CHAIRS' SUMMARY PAPER: Agroforestry

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The agroforestry session consisted of two invited review papers, one of which dealt with agroforestry in temperate zones and one of which dealt with agroforestry in tropical environments. Twenty-nine posters (14 from tropical zones, 3 from the sub-tropics and 12 from temperate regions) augmented these two papers, and were largely focused on silvopastoral systems, although information on multi-purpose tree species and shelterbelt technologies was also presented.

Martin Hawke (AgResearch, Private Bag 3020, Rotorua, New Zealand) discussed the changing focus of pastoral agroforestry in temperate zones, with specific reference to developed systems utilizing *Pinus radiata* in New Zealand. Successful establishment of silvopastoral systems in that country must embrace tree establishment guidelines gleaned from previous research, tree quality and growth parameters, pasture production and livestock performance, the complex relationship between soil and nutrient availability in these systems and other ecological factors, microclimatic factors and silvicultural considerations. The New Zealand experience generally indicates that both pasture and livestock productivity declines as trees age and as the density of the planting increases. The economics of these systems are largely geared to maximizing returns from the tree component; as with other agroforestry systems, the low returns attributable to the animal component of the system remain a problem.

However, concern about the environmental sustainability of agricultural systems is currently driving interest in integrated tree-pasture systems because of the ability of these systems to control erosion, enhance soil fertility, maintain biodiversity at several scales and address issues concerning animal welfare. Mr. Hawke then described on-going research in New Zealand on agroforestry management systems. Sophisticated computer models are currently used to analyze tree growth and pasture production relative to livestock returns and marketing strategies in order to evaluate the financial implications of planting trees on farms. The challenge remains to demonstrate to the livestock industry and others interested in land-use, the correct use of these environmentally and financially viable systems.

In New Zealand, most of the current silvopastoral research is concentrating on systems using radiata pine, although the importance of other tree species in playing a role in these systems is noted. Strategic planning, the use of interactive models and an interdisciplinary approach is essential to optimizing the utilization of pastoral agroforestry systems that promote the principles of sustainability.

I. M. Nitis (Department of Nutrition and Tropical Forage Science, Udayana University, Denpasar, Bali, Indonesia) presented a paper on silvopastoral systems in a tropical context. In contrast to temperate systems, traditional silvopastoral systems are well known and utilized by farmers in tropical areas. Dr. Nitis explained how agroforestry systems were classified in the tropics and indicated that, depending upon the amount of annual precipitation, agroforestry systems embraced either timber and energy production (humid and sub-humid tropics - 'silvicultural/agrisilvicultural' systems) or shrub and tree fodder production for animals (arid and semi-arid tropics - 'silvopastoral/agrisilvopastoral systems').

Appropriate silvopastoral systems can play an important role in the tropics, where little new land is available for agricultural production, and where the current pressure of over-population leads to a continual increase in the demand for food, feed, fuel and timber. This in turn results in over-grazing, extensive logging and continuous cropping, completing the vicious cycle and leading to more land degradation.

In the humid and sub-humid tropics, current research needs to address the adaptation of native plants and animals to high rainfall and low light scenarios, whereas in the semi-arid and arid tropics, the need is on adaptation to drought and high light intensity. As in temperate regions, a more holistic and integrated approach needs to be adopted in order to ensure the development and implementation of germane silvopastoral systems in the tropics.

The posters presented in the agroforestry session addressed many local concerns attached to the implementation of agroforestry systems in both tropical and temperate regions. A good majority of the posters dealt with some aspect of silvopasture, and were generally of two types. The first group addressed silvopasture from a systems perspective i.e. animal and tree returns were evaluated within the context of a designed and/or established silvopastoral system. It would appear that in designing such systems for temperate regions, there is great flexibility in choosing the appropriate tree density, depending upon the management outcome desired. For example, in New Zealand, at a density of 100 stems per hectare, some pasture production persisted until age 24. At higher densities of 200 to 400 stems per hectare, pasture production disappeared much earlier. Eason et al., in describing tree growth and animal performance in the U.K., found that regardless of the density utilized (100 or 400 stems per hectare), no reduction in animal production was noted eight years after planting, despite interception of up to 10% of the total photosynthetically active radiation by the developing tree canopy. Sheep carrying capacity in such temperate systems might be expected to be in the neighbourhood of about 12 sheep per hectare under 400 to 600 tree stems per hectare (Pollock et al.). With respect to the impact on soil processes at these densities, Nwaigbo et al. found, at a density of 400 stems per hectare, that soil total nitrogen, carbon and organic matter increased significantly with horizontal distance from the tree but that soil nutrients did not. They additionally found that soil penetrometer resistance increased within 4.5 m of certain tree species to a depth of 14 cm, and that this had potential negative effects on growth of trees and pastures in these plots.

The second group of posters dealt largely with the morphological and physiological responses of trees to simulated and actual browsing pressure. Due to the wide range of conditions, animals and plant species addressed, it is impossible to generalize about the research results other than to say that basic research of this is fundamental to the successful establishment of silvopastoral systems, especially in the tropics where it may not be possible to have systems as rigidly designed as those currently being developed in temperate regions. [See the poster summaries by Corniaux et al. and Gutteridge for tropical and sub-tropical examples and those of Xu et al. and Talamucci et al. for temperate examples of this type of research.]

It should be remembered that agroforestry embraces more than just silvopastoral systems and while there were few posters presented on other aspects of agroforestry (e.g. Gillingham and Hawke - shelterbelt ecology), the discipline also embraces windbreak technologies, riparian forest ecosystems, intercropping or silvoarable systems and forest farming systems. Many of these systems incorporate forage species in both temperate and tropical regimes and can offer environmentally sustainable, economic alternatives to traditional forage management and cereal production systems. Research on both silvoarable (intercropping) and silvopastoral (animal-plant) systems is moving rapidly to address the multi-component nature of these systems. Emphasis should be placed on the development of good modelling environments, system component interactions (especially those occurring below-ground), and the acquisition of basic biological, ecological and economic information of interest in the region under study.

As agroforestry is a rapidly-changing discipline, the reader may be interested in these recent books on the subject:

Gordon, A. M. and S. M. Newman (Eds.). 1997. Temperate Agroforestry Systems. C.A.B. International, Wallingford, U.K. Pp. 269.

Ong, C. K. and P. A. Huxley (Eds.). 1996. Tree-Crop Interactions: A Physiological Approach. C.A.B. International, Wallingford, U.K. Pp. 416.

Young, A. 1997. Agroforestry for Soil Management (2nd Edition). C.A.B. International, Wallingford, U.K. Pp. 350.