SUMMARY

1. The present study, apart from gaining an insight into various ecological aspects of shifting cultivation seeks to suggest innovations in the existing practice of 'Jhuming' locally called 'Lo' in Mizoram. The innovations or alterations tried in this study include the introduction of second year of cropping on the same jhum land, hitherto not commonly practiced in Mizoram. During second year of cropping, the jhum land is subjected to tilling and application of chemical fertilizers, farm-yard manure (FYM) and a combination of chemical fertilizer and FYM. This introduction of second year of cropping will help in lengthening the present jhum cycle in the state and thus would retard deforestation which is taking place at an alarming rate.

2. The experimental studies were conducted during 1988 and 1989 in Mizoram. The experimental data collected during these two years have been processed and analysed using appropriate statistical methods.

3. The study sites included two jhum fallows of different ages — 6-yr. old and 20-yr. old. Various aspects of the study were conducted during first year and second year of cropping on both the 'jhum' fallows.

4. Phytosociological studies of selected jhum fallow forests showed that vegetation on 20-yr. old jhum fallow is composed of 37 plant species and that on 6-yr. old jhum fallow is composed of 46 plant species. Melocanna bambusoides is a dominant species with IVI of 191.57 and 175.1 in 20-yr. old and 6-yr. old jhum fallows respectively. This study reveals a higher index of dominance with lower index of diversity of species on 20-yr. old jhum fallow whereas inverse was true on 6-yr. old jhum fallow. More tree species and less shrub/herb species are found to be present in 20-yr. old jhum fallow whereas less tree species and more shrub/herb species are present in 6-yr. old jhum fallow.

5. Studies on the physico-chemical characteristics of soil clearly depicted slightly higher pH value and higher concentration of nutrient elements in upper layer (0-10cm) than in lower layer (10-20cm) of soil.

6. As a whole, the soil fertility level in 20-yr. old jhum fallow is higher than in 6-yr. old jhum fallow.

7. The pre-jhuming vegetation plays an important role in determining soil nutrient status mainly through burning operation. Increase in soil pH and various elements like available phosphorus, exchangeable potassium, calcium and magnesium was evident after dried slashed pre-jhuming vegeta-

tion was burned. Exchangeable potassium showed the highest degree of increase due to burning. However, no increase was observed in organic carbon and total nitrogen contents of soil after burning. This has been attributed to the combustion of organic matter and volatilization of nitrogen during burning.

8. Decline in soil fertility during cropping was evident. This may be due to nutrient uptake by plants and losses brought about by erosion and percolation. Erosion loss was most severe on land where tilling was introduced.

9. The present study reveals that forest vegetation growing on jhum fallows reduces leaching and stores nutrients which are made available to crops to a significant degree through their rapid transformation brought about by burning during shifting cultivation.

10. Soil fertility level can be properly maintained by the application of chemical fertilizers, farm-yard manure and a combination of chemical fertilizers and farm-yard manure during second year of cropping.

11. Annual biomass production and net primary productivity were higher in 20-yr. old than 6-yr. old jhum fallow during first year and second year of cropping. The highest values for biomass and productivity were recorded when chemical

fertilizers were applied to the treatment plots, while the lowest values were recorded from the sub-plots where the tilling of land was introduced during second year of cropping.

12. Nutrient status of the soil is the main factor determining the biomass production and rate of productivity of crop (rice) and crop plus weeds.

13. Due to frequent weeding operation during shifting cultivation competition between crop (rice) and weeds do not play significant role as far as biomass production of crop or crop plus weeds is concerned.

14. Among various jhuming operations, weeding requires the highest energy input. Though the introduction of tilling of the land on jhum fallows required extra input of energy it did not increase the output. In fact, the energetic efficiency of the sub-plot was lowered due to introduction of ploughing.

15. The 20-yr. old jhum fallow was more efficient than 6-yr. old jhum fallow from energetic and productivity point of view during first year of cropping. However, not much difference between the two was evident during second year of cropping.

16. A greater production of crop biomass, better economic

yield considerably low weed biomass production and higher energy efficiency of 20-yr. old fallow during first year of cropping as compared to 6-yr. old jhum fallow depict the positive role of longer jhum cycle in regenerating the system and in making it more productive and efficient.

17. Among the treated sub-plots, the one which received chemical fertilizers plus farm-yard manure showed highest output in terms of money. However, these sub-plots showed lowest output : input ratio in terms of energy because of high energy value of fertilizers. Tilled sub-plots showed lowest output : input ratio in terms of money.

18. Among the treated sub-plots during second year of cropping the highest crop yield was obtained from the chemical fertilizers plus FYM treated sub-plots, followed by chemical fertilizers treated sub-plots and then by FYM treated sub-plots. Tilled sub-plot showed lowest crop yield. Control sub-plots slightly exceeded tilled sub-plots on both 20-yr. old and 6-yr. old jhum fallows.

19. As a whole, application of fertilizers, whether it be chemical, farm-yard manure or combination of both, caused an increase in crop yield and helped in maintaining the inherent soil fertility to some extent during second year of cropping. These treatments are therefore, recommended for

the improvement or to innovate the existing practice of shifting cultivation from productivity and soil fertility point of view. But the energetic efficiency of the sub-plots with these treatments is rather low as the high energy value of fertilizers drastically brought down the energetic output : input ratio.

20. Tilling of the soil as a means to innovate existing practice of jhum in Mizoram is not worth suggesting as this treatment did not increase the productivity and energetic efficiency of the system.

21. The inherent soil fertility level after a year of cropping was drastically reduced by the end of second year of cropping even when treated with chemical fertilizer and/or farm-yard manure during second year.

22. The present study provides factual and quantitative data on the ecological implications of traditional shifting cultivation and innovative approaches that were tried on an experimental basis with a view to minimise the ill effects of shifting cultivation in Mizoram. The study examines the merits and demerits of the innovative approaches that could be introduced as a means to improve the existing practice of 'Lo' in Mizoram, so that the deforestation and land degradation which are largely caused by shifting cultivation due to shortening of jhum cycle in the state could be controlled to some extent.

REFERENCES

Ahlgren, I. F. and C. E. Ahlgren. 1965. Effect of prescribed burning on soil microorganisms in a Minnesota Jack pine forest. Ecology. **46**, 304-310.

Allen, S. E. 1964. Chemical aspects of heather burning. J. Appl. Ecol. 1, 347-367.

Allen, S. E. (ed.). 1974. Chemical Analysis of Ecological Materials. Blackwell Scientific Publications, Oxford.

Andersson, F. 1971. Methods of preliminary results of estimation of biomass and primary production in south Swedish mixed deciduous woodland. In: Productivity of Forest Ecosystems. UNESCO, Paris, 281-288.

Andriesse, J. P. and T. Th. Koopmans. 1984. A monitoring study on nutrient cycles in soils used for shifting cultivation under various climatic conditions in tropical Asia I. The influence of simulated burning on form and availability of plant nutrients. Agric. Ecosystems and Environ. **12**, 1-16.

Andriesse, J. P. and R. M. Schellhaas. 1987a. A monitoring study on nutrient cycles in soils used for shifting cultivation under various climatic conditions in tropical Asia, II. Nutrient stores in biomass and soil. Agric. Ecosystems and Environ. 19, 285-310.

Andriesse, J. P. and R. M. Schellhaas. 1987b. A monitoring study on nutrient cycles in soils used for shifting cultivation under various climatic conditions in tropical Asia, III. The effect of land clearing through burning on fertility level. Agric. Ecosystems and Environ. 19, 311-332.

Aurora, G. S., R. K. Billory, A. Patton and P. Myrchiang. 1977. Socio-economic impact of shifting cultivation control schemes in north-eastern region. Department of Sociology and Anthropology, North-Eastern Hill University, Shillong. (Mimeographed).

Bara, S. and J. A. Vega. 1983. Effects of wildfires on forest soil in the north-west of Spain. Freiburger Waldschutz Abhandlungen. 4, 181-195.

Basic Statistics for North Eastern Region. 1987. North Eastern Council, Shillong.

Birch, H. F. and M. T. Friend. 1956. The organic matter and nitrogen status of east African soils. J. Soil Sci. 7, 156-167.

Bleasdale, J. K. A. 1960. Studies on plant competition. In: The Biology of Weeds (ed. J. L. Harper). Blackwell, Oxford. 133-142.

Borman, F. H., G. E. Likens, D. W. Fisher and R. S. Pierce. 1968. Nutrient loss accelerated by clear-cutting of a forested ecosystem. Science. 159, 882-884.

Borthakur, D. N., A. Singh, R. P. Awasthi and R. N. Rai. 1978. Shifting cultivation in the north-eastern region. In: Resources Development and Environment in the Himalayan Region. Dept. Sci. and Tech., Govt. of India. 330-342.

Carneiro, R. L. 1960. Slash and burn agriculture: A closer look at its implications for settlement patterns. In: Men and Cultures. (ed. A. F. C. Wallace). 229-234.

Chacon, J. C. and S. R. Gliessman. 1982. Use of the 'non-weed' concept in traditional tropical agro-ecosystems in south eastern Mexico. Agro-ecosystems. 8, 1-11.

Champion, H. G. and S. K. Seth. 1968. A Revised Survey of the Forest Types of India. Manager of Pucliations, Delhi.

Chidumayo, E.N. 1987. A shifting cultivation land use system under population pressure in Zambia. Agroforestry Systems. 5, 15-25.

Conklin, H. C. 1957. Hanunoo Agriculture. F.A.O. Forestry Development paper No. 12, F.A.O. Rome.

Cook, O.F. 1921. Milpa agriculture, a primitive tropical system. Annual Report of Smithsonian Institution. 1919, 307-326.

Corbet, A. S. 1934. The bacterial numbers in the soil of the Malay Peninsula. Soil Sci. 38, 407-416.

Coulter, J. K. 1950. Organic matter in Malayan soils; A preliminary study of the organic matter content in soils under virgin jungle, forest plantations and abandoned cultivated land. Malayan Forester. 13, 189-202.

Cutting, C. V., R. A. Wood, P. Brown and H. B. Ambrose. 1959. Assessment of fertility status and the maintenance of productivity of soils in Nyasaland. In: Third Inter-African Soil Conference. Dalaba. Paper No. 69.

Debell, D. S. and C. W. Ralston. 1980. Release of nitrogen by burning light forest fuels. Soil Sci. Soc. Am. Proc. 34, 936-938.

Deka, H. K. and R. R. Mishra. 1983. The effect of slash burning on soil microflora. Plant and Soil. 73, 167-175.

Dobby, E. H. G. 1950. South East Asia. University of London Press, London.

Donald, C. M. 1958. The interaction of competition for light and nutrient. Aust. J. Agric. Res. 9, 421-435.

Donald, C. M. 1963. Competition among crop and pasture plants. Adv. Agron. 15, 111-118.

Dormear, J. F. and B. D. Schaber. 1985. Chemical properties of soil as affected by a single burn of alfalfa stubble to control insects. Can. J. Soil Sci. 59, 79-86.

Dormear, J. F., U. J. Pittman and E. D. Spratt. 1979. Burning crop residues: Effect on selected soil characteristics and long-term wheat yields. Can. J. Soil Sci. 65, 357-361.

Dokuchaev, V. V. 1979. Cartography of Russian Soils. USSR Acad. Sci. Moscow.

Dwivedi, A. P. 1980. Forestry in India. Jugal Kishore and Company.

Exwall, E. 1955. Slash and burn cultivation: A contribution to anthropological terminology. Man. 55, 135-136.

Fotzo, P. T. 1977. Resource productivity and returns in rice production under alternative farming systems. A comparative study in the North-West Province of Cameroon (ms.). University of Ibadan, Nigeria.

Freeman, J. D. 1955. Iban Agriculture. A report on the shifting cultivation of hill rice by Iban of Sarawak, H.M.S.O., London.

Gangwar, A. K. and P. S. Ramakrishnan. 1987. Agriculture and animal husbandry among the Sulung and Nishis of Arunachal Pradesh. Social Action. 37, 346-372.

Gliessman, S. R. 1982. Nitrogen distribution in several Agroecosystems in the humid tropical lowlands of southeastern Mexico. Plant and Soil. 67, 105-117.

Golley, F. B. 1965. Structure and function of an old field broomsedge community. Ecol. Monographs. 35, 113-137.

Gopalan, C.B., V. Ramasastri and S. C. Balasubramanian. 1985. Nutritive Value of Indian Foods. National Institute of Nutrition, Hyderabad.

Gourou, P. 1953. The Tropical World. Longmans, London.

Griffith, G. 1949. Fertility problems in Uganda. Commonwealth Bur. Soil Sci. Tech. Communication No. 46, 160-164.

Greenland, D. J. 1975. Bringing the Green Revolution to the shifting cultivator. Science. 190, 841-844.

Greenland, D. J. and R. Herrera. 1975. Shifting Cultivation and Agricultural Practices, I.I.T.A. Ibadan.

Harroy, J. P. 1949. Afrique Terre Quimeurt. 2nd ed. Brussels.

Hart, R. D. 1984. Agroecosystem determinants. In: Agricultural Ecosystems: Unifying Concepts (eds. R. Lowrance, B. R. Stinner and G. J. House). John Wiley and Sons, Inc.

Hauck, F. W. 1974. Introduction: Shifting Cultivation and Soil Conservation in Africa. FAO Soils Bulletin. 24, 1-4.

Hrahsel, Z. 1988. Variability in Soil Properties Under Shifting Cultivation in Mizoram. M.Sc. (Agri) dissertation submitted to Assam Agricultural University.

Jaccard, P. 1912. The distribution of the flora in the alpine zone. New Phytol. **11**, 37-87.

Jackson, M. L. 1973. Soil Chemical Analysis. Prentice Hall, New Delhi.

Jenny, H. 1941. Factors of Soil Formation. A system of quantitative pedology. McGraw Hill, New York.

Jha, M. N., P. Pande and T. C. Pathak. 1979. Studies on the changes in the physico-chemical properties of Tripura soils as a result of Jhuming. Indian For. **105**, 436-443.

Joachim, A.W.R. and S. Kandiah. 1948. The effect of shifting (Chena) cultivation and subsequent regeneration of vegetation on soil composition and structure. Trop. Agric. **104**, 3-11.

Juo, A. S. R. and R. Lal. 1977. The effect of fallow and continuous cultivation on the chemical and physical properties of an alfisol in Western Nigeria. Plant and Soil. **47**, 567-584.

Khokhar, M.F.K. 1985. Biomass productivity and growth analysis of maize. In: Ecology and Resource Management in Tropics. Vol. I (ed. K.C. Mishra). Silver Jubilee Symposium of International Society for Tropical Ecology.

Khokhar, M.F.K. and H. N. Pandey. 1976. Biomass, productivity and growth analysis of two varieties of paddy. Trop. Ecol. 17, 125-131.

Knight, H. 1966. Loss of nitrogen from the forest floor by burning. For. Chron. 42, 149-152.

Kumada, K., S. Ohta, S. Arai, M. Kitamura and K. Imai. 1985. Changes in soil organic matter and nitrogen fertility during the slash and burn and cropping phases in experimental shifting cultivation. Soil Sci. Plant Nutr. 31, 611-623.

Kushwaha, S.P.S., P.S. Ramakrishnan and R.S. Tripathi. 1981. Population dynamics of Eupatorium odoratum L. in successional environments following slash and burn agriculture (Jhum). J. Appl. Ecol. 18, 529-536.

Lal, R. 1987. Tropical Ecology and Physical Edaphology. John Wiley and Sons, New York.

Lal, R. and D. J. Cummings. 1979. Clearing a tropical forest I. Effect on soil and micro-climate. Field Crops Res. 2, 91-107.

Lang, H. 1978. The economics of rainfall rice cultivation in West Africa. The case of the Ivory Coast. Diss. Hohenheim.

Leach, G. 1976. Energy and Food Production, Guildford: IPC. Science and Technology Press.

Leite, J. de L. and F. N. Ezeta. 1982. Soil variations in pastures of the Itapetinga agrosystem. I. The topo-sequence of Itaju do colonia (Bahia, Brazil). Soils Fert. 46, 170.

Lewis, O. 1951. Life in a Mexican Village. Tepoztlan restudied. University of Illinois Press, Urbana.

Lindsay, R. B. and C. D. Monk. 1981. Early regeneration of a clear cut southern Appalachian forest. Ecology. 62, 1244-1253.

Lloyd, P. S. 1971. Effect of fire on the chemical status of herbaceous communities of the Derbyshire Dales. J. Ecol. 59, 261-271.

Mey, A. W. 1978. The Economy of Shifting Cultivation in Bangladesh. Paper presented to the Tenth International Congress of Anthropological and Ethnological Sciences, India.

Mishra, B.K. and P.S. Ramakrishnan. 1981. The economic yield and energy efficiency of hill agro-ecosystems at higher elevations of Meghalaya in north-eastern India. Acta. Oecologica: Oecol. Applic. 2, 369-389.

Mishra, B.K. and P. S. Ramakrishnan. 1983. Slash and burn agriculture at higher elevations in north-eastern India. II. Soil fertility changes. Agric. Ecosystems Environ. 9, 83-96.

Mishra, B. K. and P. S. Ramakrishnan. 1984. Nitrogen budget under rational bush fallow agriculture (Jhum) at higher elevations of Meghalaya in north-eastern India. Plant and Soil. 81, 37-46.

Mishra, R. R. 1966. Seasonal variation in fungal flora of grassland of Varanasi (India). Trop. Ecol. 7, 100-113.

Misra, R. 1968. Ecology Work Book. Oxford & IBH, New Delhi.

Mitchell, R. 1979. The Analysis of Indian Agro-Ecosystems. Interprint, New Delhi.

Mitchell, R. 1984. The ecological basis for comparative primary production. In: Agricultural Ecosystems: Unifying Concepts. (eds. R. Lowrance, B. R. Stinner and G. J. House). John Wiley and Sons, Inc., New York.

Mittal, J. P. and K. C. Dhawan. 1989. Energy parameters for raising crops under various irrigation treatments in Indian agriculture. Agric. Ecosystems Environ. 25, 11-25.

Mittal, V. K., J. P. Mittal and K. C. Dhawan. 1985. Research digest on energy requirements in agricultural sector (1971-82). Coordinating Cell, All India Coordinated Research Project on Energy Requirements in Agricultural Sector, Punjab Agricultural University, Ludhiana.

Moore, A.W. and E.O. Jaiyebo. 1963. The influence of cover on nitrate and nitrifiable nitrogen content of the soil in a tropical rain forest environment. Emp. J. Exp. Agric. 31, 189-198.

Makhijani, A. and A. Poole. 1975. Energy and Agriculture in the Third World. Ballinger, Cambridge. Mass.

Mutsaers, H.J.W., P. Mbouemboue and B. Mouzong. 1981. Traditional food crop growing in the Yaounde Area (Cameroon). Part I. Synopsis of the System. Agro-Ecosystems. 6, 273-287.

Myers, N. 1979. The Sinking Ark. Pergamon Press, New York.

Nayar, M.N.C. 1972. Organic Productivity and Growth Analysis of Two Varieties of Paddy (Oryza sativa L.). Ph.D. Thesis. Banaras Hindu University, Vanarasi, India.

Norman, M.J.T. 1978. Energy inputs and outputs of subsistence cropping systems in the tropics. Agro-Ecosystems. 4, 355-366.

Norman, M.J.T. and R. Wetselaar. 1960. Losses of nitrogen on burning native pasture at Katherine. J. Aust. Inst. Agric. Sci. 26, 272-273.

Nye, P.H. and D. J. Greenland. 1960. The Soil Under Shifting Cultivation. Tech. Comm. No. 51, Commonwealth Bureau of Soils.

Nye, P.H. and D.J. Greenland. 1964. Changes in the soils after clearing a tropical forest. Plant and Soils. 21, 101-112.

Odum, E.P. 1960. Oganic production and turnover in old field succession. Ecology. 41, 34-49.

Oya, K. and J. Tokashiki. 1984. Soil fertility in a shifting cultivation on Iromote Island of Okinawa. I. Nutrients stored in the forest and their input to the soil. Japanese J. Trop. Agric. 28, 218-222.

Pimentel, D. 1984. Energy flow in agroecosystems. In: Agricultural Ecosystems: Unifying Concepts (eds. R. Lowrance, B. R. Stinner and G.J. House). John Wiley and Sons, Inc. New York.

Pimentel, D., L. E. Hurd, A. C. Bellotti, M. J. Forster, I. N. Oka, O. D. Sholes and R. J. Whitman. 1973. Food production and energy crisis. Science. 182, 443-449.

Polglase, P. J., P. M. Attiwill and M.A. Adams. 1986. Immobilization of soil nitrogen following wild fire in two eucalypt forests of south-eastern Australia. Acta Oecologica: Oecologia Plantarum. 7, 261-271.

Ramakrishnan, P.S. 1985. Tribal man in the humid tropics of the North-East. Man in India. 65, 1-32.

Rappaport, R.A. 1968. Pigs for the Ancestor: Rituals in the Ecology of New Guinea People. Yale University Press.

Rappaport, R.A. 1971. The flow of energy in an agricultural society. Sci. Am. 225, 117-132.

Rasmunsen, P.E., R.W. Rickman and C. L. Douglas (JR). Air and soil temperatures during spring burning of standing wheat stubble. Agronomy Journal. 78, 261-263.

Reed, W. W. 1951. Reconnaissance Soil Survey of Liberia. USDA. Agric. Inf. Bull. 66, Washington.

Rice, E. L. 1974. Allelopathy. Acad. Press, New York.

Ravelle, R. 1976. Energy use in rural India. Science. 192, 969-975.

Rosswall, T. (ed.). 1980. Nitrogen Cycling in West African Ecosystems. SCOPE/UNEP. Royal Swedish Academy of Sciences.

Ruthenberg, H. 1983. Farming Systems in the Tropics. Clarendon Press, Oxford.

Rourke, B.E. 1974. Profitability of cacao and alternative crops in Eastern Region, Ghana. In: Economics of cacao production and marketing (eds. R.A. Kotey, C. Okali and B.E. Rourke). University of Ghana, Legon.

Saha, N. 1976. Levels of production and income under shifting cultivation in north-east India. Proceeding of the seminar on shifting cultivation in north-east India. North East Council of Social Sciences Research.

Salas, C. de las and H. Folster. 1976. Bio-element loss on clearing a tropical rain forest. Turrialba. 26, 178-186.

Sanchez, P. A. 1976. Properties and Management of Soils in the Tropics. John Wiley and Sons, New York.

Santantonio, D., R. K. Herman and W. S. Overton. 1977. Root biomass studies in forest ecosystems. Pedobiologia. 17, 1-31.

Santen, C. E. Van. 1974. Selected economic aspects of expanding rice production in Liberia (Mimeographed). WS FI. 325. Food and Agriculture Organization.

Saxena, K. G. and P. S. Ramakrishnan. 1986. Nitrification during slash and burn agriculture in north-eastern India. Acta Oecologica: Oecologia Plantarum. 7, 307-319.

Schlippe, P. D. 1956. Shifting Cultivation in Africa. The Zande System of Agriculture. Routledge and Kegan Paul, London.

Shannon, C. E. W. Weaver. 1963. The Mathematical Theory of Communication. University of Illinois Press, Urbana.

Sharma, T.C. 1976. The pre-historic background of shifting cultivation. Proceeding of the Seminar on Shifting Cultivation in N. E. India. North East Council for Social Science Research, Shillong, 1-5.

Shifting Cultivation in North-East India, 1983. ICAR Research Complex for NEH Region, Shillong, Meghalaya, 9-16.

Simpson, E. H. 1946. Measurement of diversity. Nature. 163, 688.

Singh, A. 1986. Shifting Cultivation and Alternative Land Management. ICAR Research Complex for NEH Region. Shillong, Meghalaya.

Singh, G. B. and A. Singh. 1980. Shifting cultivation in North-East Region. Indian Farming. 29, 17-20.

Singh, J. S. and P. S. Yadava. 1974. Seasonal variation in composition, plant biomass and net primary productivity of a tropical grassland at Kurukshetra, India. Ecological Monographs. 44, 351-376.

Singh, M. P. 1971. Net Primary Productivity and Energy Content of Mung (Phaseolus aurens Roxb.) and Wheat (Triticum aestivum, L.) and their major infesting weeds at Indore. Ph.D. Thesis, Indore University, Indore.

Singh, O.P. and B. Datta. 1986. Forms of Potassium in some soils of Mizoram. J. Indian Soc. Soil Sci. 34, 187-190.

Smith, W.H., F. H. Bormann and G.E. Likens. 1968. Response of Chaemotrophic nitrifiers to forest cutting. Soil Sci. 106: 471-473.

Spedding, C.R.W. 1975. The Biology of Agricultural Systems. Academic Press, London.

Spencer, D.S.C. 1975. The economics of rice production in Sierra Leone (Mimeographed). Njala University College.

Steinhart, J.S. and C.E. Steinhart. 1974. Energy use in U.S. food system. Science. 184, 307-316.

Swift, M.J., S.A. Russel and T.J. Perfect. 1981. Decomposition and mineral nutrients dynamics of plant litter in a regenerating bush fallow in the sub-humid tropics. J. Ecol. 69, 981-995.

Tiwari, S.C., B. K. Tiwari and R. R. Mishra. 1987. Temporal and depth-wise variations in dehydrogenase and urease activities and bacterial population in pine-apple plantation soils. Proc. Indian Natn. Sci. Acad. B. 53, 173-176.

Toky, O.P. and P. S. Ramakrishnan. 1981. Cropping and yields in agricultural systems of the north-eastern hill region of India. Agro-Ecosystems. 7, 11-25.

Toky, O.P. and P. S. Ramakrishnan. 1982. A comparative study of the energy budget of hill agro-ecosystems with emphasis on the slash and burn system (Jhum) at lower elevations of north-eastern India. Agricultural Systems. 9, 143-154.

Tripathi, R.S. 1968. Studies on plant competition with reference to weeds and crops. In: Recent Advances in Tropical Ecology. (eds. R. Misra and B. Gopal). 419-425.

Tripathi, R. S. 1977. Weed problem: An Ecological perspective. Trop. Ecol. **18**, 138-148.

Uhl, C. and P. G. Murphy. 1981. A comparison of productivities and energy values between slash and burn agriculture and secondary succession in the upper Rio Negro region of the Amazon Basin. Agro-Ecosystems. **7**, 63-83.

Uhl, C., C. F. Jordan, K. Clark, H. Clark and R. Herrera. 1982. Ecosystem recovery in Amazon Caatinga Forest after cutting, cutting and burning and bulldozer clearing treatments. Oikos. **38**, 313-320.

Uhl, C., H. Clark and K. Clark. 1982. Successional pattern associated with slash and burn agriculture in the upper Rio Negro Region of the Amazon Basin. Biotropica. **14**, 249-254.

Uhl, C., C.F. Jordan and E. Montagnini. 1983. Traditional and innovative approaches to agriculture on Amazon Basin Tierra Firme Sites. In: Nutrient Cycling in agricultural Ecosystems. (eds. R.R. Lowrance, R.L. Todd, L.E. Asmussen and R.A. Leonard). The University of Georgia, College of Agriculture Experimental Station. Special Publication. 23, 73-95.

Unger, P.W., R.R. Allen and J.J. Parker. 1973. Cultural practices for irrigated winter wheat production. Soil Sci. Soc. Am. Proc. 37, 437-442.

Vidyarthi, L.P. 1975. The future of traditional primitive societies: A case study of an Indian Shifting Cultivation Society. The Eastern Anthropologist. 28(4).

Viro, P.J. 1974. Effects of forest fire on soil. In: Fire and Ecosystems. (eds. T.T. Kozlowski and C.E. Ahlgren). Academic Press, New York.

Von Uexkull, H.R. 1983. Suggestions for the management of 'problem soils' for food crops in the humid tropics. Potash Review. No. 9. Subject 4.

Walkley, A. and I.A. Black. 1934. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci. 37, 29-38.

Watters, R.F. 1971. Shifting cultivation in Latin America. FAO. Forestry Development Paper No. 17, Rome.

Wells, C.G. 1971. Effects of prescribed burning on physical properties of soil. In: Prescribed burning Symposia. USDA. For. Serv. South Eastern For. Exp. Stn., Asheville, North Carolina, 80-97.

White, G.F., D.J. Bradley and A.U. White. 1972. Drawers of Water. University of Chicago Press. Chicago. 93-107.

White, E.M., W.W. Thompson and F.R. Gartner. 1973. Heat effect on nutrient release from soils under ponderosa pine. J. Range Manage. 22, 22-24.

Williams, W.A., R.S. Loomis and C.R. Lepley. 1965. The vegetative growth of corn as affected by population density. I. Productivity in relation to interception of solar radiation. Crop Sci. 5, 211-215.

Witkamp, M. 1971. Soils as components of ecosystems. Annual Review of Ecology and Systematics. 2, 85-110.

Worthington, E.B. 1958. Science in the Development of Africa. C.C.T.A., London.

Yadav, A.S. and R.S. Tripathi. 1981. The population dynamics of the ruderal weed Eupatorium odoratum L. and its natural regulation. Oikos. **36**, 355-361.

Young, R.S. and A. College. 1948. Composition of Woodland soils and wood ash in Northern Rhodesia. Emp. J. Exp. Agric. **16**, 76-78.

Zinke, P.J., S. Sabhasri and P. Khunstadter. 1978. Soil Fertility aspects of the 'Luas' forest fallow system of shifting cultivation. In: Farmers in the Forest. (eds. P. Khuntadster, E. C. Chapman and S. Sabhasri) East-West Centre, Honolulu, Hawaii.

NEHU Library
Acc. No 102312
Acc. by
Date 7/10/91
Class by
Sub Heading by
Catalogy
Proofread by