system of tropical rest trees. Commonw. Forestry Rev. 42:19-26.

33. Kessel, van C. and J.P. Roskoski. (1981). Nodulation and $N_2$-fixation. Plant and Soil 59: 207-215.

34. Keya, S.O. (1979). The role of dinitrogen fixation in agroforestry. In: Mongi, H.O. and P.A. Huxley eds. Soils Research in Agroforestry, pp. 243-270. ICRAF, Nairobi.

35. Khanna, P.K. and P.K.R. Nair. (1980). Evaluation of fertilizer practices for coconuts under pure and mixed cropping systems in the west coast of India based on a systems analysis approach. In: Joseph, K.T. ed. Proc. Conf. Classification and Management of Tropical Soils, 1977. pp. 257-466. Malaysian Soc. Soil Sci., Kuala Lumpur.

36. Klinge, H. (1977). Preliminary data on nutrient release from decomposing leaf litter in a neotropical rain forest. Amazoniana 6:193-202.

37. Klinge, H. and W.A. Rodrigues. (1968). Litter production in an area of Amazonian Terra Firme Forest. Part I. Litter-fall, organic carbon, and total nitrogen contents of litter. Amazoniana 1: 287-302.

38. Kunkel-Westphal, I. and P. Kunkel. (1979). Litterfall in a Guatemalan primary forest with details of leaf-shedding by some common tree species. J. Ecol. 67:665-686.

39. Lal, R. (1975). Role of Mulching Techniques in Tropical Soil and Water Management. IITA Tech. Bull. No. 1, IITA, Ibadan, Nigeria.

40. Lal, R., G.F. Wilson, and B.N. Okigbo. (1979). Changes in properties of an Alfisol produced by various crop covers. Soil Sci. 127:377-382.

41. Law, R. and Cooper, P.J.M. (1976). The effect and importance of soil temperature in determining the early growth rate and final grain yield of maize in Western Kenya. East Afr. Agric. For. J. 41:189-200.

42. Misra, L.C. (1979). Nitrogen cycling in grasslands at Kanpur, India. Plant and Soil. 53:361-371.

43. Nair, P.K.R. (1983). Soil productivity aspects of agroforestry. ICRAF, Nairobi, Kenya.

44. Nair, P.K.R. and P.K. Khanna. (1978). Potassium dynamics in the soil-plant system of tropical plantation crops. In: G.S. Sekhon ed. Potassium in Soils and Crops, pp. 415-432. Potash Research Institute of India, New Delhi.

45. Nair, P.K.R., A. Singh, and S.C. Modgal. (1973). Preliminary studies on the maintenance of soil fertility under intensive multiple cropping in Northern India. Indian J. Agric. Sci. 43: 250-255.

46. Nye, P.H. (1958). The relative importance of fallows and soils in storing plant nutrients in Ghana. J. West Afr. Sci. Assoc. 4:31-49.

47. Nye, P.H. (1961). Organic and nutrient cycles under a moist tropical forest. Plant and Soil. 13:333-346.

48. Ojeniyi, S.O. and O.O. Agbede. (1980). Effects of single-crop agri-silviculture on soil analysis. Experimental Agric. 16:371-375.

49. Ojeniyi, S.O., O.O. Agbede. (1980). Soil organic matter and yield of forest and tree crops. Plant and Soil 57:61-67.

50. Ojeniyi, S.O., O.O. Agbede, and J.A. Fagbenro. (1980). Increasing food production in Nigeria: I. Effect of agrosilviculture on soil chemical properties. Soil Science. 76-81.

51. Ovington, J.D. (1965). Organic production turnover and mineral cycling in woodlands. Biol. Rev. 40:295-336.

52. Paul, E.A. (1976). Nitrogen cycling in terrestrial ecosystem. Environmental Biogeochemistry 1:225-243.

53. Radwanksi, S.A. and G.E. Wickens. (1969). The ecology of *Acacia albida* on mantle soils in Zalingei, Jebel Marra, Sudan. J. Appl. Ecol. 4: 569-579.

54. Roskoski, J.P. (1981). Nodulation and $N_2$-fixation by Inga jinicuil, a woody legume in coffee plantations. I. Measurement of nodule biomass and field $C_2H_2$ reduction rates. Plant and Soil 59:201-206.

55. Singh, K.S. and P. Lal. (1969). Effect of Prosopis spicigera (or cineraria) and Acacia arabica trees on soil fertility and profile characteristics. Ann. Arid Zone 8:33-36.

56. Wilkinson, G.E. and P.O. Ania. (1976). Infiltration of water into two Nigerian soils under secondary forest and subsequent arable cropping. Geoderma 15:51-59.

57. Wilson, G.F. and B.T. Kang. (1980). Developing stable and productive biological cropping system for the humid tropics. In: Stonehouse, B. ed. Biological Husbandry: a Scientific Approach to Organic Farming, pp. 193-203. Butterworth, London.

Journals and other Periodicals

| Journals | Publisher |
|---|---|
| Agroforestry Systems | - Martinus Nijhoff, The Hague |
| Agronomy Journal | - American Soc. Agron., Madison, Wisconsin |
| Agro-Ecosystems | - Elsevier, Amsterdam |
| Bois For. Trop. | - Centre Technique Forestier Tropical (France) |
| Commonwealth Forestry Review | - Commonwealth Forestry Association, London |
| Experimental Agriculture | - Cambridge Univ. Press, London |
| Forest Ecology and Management | - Elsevier, Amsterdam |
| Geoderma | - Elsevier, Amsterdam |
| Indian Forester | - Forest Res. Inst. Dehra Dun, India |
| J. Agric. Sci., Cambridge | - Cambridge Univ. Press |
| J. Applied Ecology | - British Ecological Society, Reading |
| Ecology | - Duke Univ. Press, San Diego, California |

| Journals | | Publisher |
|---|---|---|
| J. Forestry | - | Society of American Foresters, Washington |
| J. Indian Soc. Soil Sci. | - | Indian Soc. Soil Sci., IARI, New Delhi |
| J. Soil Science | - | British Society of Soil Science, Univ. Reading |
| J. Soil Sci. Soc. America | - | Soil Sci. Soc. Am. Modison, Wisconsin |
| J. Tropical Geography | - | Univ. of Singapore, Singapore |
| Plant and Soil | - | Marinus Nijhoff, The Hague |
| Soil Biology and Biochemistry | - | Pergamon Press, New York |
| Soils and Fertilizers | - | Commonwealth Agric. Bureaux, Slough, U.K. |
| Soil Science | - | Williams & Wilkins Co. (Rutgers University) |
| Tropical Agriculture | - | Butterworths |

There are also several other abstracting journals, notably those from the Commonwealth Agric. Bureaux, Abstracts on Tropical Agriculture from the Royal Tropical Institute, Amsterdam, and FAO, Rome.

Other Periodicals

| | | |
|---|---|---|
| Advances in Ecological Studies | - | Springer, Heidelberg/New York |
| Proc. World Forestry Congress | - | (once every four years) |
| Transactions of the International Congresses of Soil Science | - | (once every four years) |

## R7. READINGS FOR A SOCIALLY RELEVANT AGROFORESTRY - by J. Raintree

The problem of irrelevance is a thing that has plagued agricultural research in the tropics for many years. Now, as problems of tropical land use have intensified, there has emerged a new sense of urgency in research directed towards the generation of problem-solving technologies. Relevance to socially defined needs and potentials has become a major criterion of research programming.

Agroforestry, arriving late on the scene (as an organized scientific field), has every opportunity to incorporate the lessons of recent history into its foundations as an emerging scientific discipline (and no excuse for not doing so). This implies not only a heightened sense of social relevance as a guiding principle in agroforestry research and education, but also a concerted effort to assemble the tools and perspectives necessary for achievement of social objectives.

Although rural development efforts making use of agroforestry technologies will and should be mounted whenever there exist reasonably well tested and appropriate AF technologies for a given area, the newness of the field and the relative dearth of proven technologies dictate high priority on research for the short and medium term. The present review of literature for agroforestry education has been undertaken with the assumption that the most urgent task for education in agroforestry is to create a generation of agroforestry researchers to integrate existing knowledge and generate a body of sound agroforestry technology, i.e. to develop the discipline.

This assumption has exercised a certain influence over the selection of materials for this review. In the first place, not all of the works included are suitable for introductory undergraduate education. Many of the references are quite technical and/or region-specific, as befits the needs of research-oriented education at the postgraduate level, whence we may expect the new (first?) generation of "agroforesters" to emerge.

Secondly, given the richness and complexity of agroforestry as a broadly conceived approach to land management, the envisaged development of the discipline must, of necessity, be an interdisciplinary effort. Inter-disciplinarity, as opposed to mere multidisciplinarity, implies a greater degree of integration than is normally achieved. For this purpose it is necessary to relax somewhat the traditional boundaries in order to focus energies on the fertile fringe areas between relevant disciplines, where agroforestry finds its natural meeting ground.

Nowhere is this need greater than in the area of potential social science contributions to agroforestry. This reviewer, for one, has always had difficulty in dealing with the well-meaning tendency to tack on a set of recommendations on "social aspects" of agroforestry, almost as an after-thought, in nearly every agroforestry planning activity or scientific consultation. The problem is with the assumption that "social aspects" can be dealt with as a separate item on the agenda by a discrete set of social science experts, when in fact the social dimension permeates the whole enterprise of agroforestry. This follows from the definition of agroforestry as a land management system which in every instance implies a "manager" with a definite set of social characteristics.

Thus, the first task for a review of relevant social science literature is to spotlight materials helpful in understanding the relevant social characteristics, not only of potential agroforestry adopters at the unit management level (the family farm or the forest village project), but also of the wider institutional systems which constitute the environment of agroforestry development activities. This task is attempted, at a preliminary level of resolution, in the first section, on "Social and Instituional Constraints and Potentials", containing literature selections specifically addressed to the subject of agroforestry per se. The theme is continued in the next section on "Lessons from Social Forestry," dealing with literature oriented to the social dimension of forestry projects per se.

The section on "Lessons from Human Ecology", which follows, is included in order to deal with broader and

perhaps even more fundamental aspects of the "social" dimension, namely the role of human populations as components and managers of culturally organized ecosystems. Drawing mainly on the literature from geography and ecological anthropology, this section attempts to assemble a collection of the most salient material for an eventual perspective on the role of agroforestry in human ecosystems. An additional rationale for the relevance of this literature stems from the often voiced observation that "Agroforestry is a new scientific discipline, but an age old land management practice." The fact that agriculturists and foresters have heretofore not made it their business to study traditional agroforestry practices does not mean that no one has. In point of fact, there is a wealth of unindexed information on traditional agroforestry systems scattered throughout the geographic and anthropological literature. The current review is very far from a complete and balanced treatment of the literature but perhaps it will serve to stimulate an interest in promoting better access to this information.

Inevitably, at this stage in the development of agroforestry, methodological issues are of very great concern. The section "On methodology" attempts to provide at least introductory level access to the great volume of recent literature on methodologies for achieving social relevance in technology generation. Inevitably this section is far from a complete treatment of all of the approaches relevant to agroforestry.

Theoretical perspectives and research methodologies should lead to action in the field. Involvement in field projects must be seen as an integral part of the education of the new generation of agroforestry researchers; hence the section on "Regional Source Materials" to spotlight some of the background materials which may be helpful in preparing students for socially relevant research projects in the respective regions. This is perhaps the most incomplete section of all.

Finally, in the absence of a universally accepted paradigm for agroforestry, if the whole enterprise of agroforestry research and education is to develop along appropriate lines, it must be guided by a clear sense of its historical position, particularly the limits and possibilities for the emerging

interdisciplinary science in this early stage of its historical unfoldment. This too, somehow, falls with the residual category of "social aspects." Hopefully, the few selections included in this section will not be too inadequate to contribute to the sense of direction and timing which is so necessary to the advance of agroforestry as a science.

Agroforestry, as a branch of the renewed and urgent search for sustainable relationships between man and his planetary resources, is part of one of the most significant social undertakings of our time. We owe it to everyone to make it as socially relevant as possible.

Social and Institutional Constraints and Potentials

The clearest and best general introduction to the vast tangle of concerns which arise under the rubic of "social constraints" on agroforestry in traditional land-use systems is, to my knowledge, the paper by Openshaw and Morris (92). One of the strengths of the paper is the clear awareness it evokes on the difference between economic and social viability through the discussion of agroforestry innovations whose ultimate economic viability has been previously ascertained, but which nevertheless founder on location-specific social grounds when it comes to implementation.

Hoskins (61) has provided another seminal perspective in "Observations on Indigenous and Modern Agroforestry Practices in West Africa", which identifies four major areas of social concern in agroforestry projects:

1. Socio-economic values - different groups of people in a society have different needs and potentials; who benefits and who is harmed by specific agroforestry innovations?

2. Institutional needs - what kinds of arrangements are needed to coordinate local and national institutional roles to achieve project goals?

3. Legal issues - are there tenure problems, what land-use rights are implied by a given technology; will prospective agroforestry producers have the legal right to harvest and market their products?

4. Educational issues - traditional agroforestry practices rely on traditional educational mechanisms for transmission from generation to generation; what means will projects use to educate villagers on the value of non-traditional technologies and train them in their use?

As regards the thorny issue of land tenure, there is very little literature at present on tenurial constraints on agroforestry per se. The articles by Adeyoju (1,2) dealing mainly with taungya in West Africa, are noteworthy exceptions. Scattered throughout the vast, unindexed ethnographic literature on traditional systems of land tenure, however, there are many detailed accounts of the complexities which arise in connection with trees. To mention only two, the treatments found in Bohannon (10) and Swanson (120) are illustrative. Trees themselves may have their own set of associated rights distinct from rules governing land tenure. Perhaps the best place to begin a study of these relations is with the distinction between "tree-rights", "tree-holding units", and "tree-using units" made by Dove (35) in his article on the Melaban Kantuq system in Indonesia. Lest the student of land tenure and tree rights become unnecessarily discouraged about the prospects for agroforestry, particularly in Africa, a more positive note is sounded by Gershenberg (49) who notes that "One of the most commendable features of customary land tenure in Africa is its ability to adjust to change conditions." Citing the adjustment of farmers to opportunities presented by valuable tree crops all across the continent, Gershenberg implicitly shifts the onus of responsibility to project personnel in patiently demonstrating the benefits of agroforestry technologies.

A number of writings have pointed out the potential social benefits of agroforestry technologies. Eckholm (37) has done much to create an awareness of the needs and potentials of tree-based systems in providing more sustainable means of supplying basic human needs. The report by Lundgren (77) to the Office of Technology Assessment of the U.S. Congress is probably the most comprehensive and balanced review of agroforestry potentials to date. Other writers have focused on the characteristics of certain promising types (or "ideotypes") of component technologies which adapt

them to specific social needs, e.g. Felker and Bandurski (45). In a similar vein, Raintree (97) has drawn attention to the potentials of multipurpose tree legumes to combine in ways which promote the adoption of "low priority" conservation measures (in the farmer's assessment) as a kind of "piggy-back effect" of the adoption of multipurpose agroforestry technologies for their production benefits.

While the theoretical potentials for introduction of new agroforestry technologies developed by researchers is undoubtedly great, there is no automatic guarantee that specific innovations will be better than indigenous agroforestry technologies with which they may unwittingly come into conflict. Hoskins (6) cites the exmaple of a forestry project in Upper Volta which requires the clearing of a tract of "useless bushland" for planting of a fast-growing exotic fuelwood species. Unbeknownst to project planners, this bushland was in fact part of an indigenous agroforestry system which yielded not only fuelwood but also a variety of foodstuffs, cottage industry materials, medicinal plants and other useful products. Little wonder the fuelwood plantation later mysteriously burnt to the ground!

The point is we know very little about indigenous agroforestry systems and until we do we are on shakey ground in suggesting improvements. In a paper subtitled "the study of indigenous agroforestry systems" Olofson (91) provides an example of the kind of stock-taking which must rate very high on the agenda of a socially sensitive approach to agroforestry.

In seeking to introduce new agroforestry techniques we would do well to heed the advice given by Hoskins (61) for West Africa:

> As trained foresters and agriculturalists consider approaches to introducing "modern agroforestry", West African farmers will be deciding whether these new practices will reduce risks, allow them to manage their resources more effectively or offer other special advantages. They will judge new ideas in light of the advantages of their present systems and the growing pressure on their resources from population increases, demographic changes, increased technology, and rising expectations.

> Wherever technical specialists can identify currently perceived local constraints and pressures felt by farmers they will find an audience ready to hear their ideas.

Hoskins' commentary touches on issues taken up again in the methodology section of this review. For present purposes it will suffice to indicate a few references to agroforestry-related design studies which are exemplary in the amount of attention devoted to the social dimensions of the design problem. From Thailand we have several studies, including Kunstadter's (69) recommendations for upland development, the village agroforestry work of Pisit Varaurai (127), the "forest village" scheme as reported by Somsak Sukwong (112), and from Indonesia, Wiersum's (132) work on home garden and taungya, to mention just a few. Lest it be thought that social aspects of agroforestry design are the exclusive province of the social scientist, it may be worth noting that only one of the foregoing authors is a social scientist by training. Interdisciplinarity is something that can be achieved through the deliberations of a multidisciplinary team, or from interdisciplinary thought in the mind of a single individual. Good design is where you find it.

While good design is essential for successful implementation of agroforestry projects, Catterson (16) has rightly pointed out that "the component parts of a legitimate agro-forestry production system are found well beyond the boundaries of the fields where the earth is ploughed and the seeds sown. The basic step towards implementing agro-forestry must be a government policy decision to do so." The theme of finding the right institutional niche for agroforestry in government development structures has been addressed by Steppler (115) and Lundgren (77). Problems associated with existing institutional structures have been discussed by Chowdry (21) and Hoskins (61). Of particular interest are the suggestions made by Hoskins (61) and Rice (102) for village-level institutional models involving a charter for local agroforestry activities sanctioned jointly by the local community and the responsible government agencies.

## Lessons from Social Forestry

In many cases, though not always, the technological content of social forestry projects is indistinguishable from agroforestry. However, that may be, the literature on social forestry contains many social insights relevant to agroforestry. The basic references on "social" and "community" forestry have been published by FAO (40, 41). Much of the pioneering work has been done in India and many of the most valuable lessons are summarized in a volume of case study analyses edited by Tewari and Mascarenhas (121) which give concrete meaning to the concept of social forestry as a "people-oriented, value-based, joint-management system." A shorter paper on the Indian experience which could serve nicely as a brief introduction to the subject of social forestry in general is given by Pant (93).

Enabor *et al*. (39) have discussed the socio-economic prospects and limitations of conventional *taungya*-based approaches to social forestry in West Africa, and Hanafie (55) has described the classical social formula for community forestry in Indonesia. Integration of community production objectives with those of government forestry agencies has not always been easily achieved and as a testimony to this, there is considerable literature on "making social forestry work." To cite only one example, the article of this title by Comte (25) focuses on the failure to achieve project objectives in the case of an indigenous silvopastoral land-use system. Comte's conclusion, which is typical of the literature, draws attention to the need to obtain a better understanding of the clients' perception of the situation in the planning phase of social forestry projects.

Much of the difficulty experienced by forestry agencies in finding an appropriate formula for social forestry projects may be understood in terms of the historical development of forestry as, in its own right, a social institution with its own deep-seated cultural biases evolved to adapt the discipline to its traditional role as the guardian of public sector resources. The insightful and delightfully irreverant analysis of the "culture" of foresters by Duerr and Duerr (36) provides a useful starting point for the kind of educational adjustment that may be helpful in equiping foresters-turned-agroforesters for new roles in society.

On another tack, the article by West (130) provides a very useful review of the main findings from the sociological literature on adoption and diffussion of innovations (105) as applied to the special problems and potentials of community forestry. In comparison to the amount of research on agriculturally-related innovations, very little has been done to date on forestry-related innovations. This literature provides a particularly relevant point of departure for social science research in agroforestry. Zeroing in on the problem of agroforestry innovation from the standpoint of one very large and significant social class of potential adopters is the aim of an article by Hoskins (60) entitled "Community Forestry Depends on Women." The point made by Hoskins is valid in more ways than most of us have realised, and it will not go away. Better read this article and find out why.

In concluding this brief introductory section on the social forestry literature, special attention should be drawn to the lengthy, programmatic overview of research needs in social forestry by Romm (106). Many, if not all, of the concerns voiced by the authors of the previously cited works are reflected in Romm's discussion of three priority areas for social forestry research: cropping systems design, the economics of design and management, and the role of government and other institutional structures in successful community forestry programmes. Finally, the study by Wood et al. (133) on the socio-economic context of fuelwood use in rural communities is a model example of social analysis for community forestry/agroforestry projects with detailed sets of questions and guidelines.

## Lessons from Human Ecology

For a general introduction to the concepts and theoretical foundations of human or cultural ecology the student is referred to Steward (117), Vayda and Rappaport (125), Rappaport (100), Netting (87) and Garlick and Keay (47). Two examples of the general approach which have attracted the attention of a wider readership outside of these disciplines, and which may serve as introductory readings, are Rappaport (101) and Geertz (48). An important contribution to the practical application of ecological principles to economic development has been made by Dasmann et al. (31).

One of the central issues of contemporary human ecology is the relationship between population pressure and change in agrarian land-use patterns. Boserup's (11) classic treatment of "The Conditions of Agricultural Growth" is the main statement of the school of thought which sees agricultural intensification as a consequence of population pressure on resources. The basic thesis, applied to indigenous subsistence-oriented land users, is that population pressure is the main driving variable behind the adoption of more land-and labour-intensive farming practices and that farmers will tend to resist such technologies as long as extensive, less labour-requiring alternatives remain capable of satisfying their basic requirements. The idea that farmers respond to an "economic threshold" in the adoption of more intensive land-use systems has been given empirical support by many subsequent researchers in a range of different environments, but Leach's (75) classic study remains one of the clearest demonstrations on the effect. The Boserupian idea of an adoption threshold for land-use innovations, reckoned in terms of their coordinates on a grid of labour and land-use intensity, is the basic idea behind the postulation of an optimal "adoption pathway" for agroforestry innovations by Raintree (97). Lagemann's (72) study of traditional land-use systems in eastern Nigeria is another example of the Boserupian paradigm applied to research on agroforestry systems.

A brief general introduction to the debate between adherents of the Boserupian thesis and the neo-Malthusian school of thought is given by Rubin (107). A number of researchers have come forth with case studies that call some of the tenets of this thesis into question as a basis for understanding all types of land-use change, e.g. Bronson (13) and Datoo (32), but by and large the thesis has stood the test of time as a general model of population pressure on resources as one of the main determinants of technological change in agrarian systems.

Brookfield's (14) classic treatment of "Intensification and Disintensification in Pacific Agriculture" is one of the most balanced and, perhaps, one of the best short introductions to the technicalities of the subject.

The debate on population pressure must be seen in the context of the general subject of population geography, and one of the best introductions to this subject of population geography and one of the best introductions to this subject is still Prothero's (95) classic collection of case studies on "People and Land in Africa South of the Sahara". Of particular interest for introductory purposes are the contributions to this volume by Prothero (96) and Gould (53). Also to be found here are readings for and introduction to the concept of human "carrying capacity" by Allan (3) and Hunter (62). As this concept, or at least some refinement of it, must certainly figure prominently in any quantitative approach to ascertaining the "sustainability" of agroforestry and alternative land-use systems, Street's (119) critical evaluation of the use and abuse of the concept and extant computation algorithms is must reading for the serious student of AF carrying capacity.

Inevitably, in this connection, one must also make some effort to come to grips with current assessments of human population pressure in relation to the theoretical carrying capacity of the biosphere as a whole. Needless to say, the whole business of global modeling of mankind's future has an irreducible element of crystal-ball-gazing in it, and one is at a loss to identify which of the various world models gives the most "realistic" forecasts. Certainly FAO's (42) study of "Agriculture: Toward 2000" and "The Global 2000 Report to the President of the U.S.," (Barney, 5), are recent works of significance, which should be considered in conjunction with the various "private sector" world models which have come forth in recent years. One noteworthy characteristic of the Global 2000 study is the fact that the study group had no model of its own, but instead concentrated on evaluating and making use of existing sectoral models within U.S. government agencies to come up with an independent policy review. Perhaps the most valuable part of the three volume report is the appendix comparing the methodologies and results of all the major global modelling attempts to date.
Interestingly enough, while the private sector models may differ in respect to the nature of inter-sectoral linkages they assume, they are similar in having the capability to model such linkages. In this respect they contrast with the other two producers of major

world models, namely the U.S. Government and the U.N., whose modelling capabilities appear to be sectorally confined!

On a more optimistic note, we should not leave this section of the review without acknowledging the existence of more encouraging, action-oriented treatments of the human project, notably Lester Brown's (15) vision of possible pathways toward a more "sustainable society." Agroforestry, with its aim of devising sustainable production systems, may find a measure of philosophical support and, indeed, technical inspiration in the latter work.

Meanwhile, on a more mundane level, there are a number of other approaches of practical relevance to agroforestry. The whole field of "ethnobiology," the study of biological subjects from the standpoint of indigenous cultures and knowledge-systems (including "ethnobotany" and "ethnoecology"), offers methods and substantive findings of direct interest to agroforesters in the field. Olofson's (91) study of indigenous agroforestry systems in the Philippines has its foundations in this tradition, as do a number of other studies from around the world (6, 26, 30, 43, 82, 86). Again, lest it be thought that the application of ethnobiological methods is the exclusive domain of an esoteric tradition in anthropology, we have Felker's (44) excellent study of traditional *Acacia albida* systems in Africa. One of the best introductions to the methods and findings of the interdisciplinary science of ethnobotany is the textbook by Richardson and Stubbs (103), which sets forth an educational foundation for "the merger of botany, anthropology, demography and economics."

One final topic of interest under the general heading of human ecology comes to us from the long-standing professional interest in the study of traditional land-use systems in geography, which has given rise in recent years to a distinct body of literature on traditonal systems of resource management. The collection of regional overviews edited by Klee (67) provides a good introduction to this literature, and the UNESCO monograph (123) on natural resource management in Africa contributes valuable insights on differences between traditional and modern resource management strategies.

## On Methodology

As a late arrival to the applied science scene and with a deliberate focus on land-use systems, the nascent field of agroforestry is in an excellent position to reap the benefits, social and otherwise, of the past decade of vigorous progress in the methodology of farming systems research. The premier reference work in this field is, of course, Hans Ruthenberg's (109) classic study of Farming Systems in the Tropics. This work, more than any other, is responsible for establishing the concept and methodology of farming systems research (FSR) as a paradigm for researchers. While many new methodological contributions have come forth, Ruthenberg's study remains the most comprehensive treatment of farming systems theory as a body of organized knowledge on substantive aspects of tropical land use. Of particular interest is the seminal chapter on tendencies in tropical farming systems and, in the 3rd edition, the inclusion of supplementary chapters by Zanstra and Collinson on the methodology of FSR. The concept of agroforestry as a significant development potential of tropical farming systems is clearly foreshadowed in Ruthenberg's thinking and there is little doubt that, had he lived, he would have made enormous contributions to the development of agroforestry per se.

On the methodological side, the past decade has been one of tremendous ferment in FSR. Among the methodological classics are the reports of Collinson (23), Zanstra et al. (135) and Hildebrand (57) describing the results of their pioneering work on broadly similar FSR approaches, but with distinctive adaptations to the particular technologies focus and uses of FSR in their respective institutions.

Numerous other reports have been produced by these and other researchers but perhaps the most accessible source is the collection of papers from the Conference on Rapid Rural Appraisal held at Sussex University in 1979, many of which have been revised and published in a special edition of Agricultural Adminstration (Vol. 8, No.6). Recognition of the need for rapid appraisal survey techniques to maximize the social relevance of project planning activities, usually subject to severe

time constraints, has emerged as a major emphasis in the new methodologies. Chamber's (18) summary overview of the current stock of techniques is undoubtedly the best short introduction to rapid appraisal methodologies.

Another article by Chambers (17) could serve as a good short introduction to FSR methodologies in general. For a critical review of FSR methodologies the reader is referred to Norman (88) and Gilbert et al. (50). Harwood's (56) book on small farm development is a good choice for a textbook on FSR with an emphasis on the humid tropics. The recent overview of the field by Shaner et al. (110), Farming Systems Research and Development, is by far the most comprehensive treatment of the entire subject to date, with clear presentations and comparisons of all the major methodological approaches at each stage in the FSR cycle, excellent illustrations, and a lengthy appendix presenting the essential features of more than 60 selected methodological tools and procedures. If you can only get one book on farming systems methodology, this is the one to get.

Meanwhile, the adaptation and application of farming systems methodology to the special concerns of agroforestry has proceeded apace. An interesting progression from FSR to "AFSR" is recorded in a recent series of papers by Lagemann (73, 74, 75). Veer (126) has contributed valuable insights to agroforestry as an intervention in farming systems. ICRAF, following the strategy outline by Steppler (114, 115, 116), has given priority in its programme of work to the development of an inter-disciplinary "Diagnostic and Design Methodology" for agroforestry which incorporates elements of the farming systems approach in a rapid appraisal context. A draft methodology manual is slated for publication in early 1983. Two paoers by Raintree (98, 99) provide an introduction to ICRAF's methodology development work. One likely direction for the future expansion of ICRAF's adoption-oriented D & D approach is in the area of decision-making analysis, treated by Gladwin (51) and also the subject of a companion review prepared for this conference by Veer. Another is in the area of a rapid appraisal approach to combined ecosystems and farming systems analyses, necessary to identify agroforestry-related constraints and potentials at the watershed level of diagnosis, as envisaged by Rocheleau (104).

Once appropriate and adoptable agroforestry prototypes are identified for a site, the next step in the cycle of AF technology generation and testing is some suitable combination of on-farm trials with on-station research backup. Recent contributions to the methodology of this phase in the FSR cycle by Zanstra et al.(136) and Menz (81) are relevant to agroforestry. Undoubtedly, there are many other relevant methodological publications which have not appeared in this all too cursory review, but hopefully this beginning will be followed by suggestions for a more adequate set of readings.

Regional Source Materials

For a general introduction to land-use systems in the tropics Ruthenberg (109) is probably the first reference to consult. ICRISAT (63) has produced a valuable collection of papers on socio-economic constraints to development in the semi-arid zone. The articles by Clarke (22) and Vasey (124) provide a useful overview of population dynamics in land-use systems of the humid zone, and Moss and Morgan (85) focus on fuelwood production in the zone. The collection of regional reviews on agroforestry practices in different ecological zones in the tropics by Chandler and Spurgeon (19) provide a good starting point for zeroing in on AF concerns.

From Africa we have a wealth of background material, including such classics as Allan (3), De Schlippe (33) and Miracle (83). Brokenshaw (12), Benneh (8), and Gleave and White (52) provide an overview of human ecology and agricultural development in the continent. Of particular interest to students of agroforestry in Africa are Okigbo (89), Lagemann (72), and Bernard (9).

From Asia there are a number of useful materials on shifting cultivation, one of the dominant land-use systems in that part of the world. Pelzer's (94) and Spencer's (113) early classics are still excellent choices for a geographic overview of the region. Conklin's (27,28) benchmark work in the Philippines has set standards for the study of shifting cultivation which have had worldwide influence. Recently he has turned his attention to long overlooked agroforestry aspects of traditional upper-watershed management practices among the Ifugao, which play a vital protective role vis-a-vis their

world renown rice terraces (29). Other recent contributions to the study of Philippines shifting cultivation are the studies by Warner (128), describing traditional strategies for subsistence stability in a fluctuating environment, and Eder (38) on the transition from grain crops to tree crops in a modernizing swidden system. The latter two articles are part of a larger collection of studies on swidden agricultural systems edited by Olofson (90), which has the added interest of a lengthy annotated bibliography on shifting cultivation in the region (and elsewhere) with particular attention to agroforestry-related concerns. This volume, together with Olofson's (91) other work on indigenous agroforestry systems, goes a long way toward identifying the proper focus for agroforestry research in relation to shifting cultivation. A similar kind of ferment, centering around problems of upland land use in Thailand has resulted in another significant set of readings for students of agroforestry in the region (20, 54, 64, 69, 70, 71).

A completely different kind of agroforestry system found in Asia has been described by Fox (46), in which sustainable palm-based agrosilvopastoral production contrasts markedly with degrading fallow systems in the surrounding area. The Javanese home garden is a variant of another intensive Asian agroforestry system whose role in the household economy has been discussed by Stoler (118).

This preliminary review of regional source materials is very uneven and incomplete. Contributions will hopefully be forthcoming from conference participants. The Latin American region is particularly under represented, but let me start it off with references to Watter's (129) and Ruddle's (108) treatments of shifting cultivation in the region and Megger's (80) and Moran's (84) studies of human ecology and resource use in Amazonia.

## Historical Perspectives on Agroforestry

In one of the standard theoretical works on the history of science Kuhn (68) has described the process of scientific development as involving a succession of paradigms. No science can develop in the absence of a paradigm, that grand, overarching collection of assumptions and elements of worldview which defines not only the nation and boundaries of the scientific

reality being investigated but also the type of questions asked and the methodologies considered legitimate for answering them. Paradigms may be powerful but they are never permanent. Science, according to this view, progresses by a series of "paradigm revolutions" followed by periods of relative calm when research is directed to "paradigm elaboration." Paradigms fail because inevitably in the course of "normal science" anomalies are generated, factual evidence which is inconsistent with the paradigm and which eventually brings about its downfall and replacement by a new, more adequate paradigm. Old paradigms are rarely conclusively "disproven." They are normally just abandoned in favour of new paradigms.

This historical pattern is clearly visible in the emergence of agroforestry as a new paradigm for applied scientific research. Interrelated problems of food, energy and environmental deterioration in tropical land-use systems have reached such proportions that it is no longer scientifically possible to ignore the conservation benefits and sustained-yield potentials of age old agroforestry practices (the anomalies). The old paradigm, which perceived and enforced a rigid separation of agricultural and forestry research, has broken down under the weight of accumulated anomally, and agroforestry, a new interdisciplinary paradigm, has arisen to fill the gap created by the time honored but artificial separation of agriculture and forestry. Agroforestry, in this view, is now in the early paradigm development stage (116).

Elements of a new paradigm synthesis are usually found "waiting in the wings" for some time before taking their place in the new paradigm. What then are the antecedent elements of the new agroforestry synthesis? Excluding for the moment non-scientific sources, i.e. indigenous practices, we can identify at least two clearly distinct lines of scientific thinking which foreshadow agroforestry as we are now coming to understand it. From forestry we have the whole line of development associated with taungya or early "agrisilvicultural" production systems. For the first full recognition and formal presentation of agrisilvicultural concepts and potentials we are indebted to King (65). The other major converging strand in the agroforestry synthesis comes, appropriately enough, from agriculture in the broad

sense, tree crop horticulture in particular. I refer to the vision of a permanent tree crop-based agriculture put forth many years ago by Smith (111) and later elaborated by Douglas and Hart (34). This is another distinct tradition to which many contemporary "agroforestrys" trace their roots. Oddly enough, the father of the horticultural tradition in agroforestry was, by professional training, not a horticulturalist but a geographer. To this short list of major forerunners could be added a much longer list of minor contributions to the intellectual climate in which agroforestry has emerged. Some of the readings in the previous sections on human ecology and farming systems methodology may qualify, but certainly the clear foreshadowing of agroforestry in the call for a new approach to tropical land use voiced some years ago by Holdridge (59) and Tosi and Voertman (122) must be acknowledged.

However that may be, there can be little doubt that the first widely published statement of the scope and aims of the modern agroforestry paradigm was Trees, Food and People by Bene et al. (7). This was in fact the published version of the earlier consultancy report which recommended the establishment of ICRAF, thus creating an internationally recognized institutional niche for the fledgling science of agroforestry. Notable subsequent contributions to the development of a broad and internationally acceptable paradigm for agroforestry have been made by King (66), Steppler (114, 115), and Lundgren (77), among many others.

This list of readings for an historical perspective on agroforestry is undoubtedly incomplete but it may serve to remind us, as the historian of science would see it, that we are still in the paradigm development stage. The recommendations on agroforestry education which will result from the deliberations of this Workshop will, inevitably, have far-reaching consequences for the successful unfoldment of that paradigm. What we need, if this reviewer may interject a personal view, is a generation of paradigm developers. Later, once the foundations of the discipline have been established and we get down to the business of doing "normal science", we can then look to the training of an army of field-workers and other specialists to carry out the work of paradigm application and elaboration.

## R7 - REFERENCES


1. Adeyoju, S.K. (1981). Agroforestry and forest laws, policies and customs. UNU Workshop on Agroforestry in the Humid Tropics. April 27 - May 1. Ibadan.

2. Adeyoju, S.K. (1982). Some tenurial and legal aspects of agroforestry. UNU Workshop on Agroforestry. May 31 - June 5. Freiburg.

3. Allan, W. (1965). The African Husbandman. Barnes and Noble. New York.

4. Allan, W. (1972). How much land does a man require? In: Prothero ed. People and Land in Africa South of the Sahara. Oxford University Press. London.

5. Barney, G.O., ed. (1980). The Global 2000 Report to the President of the U.S. Pergamon Press. New York.

6. Bell, W.H. and E.F. Castetter. (1937). Ethnobiological studies in the American Southwest: V. The utilization of Mesquite and Screwbean by the Aborigines in the American Southwest. University of New Mexico Biological Series, 5(2):1-55.

7. Bene, J.G., H.W. Beall, and A. Cote. (1977). Trees, Food and People: Land Management in the Tropics. IDRC. Ottawa.

8. Benneh, G. (1972). Systems of agriculture in tropical Africa. Economic Geography 98:244-57.

9. Bernard, F. (1972). East of Mount Kenya: Meru agriculture in transition. IFO Institut, Africa Studien No. 75. Weltforam Verlag Munich.

10. Bohannon, P. (1964). Landuse, land tenure and land reform. In: M.J. Herskovits and M. Harwitz eds. Economic transition in Africa. Northwestern U. Press. Evanston, Ill.

11. Boserup, E. (1965). The Conditions of Agricultural Growth: The Economics of Agrarian Change Under Population Pressure. Aldine. Chicago.

12. Brokenshaw, D. ed. (no date given). Ecology and Economic Development in Tropical Africa. Res. Series No. 9. Inst. of Internat. Studies. University of California. Berkeley.

13. Bronson, B. (1972). Farm labour and the evolution of food production. In: B. Spoorer ed. Population Growth: Anthropological Implications. MIT Press. Cambridge, Mass.

14. Brookfield, H.C. (1972). Intensification and disintensification in Pacific agriculture: a theoretical approach. Pacific Viewpoint 15: 30-48.

15. Brown, L.R. (1981). Building a Sustainable Society. Norton & Company. New York.

16. Catterson, T.M. (1981). Agroforestry production systems: putting them into action. UNU Workshop on Agroforestry in the African Humid Tropics. April 27 - May 1. Ibadan.

17. Chambers, R. (1980). Lesson No. 1 for rural developers: The small farmer is a professional. Ceres 13 (2):19-23.

18. Chambers, R. (1981). Rapid rural appraisal: rationale and repetoire. Public Administration and Development 1:95-106.

19. Chandler, T. and D. Spurgeon. (1980). International Cooperation in Agroforestry. ICRAF. Nairobi.

20. Chapman, E.C. (1980). Agricultural instensification and the role of forestry in Northern Thailand. In: Ives, Sabhasri and Voraurai eds. Conservation and Development in Northern Thailand. Proc. of a Programmatic Workshop on Agroforestry and Highland-Lowland Interactive Systems. Chaing Mai Univ. Nov. 13-17. UNU., Tokyo.

21. Chrowdry, K. (1982). Agroforestry: The rural poor and institutional structures. Proc. UNU Workshop on Agroforestry. May 31 - June 5. Freiburg.

22. Clarke, W.C. (1976). Maintenance of agriculture and human habitats within the tropical forest ecosystem. Human Ecology. 4(3):247-259.

23. Collinson, M.P. (1979). Understanding small farmers. Proc. of the Conference on Rapid Rural Appraisal. Dec 4 - 7, 1979. Inst. of Der. Studies. University of Sussex. Brighton, U.K.

24. Collinson, M.P. (1981). A low cost approach to understanding small farmers. Agricultural Administration 8(6):433-450.

25. Comte, M.C. (1980). Making social forestry work. Ceres, 13(2):41-44.

26. Conklin, H.C. (1954). An ethnoecological approach to shifting agriculture. Transactions of the New York Acad. of Sciences. Series II, 17(2): 133-142.

27. Conklin, H.C. (1957). Hanunoo Agriculture. FAO. Rome.

28. Conklin, H.C. (1961). The study of shifting cultivation. Current Anthropology 2:27-61.

29. Conklin, H.C. (1980). Ethnographic Atlas of Ifugao: A study of Environment, Culture, and Society in Northern Luzon. Yale University Press. New Haven.

30. D'Antoni, H.L. and O.T. Solbrig. (1977). Algarrobos in South American cultures: past and present. In: Simpson ed. Mesquite: Its Biology in Two Desert Scrub Ecosystems. Dowden, Hutchinson and Ross. Stroudsburg, Pennsylvania.

31. Dasmann, R.F., J.P. Milton and P.H. Freeman. (1973). Ecological Principles for Economic Development. Wiley. London.

32. Datoo, B. (1973). Population density and agricultural systems in the Uluguru mountains Morogoro District. Research Paper No. 26. Bureau of Resource Assessment and Land Use Planning. Dar es Salaam.

33. De Schlippe, P. (1956). Shifting Cultivation in Africa. Rontledge and Kegan Paul. London.

34. Douglas, J.G. and R.A. de J. Hart. (1976). Forest Farming. Watkins. London.

35. Doe, M.R. (1976). Tree-rights, tree-holding units and tree-using units among the Malaban Kantug. Presented at the 1976 Ann. meeting of the Amer. Anthrop. Association.

36. Duerr, W.A. and J.B. Duerr. (1975). The role of faith in forest resource management. In: Rumsey and Duerr eds. Social Sciences in Forestry: A Book of Readings. Saudners. Philadelphia.

37. Eckholm, E. (1979). Planting for the future: Forestry and human needs. Worldwatch paper 26. Worldwatch Institute. Washington.

38. Eder, J.F. (1981). From grain crops to tree crops in the Cuyunon Swidden system. In: Olofson ed. Adaptive Strategies and Change in Philippines Swidden-based Scieties. Forest Research Institute. Los Banos.

39. Enabor, E.E., J.A. Okojie and I. Verinumber. (1981). Taungya systems: Socio-economic prospects and limitations. UNU Working on Agroforestry in the Humid Tropics. April 27 - May 1. Ibadan.

40. FAO, (1978). Forestry for Local Community Development. FAO Forestry Paper No. 7. FAO. Rome.

41. FAO. (1978). Forestry for Rural Communities. FAO. Rome.

42. FAO. (1981). Agriculture: Toward 2000. FAO. Rome.

43. Felger, R.S. (1977). Mesquite in Indian cultures of Southwestern North America. In: B.B. Simpson ed. Mesquite: Its Biology in Two Desert Scrub Ecosystems. Dowden, Hutchingson and Ross, Inc. Stroudsburg, Penn.

44. Felker, P. (1978). State of the Art: Acacia albida as a Complementary Permanent Intercrop with Annual Crops. USAID. Washington.

45. Felker, P. and R.J. Bandurski. (1979). Uses and potential uses of leguminous trees for minimal energy input agriculture. Economic Botany 33:172-184.

46. Fox, J.J. (1977). Harvest of the Palm: Ecological Change in Eastern Indonesia. Harvard University Press. Cambridge. Masschusetts.

47. Garlick, J.P. and R.W.J. Keay eds. (1977). Human Ecology in the Tropics (2nd Ed). Society for the Study of Human Biology. Symposium vol. XVI. Halstead Press. New York.

48. Geertz, C. (1963). Agricultural Involution. Univ. of California Press. Berkeley.

49. Gershenberg, I. (1971). Customary land tenure as a constraint on agricultural development: a re-evaluation. East Africa J. of Rural Development 4(1):51-62.

50. Gilbert, E.H., D.W. Norman, and F.E. Winch. (1980). Farming systems research: a critical appraisal. MSU Rural Dev. Paper No. 6. Dept. of Agric. Econ. Michigan State University. East Lansing, Michigan.

51. Gladwin, C.H. (1979). Cognitive strategies and adoption decisions: a case study of non-adoption of an agronomic recommendation. Economic Development and Cultural Change 28(1):155-173.

52. Gleave, M.B. and H.P. White. eds. (1969). Population density and agricultural systems in West Africa. In: Thomas and Whittington Environment and Land Use in Africa. Methuen. London.

53. Gould, P.R. ed. (1972). Toward a model of population-land relationships. In: Prothero People and land in Africa South of the Sahara. Oxford Univ. Press. London.

54. Grandstaff, T.B. (1980). Shifting Cultivation in Northern Thailand. Resource Systems Theory and Methodology Series No. 3. United Nations University. Tokyo.

55. Hanafie, S. (1980). Mantri and Lurah = ma-lu. Unasylva, 32(130):25-26.

56. Harwood, R.R. (1979). Small Farm Development: Understanding and Improving Farm Systems in the Humid Tropics. Westview Press. Boulder.

57. Hildebrand, P.E. (1979). Summary of the Sondeo methodology used by IGTA. Proc. of the Conference on Rapid Rural Appraisal. Dec 4 - 7. Institute of Development Studies. Univ. of Sussex. Brighton, U.K.

58. Hildebrand, P.E. (1981). Combining disciplines in rapid appraisal: The Sondeo approach. Agricultural Administration 8(6):423-432.

59. Hodridge, L.R. (1959). Ecological indications of the need for a new approach to tropical land use. Economic Botany 13:271-280.

60. Hoskins, M.W. (1980). community forestry depends on women. Unasylva, 32(130):27-32.

61. Hoskins, M. (1982). Observations on indigenous and modern agroforestry activities in West Africa. UNU Workshop on Agroforestry. May 31 - June 5. Freiburg.

62. Hunter, J.M. (1972). Ascertaining population carrying capacity under traditional systems of agriculture in developing countries. In: Prothero ed. People and land in Africa South of the Sahara. Oxford Univ. Press. London.

63. ICRISAT. (1980). Proceedings of the International Workshop on Socio-economic Constraints to Development of Semi-Arid Tropical Agriculture. 19-23 Feb 1979. ICRISAT. Pantancheru. India.

64. Ives, J.D., S. Sabhasri, and P. Voraurai. (1980). Conservation and Development in Northern Thailand Proc. of a Prog. Workshop, Agroforestry and Highland-lowland Interaction. Chiang Mai 13-17 [illegible]. 1979. UNU Tokyo.

65. King, K.F.S. (1968). Agri-silviculture: The taungya system. Bulletin No. 1 Department of Forestry. Univ. of Ibadan. Ibadan, Nigeria.

66. King, K.F.S. (1980). Concepts of Agroforestry. In Chandler and Spurgeon eds. International operation in Agroforestry. ICRAF. Nairobi.

67. Klee, G.A. ed. (1980). World Systems of Traditional Research Management. Edward Arnold. London.

68. Kuhn, T.S. (1962). The Structure of Scientic Revolutions. Univ. of Chicago Press. Chicago.

69. Kunstadter, P. (1978). Alternatives for the development of upland areas. In: Kunstadter, Chapman and Sabhasri eds. Farmers in the Forest. Univ. of Hawaii Press. Honolulu.

70. Kunstadter, P., E.C. Chapman and S. Sabhasri eds. (1978). Farmers in the Forest: Economic Development and Marginal Agriculture in Northern Thailand. Univ. of Hawaii Press. Honolulu.

71. Kunstadter, P. eds. (1980). Implications of socio-economic, demographic, and cultural changes for regional development in Northern Thailand. J.D. Ives, S. Sabhasri and P. Voraurai Conservation and Development in Northern Thailand Proc. of a Programmatic Workshop on Agroforestry and Highland-lowland Interactive Systems. Chieng Mai, 13-17 Nov. 1978. United Nations University. Tokyo.

72. Lagemann, J. (1977). Traditional African Farming Systems in Eastern Nigeria. IFO Institut. Afrika-Studien No. 98. Weltforum Verlag. Munich.

73. Lagemann, J. (1980). Methodology of the farming systems project in Central America. CATIE. Turrialba.

74. Lagemann, J. (1981). Farming Systems Research as a Tool for Identifying and Conducting Research and Development Projects. CATIE, Turrialba.

75. Lagemann, J. and J. Heuveldop. (1982). Characterization and evaluation of agroforestry systems: the case of Acosta-Purisal, Costa Rica CATIE. Turrialba.

76. Leach, E.R. (1959). Some economic advantages to shifting agriculture. Proc. of the 9th Pacific Science Congress. 7:64-66.

77. Lundgren, B. (1982). The Use of Agroforestry to Improve The Productivity of Converted Tropical Land. Report to the Office of Technology Assessment of the United States Congress. ICRAF. Nairobi.

78. Lundgren, B. and J.B. Raintree. (1982). Agroforestry. Paper presented at the Conference of Directors of National Agricultural Research Systems in Asia. October 24-29. Jakarta.

79. Marten, G.C. and L.A. Sachohiz. (1982). Ecological land-use planning and carrying capacity evaluation in the Jalapa region Veracruz, Mexico). Agro-Ecosystems, 8:83-124.

80. Meggers, B.J. (1971). Amazonia: Man and Culture in a Counterfeit Paradise. Aldens. Chicago.

81. Menz, K.W. (1980). Unit farms and farming systems research, the IITA experience. Agricultural Systems 6:45-5)

82. Metzner, H. (1981). Innovations in agriculture incorporating traditional production methods: the case of Amarasi (Timor). Applied Geography and Development 17:91-107.

83. Miracle, M.P. (1967). Agriculture in the Congo Basin. Univ. of Wisconsin Press. Madison.

84. Moran, E.F. (1979). Strategies for survivial: resource-use along the Transamazonian Highway. Studies on Third World Societies, 7:49-75.

85. Moss, R.P. and W.B. Morgan, (1981). Fuelwood and Rural Energy: Production and supply in the Humid Tropics. United Nations University. Tokyo.

86. Nabhan, G.P. and T.L Sheridan. (1977). Living fencerows of the Rio San Miguel, Sanora, Mexico: traditional technology for flood-plain management. Human Ecology 5:97-111.

87. Netting, R. McC. (1974). Agrarian ecology. Ann. Rev. of Anthropology 3:21-56.

88. Norman, D.W. (1980). The farming systems approach: relevancy for the small farmer. MSU Rural Development Paper No. 5 Dept. of Agric.

Econ. Michigan State University. East Lansing, Michigan.

89. Okigbo, B.N. (1981). Plants and agroforestry in land-use systems of West Africa: a conceptual framework for planning and establishment to research priorities. Paper presented to the Consultative Meeting on Plant Research and Agroforestry. ICRAF, Nairobi.

90. Olofson, H. (1981). Adaptive Strategies and Change in Philippines Swidden-based societies. Forest Research Institute. Los Banos, Philippines.

91. Olofson, H. (no date given). An anthropological approach to social forestry: The study of indigenous agroforestry systems. Dept. of Social Forestry. University of the Philippines. Los Banos.

92. Openshaw, K. and J. Morris. (1979). The socio-economics of agroforestry. In: Chandler and Spurgeon eds. International Cooperation in Agroforestry. ICRAF, Nairobi.

93. Part, M.M. (1979). Social Forestry in India. Unasylva, 31 (125):19-24.

94. Pelzer, K.J. (1945). Pioneer Settlement in the Asiatic Tropics. Am. Geog. Soc. New York.

95. Prothero, R.M. ed. (1972). People and Land in Africa South of the Sahara. Oxford Univ. Press. London.

96. Prothero, R.M. ed. (1972). Relationships between people and land. In: Prothero, People and Land in Africa South of the Sahara. Oxford University Press. London.

97. Raintree, J.B. ed. (1981). Conservation Farming with multipurpose tree legumes: an underdeveloped branch of tropical agroforestry research. In: L. Buck Proc. of the Kenya National Seminar of Agroforestry ICRAF. Nairobi.

98. Raintree, J.B. (1982). A methodology for diagnosis and design of agroforestry land management systems. ICRAF. Nairobi.

99. Raintree, J.B. On the logic of agroforestry diagnosis and design. Agroforestry Systems. (in press).

100. Rappaport, R.A. (1969). Some suggestions concerning concept and method in ecological Essays. National Museum of Canada Bulletin 230.

101. Rappaport, R.A. (1971). The flow of energy in an agricultural society. Scientific American 225 (2):116-132.

102. Rice, D. (1981). Upland agricultural development in the Philippines: an analysis and a report on the Ikalahan programs. In: H. Olofson eds. Adaptive Strategies and Change in the Philippines Swidden-based Society. Forest Research Institute. Los Banos, Philippines.

103. Richardson, W.N. and T. Stubs. (1978). Plants, Agriculture and Human Society. Benjamin & Co. Menlo Park, California.

104. Rocheleau, D.E. (1982). Adaptive research for rural development: the combined application of ecosystems and farming systems analysis to agroforestry production in the Sierra, Dominican Republic. Conference of Latin American Geographers. Oct. 12. Santo Domingo.

105. Rogers, E.M. and F.F. Shoemaker. (1971). Communication of Innovations. The Free Press. New York.

106. Romm, J. (1982). A research agenda for social forestry. International Tree Crops Journal, 2:25-59.

107. Rubin, J. (1972). Boserup and Malthus. Peasant Studies Newsletter, 1:36-39.

108. Ruddle, K. (1975). The Yukpa Cultivation System: A study of Shifting Cultivation in Colombia and Venezuela. Ibero-Americana No. 52. University of California Press. Berkeley.

109. Ruthenberg, H. (1971). Farming Systems in the Tropics. Clarenden Press. Oxford.

110. Shaner, W.W., P.F. Phiipp, and W.R. Schmel. (1982). Farming Systems Research and Development. Westview Press. Boulder.

111. Smith, J.R. (1950). Tree Crops: A Permanent Agriculture. Reprinted in 1978 by Harper and Row. New York.

112. Somsak Sukwang. (1982). Agroforestry in Thailand. Proc. Regional Working Party Meeting on Agroforestry Research and Development for Southeast Asia. May 24-25. SEARCA. Los Banos.

113. Spencer, J.E. (1966). Shifting Cultivation in Southeast Asia. University of California Press. Berkeley.

114. Steppler, H.A. (1981). A Strategy for the Internat. Council for Research in Agroforestry. ICRAF. Nairobi.

115. Steppler, H.A. (1981). An identity and a strategy for Agroforestry. Proc. UNU Workshop on AF in the African Humid Tropics. Ibadan, United Nations University. Tokyo.

116. Steppler, H.A. and J.B. Raintree. (1981). The ICRAF strategy in relation to plant science research in agroforestry. Proc. Consultative Meeting on Plant Science Research in Agroforestry. ICRAF. Nairobi.

117. Steward, J. (1968). Cultural ecology. Encycl. Social Science, 4:337-44.

118. Stoler, A. (1978). Garden use and household economy in rural Java. Bulletin of Indonesia Economic Studies, 14 (2):85-101.

119. Street, J. (1969). An evaluation of the concept of carrying capacity. Professional Geographer 21: 104-107.

120. Swanson, R.A. (1979). Gourmantche Agriculture Part 1: Land Tenure and Field Cultivation. Doc. 7. Integrated Rural Development. Project. Eastern ORD, B.A.E.P., Upper Volta. Contract AID. 686-049-78.

121. Tewari, R.N. and O.A. Mascarenhas (1980). Community Forestry Management for Rural Development. Natraj Publications. Dehra Dun, India.

122. Tosi, J.A. Jr. and R.F. Voertman. (1964). Some environmental factors in the economic development of the tropics. Economic Geography 40 (3):189-205.

123. UNESCO. (1978). Management of Natural Resources in Africa: Traditional Strategies and Modern Decision-Making. MAB Technical Notes 9. UNESCO. Paris.

124. Vasey, D.E. (1979). Population and agricultural intensity in the humid tropics. Human Ecology, 7 (3):269-283.

125. Vayda, A.P. and R.A. Rappaport. (1968). Ecology, cultural and non-cultural. In: Introduction to Cultural Anthropology. J.A. Clitton ed. Houghton Mofflin. Boston.

126. Veer, C.P. (1981). Agroforestry as an intervention in farming systems. In: Wiersum ed. Viewpoints on Agroforestry. Agricultural University of Wageningen. Wageningen, Netherlands.

127. Voraurai, P. (1982). Some thoughts about research and training needs on agroforestry in northern part of Thailand. Paper presented to the Regional Workshop on Agroforestry. Oct. 18-22. SEARCA. Los Banos, Philippines.

128. Warner, K. ed. (1981). Swidden strategies for stability in a fluctuating environment: The Tagbanwa of Palawan. In: Olofson, ed. Adaptive Strategies and Change in Philippine Swidden-based Societies. Forest Research Institute. Los Banos, Philippines.

129. Watters, R.F. (1971). Shifting cultivation in Latin America. Forestry Development Paper No. 17. FAO. Rome.

130. West, Patrick C. (1978). Some sociological aspects of forestry community development

projects in developing countries. Proceedings of the Eighth World Forestry Congress. Jakarta.

131. Wiersum, K.F. ed. (1981). Viewpoints on Agroforestry. Agricultural University of Wageningen. Wageningen., Netherlands.

132. Wiersum, K.F. (1982). Tree gardening and taungya on Java: examples of agroforestry technique in the humid tropics. Agroforestry Systems 1: 53-70.

133. Wood, D., D. Brokenshaw, A.P. Castro, M.S. Gamser, B.A. Jackson, B.W. Riley, D.M. Schraft. (1980). Socio-Economic Context of Fuelwood Use in Small Rural Communities. A.I.D. Evaluation Special Study No. 1. Bureau for Programme and Policy Coordination, USAID, Washington.

134. Zandstra, H.G. (1980). Methods to identify and evaluate improved cropping systems. In: H. Ruthenberg. Farming Systems in the Tropics, 3rd ed. Clarendon Press. Oxford.

135. Zandstra, H., K. Swanberg, C. Zulberti, B. Nestel. (1979). Caquesa: Living Rural Development. IDRC. Ottawa.

136. Zandstra, H.G., E.C. Price, J.A. Litsenjer and R.A. Morris. (1981). A methodology for on-farm cropping systems research. IRRI. Los Banos, Philippines.

## *R8. ROLE OF WOODY PERENNIALS IN ANIMAL AGROFORESTRY - by F. Torres

### 1. Introduction

Many definitions of agroforestry have been proposed (see Agroforestry Systems, 1982, Vol. 1, No. 1: 7-12) and its discussion is beyond the scope of this paper. Nevertheless, there appears to be a consensus that such systems involve the combination of woody perennials with herbaceous crops, including pastures, with or without animals. In this context, animal agroforestry is proposed as a generic name for all agroforestry systems which include animals (for production or performance) as one of their components. It has been suggested that these systems can be called silvopastoral when they include trees or shrubs, pasture and animals, while the agrosilvopastoral ones would contain herbaceous food crops in addition to those components included in silvopastoral systems (Torres, 1982).

Within these systems woody perennials can play a productive or a service role. The former could be characterized as that producing a tangible product (e.g., timber, fuel, fruits, fodder), while the latter would not yield a tangible product (e.g., shelter, nutrient recycling). Most of the time woody components in land management systems will not be limited to either a productive or a service role, but will probably play both. Nonetheless, such division appears as a functional way of approaching the discussion on the subject.

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*Ed's note: This article has also appeared in Agroforestry Systems 1:131-163, 1983. Therefore references which appear in this article follow the style of the journal rather than that of the other articles in this Section.

## 2. The productive role

### 2.1. Browsing systems

Browse has been defined as the 'shoots or sprouts, especially tender twigs and stems of woody plants with their leaves, which are cropped to a varying extent by domestic and wild animals' (Dayton, 1931, cited by Skerman, 1971). However, in this case the term will be broadened to include fruit or pods, which can be more valuable than foliage, particularly if the woody component happens to be a deciduous one.

A general paper highlighting the role of browse plants as drought reserves and their feeding value as sources of protein-rich fodder was written by Gray (1970). The use of fodder trees mainly as drought reserves has been emphasized by Moore (1972). A comprehensive discussion on the role of browse in the management of natural grazing lands, including the importance of fodder 'trubs' (trees and shrubs) in different ecological zones and the potential of some components (*Opuntia* sp., *Atriplex* sp., *Acacia* sp., etc.) has been presented by Le Houerou (1980), who postulates that technologies based on a permanent feed supply from fodder trubs can transform pastoral production systems into settled agropastoral ones. An extensive review by Ibrahim (1981) presents one of the most comprehensive listing of references (175) on factors affecting dry matter yield, palatability, nutritive value and utilization of fodder trubs, including recommendations for further research and development on fodder trees and shrubs. The role of woody components in animal production has also been discussed by Felker (1980), McKell and Malechek (1980). Given the different aspects involved in discussing the role of woody components in browsing systems, references are arranged according to their contribution to the knowledge of species, biomass productivity and nutritive value. Relationships between woody and herbaceous components will be dealt with later on, under the topic of the 'service' role of trees and shrubs.

2.1.1 Trub Species. Probably as a reflection of their importance in rangeland management, African fodder trubs have been described in several papers. For the Sahelian zone the thesis by Touzeau (1973) describes 42 species belonging to 15 families. Description not only includes botanical and ecological characteristics

but also distribution and utilization. Kadambi (1963) has made a selection of 10 fodder trees for the different ecological zones of Ghana, based upon their agronomic and forage characteristics. Predominant browse plants in the East African highlands are described by Dougall and Bogdan (1957) with emphasis in their use, including chemical composition. A list of the main browse plants in the Sudanian zone of West Africa is given by Toutain (1980).

For the southern part of Africa, Jurriaanse (1973) thoroughly describes 6 species useful to humid and arid areas, but concludes that they have not reached a development stage which makes them worth propagating for economic fodder production. For the more arid areas (100-500 mm rainfall), however, Kock (1967) believes that Opuntia sp. and Atriplex nummularia can play an important role in limiting fodder shortages during droughts.

A pioneer work on fodder trees and shrubs of Australia is the one by Everist (1969), including more than 100 species. Seventeen important fodder trub species for the arid grazing country in western New South Wales are described by Stannard and Condon (1968), who visualize their contribution essentially as drought reserves and to prevent soil wind erosion. Carob, Mesquite and Honey locust were proposed by Eardley (1945) for south Australia. The agronomic characteristics and uses of the widely distributed genus Leucaena is described by Brewbaker (1976). A less known but promising drought resistant legume shrub, Stylosanthes scabra Cv. Seca, has been registered (J. Austr. Inst. of Agric. Sci. 1978).

From the Americas the most relevant genus seems to be Prosopis sp., whose potential has been reviewed by Felker (1979). He concluded that pod yield could go up to 10,000 kg/ha and that selections can be developed for various ecological niches and uses.

In spite of the widespread use of fodder trubs in the Indian subcontinent, there does not seem to be a profuse literature describing useful species. Sharma (1977) briefly characterises more than 30 winter and summer fodder trees of Himachal Pradesh according to their palatability. A thesis by Panday (1975) presents a systematic list of fodder trubs in the Sindhupalchok District of Nepal, as well as observations and comments on the occurrences and

propagation, production and utilization practices. After concluding that trub leaves make up the bulk of the green fodder available during the dry season, he proposes selection criteria on the basis of chemical composition and farmers observations. Mann (1980) has described the salient features of Prosopis cineraria, the 'wonder' tree of the arid N.W. India, used by the local population as a source of fuelwood, fodder and for improvement of soil fertility.

A comprehensive list of leguminous browse species for the tropics can be found in the book by Skerman (1977) and in the paper by Felker and Bandurski (1979).

### 2.1.2 Trub productivity

Should the more ample definition of browse be accepted, i.e., including pod utilization, it would be convenient to deal separately with leaf-twig and pod production. The difficulty involved in estimating 'useful' production of leaf-twig (that accessible to the browsing animal) and the 'substitution' approach (of woody by herbaceous components) that has prevailed in range improvement, may have precluded research on trub dry matter production. A valuable review on production of browse in the savanna regions is that by Trollope (1981). Using data from other authors, he mentions that mean total biomass of such savannas is approximately 20,000 kg/ha/yr, of which 1500 are twigs and leaves, 600 stems and branches and 1000 come from growth of the herbaceous layers. Applying existing data, the same author estimates that only 33 to 76% of those browsable leaves and twigs would be within reach of the animals, or 500 to 1150 kg/ha/yr. As a result of this and other available information, Trollope (1981) concludes that '... data emphasises an important principle in savanna ecology, viz. that the herbaceous grass layer is potentially able to produce more edible plant material for domestic livestock than the browse layer. However, the grass sward can be extremely variable in its production, mainly in response to seasonal fluctuations in rainfall. Conversely, it would appear that the production of browse by the woody component is much less variable and less influenced by short-term fluctuations in rainfall, presumably because the woody plants possess deeper root systems.'

Another interesting paper on primary production of fodder trubs in the African tropics is that by Bille (1980), who shows a relationship between stem circumference and foliage and fruit biomass for several browse species in the Sudano-Sahelian zone, within a rainfall range of 250 to 600 mm. The relationship of the form log biomass = a x log diameter + c has a mean value of 2 for a and 1 for c. It means that for trub stem diameters of 5, 10 and 15 cm, biomass production will be 0.25, 2.2 and 6.2 kg respectively. An average tree in the Sahel would then produce a kilogram of leaves plus 0.250 of fruits and 4-5 kg of branches or about 1000 kg/ha of foliage. This productivity is affected by the browsing regime. Cisse (1980), experimenting with trubs from the same Sudano-Sahelian zone, found out that frequency and intensity of stripping would affect yield by as much as 100%, depending on species.

For the Sahel, Penning de Vries and Djiteye (1982) have estimated that the mean annual production of leaves of woody species ranges from around 50 kg/ha for the 500 mm rainfall zone (where soil cover of these species was in the order of 5%) to 1000 kg/ha in the 1000 mm zone (with a soil cover of 100%).

In the Mediterranean zone Le Houerou _et al_. (1982) have also found a relationship between biomass and canopy diameter using data from 622 shrubs of 4 species. The average production of leaves/phyllods per shrub for 16 species was 1.365 kg, ranging from 3.243 (_Acacia cyclops_) to 136 (_Periploca loevigata_), _Atriplex_ sp. falling within the average. This value does not differ substantially from that measured by Jones, Hodgkinson and Rixon (1969) for _Atriplex nummularia_ at 500 days from germination: 2.330 kg.

Studies on the productivity of around 20 shrub/brush species in the native grasslands of North America indicate that annual production ranges from 20 to 600 g/plant, and is affected by intensity and frequency of defoliation (Willard and McKell, 1978; Lay, 1965; and Garrison, 1953).

The marked interest in _Leucaena_ sp. has led to several experiments on its productivity (Brewbaker, Plucknett and Gonzales, 1972; Hill, 1971; Alferez, 1977; Ferraris, 1979). In humid Hawaii, Guevara, Whitney, and Thompson (1978) studied the productivity of shrubby and arboreal types of _Leucaena leucocephala_ under different plant populations and height of

cuttings. A population density of 133.000 plants (15 x 50 cm) and a cutting height of 105 cm produced higher forage yields with both types, being higher for the shrubby type (12.9 t/ha/yr) than the arboreal type (11.5 t/ha/yr), or 95 and 85 g/plant respectively. At Los Banos, Philippines, Mendoza, Altamirano and Javier (1976) experimented with frequency and intensity of cutting on a cv. Peru planted at 3.0 x 0.05 m (66,000 pl/ha). Cutting height significantly affected total dry matter yield, which was 10.7, 15.8 and 23.6 t/ha for 0.15, 1.5 and 3.0 m respectively, which correspond to 162, 239 and 358 g/plant/year. Under the sub-humid conditions of Queensland, Australia, Hutton and Beattie (1976) report total production of 5 t/ha (only 1.9 t of edible DM) for a fertilized Peruvian type at a density of 10,000 plant/ha cut at 15 cm high 3 times a year, or 500 g/plant. In the semi-arid region of India (Jhansi), Pathak, Rai and Deb Roy (1980) studied the effect of population density and frequency and intensity of cutting. On a 3 year average, density was the most important factor effecting total yield, which ranged from 5.4 t/ha for 4 plants/sq. metre to 1.9 t for 1.5 pl/sq. metre (135 and 127 g/plant/year respectively).

For an *Acacia aneura* community in Queensland, Beale (1973) reports that foliage weight per tree varied from 3 to 5 kg depending on density per hectare of 640 to 40 trees, leading to a production of 1900 to 200 kg/ha, respectively.

The literature reviewed appears to be limited but consistent in showing a relatively small scope for trubs as components that can substantially increase production of edible foliage matter, particularly in the arid and semi-arid zones.

Information available on pod production is even more scarce. Data compiled by Felker and Bandurski (1979) would indicate that species such as *Prosopis* sp., *Gleditsia triacanthos* and *Acacia albida* could produce in the order of 3-10 t/ha in different ecological zones. In the case of *Prosopis tamarugo* in the arid north of Chile, production per tree ranges from 20 to 70 kg for 14 to 22 year-old plants at a density of 100 trees per hectare (Elgueta and Calderon, 1971).

### 2.1.3 Trub nutritive value

The nutritive value of any particular fodder depends not only on its nutrient content but on the amount consumed and assimilated by the animal. Although there is a considerable wealth of information on chemical composition of fodder trubs, few of them have been evaluated in terms of animal response. A review on browse in nutrition of the grazing animal was carried out by Wilson (1969), who concluded that fodder trubs have not been shown to make a major contribution to the nutrition of domestic or most game animals and that further studies of browse-grass comparisons were needed.

The role of browsing appears to be particularly relevant for animal production systems based upon the utilization of rangelands in arid and semi-arid zones. Under these conditions protein content in the diet has been shown to be the most limiting factor affecting liveweight gains. This was the conclusion of a thorough analysis carried out by Pratchett et al. (1977) relating six range parameters, measured monthly over an 11-month period on nine ranches distributed throughout the main ecological zones of Botswana, to the monthly liveweight changes of growing cattle. Linear, quadratic and multiple regressions all indicated that liveweight change was influenced primarily by the crude protein content of the herbage selected, which accounted for 54% of the variation, while digestibility of the same samples accounted for 32%. They concluded that research efforts must be directed towards increasing the crude protein content of the diet available to beef cattle. In a study carried out with steers in the mixed tree savanna of the Transvaal, South Africa, Zimmerman (1980) estimated that the intake of digestible crude protein accounted for 79% of the variation in daily liveweight change of the cattle. Less conclusive but still supportive evidence comes from the work by McKay and Frandsen (1969) in the semi-arid upland areas of Kenya, and that of Ward (1975) for the rangelands in Arizona, particularly during summer periods. This may originate in the known negative relationship between temperature and crude protein content in grasses (Deinum 1966), as well as the direct one between crude protein content in the diet and fiber digestibility.

An increase in the availability of crude protein to the grazing/browsing ruminant could be achieved through the introduction of fodder trubs, which are known for their high protein content. This possibility is somewhat substantiated by Rees (1973), who assessed the potential of bush utilization by cattle during the latter half of the dry season in a marginal area of Zambia. Although the high standard error of the estimate precludes any firm conclusions, it appears that the fodder selected by 4 fistulated steers from 10 trubs contained 12 to 17% protein, while that of the grass was only 3%. Gohl (1981) has compiled literature on trub composition. A compilation of some of the available information on chemical composition of trub leaves and pods would indicate their potential as a protein supplement to the fodder available in the tropical and sub-tropical rangelands (see Tables 12 and 13). An analysis of a similar work done by Le Houerou (1980) on browse species of West Africa shows that the average protein content of 55 non-legume species is 14.1%, while that of 36 legumes is 18.8%. Carew, Mba and Egbunike (1981) found that in the humid zone of Nigeria the mean crude protein contents of browse, i.e., trees, shrubs and herbs (18.3, 19.7 and 19.4 respectively) were higher than those for grasses (11.1%).

This potential becomes particularly evident when protein content of browse species is compared with that of grasses from the same piece of land and harvested at the same time. Such comparison was reported by Rose Innes (1965) for monthly recordings between May and December in the coastal and interior savanna of Ghana, including data from 4 browse species and unidentified native grass. The average protein content of 8 observations in the coastal savanna was 18.1. and 5.8% for browse and grasses respectively. Corresponding values for the interior savanna were 15.1 and 4.8%. Moreover, it should be mentioned that grass protein content was always lower than 50% of that in browse (and as low as 8%), with the exception of that for the coastal savanna in May, when it reached 61% of the browse content.

As expected, protein contents will change with season (Momin and Ray, 1943; Rose Innes and Mabey, 1964b; and McLeod, 1973), but probably not nearly as much as grasses would (Majumdar, Momin and Kehar, 1967). Actually, Leigh, Wilson and Mulham (1978) have shown that seasonal variation played a minor part in

TABLE 12.

CRUDE PROTEIN CONTENT OF TRUB LEAVES AND TWIGS

| Species | Region | CP (%) | References |
|---|---|---|---|
| *Zizyphus mistol* | Argentina | 25.9 | Diaz, 1962 |
| *Acacia aneura* | Queensland, Austr. | 13.1 | Harvey, 1952 |
| *Grewia sp.* | Kenya | 19.76 | Wilson, 1963 |
| *Baphia bequaertii* | Zambia | 22.38 | Lawton, 1975 |
| *Julbernardia paniculata* | Zambia | 12.38 | Lawton, 1975 |
| *Bauhinia variegata* | India | 15.6 | Lawton, 1975 |
| *Gleditsia triacanthos* | Pakistan | 11.8 | Khan, 1975 |
| *Zizyphus mauritania* | Pakistan | 11.3 | Khan, 1975 |
| *Acacia arabica* | Pakistan | 12.8 | Khan, 1975 |
| *Albizia lebbeck* | Pakistan | 22.0 | Malik, Sheik, Shah, 1967 |
| *Acacia arabica* | Pakistan | 20.0 | Malik, Sheik, Shah, 1967 |
| *Bauhinia variegata* | Pakistan | 18.5 | Malik, Sheik, Shah, 1967 |
| *Azadirachta indica* | Pakistan | 13.4 | Malik, Sheik, Shah, 1967 |
| *Ficus religiosa* | Pakistan | 10.8 | Malik, Sheik, Shah, 1967 |
| *Gliricidia sepium* | Virgin Islands | 17.4 | Oakes & Skow, 1962 |
| *Leucaena leucocephala* | Virgin Islands | 16.0 | Oakes & Skow, 1962 |
| *Albizia lebbeck* (whole) | Virgin Islands | 16.2 | Oakes & Skow, 1962 |
| *Prosopis spicigera* | India | 15.4 | Gupta & Mathur, 1974 |
| *Commiphora africana* | Sahel | 14.2 | Clanet & Gillet, 1980 |
| *Alchornea cordifolia* | Nigeria | 23.0 | Mecha & Agdebola, 1980 |
| *Baphia pubescens* | Nigeria | 24.3 | Mecha & Agdebola, 1980 |
| *Cajanus cajan* | Nigeria | 29.8 | Mecha & Agdebola, 1980 |
| *Combretum nigricans* | Sahel | 13.2 | Bartha, 1970 |
| *Gueira senegalensis* | Sahel | 13.9 | Bartha, 1970 |
| *Grifforia simplicifolia* | Ghana | 15.7 | Rose Innes & Maybe, 1964 |

TABLE 13

CRUDE PROTEIN CONTENT OF TRUB PODS AND SEEDS

| Species | Region | Pods | Seeds | References |
|---|---|---|---|---|
| *Acacia aroma* | Argentina | 14.0 | | Diaz, 1962 |
| *Acacia cavenia* | Argentina | 11.1 | | Diaz, 1962 |
| *Cesalpinia paraguariensis* | Argentina | 4.6 | | Diaz, 1962 |
| *Prosopis alba* | Argentina | 6.4 | | Diaz, 1962 |
| *Prosopis nigra* | Argentina | 8.9 | | Diaz, 1962 |
| *Zizyphus mistol* | Argentina | 8.2 | | Diaz, 1962 |
| *Acacia albida* | Tanzania | 13.5 | 26.6 | Gwynne, 1969 |
| *Acacia albida* | Uganda | 10.0 | 28.4 | Gwynne, 1969 |
| *Acacia nilotica* | Kenya | 12.4 | 20.8 | Gwynne, 1969 |
| *Acacia sieberiana* | Uganda | 11.7 | 18.9 | Gwynne, 1969 |
| *Prosopis juliflora* | India | 10.1 | | Mahadevan, 1954 |
| *Ceratonia siliqua* | Brasil(s) | 7.5 | 13.1 | Hall, G., 1976 |
| *Phitecolobium saman* | Venezuela | 14.6 | | Fornaroli, 1961 |
| *Acacia albida* | Zambia | 11.5 | 22.2 | Skerman, 1977 |
| *Acacia litakuensis* | Rhodesia | 17.3 | 37.8 | Skerman, 1977 |
| *Acacia nilotica* | Uganda | 10.0 | | Skerman, 1977 |
| *Acacia nubica* | Kenya | 15.2 | | Skerman, 1977 |
| *Acacia polyacantha* | Zambia | 10.4 | 27.4 | Skerman, 1977 |
| *Acacia senegal* | Uganda | 19.6 | | Skerman, 1977 |
| *Acacia siaberiana* | Zambia | 10.3 | 18.5 | Skerman, 1977 |
| *Acacia tortilis* | Kenya | 14.1 | | Skerman, 1977 |
| *Albizia versicolor* | Zambia | 12.6 | | Skerman, 1977 |
| *Bauhinia carronii* | Australia | 10.8 | | Everist, 1969 |
| *Ceratonia siliqua* | Australia | 9.3 | | Everist, 1969 |
| *Dichrostachys cinerea* | Rhodesia | 11.4 | | Everist, 1969 |
| *Gleditsia triacanthos* | Australia | 14.3 | | Everist, 1969 |
| *Piliostigma thonningii* | Rhodesia | 6.4 | | Everist, 1969 |
| *Acacia nilotica* | Siwalik | 16.1 | | Lal, M., 1977 |
| *Acacia cynophylla* | Cyprus | | 30.7 | Ramadan, 1957 |
| *Dalbergia sisso* | Agra | 11.9 | | Saraswat, Singh, Sachdeva, 1974 |

determining browse quality of four Australian fodder trubs. Pal et. al (1979), processing the information on chemical composition of 26 species of fodder trees from Himachal Pradesh, India, found that average crude protein content was significantly higher in April (16.7%) than in August and December (14.7 and 14.3% respectively).

As mentioned, laboratory analyses may be of limited value in assessing fodder nutritive value. As is well known, the Weende system may not reflect the availability of cell-wall constitutents, which may be hindered by a high lignin or silica content (Van Soest, 1969). A high protein content may not, therefore, necessarily represent a potential protein supplement. Nevertheless, data compiled in Table 14 would indicate that actual protein digestibility of fodder trubs does not differ considerably from that estimated by a widely accepted regression equation for digestible crude protein on crude protein (McDonald, Edwards and Greenhalgh, 1973). On the average, for the 38 sources measured, digestible crude protein would be only 90% of that estimated, but the range of values (34 to 127%) would suggest large variations between trub species.

But even digestibility may not be a good indicator of nutritive value. Experimenting with dried leaves of 4 shrub and 4 tree species, Wilson (1977) found that those of higher digestibility were eaten sparingly, there being no correspondence between digestibility and organic matter intake, probably as a consequence of unpalatability factors. In a recent review on the nutritive value of Australian browse plants Wilson and Harrington (1980) go even further, stating that "There are no browse species of both high quality and high palatability and perhaps we should not expect them to be (because they will succumb to over-browsing)." Ibrahim (1981) discusses different plant and animal factors affecting palatability.

Information on pod digestibility seems to be rather scarce. The paper available on Prosopis juliflora (Kargaard and van der Merwe, 1976) shows that when used as the only source of feed, dry matter digestibility (DMD) was 65%, while that for crude protein was 67.2%. It should be mentioned that pods were hammer milled; otherwise seeds may pass

TABLE 14 PROTEIN DIGESTIBILITY OF FODDER TRUBS

| Trub species | Animal | 1 Crude Protein CP(%) | 2* Estimated CPD (%) | 3 Measured CPD (%) | 3/2 (%) | References |
|---|---|---|---|---|---|---|
| *Prosopis cineraria* | Sheep | 14.2 | 65.3 | 22.0 | 33.7 | Bohra, 1980 |
| | Goat | 14.2 | 65.3 | 38.9 | 59.6 | Bohra, 1980 |
| *Ficus religiosa* | Cattle | 14.0 | 64.9 | 56.6 | 87.2 | Mia *et al.*, 1960 |
| | Goat | 14.0 | 64.9 | 54.3 | 83.7 | Mia *et al.*, 1960 |
| *Ficus religiosa* | Cattle | 11.9 | 60.3 | 58.3 | 97.0 | Ram & Ray, 1943 |
| *Ficus infectoria* | Cattle | 9.6 | 52.9 | 56.0 | 105.8 | Ram & Ray, 1943 |
| *Zizyphus jujuba* | Cattle | 8.6 | 48.5 | 35.5 | 73.2 | Ram & Ray, 1943 |
| *Ailanthus excelsa* | Sheep | 16.2 | 68.5 | 80.2 | 117.1 | Bhandari & Gupta, 1972 |
| *Zizyphus nummularia* | | 14.1 | 65.1 | 53.5 | 82.1 | Nath, Malik & Singh, 1969 |
| *Atriplex vesicaria* | Sheep | 12.5 | 61.8 | 71.4 | 115.5 | Wilson, 1977 |
| *Atriplex nummularia* | Sheep | 20.6 | 73.3 | 82.0 | 111.8 | Wilson, 1977 |
| *Mayreana pyramidata* | Sheep | 13.1 | 63.1 | 55.1 | 87.3 | Wilson, 1977 |
| *Bassia diacantha* | Sheep | 12.5 | 61.8 | 49.3 | 79.8 | Wilson, 1977 |
| *Acacia pendula* | Sheep | 16.9 | 69.4 | 63.2 | 91.0 | Wilson, 1977 |
| | Goat | 16.9 | 69.4 | 68.8 | 99.1 | Wilson, 1977 |
| *Casuarina cristata* | Sheep | 9.4 | 52.1 | 22.1 | 42.4 | Wilson, 1977 |
| | Goat | 9.4 | 52.1 | 32.3 | 62.0 | Wilson, 1977 |
| *Grewia elastica* | Goat | 19.9 | 72.7 | 71.2 | 97.9 | Khajuria & Singh, 1968 |
| *Ficus bengalensis* | Cattle | 9.6 | 52.9 | 20.0 | 37.8 | Mia *et al.*, 1960 |
| | Goat | 9.6 | 52.9 | 42.5 | 80.3 | Mia *et al.*, 1960 |

*Calculated as Distrible Crude Protein (DCD)/Crude Protein Content (CP), DCP being estimated as: %DCP=(%CP X 0.9115) - 3.67.

TABLE 14 Cont'd..

| Trub species | Animal | 1 Crude Protein CP(%) | 2* Estimated CPD (%) | 3 Measured CPD (%) | 3/2 (%) | References |
|---|---|---|---|---|---|---|
| Albizia lebbeck | Cattle | 20.1 | 72.9 | 64.5 | 88.5 | Khajuria & Singh, 1968 |
| Albizia lebbeck | Sheep | 16.8 | 69.3 | 65.0 | 93.4 | Gupta, 1980 |
| Atriplex nummularia | Sheep | 21.7 | 74.2 | 78.0 | 105.1 | Wilson, 1966 |
| Atriplex nummularia | Sheep | 17.0 | 69.6 | 83.0 | 119.3 | Wilson, 1966 |
| Atriplex vesicaria | Sheep | 18.4 | 71.2 | 74.0 | 103.9 | Wilson, 1966 |
| Atriplex vesicaria | Sheep | 11.1 | 58.1 | 71.0 | 122.2 | Wilson, 1966 |
| Kochia pyramidath | Sheep | 15.1 | 66.8 | 57.0 | 85.3 | Wilson, 1966 |
| Antiaris africana | Cattle | 12.1 | 60.8 | 77.5 | 127.4 | Mabey & Rose Innes, 1966 |
| Grewia carpinifolia | Cattle | 15.8 | 67.9 | 77.8 | 114.5 | Mabey & Rose Innes, 1966 |
| Baphia nitida | Cattle | 23.1 | 75.3 | 72.3 | 96.1 | Mabey & Rose Innes, 1964 |
| Griffonia simplicifolia | Cattle | 18.6 | 71.4 | 81.4 | 114.0 | Mabey & Rose Innes, 1964 |
| Ficus glomerata | Goat | 11.2 | 58.4 | 59.7 | 102.2 | Majumdar & Momin, 1960 |
| Morus indica | Cattle | 11.5 | 59.2 | 68.6 | 115.8 | Rao, Kumar & Sampath, 1971 |
| Mellotus philippensis | Sheep | 14.5 | 65.8 | 53.2 | 80.8 | Bhargava, Katyar, Saxena, 1977 |
| Brachychiton populneum | Sheep | 14.6 | 66.0 | 75.8 | 114.8 | Norton et al., 1972 |
| Acacia aneura | Sheep | 14.9 | 66.5 | 63.1 | 94.9 | Norton et al., 1972 |
| Zizyphus nummularia | Sheep | 10.5 | 56.2 | 33.1 | 58.9 | Singh & Gupta, 1977 |
| | Goat | 10.5 | 56.2 | 36.2 | 64.4 | Singh & Gupta, 1977 |
| Bamboosa arundinaceae | Sheep | 18.6 | 71.4 | 72.4 | 101.4 | Sharma, Chawla & Negi, 1968 |
| Bauhenia variegata | Sheep | 13.8 | 64.5 | 36.0 | 55.8 | Sharma, Chawla & Negi, 1968 |
| Sesbania aegyptiaca | Goat | 19.5 | 72.3 | 80.8 | 111.7 | Singh, Kumar & Rekib, 1980 |

*Calculated as Distrible Crude Protein (DCD)/Crude Protein Content (CP), DCP being estimated as: %DCP=(%CP X 0.9115) - 3.67.

undigested through the digestive tract. For Ceratonia siliqua Charalambous (1966) reports a DMD of 82.6% and CPD of 80.1% from sheep digestibility trials carried out by others. Toxicity may be another factor limiting the nutritive value of fodder trubs. The toxic effect of mimosine contained in Leucaena leucocephala has been known for years (Brewbaker and Hylin, 1965). The alkaloid could significantly affect animal response (Homes, 1981), which may be alleviated through mineral supplementation (Jones, Blunt and Nurnberg, 1978) or, better still, by breeding low mimosine cultivars (Winter and Jones, 1980).

Trials assessing the potential of fodder trubs in terms of animal production are rather scarce. The use of Leucaena sp. as a protein supplement is probably the best documented. A recent review by Jones (1979) indicates that for beef fattening effects are comparable with those derived from concentrated protein sources, when limited amounts are offered. Under grazing conditions the wide range in daily gains recorded (0.29 to 0.93 kg) was attributed by the same author to environmental factors influencing Leucaena growth and mimosine content, as well as to the intake of Leucaena and the corresponding alkaloid level. In the same review Leucaena was found to improve milk production, but also tainted the milk produced; this can be reduced by preventing cows from browsing Leucaena for several hours before milking. When Leucaena was substituted for a commercial ration for growing pigs, Malinycz (1974) found that weight gain and feed conversion ratio were adversely affected at levels higher than 20 per cent. Results of studies with chenopodiaceous shrubs are somewhat controversial. Those of Leigh, Wilson and Williams (1970) indicate that these shrubs are of little or no value in reducing seasonal fluctuations in wool growth when growing in an established perennial grassland pasture. Their low contribution may stem from shrubs not being consumed when grass is available, and from their limited value as protein supplements when pastures contain an acceptable nitrogen level. Leigh, Wilson and Mulham (1968) report that Kochia aphylla contributed a maximum of 2% of the diet at low and 7% at high stocking rates in autumn, when crude protein content in the selected diet was well above 12% at both stocking rates. Although Kochia has been shown to have a higher palatability than Atriplex and Artemisia (Nemati, 1977) it is probably not the relative value among shrubs that matters, but the one

to the adjacent pasture. Eyal, Benjamin and Tadmor (1975) also found that sheep performance was lower when unimproved native pasture in the 200-400 mm rainfall belt of southern Israel was substituted by 1600 Atriplex halimus/ha. On the other hand, a comparison between the productivity of sheep and cattle browsing/grazing a semi-arid Atriplex vesicaria community over a 4-year period (Wilson and Graetz, 1980), showed that liveweight gain per hectare, per year was 12.9 and 19.4 kg for cattle and 13.4 and 20.1 kg for sheep under low and high stocking rates respectively (11.7 and 17.5 ha/cow and 1.7 and 2.5 ha/ewe).

Experiments using Glyricidia maculata as a supplement to Brachiaria brizantha in the diet of milking cows indicate that incorporating the tree foliage in proportions of 50 and 100% of the diet produces liveweight gains of 14 and 10 kg/cow in a month and yields of 6.6 and 7.6 lt milk/cow/day respectively, as compared to a loss of 12 kg and a production of 5.8 lt when cows were given grass alone (Chadhokar and Lecamwasam, 1982). Reservations on the experimental methodology throw some doubt on the conclusiveness of these findings, but nevertheless suggest the high fodder potential of Glyricidia. More reliable evidence of this potential was provided by Chadhokar and Kantharaju (1980) when Glyricidia was used as a supplement to Brachiaria miliiformis in the diet of pregnant ewes. Proportions of 25, 50 and 75% of Glyricidia in the diet increased lamb survival from 33 (no Glyricidia) to 75, 71 and 100%, and lamb weight at 15 weeks from 5.4 to 9.9, 10.0 and 11.0 kg respectively. Using Glyricidia sepium, Carew (1980) found that sheep and goats fed for four months made a liveweight gain of only 30 and 14 g/day respectively, despite a DMD of 66%, a CP content of 26.1% and a dry matter intake of 3.2 and 3.1 as a percent of metabolic body weight. A closer analysis shows an adaptation period of 9 weeks, after which liveweight gains were of the order of 64 and 25 g/day for sheep and goats respectively. Hence, the slower rates would suggest a mineral deficiency.

Available information would indicate, therefore, that of the major nutritive components in a ruminant diet, foliage from fodder trubs should be mainly considered as a source of protein. Fruits, particularly pods from legume trubs, could be used as both energy and protein supplements, provided that seed protein is made digestible through mechanical treatment.

The literature reviewed on the role of fodder trees and shrubs in animal production under rangeland conditions would suggest that:

- several species have been identified for different ecological zones, which are potential sources of fodder;
- although dry matter productivity from the foliage of trubs seems to be rather small, its reliability in bad years and its presence during dry seasons makes it particularly valuable, while pod producing trubs may become a very useful source of energy and protein concentrate;
- protein supply appears to be the main nutritive role of trubs, which could be limited by low intakes;
- there is a need to undertake studies evaluating the animal production potential of fodder trubs vis-a-vis alternative sources.

## 2.2 Forest grazing

This has been defined as "any situation where trees (meaning timber producing ones) and grazed pasture are grown together as an integrated management system, the prime objective being to increase long-term net profit per hectare." However, such a system may have a quite different meaning according to the manager. As McQueen, Knowles and Hawke (1976) put it: "To the forester it may be a question of growing pasture under trees as an alternative source of intermediate income to production thinning for posts or pulpwood. It has other attractions for foresters, such as greatly improved access for pruning and thinning, and reduced fire risk. The farmer, on the other hand, regards forest farming as the growing of tree crops on pasture land for a long-term investment with the minimum of prejudice to current farm production. Forest grazing can be seen as a complete production system, perhaps comparable with grain and fat lamb farming systems, rather than as an opportunist enterprise. Accordingly, in research as in practice, it is necessary to place equal emphasis on both the agricultural and the forestry aspects."

Forest grazing is practised as a commercial system in Australia (Borough, 1977), Britain (Adam, 1975), Fiji (Bell, 1981) New Zealand (Tustin and Knowles, 1975), USA (Burton, 1973); Knowles, 1979) and it has been

suggested as an alternative form of land use for the Amazonia (Kirby, 1976). A comprehensive overview of the technology as practised in Australia has been published by the CSIRO (Anonymous, 1978), and a list of most relevant references has been put together by ICRAF (1981).

Results from economic analysis of forest grazing are somewhat contradictory. Borough and Reilly (1976) carried out a theoretical analysis of three alternative strategies, namely: (1) grazing beef cattle on improved pastures (beef strategy of BS); (2) radiata pine plantations (RPS); and (3) combined beef grazing and radiata pine plantations (FGS). Pulpwood and sawlogs were assumed to be produced from the RPS and FGS over rotations of 30 and 25 years respectively, and two levels of log prices were examined. Results in terms of the Present Net Worth (or the sum of the discounted returns and discounted costs over one rotation) showed the RPS to be the most profitable alternative ($231 and 368/ha for low and high sawlog prices respectively), followed by the FGS ($224 and 347) and the BS ($101). In discussing the small difference between RPS and FGS, the authors assumed that early returns from pasture and beef and the additional value added to sawlogs due to early thinning and pruning in the FGS, apparently offset the bulk of the losses induced by the pruning and thinning operations. They conclude that if some allowance is made for the riskiness of the three alternatives the farmer would almost certainly opt for the FGS (Forest Grazing Strategy).

The assumption of Borough and Reilly (1976) that wider spacement in FGS does not affect the yield of sawlog has been substantiated by McKinnell (1979). The data in Table 15 indicate that total volume of timber produced under two thinning regimes of radiata pine planted in 1957 was not significantly different.

However, it should be stressed that the larger branch diameter induced by wider spacement of the FGS required a strictly timed pruning of the limbs up to 10 m from the ground; otherwise large knots would have affected wood quality. The labour and equipment necessary for this kind of operation may become an economic drawback in the application of such a system. (Using other trees with self-pruning properties would be particularly relevant, like Jacaranda copaia in the lowland humid tropics, which is being used for ship

TABLE 15 COMPARISON OF YIELD DATA, TREATMENTS 1 AND 6, MUNGALUP EXPRIMENT (McKinnell, 1979)

| Age | Treatment 1 | | | Treatment 6 | | |
|---|---|---|---|---|---|---|
| | spha | Yield ($m^3$/ha) Pulp | Yield ($m^3$/ha) Saw | spha | Yield ($m^3$/ha) Pulp | Yield ($m^3$/ha) Saw |
| 8.2 | 1108 | - | - | 500 | 76.6 | - |
| 12.6 | 1108 | - | - | 250 | 133.1 | - |
| 19.5 | 500 | 114.5 | 59.3 | 125 | 18.0 | 196.4 |
| Standing volume at 20.5 yrs ($m^3$./ha) | | 110.0 | 429.3 | | 17.5 | 304.0 |
| Total volume produced ($m^3$ $ha^{-1}$) | | 224.5 | 488.6 | | 245.2 | 500.4 |

board manufacturing in the Peruvian Amazon). Nevertheless, an economic analysis carried out by Gisz (1978) challenges the results obtained by Borough and Reilly (1976). Results show that assuming a 25 year rotation the internal rate of return for a FGS would be 16.1%, while that of a sheep-only strategy would reach 22.1%. On the other hand, Knowles (1975) arrived at the conclusion that the financial return from sheep grazing operation would be $66.1/ha, while those from a forest grazing system would be $84.9. In this paper he discusses some factors the farmer should consider in evaluating a forest grazing approach, such as farm size and stocking rate, farm location and plot size.

Practices to be followed in implementing a forest grazing system seem to have reached a 'prescription' stage, at least for the combination of Pinus radiata with improved pastures in the temperate zones of Australia and New Zealand.

On the establishment of trees (Pinus radiata) on pasture the recommended technique is to apply Paraquat-simazine as spots or strips before planting. For 1 and 1.5 year-old seedlings, growth rate at 18 months was 29 and 33% faster respectively when the herbicide was used than when it was not (Tustin, 1974). On the effect of browsing damage to trees, studies indicate that growth rate is affected by 10% when tree leaders are browsed in the first spring only, by 34% when leaders are browsed in the first spring and autumn, and by 46% when in addition to that they are browsed in the second spring (Tustin, 1975). However, cattle display a marked propensity to browse and debark trees, so it is preferable to use sheep, which can be introduced from the second year onwards. According to Tustin, Knowles and Klomp (1979), a suitable grazing system for both weaned lambs and older sheep is to stock at 12-25 animals/ha in autumn (March) so that the pasture is eaten out by early spring (August/September), and then to remove the sheep for 3-4 months to prevent browsing during the critical spring period. In the intervening period hay silage cropping is advocated (Gillingham, Klomp and Peterson, 1976). It is interesting to note that no mention is made of a taungya alternative, which appears as biologically feasible and economically viable (establishing trees in combination with food crops, which are substituted by pastures when trees are out of reach of animals). Cattle should not be

introduced until trees are more than 4 m high.

The recommendation on silvicultural management calls for planting pines in improved pasture at 2 x 5 m spacing (1000 trees/ha; thin at age 5 to 500 trees/ha and pruning the remaining trees to 30% of height; prune trees to 40% tree height at age 8; thin to 200 trees at age 12 and prune remaining trees to 50% of height; and finally clearfell trees at age 25 (Knowles, Klomp and Gillingham, 1973). Livestock carrying capacity will be negatively related to tree age. If it is considered 100 when trees are 3 years old, it will be reduced to 90 when they are 4, 80 when 5, 50 when 11 and 10 when 18 (Forest Research Insitute, 1978).

Available information would suggest that forest grazing is a technically feasible alternative, its economic viability depending on the technical and economic potential of the timber tree and the livestock enterprise, as well as the duration of the production cycle and access to financial capital.

## 2.3 Plantation grazing

Intercropping of tree crops, particularly coconuts, for increasing agricultural production in the tropics is an old practice. The application of multiple cropping principles can produce substantial amounts of additional crops without impairing coconut yields and the fertility of the soil (Ramachandran Nair, 1979). Only intercropping of tree crops with pastures for animal production will be considered under this topic.

### 2.3.1 Coconut Plantations

A comprehensive and updated review of all aspects related to managing pastures and cattle under coconut can be found in the book by Plucknett (1979). An annotated bibliography containing 328 references has also been prepared by Reynolds (1978a). In a recent review Reynolds (1980) concluded that the grazing of cattle on improved pastures under coconuts results in extra income from the sale of animal products and increased returns from copra, although he admits that debate about which crop to establish under coconuts will continue. Although pasture establishment costs as estimated by Reynolds (1980) appear quite high (US$128/ha), they would be compensated by returns from beef (US $97 to $153, depending on the pasture species

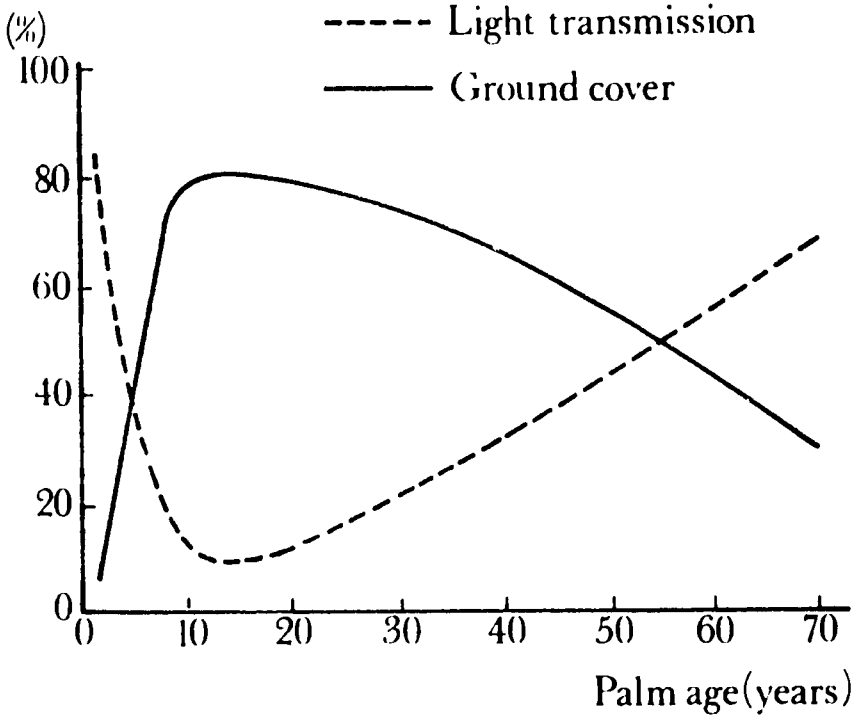
used), particularly considering the maintenance costs after establishment are in the order of US $35/ha/yr.

The main factor governing the intercropping of pastures and coconuts is the shading effect of coconut trees. Figure 7 shows that pastures could only thrive under young and mature stands.

Under such conditions, shade tolerance of grasses appears as one of the most important factors for a successful combination.

In Western Samoa Reynolds (1978b) compared the production of native pastures with that of 15 species growing under coconuts allowing approximately 50% light transmission. Two Panicum maximum varieties were ranked within the top production level grouped (14-16 t of DM/ha/yr), followed by another P. maximum (var. Embu, or Creeping guinea) and Brachiaria

Figure 7. Effect of stand age on light transmission (Nelliat, Baapa and Nair, 1974).



humidicola in the 10-14 t group. Production from local pastures was in the order of 8 t/ha/yr.

These results have been somewhat challenged by experiments in the Solomon Islands, where mean light transmission was 30.7%, but actually 43% of the area under coconuts received less than 10% of the outside intensity (Steel and Whiteman, 1980). All ten grasses evaluated showed a general pattern of declining yield with time, dropping from a level of 1120 kg DM/ha at first harvesting to approximately 200 kg in the second year. In the first year P. maximum cv. Embu and Brachiaria miliiformis were the highest yielding, but both suffered considerable insect damage and failed to recover, while B. brizantha gave the highest yield in the second year after a poor establishment. Results suggested that where Axonopus sp. (a naturalized grass) is already established there may be little advantage in planting introduced species.

A possible explanation of these apparently contradictory results may lie with the applied level of management. As a result of experiments carried out over nearly four years on pastures under coconuts with 50-80% light transmission in Western Samoa, Reynolds (1981) concluded that when low management levels are employed Ischaemum muticum would give a moderate increase in animal production over local pastures, possibly offset by a slightly adverse effect on coconut yields. For better management levels fertilized Brachiaria miliiformis, brizantha and humidicola offer considerable increases in forage production, liveweight gains and possibly coconut yields.

The inclusion of legume species in the sown pasture seems not only to increase the carrying capacity but also coconut yield. Experiments in Bali, Indonesia, show that a mixture of grass and legume species (where Brachiaria decumbens and Centrosema pubescens were the most successful) was able to produce 733 kg/ha of liveweight at 6.3 beasts/ha, and to increase nut yield and weight by more than 50% when compared to the volunteer pasture (Rika, Nitis and Humphreys, 1981).

### 2.3.2 Rubber plantations

Wan Embong (1978) has proposed the application of an integrated farming concept to rubber smallholdings, where livestock will play a role after food

intercropping becomes uneconomical due to shading in the interrow. Under these circumstances two livestock enterprises appear possible: poultry and small ruminants.

Poultry rearing is actually based on the utilization of feed either purchased or produced outside the plantation. This is only used as a place to build the housing facilities for poultry and to supplement concentrate feeding with grasses and herbs growing underneath rubber trees. Profitability of the poultry enterprise has been shown to range between 16 and 26%, depending mainly upon the cost of feed (Lee, Ng and Goh, 1978).

Interaction with the tree components comes mainly as a result of both 'weeding' of the plantation by the roaming chickens and 'manuring' via poultry droppings. Wan Embong and Yan Kuan (1976) reported that in an 18-month period the average girth increment of rubber trees in the plot where poultry were reared was 12% higher than in control trees. Wan Embong (1977) has also studied the potential of sheep rearing under rubber. Forage dry matter yield of the natural vegetation (composed of grasses, broad leaves and ferns) was in the order of 500-600 kg/ha, 60 to 70% of the components being suitable for ruminant feeding with a crude protein content of 10-11%. Performance of sheep grazing this vegetation was found to be comparable to 'normal' rearing, but unfortunately no carrying capacity data were provided. As in the case of coconut, there is certainly scope for improving the quantity and quality of fodder growing underneath rubber trees by substituting introduced species for natural vegetation.

### 2.3.3 Cashew plantations

As a result of experiments carried out in the coastal zone of Kenya, Goldson (1980) concluded that milk production from cashew pastures can be equal to that from open fields, although it should be stressed that pasture availability was never a limiting factor. The main beneficial effect of the cashew trees appear to be the provision of shade and comfortable conditions to animals, under which they could spend a longer grazing time. The indirect effect through the pasture was apparent at certain times of the year, but it was not directly proved.

Grazing under tree crop plantations appears, as in the case of forest plantations, a technically feasible and economically viable alternative land management system. Conclusions reached by Thomas (1978) in his review appear still to be valid ones, when he says that: "Of the three tree crops considered (rubber, oil palm and coconut), the greatest opportunity for pasture establishment and livestock integration exists within mature coconut plantations where tall unimproved strains are grown. Pasture growth would not be severely limited by low light intensity and there would be no competition for light detrimental to the coconut. However, there is a need for more quantitative information on the comparative productivity of grasses, legumes and grass-legume mixtures under coconuts and the effect of different stocking rates and grazing systems."

## 3. The service role

There are many service roles trees can play and a comprehensive review of them is beyond the scope of this paper. Discussion will therefore be limited to those roles considered more relevant for silvopastoral systems, i.e., those affecting productivity of the understorey vegetation, providing shelter, and functioning as living fences.

### 3.1 Overstorey-understorey relationships

An analysis of relationships occurring in the arid and semi-arid zones is given by Shankar (1981). Ffolliot and Clary (1972) produced an annotated bibliography with 262 references covering mainly interactions that take place in the rangelands of North America.

Most of the literature of the temperate zones reports a negative relationship between tree basal area and herbaceous forage produced in the same unit of land. Under the coniferous forests of North America McConnell and Smith (1970) and Grelen, Whitaker and Lohrey (1972) reported a linear relationship, where canopy percentage or tree basal area accounted for 94 and 58% of the variation in herbage yield respectively. Pase (1958) established a logarithmic relationship and Jameson (1967) and exponential one. In an interesting analysis of the causal relationship between forest density and herbage production in a Pinyon-Juniperus community on two different types of soil, Jameson (1966) found that in all cases litter,

and not basal area, was the most important factor influencing blue grama production. As expected, the negative effect of tree basal area on herbage production also negatively affects the carrying capacity of the range (Clary, Kruse and Larson, 1975). Studies on Mulga (Acacia aneura) communities in Australia have shown similar relationships (Beale, 1973 and Pressland, 1976). In the same zone and in woodlands dominated by Eucalyptus populnea, Walker, Moore and Robertson (1971) had also found that the relationship between herbage weight and woody plant density consistently had the same form and closely fitted a transition sigmoid curve. However, when tree-grass relationships were analyzed on a individual basis (as opposed to per unit of land) Christie (1975) found that the yield of Cenchrus ciliaris from the microhabitat under Eucalyptus populnea was much higher than the one from the inter-tree areas (300 and 107 g/per sq. metre, respectively). This increase, attributed mainly to higher pH, phosphorus and potassium levels (Ebersohn and Lucas, 1965), means that 7% of the area (for an average microhabitat area of 700 sq. metre with a tree density of 20/ha) has the potential to produce around 20% of the total available herbage per hectare. Would the apparent contradiction be explained by the tree density data used to derive the equations, (which in the case of Pressland's work range from 40 to 640)? Analyzing the effect of varying density of Zizyphus nummularia on grass production Kaul and Ganguli (1963) reported that yield was higher when shrub density increased from 11 to 14% (770 to 875 kg/ha respectively), but declining to 545 kg when shrub density reached 18%.

Studies on the effect of tree canopies on yield of Panicum maximum in semi-arid zones tend to corroborate the beneficial relationships at the microhabitat level. Using data from a sub-tropical 'miombo' savanna on sandy soils with low inherent fertility, Kennard and Walker (1973) found that yields of Panicum were highest under open canopy sites (447 g/sq. metre), followed by those from the open grassland (302 g/sq. metre and the closed canopy (276 g/sq. metre). It was reported that sites under closed and open canopies were associated with a higher rate of water infiltration and a higher water-holding capacity, exchangeable magnesium, calcium, potassium and organic carbon in the soil, while average light intensity and mean surface temperature were lower. These results are supported by data from the sweet bushveld in the

Transvaal (Bosch and Van Wyk, 1970). In association with Combretum apiculatum the number of Panicum plants per square foot outside and inside the canopy were 0.00 and 1.13 respectively. Corresponding figures for Boscia albitrunca were 1.00 and 1.52, for Acacia senegal 1.00 and 2.87 and for Acacia tortilis 2.62 and 3.92. Greenhouse experiments using 'open soils' and 'tree soils' indicated that beneficial effects of the Panicum-tree association are largely due to soil enrichment by trees.

Beneficial effects of tree microhabitat on pasture growth have also been reported for humid zones. Jagoe (cited by Masefield, 1957) showed that in Malasia Axonopus compressus gave higher yields and contained higher protein when grown under Samanea saman (raintree) and two other leguminous trees, than when grown under non-leguminous trees or in the open. Similar results were found by Daccarett and Blydenstein (1968) in Turrialba, when analyzing the relationship between Erythrina peoppegiana, Phitecelobium (or Samanea) Saman, Glyricidia sepium and Cordia alliodora and the Panicum maximum -- Papspalum fasciculatum -- Homolepis aturensis -- Digitaria decumbens pasture growing underneath. None of the trees reduced dry matter production significantly, in relation to the unshaded control plot. Protein percentage of the herbage under Erythrina was significantly higher than under any other species.

Differences between tree species in the beneficial effect of their microhabitat are also apparent in the arid zones. Comparing the yield of Cenchrus ciliaris under the canopies of leguminous trees in Rajhastan Shankar, Dadhich and Saxena (1976) found that differences in dry matter production between tree species could differ as much as 287%. Giving a value of 100 for the amount of grass grown under Prosopis juliflora and Acacia senegal (800 kg/ha), that under Albizia lebbeck was 163, beneath Tecomella undulata 200, and 287 for Prosopis cineraria. As mentioned, most of these beneficial effects deriving from a close association between tree and grasses have been attributed to improvements in soil fertility. It is well known that the agroforestry 'wonder' tree (Acacia albida) can increase C, N, available P and Total Exchangeable Cations by 92, 94, 134 and 90% respectively (Charreau and Vidal, 1965). Although the higher nutrient content in soils under Acacia albida

may in part have been transferred from elsewhere by livestock either taking shelter from the sun or browsing lopped branches (personal observation), it could not explain by itself the recorded level of increase. The genus Prosopis has also been associated with higher organic C, total N and available P in soils underneath the canopy (Singh and Lal, 1969) and Tiedemann and Klemmedson, 1973). But soils under Tecomella undulata and Albizia lebbeck have been shown to have higher total N than under Prosopis cineraria and juliflora (Aggarwal et al., 1976). Garcia Moya and McKell (1970) also found in a low fertility desert plant community (mainly Acacia Gregii, Cassia armata and Larrea divaricata) that soil N content decreased significantly as a function of radial distance from the centre of the shrub canopy. These findings may be particularly relevant in the light of the predominant role that N may have over moisture availability for plant productivity in semi-arid regions (Felker et al., 1980)

But soil enrichment may not be the only reason for an improved microhabitat. Tiedemann and Klemmedson (1977) conducted studies in the mesquite-desert grassland to assess effects of shade, roots and litter of mesquite trees on understorey vegetation and microenvironmental factors. They concluded that Prosopis juliflora exerted a strong influence on net radiation and soil temperature in the area directly beneath the canopy. This improved conditions for establishment and growth of vegetation compared to surrounding open areas.

Redistribution of rainfall may be another cause for the development of a favourable microhabitat underneath the canopy. A high proportion of the incoming precipitation may be intercepted by the canopy, depending on its structure. Some of the intercepted water is lost to the atmosphere, some falls to the soil surface (throughfall); and some is held by the various canopy surfaces (such as leaf and bark), while the remainder is channelled to the ground by the leaves, branches and stems (stemflow), to penetrate in close proximity to the tree bole.

Working with Acacia aneura Slatyer (1965) and Pressland (1973) found stemflow to be ecologically important, calculating that redistribution of a 25 mm rainfall would amount to 140mm of rain in the 'area of infiltration' around the trunk.

## 3.2 Shelter

Of the many uses of shelter only those affecting livestock directly or indirectly (through pasture production) will be discussed here. An extensive bibliography on the effects of environement on livestock has just been published (Stevens, 1982). Although unfortunately it has not been arranged by subject matter but in aphabetical order, the more than 1900 references on the effect of temperature, humidity, wind, thermal radiation, rain, noise and altitude for cattle, swine, sheep and poultry makes it a very valuable document.

Literature on the specific effect of shade trees or tree windbreaks is very scarce. A thesis by Goldson (1973) on dairy production in a cashew-pasture combination in coastal Kenya indicates that the biggest contribution of the trees to the animal was the reduction of solar radiation, reflected on the animal behaviour. However, there was no difference between the milk yields of animals in four treatments with and without shade during the wet and dry seasons.

Under the cold windy weather of New South Wales sheltering lambing ewes from the wind chill by using a tall unpalatable phalaris (not precisely a woody perennial!) reduced mortality of single lambs from 17.5 to 8.9%, and that of multiple births from 51.3 to 35.8% (Alexander et al., 1980).

Shelter of pasture is an important aspect in animal production under grazing conditions. The effect of shelter on the productivity of grasslands was reviewed by Marshall (1967). The effect of artificial windbreaks (sheet iron fences!) on behaviour and production of sheep in adjoining paddocks was studied by Lynch and Marshall (1969), during drought and non-drought years, at three stocking rates. During the drought year increase in sheep body-weight was higher in the sheltered than unsheltered paddocks, ranging from 7.4 to 21.6% in the low and medium stocking rates. Pasture production from the sheltered paddocks was about double that of the unsheltered ones in all stocking rates. Differences in body weight during the rainy years were in the order of 20%, but only for the medium and high stocking rates. Again pasture production was twice as much in the sheltered paddocks than in the unsheltered ones. It was concluded that variation in animal productivity was

largely due to differences in pasture avalability rather than to an effect of shelter as such. This increase in pasture availability under sheltered conditions may have been due to an increase in soil water availability, as reported by Lynch, Elwin and Mottershead (1980). They recorded soil water in 80 x 30 m paddocks, protected with 1 m high poly-ethylene mesh along the 80 m side, over a dry period of 29 days after soil had drained to field capacity. Significantly less water (12.3 mm) was lost from the two sheltered paddocks, resulting in a higher herbage availability and in an 18% higher metabolizable energy intake by the grazing sheep. Should this beneficial effect of artificial barriers not be offset by the tree-pasture competition in trub windbreaks, these should be considered in environments where there are periods during which water stress is the main factor limiting plant growth.

Wind may also affect pasture growth directly. In experiments where Festuca arundinacea and Lolium perenne grasses were exposed to constant windspeeds of 1.1, 4.0, 7.4, and 10.0 m $s^{-1}$ m in a wind tunnel for 14 days, Russell and Grace (1978a and 1978b) found that increasing windspeed reduced the rate of leaf extension, the relative growth rate and the leaf area ratio. These effects could not be attributed to water stress, for, although leaf conductance increased with exposure to high wind, no effect on leaf water potential was detected. Having observed that rate of photosynthesis was not affected either, they concluded that mechanical stimulus itself may have caused the reduction in leaf growth rate.

It has been shown that shading may have an adverse effect upon both growth and chemical composition of pasture species, at least under temperate conditions. When two grasses and two legumes were grown at three illuminances (between 100 and 34%), Ludlow, Wilson and Heslehurst (1974) reported that the relative growth of grasses was more affected than that of legumes, resulting mainly from a greater decrease in net assimilation rate. Shading temperate grasses has been shown to reduce the proportion of soluble carbohydrates, calcium and phosphorus, and increase the proportion of cellulose and lignin (McEwen and Dietz, 1965; Hight, Sinclair and Lancaster, 1968). However, the known negative effect of temperature upon quality of forage grasses (Deinum, 1966) may lead to a beneficial effect of shading under tropical conditions.

### 3.3 Living fences

The role of woody perennials as components of living fences could be that of providing living poles, on which wire is fastened, or living fences, which would not require wiring. These management tools, especially living fences, acquire particular relevance under grazing/browsing systems, either under arid to semi-arid conditions (where the cost of fencing per head of livestock goes up as carrying capacity decreases), or in the more humid regions (where poles have to be replaced quite often). In an analysis on the economic aspects of browse development in Africa done by ILCA (1980) investments on wire fences appear as one of the most limiting factors affecting the economic viability of browse trub plantations. This author has estimated that for a 30 ha property in the Pucallpa area of the Peruvian Amazon the maintenance of boundary fencing and two internal divisory lines would have an annual cost equivalent to the gross income from hectare of rice.

Recognizing that the use of trubs as living poles has become a widely diffused technique in various ecological zones of Costa Rica, Sauner (1979) identified 57 species as being regularly planted as components of fences. The 26 most important ones are described in his paper. Looking for a fast growing shrubby plant, easily propagated by cuttings and unpalatable to animals, Calvert and Errington (1975) tried in the New Hebrides four species (Citrus acida, Bougainvillea, Pandanus and Nerium oleander) with varying degrees of success. Crane (1945) has also described species and methods used in Cuba at that time.

In addition to the species mentioned in the cited references, this author has seen a very impressive 'bull strong, horse high and pig tight' living fence made of bread fruit (Artocarpus altilis) in the alluvial plains of Peruvian Amazon, which serves a double purpose, as fence and as a source of food and pig feed. The use of Euphorbia sp. in the medium potential highlands of East Africa by small farmers is a common feature as a single purpose fence. In the Rajhastan desert this author has also seen the use of Prosopis juliflora as a double-purpose living fence, which had to be protected during the first few years of development.

Although limited, the literature reviewed serves to indicate the potential for a service role in woody perennials as components of agroforestry systems that include livestock. Moreover, it would suggest the scope for incorporating that role in species playing a productive one.

## 4. Conclusions

Despite the relative scarcity of information reviewed, it suggests some tentative conclusions to guide research efforts in the field of woody perennials as components of silvopastoral or agrosilvopastoral land management systems.

i) There appears to be a greater scope for improving the contribution of woody perennials to the so-called browsing systems than to either forest or plantation grazing;

ii) Improvements in forest and plantation grazing systems would be mainly linked to research on the pasture components (particularly selecting for shade tolerant species), although something can be achieved through silvicultural or horticultural management or by selecting less competitive self-prunning species, if marketable (e.g., *Jacaranda copaia* for the lowland humid tropics).

iii) It seems that the contribution of woody perennials to browsing systems could be channelled through the foliage-producing shrubby type of plants or the fruit bearing tree type ones, although a clear differentiation between the two types may appear rather arbitrary at this stage.

iv) Of the two types the fruit-bearing tree one appears as the most promising alternative.
- their potential for contributing to the quantitative and qualitative fodder availability in the systems seems higher, although available information is not conclusive. In the lowland humid tropics the advantages of *Leucaena* over herbaceous legumes as a fodder source under more intensive systems has to be tested, particularly when the management drawback of toxicity is considered.

Under more arid conditions foliage producing shrubs can certainly offer protein-rich dry matter during the dry period, but the palatability factor throws some shadow on their nutritive value.

- Competition with the other source of fodder in the system (associated grassland) would appear to be lower, or even non-existent, for the tree type, while closeness to the ground of the shrubby type would affect not only grass growth but accessibility to herbage of the grazing animal.
- Direct harvesting of shrub foliage would constrain its use to browsers unless lopping is envisaged, with the corresponding increase in labour (probably not in a critical period). On the other hand, ripe fruits (particularly legume pods) are usually relished by both grazers and browsers, although full utilization of their nutrient contents will, in most cases, require mechanical crushing or grinding.
- Harvesting and storing of fruit fodder would be much simpler than for foliage, if there is a need to use it at other times than when fodder is produced.
- Trees appear better than shrubs at providing the auxiliary role of shelter for animals.

v) Whatever strategy is followed (foliage or fruit) the service role of species (particularly fostering of pasture growing underneath) should be a determining factor in the selection process. Certainly the legume family has definite advantages in this field.

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## R8 - REFERENCES


Adams S.N. (1975). Sheep and cattle grazing in forestry: A review. J. Appl. Ecol. Vol. 12: 143-152.

Aggarwal P.K., Gupta J.P., Saxena S.K. and Muthana K.D. (1976). Studies on soil physicochemical and ecological changes under twelve years old five desert tree species of Western Rajasthan. Indian Forester 102:863-872.

Alexander G., Lynch J.J., Mottershead B.E. and Dondly J.B. (1980). Reduction in lamb mortality by means of grass windbreaks: results of a five year study. Proc. Austr. Soc. Anim. Prod. 113:329-332.

Alferez A.C. (1978). Management of ipil-ipil for forage. In: Int. Consultation of Ipil-Ipil Research. A PCARR, Philippines and NAS, USA Publications, pp. 51-56.

Anonymous (1978). Agroforestry, a new kind of farming? Rural Research, A CSIRO quarterly 99:4-9.

Bartha R., ed. (1970). Fodder plants in the Sahel zone of Africa. IV Chemical analyses of the fodder plants. pp. 257-275.

Beale, I.F. (1973). Tree density effects of yield of herbage and tree components in South West Queensland mulga (Acacia aneura F. Muell.) Scrub. Trop. Grassl. 7(1):135-142.

Bell T.I.W., (1981). Tree spacing and cattle grazing in young Pinus caribaea plantations in Fiji. Fiji Pine Research Paper.

Bandari, D.S. and Gupta, M.L., (1972). Studies on the digestibility and nutritive value of Ardu (Ailanthus excelsa Roxb.). Indian Vet. J. 49(5):512-517.

Bhargava, B., U.C. Katiyar and R.P. Saxena, (1977). A note on the nutritive value of rainy (Mellotus philippenisis) tree leaves as sole feed for sheep. Indian J. Anim. Sci. 47(9): 594-595.

Bille, J.C. (1980). Measuring the primary palatable production of browse plants. Int. Symp. on browse in Africa, ILCA, Addis Ababa, April (In press).

Bohra H.C. (1980). Nutrient utilization of Prosopis cineraria (Khejri) leaves by desert sheep and goats. Annals, of Arid Zone 19(1 and 2), 73-81.

Borough C.J. and Reilly J.J. (1976). Integrated farming and forestry. 'Limits to growth and options for action.' Aust. Inst. Ag. Sci. National Conference.

Borough C.J. (1977). Multi-tier forestry in Australia. Australian Forestry Development Institute National Conference. Part I. Papers and Proceedings.

Bosch O.J.H., and Van Wyk J.J.P. (1970). The influence of bushveld trees on the productivity of Panicum maximum: a preliminary report. Proc. Grassl. Soc. S. Africa. 5:69-74.

Brewbaker, J.L., Plucknett D.L. and Gonzalez V. (1972). Varietal variation and yield trial of Leucaena leucocephala (Koa Haole). Hawaii, Agric. Expt. Station, Univ. of Hawaii. Res. Bull. 166, 29 pp.

Brewbaker, J.L. and Hylin, J.W. (1965). Variations in Mimosine among Leucaena species and related Mimosaceae. Crop Science 5:348-349.

Brewbaker, J.L. (1976). The woody legume Leucaena: promising source of feed, fertilizer and fuel in the tropics. Univ. of Hawaii, Honolulu, Hawaii, USA.

Burton, G.W. (1973). Integrating forest trees with improved pastures. In: Range resources of the southeastern United States. Amer. Soc. Agron. Special Pub. No. 21.

Calvert, K.C. and Errington, S. (1975). Some experiments in local fencing materials in the New Hebrides. South Pacific Bulletin, 4th quarter, pp. 24-25.

Carew, B.A.R. (1980). Use of Gliricidia sepium as a forage feed in small ruminant production: A progress report, mimeo ILCA, Ibadan, Nigeria.

Carew, B.A.R., Mba, A.U. and Egbunike, G.N. (1981). Chemical composition and nutritional value of browse plants in the humid zone of Nigeria. Paper presented at the 3rd Int. Symposium on nutrition and systems of goat feeding, Tours, France.

Chadhokar, P.A. and Kantharaju, H.R. (1980). Effect of Gliricidia maculata on growth and breeding of Bannur ewes. Trop. Grassl, 14, (2):78-82.

Chadhokar, P.A. and Lecamwasam, A. (1982). Effect of feeding Gliricidia maculata to milking cows: A prelimimary report. Trop. Grassl, 16, (1):46-48.

Charalambous, J. (1966). The composition and uses of carbon bean. Central Chemistry Laboratory, Agric. Res. Inst, Nicosia, Cyprus.

Charreau, C. and Vidal, P. (1965). Influence de l'Acacia albida Del. sur le sol, nutrition minerale et rendements des mils Pennisetum au Senegal. Agron. Tropicale 20:600-626.

Christie, E.K. (1975). A note on the significance of Eucalyptus populnea for buffet grass production in infertile semi-arid rangelands. Trop. Grassl. 9(3):243-246.

Cisse, M.I. (1976). Effects of various stripping regimes on foliage production of some browse bushes of the sudano-sahelian zone. ILCA, Addis Ababa.

Clanet, J.C. and Gilliet, H. (1980). Commiphora africana, browse tree of the Sahel. Int. Symp. on browse in Africa, ILCA, Addis Ababa.

Clary, W.P., Kruse, W.H., and Larson, F.R. (1975). Cattle grazing and wood production with different basal areas of ponderosa pine. J. Range Manage 28(6):434-437.

Crane, J.C. (1945). Living fence posts in Cuba. Agriculture in the Americas 5(2):34-38.

Daccarett M y Blydenstein J. (1968). La influencia de arboles leguminosos y no leguminosos sobre el forraje que crece bajo ellos. Turrialba 18:405-408.

Deinum, B. (1966). Influence of some climatological factors on the chemical composition and feeding value of herbage. Proc. of the X Int. Grassl. Cong., Finland, Sect. 2 (paper 15):415-418.

De Kock, G.C. (1967). Drought resistant fodder crops. Proc Grassl. Soc. S. Afr. 2:147-156.

Diaz, H.B. (1962). Especies arboreas mas comunes de las zonas ganaderas de la Provincia de Tucuman que sirven de alimento al ganado. Turrialba, 12:195-199.

Dougall, H.W. and Bogdan A.V. (1958). Browse plants of Kenya with special reference to those occurring in South Baringo. The E.A. Agric Journal April, pp. 236-245.

Eardley, C.M. (1945). Tree-legumes for fodder. Dept. Agric. Aust. 48:342-345.

Ebersohn, J.P. and P. Lucas (1965). Trees and soil nutrients in southwestern Queensland. Qld. J. Agric. and Anim. Sci. 22:431-435.

Elgueta, S.H. and Calderon, S. (1971). Estudio del tamarugo como productor de alimento del ganado lanar en la Pampa del Tamarugal. Instituto Forestal, Inf. Tecnico No.38, 36 p.

Everist, S.L. (1969). Use of fodder trees and shrubs. Queensl. Dept. of Primary Industries Div. of Plant Industry Advisory Leaflet No. 1024, pp. 1-44.

Eyal, E., Benjamin, R.W. and Tadmor, N.H. (1975). Sheep production on seeded legumes, planted shrubs, and dryland grain in a semi-arid region of Israel. J. Range Mgmt. 28:(2):100-107.

Felker, P. (1979). Mesquite, an all-purpose leguminous arid land tree. In: New Agricultural Crops, ed. by G.A. Ritchie, AAAS Selected Symposium 38, pp. 89-132.

Felker, P. (1980). Paper to the OTA, No. 3: Development of low water and nitrogen requiring plant ecosystems to increase and stabilize agricultural production of arid land developing countries. Dept. of Soil and Environmental Sciences, Univ. of California, Riverside.

Felker, P. and Bandurski, R.S. (1979). Uses and potential uses of leguminous trees for minimal energy input agriculture. Economic Botany, 33(2):172-184.

Felker, P., Clark, P.R. Osborn J. and Cannell G.H. (1980). Nitrogen cycling - water use efficiency interations in semi-arid ecocystems in relation to management of tree legumes (Prosopis). Paper presented at the Int. Symp. on Browse in Africa, ILCA, Addis Ababa, Ethiopia. 31 p.

Ffolliot, P.F. and Clary W.P. (1972). Selected and annotated bibliography of understorey-overstorey vegetation relationships, Agric. Exp. Station, Univ. of Arizona Tech. Bull No. 198. 32 p.

Ferraris, R. (1979). Productivity of Leucaena leucocephala in the wet tropics of North Queensland. Trop. Grassl. 13(1):20-27.

Forest Research Insitute (1978). Forest farming research: A report by the interdepartmental working group on the concept of combined grazing and tree growing. Private Bag, Rotorua, New Zealand.

Fornaroli, D.D. (1961). Il Saman, Provvidenziale Planta del Venezuela. Prima nota informativa, Zootecnica E. Veterinaria 16:238-241.

Garcia-Moya E. and McKell C.M. (1970). Contribution of shrubs to the nitrogen economy of a desert-wash plant community. Ecology 51(1):81-88.

Garrison G.A. (1953). Effects of clipping on some range shrubs. J. Range Mgmt. 6:309-317.

Gillingham, A.G., Klomp B.K. and Peterson S.E. (1976). Stock and pasture management for establishment of radiata pine in farmland: Reprinted from Proceedings of the New Zealand Grassland Association 37(1):38-51.

Gisz, P.L. (1978). Economic analysis of private investment in Radiata pinesheep production. Unpublished information.

Gohl, B. (1981). Tropical feeds. FAO, Rome.

Goldson, J.R. (1973). The effect and contribution of the cashew tree (Anacardum occidentalis) in a cashew-pasture-dairy cattle association in the Kenya coast. An unpublished thesis presented to the University of Reading for the degree of Doctor of Philosophy.

Goldson, J.R. (1980). A brief description of a research project to investigate the effect and contribution of the cashew tree (Anacardium occidentale L.) in a cashew-pasture-dairy cattle association at the Kenya coast. Kenya National Seminar on Agroforestry, ICRAF, Nairobi.

Gray, S.G. (1970). The place of trees and shrubs as sources of forage in tropical and sub-tropical pastures. Trop. Grassl, Vol. 4:57-62.

Grelen, H.E., Whitaker L.B. and Lohrey, R.E. (1972). Herbage response to precommercial thinning in direct seeded slash pine. J. Range Manage 25:435-437.

Guevarra, A.B., Whitney, A.S. and Thompson, J.R. (1978). Influence of intrarow spacing and cutting regimes on the growth and yield of Leucaena. Agron. J. Amer. Soc. 7(6): 1033-1037.

Gupta, B.S. (1980). Nutritive value of Siris, (Albizzia lebbeck) tree leaves. Ind. J. Nutr. Dietet, 17:187.

Gupta, M.L. and Mathur C.S. (1974). Studies on the seasonal variation in the chemical composition of Kheiri (Prosopis spicigera LINN.). Ind. For, 100:269-273.

Gupta, P.R., Guha P.C., Kehar, N.D. and Goswami M.N.D. (1951). Bauhinia variegata leaves as cattle feed. Science & Culture, Vol. 16, No. 10.

Gwynne, M.D. (1969). The nutritive values of Acacia pods in relation to Acacia seed distribution by ungulates. E. Afr. Wildl. J. 7:176-178.

Hall, G.A.B. (1976). Evaluation of the seed pod of Cenratonia siliqua as a feed for animals. I Chemical characterization. Rev. Centro Ciencias Rurais 6(4):367-373.

Harvey, J.M. (1952). The nutritive value of some Queensland fodders. The Queensl. J. of Agric. Sci. 9:(3)169-184.

Hight, G.K., Sinclair D.P. and Lancaster, R.J. (1968). Some effects of shading and of nitrogen fertilizer on the chemical composition of freeze-dried and over-dried herbage, and on nutritive value of over-dried herbage feed to sheep. NZ. J. Agric. Res. 11:286-302.

Hill, G.D. (1971). Studies on the growth of Leucaena leucocephala. Papua New Guinea Agric. J, 22:73-76.

Holmes, J.H.G. (1981). Toxicity of Leucaena leucocephala for steers in the wet tropics. Trop. Anim. Hlth. Prod, 13:94-100.

Hutton, E.M. and Beattie, W.M. (1976). Yield characteristics in three bred lines of the legume Leucaena leucocephala. Trop. Grassl, 10:(3)187-194.

Ibrahim, K.M. (1981). Shrubs for fodder production. Advances in food producing systems for arid and semi-arid lands. Academic Press, 601-642.

ICRAF, (1981). Bibliography on forest grazing. 3 pp. (listing 36 references) April.

ILCA, (1981). Economic aspects of browse development. ILCA Bulletin 12, 19 p. Addis Ababa.

Jameson, D.A. (1966). Pinyon-juniper litter reduces growth of blue grama. J. Range Manage. 19:214-217.

Jameson, D.A. (1967). The relationship of tree and herbaceous understorey vegetation. J. Range Manage. 20:247-249.

Jones, R.J. (1979). The value of Leucaena leucocephala as a feed for ruminants in the tropics. World Animal Review. 31:13-23.

Jones, R., Hodgkinson K.C. and Rixon A.J. (1970). Growth and productivity in rangeland species of Atriplex. In: The Biology of Atriplex, ed. by R. Jones, Division of Plant Industries, CSIRO, pp. 31-42.

Jones R.J., Blunt C.G. and Nurnberg B.I. (1978). Toxicity of Leucaena leucocephala. The effect of iodine and mineral supplements on penned steers fed a sole diet of Leucaena.

J. Austr. Inst. Agric. Sci. (1978). Register of Australian herbage plant cultivars, B. Lugumes, 12 Stylosanthes scabra Veg. cv Seca, 44:63-64.

Jurriaanse A. (1973). Are they fodder trees? Pamphlet 116. Dept of Forestry Pretoria, South Africa.

Kadambi, K. (1963). Useful fodder trees and grasses for cultivation in Ghana. The Ghana Farmer, 3: (2)75-80.

Kargaard, J. and van der Merwe F.J. (1976). Digestibility studies with Prosopis juliflora (Mesquite thorn) pods. S. Afr. Anim. Sci. 6:35-39.

Kaul, R.N. and Ganguli B.N. (1963). Fodder potential of Zizyphus in the scrub grazing lands of arid zone. Indian Forester 89(9):623-630.

Kennard, D.G. and Walker B.H. (1973). Relationships between the canopy cover and Panicum maximum in the vicinity of Fort Victoria. Rhod. J. of Agric. Res. 11:145-133.

Khajuria, R.R. and Singh K. (1967). Studies on the chemical composition and digestibility of Dhaman tree (Grewia elastica) leaves. Indian Vet. J. 44:429-433.

Khajuria, R.R. and Singh K. (1968). Studies on the chemical composition and digestibility of Sarrien (Albezzia lebbeck) fodder tree leaves. Indian Vet. J. 45(1):70-75.

Khan, A.A. (1975). Chemical composition of certain trees and shrubs. The Pakistan Journal of Forestry Vol. 25(1):42-45.

Kirby, J.M. (1976). Forest grazing. World Crops, November/December:248-251.

Knowles R.L., Klomp, B.K. and Gillingham A.G. (1973). Trees and grass - an opportunity for the hill country farmer. Proc. of the Ruakura Farmer's Conference: 110-121.

Knowles, R.L. (1975). Trees and Grass. Farm Forestry 17(3):63-74.

Knowles, R.L. (1979). Forest grazing research and management in the United States. Forest Research Institute, New Zealand Report No. 134.

Kock, G.C. de (1967). Drought resistant fodder crops. Proc. Grassl. Soc. S. Afr. 2:147-156.

Lal, M. (1977). The pods and leaves of Acacia nilotica as nutritive cattle feed in the Siwaliks. Soil Conservation Digest, 5(2):67-69.

Lawton R.M. (1967). The value of browse in the dry tropics. E.A. agric. For J. 33(3):227-230.

Lay, D.W. (1965). Effects of periodic clipping on yield of some common browse species. J. Range Mgmt. 18:181-184.

Lee, K.A., Ng, L.N. and Goh C.L. (1978). Economics of poultry rearing under rubber. Proc. of the Seminar on Integration of Animals with Plantation Crops. Kuala Lumpur, Malaysia.

Legumes B. (1978). Registerof Australian herbage plant cultivars. J. Aust. Inst. Agric. Sci. 44: 63-64.

Le Houerou, H.N. (1978). The role of shrubs and trees in the management of natural grazing lands (with particular reference to protein production). 8th World Forestry Congress, Jakarta, Indonesia.

Le Houerou, H.N. (1980). Chemical composition and nutritive value of browse in tropical West-Africa. Int. Symp. on Browse in Africa, ILCA, Addis Ababa, April (In press).

Le Houerou, H.N.,Dumancic, D., Eskileh M., Schweisguth, D. and Telahigue T. (1982). Anatomy and physiology of a browsing trial: a methodological approach to fodder shrub evalauation. Techn. Note No. 03. Coordination of Range Research and Development. Project FAO/UTFN/LIB/018. Tripoli, March.

Leigh, J.H., Wilson, A.D. and Mulham W.E. (1968). A study of merino sheep grazing a coconut-bush (Kochia aphylla)-grassland: (Stipa variabilis-Danthonia-caespitosa) - Community on the Reverrine plain. Aust. J. Agric. Res. 19-947-961.

Leigh, J.H., Wilson, A.D. and Williams, O.B. (1970). An assessment of the value of three perennial chenopodiaceous shrubs for wool production of sheep grazing semi-aric pastures. Proc. XI Int. Grassl. Congr. pp. 55-59.

Leigh, J.H., Wilson, A.D. and Mulham W.E. (1978). Seasonal variations in the leaf fall and quality of the leaves of four Australian fodder trees. Austr. Rangeland J. 1(2):137-141.

Ludlow, M.M, Wilson, G.L. and Heslehurst, M.R. (1974). Studies on the productivity of tropical pasture plants. V. Effect of shading on growth, photosynthesis and respiration in two grasses and two legumes. Austr. J. Agric. Res. 25:425-433.

Lynch, J.J. and Marshall, J.K. (1969). Shelter: A factor increasing pasture and sheep production. Aust. J. Sci. 32(1):22-23.

Lynch, J.J., Elwin, R.L. and Motterhead, B.E. (1980). The influence of artificial windbreaks on loss of soil water from a continuously grazed pasture during a dry period. Aust. J. Exp. Agric. Anim. Husb. 20:170-174.

Mabey, G.L. and Innes, R.R. (1964.a). Studies on browse plants in Ghana. II Digestibility. (a) Digestibility of Griffonia simplicifolia from the Accra Plains using local cattle as experimental animals. Empire J of Exper. Agric. 32(126): 125-130.

Mabey, G.L. and Innes, R.R. (1964.b). Studies on browse plants in Ghana. II Digestibility. (b) Digestibility of Baphia nitida from the Accra Plains, using local cattle as experimental animals. Emp. J. of Exper. Agric. 32:126-130.

Mabey, G.L. and Innes, R.R. (1966.b). Studies on browse plants in Ghana. II Digestibility. (d) Digestibility of Grewia carpinifolia from the Accra Plains, using local cattle as experimental animals. Expl. Agric. 2:113-117.

Mahadevan, V. (1954). The composition and nutritive value of Prosopis juliflora pod. Indian Vet. J. 31, 185-187.

Majumdar, B.N and Momin, S.A. (1960). Studies on tree leaves cattle fodder. Part V. The Nutritive value of young Gular leaves (Ficus glomerata). Indian J. Dairy Sci., 13:16-19.

Majumdar, B.N., Momin, S.A. and Kehar, N.D. (1967). Studies on tree leaves as cattle fodder. I Chemical composition as affected by the stage of growth. Indian J. Vet. Sci. 37:217-223.

Malik, M.Y., Sheikh, A.A. and Shah W.H. (1967). Chemical composition of indigenous fodder tree leaves. Pakistan J. of Sci. 19(4):171-174.

Malynicz, G. (1974). The effect of adding Leucaena leucocephala meal to commercial rations for growing pigs. Papua New Guinea Agric. J. 25(Nos. 1 and 2):12-14.

Mann, H.S. (1981). Salient features of Khejri. Proc. of Summer Inst. on Agroforestry 4 Vol - CAZRI, India.

Marshall, J.K. (1967). The effect of shelter on the productivity of grasslands and yield crops. Field Crop. Abstr. 20(1):1-14.

Masefield, G.B. (1957). The value of legumes in crop associations in the tropics. World Crops. 9:479-481.

McConnell, B.R. and Smith, J.G. (1970). Response of understorey vegetation to ponderosa pine thinning in eastern Washington. J. Range Mgmt. 23:385-399.

McDonald, P., Edwards, R.A. and Greehalgh, J.F.D. (1973). Animal nutrition 2nd ed. Oliver & Boyd Edinburgh.

McEwen, L.C. and Dietz, D.R. (1965). Shade effects on chemical composition of herbage in the Black Hills. J. Range Mgmt. 18:184-190.

McKay, A.D. and Frandsen, P.E. (1969). Chemical and floristic components of the diet of Zebu cattle (Bos indicus) in browse and grass range pastures in a semi-arid upland area of Kenya. Trop. Agric., 46:279-292.

McKell, C.M. and Malechek, J.C. (1980). Wildland shrubs - a forage resource for increasing animal protein production. ILCA, Addis Ababa (Browse Symp.).

McKinnell, F.H. (1979). Silviculture of Pinus radiata in an agroforestry management system. Forests Department of Western Australia, Research Paper 51.

McLeod, M.N. (1973). The digestibility and the nitrogen, phosphorus and ash contents of the leaves of some Australian trees and shrubs. Aust. J. Exp. Agric. & Anim. Husb., Vol. 13:245-250.

McQueen, I.P.M., Knowles, R.L. and Hawke, M.F. (1976). Evaluating forest farming. Proc of the New Zealand Grassl. Association 37(2):203-207.

Mecha, I and Agdebola, T.A. (1980). Chemical composition of some southern Nigeria forage eaten by goats. Int. Symp. on Browse in Africa, ILCS, Addis Ababa.

Mendoza, R., Altamarino, T.P. and Javier, E.Q. (1976). Herbage, crude protein and digestible dry matter yield of Ipil-Ipil (Leucanea latisiliqua CV. Peru) in hedge rows. Philippine J. Crop. Sci., Vol. 1(1):149-153.

Mia, W.H., Sahai, B., Majumdar, B.N. and Kehar, N.D. (1960). Studies on tree leaves as cattle fodder. Part. III The nutritive value of Bargad leaves (Ficus bengalensis). Indian J. Dairy Sci., 13:1-8.

Mia, W.H., Majumdar, B.N., Sahai, B. and Kehar, N.D. (1960). Studies on tree leaves as cattle fodder. Part IV The nutritive vlaue of Pipal leaves (Ficus religiosa). Indian J. Dairy Sci., 13:9-15.

Momin, S.A. and Ray, S.C. (1943). Tree leaves as cattle fodder. Indian J. Vet. Sci. Vol. 13:183-190.

Moore, R.M. (1972). Trees and shrubs in Australian sheep grazing lands. Plants for sheep in Australia by Leigh, J.H. and Noble, J.C., pp. 55-64.

Nath, K., Malik, N.S. and Singh, O.N. (1969). Utilization of Zizyphus nummularia leaves by three breeds of sheep. Aust. J. Agric. Res., 20:1137-1142.

Nelliat, E.V., Bavappa, K.V. and Nair, P. (1974). Multi-storeyed cropping, a new dimension in multiple cropping for coconuts. World Crops., 26:262-266.

Nemati, N. (1977). Comparative platability of Atriplex canescens. J. Range Mgmt. 30(5):368-369.

Norton, B.W., Jones, W.R., Ball, F., Leng, R.A. and Murray, R.M. (1972) Nitrogen metabolism and digestibility studies with merino sheep given Kurrajong (Brachychiton populneum), Mulga (Acacia aneura) and native pasture (Stipa spp.). Proc. Aust. Soc. Anim. Prod. 9:346-351.

Oakes, A.J. and Skov. O. (1962). Some woody legumes as forage crops for the dry tropics. Trop Agric. Trin. 39:281-287.

Pal, R.N., Dogra, K.K., Singh, L.N. and Negi, S.S. (1979). Chemical composition of some fodder trees in Himachal Pradesh. Forage Res. 5:109-115.

Panday, K. (1975). Improtance of fodder trees and tree fodders in Nepal. Post Graduate Diploma-Thesis submitteed to Prof. Dr. J. Noesberger, Inst. of Plant Production Fed. Tech. Univ. Zurich, Switzerland.

Pase, C.P. (1958). Herbage production and composition under immature ponderosa pine stands in the Black Hills. J. Range Manage. 2:238-243.

Pathak, P.S., Rai, P. and Deb Roy, R. (1980). Forage production from Koo-Babool Leucaena leucocephala LAM). de Wit.). I. Effect of plant density, cutting intensity and interval. Forage Res. 6:83-90.

Penning de Vries, F.W.T. and Djiteje, M.A. (1982). La productivité des pasturages sahéliens. PUDOC, Wageningen, The Netherlands, p. 292.

Plucknett, D.L. (1979). Managing pastures and cattle under coconuts. Westview Trop. Agric. Series No. 2, Boulder, Colorado.

Pratchett, D., Capper, B.G., Light, D.E., Miller, M.D., Rutherford, A.S., Rennie, T.W., Buck, N.G. and Traii, J.C. (1977). Factors limiting liveweight gain of beef cattle on rangeland in Botswana. J. of Range Mgmt 30(6):442-445.

Pressland, A.J. (1973). Rainfall partitioning by an arid woodland (Acacia aneura F. Muell.) in south western Queensland. Aust. J Bot. 21:235-245.

Pressland, A.J. (1976). Possible effects of removal of mulga on rangeland stability in south western Queensland. Aust. Rangel. J. 1:24-30.

Ram, C and Ray, S.C. (1943). Tree leaves as cattle fodder. II. Digestibility coefficient and nutritive value of some tree leaves. Indian J Vet. Sci. and Anim. Husb. 13:191-195.

Ramachandran Nair, P.K. (1979). Intensive multiple cropping with coconuts in India - Verlag Paul Parey, Berlin.

Ramadan, D. (1975). A note on the nutritive value of Acacia cyanophylla seeds. Empire Journ. of Exper. Agric. Vol. 25, No. 97:37-39.

Rao, A.S., Amrith Kumar, M.N. and Sampath, S.R. (1971). Studies on Mulberry (Morus indica) leaf-stalk-palatability, chemical composition and nutritive value. Indian Vet. J Vol. 48:853-857.

Rees, W.A. (1973). Preliminary studies into bush utilization by cattle in Zambia. Journ. of Appl. Ecol. Vol. 2:207-214.

Reynolds, S.G. (1978a). Cattle under coconuts bibliography: Report number 31:Livestock and pasture agronomy report series, Dept. of Agric. Apia, Western Samoa.

Reynolds, S.G. (1978b). Evaluation of pasture grasses under coconuts in Western Samoa. Trop. Grassl. Vol. 12, No.3:146-151.

Reynolds, S.G. (1980). Grazing cattle under coconut. World Anim. Rev. 35:40-45.

Reynolds, S.G. (1981). Grazing trials under coconut in Western Samoa. Trop. Grassl. 15(1):3-10.

Rika, I.K., Nitis, I.M. and Humphreys, L.R. (1981). Effects of stocking rate on cattle growth, pasture production and coconut yield in Bali. Trop. Grassl. 15(3):149-157.

Rose Innes, R.R., and Mabey, G.L. (1962a). Studies on browse plants in Ghana. I. Chemical composition: a) monthly chemical analyses of several species of trees, shrubs, and vines browsed by free-ranging cattle on the Accra Plains. Empire Journ. of Exper. Agric. 32(126):114-124.

Rose Innes, R.R. and Mabey, G.L. (1964b). Studies on browse plants in Ghana. III. Browse/grass ingestion ratios. (a) Determination of the free-choice Griffornia/grass ingestion ratio for West African short-horn cattle on the Accra Plains using the 'simulated shrub' technique. Empire Journ. of Exper. Agric. Vol. 32, No. 127 pp. 180-190.

Rose Innes, R.R. (1965). The concept of the 'woody pasture' in low-altitude tropical tree savanna environments. IX Int. Grassl. Congr. Proc. Vol. 2:1419-1423.

Russel, G. and Grace J. (1978a). The effect of wind on grasses. V. Leaf extension, diffusive conductance and photosynthesis in the wind tunnel. J. Exp. Bot. 29(12):1249-1258.

Russell, G. and Grace J. (1978b). The effect of windspeed on the growth of grasses. J Appl. Ecol. 16:507-514.

Sauer, J.D. (1979). Living fences in Costa Rican agriculture. Turrialba 29(4):255-261.

Salinas, H.E. and Sanchez, S.C. (1971). Estudio del Tamarugo Como productor de alimento del Ganado Lanar en la Pampa del Tamarugal. Informe. Technico. No 38. Inst. Forestal, Santiago, Chile.

Saraswat, B.L., Singh, K.S. and Sandeva, K.K. (1974). A study on the chemical composition of Shisham (Dalbergia sissoo) pods at different stages of maturity. J of Agric. Sci. Res. Vol. 14, No. 1:12-15.

Shankar V., Dadhich N.K. and Saxena S.K. (1976). Effect of Khejri tree (Prosopis cineraria Macbride) on the productivity of range grasses growing in its vicinity. Forage Res. 2:91-96.

Shankar, V. (1981). Interrelationships of tree overstorey and understorey vegetation in silvipastoral systems. Lecture delivered at the Summer Institute 'Agroforestry in the Arid and Semi-Arid Zones.' CAZRI. Jodhpur, June 15 to July 14, 1981. 14 p.

Sharma, D.D., Chawla, M.S. and Negi, S.S (1968). Chemical composition and nutritive value of Bamboo (Bamboosa arundinaceae) and Kachnar (Bauhenia variegata) tree leaves. J. Res. Punjab Agric. Univ. 5(2):253-258.

Sharma, O.P. (1977). Fodder trees of Himachal Pradesh. Indian Farming:88-89.

Singh, C., Kumar., P and Rekbi, A. (1980). Note on some aspects of the feeding value of Sesbania aegyptiaca fodder in goats. The Indian Journal of Animal Science 50(2):1017-1020.

Singh K.S. and Lal P. (1969). Effect of Khejri (Prosopis speicigera Linn.' and babool (Acacia arabica) trees on soil fertility and profile characteristics. Ann Arid Zone 8:33-36.

Singh, K. and Gupta, P.C. (1977). A note on the nutritive value of Pala (Zizyphus nummularia) hay for sheep and goat. Annals of Arid Zone 16(1):157-160.

Skerman, P.J. (1977). Tropical forage legumes. FAO., Rome Chpt. 15:431-525.

Slatyer, R.O. (1965). Measurements of precipitation interception by an arid zone plant community (Acacia aneura F. Muell.). Arid zone Res. 25:181-192.

Stannard, M.E. and Condon, R.W. (1968). Fodder trees of western New South Wales. J Soil Conserv. Service, NSW., 24:74-95.

Steel, R.J. and Whiteman, P.C. (1980). Pasture species evaluation, pasture fertilizer requirements and week control in the Solomon Islands. Solomon Islands Pasture Research Project. ADAA Qld. Univ.

Stevens, D.G. (1982). The effect of environment on livestock: A bibliography. US Department of Agriculture, Agricultural Research Service, ARMS-23 52 p.

Thomas, D. (1978). Pastures and livestock under tree crops in the humid tropics. Trop. Agric. 55(1):39-44.

Tiedmann, A.R. and Klemmedson, J.O. (1973). Nutrient availability in desert grassland soils under mesquite (Prosopis juliflora) trees and adjacent open areas. Soil Sci. Soc. Amer. Proc. 37:107-111.

Trollope, W.S.W. (1981). The growth of shrubs and trees and their reaction to treatment. In:Veld. & Pasture Management in South Africa, edited by N.M. Taiton. Pietermaritzburg, South Africa - Shuter & Shooter Publ. pp. 251-261.

Torres, F. (1982). Agroforestry: concepts and practices. Proc. of the Workshop on Agroforestry for Tobacco-based farms. ICRAF/BAT (in press).

Toutain, B. (1980). The role of browse plants in animal production in the Sudanian zone of West Africa. Int. Symp. on browse in Africa. ILCA, Addis Ababa - April (in press).

Touzeau, J. (1973). Les arbres fourragers de la zone Sahélienne de l'Afrique. Thèse pour DV., Ecole Nationale Vétérinaire de Toulouse, N 75 125 p.

Tustin, J.R. (1974). What's New in Forest Research, No. 11. Forest Res. Inst, Rotorua, New Zealand.

Tustin, J.R. (1975). What's New in Forest Research, No. 12. Forest Res. Inst., Rotorua, New Zealand.

Tustin, J.R., Knowles, R.L. and Klomp, B.K. (1979). Forest farming: a multiple land use production system in New Zealand. Forest Ecology and Management, 2:169-189.

Tustin, J.R. and Knowles, R.L. (1975). Intregated farm forestry. New Zealand Journal of Forestry 20(1):83-88.

Van Soest, P.J. (1969). Newer knowledge on the composition and methods of analysis of feeding stuffs. In: Int. Encyclop. on Food and Nutrition ed by D. Cuthbertson, Vol. 17 part 1:37-58.

Walker, J., Moore, R.M. and Robertson, J.A. (1972). Herbage response to tree and shrub thinning in Eucalyptus populnea shrub woodland. Aust. J Agric. Res. 23:405-410.

Wan Embong and C.Y. Kuan (1976). Maximising returns in immature rubber smallholdings. Proc. of the RRIM Planters' Conference, Kuala Lumpur, Malaysia.

Wan Embong (1977). Utilization of ground vegetation in rubber plantation for animal rearing. Proc. of RRIM Planters' Conference, Kuala Lumpur, Malaysia.

Wan Embong (1978). The concept and potentials of integrated farming with rubber. Proc. of the Seminar on Integration of Animals with Plantation Crops. Kuala Lumpur, Malaysia.

Ward, D.E. (1975). Seasonal weight changes of cattle on semi-desert grass-shrub ranges. J of Range Mgmt. 28(2):97-99.

Willard, E.E. and C.M. McKell (1978). Response of shrubs to simulated browsing. J Wildl. Manage. 42(3):514-519.

Wilson, A.D. (1966). The value of Atriplex (Saltbush) and Kochia (Bluebush) species as food for sheep. Aust. J Agric. Res. 17:147-153.

Wilson, A.D. (1969). A review of browse in the nutrition of grazing animals. J Range Mgmt. 22:23-28.

Wilson, A.D. (1977). The digestibility and voluntary intake of the leaves of trees and shrubs by sheep and goats. Aust. J. Agric. Res. 28:501-8.

Wilson, A.D. and Graetz, R.D. (1980). Cattle and sheep production on an Atriplex vesicaria (Saltbush) community. Aust. J Agric. Res. 31:369-78.

Wilson, A.D. and Harrington, G.N. (1980). Nutritive value of Australian browse plants. Int. Symp. on browse in Africa. ILCA, Addis Ababa. April (In press).

Wilson, J.G. (1963). Nutrititional value of some common cattle browse and fodder plants of Karamoja, Northern Province, Uganda. EA Agric. For. J. 28:204-208.

Winter, W.H. and Jones, R.J. (1979-80). Animal production from low and high Mimosine Leucaena. Annual Rpt. Trop. Crops. and Past. Div. of CSIRO:135-136.

Zimmermann, I. (1980). Factors influencing the feed intake and liveweight change of beef cattle on a mixed tree savanna in the Transvaal. J of Range Mgmt. 33(2):132-136.

## R9. MANAGEMENT OF AGROFORESTRY: A SELECTIVE ANNOTATED BIBLIOGRAPHY FOR EDUCATIONAL PURPOSES

- by C. P. Veer

### Introduction

The criteria used for the selection of literature on agroforestry management was that it should deal with decision making and control of tree growing and interactions of trees, agricultural crops and animals. Sources dealing with the management of interventions in land management systems and potential agroforestry systems were also included.

The selected sources are presented in the following order: a) theoretical aspects of decision making in agriculture and forestry, b) empirical studies of management of natural resources under different conditions, and c) management of interventions.

### Theoretical Aspects of Decision Making in Agriculture and Forestry

Three books representing the major theoretical perspectives in decision making have been selected for the purpose of this review. Two of them deal with agricultural decision making and one with forest management.

The first is the work of Anderson *et al*. (1). His approach is a conditionally normative and logical one and the subject is risky choice, i.e. the choice between alternatives with uncertain consequences. The concepts of probability and utility are analysed, followed by a presentation of different procedures for decision analysis. Chapters on production under risk and whole farm planning under risk conclude the book. Until true experts in this field advise otherwise, this book is considered as a good overview of the normative approach to decision analysis in agriculture.

The second book is that of Barlett (2) where he presents different approaches to the study of farmer's decisions in developing countries. Although the normative approach is discussed, all studies represent the empirical approach, i.e. acknowledge that although often the same variables play important roles in affecting agricultural decisions, worldwide verities

do not exist. The major contributions of this book are on the presentation of: a) theoretical and methodological issues concerning the use of formal models, statistical behaviour models of decision making as compared cognitive models, attentive and preattentive aspects of decision making, measurement of alternatives open to farmers, the difference between risk and uncertainty and differential farmers' responses to these, and the tools to study agricultural decisions over the lifecycle of the household; b) comprehensive studies exploring the patterns of agricultural choices within one rural community e.g. impacts of non-agricultural alternatives on agricultural decisions, the causes and effects of traditional share cropping arrangements, and the importance of economic stratification and differential access to resources; and c) discussions on the implications of decision making research for agricultural development policy and exploration of the decision making context of aid programmes. No other reference, of the same quality work, has been identified in the literature. Collinson (5) could be used as an equivalent of a more applied nature.

Thirdly, forestry and decision making in general are described in Duerr (7) as open systems. The different services of American forests (timber, recreation, aesthetic values, water and watershed protection, rangeland and wildlife) are described as well as the social environment of forests and forestry. The presentation of models in decision making illustrates the persistent theoretical dualism of normative and empirical approaches. Although efforts have been made to integrate the two perspectives this integration has not succeeded; different aspects are described from the point of view of the different perspectives. Among the cases of American forest resource management discussed, one is of particular relevance to agroforestry: "Integrating farm and forest decisions." This book may also be relevant to agroforestry in a more indirect way. While other textbooks and courses on forest management often tend to over-emphasize the regulation of timber harvesting e.g. Osmaston (17), this book emphasizes the importance of the social environment of forests and forestry and the multiplicity of services of forests and forestry. Thus it contributes to a more "open" attitude of foresters which may be one of the prerequisites for their successful participation in agroforestry.

For some general introduction to decision-making theory refer to Hill (8), Kickert (9), Simon (20) and Thompson in Wood and Mosher (25).

Empirical studies of management of natural resources under different conditions

References under this heading include studies on the ways natural resources (preferrably trees) are controlled by hunter-gatherers, shifting cultivators and sedentary -- subsistence -- agriculturists. Very often the analysis here is not made from an explicit decision-making perspective.

Contrary to common beliefs about hunter-gatherers, Williams and Nunn (24) show that they "do actively manage their resources, through strategic ecological or economic courses of action via social controls and political maneuver or by virtue of the power of symbol and ritual." Discussions revolve around themes, such as: the relationship between scarcity of resources and its management technique, enhancing the productivity of resources and in this respect comparable to cultivation; a comparison of contrasting hunting-gathering patterns; and political aspects of resource use, land-use rights and ownership. Suggestions for agroforestry interventions for hunter-gatherers can be found in Bijttebier (3) and UNESCO (23).

An overview of different ways in which the natural environment is controlled by shifting cultivators in the Philippines was compiled by Olofson (15). The work also contains an extensive annotated bibliography (174 references) on shifting cultivation all over the world. Papers deal with societies that preserve their traditional systems versus those that change into shifting cultivators. For the traditional systems it is shown how agro-ecosystems have been developed which produce nutritional stability without destroying the environment by using a strategy of ecological variation in space and time. The importance of the role of women and of supplementary activities (like hunting and gathering) is shown. The examples of change include cases of traditional hunter-gatherers pressured into expansion of swiddens by the adjacency of lowland shifting cultivators; the effects of planned change from outside interventions; and a transition to market gardening that does not lead to a decline in labour efficiency (a very interesting case

from the agroforestry point of view). The emphasis on management of the natural environment, the combination of papers on well functioning traditional systems and on changing systems and last but not least, the extensive annotated bibliography make this book very attractive for education in agroforestry management.

A perfect source of information for educational programmes can be found in Conklin (6). To quote an expert on this atlas "The text and maps of this magnificent and detailed atlas, a tour de force made possible by aerial photography in conjunction with 2 decades of ground reconnaissance and participant observation by the anthropologist, trace the relationships between forest, food, and water among the Ifugao wet-rice terrace-builders and shifting cultivators of the Cordillera Central, Luzon. The text moves from an explanation of the composition of the atlas and the research that went into it, to the background on the relation between land and society, a detailed analysis of the ritually monitored agricultural year, and finally an interpretation of the data. It covers 39 pages...and a bibliography of 143 sources relevant to the Ifugao.... Moreover there are 187 illustrations, 111 maps and 30 historical maps." In his review article on "an ancient social forestry" (The Phillippine Forest Research Journal 5 (4): 255-262, 1980), Olofson makes more explicit the significance of these managed woodlots as indigenous models for development. It is therefore recommended that this article be studied in conjunction with the atlas.

Moving towards other geographical areas Kunstadter et al. (10) and Ruddle (19) are considered good sources of information on shifting cultivation in Thailand and Latin America (Venezuela), respectively. Kunstadter provides an analysis of economic, institutional and ecological aspects of shifting cultivation, subsistence and commercial agriculture in the forest areas of northern Thailand, Ruddle presents a very good introduction on partial and integral shifting cultivation systems in general and special attention to the role of trees in the Yukpa systems.

Based on an analysis of the differences between commercial agriculture and agriculture with a substantial subsistence component, Collinson (5) advocates an appropriate approach to the study of farm management and to interventions (research and policy)

in peasant agriculture. Procedures for empirical research of farm management are described and the efficiency of agricultural research is discussed. Also the impact of government policy on agricultural development is analysed. The analysis of the different decision premises in commercial and subsistence agriculture and the outline for empirical research make this handbook also relevant for agroforestry. Other sources on peasant farm management are Mbithi (13), Newman (14) and Ryan and Thompson (18).

Management of interventions

Three types of sources are presented here that deal with the differences between traditional and modern decision making, agroforestry-like interventions and interventions, in general. Traditonal strategies in the use and management of natural resources are defined in UNESCO (22) as a set of internally consistent activities and behavioral patterns of a group, based on a dominant value. Different strategies in three zones -- North Sudan-Sahel, South-Sahel and forest and preforest zones — are described and compared with interventions based on modern decision making. In all zones the role of trees and forests in some traditional strategies and/or interventions is discussed. Generally a profound disparity is found to exist between traditional and modern strategies, and the need for a - better - integration is emphasized. A large number of mainly West African examples is found in ORSTOM (16), especially in chapters III and IV where types of environmental strategies are described and the role of research and technology transfer is discussed. As they relate to community forestry, different institutional arrangements and production systems are discussed in Tewari and Mascarenhas (21) in the proceedings of a workshop held in India in 1980. The professional background of the majority of the participants — foresters and management scientists -- is reflected in the nature of most papers, directed at improving the contribution of the forest department to rural development through improved management of its intervention.

An introduction to systems analysis in general, and in the rural world in particular, is presented by Thompson in Wood and Mosher (25) where he makes a distinction between open systems and closed system

strategies for studying organizations. The management of agricultural development projects and analytical tools for agricultural administrators precede the final section on the task environment; this concept is illustrated with some cases.

The need for improvement in the management of agricultural interventions by extension workers and foresters is emphasized by Chambers (4). The main theme of this work is that whatever the priorities in rural and agricultural adminstration, the management of extension agents and the commercial natural resources should be high in the list.

## R9 - REFERENCES


1. Anderson, J.R., J.L. Dillon and B. Hardaker. (1977). Agricultural decision analysis. Ames: The Iowa State University Press. 344 p.

2. Barlett, P.F., ed. (1980). Agricultural decision making. Anthropological contributions to rural development. New York: Academic Press. 370 p.

3. Bijtterbier, J. (1981). Agroforestry and fight against the penury of food in the Third World - Rationalisation of the picking by the Pygmies. 74. p. Research Center for Agroforestry in Missions and Development Countries, Lalein Bijgaardenstraat 27 A, B - 1600 St. Pieters Leeuw, Belgium.

4. Chambers, R. (1975). Two frontiers in rural management: Agricultural extension and managing the exploitation of communal natural resources. Institute of Development Studies Communication No. 113. Brighton: University of Sussex. 12 p.

5. Collinson, M.P. (1972). Farm management in peasant agriculture. A handbook for rural development planning in Africa. New York: Praeger.

6. Conklin, H.C. (1980). Ethnographic atlas of Ifugao. A study of environment, culture, and society in Northern Luzon. New Haven and London: Yale University Press. 116 p.

7. Duerr, W.A., D.E. Teeguarden, M.B. Christiansen, S. Guttenberg, eds. (1979). Forest resource management. Decision making principles and cases. Philadelphia: W.B. Saunders Company. 603 p.

8. Hill, P.H., et al., eds. (1979). Making decisions: A multidisciplinary introduction. Reading, Massachusetts: Addison-Wesley. 230 p.

9. Kickert, W.J.M. (1979). Organization of decision making: A systems-theoretical approach. Amsterdam: North Holland Publishing Company. 259 p.

10. Kunstadter, P., E.C. Chapman, Sanga Sabhasi, eds. (1978). Farmers in the forest. Economic development and marginal agriculture in Northern Thailand. Honolulu: The University Press of Hawaii. 402. p. (with photographs).

11. Lorrain-Smith, R. (1982). The nature of environmental management. Journal of Environmental Management 14, p. 229-236.

12. Lundgren, B. (1982). Introduction. Agroforestry Systems. (An international journal). 1(1):3-6.

13. Mbithi, P.M. (1977). Farm decision making with respect to social psychological elements and the human factor in agricultural management. In: Dams, Th. and K.E. Hunt eds. Decision making and agriculture. Papers and reports. Sixteenth international conference of agricultural economists. Oxford: Alden Press,

14. Newman, M., I. Ouedraogo, and D. Norman. (no date given). Farm level studies in the semi-arid tropics of West Africa.

15. Olofson, H. ed. (1981). Adaptive strategies and change in Philippines swidden-based societies. Quezon City: Forest Research Institute College. 181 p.

16. Orstom, (1979). Maitrise de l'espace agraire et developpement en Afrique tropicale. Logique paysanne et rationalite technique. Actes due colloque de Ougadougou. Memoires Orstom. No. 89. Paris: Orstom 595 p.

17. Osmaston, F.C. (1968). The management of forests. London: George Allen and Unwin Ltd. 384 p.

18. Ryan, J.G. and H.L. Thompson eds. (1979). Proceedings: International workshop on socio-economic constraints to development of semi-arid trop. Agriculture. Andhra Pradesh: ICRIAST p. 241-263.

19. Ruddle, K.(1975). The Yukpa cultivation system: A study of shifting cultivation in Colombia and Venezuela. Berkeley: Univ. of Cal. Press,

20. Simon, H.A. (1979). Rational decision making in business organizations. The American Economic Review. September p. 493-513.

21. Tewari, R.N. and O.A. Mascarenhas. (1980). Community forestry management for rural development. Selected papers and proceedings of the second workshop. Dehra Dun: Natraj Publishers. 214 p.

22. UNESCO. Management of natural resources in Africa: traditional strategies and modern decision-making. MAB Technical Notes No. 9.

23. UNESCO. (1978). Tropical forest ecosystems. A state-of-knowledge report prepared by UNESCO/UNEP/FAO. (See especially part II). Paris: UNESCO 683. p.

24. Williams, N.M. and E.S. Nunn eds. (1982). Resource managers: North American and Australian hunter-gatherers. Boulder, Colorado: Westview Press. 247 p.

25. Wood, G.P. and A.T. Mosher eds. (no date given). Readings in agricultural administration, New York: Agricultural Development Council. 243. p.

# SECTION 4 - WORKING GROUPS

Early in the organization of the Workshop it was decided that six working groups (WGs) were to be convened to discuss topics related to: a) regional needs, constraints and potentials for agroforestry education; b) career prospects for professional agroforesters; c) agroforestry in existing programmes; d) agroforestry as a new programme; e) course content and teaching methods; and f) teaching materials.

Chairpersons were selected prior to the Workshop and invited to arrive in Nairobi a day ahead of the rest of the participants. A prelimimary meeting was held on December 5 where Workshop coordinators and working group chairmen met to prepare a plan of action for the six WGs and to discuss the general scope and expected outcomes of each. Participants were invited to submit written comments for other WGs to consider. WGs met individually and/or joined other groups temporarily when considered necessary. The WGs' inter-relationships are shown in Figure 8. Two plenary meetings were held to report on the advancement of the working groups and a final plenary session took place on the last day to present and discuss the results of the Workshop.

The key questions addressed and the conclusions and recommendations of the WGs are presented below.

## Working Groups Distribution and Inter-relations

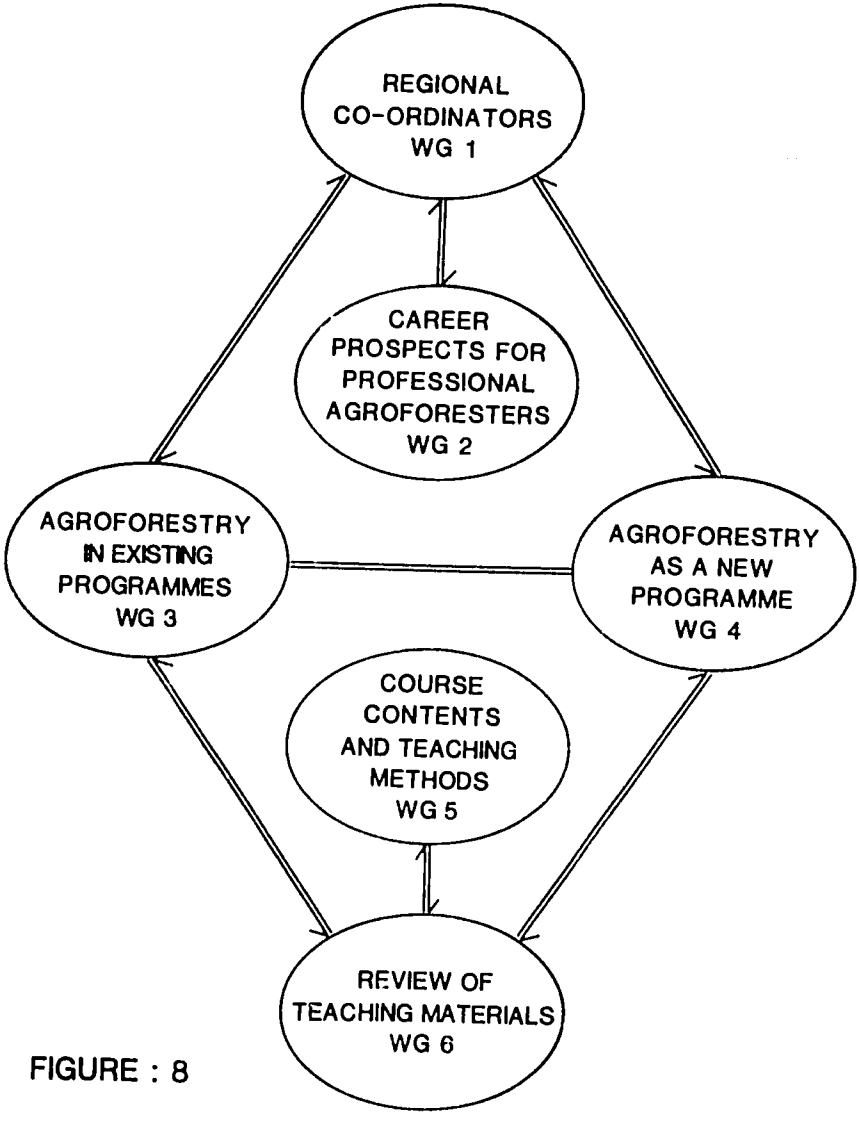


FIGURE : 8

. WORKING GROUP 1: "Regional Surveys"

. CHAIRPERSON: El-Hadji Sene

. RAPPORTEUR: N.J. Joshi

. KEY QUESTIONS ADDRESSED:

1. What is the present overall agroforestry educational situation?

2. What are the common problems and constraints of agroforestry education?

3. Are there any particular regional needs?

4. How do we keep up-to-date with what is happening in agroforestry education?

5. What are the problems of development and/or conservation of agroforestry systems that we should educate for?

6. What are the opportunities for co-operation between countries with regard to educational institutions?

MAIN CONCLUSIONS AND RECOMMENDATIONS:

1. In assessing the overall agroforestry education situation the group felt that there is a great deal of enthusiasm to include agroforestry in existing programmes but few indications that this will take place in the near future. This is in part because agroforestry is not yet a well-"defined" discipline, due to the rigid structures of existing institutions that makes difficult the cutting across of a multidisciplinary programme such as agroforestry, and also due to the lack of teaching materials. On this last point it was strongly recommended that the inventory of traditional systems be undertaken as a priority so as to start providing relevant teaching materials.

2. Among the main problems and constraints in promoting agroforestry education the following were identified:

- lack of integrated educational programmes usually as a consequence of poor institutional communications between the disciplines involved e.g. agriculture, forestry and others, thus leaving a heavy burden on the students who have to try and integrate a set of courses not always "integrated or integrable";

- inadequate knowledge about agroforestry as a land-use system e.g. solid data on land tenure problems, farmer needs and traditional systems, etc.;

- a cultural gap between those who have to promote agroforestry education (scientists) and those for whom (farmers) agroforestry is to be understood, improved and implemented.

3. In order to keep up-to-date with what is happening in agroforestry education, it was recommended that:

- the work started for the ICRAF/DSE Workshop be continued and updated with the help of regionally appointed institutions or individuals who will collect and disseminate information on agroforestry education on a regular basis. International and regional institutions such as ICRAF, CATIE, IICA, FAO and others should cooperate in this.

- publication, and circulation of journals or gazettes on agroforestry be encouraged.

- for agroforestry awareness, substantiation and buildup, short courses, and seminars be encouraged and multiplied on a regional basis. They should be well prepared as far as resource documents, demonstrations, field practice, and visual aids are concerned.

4. There are ancient old agroforestry systems in all the continents e.g. homegardens, chinampas, etc. that are at present threatened by modern agricultural schemes. The group recommended that people be educated to protect and study them as they constitute a valuable reservoir of knowledge, germplasm and demonstration.

5. In order to develop cooperation in agroforestry education it was recommended that:

- south-south exchanges of human resources and/or information be encouraged with the involvement of regional and international agencies;

- cooperation between teaching and research intitutions in developed and developing countries be favoured through whatever arrangements are suitable e.g. twinning in areas such as information exchange, library exchange, exchange of lecturers, research workers, student and field workers, and exchange of germplasm for field work;

- support from funding institutions be sought and encouraged to help implement the above.

RESOURCE DOCUMENTS

An addendum of institutions teaching elements of agroforestry, or likely to do so in the near future, was prepared by the group to complement the information gathered by Regional Coordinators. The list is included in Appendix E.

. WORKING GROUP 2: "Career Prospects"

. CHAIRPERSON: Jeffrey Odera

. RAPPORTEUR: H.J. von Maydell

. KEY QUESTIONS ADDRESSED:

1. What will be expected of professional agroforesters?

2. What are the present/future job prospects after qualifying as an agroforester?

3. What sort of numbers are involved (do we need manpower surveys)?

4. What ultimate career prospects are there?

5. What are the "re-training" needs?

6. What kind of educational programmes should be given priority?

7. How do we influence educational policy?

8. What are the material infrastructural problems?

## MAIN CONCLUSIONS AND RECOMMENDATIONS

1. The agroforester is seen as a specialist in multidisciplinary land-use projects/programmes with the specific function to coordinate the inputs of all disciplines involved. The agroforester can be an agent of change, a researcher or a teacher-coordinator. As <u>an agent of change</u>, the agroforester is expected to be able to identify problems and constraints to development, and potential invention points; to evaluate land-use practices and systems; to initiate agroforestry programmes; to coordinate rural development activities; to identify and recommend sources of expertise and appropriate skills needed in projects/programmes. As a <u>researcher</u>, the agroforester is expected to become involved in the evaluation of existing traditional knowledge and practices with a view to developing technology packages adapted to the farmers' needs and conditions. The agroforester -- by the nature of the discipline -- is to conduct research in a multidisciplinary, team fashion. As a <u>teacher-coordinator</u>, the agroforester is expected to integrate teams of specialists to design and develop educational and training programmes in agroforestry. These should focus on the development of desirable attitudinal and behavioural skills so as to enable students to relate with colleagues in other disciplines without undermining their prospects for career advancement.

2. A professional agroforester is likely to be employed as an extension (change) agent, researcher, production and general manager, teacher/trainer, planner and administrator. Institutions identified as likely to employ agroforesters were: government agencies such as forest services, agricultural and soil conservation services, rural development services;

ministries of environmental/planning and energy, etc.; research organizations; parastatals; universities; investment/development agencies; development banks; cooperatives; non-governmental organizations (NGO's); international organizations and private land-use enterprises. These lists are, obviously, non-exhaustive. The group found it difficult to estimate the numbers of people working in areas requiring agroforestry skills.

3. Manpower surveys were seen as valuable only if directed towards determining training needs in a specific region or when examining prospects for establishing regional agroforestry education/ training. Rather the group recommended that priority be given to surveys on the level of institutionalization of agroforestry. This will help identify those intitutions most adapted to accommodating professionally trained personnel in agroforestry. Updating of such information could be achieved either through the activities of IUFRO 1.7.7. (the working party on agroforestry), through ICRAF, and/or other regional or international organizations.

4. It was stressed that there are good career prospects in traditional agricultural, livestock production and forestry research and training institutions; in site-bonded programmes of integrated rural development and irrigation programmes; also in administration, supervision and implementation of extension programmes. Agroforestry training would greatly enhance managerial and decision-making skills of people expected to have working knowledge of national land use. It was further recommended that people trained in agroforestry work within existing professional career prospects at a national level as any other professional.

5. Re-training was recommended with high priority for educated specialists through in-service training programmes. A distinction was made between "additional training" and "re-training." The first was seen as developing new skills, attitudes and knowledge while the latter was more concerned with the reorientation of those skills, attitudes and knowledge. It was recommended that re-training be focussed on monitoring and evaluation of projects under implementation in

order to identify avenues for optimization of land use through the use of standard models such as ICRAF's Diagnostic and Design Methodology. The organization of an international course for potential leaders in agroforestry development was also mentioned.

6. Agroforestry education programmes are seen to be more appropriately started at the postgraduate level e.g. one year M.Sc. programmes. This could be followed by research projects. AF could however, also be incorporated as a basic subject to be offered in lectures or courses common to all relevant rural development sciences at an early stage of university education or as a course elective. Once manpower training has reached a certain level -- in terms of numbers -- agroforestry educational programmes at the middle level can be considered.

7. The group concluded that it would be premature to consider a direct confrontation with policy makers regarding agroforestry education. The recommendation was to look for ways to promote the diffussion of land facts in agroforestry research and development e.g. field demonstrations portraying the benefits of agroforestry, technical packages to s lve rural development problems, etc.

8. No major material infrastructural problems were identified as a constraint to promote agroforestry education. However, attention was drawn towards the establishment of field demonstration plots.

. WORKING GROUP 3: "Agroforestry in Existing Programmes"

. CHAIRPERSON: Eduardo Escalante

. RAPPORTEUR: David U. Okali

. KEY QUESTIONS ADDRESSED:

1. How is agroforestry being taught at present and in what kinds of programmes?

2. How best can we relate agroforestry to other disciplines/programmes?

3. Where is it easiest to start?

4. Is there a danger of "overlap" - and how do we deal with this?

5. What are the areas of emphasis and/or selection?

MAIN CONCLUSIONS AND RECOMMENDATIONS

1. Full programmes in agroforestry are only offered in non-degree/short training courses in Southeast Asia, the South Pacific, and North and Central America. At the undergraduate and postgraduate levels agroforestry is mostly included as an element of existing courses in forestry programmes and to a lesser degree in agricultural programmes.

2. The group recommended that relevant topics of agroforestry be included in forestry, agriculture and land-use related courses at all levels -- undergraduate, postgraduate, middle, short courses, etc.

3. A high priority is to establish agroforestry educational programmes at the postgraduate (M.Sc.) level. It was recommended that M.Sc. programmes in agroforestry be responsive to the local priorities and needs -- with the support of international funding agencies.

4. It was the general consensus of the group that a certain degree of "overlapping" in teaching agroforestry is not harmful. And indeed it may result in a beneficial means to link topics or subjects and/or reinforce important points. Even when the same topic is treated in different programmes, the emphasis is likely to be different. Overlapping is however undesirable if a full agroforestry programme is to be developed in agriculture and in forestry within the same faculty. This responsibility falls within existing faculty curriculum review committees.

5. The areas of emphasis to be included in agroforestry education differ from region to region. They depend on the needs and existing

problems. It is precisely the point that agroforestry concepts in curricula should be developed with an awareness of local problems and solutions. However, the group made an attempt to identify those aspects that are common to all regions.

| Production | Environmental/ Conservation | Socio-Economic |
|---|---|---|
| cropping systems | shelterbelts | risk distribution and minimization |
| taungya systems | windbreaks | income maximization |
| fuelwood | soil conservation | employment |
| multipurpose trees | soil fertility maintenance | land tenure |
| tree/crop/animal interactions | nitrogen-fixing trees | |
| range management | | |

RESOURCE DOCUMENT

The group summarized the involvement of agroforestry in existing educational programmes in forestry, agriculture and land use by region. See Table 16.

. WORKING GROUP 4: "Agroforestry as a New Programme"

. CHAIRPERSON: G.L. McClymont

. RAPPORTEUR: Lucrecio Rebugio

. KEY QUESTIONS ADDRESSED:

1. Should we teach agroforestry as a new (independent) programme?

2. What kind of approaches should we adapt to the teaching of agroforestry?

3. What are its limits? Are there "displacement" problems vis-a-vis other programmes?

4. What resource and infrastructural problems are there for various teaching institutions in setting up a new programme?

TABLE 16 AGROFORESTRY IN EXISTING PROGRAMMES BY REGION

| REGIONS | SHORT COURSES (NON-DEGREE) | | | | FORESTRY | | | | | | | | | | | | AGRICULTURE | | | | | | | | | | | | FORESTRY/AGRICULTURE | | | | | | | | | | | | OTHER (Related to land use disciplines) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | DIPLOMA | | | | UNDER GRADUATE | | | | POST GRADUATE | | | | DIPLOMA | | | | UNDER GRADUATE | | | | POST GRADUATE | | | | DIPLOMA | | | | UNDER GRADUATE | | | | POST GRADUATE | | | | | | | |
| PROGRAMMES | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D |
| Africa Anglophone | | X | X | | | X | X | X | | X | X | | | X | X | X | | | | | | | X | | | X | | | | | | | | X | X | | | | | | | X | | | |
| Africa Francophone | | X | X | | | | | | | X | X | | | X | X | | | | | | | X | X | | X | X | | | | | | | | | | | | | | | | | X | | |
| North Africa & Middle East | | | | | | | | | | | | X | | | X | X | | | | | | X | | | | X | X | | | | | | | | | | | | | | | | X | | |
| Southeast Asia | X | X | X | | | | X | | | X | X | X | | | X | | | | X | | | X | | | | X | | | | | | | | | | | | | | | | | X | | |
| South Pacific | X | | | | | | | | | | X | | | | | X | | | | | | X | | | | | X | | | | | | | | | | | | | | | X | | | |
| Indian Sub-Continent | | X | | | | | X | | | | X | X | | X | X | | | | X | | | X | | | X | X | | | | | | | | | | | | | | | | X | | | |
| Europe West | | X | X | X | | X | X | X | | | X | X | | X | X | X | | | X | | | X | | | | X | X | | | X | | | X | X | | | | X | | | | X | X | | |
| America North | X | X | X | | | X | | X | | | X | X | | X | X | X | | | | | | X | | | | X | | | | | | | | X | | | | X | | | | X | X | | |
| America Central | X | X | | | | | X | | | | | X | | | X | X | | | X | | | X | | | | X | | | | | | | | X | | | | X | | | | | | | |
| America South | | | | | | X | X | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | | | | | | |

A. Full programme in agroforestry

B. Agroforestry included as an element in courses

C. Issues related to agroforestry included in courses

D. Problems related to agroforestry studied at the specialisation level

Diploma: Middle-level technical schools
Undergraduate: B.Sc. or Engineer
Postgraduate: M.Sc. and Ph.D.

5. Which should be the areas of emphasis and/or selection?

## MAIN CONCLUSIONS AND RECOMMENDATIONS

1. In order to introduce agroforestry education at the professional level, it is recommended that agroforestry be included in existing forestry and agriculture programmes. Gradually, and according to countries' land-use problems, needs and priorities, agroforestry could be incorporated as a new and independent programme.

2. The group stressed that each country should choose the approach to the teaching of agroforestry that better fits its needs and priorities. Some alternatives to include agroforestry teaching in existing programmes are i) include aspects of agroforestry e.g. concepts, methods, case studies, etc. in forestry and agriculture programmes; ii) offer an optional course in agroforestry at the undergraduate level; iii) offer an agroforestry specialization at undergraduate and postgraduate levels; iv) short courses and in-service training for middle-level (extension) personnel. It was strongly recommended that an "international course" at the M.Sc. level be developed for potential leaders in agroforestry research and development. The course could be run in Nairobi by an association of several international agencies e.g. United Nations University (UNU), ICRAF, ILCA and a national university in Kenya. Teaching staff could be drawn from ICRAF.

3. No limits or displacement problems vis-a-vis other programmes were envisaged in introducing agroforestry teaching.

4. Similarly no infrastructural problems were identified to impede the teaching of agroforestry in existing institutions.

5. It was recommended that countries consider the establishment of ad hoc committees to examine the overall status of agroforestry education and training, research and extension and make suggestions for its development or improvement.

. WORKING GROUP 5: "Course Contents and Teaching Methods"

. CHAIRPERSON: Jeff Burley

. RAPPORTEUSE: Amanda Jones

. KEY QUESTIONS ADDRESSED:

1. How do we summarize the types of programmes most likely to be required in the future for agroforestry education/training?

2. What components of knowledge would be expected of agroforestry?

3. What major types of teaching methods are applicable to agroforestry education?

MAIN CONCLUSIONS AND RECOMMENDATIONS

1. The types of programmes most likely to be required in the future are: re-training, short courses, certificate and diploma courses, B.Sc. in Agroforestry and other disciplines, M.Sc. in Agroforestry, Agriculture and Forestry and programmes for teachers of agroforestry and research degrees. More details on duration, audience and disciplines are presented in Table 17.

2. A list of subjects in which substantial knowledge would be required of agroforesters was compiled. Even though the checklist was meant to be of general applicability for all types of programmes much of the discussion centered on its application to a Master's programme. The list is seen as an aide memoire in programme construction; local conditions will dictate the optimum combination of courses. Throughout the development of the checklist, the learning objectives were taken to be knowledge, skills and attitude. It was stressed that the agroforestry programme should develop in the students an aptitude for identifying and solving problems. Four major groups of subjects were identified as components of knowledge expected of agroforesters. They are:

. the social and economic environment;

TABLE 17

## TYPES OF PROGRAMMES IN AGROFORESTRY EDUCATION/TRAINING

1. Re-training Short Courses (1-3 months)

   Aimed at:

   A. Policy-makers and administrators
   B. Senior/Middle Managers
   C. Local project staff
   D. University teachers

2. Certificate and Diploma Courses (6-12 months)

   For graduates of agriculture, forestry, biology, anthropology, rural sociology, rural development, geography, horticulture, etc.

3. B.Sc. in Agroforestry (3-5 years)

4. B.Sc. in other disciplines (3-5 years)

   Agriculture
   Forestry
   Applied Biology
   Ecology
   Horticulture
   Geography
   Rural development
   Rural sociology

   (The agroforesty may be covered by an additional option or by reduction/substitution of existing material)

5. M.Sc. in Agroforestry (1-2 years)

6. M.Sc. in Agriculture or Forestry (1-3 years)

7. Programmes for Teachers of Agroforestry

8. Programmes for Research Degrees

- the biophysical environment and resources;
- production of plants and animals and the associated land-management systems; and,
- agroforestry *per se*.

Depending on the type of programme, a basic corpus of knowledge of biology, chemistry, mathematics and physics is assumed. The main subdivisions of these are summarized in Table 18.

The relative weight given to each course will obviously vary among teaching institutions. However, at the level of a Master's programme, the first three subject groups were considered as foundation courses. Thus, before entering the agroforestry component, an agronomy graduate might concentrate on 3B (animal production) and 3C (land management systems while needing little of 3A (plant production) -- perhaps those sections relating to trees. Similarly an ecology or biology graduate would concentrate on 1 and 3 while a geography graduate might concentrate more on 2 and 3. Foundation courses are expected to occupy up to one-third of taught sections of a programme.

In addition to the four groups of taught subjects, the thesis or dissertation is considered to be an important part of knowledge, skill and attitude development, particularly if based on practical field research. Since M.Sc. programmes vary from one to two years, the thesis may occupy from 3-12 months. In common with all research degrees the choice of topic will be torn between two conflicting criteria -- the academic needs and standards of the educational institution and the practical, relevant needs of the student and/or country. However, the agroforestry profession, possibly above all others, must be based on regional understanding and practical ability.

Whether or not a thesis is included throughout the programme, it is recommended that attention be paid to the practical techniques and instrumentation relevant to research development and extension of agroforestry. With regard to programmes concerned with the training of teachers, additional courses covering appropriate teaching methods may be necessary.

TABLE 18

CHECKLIST OF COMPONENTS OF KNOWLEDGE EXPECTED OF AGROFORESTERS

| MAJOR COMPONENTS | SUB-TITLES | CONTENT |
|---|---|---|
| 1. The Socio-economic Environment | A. Human Ecology | i) Theoretical analysis of the dynamic relationships between human societies and their natural environments.<br>ii) Case studies of perception and management of natural resources under different societal conditions. |
| | B. Social & Institutional Constraints and Potentials of Land-Use Systems | i) Values, attitudes, conflicts of interest between groups<br>ii) Legal aspects (e.g. land tenure); educational and institutional needs for intervention. |
| | C. Economic Analysis | i) Production analysis, Input/Output relationships, Resource allocation, Multi-period analysis<br>ii) Markets<br>Factor<br>Product<br>Supply response |
| | D. Social & Economic Decision Making Theories and Techniques under Uncertainty | i) Cognitive theories<br>ii) Risk and uncertainty |
| | E. Rural Development | i) Methodologies for intervention in land-use systems<br>ii) Objectives, concepts, strategies, planning in relation to land-use policies and other national policies<br>iii) Extension methods |
| 2. The Biophysical Environment | A. Land as a Natural Resource | i) Geomorphology and land form<br>ii) Soil formation, soil biology, soil physics and soil chemistry (in relation to plant growth)<br>iii) Hydrology |

| | | |
|---|---|---|
| | B. Climate | i) Meteorology<br>ii) Climatology (Agroclimatology)<br>iii) Micrometeorology |
| | C. Taxonomy and Resources of Major Plant & Animal Groups | |
| | D. Ecology | i) Autecology and synecology of plants and animals<br>ii) Population dynamics<br>iii) Vegetation types and distribution<br>iv) Resource conservation management |
| | E. Land Use | i) Past<br>Land-use history<br>Human influence<br>Animal influences<br>Plant influences<br>ii) Present<br>Major land-use systems, including shifting agriculture<br>Diagnosis of land-use systems<br>Survey and mapping<br>iii) Future<br>Land tenure<br>Competing uses<br>Land capability classification |
| 3. Production | A. Plant Production | i) Environmental plant physiology and biochemistry<br>ii) Production techniques for annual and perennial crops<br>Seed production, storage, testing, sowing<br>Nursery management<br>Vegetative propagation<br>Breeding<br>Group preparation (including zero tillage)<br>Irrigation<br>Fertilization<br>Planting density<br>Inoculation techniques<br>Weeding<br>Protection (disease, insect, fire, animals)<br>Re-spacing (thinning) of trees<br>Pruning and training<br>Coppicing and pollarding<br>Pollination<br>Harvesting<br>Storage and processing |

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| | |
|---|---|
| | iii) Properties of products<br>Assessing of quantative yield including tree mensuration and biomass partition. Quality of products including anatomical, chemical, physical and processing properties (including palatability)<br>iv) Engineering and building |
| B. Animal production (including Amphibians, Reptiles, Fish, Crustacea, Birds and Mammals | i) Environmental animal physiology and biochemistry<br>ii) Nutrition and growth<br>iii) Reproduction and feeding<br>iv) Management (range and stall-fed cattle, fisheries, etc.)<br>v) Health and hygiene<br>vi) Behaviour<br>vii) Engineering and building<br>viii) Product quantity and quality assessment |
| C. Land-management systems | i) Principles and objectives (including concepts of sustention)<br>ii) Systems analysis<br>iii) Farming systems<br>Hunter-gatherers<br>Shifting cultivation<br>Fallow systems<br>Ley systems<br>Permanent cultivation systems<br>Livestock systems (including grazing and stall-fed cattle)<br>Other animals<br>iv) Silvicultural systems<br>Exploitation of natural forest<br>Natural forest management to maintain yield<br>Plantations<br>Coppice systems<br>v) Agroforestry systems<br>Agrosilvicultural<br>Silvopastoral<br>Agrosilvopastoral<br>Horticultural tree systems (multipurpose trees)<br>vi) Historical and regional perspectives |

| | | |
|---|---|---|
| 4. Agroforestry | A. Ecophysiology in agroforestry | i) Crop physiology<br>ii) Component interactions<br>iii) Occurrence and exploitation of size heterogeneity<br>iv) Microclimate<br>v) Nutrient cycling<br>vi) Chemical interactions |
| | B. The effects of woody plants on other components of agroforestry systems | i) On soil<br>ii) On other environmental features<br>iii) On other crop components<br>iv) On human populations<br>v) On the interactions of crops & animals |
| | C. Joint production of crops and animals | i) The major agroforestry system<br>ii) Appropriate scale of operation<br>iii) Management of mixtures<br>Constraints and benefits<br>Breeding for mixtures<br>Protection<br>Fertilization<br>Range carrying capacity<br>Animal management<br>Harvesting |
| | D. Special topics in agroforestry | i) Multipurpose species<br>ii) Biomass for energy<br>iii) Trees for fodder and forage<br>iv) Location and management of difficult environments<br>v) Soil and water conservation including erosion control<br>iv) The place of research in agroforestry<br>vii) Trees managed for mulch and organic matter<br>viii) Economics in agroforestry |

3. It was stressed that the optimum method of teaching varies with the topic. However, major types that are applicable to agroforestry education were identified as follows: i) lectures (staff, visitors); ii) seminars (staff, visitors, students); iii) case studies (staff, visitors); iv) tutorial; v) laboratory practicals; vi) field practicals (research station, farm, forest, village/market); and library searches.

RESOURCE DOCUMENTS

The group produced a programme prospectus to indicate the composition of each course within the programme as outlined in Table 18 above. This is shown in Appendix F at the end of this section.

- WORKING GROUP 6: "Review of Teaching Material"
- CHAIRPERSON: Melvin Cannell
- RAPPORTEUR: John Raintree
- KEY QUESTIONS ADDRESSED:

1. What materials are available for teaching agroforestry and what recommendations can be made about them?

2. What additional materials should be prepared?

MAIN CONCLUSIONS AND RECOMMENDATIONS

1. The task of integration and selection of the principles relevant to agroforestry is very great in certain fields, such as socio-economics and crop eco-physiology. It was, therefore, recommended that specialists who are familiar with agroforestry be assigned to prepare digests of literature in their fields for use in agroforestry teaching.

2. It was further recommended that: a) visual aid slide packages be prepared together with an explanatory booklet to illustrate the concepts, complexity and diversity of agroforestry land-

use systems existing around the world; b) the review "The role of woody perennials in animal agroforestry" be published in an international journal, perhaps in a condensed form; c) other reviews of teaching materials, after suitable editing, be supplemented by references obtained during the Workshop, and provided with an introduction explaining the difference in approach of the reviewers. This compendium should then be bound, advertised by ICRAF, and distributed in mimeographed form.

3. The group recognized the importance of field projects and living demonstrations in agroforestry teaching, but concluded that these have to be defined at the local level by planting demonstration plots and/or studying local AF systems.

4. A breakdown of existing AF bibliographies available for teaching reveal weaknesses in the following areas: a) the definition of AF varies in different parts of the world, b) less than half of the references in any bibliography consist of authoritative, refereed papers in scientific journals or books, c) although there are many useful <u>descriptions</u> of AF practices, there are few in-depth case studies.

# APPENDIX E

## ADDENDUM OF INSTITUTIONS TEACHING AGROFORESTRY OR LIKELY TO DO SO IN THE NEAR FUTURE

1. Faculty of Forestry
   Kobenhaon, DENMARK

2. Freiburg University
   Freiburg, FEDERAL REPUBLIC OF GERMANY

3. Hamburg University
   Hamburg, FEDERAL REPUBLIC OF GERMANY

4. Munchen University
   Munchen, FEDERAL REPUBLIC OF GERMANY

5. Gottingen University
   Gottingen, FEDERAL REPUBLIC OF GERMANY

6. Padjadjaran University
   Faculty of Science
   Bandung, INDONESIA

7. Mulawarman Univesity
   Faculty of Forestry
   Bandung, INDONESIA

8. Faculty of Forestry
   Wageningen, THE NETHERLANDS

*9. Oxford University
   Commonwealth Forestry Institute
   South Parks Road
   Oxford, UNITED KINGDOM

*Offers: i) a B.Sc. in Agricultural and Forest Sciences with a few lectures on agroforestry, 3 years duration; ii) M.Sc. on Forestry and its Relation to Land Management with several options including one in agroforestry, 1 year; iii) research degree at M.Sc. and Ph.D. levels in agroforestry; and iv) intensive summer courses with a tropical orientation.

**10. Bangor University
Department of Forestry & Wood
Sciences & Department of Agriculture
University College of North Wales
Bangor, UNITED KINGDOM

11. Dr. Sebiati Sastrapradja
Lembaga Biologi National (LBN)
Jalan Ir. Juanda
Bogor, WEST JAVA

12. Prof. Dr. Ir. Otto Soemarwoto
Institute of Ecology
Padjadjaran University
Jalan Sekeloa
Bandung, WEST JAVA

13. Prof. Soedarwono
Faculty of Forestry
Gadjah Mada University
Bulak Sumur, YOGYAKARTA

14. Prof. Dr. Edy Noerhadi
Insitute Technology Bandung
Jalan Gamesha
Bandung, WEST JAVA

15. Prof. Soekiman Atmosoedaryo
Mulawarman University
Faculty of Forestry
Samarinda, EAST KALIMANTAN

16. Prof. Ir. Haryono Danesastro
Faculty of Agriculture
Gadjah Mada University
SEKIP, YOGYAKARTA

**Offers: i) B.Sc. in Forestry with agroforestry lectures as part of a course on Tropical Forestry and Land Use; ii) B.Sc. jointly given by the Forestry and Agriculture Departments, containing all major elements of agroforestry; and iii) M.Sc. on Environmental Forestry with agroforestry lectures as part of a course on Tropical Forestry, 1 year duration.

# APPENDIX F

## PROSPECTUS OF COURSES COMPRISING AN AGROFORESTRY PROGRAMME

### 1. The Socio-economic Environment

1A. Human ecology deals with Man as an element of the biosphere. It provides theoretical perspectives and methods for studying the technological adaptation of human populations to their environments by means of culturally organized systems of resource use. As an approach to the realization of agroforestry potentials for improving the stability and productivity of human ecosystems, the major relevant themes in human ecology include: cultural patterning or resource perception and traditional strategies of resource managment; the concept and methodologies for assessing the human carrying capacity of different environments under different land management systems; theoretical and empirical studies of population pressure on resources as a driving variable in the evolution of land-use practices and the adoption of new technologies; and regional perspectives on indigenous land-use systems.

1B. Social and Institutional Constraints and Potentials of Land-Use Systems

Different groups of people in society have different values, different needs and different potentials for the adoption of agroforestry technologies. Who benefits and who is adversely affected by specific agroforestry innovations? What kinds of institutional arrangements are needed to coordinate local and national roles in the implementation of agroforestry projects? Traditional land-use practices are transmitted from generation to generation by traditional educational mechanisms. What means will be used to train people on the use of non-traditional agroforestry techniques? What legal and land tenure or tree rights are implied by a given agroforestry technology? Will agroforestry adopters have the legal right to harvest and market their products?

What are the range of technology options and which technologies are most consistent with the pattern of constraints and potentials in given land-use systems? These are the kinds of questions which must be considered when assessing social and institutional constraints and potentials of agroforestry in specific land-use systems. The basic concepts of anthropology and rural sociology would be included in suitable courses.

1C. Economic Analysis

The object of this section is to present the theory of optimum resource allocation under certainty and introduce relevant contemporary tools of analysis. It is recommended that the analysis of the multi-product multiple constraints production systems of agroforestry be handled within a linear programming framework with emphasis on opportunity costs and shadow prices. Multi-period analysis should be approached from a discounted cash flow perspective emphasizing the evaluation of proposed new technologies.

The establishment of market prices for inputs and products will be the focus of the second half, culminating in an examination of case studies of smallholder response to price changes in perennial crop production.

1D. Social and Economic Decision-Making Theories and Techniques under Uncertainty

Special attention should be paid to risky choice, i.e. the choice between alternatives with uncertain consequences. Based on an analysis of the concepts of probability and utility, different procedures -- formal stochastic models -- for decision analysis should be presented.

This should be followed by a presentation of theories and methods for the empirical investigation of the decision-making process of different categories of land managers. Empirical testing of formal economic models and exemplary case studies, at the levels of

the individual farmer, the local community, and policy making, should be included. Conclude with comparisons of modern and traditional decision-making strategies.

1E. Rural Development

It is assumed that agroforestry research will bring to light systems of production that will substantially improve production potential from smallholder farms. This section will examine the ways and means of extending and implementing the adoption of such improved practices. The course will teach the skills required to plan the phasing, management and monitoring of agroforestry projects in relation to land use and other national policies. It will also consider the evolution of farmers' organizations, from associative forms to cooperatives, with special reference to implementation of community field work, post-harvest problems, credit accessibility and the transportation and marketing of products.

2. The Biophysical Environment and Resources

2A. Land as a Natural Resource

This section deals with the physical processes of weathering and soil formation, covering the major soil groups. The agroforestry significance of these soils should be discussed in relation to the effects of management practices and tillage of their physical characteristics and chemical properties, including soil reactions (such as liming).

Environmental factors of soil, water, air and temperature must be covered, together with the interactions between plant roots and rhizosphere micro-organisms (mycorrhizal and bacterial symbioses). Also necessary is the importance and maintenance of soil organic matter, and the formation of humus -- assessing potential soil productivity in relation to plant nutrient economy.

2B. Climate

An introduction to the concepts of meteorology is important due to the crucial effect of the weather on production, forecasting and planning. A basic understanding is needed of the nature of the atmosphere, weather maps, and the meteorological elements of radiation, temperature, precipitation and evaporation. Knowledge of measurement techniques, monitoring, climatological records and presentation of data is also of direct relevance.

Both agroclimatology and micrometeorology are concerned with interactions between meteorological and hydrological factors and agriculture. This covers the "soil-plant-atmospheric" system, including not only the natural climate at different scales and its variations, but also the relevant aspects of environmental modifications initiated by man, for example windbreaks and shelterbelts.

2C. Taxonomy and Resources of Major Plant and Animal Groups

Although a knowledge of the plant and animal kingdoms should be a pre-requisite, this section would identify the major plant and animal species that are currently used or have potential for future use. Depending on the type of programme this section may have a global, regional or zonal bias. Practical herbarium or laboratory sessions with individual specimens should be supported where possible by field demonstrations of crops.

The natural origins, extent of use as exotics, variability and germplasm resources would be described together with the activities of international and national agencies concerned with the exploration, evaluation and conservation of genetic resources.

2D. The pre-requisite basic biology course would have introduced the student to concepts of ecology and ecological assessment. This

section details the autecology and synecology of the major groups of species with potential value in agroforestry. It examines the classification and distribution of vegetation types and the population dynamics of animals. It examines the method of managing natural ecosystems for resource conservation and indicates the caurses, effects, and rates of change in the distribution of particular ecosystems (e.g. tropical forest loss, desertification, degraded lands).

2E. This section deals with the way in which physical resources have been used and are being used by living organisms (including man) and with the way in which the physical resources are in turn influenced by the living organisms. A perspective is provided on how the intensity to which land has been used has changed through the ages (hunters, gatherers, shifting cultivation, fallow cultivation and permanent cultivation). Human influences on the physical environment are both direct and indirect (e.g. mediated through vegetation changes) and pertain both to the immediate environment being used and to more wide ranging effects such as the shifting of water courses due to increased erosion upstream (through siltation) or influences on the climate. The direct or indirect influence of pests, animals and plants on the physical resources -- soil, hydrology, etc. -- are also discussed.

The major present land-use systems are described (forests, agronomy, pastoralism, shifting cultivation, mining, dam building, urban development, etc.). Techniques needed to identify, delineate, locate and map the extent of such land-use systems must be included. The major human factors which predetermine, to a large extent, the way in which land can be used in the future (e.g. land tenure, demography) should be discussed, followed by a discussion on the increasing competition for land by different user interests. Finally the techniques for classifying land capabilities for different uses should be explored.

## 3. General Introduction: Production

This section of the programme is intended to provide the knowledge of establishment, management, harvesting and use of plants and animals. The three major topics include plant production, animal production and land management systems. The first two may be considered optional depending on the student's background. Throughout emphasis is given to both the underlying theory and the practical application and implications (good and bad) of the various land management systems.

### 3A. Plant Production

This course opens with consideration of environmental physiology and biochemistry factors that influence the growth and development of annual and perennial plants (considered as a crop rather than an individual plant). It then describes the principles and practices of seed production and handling, vegetative propagation, genetic improvement and the establishment, post-planting culture, harvesting, yield and properties of the products. Some background in the field engineering and building is desirable.

3B. Animal Production (including Amphibians, Reptiles, Fish, Crustacea, Insects, Birds and Mammals) A basic understanding is needed of animal physiology and biochemistry and how these are affected by the environment. The student should be aware of the effect of these environmental factors on aspects such as nutrition and growth, reproduction and breeding, and behaviour (for example, conditions such as heat and cold stress).

Different management systems should then be considered in terms of how modifications in these can optimise production for specific end uses, at the same time making the best use of available resources. The inter-relationships of the system components are of vital importance. Knowledge of health and hygiene, and different housing

conditions, is also necessary, together with the concept of qualitative and quantitative production assessment.

3C. Land Management Systems

This section should cover the principles and practices of existing land-use systems. The objectives of maintenance of yield and soil improvement are discussed in relation to the role of mixed cropping, multi-layered systems and species diversity.

The land management systems include hunting-gathering, shifting cultivation and other farming systems, together with both environmental and human influences on these. Silvicultural systems include the exploitation of natural forest, the management of natural forest to maintain yield, plantation and coppice systems. In all cases both a historical perspective and the problems and advantages associated with their management are stressed, in relation to the objective of a sustained yield.

Agroforestry is defined and an introduction to agroforestry systems is given. These systems (agri-silviculture, silvopastoralism, agri-silvopastoralism and horticultural tree systems covering multipurpose trees) are then discussed in detail.

Finally, historical and regional perspectives of all three kinds of land management systems should be covered. This section deals with the historical development and regional variations of systems and the modern influences of international relations and the socio-economic climate. The importance of using local crop types in aiming to improve local systems should also be included.

4. Agroforestry Science and Practice

This deals with the actual science of crop, tree and animal mixtures and interactions.

Ecophysiology includes, for example, how the architecture of foliage canopies, dry matter partitioning and water relations effect the physiological basis of yield and yield maintenance. Interactions between systems components -- both in the horizontal, vertical and temporal dimensions -- include complementary, supplementary and competitive relations. Knowledge of such interactions and of plant responses to resource deprivation enables site heterogeneity to be exploited. Specific crops may be utilized in multiple cropping systems according to the site characteristics.

The microclimatology of agroforestry systems (for example the effect of mulching, shelterbelts and mixed canopy profiles) is important in relation to temperature, radiation and humidity. This should be discussed with reference to the effect of microclimate on plant and animal production and on nutrient and chemical interactions.

## 4A. Effects of Woody Plants on other Components of Agroforestry Systems

Trees are essential elements in agroforestry systems where they can affect some or all of the other components either in a beneficial or detrimental way. The nature of trees' effect upon supporting, adjacent or succeeding components may not necessarily correspond with that on the system as a whole, i.e. a detrimental effect on one particular component can be offset by beneficial effects on others, and vice versa, as well as by the contribution of trees themselves. The effect of trees on components can take a material form (fuelwood, fruit, fodder, etc.) or a not so tangible one (shade, soil enrichement, windbreaks, etc.). It is the latter which will be mainly dealt with in this topic, in relation to other components such as soils, plants, animals and man.

## 4B. The Joint Production of Crops and Animals

i) The major existing and theoretical agroforestry systems are described e.g. (Combe and Budowski, 1978) and include considerations of the organization of components in time and space as well as the role of the components (production/service).

For each system, the emphasis is on the reasons for which the joint production is advantageous i.e. the range of ecophysiological and socio-economic factors which make the joint production desirable.

ii) It is desirable to discuss the influence which the scale of operations (size of management unit, labour force, machinery available, etc.) is likely to have on the degree to which it is possible to maximize the positive interactions between different joint production components.

iii) The various means by which one can maximize their positive aspects should be tackled. This would include the appropriate management for each component of the system. On the plant side this includes: horizontal and vertical manipulation (row orientation, cutting, training, spacing - see Cannell, 1980); protection; and pest management. The breeding of appropriate genotypes, e.g. for reduced light quality or changed light, for improved or reduced palatability, increased nutrient use efficiency, etc.; nutrient and water management; harvesting. On the animal side, it would include the importance of appropriate herd management methods to enable optimum production levels to be achieved in silvopastoral and agri-silvopastoral systems. Herd management includes estimates of range carrying capacity. Attention would be given to the effects of fertilizers and pesticides on man and his environment, particularly pollution effects in closely cropped mixtures.

## 4C. Special Topics in Agroforestry

Although most of these topics can be considered to fall logically in other sections, it is justifiable to identify some ten subjects that have particular relevance in teaching agroforestry.

### i) Multipurpose Species

Traditionally trained agriculturists and foresters tend to think of monocultures and single products, e.g. trees for pulpwood, maize for seed, cows for milk. Agroforestry encourages multicultures in which more than one species is grown, and multiple products or benefits, e.g. the tree species may be used for shade, shelter, soil improvement, fodder, poles and fuelwood; chickens may be reared for eggs or meat depending on the cultural conditions; cows may be used for ground preparation, crop planting, milk and hides. The object of this section is to introduce students to this multiple-use concept, to illustrate appropriate examples, and to describe the principles of species choice, evaluation and use.

### ii) Biomass for Energy

Over half the wood used in the world is burned for cooking and heating. Most agroforestry systems and multipurpose trees are likely to have energy production as an objective. This section describes the various types and sources of biomass and the processes that can be used to convert it to energy. The former include woody trees and shrubs, other plants and plant waste, animal or human dung; the latter include unprocessed firewood, charcoal production, densified and pelletised wood, pyrolysis and gasification. The concept of appropriate technology should be emphasized, e.g. type of stove or crematorim, size of generator.

iii) Trees for Fodder and Forage

Although covered also in multipurpose trees, this topic needs special treatment because of its unfamiliarity to traditional foresters. It includes the measurement of local yield, palatability, methods of harvesting, storage, drying, protein and energy yields; it considers undesirable chemical and physical features of various species. It may include the production of honey and silk and also leaves for human consumption e.g. (smoking, digestive and medicinal material).

iv) The Location and Management of Difficult Environments

The principles of research and management of plants and animals apply to all sites but the practices are site specific. Techniques do exist for establishing productive units on the most difficult sites and these merit special treatment. The environments include arid zones (particularly hot deserts), alkaline and saline soils, swamps, areas subject to heavy precipitation, critical slopes, industrial wastes, and degraded lands.

v) Soil and Water Conservation, Including Erosion Control

This section describes the factors affecting soil loss and the water balance and it emphases downstream effects. Methods to minimize erosion and to encourage water retention include trenches, bench terraces, limans, microcatchments, check dams, vegetation fences, grass planting, etc. The students would also be introduced to methods of assessing water yield and soil loss.

vi) The Place of Research in Agroforestry

This includes the fundamentals of research philosophy and the research questions in agroforestry. Multivariate techniques are

described together with appropriate experimentation, sampling, social survey and diagnostic analysis. The principlesand methods of data handling and analysis are detailed together with computer appreciation and report writing.

vii) Trees Managed for Mulch and Organic Matter

In some systems trees particularly nitrogen fixing legumes are systematically lopped to produce mulch (principally for moisture conservation, weed suppression and production of organic matter) either to be disposed of near the trees lopped or at other locations. These practices may vary in tree species, crops to be mulched and frequency of lopping; also there may be different influences on the soil.

viii) Economics in Agroforestry

Agroforestry systems are potentially extremely complex with variable externalities so that case studies in the economic evaluation of such systems will be essential teaching material. It will provide a mechanism for building up relevant tools and techniques in addition to those proposed in 1C, D and E, particularly for quantifying risk and the retention or foreclosing on options.

ix) Extension Methods and Appropriate Technology

Probably the most important agroforestry activity is the transfer of technology to the community and individual farmer. The student would be instructed in the wide range of extension techniques and educational aids including the training and visit system, the value of demonstration plots and demonstrations of practical techniques, displays, illustrated booklets, film strips for schools, and a knowledge of incentive schemes. He would be instructed in the principles of ergonomics.

x) Study of Traditional Practices

Many new and enthusiastic graduates wish to introduce new species, techniques and systems. Students should be taught the value and methods of studying existing practices, to search for their good and bad points and to describe qualitatively the methods applied in their districts.

4D. The Systems Approach in Agroforestry

A systems approach is required in agroforestry in order to:

i) deal with the complexity of interactions in multi-component, multipurpose, agroforestry cropping systems;
ii) relate the functional potentials of agroforestry systems and practices to the functional needs and objectives of land-use managers; and,
iii) ascertain the sutainability of agroforestry land-management systems in relation to the resource base and carrying capacity of the wider ecosystems of which they are a part.

Different types of systems analysis are needed to deal with these three different levels of application, i.e. a) methodologies for studying interactions among components of plant-soil-climate systems at the field level; b) methodologies for diagnosing land-management constraints and agroforestry potentials at the farm, watershed and other unit management levels; and c) methodologies for assessing dynamic relationships and long-term trends in agroforestry-related human ecosystems.

5. Thesis/Dissertation

Many undergraduate programmes in agriculture, forestry and related topics and most Masters' programmes require students to conduct a small research project. At the Masters' level this is typically one quarter of a 1-year course or one half of a 2-year course.

The practice of agroforestry at the professional level requires an exceptional ability to be innovative and practical in field actitivies, and the preparation of a thesis or dissertation is considered to be of great significance in the training of both field and research workers.

The topic selected may be in any aspect of enviromental, plant or animal science but should be clearly related to the special case of the joint production and the interaction of the components of agroforestry systems. It may be concerned with existing plots managed by traditional systems or with newly designed and replicated experiments. If possible it should cover a complete annual field cycle. In conducting the research, considerable information may be obtained from traditional farmers.

## ANNEX 1

### LIST OF PARTICIPANTS* AND CONTRIBUTIONS

| Regional Coordinators | Summary of Regional Information from: |
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| 1. Abdul Manap Ahmad<br>Dean, Faculty of Forestry<br>University Pertanian Malaysia Serdang, Selangor<br>MALAYSIA | SOUTH EAST ASIA |
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| 3. Jean Dubois<br>IICA-TROPICOS<br>C.P. 2044 (Sao-Bras)<br>66000 Belem, Para<br>BRAZIL (Tel: 091/2264318) | SOUTH AMERICA |
| 4. Francis Halle<br>Laboratoire de Botanique<br>Institut Botanique<br>163 Rue Auguste-Brossonet<br>34000 Montpellier<br>FRANCE (Tel: (67) 41-37-48) | WESTERN EUROPE |
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| Contributors of Position Papers | Titles |
|---|---|
| 12. Emiliana N. Bernardo<br>Visayas State College<br>of Agriculture<br>Baybay Leyte<br>PHILIPPINES | Need for an agroforestry curriculum in the Philippines. |
| 13. Ebarhard F. Brunig<br>Insitute/Chair for<br>World Forestry<br>University of Hamburg<br>Leuschenerstrasse 91<br>D-2050 Hamburg 80<br>FEDERAL REPUBLIC OF<br>GERMANY<br>(Unable to attend) | The network and twinning concepts of research and training: What do they mean to education in agroforestry? |
| 14. Jeffrey Burley<br>Department of Agriculture &<br>Forest Sciences<br>University of Oxford<br>South Parks Road<br>Oxford OX1 3RB<br>ENGLAND | Agroforestry course studies and context at the degree and postgraduate course level. |
| 15. Peter von Carlowitz<br>ICRAF<br>P.O. Box 30677<br>Nairobi, Kenya | Concepts and constraints of education in agroforestry. |
| 16. Linda Christanty<br>Institute of Ecology<br>Pajadjaran University<br>Jalan Schela<br>Bandung, INDONESIA<br><br>(Current address: Resource<br>Management Sciences<br>University of British<br>Columbia in Canada) | Traditional agroforestry systems in West Java, Indonesia. |
| 17. Oghenetsavbuko T. Edje<br>Crop Production Department<br>University of Malawi<br>P.O. Box 219<br>Lilongwe, MALAWI | Agroforestry programme and agroforestry education in Malawi. |

| | |
|---|---|
| 18. Eduardo E. Escalante<br>Apartado Postal 197<br>Trujillo, Estado<br>Trujillo,<br>VENEZUELA 3102-A | Guidelines for an agroforestry educational programme in Venezuela. |
| 19. Dan M. Etherington<br>Development Studies<br>Centre, The Australian<br>National University<br>P.O. Box 4<br>Canberra ACT 2600<br>AUSTRALIA | Education in the economics of agroforestry land-use systems: Economics for agroforestry. |
| 20. Peter Huxley<br>ICRAF<br>P.O. Box 30677<br>Nairobi, KENYA | A combined case study /systems approach for agroforestry teaching |
| 21. Esther Kariuki<br>Kenya Agricultural<br>Research Insitute<br>P.O.Box 74<br>Kikuyu, KENYA | The need and level of agroforestry education. (Combined paper with J. Maghembe) |
| 22. Joseph C. Madamba<br>Director<br>Southeast Asian Regional<br>Centre for Graduate<br>Study & Research in<br>Agriculture (SEARCA)<br>College, Laguna 3720<br>PHILIPPINES | Building in-country capabilities for the development of efficient agroforestry systems in Southeast Asia. |
| 23. Jumanne Maghembe<br>Division of Forestry<br>Faculty of Agriculture<br>Forestry & Veterinary<br>Science University of<br>Dar-es-Salaam<br>c/o Sub Post Office<br>Morogoro<br>TANZANIA | The need and level of agroforestry education. (Combined paper with Esther Kariuki) |
| 24. B.K. Maiyo<br>Lecturer, Kenya<br>Forestry College<br>P.O. Box 8<br>Londiani, KENYA | The scope of using the existing forestry programme structures for agroforestry education |

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| 25. H.J. von Maydell<br>Institut fuer Weltforst-wirtschat Leuschner-Strasse 91<br>D-2050 Hamburg 80<br>FEDERAL REPUBLIC OF GERMANY | What will be expected of professional agro-foresters? |
| 26. G.L. McClymont<br>Australia Rural Adjust-ment Unit, University of New Zealand<br>Armidale NSW 2351<br>AUSTRALIA | An agrosystem - ecosystem and farming system framework for professional agrofo-restry education |
| 27. J.A. Odera<br>Deputy Director<br>Forestry Research Depart-ment, Kenya Agriculture Research Institute<br>P.O. Box 74<br>Kikuyu, KENYA | Agroforestry educa-tion for contempo-rary and future land use development in Kenya |
| 28. David U. Okali<br>Head, Department of Forest Resources Management<br>University of Ibadan<br>Ibadan, NIGERIA | Elements of agrofo-restry in existing forestry education programmes in Nigeria |
| 29. Lucrecio L. Rebugio<br>Director, Centre for Forestry Education and Development for Asia and the Pacific College of Forestry College, Laguna, P.O. Box 434, PHILIPPINES | Logic of agroforestry curriculum develop-ment - the case of UPLB. |
| 30. Mandivamba Rukuni<br>Department of Land Mana-gement, University of Zimbabwe<br>P.O. Box 167<br>Harare<br>ZIMBABWE | Agroforestry in land management education programmes. |
| 31. Soekiman Atmosoedaryo<br>Faculty of Forestry<br>University of Mulawarman<br>Samarinda East Kalimantan<br>INDONESIA | Education and training on the rural community development |

| | | |
|---|---|---|
| 32 | Michael Stocking<br>Overseas Development Group<br>University of East Anglia<br>Norwich, NR4 7TJ<br>ENGLAND | Agroforestry education for rural development. |
| 33. | Abd-El-Azim O. Tantawy<br>Secretary General of the Association of the Faculties of Agriculture in Africa, c/o Institute Agronomique at Vet.,<br>P.O. Box 704 AGDAL<br>Rabat, MOROCCO | Staff specialization and teaching courses in faculties of agriculture in Africa |
| 34. | Khubchand Tejwani<br>25/31 Old Rajindra Nagar<br>New Delhi 1100060<br>INDIA<br>(Unable to attend) | Personpower in agroforestry. |
| 35. | Peter Wood<br>ICRAF P.O. Box 30677<br>Nairobi, Kenya<br>(Unable to Attend) | The need for agroforestry in short courses |

| Contributors of Reviews of Source Materials | | Titles |
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| 36. | M.G. Cannell<br>Institute of Terrestrial Ecology, Bush Estate<br>Penicuik, Midlothian EH26 OQB<br>Scotland, U.K. | Review of key literature materials relevant to plant aspects of agroforestry. |
| 37. | Till Darnhofer<br>ICRAF,<br>P.O. Box 30677<br>Nairobi, KENYA | Agricultural meteorology in agroforestry: A review of source materials and literature. |
| 38. | Dirk Hoekstra<br>ICRAF<br>P.O. Box 30677<br>Nairobi, KENYA | Review of economic literature relevant for agroforestry. |

| | |
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| 39. Melinda Khan<br>Environment Liaison Centre<br>P.O. Box 72461<br>Nairobi, KENYA<br>(Unable to attend) | NGO's and agroforestry. |
| 40. Richard Labelle<br>ICRAF<br>P.O. Box 30677<br>Nairobi, KENYA | A qualitative overview of sources of agroforestry information. |
| 41. P.K.R. Nair<br>ICRAF<br>P.O. Box 30677<br>Nairobi, KENYA | Soils and soils management in agroforestry |
| 42. John Raintree<br>ICRAF<br>P.O. Box 30677<br>Nairobi, KENYA | Readings for a socially relevant agroforestry. |
| 43. Filemon Torres<br>ICRAF<br>P.O. Box 30677<br>Nairobi, KENYA | Role of woody perennials in animal agroforestry. |
| 44. Cor Veer<br>Department of Forest Management,<br>Wageningen Agricultural University, Gen. Foulkesweg 64, P.O. Box 342,<br>6700 AH Wageningen<br>THE NETHERLANDS | Management of agroforestry: A selective annotated bibliography for educational purposes. |

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