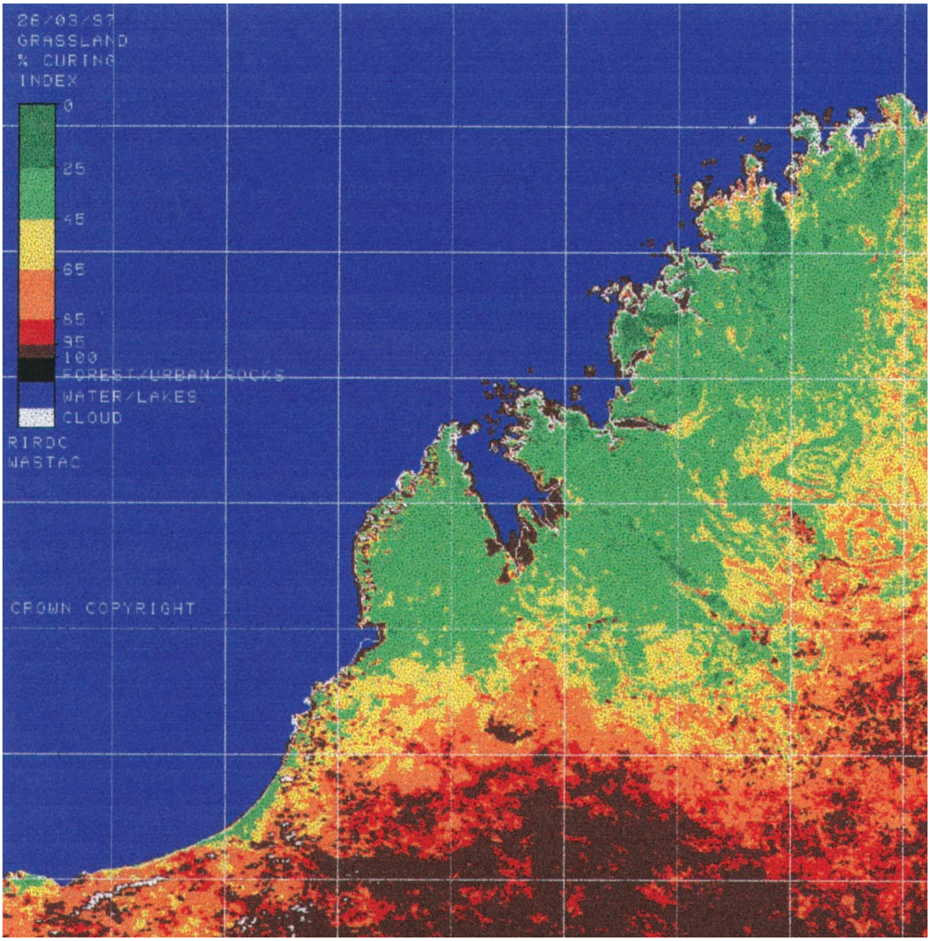
FIRE AND SUSTAINABLE AGRICULTURAL AND FORESTRY DEVELOPMENT IN EASTERN INDONESIA AND NORTHERN AUSTRALIA



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Fire and Sustainable Agricultural and Forestry Development in Eastern Indonesia and Northern Australia

Proceedings of an international workshop held at Northern Territory University, Darwin, Australia, 13–15 April 1999

Editors: Jeremy Russell-Smith, Greg Hill, Siliwoloe Djoeroemana and Bronwyn Myers

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Contents

Foreword

Over the past decade or so there has been growing recognition of the impacts, both environmental and political, of biomass burning in the wet forests of Sumatra, Kalimantan and Irian Jaya in Indonesia. This has translated into considerable research effort in these regions, particularly in the last few years (Dennis 1999; Laumonier et al. 1999). In contrast, much less attention has been given to annual, mostly prescibed burning practices and associated land management issues, across the extensive savanna landscapes of the eastern Indonesian archipelago, the Transfly region of Irian Jaya and Papua New Guinea, and northern Australia. While there has been considerable preliminary research undertaken into fire management and associated ecological issues in northern Australia over the past couple of decades, scant documentation is available concerning the extent of burning in different regions, traditional and contemporary practices, and impacts and benefits of fire management in eastern Indonesia cultural settings.

Building on the establishment of formal linkages in the 1990s between a number of eastern Indonesian and northern Australian institutions (universities especially), and recognition by all parties involved that fire management constituted a significant regional economic and social issue warranting cooperative applied research, in 1998 the Australian Centre for International Agricultural Research (ACIAR) offered support for a workshop where these problems could be defined and prioritised. The resulting workshop was held in Darwin, at the Northern Territory University, between 13 and15 April 1999. The workshop attracted approximately 60 participants, about half of whom were from Indonesia or further afield. The Tropical Savannas Cooperative Research Centre (based in Darwin) and the World Wide Fund for Nature (WWF) provided additional funding for overseas participants.

These proceedings comprise 26 papers presented at the Darwin workshop, summaries of the workshop discussion group sessions, and participant contact details. The papers are arranged in four groupings (Workshop opening and regional overview; Fire management issues in eastern Indonesia; Fire management issues in northern Australia; Institutional linkages and cooperative approaches), not necessarily in order of presentation at the workshop. In particular, the editors wish to compliment Indonesian authors for the outstanding quality of papers prepared and, in most instances, delivered in English.

As indicated in the workshop discussion group summaries, considerable progress was made in identifying and prioritising problems. Suggested resolutions include appropriate methodologies for undertaking demonstration-based activities, with associated training, educational and institutional linkage opportunities. In sum, we consider the workshop provided an excellent forum for constructive interaction between eastern Indonesian and northern Australian fire researchers, managers and policy-makers, establishing a sound platform for future cooperation. We wish to acknowledge with thanks the contributions of Heather Crompton of ACIAR, the Northern Territory University, the Tropical Savannas Cooperative Research Centre, all workshop participants, those involved with organisation (especially Julian Gorman), and Janet Lawrence (ACIAR) for her excellent technical editing of the proceedings.

Jeremy Russell-Smith
Greg Hill
Siliwoloe Djoeroemana
Bronwyn Myers

January 2000

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Pendahuluan

Selama lebih kurang satu dasawarsa terakhir orang mulai mengakui dampak lingkungan dan politik sebagai akibat dari pembakaran biomassa (seluruh hayati) yang ada di blok-blok hutan basah di Sumatra, Kalimantan dan Irian Jaya, Indonesia. Hal ini menyebabkan banyak usaha penelitian dilakukan di daerah-daerah ini, khususnya dalam beberapa tahun terakhir (Dennis 1999; Laumonier et al. 1999). Sebaliknya, sangat sedikit perhatian yang diberikan terhadap praktik pembakaran tahunan yang sebagian besar telah ditentukan dan persoalan yang berhubungan dengan pengelolaan lahan di savana yang luas di kepulauan Indonesia timur, daerah antar lintas udara di Irian Jaya dan Papua Nugini, dan Australia utara. Sementara itu, telah banyak penelitian pendahuluan yang dilakukan dalam bidang pengelolaan kebakaran dan yang berhubungan dengan masalah ekologi di Australia utara selama dua dasawarsa terakhir. Akan tetapi pendokumentasian mengenai luasan pembakaran di berbagai daerah serta praktik-praktik tradisional maupun kontemporer masih terbatas. Hal serupa juga terjadi pada pendokumentasian dampak serta keuntungan pengelolaan kebakaran pada latar budaya Indonesia bagian Timur.

Sebagai pengembangan dari penetapan hubungan formal pada tahun 1990an antar sejumlah lembaga di Indonesia timur dan Australia utara, khususnya perguruan tinggi, serta pengakuan oleh semua pihak yang terlibat bahwa pengelolaan kebakaran merupakan persoalan ekonomi dan sosial regional penting, yang menjamin kerjasama penelitian terapan, maka pada tahun 1998 ACIAR (Pusat Penelitian Pertanian Internasional Australia) menawarkan diri untuk menjadi tuan rumah lokakarya dalam rangka mendifinisikan dan memprioritaskan persoalan tersebut di atas. Lokakarya itu akhirnya dilaksanakan di Darwin, tepatnya di Northern Territory University, pada tanggal 13–15 April 1999. Lokakarya tersebut dihadiri oleh sekitar 60 peserta, separohnya berasal dari Indonesia dan sekitarnya. Pusat Penelitian Kerjasama Savana Tropis yang berkantor di Darwin dan Lembaga penyandang dana Internasional untuk pelestarian satwa liar (WWF) telah menyediakan dana tambahan untuk para peserta dari luar negeri.

Laporan ini terdiri atas 26 karya tulis yang disajikan dalam lokakarya di Darwin, dan disertai dengan ringkasan sesi diskusi kelompok lokakarya serta daftar alamat serta nomor-nomor yang bisa dihubungi dari para peserta. Karya tulis tersebut disajikan dalam 4 kelompok (Pembukaan lokakarya dan tinjauan regional, Persoalan pengelolaan kebakaran di Indonesia timur, Persoalan pengelolaan kebakaran di Australia utara, Hubungan kelembagaan dan pendekatan kerjasama), tetapi penyajiannya tidak sebagaimana disajikan dalam lokakarya. Tim penyunting ingin menyampaikan penghargaan khususnya kepada para penulis dari Indonesia atas karya tulis mereka yang berbobot dan sebagian besar disajikan dalam bahasa Inggris.

Sebagaimana dinyatakan dalam ringkasan diskusi kelompok lokakarya tersebut, telah banyak kemajuan yang dicapai dalam mengidentifikasikan dan memprioritaskan masalah-masalah. Pemecahan-pemecahan yang disarankan mencakup metodologi-metodologi yang tepat untuk melaksanakan kegiatan peragaan, dan kesempatan-kesempatan yang berhubungan dengan pelatihan, pendidikan dan hubungan kelembagaan. Ringkasnya, menurut hemat kami lokakarya ini telah menyediakan forum yang luar biasa untuk interaksi konstruktif antara para peneliti kebakaran dari Indonesia timur dan Australia utara, para manajer dan pembuat keputusan. Lokakarya ini juga telah menjadi wadah yang baik untuk kerjasama di masa mendatang. Kami juga ingin menghaturkan terima kasih khususnya kepada Heather Crompton dari ACIAR, Northern Territory University, Pusat Penelitian Kerjasama Savana Tropis, para peserta lokakarya atas konstribusinya, dan semua yang terlibat di dalam pengorganisasian lokakarya ini (khususnya Julian Gorman) dan Janet Lawrence (ACIAR) atas penyuntingan teknis beliau yang luar biasa terhadap laporan-laporan ini.

Jeremy Russell-Smith
Greg Hill
Siliwoloe Djoeroemana
Bronwyn Myers

Januari 2000

Workshop Opening
and Regional Overview

A Framework to the ACIAR Project on Fire Management in Eastern Indonesia and Northern Australia –and Welcome to the Workshop

Greg Hill[1]

THIS CURRENT project had its beginnings at the International Conference on Agricultural Development in Semiarid East Nusa Tenggara, East Timor and South East Maluku which was held in Kupang from 11 to 15 December 1995. Arranged through an organising committee headed by Satya Wacanna University, the conference attracted wide support from within Indonesia and the region. The Northern Territory Department of Primary Industry and Fisheries (NTDPIF) and the Northern Territory University (NTU) were core participants in the conference. In the case of NTU, participation was linked to the Memoranda of Understanding (MOUs) the institution had established with five Indonesian universities in the region (refer paper by Healey, these proceedings). The NTDPIF also had well established partnerships in place and a long history of involvement in the agricultural sector of eastern Indonesia.

A major outcome of the conference was the establishment of an Information Centre on Semi Arid Agriculture which has operated out of Kupang since 1996 (refer paper by Djoeroemana, these proceedings). The partners in the original conference are the core members of the Information Centre. Fire management was raised as an issue at the 1995 conference and the need for research in this area was further developed by the Information Centre over the following year. When in 1997 the massive forest fires that ravaged Indonesia and other neighbouring countries grabbed the world's attention, there was also the realisation that issues of fire management in semiarid, wet/dry tropical regions, particularly in eastern Indonesia, were poorly understood. This provided the framework for approaching ACIAR with the concept of a fire management proposal. The Workshop we are attending today is the culmination of these activities which have proceeded over the previous three plus years. The discussions that have taken place over this time have been collaborative, accepting that both Indonesia and Australia have much to gain through sharing of knowledge and joint research directed towards the issue of fire management.

A notable aspect of the current proposal was that it was developed through the Darwin-based Cooperative Research Centre (CRC) for Sustainable Development of Tropical Savannas. The Tropical Savannas CRC coordinates fire management research across the Northern Territory, Queensland and Western Australia and a project dealing with fire management in northern Australia was part of the core program when the CRC was opened in 1995. This project has been particularly successful with regard to its research and extension activities (e.g. Jacklyn and Russell-Smith 1998; Russell-Smith et al. 1997 a, b; Schultz 1998).

The key CRC agency involved in this work is the Northern Territory Bushfires Council, which has pioneered research into the use of satellite imagery for

[1]Science and Education Faculty Group, Northern Territory University, Darwin 0909 Australia

detailing fire histories for savanna environments (Russell-Smith et al. these proceedings). Data provided by the Western Australia Department of Land Administration are routinely used for mapping and monitoring fire activity in the Northern Territory and the Kimberley region of Western Australia (Smith et al. these proceedings) and the program has recently been extended to Queensland to complete an integrated coverage for northern Australia. The Bushfires Council has also been proactive in engaging savanna stakeholder groups in fire management activities and workshop programs. This has incorporated integrating traditional indigenous knowledge into analysis of current and past fire regimes. The Bushfires Council has been an important agent of change, alerting managers and landholders to the implications of particular fire regimes and how these can be manipulated to achieve desired outcomes.

In association with the work of the NT Bushfire Council, a parallel development of infrastructure and expertise has been occurring in the other core partner in our current project, the Northern Territory University remote sensing group. Environmental Remote Sensing is recognised as an Area of Research Strength at NTU. Over the last 3 years the program has attracted more than $500 000 in research infrastructure through funding agencies such as the Australian Research Council (ARC), Research Infrastructure and Equipment Fund (RIEF). Laboratory facilities for computer-based processing and analysis of remotely sensed data are first class and recent funding has provided sophisticated data collection and field equipment, such as a digital aerial camera which was purchased this year. The group has also been successful with research grants including those provided by the ARC Large Grants Scheme and the ARC Strategic Partnerships with Industry Research and Training (SPIRT) Scheme.

The Northern Territory University has a well established reputation for education and training, ranging from postgraduate research degrees through to TAFE level courses in the vocational education sector. The University is one of only a handfull of Australian universities that is a dual sector institution, offering the full spectrum of post-secondary education opportunities from Certificate to PhD. In activities with a focus on technology transfer, this mix of expertise is a valuable combination. The Bushfires Council also has a well established training program for its own staff which has the potential for application in Indonesia. There is established exchange of students between the University and its MOU university partners in eastern Indonesia and both the University and the Northern Territory government agencies (e.g. NTDPIF, NT Department of Lands Planning and Environment) run training programs in the region. Research partnerships with agencies such as the World Wide Fund for Nature (WWF) provide additional linkages within the region.

The Tropical Savannas CRC

In recent years the tropical savannas of northern Australia have experienced a (long overdue) boost in status. Factors responsible include the recognition of: aboriginal title to land; new trade developments with the Asian countries (e.g. live cattle exports); the relatively pristine state of much of the region; and the growth in nature-based tourism. Factors such as these, combined with the distribution of the savannas across state and territory boundaries and the comparatively small research effort expended on the region to date, were presumably a strong motivation for establishing the CRC. The mission of the CRC is to undertake research and education that will enhance for Australia and its people the sustainable development of our tropical savannas. The semiarid tropical savannas cover more than 20% of Australia but support only 5% of the continent’s population. Nevertheless, via mining, tourism and the pastoral industry this region provides more than 25% of the country’s export income. The need for an accelerated and innovative research effort in the region, to optimise economic, environmental and social gains, has been the impetus for the formation of the Centre.

The research program of the Centre is based around the ecology, use and management of the savannas. Firstly, the CRC is interested in how savanna plants and animals are affected by soils, storms, fires and tropical wet and dry seasons. Secondly, there is a requirement to know how the savannas are affected by the uses people make of them. Above all, the CRC intends to work with users to understand the effects of their management of the land, so they can be confident that their enterprise will continue and develop sustainably.

But there is more to sustainability than just ecology and the effects of land uses on ecology. People will not be able to manage their land properly if their enterprise is uneconomic or does not meet their other social needs. So the Centre is looking at the economics of land use and people’s social aspirations as well as ecology. It is examining management options for the users of the savanna to ensure their needs are being met. The principal users of the savannas that the Centre presently aims to serve are the pastoralists/agricultural sector, the mining and tourism industries, the Aboriginal landowners and conservation interests. It is developing its program with their advice to ensure it is doing research which reflects their interests. These users produce very different products from their use of their land. But they share a basic infrastructure—the savannas themselves—and it is the development and maintenance of that infrastructure for them, and for all Australians, that is the concern of the Centre.

The consortium comprising the CRC encompasses the major research and management agencies servicing the tropical savannas together with the region's universities:

Participating Organisations (Core)
Northern Territory Government

Parks and Wildlife Commission; Primary Industry & Fisheries; Lands Planning and Environment

Queensland Government

Primary Industries; Lands

Western Australia Government

Agriculture, Conservation & Land Management

Federal Government

Environment Australia

CSIRO (Tropical Agriculture; Wildlife & Ecology)

Universities

Northern Territory; James Cook; Australian National University (NARU)

Participating Organisations (Supporting)
Meat Research Corporation

Land and Water Research and Development Corporation

Northern Territory Power and Water Authority

Northern Land Council

Northern Territory Mines & Energy

Northern Territory Tourist Commission

Batchelor College (aboriginal education)

A perusal of these organisations indicates that most of the major research and management agencies responsible for usage and development of the tropical savannas are represented in the CRC structure. These groups supply the staff who are responsible for designing and implementing the CRC's programs. While collaborative research between these organisations has developed rapidly in recent years, it has been mainly restricted to within State and Territory boundaries. The Centre is committed to expanding these activities and ensuring that industry and stakeholder requirements are met.

To achieve its mission, the Centre is bringing its staff together from right across Australia's Top End in a way that has never been done before. Because they are part of the Centre, they can cross the State and Territory boundaries and work beyond their employer's local interests. The program has started from a base provided by the organisations which make up the Centre. They all have well established research programs and we have drawn relevant parts from them to establish the starting point of the Centre program. The Centre is now building from that start by adding new, high quality, value-adding components to the program which are directed specifically at the needs of savanna users. The program of the Centre is not complete and never can be. No research body will ever have the resources to deal with all the problems that the savannas face. Nor could it deal with all the possible uses to which the savannas are, or could be, put. Instead, it is a program based on priorities and opportunities that were seen at the time the Centre started. It will change with time as new problems and opportunities arise and as the aspirations of savanna users change.

The Tropical Savannas CRC and Eastern Indonesia

The activities of the CRC for Tropical Savannas are of direct interest to eastern Indonesia and many other parts of the globe which experience similar climatic regimes and management problems. The link with Indonesia is particularly strong because of geographic proximity and the existing relationships between major partners in the CRC (e.g. Northern Territory University, Northern Territory Department of Primary Industry and Fisheries) and their counterparts in this neighbouring country. The establishment of the CRC will hopefully strengthen these existing ties and facilitate greater cooperation between relevant agencies. Many of the issues being addressed by the CRC are of direct relevance and concern to eastern Indonesia. This will undoubtedly strengthen the case for collaborative research and information exchange which will be of great benefit to both countries.

Northern Australia is remote from the main population centres in the south of the continent and has undoubtedly been neglected as far as investment in research activity is concerned. It could be argued that a major encumbrance to accelerated development and growth is the lack of appropriate research leadership to support the aspirations and activities of the existing participants and facilitate the entry of new ones. A situation such as this would find sympathy with parallel organisations and personnel in eastern Indonesia, which experiences similar geographic 'problems'.

Conclusion

Fire is a prime environmental driver in all wet/dry tropical areas of the world and the mechanisms, impacts and management issues related to fire in such environments are unique, hence the need for focused research. Likewise, there is an associated requirement for appropriate technology transfer and educational activities so that research outcomes and knowledge are effectively shared and applied, to enhance human welfare and environmental sustainability. This Workshop provides an outstanding opportunity for information sharing on fire related issues between Indonesia, Australia and other neighbouring countries. The Workshop provides a forum to build on existing governmental, institutional and research relationships and create new ones. There is scope for highlighting the key issues relevant to the participants and for developing joint initiatives that contribute to fire management systems in both eastern Indonesia and northern Australia.

Welcome to the ACIAR Workshop on Fire Management in Eastern Indonesia and Northern Australia. I trust the next 3 days will be productive and stimulating. I look forward to working with you to achieve our goals.

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Message of Welcome from East Nusa Tenggara

Siliwoloe Djoeroemana[1]

On behalf of the Governor of East Nusa Tenggara, I would like to express my gratitude for the interest and the invitation from the Northern Territory University resulting in our being able to attend and participate in this workshop. I warmly welcome this workshop, because it is very strategic and urgent. The workshop will give a great contribution to the development of eastern Indonesia, especially the development of East Nusa Tenggara, and at the same time provide valuable information for the development of the Northern Territory in Australia. This activity constitutes the first step to further agricultural and forestry collaboration between Indonesia and Australia in the future.

In this I feel that the Northern Territory University and the Australian Centre for International Agricultural Research (ACIAR), along with the Northern Territory Government, are very consistent, because this workshop represents a follow-up from an International Conference on Agriculture in the Semiarid Areas of NTT, East Timor and Central Malukku, which was held in Kupang, from 10 to 16 December 1995. At that conference it was decided to create an Eastern Indonesia Semiarid Agriculture Information Centre to follow up on the conference results.

Because of this I request that NTU and ACIAR work closely together with the Information Centre to follow up on the results of the Workshop for the sake of development in East Nusa Tenggara and the Northern Territory. This information centre is fully supported by the local government of East Nusa Tenggara and a number of universities in East Nusa Tenggara. The local government of East Nusa Tenggara greatly supports the holding of this workshop.

The last two days of visiting a few places in the Northern Territory have left lasting impressions with us. Because of this we feel that basically we have the same problems. With close collaboration in future we can help each other to develop our respective regions. Let us continue to encourage the collaboration between East Nusa Tenggara and Northern Territory through the NTU and ACIAR by holding research activities that will increase inputs to the determination of policies by the local government of East Nusa Tenggara.

[1]Universiti Satya Wacana, Sumba, Indonesia

Background to the Project 'The Use of Fire in Land Management in Eastern Indonesia and Northern Australia'

Bronwyn Myers[1], Greg Hill[1,3] and Jeremy Russell-Smith[2,3]

Abstract

Eastern Indonesia has a semi-arid climate with large areas of savanna vegetation, and consequently the region is fire-prone. The land is used mainly for low-yielding subsistence agriculture and the region faces major problems of land degradation and forest degeneration. Fire is a fundamental component of traditional and current land management. Prescribed fire is used in slash and burn cultivation, for land clearing, weed control and to increase nutrient status. Fire is also used to promote new grass growth for cattle grazing and to provide some protection from wildfire. Some fire regimes have undesirable effects. Some fire and grazing regimes encourage the invasion of grazing lands by shrubs, threaten lives, property and forestry reserves, and contribute to regional atmospheric pollution. Fire has impacts on soil and water conservation, which all affect the long-term productivity of the land.

Although the extent, severity and impacts of fire appear to be increasing, these changes are poorly documented. There is little understanding of the processes affecting fire behaviour in eastern Indonesia and the steps necessary to better manage fire.

Current and past work by non-government organisations and international funding agencies in eastern Indonesia verify the importance of integrating fire management with animal husbandry and other farming practices when recommending modifications to land management practices. An understanding of the cultural and economic restrictions within Indonesian communities is essential for the successful adoption of recommendations for change.

The objectives of the workshop were to:

- review fire management in eastern Indonesia and northern Australia
- develop closer regional and institutional links between researchers and land managers in northern Australia and eastern Indonesia

The workshop included position papers, describing the state of knowledge in a range of fire management issues, followed by discussion sessions.

Workshop tasks were to:

- identify and describe the key fire management issues for eastern Indonesia and northern Australia;
- summarise recommendations and resolutions generated by the discussion sessions;
- discuss methodology appropriate for adoption of recommendations and for research and training programs in eastern Indonesia and northern Australia;
- publish the proceedings of the workshop in the ACIAR Proceedings series.

Project Description

Background

This project proposal had its origins with discussions between ACIAR and staff of the CRC for Tropical Savannas during the severe and prolonged fire season in Indonesia in 1997.

[1]Northern Territory University, Darwin 0909, Australia
[2]Bushfires Council of Northern Territory, PO Box 37346, Winnellie NT 0821, Australia
[3]Tropical Savannas CRC, Northern Territory University, Darwin 0909, Australia

Eastern Indonesia has major problems of land degradation and forest degeneration, particularly in the driest districts (with wet/dry climate and annual rainfall <1000 mm) (Barlow et al. 1990). 'Understanding agricultural systems within Nusa Tenggara and Maluku is essential for the management of nearly 40% of the land and for improving the lives of most of the people of the region' (Monk et al. 1997). The dominant system of cultivation is the production of low yielding crops by slash and burn agriculture—the swidden cycle. As the population has increased, land degradation has become widespread, particularly where cultivation has extended onto land with slopes greater than 30%. Also there has been degeneration from forests to secondary forests to savanna, and in places to 'arid steppe' (Ormeling 1957). These processes have been accelerated by large increases in cattle numbers early this century and the use of fire for burning off scrub and old grasses (Barlow et al. 1990). The consequent effects on hydrology and increased erosion have threatened the viability/productivity of irrigated areas downstream (Barlow et al 1990).

Fire is a fundamental component of current land management practices in the wet/dry regions of eastern Indonesia. Prescribed fire is used for land clearing, release of nutrients for crop establishment and weed control at the beginning of the swidden cycle and for both weed control and to encourage new grass growth for cattle grazing in savannas. Fire management, both the wise use of prescribed fire and effective control of wild fire, has major impacts on retention of forest cover (only 6% of the original forest remains on Sumba), the relative proportions of grasses and shrubs, and soil and water conservation. Although the extent, severity and impacts of fire appear to be increasing there is little understanding of the processes affecting fire behaviour and the steps necessary to better manage fire. Improved fire management practices would aim to use fire to control weeds and promote regeneration of palatable vegetation whilst conserving topsoil and surface soil structure, thus increasing water infiltration and water holding capacity of the soil as well as preserving the nutrient status of the soil.

These factors are particularly important at the beginning of the wet season when crops are being established and also would affect productivity of both crops and rangelands.

Eastern Indonesia, with its semi-arid environment and relatively low population density (by regional standards), contains the poorest provinces in the country. Annual rainfall and the length of the wet season are highly variable and a particularly dry wet season occurred in 1997–1998. The region's 'capricious relief' (Ormeling 1957) causes local rain shadows which exacerbate the divergence in agricultural potential. The area is remote from Jakarta and the government agencies promoting development. The need for international assistance in this region is widely acknowledged. During the recent problems with choking haze in the region, the Tropical Savannas CRC, through its partner agencies, has provided remotely sensed imagery of the fires in eastern Indonesia on a daily basis at the request of the Environment Ministry in Jakarta. Management agencies within the region have listed fire management as one of the issues of high priority for scientific input (Information Centre for Semi-arid Agriculture, Kupang, pers. comm.). In 1997, the Information Centre submitted to ACIAR and NTU a list of projects of high priority. It included a 'Biophysical study of traditional fire management in shifting cultivation' and other projects of which fire management would be an essential part ('An inventory of indigenous wisdom' and 'The integrated control of *Chromolaena odorata*'). The Nusa Tenggara Regional Development Consortium (NTRDC), a collaborative network with over 100 partners, has identified the need for investigation of fire management to complement current activities in land management.

The NTRDC provides a network for collaborative work aimed at development in Nusa Tenggara. The Agroforestry and Conservation of Natural Resources Working Groups of NTRDC have fostered cooperative projects by a wide range of groups (government, NGO, farmers and educational institutions). Several of these projects, which are currently in progress in eastern Indonesia, are highly relevant to fire management issues. Works by various NGOs have attempted to reduce the extent of fires by encouraging the planting of fire tolerant species around the farm, the use of fire breaks, closer control of the fires lit by farmers and the use of controlled/'polite' fires on the farm. Burning is an integral part of traditional farming that has been practised for generations, however there has been some success in modifying fire management practices. The impacts of changes to fire management have been poorly documented to date (S. Wodicka pers. comm.).

The Tananua Foundation (a local NGO) is working on improving farm management practices in Sumba where fire is used chiefly for improving feed for free-ranging cattle but also as part of hunting for wild boar and deer and scavenging wild tubers. Further work on fire management needs to be integrated with studies of cattle husbandry (S. Wodicka, pers. comm.).

In Sumba there has been a steady invasion of the dominant *Imperata* grasslands by the woody shrub *Chromolaena*, which burns easily and is unpalatable. This reduction in grazing land increases the pressure on farming land from free-ranging grazing animals. Fire management could play a vital role in modifying vegetation change in grazing land such as east Sumba.

A group headed by Dr Jeff Fox (East West Centre, Hawaii) has begun a project aiming to develop local capacity in spatial information analysis to assist the Nusa Tengarra Regional Development Consortium (NTRDC), with funding from the Ford Foundation.

Fire is also a major land management issue for the sparsely populated savanna regions of northern Australia. Savannas predominate in northern Australia where annual rainfall exceeds 500 mm—northwestern Western Australia, the northern half of Northern Territory and north Queensland—representing 25% of the continent. Fire is extensive in Australian savannas; for example, 50% of the Top

End of the Northern Territory was burnt in 1996. Fire is also frequent in Australian savannas. In humid savannas (> 1000 mm annual rainfall), fires occur one year in two or two years in three (Braithwaite and Estbergs 1985; Press 1988; Russell-Smith 1995). In semi-arid savannas (500–1000 mm annual rainfall) fire is a common land management tool in free-range cattle grazing systems, the predominant land use. Prescribed fire is used to control woody weeds in semi-arid savannas (Grice 1997). Management of grazing and fire affects the long term productivity of the land via effects on (i) the soil condition and its influence on distribution of nutrients and water, and (ii) the species composition of pastures, particularly the relative abundance of perennial and annual grasses, and therefore the value of this pasture for grazing (Williams et al. 1997).

Fire in northern Australia is the subject of a major coordinated effort through the Cooperative Research Centre for Tropical Savannas, based at Northern Territory University (NTU) in Darwin (Russell-Smith 1997). The CRC program involves: (i) the development of broad- and finer-scale satellite monitoring technologies to assess the extent, seasonalities and frequency of fires in different regions and across sectors (Hill 1997); (ii) the undertaking of focused research to assess the impacts of different fire regimes on natural and pastoral systems; (iii) the development of regional management strategies involving all community sectors as a means for developing effective, integrated approaches to fire management (Russell-Smith 1996). Such an approach provides an appropriate framework for addressing fire management issues in the eastern Indonesian region also (Hill 1995).

The phenomenon of regional haze associated with smoke and dust aerosols has long been observed in Southeast Asia. Braak (1929) observed regional haze over Indonesia and attributed this in part to dust aerosols from Australia. Since 1980, there has been ‘an unprecedented amount of wildfire activity’ in the region (Tapper et al. 1995).

The problem is particularly acute following severe droughts associated with the El Nino–Southern Oscillation (ENSO) events and due to the increased flammability of drought-stressed vegetation, e.g. 1982–83, 1987 (Goldammer 1993) and 1991–92, 1994 (Tapper et al. 1995). Tapper et al. (1995) suggested that the periodic regional haze over Southeast Asia results from a variety of causes: traditional Indonesian slash and burn agriculture and associated break-away fires; clearing of primary and secondary rainforests; fires in seasonally-dry monsoon savanna forests of mainland South Asia and northern Australia; fires in coniferous forests of South Asia; burning of agricultural residue, domestic wood fires and urban-industrial emissions. The development of fire management strategies for Indonesia should include a consideration of the impacts on atmospheric chemistry. The regional and global scale problems of fire in Indonesia and northern Australia are the subject of the South East Asia Fire Research Experiment (SEAFIRE), which is an International Global Atmospheric Chemistry (IGAC) project, a core project of the International Geosphere-Biosphere Program (IGBP).

Objectives and Outputs

The project aims to :

a) overview existing knowledge of fire management in eastern Indonesia and northern Australia;
b) identify and prioritise the key fire management issues;
c) develop closer regional and institutional links between researchers and land managers in northern Australia and eastern Indonesia;
d) publish the proceedings of the workshop in the ACIAR Proceedings series, documenting the state of knowledge and disseminating the workshop resolutions and recommendations.

The workshop facilitated the exchange of information, including that which is not yet available in written form, established a network for communication between workers in this area and promoted the development of cost-effective research and training programs.

Economic Significance

Fire has major impacts on two critical resources in eastern Indonesia—land and water. Prescribed fire has direct effects on slash and burn cropping and extensive grazing in savannas and secondary forests. In Nusa Tenggara, in terms of land area, 15% is food and tree crop agriculture, 21% is forest that is encroached on by grazing and some slash and burn, and 64% is degraded secondary forest and savanna used for cattle grazing (1986 data, Barlow et al. 1990).

Fire management has direct impacts on agricultural production in the long term. In Nusa Tenggara Timur during 1995 (Nusa Tenggara Timur Dalam Angka 1995) agriculture contributed about 40% of the region’s gross domestic product (RGDP) with food crops constituting 57% and livestock constituting 24% of agriculture’s contribution (945 Rp billion) to RGDP. Agriculture employed 70–80% of the population directly (Barlow et al. 1990).

In Australia fire is also of major significance, as a tool in pasture management for the tropical beef industry but in a more negative way as a factor in land degradation, also in loss of human life and property.

Literature Review

Almost all the published work on fire in Indonesia is based in the wet tropics, particularly on Java (e.g. Pickford et al. 1992, Christanty et al. 1997). Upland areas (>1500 mm annual rainfall) have been the focus of a study of smallholder farming systems in *Imperata* areas in Southeast Asia that has provided evaluations of land management practices, including use of fire (Grist and Menz 1996/7, Menz et al. 1996/7). The scarcity of written information on fire in Indonesia is illustrated in the recently published 'Biomass burning and global change' (Levine 1996) in which the section on Southeast Asia comprises two papers neither of which includes Indonesia.

Monitors of fires in Indonesia now use satellite imagery processed by the Western Australian Department of Land Administration, a member of the Tropical Savannas CRC. On a regional scale, monitoring of the fire theatre and implications for atmospheric pollution have begun with the establishment of the South East Asian Fire Experiment (SEAFIRE) in 1996. The broad aims of SEAFIRE are 'to identify the magnitude, patterns, quality and impacts of fire on the local terrestrial ecology and regional atmosphere' (Tapper et al. 1995). However at this stage, data available through SEAFIRE are mostly based in the wet tropics (Goldammer 1993), particularly Borneo (Goldammer pers. comm.), and include the ecological impacts of wildfire with some information about fire in maintaining agricultural and pastoral systems and the implications for atmospheric pollution.

Some useful summaries of current fire research in northern Australia include the proceedings of *Bushfire 97* (conference held in Darwin in July 1997), a workshop on remote sensing in Kununurra on 6 August 1997 and reports from a workshop organised by the Tropical Savannas CRC on Fire Management, held in Darwin in March 1998.

Economic Impact of the Research and Development

The immediate economic benefits from this workshop will be the efficient exchange of information and the opportunity for productive discussion between scientists (both Australian and Indonesian) and representatives of the Central and Provincial Governments of Indonesia. Greater benefits will follow from further research conducted as a result of research priorities identified at this meeting. The inclusion of socioeconomic considerations will ensure that research is developed and knowledge disseminated in a way that will be most readily adopted by farmers.

Benefits to Australia will be primarily related to developing closer international ties with our closest neighbours. More specifically, this project will (1) allow Australia to contribute to increased understanding of regional environmental issues, including regional smoke haze, (2) increase opportunities to export technologies, and (3) assist in the sustainable development of one of Australia's strongest export markets, thereby improving the regional economic outlook.

Application of Research

Recommendations for land managers, based on current knowledge and effective means of implementation, will be published in the proceedings. The research and development priorities identified at the workshop will also be published in the proceedings and will provide a framework for future activities for research funding bodies. Policy makers in the Indonesian government will be advised by the representatives of forestry and agriculture departments of both Central and Provincial Indonesian governments who have participated in the workshop and the proceedings will provide a further source of information for consideration in policy development.

Environmental Impact

The longer-term outcome of the project will be to assist development of more sustainable land management in eastern Indonesia. Modification to fire management will ultimately improve the productivity of farmers via improvement to the condition of the land and conservation of water resources. Those involved will place special emphasis on design of the most effective mechanisms of adoption. Any research and training projects proposals will promote the sustainability of productivity of the land and water resources and enhancement of forest regeneration and native biodiversity.

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Shifting Cultivation and Fire: a Challenge to NTT's Development

Esthon L. Foenay[1]

Abstract

East Nusa Tenggara Province (NTT) is one of the archipelagic provinces in Indonesia, consisting of 566 islands, of which 50 are inhabited by 3.5 million people speaking more than 50 tribal languages and dialects. This paper gives an overview of the agriculture practised throughout the province and the way in which fire is used in the cropping cycle and in the raising of livestock.

EAST NUSA TENGGARA PROVINCE (NTT) is one of the archipelagic provinces in Indonesia. This archipelago consists of 566 big and small islands, of which 50 are inhabited by 3.5 million people who speak more than 50 tribal languages and dialects. The total land area is about 47 000 km^2 or about 20% of the total land and water area combined. This brings problems of transportation and development management. Many agricultural activities of traditional smallholders cannot be effectively controlled on the land areas, nor can the fishing and marine activities on the water or coastal areas. As the closest neighboring country to Australia, many fishermen from NTT enter Australian waters and harvest the marine resources.

Agricultural Activities

The livelihood of approximately 80% of the NTT population depends on dryland cultivation and extensive cattle husbandry. Most still practice shifting cultivation, and about 10% work on wet rice field and cash crops. This is largely a consequence of low rainfall.

Average annual rainfall varies from 700 to 2900 mm (1992–1997) and is distributed unevenly among the islands. We have only two seasons, wet and dry. The wet season begins in November and lasts until February (normally ends in January) while the dry takes up the rest of the year, approximately 9 months. As agricultural activities depend mainly on rainfall and soil fertility these two natural phenomena have a great effect on the variation of agricultural products and the income of farmers. Foodstuffs such as maize, cassava, peanuts, various kinds of beans, green grains and rice (paddy) are very dependent on rainfall intensities.

Too little rain disturbs the growth of food crops. But too much rain also disturbs the harvest of maize, particularly at the moment, as La Nina brings more rainfall than usual. The maize fortunately ripened well, but farmers have less opportunity to harvest on time. This means the rain has tended to damage the corn. On the other hand the wet paddy farmers have happily cultivated their wet land and prepared their seedlings. By comparison, last season farmers failed to harvest because of the drought brought by El Nino.

Various agricultural efforts are carried out by the government (at the national and local level) to increase farmer income—for instance, instant credit for agricultural land processing, and subsidies on chemical fertilisers, on supply of high yielding variety seeds, and on the marketable price of the farmers rice. Such innovations have been successfully dispersed among the wet rice farmers and cash crop planters, but less to the traditional dryland cultivators. Unfortunately, they adopted the innovation of the high yield variety of maize (limited amount of fertilisers) and grew it for market purposes rather than family food stocks.

[1]BAPPEDA (Regional Development Planning Board of Nusa Tenggara Timur)

Agricultural innovations are adopted for cash while the farmers still practice their local knowledge for subsistence.

On average, the per capita income of NTT's population in 1988 (calculated at the current price) was Rp. 278 000, increasing to Rp. 466 000 in 1992 and then to Rp. 877 000 in 1997. With the current exchange rate of Rp. 9000 per US$ it meant that NTT's income per capita in 1997 was only about US$97.00. This income figure shows the poverty rate of the people and the decreasing of their welfare as Indonesia's currency drops in relation to the US$.

Land Cultivation, Cattle Husbandry and the Means of Fire

Agricultural activities of most farmers are a mixture of dry field or wet land farming and cattle farming. Problems usually occur between July and October, the time for preparing dry fields. Since soil fertility is maintained by land rotation rather than crop rotation the trees and bushes are cut down, left to dry for a period and then cleaned up by means of fire. In many cases fires become uncontrollable and burn all surrounding bushes, forests and pastures. This practice is done repeatedly for 3–4 years, then farmers move on when the productivity of the land decreases.

Local beliefs also lead people to choose a certain type of land. Usually land areas on a steep slope are chosen rather than flat areas. It seems that cost savings must also be brought into consideration—no energy spent for weeding, and no environmental considerations. Top soil is damaged by water runoff, the fertility decreases, and then the farmer leaves the deteriorated area to repeat the process on a new area.

To avoid the types of mistakes in land cultivation that were just mentioned, there have been many efforts made by the local governments, e.g., lamtoro (*Leucaena leucocephala*) is introduced for land covering and steeply sloped field terracing. Farmers also benefit from lamtoro in another way and that is for feeding their cattle. The 1960s was a period of rejection of lamtoro because it was claimed to cause hair loss in horses, because at that time horses had a role in transportation. But in the 1970s, coinciding with the introduction of cattle fattening programs, people began to adopt lamtoro. Since then lamtoro has been gradually adopted throughout the islands of NTT, but fire damage is still a challenge. Besides the land clearing process, high temperatures in the dry season also contribute to the burning of dry grass and forests, leading to even worse land deterioration.

It was reported that between 1995 and 1998 some 13 000 ha of critical land were planted with various kinds of trees. This excludes what was planted before then. An official report shows that in 1997 there were some 39 000 ha of forests and pastures burnt out and in 1998, 7000. Therefore there is actually no guarantee that all the trees planted are still growing as the figures above suggest. The challenge is still dryness and associated fire.

An extensive contribution to the lifting of farmers' incomes has come from cattle raising, it also brings a fairly serious problem of over grazing. It was reported in 1997 that there were about 781 000 cows, 476 000 buffaloes, 137 000 horses, 738 000 goats and 174 000 sheep spread out in 12 districts of the main islands and the surrounding satellite islands. Overgrazing cannot be avoided, because the cattle graze freely throughout the forests and pastures. Unfortunately at the peak of the dry season when available stocks of cattle feed are low, farmers intentionally burn pastures with the expectation that young grass will sprout. But the fires, blown by strong winds, often grow bigger and sweep through the surrounding forests and pastures. If heavy rains fall then the flood will wash away topsoil and leave behind barren land.

There is no real effort to extinguish these burning forests and pastures. The poor pastures constitute non-plantable land and lack of water is the main problem. However it is not only that. The cultural value systems also play a dominant role. The highland people of West Timor (Helongese) for instance are dryland cultivators. Wet land cultivation was introduced in the 1970s and extended in the 1980s. Growing wet rice was new to their culture. After sowing wet rice seedlings no weeding or pest protection were employed (such practices are not used in dryland culture), but the farmers still expected an abundant harvest. One can easily imagine that insect attack and damage from mice would affect the young rice plants. The uncleared bushes surrounding the rice fields provide a favorable environment for mice and insects to multiply rapidly.

In places where water was still available during the dry season there were no efforts by farmers to undertake farming activities, for example to grow various kinds of vegetables or cultivate freshwater fish. After this period there was a disparity between the lowland Timorese and the Helongese communities. Small dams were built in the mentioned communities to provide a clean water supply, and the water was also used for growing various vegetables and beans during the dry season, implementing a new method of dryland cultivation with assured supply of water, introduced by agricultural extensionists. The farmers, of course, gain extra income without incurring extra costs. They need to be advised and encouraged for approximately 4 years by agricultural extensionists.

The Timorese coastal inhabitants have not considered coastal waters as a potential food source. But this is actually changing slowly with the younger generation. Once about 5 years ago I met two young Timorese men in their small sailing boat with a net on hand to catch small fish. They were not confident enough to sail more than 50 metres from shore. After they returned to the shore, when I asked them about their new experience in catching fish, they told me that their neighbour, an elderly Chinese man, had taught them.

Acknowledgments

That concludes the few thoughts that I wished to raise at this opportunity. We would like to express our deepest thanks for your attention and interest. On behalf of the Governor of Regional Level One, East Nusa Tenggara, we would like to express our thanks to the University for their interest and for the invitation enabling us to participate in this workshop.

Atmospheric Issues for Fire Management in Eastern Indonesia and Northern Australia

Nigel Tapper[1]

Abstract

Using the McArthur Fire Danger Index as a framework for discussion, this paper provides an overview of atmospheric issues of fire management in the tropics, with particular reference to eastern Indonesia and northern Australia. After a brief discussion of the background meteorology of the region, atmospheric influences on regional fire regimes that may operate over a range of time scales are examined. Longer-term influences associated with predicted greenhouse warming suggest an increased fire danger for the region. Inter-seasonal and inter-annual climate variabilities associated with the El Niño–Southern Oscillation phenomenon are also shown to impact on the regional fire regime. While impacts of seasonal drought associated with the north-south movement of the inter-tropical convergence zone (ITCZ) are well known to fire managers, general atmospheric transport patterns associated with movement of the ITCZ are not. Some results of recent trajectory modelling are presented to elucidate these patterns. Intra-seasonal and synoptic-scale influences on regional fire regimes, especially as they impact southern parts of the region, are also discussed. Finally, suggestions are made about some priority areas for further research.

THIS PAPER provides an overview of atmospheric issues of fire management in the tropics, with particular reference to eastern Indonesia and northern Australia (referred to hereafter as EINA). This broad region, lying at the southern margin of the maritime continent, is characterised by its seasonally wet climate and a fire regime dictated largely by seasonal drought.

Regional fire regimes can be defined by characteristic fire intensities, fire frequencies and season of burn. Atmospheric factors exert fundamental controls on this regime, and also determine the transport of products of burning. Around the globe there are various indices employed, mainly for predictive purposes that represent aspects of a fire regime. In many areas of Australia the McArthur Forest Fire Danger Index Mark 5 (McArthur 1968) is commonly used to represent the daily fire danger, where the index is indicative of a fire starting, its rate of spread, intensity and difficulty of suppression. The Fire Danger Index (FDI) is defined mathematically as:

$$FDI = 1.275D^{0.987}*[\exp(0.0338T+0.0234V-0.0345H)]$$

where D is a drought factor, T is air temperature (°C), V is the 10 metre wind speed (km/hr) and H is the relative humidity (%). Details of the equation and its derivation can be found in Noble et al. (1980).

As well as its regionally specific application in predicting/quantifying fire danger on a day-by-day basis (the purpose for which it was intended), the FDI is also a valid indicator of fire danger over the entire continent (and by extension the islands immediately to the north of Australia that share a similar climate) and can be used for comparison of regional, intra-seasonal and inter-annual fire danger variability. The meteorological and climatological parameters represented in the FDI therefore provide a useful conceptual framework for the discussion of the fire regime in the EINA region that follows in the remainder of this paper. However, it must be remembered that although fire regime characteristics are highly coupled with weather and climate, the relationships are often complex. For example, variations in fuel also influence the properties of a fire regime such as fire frequency and fire intensity.

Luke and McArthur (1978), in their landmark text on Australian bushfires, produced a map based on fire statistics showing the generalised pattern of seasonal fire occurrence in Australia (Figure 1). Generally, the trend is for the fire season to be progressively delayed from north to south across the continent. In northern Australia (and by inference much of eastern Indonesia), which has a true monsoonal climate, the long austral winter dry season produces a late austral

[1]School of Geography and Environmental Science and CRC for Southern Hemisphere Meteorology, Monash University, Clayton 3168, Victoria

winter–early spring fire season. The fire seasonality of northern Australia suggested by Luke and McArthur is supported by an analysis of fire ban records for the Northern Territory (Figure 2). Declaration of a fire ban is strongly influenced by fire weather warnings issued by the Bureau of Meteorology on the basis of predicted FDI (predicted FDI>45 provokes a warning). Over the Northern Territory as a whole, fire ban days are at a minimum in April and at a maximum in the August–November period. However there are clear regional differences exhibited in Figure 2, with the apparent fire season in the Top End (north of 16°S) extending from May to October (dry season), in the central region (16–21°S) from August to November, and in the southern region (21–26°S) from August to March. Clearly there are regional fire regimes in the Northern Territory that can be documented in distinctive seasonal distributions of FDI.

The following sections of this paper place the meteorology of the EINA region in a global context and discuss the major atmospheric influences on the fire regime of the region, particularly as they affect the component parameters of the FDI. Atmospheric influences on the transport of the products of burning are also considered.

Background Meteorology

The EINA region lies on the southern edge of the maritime continent region, one of three regions of enhanced tropical convective activity located around the world. Figure 3, showing mean outgoing long-wave radiation (deep tropical clouds have low outgoing long-wave radiation) identifies Central Africa and Amazonia as the other areas of intense tropical cloudiness, but both of these are continental by comparison with the EINA region. Hence the term 'maritime continent' coined by Ramage (1968). The enhanced cloudiness in these regions represents massive exchanges of energy that are fundamentally important in the general circulation of the global atmosphere. Of these regions, none is more important in global climate dynamics than the Indonesian region, because of its role in both the north–south tropical Hadley circulations and the east–west Walker circulations (Sturman and Tapper 1996).

The other major characteristic of Indonesian climate is the seasonal reversal of wind flow across the region as a pivotal part of the Asian–Australian monsoon which is an important component of the planetary monsoon system. Figure 4, illustrating wind flow at 500 m, clearly shows the seasonal reversal in low-level monsoon currents, particularly in the South China Sea (northeasterly trade winds in January and the southwest monsoon in July) and the Timor Sea region (moist westerly monsoon flow in January and dry southeasterly trade wind flow in July). Winds in the

Figure 1. Patterns of seasonal fire occurrence in Australia (from Luke and McArthur 1978).

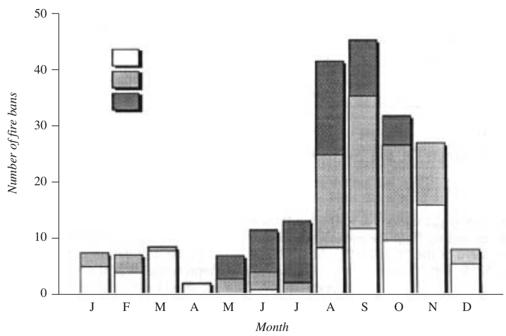


Figure 2. Monthly distribution of fire ban days by latitude band in the Northern Territory 1980–1990 (from Tapper et al. 1993).

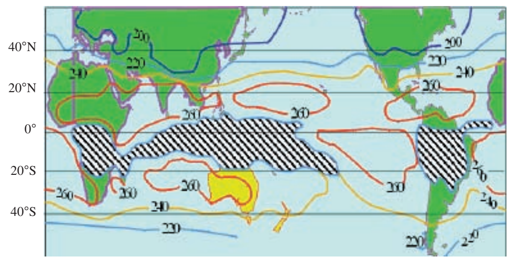


Figure 3. Mean annual outgoing long-wave radiation (W/m^2) for December–February. Tropical areas with outgoing long-wave radiation <240 W/m^2 are shaded (from Sturman and Tapper 1996).

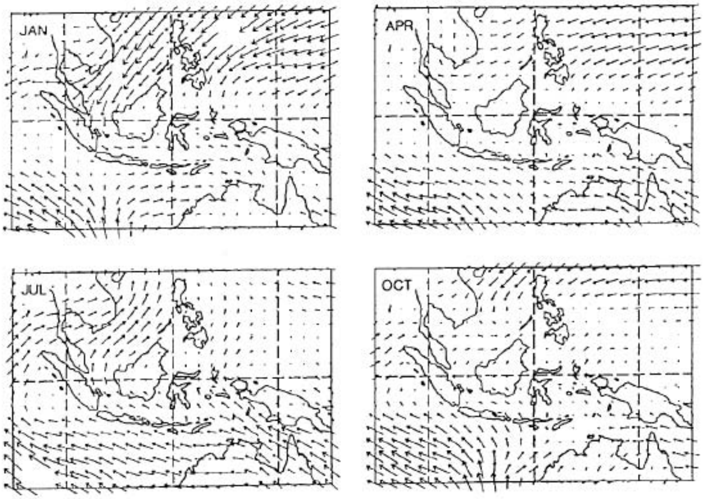


Figure 4. Regional scale low-level winds at four times of the year, showing the seasonal reversal of the monsoon flow. The length of arrow denotes the strength of wind (from McBride 1992).

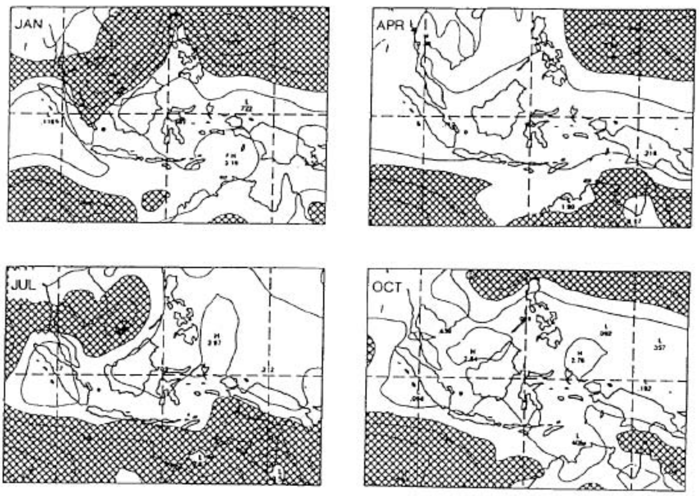


Figure 5. Regional scale wind speed at 500 metres at four times of the year. Isotachs are at 2 m/sec intervals and winds >4 m/sec are shaded (from McBride 1992).

EINA region are relatively light (Figure 5), particularly in Indonesia and in the monsoon transition periods of March–April and October–November as the Inter-Tropical Convergence Zone (ITCZ) moves north and south across the region. The ITCZ, which represents the broad zone of convergence of tropical easterly flow from each hemisphere, achieves its greatest seasonal movement in the Asian region (Figure 6). As easterly flow from one hemisphere crosses the equator, earth rotation causes the flow to recurve to become westerly monsoon flow in the other hemisphere.

The climatological characteristics of regional air flow described above are present more or less every year, and are important both in the seasonal distribution of rainfall and the dispersion of smoke from biomass burning. Southern and eastern parts of Indonesia and northern Australia generally have low rainfall May–October under the influence of the dry trade winds blowing out of central Australia, with

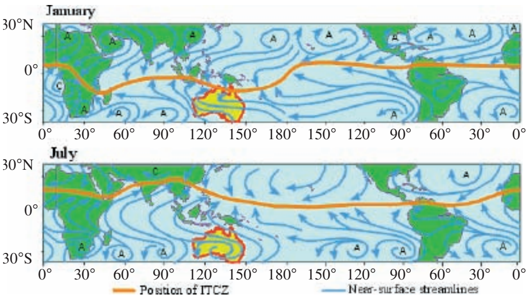


Figure 6. Mean position of the ITCZ during January and July and streamlines of near-surface windflow in the tropics (from Sturman and Tapper 1996).

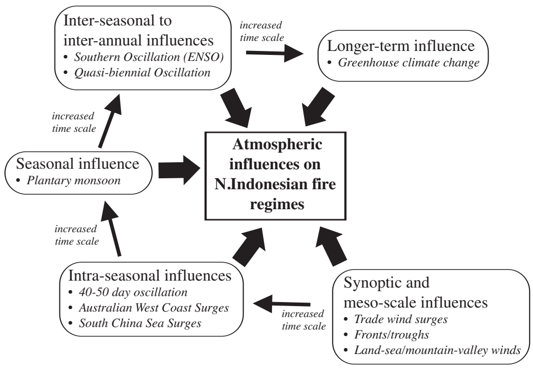


Figure 7. Scales of atmospheric influence on the eastern Indonesian–northern Australian fire regime.

rainfall increasing into the transition seasons and during the monsoon period. Weak low-level winds across southern Indonesia during the transition seasons mean that there is considerable air stagnation, leading to unacceptable levels of haze when forest and peat fires burn uncontrolled. Further south, winds are stronger over northern Australia, particularly during the austral winter. Upper air inversions that are characteristic of most trade wind flow regimes (Sturman and Tapper 1996) are seen at heights of ~2000 m over northern Australia, but are less distinct over Indonesia. Nevertheless characteristic maximum atmospheric mixing depths that help define the height of dispersion of products of burning away from the surface during the dry season would appear to be about 1500 m over Indonesia (Nurhayati 1994 unpubl.).

Over much of the EINA region it is probable that seasonal drought is the greatest influence on FDI, since temperature and relative humidity tend to be relatively constant and high, and wind speeds relatively low. Away from the coast, and further south in the region, temperature, relative humidity and wind speed are likely to become more important.

Atmospheric Influences on Fire Regimes of Eastern Indonesia and Northern Australia

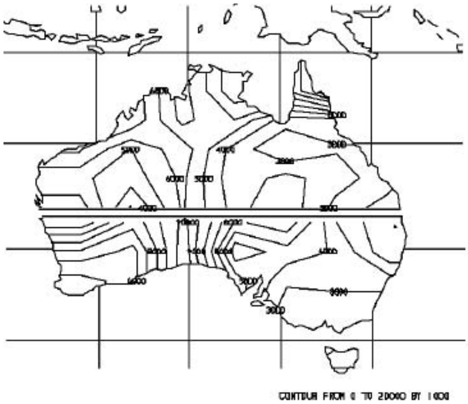
While EINA regional climate exhibits a general degree of predictability, i.e. warm-tropical, seasonally wet with a seasonal reversal of prevailing low-level winds, there is a range of influences operating over varying time scales that affect the region's climate and fire regimes. These are illustrated in Figure 7 and are discussed in the following sections, beginning with those influences over the longer term.

Longer-term influences

There is much uncertainty about the effects of enhanced greenhouse warming on global and regional climates. Any climate change is likely to have significant effects on biosphere–atmosphere interactions, including fire regimes. Recent work in our group (Williams 1997 unpubl.; Williams et al. 1999) has sought to quantify the impact of climate change on Australian fire regimes by estimating changes in fire weather parameters and the FDI for a doubled-CO_2 climate. The CSIRO-9 level general circulation model (GCM) was used in these simulations. Figure 8 shows both the cumulative fire season FDI (daily FDI summed over the entire fire season defined as July–November for northern Australia) associated with $2 \times CO_2$, along with percentage changes in SFDI from $1 \times CO_2$ to $2 \times CO_2$ simulations. This indicates that fire danger increases significantly over all of northern Australia, with the largest increases (30%) occurring on the northeast coast and in the south of the region. The change in FDI across the region is a result of increased temperature and reduced humidity during the fire season, with wind speeds and rainfall showing no significant change. Williams et al. also show that the frequency of extreme FDI occurrence increases markedly across all of northern Australia.

As will be shown below, the El Niño–Southern Oscillation (ENSO) phenomenon has an important impact on fire regimes in the EINA region. Some recent GCM simulations coupling atmosphere and ocean have raised concerns about possible changes in ENSO under enhanced greenhouse conditions. Meehl et al. (1993), Knutson and Manabe (1994, 1995) and Smith et al. (1996) all produced ENSO-like events in their greenhouse simulations, while the work of Gordon and O'Farrell (1996) indicated weakened ENSO-like phases. This highly sophisticated

Seasonal ΣFFDI for 2 × CO_2 scenario



Seasonal ΣFFDI: % change from 1 × CO_2 to 2 × CO_2 scenario

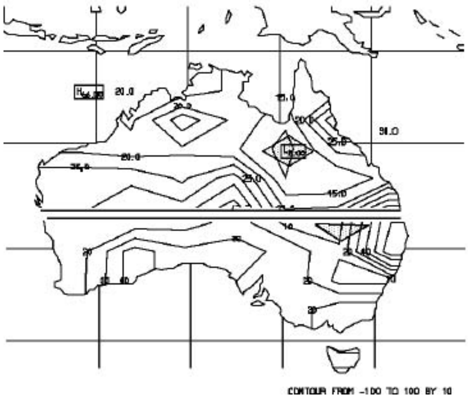


Figure 8. Fire season cumulative FDI for 2 × CO_2 (top) and percentage changes in fire season cumulative FDI from 1 × CO_2 to 2 × CO_2 (bottom). The continent has been divided into a northern and southern fire season (from Williams et al. 1999).

modelling work must continue for us to be better informed about likely future impacts on ENSO.

Inter-seasonal and inter-annual influences

The Walker circulation is a major circulation cell moving air between the eastern and western sides of the southern Pacific Ocean. It is oriented north–west to south–east across the Pacific with a rising limb centred over Indonesia and descending motion over the eastern Pacific (Figure 9). Fluctuations in the intensity of this circulation occur during ENSO events (Figure 9) with a quasi-periodic time scale of 2–3 years. The Southern Oscillation refers to the associated global-scale pressure fluctuations, while El Niño refers to the rapid rise in sea surface temperatures in

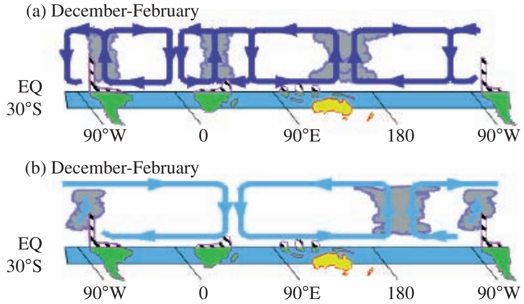


Figure 9. (a) Normal Walker circulation and (b) its breakdown during ENSO events (from Sturman and Tapper 1996).

the tropical eastern Pacific that occurs during the breakdown of the normal Walker circulation. The strength of the Walker circulation is proportional to the difference in pressure between Indonesia and the eastern region of the South Pacific. The Southern Oscillation Index (SOI), derived from the pressure difference between Tahiti and Darwin, is a measure of the strength of the Walker circulation and its direction. ENSO has been shown to be the major control on rainfall variability across large parts of the globe (Nicholls and Wong 1990), with the strongest amplification of variability occurring at lower latitudes and in lower rainfall regions. This is therefore particularly relevant to the monsoonal areas of the EINA region. It has been well documented for many years that extremes in Indonesian and Australian rainfall are strongly related to variations in the Southern Oscillation (Braak 1919; Berlage 1927; Nicholls 1981, 1983; McBride and Nicholls 1983; Hastenrath 1987; Drosdowsky and Williams 1991; Yamanaka 1998). For Indonesia correlation between rainfall and SOI is strongest in the south and east, and during the dry and monsoon transition seasons (Figure 10). The major reason for rainfall suppression over eastern Indonesia during ENSO years is a delayed monsoon arrival and early dry season onset (Kirono and Tapper 1999), allowing a much extended fire season. However it should be remembered that drought may also impose limitations on fuel availability. For northern Australia correlations between SOI and rainfall are also strongest during the transition (monsoon build-up) season (Figure 11).

There is strong documentary evidence linking major fire episodes in Indonesia to ENSO. Five major fire events have been recorded (Denis 1998); large fires occurred in Central Kalimantan in 1877, in South and East Kalimantan in 1914, in East Kalimantan in 1982–83, throughout Kalimantan in 1986–87, in Sumatra, Java and Kalimantan in 1991–94, and in Sumatra and Borneo generally in 1997–98. All of

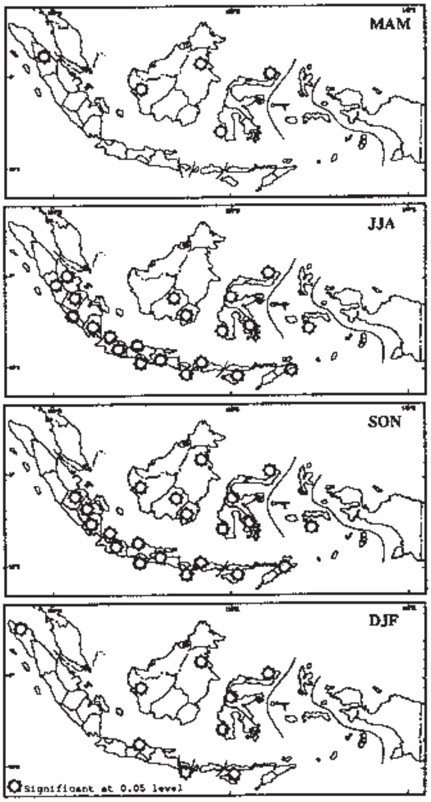


Figure 10. Spatial distribution of stations in Indonesia exhibiting a significant simultaneous correlations between monthly rainfall and SOI. Data for 1950–1998 (from Kirono and Tapper 1999).

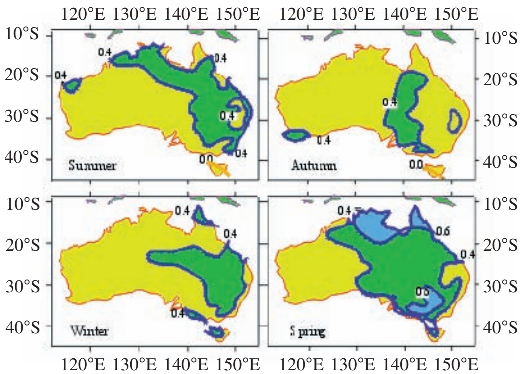


Figure 11. Correlation of the SOI with precipitation over Australia by season (from Sturman and Tapper 1996, after Drosdowsky and Williams 1991).

these fire events were associated with strong ENSO events (defined as having dry season SOI below –10). Interestingly, none of these large fire events, with the possible exception of the 1997–98 event, saw much large-scale burning in eastern Indonesia. This possibly indicates that it is the drying out of the more heavily forested areas further west, particularly in Kalimantan and Sumatra, that is most problematic. The link between ENSO and fire activity in Indonesia is further documented in Figure 12. This figure indicates a curvilinear relationship between forest area burnt and SOI, with relatively little burning occurring in seasons with SOI above –5.

Williams and Karoly (1999) document ENSO impacts on FDI for a number of sites in Australia. Composites of cumulative fire season FDIs for the 6 years with the most negative annual SOI and for the 6 years with the most positive annual SOI between 1960 and 1992 were compiled (Figure 13). Alice Springs, Roebourne, Normanton and Miles all represent northern Australian stations, and all except Miles show higher SFDI with more negative SOI. More detailed analysis indicated that the increased FDIs are largely associated with reduced rainfall, lower humidities and higher temperatures. However Williams and Karoly warn that not all of the inter-annual variability of fire danger is associated with ENSO and that actual fire occurrence depends on many other factors including vegetation type and fuel load.

Apart from impacts on drought and fire occurrence, the two extreme modes of the Walker circulation also have implications for haze dispersion. During the 'normal' phase enhanced vertical motion (convection) over Indonesia and stronger trade winds provide better conditions for moving haze out of the region both horizontally and vertically, as well as providing rain-out of particulate matter. During ENSO years the trade winds slacken and convection is reduced, particularly over Indonesia, resulting in greater stagnation of haze.

A quasi-biennial oscillation (QBO) signal has also been seen in EINA rainfall (Yasunari 1981), but in turn the QBO also appears to be at least partly related to fluctuations in the Walker circulation. However ENSO remains the greatest source of year-to-year variability in regional rainfall.

Seasonal influences

The most important seasonal influence on EINA meteorology and its fire regime is clearly the planetary monsoon circulation. Broad characteristics of the circulation relevant to the region were discussed above. The monsoon is responsible for a large component of annual rainfall over much of the region, with much of the rainfall falling over the land and islands which provide a number of the mechanisms

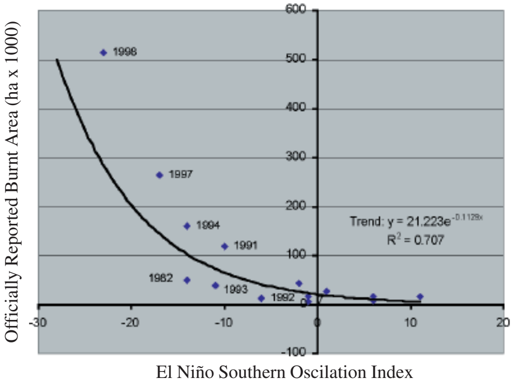


Figure 12. The relationship between SOI and area burnt in Indonesia (after Badawi et al. 1998).

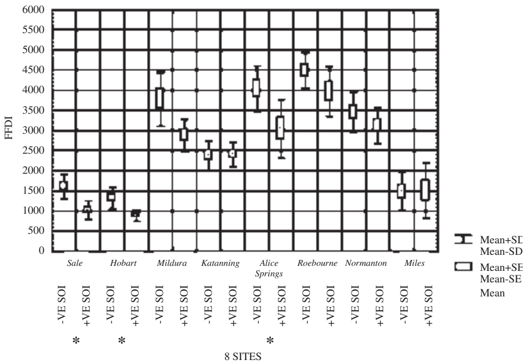


Figure 13. Differences in fire season cumulative FDI between extreme positive and extreme negative SOI years 1960–1992 (from Williams and Karoly 1999).

required for air mass uplift. The retreat northwards of the ITCZ and associated monsoon flow in the austral autumn initiates the drying necessary for annual burning to commence, while the southward movement late in the year (and the thunderstorm activity associated with the build-up) normally means the end of the burning season. These atmospheric influences are generally well known to fire managers of northern Australia and will not be discussed further here. Inter-seasonal monsoon variability associated with ENSO of significance to the particular seasonal fire regimes was discussed previously.

One of the most significant seasonal influences is the impact of characteristic wind flow regimes on the transport of the products of biomass burning. The last three years have seen many countries in Southeast Asia, Central and South America severely affected by trans-boundary smoke haze originating from uncontrolled forest fires burning mainly in tropical forests severely affected by drought. Recent developments in numerical weather prediction (NWP) and atmospheric transport modelling (ATM) provide an ability to predict transport patterns, impact area and pollution concentrations downwind of fire source areas. Our research group is currently utilising the HYSPLIT_4 trajectory-dispersion model coupled with Bureau of Meteorology NWP output to develop an atmospheric transport climatology for the entire South East Asian–northern Australian region. Figure 14 shows monthly trajectory composites (~30 daily forward trajectories each extending out for 5 days) for July 1994 (EINA dry season) and February 1995 (EINA wet season) for three locations in the EINA region—eastern Indonesia on the equator (0.0°N, 125.00°E), Jabiru in the Top End (12.86°S, 132.35°E) and east–central Northern Territory close to Tennant Creek (20.00°S, 135.00°E). These give characteristic regional transport patterns for the respective seasons. During the wet season transport from the northern location is dominantly toward the southeast in the northwest monsoon flow. Many of the 5-day trajectories impinge on mainland Australia. Transport from the mainland Australian locations is more variable, possibly reflecting monsoon and monsoon-break conditions. However a large amount of re-circulation occurs, consistent with persistent continental low pressure at this time of the year (Sturman and Tapper 1996).

Dry season flow is less complex. The Australian locations exhibit consistent transport to the northwest in the southeasterly trade wind flow, but some re-curvature toward the northeast is seen as trajectories cross the equator. Clearly there is some potential for transport of products of biomass burning into the Indonesian region. Interestingly a Dutch colonial meteorologist raised the possibility of transport of dry season haze from Australia into the Indonesian region back in the 1920s (Braak 1929). Transport from the northern station is dominantly toward the northeast as the trade winds re-curve over the equator to become the southwest monsoon. The position of the ITCZ thus has a major influence on the transport patterns, as was seen during the major Southeast Asian haze episode of September–October 1997. Through much of this period the ITCZ lay well north over Indo-China and the Philippines, allowing smoke from fires in Kalimantan and Sumatra to be transported northward over Singapore and Peninsula Malaysia. Smoke haze cleared from these areas as the ITCZ moved southward.

One outcome of the recent global forest fire activity has been a move by the World Health Organization to establish guidelines relating to health effects of exposure to emissions from biomass burning (WHO 1999). Almost certainly implementation of these guidelines will involve the use of atmospheric transport models similar to the one described above to calculate ground level concentrations of pollution. Current atmospheric transport models (ATMs)

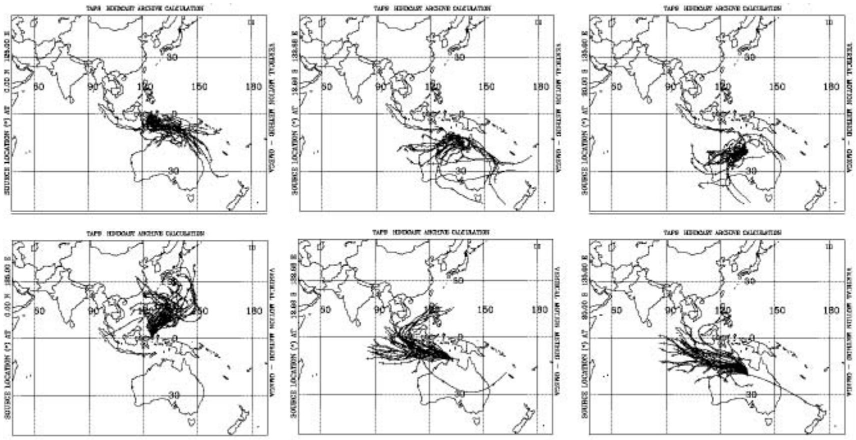


Figure 14. Daily 950 hPa forward trajectories (5-day runs) from three locations in the EINA region. Upper boxes are for February 1995, lower boxes are for July 1994 (from Wain 1999 unpubl.).

utilising numerical weather prediction are well advanced in terms of their meteorology and computation of dispersion characteristics, but the required level of information on emission rates from forest fires and smoke deposition rates for input to the ATMs is lacking (Tapper and Hess 1999). This is an area that must be quickly addressed if a capability to issue smoke predictions for the guidance of the relevant authorities is to be rapidly achieved.

Intra-seasonal influences

A range of intra-seasonal meteorological phenomena play an important role in rainfall processes in the region, particularly as they influence monsoon onset and the timing of major rainfall periods within the monsoon season. Northerly surges of low-level wind from the South China Sea associated with fluctuations in the intensity of the Siberian high pressure system are important in regulating convective activity and rainfall over northern Indonesia. The surges are considered a mechanism for monsoon onset over southern Indonesia and northern Australia (Manton and McBride 1992). Australian west coast surges are similarly thought to be important. Another influence on monsoon onset over the region and on intra-seasonal rainfall is the 40–50 day oscillation in equatorial wind and rainfall first identified by Madden and Julian (1971, 1972). This large-scale wave of enhanced convection is first seen in the Indian Ocean and moves from west to east with a propagation speed of ~20 metres per second.

Synoptic influences

Over time scales measured in hours to days, synoptic-scale influences can have an important role in determining levels of fire danger. Although the EINA region is characterised by extended periods of moderate to high fire danger during the dry season, two distinct synoptic-scale weather patterns provide extreme fire weather situations, at least over the region's southern parts (Tapper et al. 1993).

The passage of mobile pre-frontal troughs through southern and central parts of the Northern Territory is one such weather situation. These troughs occur in association with the eastward passage of higher latitude cold fronts during the austral spring and early summer and are associated with hot windy conditions and sometimes 'dry' thunderstorms with lightning. Tapper et al. (1993) provide a detailed discussion of the impacts of pre-frontal troughs on fire danger in the Territory.

Of more significance in the northern tropics is the influence of intense subtropical ridging over the south of the continent during the austral winter and early spring. This strong ridging can be associated with a southeasterly trade wind surge of sufficient strength and dryness to generate extreme fire danger over the northern region. Curing is greatest in the north at this time of year and fuel loadings can be high, particularly if there has been heavy rainfall during the preceding wet season. The weather pattern associated with trade wind surges is typically quite slow-moving, so extreme fire danger may persist for several days. Figure 15 illustrates a typical synoptic pattern that in this case was associated with the strong trade wind surge of 8–13 August 1987. Although temperatures were generally below average, surface winds of

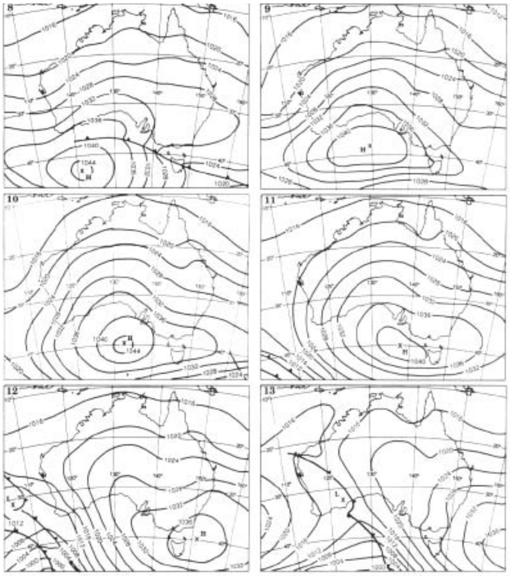


Figure 15. Daily sea level pressure analyses for the trade wind surge event of 8–13 August, 1987—units in hPa (from Tapper et al. 1993).

40–60 km/hr were widespread and relative humidity readings were generally below 20%.

These meteorological factors, combined with seasonal drought, generated extreme FDI values in the range of 45–60 across the north. Trade wind surges appear to be associated with degenerating cold fronts penetrating the tropics and it is the strong outbreak of dry air of southern origin that is instrumental in elevating fire danger. The rapid drying of the air mass following the passage of a trough–front system is clearly shown in Figure 16, which illustrates a mixing ratio time series obtained from Mt Isa during September–October 1991. A deep moist air mass precedes the passage of all trough–front systems, but the air mass dramatically dries out behind the system and remains dry for several days. Although subtropical ridging and associated trade wind surging is an important mechanism in the generation of high fire danger over northern Australia, it is unlikely to be of significance in the eastern Indonesian region. Synoptic situations associated with high fire danger here require investigation.

Conclusions

In providing an overview of atmospheric issues relating to fire management in the EINA region, this paper has identified a number of areas worthy of further research. Hopefully this forum will identify some of these areas as important research priorities:

1. Very little is known about the likely impacts on regional fire regimes of predicted global warming. The small amount of available evidence suggests a significant increase in fire danger in northern Australia, but this would need to be confirmed and extended into the eastern Indonesian region.
2. Links between fire activity and ENSO climate variability have also been tentatively established for the region, but need to be more firmly established. In particular the relative impacts of increased (meteorological) fire danger and (probable) reduced fuel loadings during ENSO warm events must be examined further.
3. Work continues on developing regional transport climatologies to link possible source areas of smoke from biomass burning to likely impact locations. However this work should be extended if possible to examine variability in transport patterns and processes between warm and cold ENSO events, since warm events appear to be associated with more burning, especially in more heavily forested regions.
4. Little appears to be known about synoptic influences (if any) on fire danger in eastern Indonesia. This information plays an important role in fire management practises in Australia and would be most useful for the eastern Indonesian region.
5. More generally, ATMs have the capability to provide useful information to fire managers and public health authorities on the transport and level of pollution from fires. However the usefulness of these models is limited by current poor level of knowledge about the relevant fire emission rates and atmospheric deposition rates for input to the models. This is an area that must be quickly addressed by research.

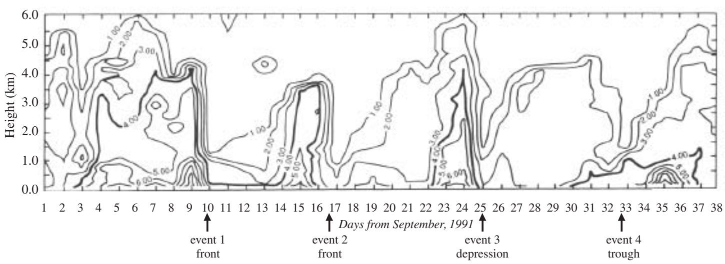


Figure 16. Time series of mixing ratios obtained from radiosonde ascents at Mt Isa, September–October 1991—units in g/kg (from Tapper et al. 1993).

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Fire Management Issues in Eastern Indonesia

Land-use and Land-cover Change in Nusa Tenggara Timur, Indonesia

Jeff Fox[1]

Abstract

Land-use/land-cover change (LUCC) research is central to the science of global environmental change. LUCC influences, and is affected by, climate change, loss of biodiversity, and the sustainability of human–environment interactions, such as food and fibre production, fire regimes, and human health and quality of life. Little has been written about LUCC in Nusa Tenggara Timur (NTT), Indonesia. This paper reviews annual statistics published by the Biro Pusat Statistik on land utilisation in NTT, reviews the literature on land use in NTT, and discusses a project in NTT being conducted by the East-West Center. Preliminary results suggest that traditional land uses in NTT (swidden cultivation and livestock raising) and land cover (secondary vegetation) have remained fairly stable over the last 20 years. But land-use change is occurring at an increasingly rapid rate as farmers switch from subsistence farming to commercial crops. Both the market potential of cash crops and the deterioration of environmental conditions that constrain the cultivation of traditional crops are driving these changes. The large amount of land zoned 'state forest land' is also affecting land cover and land use. These changes have long-term implications for biodiversity, environmental stability, and fire regimes in the region.

THE LONG-TERM EFFECTS of changes in land use and land cover on human welfare and the physical environment may be as significant, if not more so, than those associated with climate change. Unlike global warming, however, land use and cover changes are undisputed aspects of global environmental change. Notwithstanding the significance of the potential effects of land-use and land-cover changes, our understanding of the scale and pace of these changes, their human and biophysical origins, and their linkages to other global change is inadequate. Nusa Tenggara Timur is a region of the world where we know little about land-cover change.

NTT is part of an arc of islands stretching from the east of Bali, to the north of Australia's Northern Territory. The main islands are the western half of the island of Timor, and the Alor archipelago—Sumba, Roti, Sabu, Flores. The province has a population of around 3.75 million and a low population density of around 75 persons per km^2. Higher population densities are found in a few places, namely in the Sikka region in Flores, and around Kupang, the province's capital in Timor. NTT is one of the poorest and least developed of Indonesia's eastern provinces, with the majority of the population living a subsistence agricultural lifestyle. Indeed, NTT had the lowest per capita gross domestic product of all of Indonesia's 27 provinces in 1997.

Most islands in the region have rugged topography, but while the islands of the northern chain are covered by volcanic soils, uplifted marine deposits form the southern islands or the 'outer arc'. In climate the islands of this arc are affected by their proximity to Australia. Characteristic features are a long dry season, low rainfall, and consequent semiarid conditions in comparison with the more tropical areas of Indonesia. The eastern and western ends of the arc swing upward to the north; thus west Sumba and east Timor are less dry than areas in the southern circumference of the arc.

Biro Pusat Statistik

The Biro Pusat Statistik (PBS) in Indonesia compiles and publishes statistics on a variety of subjects for all of Indonesia and for some subjects by province. One has to be careful in reviewing land cover data, however, since most fields and even many forests in NTT have not been mapped. In addition, because PBS collects data on agricultural and forestlands from different line agencies (i.e., agriculture, estates, forestry, etc.) these data do not always agree with each

[1]Environmental Studies, East-West Center, 1601 East-West Road, Honolulu, Hawaii 96848-1601

other. Yet these data provide perhaps the best regional picture we have of what is happening to land use and land cover in NTT and may be useful if we examine them in terms of the magnitude and direction of change and not in terms of absolute numbers.

Table 1 shows data on land utilisation for NTT in 1979 and 1995. Note that in 1995 the figures on different land covers add up to 118% of the total land area of the province! The most likely explanation for this error is that the agriculture and forestry departments double counted some land. This error is significant but a second figure is perhaps more important. Between 1979 and 1995 'state' forest (*hutan negara*) grew from 22 to 66% of the landscape. While this figure undoubtedly contains error, there can be no doubt that during this 16-year period, the national and provincial forestry departments laid claim to a much larger portion of the province.

Among the remaining land categories it is important to note the following changes. Fallow and grass lands decreased by approximately 7% of the land area while woodlands (non 'state' forest areas covered by trees) increased by almost 3%, agricultural lands (dryland and rice) increased by over 3%, and estate crops also increased by approximately 2%. While the total amount of land devoted to growing vegetables is still less than 1%, this category has grown by more than 10% every year since 1979.

Table 2 summarises data on dryland crops. In 1995, maize accounted for 70% of the land devoted to these crops and the amount of land devoted to maize has increased by 2% per year since 1979. The amount of land devoted to cassava has decreased at a rate of 1% per year. Perhaps more importantly, the amount of land devoted to soybeans, while still insignificant, has been growing at a rate of 18% per year.

Table 3 summarises data on vegetable crops. The total amount devoted to growing vegetables is still small but has been growing at a rate of 10% per year since 1979. The amount of land devoted to potatoes, cabbage, and mustard greens has been growing even faster, at rates of 12–14% per year, throughout this period.

Table 4 summarises data on livestock. Cattle account for the largest number of big livestock and have increased at a rate of 4% per year since 1979. The number of horses has decreased at a rate of almost 1% per year. Goats, sheep and pigs have all increased at rates of 5–6% per year.

These data suggest a trend away from less intensive land uses (fallow and grass) towards more intensive and commercial land uses (agriculture, estates, and woodlots). In addition, a considerably larger

Table 1. Land use in NTT in 1979 and 1995.

Land use	1979 (ha)	1995 (ha)	1979 (%)	1995 (%)	1995–1979 (%)	Annual rate of change (%)
House compound Pekarangan/lahan untuk bangunan dan halaman sekitarnya	72414	119220	2	3	1	3
Dryland agriculture Tegal/kebun/ladang/huma	387708	464555	8	10	2	1
Rice—irrigated and upland Luas panen padi (padi sawah + padi ladang)	117643	159823	2	3	1	2
Vegetables Luas panen tanaman sayur-sayuran	516	2490	<1	<1	<1	10
Estate crops (coffee etc.) Perkubenunan negara/swasta	101934	196131	2	4	2	4
Grasslands Padang rumput	551934	498663	12	11	-1	-1
Fallow land Lahan yang sementara tidak diusanhankan	869684	589060	18	12	-6	-2
Woodland Lahan untuk tanaman kayu-kayuan	298438	434726	6	9	3	2
Forests Luas hutan berdasarkan tata guna hutan kesepakatan	1063000	3135000	22	66	44	7
Water ponds/dykes Kolam/tebat empang/tambak	15260	5841	<1	<1	<1	-6
Total	3478531	5605509	73	118		
Total land area in province	4735000	4735000				

Table 2. Dryland crops in NTT in 1979 and 1995.

Land use	1979 (ha)	1995 (ha)	1979 (%)	1995 (%)	1995–1979 (%)	Annual rate of change (%)
Maize	179108	254189	60	70	10	2
Cassava	96472	81396	32	22	-10	-1
Sweet potatoes	13988	11963	5	3	-2	-1
Peanuts	8485	10540	3	3	0	1
Soybeans	410	5627	0	2	2	18
Total	298463	363715	100	100	–	1

Table 3. Vegetable crops in NTT in 1979 and 1995.

Vegetables	1979 (ha)	1995 (ha)	Annual rate of change (%)
Onions	24	67	7
Shallots	293	978	8
Potatoes	56	331	12
Cabbage	33	271	14
Mustard greens	110	767	13
Carrots	0	76	51
Total	516	2490	10

Table 4. Livestock in NTT in 1979 and 1995.

Livestock	1979 (no.)	1995 (no.)	Annual rate of change (%)
Cattle	414203	785100	4
Buffalo	147373	191100	2
Horse	192831	170600	-0.7
Goat	225181	612200	6
Sheep	47419	111500	5
Pig	696738	1538000	5

proportion of the landscape was classified as state forests in 1995 than in 1979, suggesting that the potential for conflict between local land users and provincial and national forest departments may have also grown proportionally.

Literature Review

There have been three major works on land-use practices in Nusa Tenggara since the late 1970s. These include Jim Fox's work on Roti and Savu (Fox 1977), and Joachim Metzner's books on Flores (1982) and East Timor (1977) (East Timor is not part of the province of NTT). In addition, there have been several smaller works by both Indonesian and western authors (e.g., Dewa 1995; Molnar 1994; KEPAS 1986; Siskel 1986).

Fox (1977) argued that the 'traditional' agriculture of the present day — especially the swidden areas of Sumba and Timor — is in large measure the creation of the period following the arrival of the Dutch and the introduction of new food sources. The most prominent of these was maize; of lesser importance were sweet potato and cassava, and along with these, squash, onions, garlic, eggplant, and in the 1970s tomato. Prior to European arrival, the seven most important crops were rice, millet, sorghum, Job's tears, green gram, pigeon pea, and sesame. Fox maintains that it is not swidden agriculture per se that accounts for the precarious subsistence base of the peoples of Timor and Sumba, but the historical creation of a monolithic form of swidden overly dependent on maize. The KEPAS (1986) study also points out that in most dryland swidden systems agrochemical inputs are rarely utilised, and the use of organic fertilisers is also minimal.

About 80% of the farm households in NTT maintain trees around their houselots or in abandoned swidden fields and in recent years commercial cultivation of a variety of tree crops has grown in importance. This is particularly true on the island of Flores (Metzner 1982). These systems have developed as marketing channels have improved and the technologies and capital essential for their development have become more readily available. Tree crops given particular attention by the region's farmers include coffee, coconuts, cocoa, cloves, and candlenut. KEPAS (1986) presents case studies from around the province that show increasing market orientation. Better communication systems and improved access to consumer goods and services have increased the demand for cash. However, the intensive management of major cash crops is a new phenomenon in much of this region and problems both in their cultivation and marketing are common.

In Flores high population density puts a limitation on the available land per family and the use of land for shifting agriculture (Metzner 1982). Dewa (1995) argues that as population density has increased and land has become scarcer, the fallow period has often been shortened and many fields have come under sedentary cultivation.

Metzner (1982) estimated that grassland savannas covered 50% of the islands of Sumba, Alor, Flores and Timor in the late 1970s and early 80s. Grasslands are often owned communally and used as fallowed swidden fields or grazing lands. Cattle are the most important livestock in this system. In the past, elite groups representing only 2–10% of the population owned large cattle herds and monopolised common property pasturage. In recent decades a semi-intensive fattening system has developed in some areas in Timor. Since a family can rarely tend more than a few cattle, the system has improved the equity and freed pasturelands for small farmers to cultivate (KEPAS 1986). Other important animals are horses in Sumba, water buffaloes, goats and sheep. Pig raising is ubiquitous and practiced by almost every household.

Increases in animal population particularly in Timor and Sabu have put more pressure on land available for agriculture. For swidden farmers fencing is essential to protect their crops from straying animals, requiring a larger investment in labor for fence construction and maintenance. In some areas up to 30% of farm labor is allocated to the building of fences around individual fields. In other areas communal fences are built to protect the agricultural area with maintenance responsibility divided among the members. In Sabu, the use of 'living fence' substantially reduces labor demand for maintenance (KEPAS 1986; Fox 1977).

As land is increasingly fenced and thereby zoned for grazing and agriculture, it becomes more difficult to practice extensive shifting cultivation. In Sumba zoning is now enforced through forestry regulations that ban the use of forestlands for agriculture, including swiddening (KEPAS 1986).

This literature review suggests that in most of NTT two forces are increasingly determining land-use systems. First, market pressures — the commercialisation of subsistence resources and the substitution of commercial crops for subsistence crops — are providing a pull factor encouraging farmers to engage in new and different forms of commercial agriculture. And second, the growth of land extensive livestock management systems, as well as national forest and land tenure policies — the nationalisation of forest lands and efforts to increase control over upland resources by the central and provincial governments — are providing a push factor that makes it increasingly difficult for farmers to maintain their traditional swidden land-use practices. Combined these forces will eventually cause a major change in land-use practices from swidden agriculture to commercial crops, and a change in land cover from secondary vegetation to monoculture commercial agriculture.

Work at the East-West Center

At the East-West Center in Hawaii we have been collaborating with the Nusa Tenggara Uplands Development Consortium to improve local capacity to incorporate spatial information into community-based resource management projects. Specific objectives of this project include providing training in acquiring and analysing spatial information and developing capacity to use spatial information to produce practical and policy-relevant insights into resource management issues.

Working in collaboration with KOPPESDA (Coordination Team for Natural Resources Research and Analysis), one set of activities has focused on understanding land use and land cover change for an area in and around Wanggameti Protected Area/National Park in eastern Sumba. Project methodology has included incorporating information collected from interviews with key informants and farmers with the development of a spatial database based on satellite images.

There are 14 villages around the conservation area and two 'enclave' villages located within the conservation area. EWC and KOPPESDA researchers have mapped villagers' views of their customary boundaries in order to further negotiations with the park/forest officials on boundaries for the protected area/national park.

Maps showing changes in land cover for Wanggameti were developed from two satellite images — October 4 1973 and October 17 1997. The amount of vegetation in the images was calculated using a normalised difference vegetation index (NDVI). The NDVI compares the amount of reflectance in the near infrared (NIR) and red (R) spectral wavelengths. An area with a lot of vegetation has a high reflectance value in NIR and a low reflectance value in R and therefore a high NDVI. An area with little vegetation, or unhealthy vegetation, has a lower reflectance in NIR than in R, and hence a low NDVI. Studies of NDVI ratio results have shown that forests, and tree-covered areas in general, have higher NDVI values than grass and shrub covered areas. Also burned areas have very low NDVI values, but soon recover as grasses and other vegetation grow back. Because the same wavelengths are used to calculate the NDVI from images obtained from different satellites, the calculations are fairly comparable between satellites and over time.

Preliminary analysis of the NDVI data is shown in Figure 1 and Table 5. Figure 1 shows vegetation cover around Wanggameti in 1973 and 1997. These images (as summarised in Table 5) suggest a shift from more densely vegetated categories towards less dense vegetation. This analysis supports the hypothesis that population growth and shortened fallow periods are leading to less biomass.

Figure 2 shows a supervised classification of the 1997 image. This classification is based on relating ground cover located with a GPS in the field with spectral reflectance values from the image. We did not have sufficient ground truth to conduct an accuracy assessment of this classification. This image provides

Table 5. Percentage changes in land cover in Wanggameti, Sumba as observed from Landsat images.

	Wanggameti, Sumba (124 000 ha)		
Land cover	NDVI 1973	NDVI 1997	Annual rate of change 1973–1997
Most vegetation(tall)	48	30	-2.0
Some vegetation (medium)	24	13	-2.5
Less vegetation (short)	12	33	4.3
Little or no vegetation	1	9	7.8

support for the amount of area mapped as low or lowest vegetation cover in the NDVI analysis. This image, however, also suggests that a large part of the most vegetated class is a mix of species similar to those found in village tree gardens. In other words, the image suggests that land cover the Department of Forestry classifies as 'forest' is, in reality, vegetation managed for subsistence purposes by the people who live in and around the park.

Our preliminary conclusions hence support the view of east Sumba as a dry environment where swidden is the main land-use practice. Land cover in this environment may be slowly degrading from greater to lesser biomass. On the other hand, however, a large part of the new conservation area/national park may actually be home gardens planted and maintained by generations of villagers from surrounding villages.

Discussion and Conclusions

Both national statistics and the case studies reviewed suggest that land-use in NTT is slowly shifting away from less intensive uses (fallow and grass) towards more intensive and commercial uses (agriculture, estates, and woodlots). These trends are stronger in the wetter portions of the province (western Sumba, Flores, and eastern Timor) and less strong in the dryer portions (eastern Sumba) (note we have not reviewed the lontar economies of Roti and Sabu). In terms of this conference it is important to note that the less intensive land uses (fallow and grass) were traditionally managed by fire, whereas fire plays a smaller role in the management of the more intensive and commercial land uses. In addition, the fact that a considerably larger proportion of the landscape was classified as 'state forest' in 1995 than in 1979

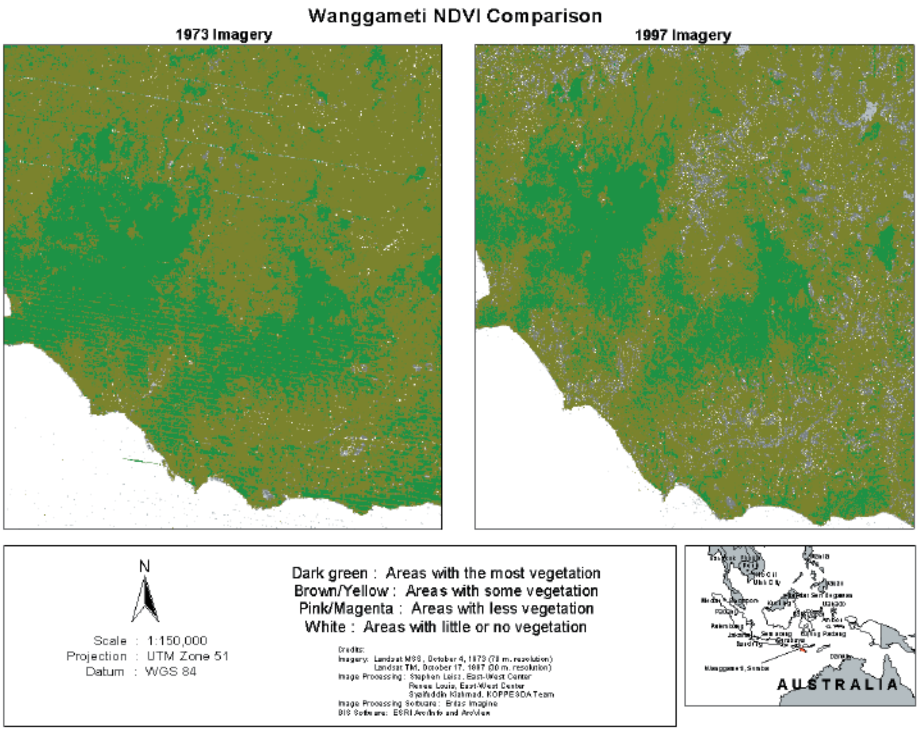

Figure 1. Comparison of vegetation cover around Wanggameti protected area in 1973 and 1997.

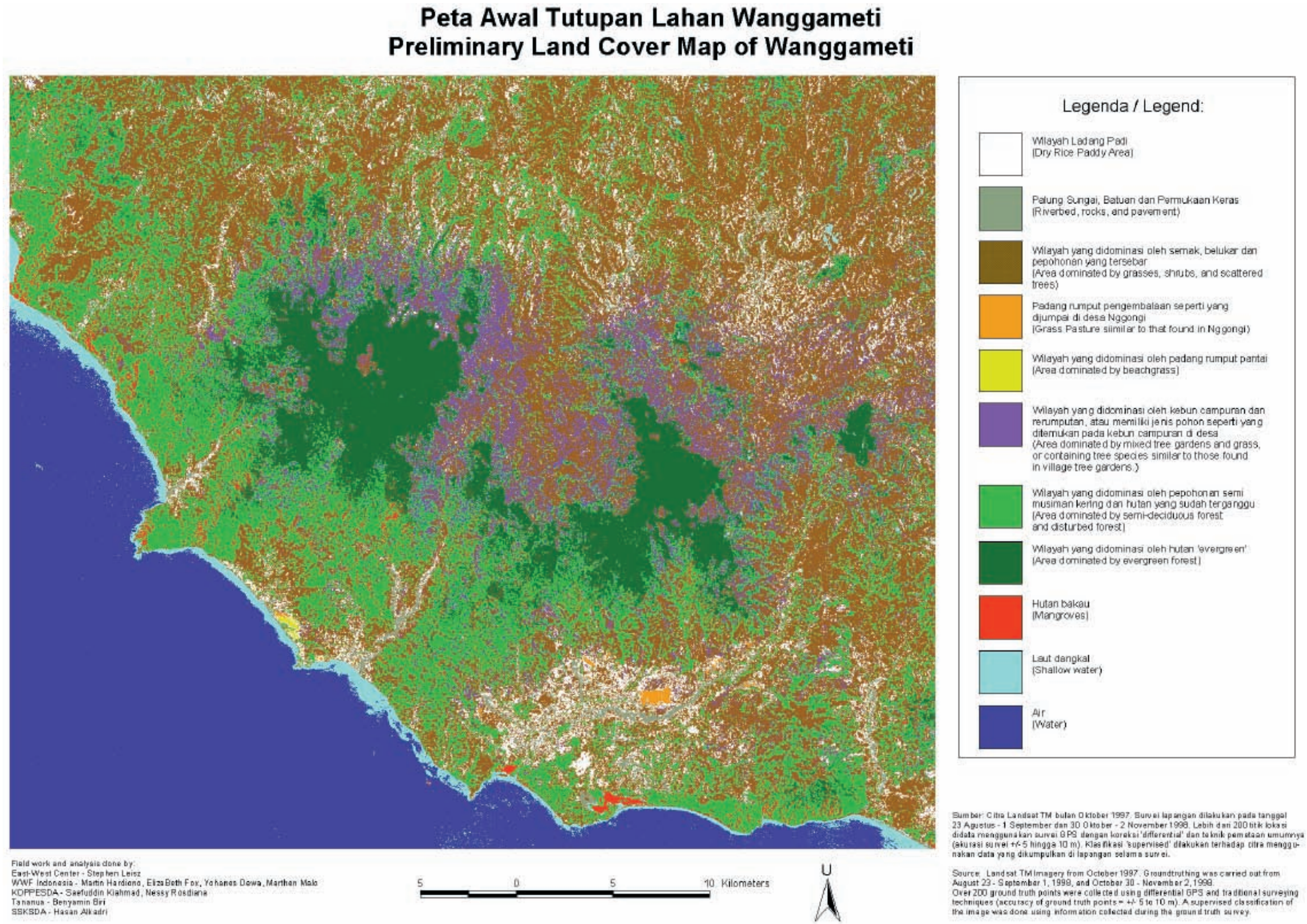

Figure 2. Preliminary land cover map of Wanggameti protected area, October 1997.

suggests that the potential for conflict between local land users and provincial and national forest departments may have grown proportionally. These ‘potential’ conflicts may be reflected in an increase in the ‘accidental’ burning of disputed lands.

The slow switch from subsistence swidden to commercial agriculture will provide an incentive to local people to prevent uncontrolled fires. On the other hand, tropical biodiversity conservation is currently undergoing a conceptual transition where isolated forest fragments, logged forests, and secondary growth forests (swidden fallows) are now being recognised for their value in the conservation of biological diversity (Chazdon 1998). These studies reinforce a new paradigm in the management of tropical biodiversity that extends conservation to human-impacted lands (Pimentel et. al. 1992; Janzen 1998). The commercialisation of agriculture and concomitant control of fires may hence lead to less biodiversity. Planners in NTT should consider that swiddening may be the most ecologically appropriate and culturally suitable means available for preserving biodiversity in many upland areas. Rather then encouraging the uniform spread of commercial agriculture, it may be useful to begin investing in methods of maintaining the biodiversity associated with swidden fallows while increasing the productivity and soil-sustaining properties of these lands.

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Management of Fuel and Fire in Preparing Land for Forest Plantations and Shifting Cultivation

Bambang Hero Saharjo[1], Endang A. Husaeni[1], Kasno[1] and Hiroyuki Watanabe[2]

Abstract

Sources of Indonesian fires in 1997 and 1998 are believed to be in land preparation areas where fire was used for forest plantations or agricultural purposes (oil palm and rubber plantations), logged-over forest areas and shifting cultivation. In fact, it has been recognised for several years that logs in land preparation areas and shifting cultivation have caused the conditions to deteriorate, although the reasons for this in logged-over forests and planted forests have not emerged.

Fuel and fire have important roles in land preparation areas for forest plantation and shifting cultivation. Burning is easy, cheap, and very simple and free minerals result from the ashes. Unfortunately, high quantities of fuel in overly expansive land preparation areas will burn, causing heavy smoke and widespread damage, sometimes crossing into neighboring countries as well. For these reasons, the use of fire and fuel in land preparation areas for forest plantation and shifting cultivation should be carefully managed, reducing the negative impact on the environment. The potential and methods for such management are examined here.

In 1997 and 1998, when fires destroyed forests and land not only in East Kalimantan but also in other provinces in Indonesia, shifting cultivation was blamed as the source of smoke and associated environmental problems. Subsequently it was proved that the sources of the fires there were mostly from land preparation areas for forest plantations controlled by forest concession holders and farm estate companies. It was shown that between 65% (Anon. 1998) and 80% (WWF 1998) of the forest area burned in East Kalimantan was within the forest concession. From January to May 1998, fires in East Kalimantan destroyed 507 000 ha of forest and 11 000 ha of land belonging to the people. The total area burned comprised 315 000 ha in the forest concession area and 84 400 ha in the forest plantation; 71 000 ha in Kutai national park; 10 600 ha in an ex-forest concession area; 8800 ha of protected forest; 4200 ha in Taman Hutan Raya Bukit Soeharto; 2200 ha in the Wanariset Samboja and conservation area, and 10 800 ha on private land (Anon. 1998).

[1]Faculty of Forestry, Bogor Agricultural University, P.O. Box 168, Bogor 16001, West Java, Indonesia

[2]Laboratory of Tropical Forest Resources and Environments, Division of Forest and Biomaterials Science, Graduate School of Agriculture, Kyoto University, Kyoto 606-8502, Japan

Fire is used because it is easy, cheap and simple. Much of the haze came from huge conversion burns used to prepare land for pulpwood and oil palm plantations (Schindler 1998). Use of fire is officially forbidden although every company uses it, because this is the only viable and economic method of reducing the huge biomass. The underlying cause is, therefore, the policy that plans to convert 500 000 ha of forest into plantations every year (Schindler 1998). The government has licensed and encouraged many companies to develop new industrial plantations of rubber, oil palm and pulpwood, as well as transmigration sites (CIFOR 1998). These activities require the clearing of hundreds of thousands of hectares of land, and fire is their cheapest option. The traditional method of claiming forested land, as in many parts of the world, has been to burn and then plant.

Shifting cultivators burned the land in order to prepare it mainly for agricultural purposes. Such activities have been done for thousands of years. Free minerals are released from the ash after burning—phosphorus, magnesium, potassium, sodium, and organic carbon (Daubenmire 1968; Viro 1974; Lal and Cummings 1979; Pritchett and Fisher 1987; Saharjo 1995). The increase of these minerals after burning is temporary, with decreases recorded in the second year and thereafter (Garren 1943; Jordan 1985; Whitmore 1990).

Although it should be remembered that shifting cultivation activities have occurred for thousands of years, unfortunately it has recently become a serious environmental problem. Observations reveal that illegal shifting cultivation was behind most of the smoke damage and these people are not true shifting cultivators (Saharjo and Husaeni 1998). They are newcomers from other regions that usually work in the paddy fields. True shifting cultivators have the knowledge of how to burn and prevent the fires from jumping to other regions. This experience and knowledge cannot be learned from only one or two burnings without prior practice.

Observers in the field believe that shifting cultivators will never stop using fire in land preparation, and this situation will remain in the agricultural and forest plantation sectors (as fire is the cheapest method) while government laws are not enforced. One possible solution then should be to allow the use of fire but to eliminate problems of smoke and environmental damage.

For that reason, the objective of the research described below is to find patterns and methods for forest plantation and shifting cultivation that enable safe burning on land preparation areas without affecting the environment.

Research Methods

Studies were carried out in three time periods and different locations. The first burn took place at Subanjeriji, South Sumatra, from August to September 1994, in a shifting cultivation area belonging to 13 families with a total area of 20 ha. The second burning was done from August to September 1995 in an area belonging to one forest concession area located in Subanjeriji with a total area of 4 ha. The third (last burning) involved a test on a 1 ha area belonging to one person in Jasinga, West Java. Owner/renters of the land and their families undertook the first and second burnings, while the authors carried out the third test. Parameters monitored were fuel load, fuel bed depth, rate of the spread of fire, flame temperature and fire intensity.

Parameter measurements and calculations

Estimation of fuel load

In each quadrat of 1 ha in the South Sumatra and West Java plots, 10 subplots of 1 × 1 m were chosen for the estimation of fuel load and moisture content. Fuel load was estimated by collecting all the materials, both dead and alive, in the subplot. These materials were then brought to the laboratory to measure weight and moisture content. Fuel moisture content was based on weights calculated before and after placing in an oven for 24 hours at 105°C.

Estimation of fuel bed depth

Fuel bed depth was the average height of the association of living and dead plant materials of various sizes and shapes that extended from mineral soil to the top of the vegetation layer.

Experimental burning procedure

Burning was conducted in the quadrat in the afternoon between 13.00 and 16.00. A study in Manitoba and Saskatchewan showed that the burn must be made on a day when the humus layer has a moisture content ± 20% (Williams 1960). Torches were used as the source of fire. Fires were set on the sides of the quadrate at the same time and allowed to propagate naturally. Burning was allowed until most of the fuel was spent.

Estimation of flame temperature

Flame temperatures on the soil surface and 1 cm beneath were estimated using 'Tempilaq' (temperature indicating liquid), which melts at a specified temperature and provides estimates of maximum temperatures. Liquid was contained in 30 cm lengths of 2 cm aluminium pipe (Saharjo 1995). The temperature sensors were placed in the vegetation at two locations.

Estimation of rate of the spread of fire

Rate of the spread of fire was estimated by measuring the average distance perpendicular of the moving flame front per minute. The monitors used a stopwatch and measurement tape.

Estimation of flame height

Flame length was estimated by measuring the average distance between the tip of the flame and the surface fuel. Tree height equipment and a counter were used.

Fire intensity

Fire intensity is the product of the available heat of combustion per unit area of ground and the rate of the spread of fire. It was calculated by using Byram's equations (Chandler et al. 1983), FI: $273 (L)^{2.17}$, where FI is fire intensity (kW/m) and L is flame height (m).

Results

A case study in Subanjeriji burning

South Sumatra is famous for the many shifting cultivation activities there. It is sometimes difficult to recognise which lands are private and which government, because there are no clearly marked borders. One thing certain is that the people seek to claim the land and cultivate it as soon as possible.

Some illegally cut the reforestation trees belonging to the government and convert the areas to rubber plantations for maximum profit (Saharjo 1997a).

Fuel preparation

All trees with both large and small diameters found in the burning area were cut, and shrubs and grass were included. A chain saw was used for large trees and a machete for small branches, shrubs and grass. Trees with a diameter of more than 50 cm in the burning area become sawn timber, while others with diameters of less than 40 cm, together with shrubs and grass, were left in the area as fuel for burning. These fuels were separated in the burning area.

This activity is usually done in the dry season from August to September, when rainfall is low. At this time the air temperature is quite high, around 35–36°C, and relative humidity is 70–80%. These high temperatures will hopefully reduce fuel moisture content, and for this the fuels are left to dry for at least 2–3 weeks before burning. It is hoped that the moisture content level is low and relatively uniform, then the fire can spread easily and quickly.

Different fuel loads were found in the plot in Subanjeriji, resulting in differing smoke and environmental effects. Plot A has a total area of 20 ha with fuel load 15 t/ha. This fuel load was dominated by trees with diameters of 10–20 cm, averaging 10 cm. Fuel depth was 0.5 m and fuel moisture content was 5–25% (Table 1). In plot B, the total area for burning was 4 ha with a fuel potency of 40.3 t/ha. The fuel load was dominated by tree diameters ranging from 20 to 40 cm, averaging 20–30 cm. Fuel bed depth was 0.6 m and moisture content was 7–35%. In the Jasinga plot, the total area burned was 1 ha with a fuel load potency of 29.5 t/ha, mostly consisting of trees with a diameter of less than 10 cm. Fuel bed depth was 0.3 m and fuel moisture content was 3–14% (Table 1).

Burning

Before burning, the areas selected were usually protected by a firebreak 2–3 m wide. Clearing everything within that range made this firebreak. This is to cut the continuing fuel load in order to prevent the spread of wildfires.

Burning was done in the afternoon, between 15.00 and 17.00. The principal used in this burning was for each head fire to meet in the middle of the burning area, hopefully spreading directly into the centre of the area. With this method, the possibility of the fire jumping to other regions can be reduced. It is important to remember that burning depends greatly on the wind direction and slope. For this reason, the parameters should be known before burning.

Burning commenced from sharp slopes and progressed to flat areas. For this several persons had to be involved as burners at different burning locations. For instance, for a 1-ha burning area at least three burners should stand by in three different positions equally distanced from each other. Burning was started under one command. Running slowly, a burner moves to an exact point clockwise or anti-clockwise, following the wind direction and making fire points at 0.8–1 m intervals. Ideally, no gap between one fire point and another will allow the fire to jump (Figure 1).

With a fuel potency of 15 t/ha and dominated by trees with small diameters, plot A with a total area of 20 ha needed only 56 minutes to burn. Maximum

Table 1. Weather conditions and fires behavior when burning was conducted in South Sumatra and West Java.

Parameter	South Sumatra		West Java
	A.	B.	
Weather conditions			
Air temperature (°C)	33	35	36
Relative humidity (%)	65	70	80
Wind speed (m/sec.)	1.7	1.6	1.8
Fire behaviour			
Fuel load (t/ha)	15.0 ± 0.2	40.3 ± 6.3	29.5 ± 8.2
Fuel bed depth (m)	0.5 ± 0.1	0.6 ± 0.2	0.3 ± 0.1
Fuel moisture content (%)	5.2–25.2	7.1–35.3	3.1–13.9
Flame height (m)	2.75 ± 0.19	3.13 ± 1.35	2.5 ± 0.3
Rate of the spread of fire (m/minute)	1.30 ± 0.21	1.20 ± 0.11	1.5 ± 0.3
Flame temperature above and below soil (°C)			
0 m	760	1010	720
1 m	302	316	93
2 m	159	170 76	
-0.01 m	< 38	38–42	< 38
Fire intensity (kW/m)	2468.03 ± 376.55	3962.42 ± 1753.25	2026.23 ± 648.47
Slope (%)	< 8	7– 30	5– 25
Burning area(ha)	20	4	1

flame temperature reached was 760°C with a mean flame height of 2.75 m. Maximum flame height was 8 m with a fire intensity of 2568 kW/m. Plot B had a fuel potency of 40.3 t/ha and was dominated by trees with larger diameter than plot A over a total area of 4 ha. This needed only 25 minutes to burn. Maximum flame temperature reached was 1010°C with an average flame height of 3.13 m, reaching a maximum of 12 m and fire intensity of 3962 kW/m. This demonstrated that high availability of fuel dominated by large diameter trees will cause higher flame temperatures and more damaging effects.

Burning test: a case study in Jasinga, West Java

Based on the experience in Subanjeriji (South Sumatra), a burning test was applied in Jasinga (West Java). Total area burned was 1 ha with a slope range of 5–25%, a fuel potency of 29.5 t/ha dominated by trees with diameters of 5–10 cm and shrubs with a fuel moisture content of 3–14% and fuel bed depth of 0.35 m.

As with both plots in Subanjeriji, all the materials found in the plot, whether dead or alive—including trees, shrubs and grass—were cut down and separated in a circular plot. This activity enabled the fuel load to dry for at least 2 weeks and thus decreased the fuel moisture content.

Before burning, the surrounding area was protected by a 2–3 m wide firebreak by cleaning away all of the materials within that range. Wind speed and direction, important factors in considering the starting point for the fire, were determined with an anemometer. Measuring was done several times in order to decide the best time for burning, ideally with a wind speed of 100 m/minute and in the afternoon. Air temperature and relative humidity was measured using dry and wet bulb thermometers.

Three burners stood by at three different points waiting for the command to start the fire. At 13.05 p.m., burning commenced by making one fire point, followed by two others (Figure 1). Between one fire point and another was 0.8–1 m. The head fire was clearly observed coming from the different points and moving toward the centre of the burning area. In only 15 minutes the 1-ha plot was burned. Maximum flame temperature was 720°C with a maximum flame height of 8–10 m and a fire intensity of 2026 kW/m (Table 1).

Discussion

The two burning cases in land preparation in Subanjeriji and one test in Jasinga proved that high flame temperatures were caused by the high fuel

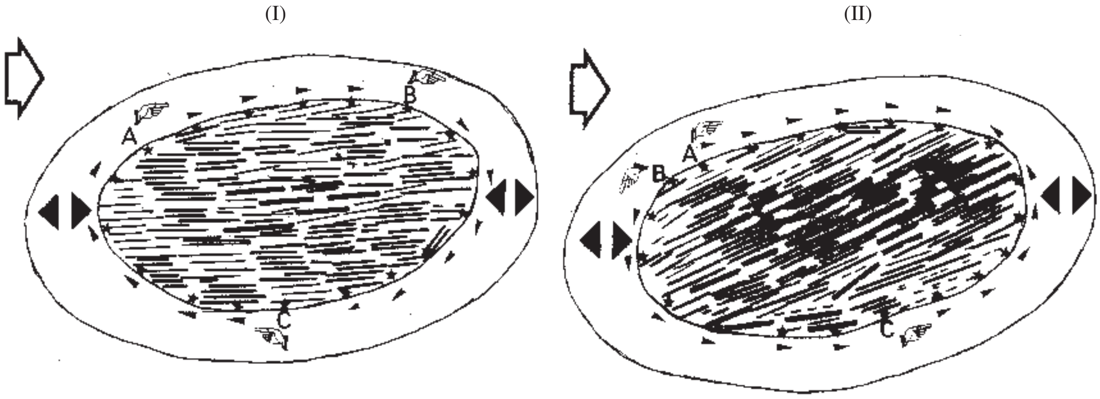

Figure 1. (I) Burning method type 1
(II) Burning method type 2

Legends
- ➪ wind direction
- A, B, C burner
- ► burning direction
- ◄► firebreaks
- ★ burning point
- ═ fuels

content dominated by logs with large diameters. Variations of this can be seen from the different flame heights at three different plots.

Saharjo (1996a) reported that a fuel load comprising shrubs 1–2 cm in diameter with a potency of 20 t/ha can reach flame temperatures of 649°C with an average flame height of 1.5 m, while at a potency of 10 t/ha, flame temperature will reach 550°C. Temperatures 1 cm below the soil surface can reach < 38°C, but do not disturb soil organisms (Table.1).

These facts reveal the steps that can be taken to prevent large fires during burning of land preparation areas, preventing high temperatures and the resulting pollution and smog. Essentially, trees of more than 5 cm diameter should be removed, but smaller trees can be kept in the burning area together with small branches, shrubs and grass. In addition, observation shows that logs with diameter of more than 30 cm are quite difficult to burn, and continue burning when all other fuels have been spent. These conditions invite an increased fire danger, especially in logged over forests.

Burning with fuel loads consisting of small diameter materials has also been done by the people of Sampoku, Niigata, Japan (Watanabe 1995) since the 17th century, preparing the land for Sugi (*Cryptomeria japonica*) plantations. In this area large diameter logs were removed from the area, while small branches and leaves were left. The burning area was not so large, usually about 0.05–1.2 ha divided into blocks based on ownership or rental agreement. Burning was done from the top to the foot of the slope. The fire was kept in horizontal lines moving slowly down the slope. The burning was mainly done in the dry season, July or August, in early mornings until afternoon, as the morning wind speed is not high and can be controlled.

For burning with less smoke, the burning pattern that was done in Subanjeriji was revised, based on the burning test in Jasinga. It is recommended as one alternative for burning in land preparation, but it must be followed by a revision of fuel load weight and form. Only logs less than 5 cm in diameter should be used, while the larger ones should be removed. The maximum area to be burned should be no more than 1 ha. For areas of more than 1 ha, the procedure must be done several times in order to reduce fire jumps and smog. Fuel drying should be conducted at least 2 or 3 weeks before burning, with shrubs and grass cut down and separated in the plots. Relative humidity must be around 70–80%, with a wind speed of 1.6–1.8 m/second and fuel moisture content between 5 and 20% in an area dominated by dry fuels. Firebreaks should be 3 m wide and surround the fire zone. It must be clean in order to prevent wildfires.

For a 1-ha burning, at least three burners should be involved and should stand at equal distances from each other. They should move with the wind direction and clockwise or anti-clockwise, but to a certain point (Figure 1). Burning should be conducted in the afternoon between 14.00 and 16.00, as hopefully at this time the fuel load drying is relatively uniform. If the burning is done in the morning, it may not burn well because of low temperatures that affect fuel moisture content and a high relative humidity that will block the process and rate of the spread of fire. This will invite an unpredictable fire invasion as happened in Indonesia in 1994 (Saharjo 1996b, 1997b). Afternoon burning is relatively safe and preferred because when wildfires occur, fire brigades can work more easily in locating the fires, as compared to the difficulties and dangers of night fires.

Conclusions

Fuel and fire management in land preparation for forest plantation and shifting cultivation is very important in order to reduce air pollution impacts and other dangers.

For this, the burning patterns observed in Subanjeriji, South Sumatra and applied in a burning test in Jasinga, Bogor, West Java, can be used for land preparation. Their application is simple and inexpensive, and does not cause any environmental disturbances. The three cases described provide the background for further expanded study.

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Land and Forest Fire in East Kalimantan Province

Riyanto[1]

Abstract

Land and forest areas in East Kalimantan Province were frequently burned in conjunction with the long dry period of climatic deviation due to the impact of El Nino in 1997–98. Long dry periods give the opportunity for farmers, workers of forest estates and agricultural plantations to use fire for land preparation. However, safe burning techniques were not managed correctly and as a result wildfire spread uncontrolled to the land and forest areas. Impact of land and forest fires was serious, not only for public health, but also hazy weather conditions hampered land, water and air transportation. The worst impacts were reduction in growing stock, loss of natural regeneration, decreased biological diversity, loss of crops and flooding.

The local government of East Kalimantan Province with Mulawarman University took the initiative to conduct a workshop on land and forest fire prevention and rehabilitation and rearrange the Bukit Soeharto forest tour, in which outputs covered: basic needs for rehabilitation; rehabilitation policy; implementation techniques for rehabilitation.

East Kalimantan Province covers an area of 21 million hectares, comprising 17.3 million ha of basic forest and 3.8 million ha of non-basic forest. Based on the Forest Land Use Consensus (1983), basic forest is divided into production forest without restriction (5.5 million ha), production forest with restriction (4.8 million ha), protection forest (3.6 million ha), reserve and park forest (2 million ha), forest for research and education (17 560 ha) and converted forest area (1.3 million ha).

After nearly 25 years of forest exploitation, the local government reviewed the overall condition of the forest areas from the environmental point of view. As a result in 1992, the local government declared The Provincial Spatial Plan and removed 1.5 million ha from the area of product forest (with restriction) and converted it to protection areas, i.e. protection forest, peat area, wildlife reserve, cultural preserve, national park etc., therefore the total of protection areas grew to 7 million ha.

Fires during the 1997–98 El Nino had the most serious effects on natural forest, industrial timber estates and community forests. Much has been said about excessive logging, but in fact, it was not true that logging activities contributed to deforestation in East Kalimantan. The Department of Forestry launched the TPI system (Indonesian Selective Cutting System) regulating forest exploitation in the early 1970s and improved it by using the TPTI system (Indonesian Selective Cutting and Planting System) in 1992–1993. With those regulations, logging only removed 2–7 trees per hectare. Other trees, either lesser known or non-marketable trees, were left undisturbed, but there were 3–4 trees destroyed each time by falling trunks.

Clear cutting was done for several purposes, such as for transmigration, mining, industry, plantations/estates (either agriculture or forest plantation estate) or slash and burn activities. There was false information from several sources regarding deforestation. Possibly they had never visited East Kalimantan Province. Several groups of international journalists visited and saw the implementation of the TPI system, also members of the All Anglo-Indonesian Parliamentary Group in September 1994. Most of them were satisfied with what they saw in East Kalimantan, including development of HTI (forest plantation estates) in several areas that are owned and handled by private timber industries. The wood products of HTI will be used for their industries and the use of natural forest as a source of timber will decrease with enhancement of the development HTI. The estimated areas will be 6 million hectares in Indonesia in the year 2000.

Burning as a tool for land preparation and weed control has been used for a long time in agriculture, plantation, and forestry. The indigenous farmers in East Kalimantan use fire for land preparation of their lots. However, they are practised in this and the fire never spreads to the forest areas. With time, more

[1]University of Mulawarman, Samarinda, East Kalimantan, Indonesia

people from other islands are coming to East Kalimantan for a better life. Some of them work in agricultural sectors, and of course in doing land preparation, most of them live by their own traditional practices. Under unfamiliar conditions the burning of land is often uncontrollable and fire spreads around their lots and enters the forest areas. This is also done by the workers of agricultural plantations and HTI, therefore during a long dry season such as an impact of El Nino, the land and forest fires could not be controlled effectively.

It is the responsibility of local government to adopt either fire techniques or regulations, to train people in burning in the correct manner and to prohibit the estates and plantations from using fire for land preparation. Other regulations should be implemented and pushed by law enforcement.

Based on the report from local government and by gathering data from field reports an estimated 390 000 ha in East Kalimantan were affected by forest fires in 1998. The Integrated Forest Fire Management (IFFM) has an office in Samarinda and I met with team leader Mr Ludwig Schindler and Ms Anja A. Hoffman on July 28 1999. We discussed the reported 8 million hectares of forest fire in 1999, and I was informed that the 8 million hectares of forest fire encompassed East and South Kalimantan. By using radar imagery, the IFFM Samarinda has already produced more accurate results, determining that the fire in East Kalimantan affected 5.2 million hectares (3 million hectares forest area and 2.2 million hectares non-forest area). These details have not yet been released by the IFFM and will be discussed with the local government. In addition, there was an area of surface peat swamp fire in East Kalimantan, but IFFM has not yet computed the size of the area.

Land and Forest Fire

Most farmers in East Kalimantan prepare their land by burning weeds and shrubs. Land is prepared in the early dry months of June or July and planting takes place in September. During El Nino periods the winds are hot, drying and stronger than usual, and fire frequently gets out of control.

Forest concession holders also burn areas in preparation for industrial timber estates and rubber or oil palm plantations, and these fires have a greater impact than those set by the farmers.

Fire is an important factor in forest and grassland regions but since the early 1980s it has become a persistent threat in East Kalimantan. Crown fires are very intense and cause major damage to all vegetation and soil organic matter, whereas surface fires are far less severe. Frequent fires reduce growing stock, decrease natural regeneration and reduce biological diversity, and the smoke haze causes major disruptions to land, water and air transport and affects health of humans and animals. Loss of vegetation leads to increased surface run-off and in times of heavy rain this can lead to flooding. Fires also affect nearby crops such as upland rice, corn, cassava, banana and vegetables and non-wood forest products such as rattan and honey. Loss of soil organic matter reduces the water-holding capacity of the soil.

Fire Control Measures

There is great concern about the rapid rate of tropical deforestation, brought about by temporary or permanent clearance of forest with fire to make way for agriculture and other purposes. Logging activities in tropical rainforests do not have to cause deforestation but selective cutting is rare. Only a few of the thousands of species of tropical tree species are marketable and logging usually only removes 2–7 trees per ha.

Surface coal outcrops ignited during the El Nino of 1982–83. Several are still burning and they become a source of persistent fire in normal dry periods as well as El Nino years.

Concerns about the fires of 1997–98 have led the East Kalimantan local government to introduce new measures to combat the fires.

Fire fighting

A local land brigade of volunteers, totalling around 700 people, has been formed. They use water and chemical extinguishers, including Chinese grenade extinguishers, and construct fire breaks. However the result is unsatisfactory—there are too few people and they have insufficient equipment.

Since February 1998 aircraft have bombed areas of Kutai National Park with water and Hartindo AF-31 chemicals. Fifteen sorties have been undertaken, but poor coordination has meant the results are only partly satisfactory. Also attempts at rainmaking by seeding clouds with sodium chloride failed because of wind and low humidity.

The NOAA satellite provided data that gave early warning of fire outbreaks and pinpointed hot spots.

Training

A ‘Train the Trainer’ course took place in March 1998. Swedish instructors taught 38 people the skills of fire fighting and fire prevention measures so that they could train others. This was a joint cooperative effort involving the Government of East Kalimantan and Raddings Vervet UNDP.

Skilled people in East Kalimantan now number 13 742, comprising 97 training instructors, 1637 forest guards, 11 447 forest concession security guards and 551 people who live near the forest.

Firefighting equipment

The Government of East Kalimantan has received two consignments of firefighting equipment from the Swedish Government. One consignment contained equipment for basic firefighting, the other equipment to combat peat fires. There was sufficient to equip seven districts in East Kalimantan.

Prevention and Rehabilitation

Some years ago several seminars and workshops were held in Samarinda but little was done by local government to implement the recommendations arising from them. When the huge fires broke out in 1997–98 people were affected both in and outside East Kalimantan. Now a newly established Local Environmental Impact Control Board (Bapedalda) has taken responsibility for dealing with land and forest fires.

The Board now takes steps to involve local communities and has worked with Mulawarman University to conduct a workshop involving all parties concerned with land and forest fires. Participants came from Bapedalda, Mulawarman University, national and regional departments of Forestry and Horticulture, regional Departments of Transmigration and Agriculture, private universities, non-government organisations, forest concession operators, private and state-owned plantations, mining industries and leaders of indigenous communities. Workshop outcomes are listed below.

Statement of basic need for rehabilitation

1. East Kalimantan has rich ecosystems of great biological diversity. Its huge natural forest areas support human and animal life and provide economic benefit.
2. Land and forest fires have seriously threatened the natural resources and environment, affected the aesthetic qualities of the forest and reduced economic benefits and biological diversity.
3. Smoke haze from the fires has affected public health, interrupted transportation over land, air and water, and caused local and international problems.
4. Following the fires the bare land has eroded, leading to siltation of rivers and lakes and flooding from the increased water runoff.
5. The essence of rehabilitation is to restore the ecological functions and socioeconomics of the land and forests.

Rehabilitation policy

The forest ecosystem has a protective, regulative, and productive function at the ecosystem level. These functions can acquire utility value for people and become a function of the cultural ecosystem. Therefore, the aim is to rehabilitate the degraded land and forest after burning by using the multipurpose functions of the trees which should generate economic growth and improve quality of life.

Techniques of rehabilitation

1. To select appropriate crops/forest trees (trees that have multipurpose functions and high economic value). Properties sought include fast growth, resistance to fire, ease of planting, and useful timber, bark, leaves, fruit and seeds.
2. Develop culture techniques that can be used for labour-intensive enterprises that will benefit people living near the forest.
3. Regreening as a result of rehabilitation activities after burning will enable land and forest areas to improve soil and water conservation which may needed by farmers for farming. Regreening also helps people to get a wide supply of raw materials to meet their growing demands, and supplies employment.

Conclusions

1. Land and forest areas in East Kalimantan Province were frequently burned in conjunction with the long dry period of climatic deviation due to the impact of El Nino.
2. Long dry periods give the opportunity for farmers, workers of HTI and agricultural plantations to use fire for land preparation. However, safe burning techniques were not managed correctly and as a result wild fire spread uncontrolled to the land and forest areas.
3. Impact of land and forest fire was serious, not only for public health, but also daily weather conditions which hampered land, water and air transportation. The worst impact was reduction in growing stock, loss of natural regeneration, decrease of biological diversity, loss of crops and flooding.
4. The local government of East Kalimantan Province with Mulawarman University took initiative to conduct a workshop on land and forest fire prevention and rehabilitation and rearrange the Bukit Soeharto forest tour, in which output covered:
    - basic needs for rehabilitation,
    - rehabilitation policy and
    - implementation techniques for rehabilitation.

Recommendations

1. Since tropical rain forest is a fragile ecosystem, then all stakeholders should shoulder the responsibility of reducing or preventing wild fires from destroying forest resources.
2. Local government could ask assistance of international institutions that have competency and capability in fire management, including the use of IFFM (Integrated Forest Fire Management) which recently worked in East Kalimantan.

Forest Fire Management in Komodo National Park

Bambang Hartono and Heru Rudiharto[1]

Abstract

Komodo National Park is designated as a World Heritage Site. Located in one of the driest parts of Indonesia, it has a dry season lasting 9 months of the year and low rainfall (500 mm/year). Seventy per cent of the area is grassland. Fire frequently occurs in the area, started for agricultural purposes to improve grazing and drive out game. Natural fire, usually caused by lightning, is rare. While fire is important to maintain grassland for rusa deer and other browsers, uncontrolled fires cause great destruction. This paper describes the challenges faced by park management in dealing with uncontrolled fire, taking account of untrained fire fighters, insufficient tools and equipment and the difficult terrain.

KOMODO NATIONAL PARK is located in the province of Nusa Tenggara Timur. It encompasses an area about 173 300 ha of land and sea. One third of the area is land, consisting of three main islands: Komodo (33 900 ha), Rinca (19 600 ha), Padar (2020 ha) and numerous small islands.

This national park was established on March 6 1980, and listed as a World Heritage Site in December 1991. The park preserves a truly unique ecosystem, including a fascinating assemblage of plants and animals. Under the influence of the prolonged dry season and low rainfalls, vegetation differs dramatically from other regions of Indonesia.

The park is home to active volcanoes, hearty villagers, and many fascinating, even mystical creatures including the komodo dragon. Open fields of drought-tolerant plants dominate the landscape.

It is the savanna grassland that best characterises the topography of Komodo National Park. Over 70% of the islands are carpeted by sea tawny, chest high grasses extending from sea level to 500 m. Alang-alang (*Imperata cylindrica*) dominated grassland, known as padang, arises from periodic burning.

Fires occur frequently in these areas, mainly associated with the agricultural purpose of making it easier to walk through the savanna and to improve grazing, but also to drive game. Fire becomes more intense during the dry season, and many fires are difficult to suppress due to limitations of personnel and equipment. Though fire is important in shaping the ecology of Komodo National Park it needs to be managed properly to prevent it becoming a destructive agent.

General Conditions

Geological description

The Park is located in the Lesser Sunda Islands of Indonesia. In this region massive tectonic plates collide beneath the Flores Sea; the general aspect of the islands in the park is a typical arid, uplifted region. The permeable ground of these areas receives and holds water runoff from the hills, supporting an open forest

Most of the land is built on igneous core composed largely of fine grained, slightly basic rock, of which the chief mineral is plagioclase. Flanking this volcanic mass are lenses of tuff, sandstones, and conglomerates with intercalated limestone, sandy shoals, and clays. The eastern part of Komodo Island is composed mainly of steeply tilted beds of corralling limestone. One of the chief volcanic belts of the world passes through the island belts of the National Park. In many parts of the archipelago slight earth tremors are felt every few weeks, and as might be expected some shocks are very destructive.

Climate

Precipitation

The geographic range of Komodo National Park includes the driest part of Indonesia. Rainfall in

[1]Komodo National Park, Flores NTT, Indonesia

Komodo National Park is the lowest of any surrounding area for which information is available, with a total of about 500 mm of rain per year. The typical rainfall pattern for this part of the world is heavy precipitation in the monsoon months of December to March. Most monsoon rainstorms last a few hours or less, often in the form of cloudbursts.

There is less rainfall on Komodo than on any of the surrounding large islands. This is partly because the January storms are more to the southeast, and most of the rain from the northwest-moving storms arising from high-pressure systems over Australia has already fallen on other islands.

The rainfall pattern of Komodo is very similar to that reported for Derby, Australia, with a similar total. Small cloudbanks commonly hide high peaks from late November well into May. This would suggest that the higher forest of Komodo probably receives small amounts of rain year round. The pattern at that elevation is probably similar to that of Darwin.

Ground water

Free water is available in pools at all elevations on Komodo during the rainy seasons. The largest and longest lasting are those at high elevations in the Gunung Satalibo–Ara Complex. Here natural depressions filled with water are enlarged by boar and water buffalo. Some are up to 1 m deep and 25 m across, often holding water all year long. More commonly pools formed at medium to high elevations along streambeds, and rarely hold water for more than a few days after rain.

Wind

The prevailing wind is southerly, from the Indian Ocean. During the dry season winds may occasionally be northerly. These increase in frequency with the approaching monsoon, accompanied by a heavy cloud cover. By the early part of the rainy season storm winds shift to the northwest, bringing the first hard rains. By middle February the monsoon season is at its peak, and the rains approach Komodo from all but the southeast quadrant. However, the strongest winds come from the northwest and southwest.

The average wind velocities (km/hr) are 0.6 in April–May and 5.6 in August–September. Strong winds are infrequent and usually come from the south, accompanying rainstorms. Exposed hilltops usually have only slightly higher velocities.

Relative humidity

Mean percent RH near the coast was highest during the monsoon and lowest at the end of the dry seasons in October and November.

Solar radiation

In this part of Sunda Islands solar radiation varies from 13 128 cal/m^3/day in June to 16 732 cal/m^3/day in October.

Temperature

Maximum air temperature during the year is 43°C, minimum 17°C. Black bulb temperature varied from 23°C at night and on cloudy days to 54°C (126°F) after the short rainy season and before the beginning of the dry season. Highest temperature is recorded at noon and slightly after. Average annual temperature at sea level on Komodo was 26.7°C.

Vegetation

Many systems of tropical vegetation analysis have been proposed since the important work of Schimper (1903) but none has been generally accepted on a worldwide basis (Richards 1952). Of all the plant formations recognised by Schimper three major low land types can be recognised on Komodo and adjacent islands: *monsoon forest*, *savanna* and *grassland*. In addition, most islands in this area possess small fringing mangrove forests, as well as montane closed forest at elevations above 500 m.

Montane closed forest Most trees in the dry lowland of Komodo are light shade producers; heavy shade producers are found only in the mesic quasi cloud forests found on the highest pinnacles and ridges at 500–700 m. These forest are shady, cool, and moist for most of the year.

Savanna forests Savanna forest covers most of Komodo. The open canopy lets through a great deal of sunlight, particularly when the leaves have fallen in the dry season. The understorey comprises mostly medium and tall grasses. Fires are common during the long dry season. Grass productivity in most areas is fairly high. Fire usually occurs only once in most areas each year and overgrazing is seldom a problem on Komodo.

Monsoon forest The other major forest association of Komodo is the tropical deciduous monsoon forest. Like the savanna forest it is largely fire resistant and many of the trees are almost leafless in the dry season. The surrounding savanna can be considered the broad edge or border of the forested area. It is found at elevations below approximately 500 m., an area of almost continually dry, hot climate known as hot ground. Repeated annual burning leads to a derived grassland (*ladang*) that is an obviously deteriorated habitat.

Grassland Tropical grassland is another important floristic formation in relation to fire management. Grassland formation in the Lesser Sundas is undoubtedly based on the often-repeated errors of grassland communities of this island that lead to establishment of *alang-alang* (*Imperata cylindrica*). *Alang-alang* in Komodo is found only in the moist gardens of the main village and in a few small stands adjacent to permanent springs. The *alang-alang* dominated grassland that arises by periodic burning (*padang*) have often formed within the memory of present day villagers, and the *ladang* to *padang* sequence is well know to most of them. Such *padang* areas may remain for a long time, even without fire.

Fire Occurrence

Sources

In the Lesser Sundas fires, as previously mentioned, are deliberately set. Besides man, many natural phenomena cause vegetation to ignite, including lightning, volcanism and spontaneous combustion. Of these the most common is lightning. Most fires are generated when pulsating general storms occur after a long drought, particularly if the storms pass over an area in which the forest or grassland contains a quantity of flammable material. The pre-monsoon period in the Lesser Sundas meets these conditions perfectly.

In addition, the Komodo topography favours ignition, since mountainous areas are more prone to lightning fires. The importance of lightning in the formation and maintenance of savanna and grassland in the Lesser Sunda Islands can hardly be disputed. This does not, of course deny that man starts fires, or that he has not been an important factor in shaping the ecology of the area.

Occurrence

Almost each year fire passes through this area, mainly during the dry period between March and November. Occurrences of fire in Komodo National Park during the last 6 years are listed in Table 1.

Fire brigade

Komodo National Park has 60 forest rangers, but only six have been trained in basic forest fire suppression. The rangers are posted at 10 different locations on the islands. Twenty days a month they stay at their post guards and 10 days they are at headquarters.

While at their post, guards mostly spend their time patrolling the area and undertaking fire mitigation, prevention and suppression. There are no special fire brigades in the park. The rangers have radio communication at each post and report daily activities to park headquarters.

Once post guards report a fire, the park manager calls the duty personnel immediately and sends them to the fire location. Experience has taught most of the rangers how to handle the situation and they know what to do even with insufficient training.

Tools and equipment

Komodo National Park has very limited forest fire hand tools and only one unit portable water pump with 200 m hoses. All tools and equipment are located at park headquarters. Whenever fire is reported, the duty person selects the firefighting equipment and sends it to the fire location. In many cases the fighters don't use the equipment, because it is inappropriate for the type of fire. Most use traditional tools, such as palm leaves/gebang (*Corypha utan*) and agricultural shovels. Portable water pumps have never been used to combat the fires, due to the lack of water resources during the fire season (dry season).

The fire fighter is not equipped with personal safety equipment like fire-resistant boots, long sleeved shirts and gloves, or even a mask to prevent smoke

Table 1. Fire record 1993–1998 in Komodo National Park.

No	Date	Location	Area affected(ha)
1.	Oct 1993	Loh Pinda (Komodo Island)	1500
2.	Oct 1993	Loh Letuho (Komodo Island)	300
3.	Oct 1993	Loh Kima (Rinca Island)	200
4.	Oct 1993	Loh Ginggo (Rinca Island)	800
5.	Oct 1993	Muang Island	1
6.	Oct 1993	Sok Nio (Rinca Island)	1700
7.	Oct 1994	Padar Island	300
8.	Oct 1994	Gililawa (Komodo Island)	900
9.	Nov 1994	Loh Laju Pemali (Komodo Island)	75
10.	Nov 1994	Loh Keka (Komodo Island)	50
11.	Nov 1994	Boe Timba (Rinca Island)	4
12.	Nov 1994	Muang Island	4
13.	Nov 1995.	Serai Island	2
14.	Sept 1996	Loh Hung (Komodo Island)	15
15.	Oct 1996	Toro Somba (Rinca Island)	20
16.	July1997	Loh Letuho (Komodo Island)	5000
17.	Nov 1997	Loh Laju Pemali (Komodo Island)	10
18.	Oct 1998	Gililawa Darat Island	10
19.	Dec 1998	Loh Ginggo (Rinca Island)	700

inhalation. Fighting fire is a high-risk job and can cause serious injury or death even with trained personnel and sufficient equipment, but at KNP they combat fires bare-handed, with only experience and familiarity with the area/topography to ensure success.

Needs of Komodo National Park

Though fire is part of the vegetation succession in the park, to maintain rusa deer and other browser habitats, it certainly needs to be managed properly. The following basic requirements have been indicated and need to fulfilled.

- A fire brigade with well-trained personnel to mitigate, prevent and suppress fires, and regular training.
- Sufficient personal tools and equipment as well as the brigade.
- Establish water tanks at certain locations to provide water all year long.
- Develop and maintain fire lines/firebreaks starting in the early dry season. To date there is already a 15-km firebreak.
- Provide a well equipped transportation unit, suited to the park topography and able to deliver fire fighters promptly.

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The Implications of Fire Management and Reforestation for Economic Development in East Nusa Tenggara

Siliwoloe Djoeroemana[1], Haryono Semangun[2], Bungaran Saragih[3] and Achmad Sulthoni[2]

Abstract

The livelihood of most of the population of Nusa Tenggara Timur depends on dryland agriculture, raising livestock and harvesting forest products. Much of the region's forests has been removed to satisfy the need for timber and fuelwood. This paper outlines the efforts made to prevent further deforestation by replanting with trees of high economic value. Uncontrolled burning from surrounding grasslands and within the forest has been a major setback to these efforts, and the authors discuss how the institution of more effective methods of fire management would aid the region's economic development.

FROM AN ECONOMIC point of view, the role of forests is extremely prominent in Indonesia. The contribution of forest products to the Indonesian economy has increased both in terms of the national income and of the foreign currency earned. In addition, forests have a significant influence on the condition of land, water resources, housing, industrial development and the environment.

On the other hand, there is concern about the conservation of forests in Indonesia. Since the 1970s there has been extremely intensive and uncontrolled exploitation of forests. In East Nusa Tenggara (NTT), uncontrolled exploitation of the land has occurred for many years. One form of traditional exploitation of forests is the burning of grass around forests, with the result that the edges of forests have been converted into grasslands.

This uncontrolled exploitation of land encourages us to find ways to manage fires and to overcome the destruction of forests and work for their conservation. In the context of NTT, this paper will look at the problem of fire management and reforestation from an economic standpoint and its implications for economic development in NTT. It should be mentioned that this paper is hypothetical and needs to be tested through later research.

[1]Wira Wacana Christian School of Economics, Sumba, Indonesia
[2]Gadjah Mada University, Yogyakarta, Indonesia
[3]Bogor Agricultural University, Bogor, Indonesia

The Basis of NTT's Economy

Since the first Pelita (Five Year Development Plan), in fact ever since NTT became a separate province, NTT's economy has been dominated by the agricultural sector in the broad sense, even though agriculture's contribution to the Gross Regional Domestic Product (GRDP) has decreased from year to year. The agricultural sector, in its widest sense, covers food crops, plantations, livestock, forests and fisheries. Data for the GRDP for the years 1992–1997 based on constant prices at the 1993 level are shown in Table 1.

The data show that the structure of NTT's economy is still based on the agricultural sector in the widest sense. This is followed by services, trade, transport, and communication and construction. The agricultural sector's contribution to the GRDP is decreasing, whilst construction, trade and transport and communication tend to increase from year to year. Services tend to decrease although in the year 1994 they increased.

In the agricultural sector, food crops made the greatest contribution to the GRDP of NTT (see Table 2). This is followed by livestock and livestock products, plantations and forestry.

The two tables show that the main source of income for residents of NTT is still agriculture. As a result, it is best to develop the NTT economy using agriculture in the broadest sense as the basis.

Table 1. The percentage distribution of the Gross Regional Domestic Product based on 1993 constant prices according to industry of origin/sector.

No	Industry of origin	1993	1994	1995	1996	1997
	Agriculture	41	40	38	38	38
	Mining and quarrying	1. 6	1.6	1.7	1.7	1.6
	Manufacturing	2.5	2.6	2.6	2.6	2.4
	Electricity, gas and water	0.7	0.7	0.7	0.7.	0.8
	Construction	8.1	8.1	8.8	8.9	8.2
	Trade	12.5	11.8	12.4	13.3	13.7
	Transport and communication	9.2	9.8	10.5	10.4	10.4
	Finance, rental and business services	4.4	4.4	4.3	4.6	4.7
	Services	20	21	21	20	20
	Gross Regional Domestic Product	100.00	100.00	100.00	100.00	100.00

Source: NTT in figures for 1996 and 1997.

Table 2. The percentage distribution of the GRDP based on constant prices for 1993 for the agricultural sector, 1993–1997.

No	Agricultural sector	1993	1994	1995	1996	1997
	Food crops	23	22	22	22	22
	Plantations	4.4	4.0	3.8	3.9	3.8
	Livestock and their products	9.6	9.7	9.0	9.0	8.7
	Forest	0.6	0.6	0.6	0.6	0.5
	Fisheries	3.7	3.5	3.1	3.0	3.2
		41	40	38	38	38

Source: NTT in figures for the years 1996 and 1997.

Burning Off and Reforestation

Currently forests cover 12.6% of the land area of NTT. The area has been decreasing over many years due to the uncontrolled exploitation of the forest. One way of exploiting the forest is by burning off the grass around the forest and the forest for economic purposes. The prominent use of fire to burn off grasslands and forests in places like Sumba led one writer to observe in 1928 that in Sumba the fire from burning grasslands and forests lit up the dark evening skies.

Historically, a majority of the people of NTT depends for their livelihood on dry land agriculture, livestock and forest products. For them, the forest is one source of their livelihood. Therefore the forests have an extremely important role in the economic livelihood of the people of NTT, especially rural people.

Rural people exploit forest resources for economic purposes. In the case of Sumba they cut down trees from the forest to build their homes. Initially, trees were cut down to build their homes but later they were cut down to be sold. They also cut down trees for firewood. Firewood is used not just in villages but also in the towns so that firewood becomes a source of income for the villagers.

The forests are also exploited for medicinal purposes, food and a variety of products for sale. In the case of Sumba, the commodities sold include cinnamon, rattan, eaglewood, gnetum and colouring materials. All these are sources of income for them.

In an effort to offset the destruction of forests, the government has carried out reforestation projects using economically valuable plants in endangered parts of forests. Before the first Pelita, the endangered land comprised 348 000 hectares. The plants planted included teak, mahogany, cassia, gmelina, eucalyptus, dal bergia, albizzia, sandalwood, melaleuca, calliandra, candelnut, cashewnut, tamarind, java almond, cinnamon and jackfruit.

From the First to the Sixth Five Year Development Plan, in fact even before the First Five Year Development Plan, the area of reforestation was 126 000 hectares (36%) of the endangered land in the forests which totalled 348 000 hectares before the First Five Year Development Plan. The details of reforestation from before the First Five Year Development Plan up to the Sixth one is shown in Table 3.

As mentioned above, Table 3 shows that the land under reforestation covers 126 000 hectares (36%). It also shows that the remaining endangered land within forests is 223 000 hectares (64%). Thus there is a need for all parties, both the government and the general public, to undertake reforestation.

How far has reforestation succeeded? No information is yet available to show the success rate. The Forest Service for NTT has informed us that no systematic and accurate evaluation has yet been made about the level of success of reforestation programs. However, community leaders and NGOs (specifically in Sumba) have stated that in general reforestation has not been very successful, although in certain locations

Table 3. Reforestation (in hectares) since prior to Pelita and up to Pelita VI.

No.	Regency	Area of endangered land in forest	Reforestation							Area of land reforestation	Remaining endangered land
			Prior to Pelita I	Pelita I	Pelita II	Pelita III	Pelita IV	Pelita V	Pelita VI		
1.	Kupang	51700	1060	310	2930	5510	1310	4400	2.0	18290	33410
2.	TTS	19170	240	480	2125	2190	4615	6560	1.2	14180	4990
3.	TTU	56270	270	425	2630	5540	2525	2800	1.2	12630	43640
4.	Belu	9640	560	260	2100	3680	1090	3600	1.2	9500	140
5.	Alor	46930	140	180	280	3620	110	2050	946	7330	39600
6.	FLOTIM	17560	50	120	400	2270	90	1450	1.2	7270	10290
7.	Sikka	21250	90	280	470	2890	-	4400	1.4	9430	11810
8.	Ende	17790	300	110	430	3940	920	2740	1.5	9950	7840
9.	Ngada	23050	250	-	255	3770	1750	3000	961	10350	12690
10	Manggarai	10720	40	-	460	3000	1730	2100	1.2	8590	2120
11	S. Timur	43740	260	680	210	2950	440	3230	1.3	9110	34270
12	S. Barat	30970	600	140	320	3650	485	2750	1.2	9150	21820
	Total	348790	3860	2985	12610	43010	15065	39080	1920.4	125780	222620

Source: Report of the NTT Forestry Service 1999.

it has been relatively successful. Comprehensive evaluative research into the implementation of reforestation in NTT is required.

One reason why reforestation has been rather unsuccessful is that uncontrolled burning off has continued in grasslands and forests. This burning off has consumed the trees planted in reforestation programs. Uncontrolled burning off, carried out to open up new fields, has resulted in neighbouring areas under reforestation being burnt too. Also as in the case of Sumba, burning of grasslands and forests occurs because of cigarette butts thrown out of vehicles passing through particular areas.

The Forestry Service has tried to control fires by using two different methods—the yellow strips and the green strips. The green strip is done by planting fire-resistant plants such as lannea and glyricidia which have a dual function in surrounding the area of reforestation. This approach has not been used systematically due to lack of funds. The yellow strip is done by clearing the land around the area of reforestation to a width of about 20 metres to prevent fire entering the area under reforestation. This method has also not been used to the full due to lack of labour.

Information obtained from interviews with village community leaders and non-government organisations in Sumba shows that the people of Sumba utilise certain fire-resistant plants such as *ramie*. In the past these plants were used as fences around food gardens to protect them while fires were burning off grasslands.

From the above description, it is clear that fire was traditionally used for economic purposes. However, the uncontrolled use of fire has brought disaster in the form of destruction of the forests with all the negative implications for the sustainability of forest resources. This destruction will in its turn destroy the economic resources needed to raise the level of wellbeing of the people of NTT.

Reforestation has also had an economic purpose. Economically valuable plants, in addition to improving the structure of the soil, also help to improve the wellbeing of the people of NTT. However, reforestation is also threatened by the burning of grass and forests.

Implications for Economic Development in NTT

The above information demonstrates that the uncontrolled use of fire is a major cause of the destruction of forests and the failure of reforestation programs. This has resulted in a reduction in soil fertility, elimination of forest resources and a decrease in the availability of economically valuable varieties of wood in NTT. As a result the contribution of forests to the economy of NTT is very small.

Starting from agriculture as the basis of NTT's economy, the most appropriate strategy for the development of NTT's economy is to make agro-business the major motor. Forestry resources are very important to support the development of agro-business. At the national level, manufactured goods made from wood, which are extractive in nature, make the greatest contribution to agro-industrial exports. Therefore, economically valuable reforestation plants, in addition to other forest resources, have good potential for the development of agro-industry and agro-business in NTT.

Indonesia's empirical experience shows that agro-industry and agro-business have significant prominence. Dasril's analysis, as quoted by Saragih points to several outstanding features of agro-industry in Indonesia for the years 1971–1990. It has contributed considerably to the aggregate value of non-oil and gas industrial products and industrial exports. The added value contribution of the non-oil and gas industries was 63% in 1971, 64% in 1975, 66% in 1980, 67% in 1985 and 62% in 1990. Whilst the contribution of non-oil and gas export products was 79% in 1971, 46% in 1975, 47% in 1980, 75% in 1985 and 81% in 1990.

In terms of employment opportunities, the non-oil and gas industries were also significant. In 1971 76%, in 1975 63%, in 1980 71%, 1985 79% and 1990 76%. The multiplier effect of the added value increased continuously. In 1971 it was 0.9, in 1975 0.8, in 1980 2.2, in 1985 2.3 and in 1990 2.9. This quite high multiplier effect is a source of growth through backward and forward linkage as well as sideways linkages.

It is necessary to explain here that the major source of growth for agro-industry is private consumption. This means that the development of agro-industry to date has not been a heavy burden on the government budget. In fact it has helped to encourage capital formation and supported the principle of economic self-sufficiency. In addition agro-business has shown a vertical linkage between agro-business subsystems and a horizontal linkage with external systems or subsystems such as the banking services, transport services, trade services and educational services.

The potential of agro-business is also evident in its ability to survive in the development period of the new order which undertook industrialisation with the support of an overvalued exchange rate policy. At the moment, agro-business in Indonesia is facing pressure for the following reasons:

1. increase in the import of agricultural products because of a subsidy of the exchange rate;
2. pressure on the export of agricultural products because of a 'tax' on the exchange rate;
3. a high domestic interest rate because funds have been absorbed into costly projects and the high maintenance costs in banking.

Nonetheless, the balance of trade on agro-business is still in surplus and increases annually. Without the pressures mentioned above, the surplus from trading in agro-business would be greater still.

We can therefore see that the agro-business sector has made an important contribution to net exports for the 30 years in which Indonesia has been developing. The agro-business sector has also been capable of holding out in the economic crisis. This picture shows that with the existing agricultural basis, NTT can develop its agro-business sector as part of the development of NTT's economy.

Fire management and reforestation should be handled as efficiently and effectively as possible to enable the forestry sub-sector to play a positive role in the development of agro-business in the development of NTT's economy. So fire management and reforestation have positive implications for the economic development of NTT.

Conclusions and Recommendations

It can be concluded that the uncontrolled use of fire had led to the destruction of forests, a thinning of economic resources in forests, and the destruction of economically valuable reforestation plants. Therefore, to minimise the use of uncontrolled burning, efficient and effective fire management and reforestation programs are required for the economic development of NTT. In this way, the development of NTT's economy, which is driven by the agro-business/agro-industrial sector, can be enhanced.

Based on this conclusion, we recommend that a series of research studies be carried out regarding the management of fires and reforestation in ways which will support agro-business as part of the economic development of NTT.

Fire and the Management of Agricultural Systems in East Nusa Tenggara

Wayan Mudita[1]

Abstract

East Nusa Tenggara (ENT) boasts very diverse agricultural systems within which fire still plays important roles. Depending on how it is used, fire may be either beneficial or destructive. Despite the important roles and widespread use of fire, the current policy is more on fire suppression than on fire management. Fire has been blamed by the policymaker as the factor that contributes to creating marginal lands, while on the other hand it is praised by local communities as the most efficient tool available for land preparation, soil fertility improvement, and weed and pest control. However, if proper management is not initiated, the negative impacts will prevail and unavoidably threaten the sustainability of agriculture in the province. Therefore, fire has to be incorporated into agricultural development policy in ENT. For this purpose, the currently adopted commodity-based, productivity oriented approach must be reconsidered. An agroecosystem approach that allows trade-off between productivity, stability, and equitability must be formulated on the basis of local environmental carrying capacity.

East Nusa Tenggara (ENT) is climatically among the driest regions in Indonesia. This condition is due to a combination of unevenly distributed, low annual rainfall, high wind speeds, and intense solar radiation (Monk et al. 1997). Heavy rains do occur, but their erratic patterns—frequently after a long drought period—contribute most to runoff causing erosion (Crippen International 1980a). Mountainous landscapes further increase the adverse effects of erosion on relatively infertile soil derived from either volcanic or sedimentary parent materials. Savanna and grassland become the most dominant vegetation cover in this type of environment. It is to cope with this harsh environment that most peasant farmers in the province engage in more than one agricultural system as a matter of insurance (Metzner 1982).

Fire can start either naturally or artificially in savannas or grasslands (Barbour et al. 1987; Monk et al. 1997). Frequency, intensity, and extent of natural fire in such environments increase because grass cover provides large amounts of fuel and the microclimate causes this fuel to dry rapidly and fire to spread readily (D'Antonio and Vitousek 1992). These factors also favour burning practices for several purposes, notably as an integral part of agricultural practices evolving in savanna and grassland ecosystems (Monk et al. 1997; Crippen International 1980b).

[1]Environmental and Natural Resources Research Centre, Nusa Cendana University Jl. Adisucipto, Penfui, Kupang 85001, NTT, Indonesia

For peasant farmers lacking capital and skills, fire is the only tool available for coping with land clearing and weeding problems. Unless more feasible alternatives are made available, the use of fire will continue despite any negative impacts it may cause. Whatever are the final conclusions about the use of fire as an integral component of the existing traditional agriculture in ENT and anywhere else in the world, opportunities do exist for development towards more sustainable systems.

This paper will attempt to describe the characteristics of fire and agricultural systems in ENT. The description will hopefully provide a sound basis for better understanding the extent of fire in ENT and a background for discussing issues related to the need for fire management policy and practices to support agricultural development in the province.

Characteristics of Fire and Agricultural Systems

Landscape, vegetation cover and agricultural practices

ENT landscapes are mountainous; 45% of total land area has slopes over 40% (Dick 1991). Sedimentary limestones are the most important rock components on the outer arc (Sumba, Sabu, Rote, and Timor), producing a surprising variety of karst land forms and raised coral terraces. On the other hand, the inner arc

(Flores and the neighbouring small islands) consists of strongly dissected old volcanoes as well as conical young volcanoes (RePPProT 1989a). Alluvial and colluvial plains do occur, but they occupy relatively small areas in comparison with other land forms. These plains, along with river terraces common in Timor and sedimentary basins in Rote, have tended to become important areas for certain types of permanent agriculture, notably wetland rice fields.

The rest of the areas are covered mostly by secondary vegetation; only 10% of the total land area is currently under closed forest cover (RePPProT 1989a, b). Secondary forest is not climax vegetation but the product of disturbance. The disturbances can be natural or anthropogenic in their origins, and fire is the most important. Frequent burning of monsoon forest will produce savannas and grasslands, but natural savannas and grasslands may also occur in some of the driest parts of Sumba, Timor, and other smaller islands. Although fire may start naturally in the climatically dry areas with abundance of standing dry biomass, fire in ENT is closely related to agricultural practices, notably shifting cultivation. For some reasons, this type of agricultural practice is performed mostly in mountainous areas. First, lands with steep slopes are considered as having less weed problems compared with flat lands where weed seeds are deposited by runoff. Second, almost all fertile coastal alluvial plains have been used for permanent agriculture. Third, mountainous areas are relatively free from roaming livestock that could easily destroy the crops.

NTT boasts not only shifting cultivation but many other agricultural systems as well (Monk et al. 1997). One of the most traditional agricultural systems, i.e. hunting and gathering, is still practised in ENT, together with other traditional mixed tree gardens and free-grazing livestock. Some sorts of more recent permanent agricultural systems such as permanent upland agriculture, homegardens, irrigated and rainfed rice fields, etc., also exist, although only on more limited areas. Few people in ENT depend on only one system but on a combination of these systems. These diverse agricultural systems can be seen as some sort of adaptation to the harsh ecosystems. Peasant farmers attempt to keep risks as low as possible by having several fields with different agricultural systems as dictated by their environmental conditions. According to Metzner (1982), risks are also reduced by selecting drought resistant instead of high yielding crop varieties and by binding to traditional values.

Time and frequency of burning

Burning is carried out late during the dry season, usually starting from October or November. Starting from the middle of the dry season, peasant farmers cut down trees and clear shrubs either in new sites or in old fields. The cut-down trees and shrubs are left to dry for 2–3 months before being burned towards the end of the dry season (Monk et al. 1997). The availability of dry biomass is important in shifting cultivation since the purpose of burning is not only to clear the land but also to produce ample amount of ash required to fertilise the soil and to obtain heat to kill weed seeds and rhizomes, soil-dwelling insect pests, and soil-borne pathogens (Rambo 1984). When burning is incomplete in the first occasion, secondary burning is carried out to make sure that the required amounts of ash and heat have been produced.

Early burning, such as practised in Kakadu National Park, Australia (Russell-Smith 1995b), may also take place, but is certainly not intended for shifting cultivation. Grass may set to fire accidentally early in the dry season to promote new regrowth for cattle grazing (Crippen International 1980b). This type of fire is not intensive since there are limited fuel loads and driving climatic factors, notably wind. Early burning for shifting cultivation is not performed for at least two reasons. First, early burning is restricted in old fields because shifting cultivation involves mixed cropping of early and late crops (Friedberg 1989; Hoskins 1989). Second, peasant farmers must spend their times for harvesting the crops so that cutting down trees and clearing shrubs for new fields can only be done afterward (Monk et al. 1997). Burning grasslands to promote grass regrowth and to drive out game animals is also more common late in the dry season since only during this period grass is scarce and time is available for hunting (Crippen International 1980b; Suhardjono 1988).

Purpose and scale of burning

To some extent burning is practised in all agricultural systems found in ENT but in some ways the reasons are still not fully understood. Rice straw in wet rice fields is sometimes burned after harvest. In permanent systems such as home gardens and permanent dryland farming, dry plant materials are collected from somewhere else, spread under a crop canopy, and burned at the end of the dry season. According to Crippen International (1980b) burning is intended to prepare land, provide neater fields and easier access in shifting cultivation, to stimulate grass regrowth for hunting and free grazing livestock, to protect property from wild fires in permanent cultivation systems, and simply to have fun in abandoned fields. Burning helps to remove large quantities of mostly thorny or prickly vegetation and thereby to deposit nutrient-rich ash on the soil surface, naturally providing the newly planted crops with the necessary nutrients (Monk et al. 1997; Rambo 1984). Burning is also considered helpful for getting rid of weeds and other pests, especially in old fields (Barbour et al. 1987; Rambo 1984). It is the increased demand for human labour in weeding rather than the decline of soil fertility *per se* that leads to decisions for cultivated fields to lie fallow for several years.

Use of fire in permanent systems such as in permanent dryland farming, home gardens, irrigated rice fields, etc. is much more restricted than that of shifting cultivation, hunting and gathering, and free-grazing livestock systems (Monk et al. 1997). The use of fire in the later agricultural systems in ENT is most intensive and therefore, these systems are referred to hereafter as fire-based agricultural systems.

Burning in the fire-based agricultural systems in ENT is mostly small-scale. The area of most shifting cultivation fields is less than 1 ha. Larger areas may be burned to promote grass regrowth in the grasslands, but fire in this type of vegetation is certainly less intensive. Although small in size, the percentage of burned areas to the total land area of ENT is much bigger than that in a continent such as Australia. This has tremendous implications to the individual small islands of the island ecosystems. As Brookfields (1990) notes, vulnerability is almost directly correlated to small size.

Use of Fire and the Trend of Agricultural Development

Possible impacts of fire

In reviewing impacts that burning may have on relatively small islands of ENT, one must carefully consider observations made by Hess (1990). Impacts of burning in small islands cannot be simply extrapolated from those in the continents because: (1) small land mass, with coastal regions making up a higher percentage of land, is vulnerable to disturbance, (2) water catchments are smaller and erosion levels higher, and (3) their environments may be more specialised and endemicity higher.

Shifting cultivation and other fire-based agricultural systems are often praised for efficiency in terms of energy and labour input. However, Rambo (1984) has argued that use of fire does not mean a free lunch, it is neither energetically efficient nor environmentally benign. The difference is only on the form of energy subsidy in use, biological or fossil fuel, and the form of cost, direct or indirect.

Fire can be seen as a form of biological energy subsidy to fire-based agricultural systems, comparable to fuel energy and fertilisers to the more intensive agricultural systems. However, the nutrient-rich ash resulting from burning for shifting cultivation in ENT is soon removed by runoff and further soil erosion steadily depresses soil quality (Crippen International 1980b). While making some nutrients biologically more available, fire also volatilise others, notably nitrogen, sulfur and carbon (D'Antonio and Vitousek 1992; Raison 1979). During the next dry season, soil will be more exposed and its humus will breaks down more rapidly. Finally, repeated clearing and burning rapidly encourage the growth of flammable grasslands (Freifelder et al., 1998; Mack and D'Antonio 1998). These effects are certainly less significant in larger, old land masses such Australia. In the Kakadu National Park for example, in spite of the intense, highly seasonal rainfall, the generally low slope angle slows down erosion (Russell-Smith et al. 1995). Even when there is erosion; it simply enriches the floodplains. Volatile nutrients may be deposited somewhere but they will finally be brought back by runoff and streams to the floodplains.

Burning for shifting cultivation may cause more devastating off-site than on-site impacts. While some portions of the extensive deciduous scrub currently found in ENT are the products of on-site impacts of burning, most result from escape fires. Monk et al. (1997) have provided succinct empirical evidence that fire, whether caused by human activity or natural, has added substantially to, if not been the cause of, the development of extensive savanna and grasslands in ENT. Remnant forests are the only refuge available for wildlife and therefore careless burning on adjacent sites poses, contrary to that in Australia's Kakadu National Park (Press et al. 1995; Russell-Smith 1995a), a serious threat to conservation of biological diversity of the area. Off-site impacts imposed by burning are not limited to habitat destruction, but the even more far reaching and in many ways cumulative are flooding, sedimentation, destruction of wood fences, and reduction of air quality (Crippen International 1980a; Metzner 1982; State Ministry of Environment 1998).

Despite all debates on the positive and negative impacts of burning, little experimental work has been done locally to support either side. Fire-based agricultural systems may have a number of ecological advantages under a seasonally dry tropical environment, but only if they are practised at an appropriate level of population density and in accordance to indigenous knowledge and practices (Brady 1996). As a report by the State Ministry for Environment (1998) has clearly pointed out, erosion of indigenous knowledge and practices on safe burning is, unfortunately, an important factor influencing forest and land fires in Indonesia.

Present trend of agricultural development

Shifting cultivation and free grazing of livestock have been practised for generations and are still extensively practised today. They may cause environmental degradation that now the province has to deal with, but they are also the only sound alternatives for a region where topography, soil, and rainfall limit the development of permanent agriculture. The solution is therefore not as simple as forcing peasant farmers to adopt some sorts of intensification without clear understanding of the underlying ecological principles. Despite much criticism (e.g. Metzner 1982), it seems that the policy of agricultural development in the province still lacks this understanding.

The recent introduction of new, high-yielding maize varieties into ENT provides a good example. As a general rule, any high-yielding variety requires favourable environmental conditions to produce its high yield. The reality is that maize in ENT is a crop of shifting cultivation. The environment of shifting cultivation cannot naturally support the requirements of a high-yielding variety nor can agrochemical input be provided by the peasant farmers who lack capital and the necessary skills. Peasant farmers stick to local maize because what is important to them is not to increase production but to secure food up until the next rainy season (Monk et al. 1997). Also this newly introduced maize cannot meet this purpose because its grains are destroyed by weevils soon after harvest. Although lower in yield, local maize has an important advantage that it can better withstand water shortage due to the erratic pattern of rains.

Another example is the so-called integrated agricultural development project. Metzner (1982) considered integration of food crops, cash crops, and livestock as being the most ideal for a region limited in resources. To be truly integrated, the project must, to some degree, address the conflict between shifting cultivation and free-grazing livestock. In fact, however, integration occurs only on the table of the project manager. In the field, the crop component goes simply as an add-on to shifting cultivation in one village while the livestock component to another location with a large area of open land. To many government officials, large open land means grassland, ignoring the fact that weeds have taken over most of the grassland areas (Monk et al. 1997).

Need for sound fire management

Use of fire in tropical agricultural systems has long been controversial (Sanchez 1976). The government tends to blame burning for the creation of new marginal lands, but the policy toward fire is not clear. The Indonesian Ministry of Agriculture has no regulation related to fire and no fire management unit (State Ministry for the Environment 1998). There is a ban on burning for land clearing, but that is for plantations now under the Ministry of Forestry and Plantations.

All conflicting arguments on the positive and negative impacts of fire suggest that sound fire management is necessary if agricultural development in ENT is to be sustainable. A complete ban on fire use is certainly unlikely to fulfil this goal. Instead, the currently adopted commodity-based, productivity-oriented approach must be reconsidered and fire-based cultivation systems be given appropriate recognition within mainstream agricultural development policy. An agroecosystem approach that allows trade-offs between productivity, stability, and equitability must be formulated on the basis of local environmental carrying capacity (Conway 1984, 1985; Mudita 1998). For this purpose, recognition of the existing traditional system and development of modern agroforestry systems with nitrogen-fixing and fire-resistant trees and shrubs are the most feasible alternatives. An important advantage of agroforestry is that extensive burning to release nutrients or kill weeds and soil-borne pests and pathogens is no longer possible and needed. However, agroforestry in itself will do little to reduce all the negative impacts of burning until a comprehensive improvement has been made to the present uncontrolled land-use practices and complicated land tenure systems leading to what Conway and Barbier (1990) call the common property problems.

Current Issues and Discussion

A great diversity of fire management practices does exist in other regions (e.g. Russell-Smith 1995b), but introduction of a particular practice to ENT needs careful examinations. At least, any introduced practice has to fit to the existing agricultural systems. More preferably, such practice should have the capacity of improving the overall system performances (i.e. not only to increase productivity) and be acceptable to local social and cultural values (Vivian 1995). At the same time, locally available fire management practices should be identified, documented, and carefully studied. In both approaches, training will be required, including advanced training at postgraduate level that will enable local university staff to carry out research useful for decision-making processes.

Interaction between fire and agricultural systems has been extensively studied but in different environmental settings. Understanding various factors that maintain this interaction locally will be helpful for at least two reasons. First, the effect of fire on soil and vegetation is mostly a local phenomenon. Whether fire will be beneficial or destructive depends on the available fuel loads, effects of local environmental factors (e.g. winds), and the practice of burning itself. Second, disturbance to such interaction may lead to different direction according to variation in local environmental setting. For example, invasion by an exotic plant such as *Chromolaena odorata* to dry areas such as ENT will maintain repeated fires, but to wet areas such as in Sumatra may promote succession toward forest (Tjitrosoedirdjo 1999).

At this moment *C. odorata* invasion has considerably changed burning practices among rural communities as well as the existence of natural fire in ENT. Peasant farmers consider *C. odorata* as being beneficial for shifting cultivation but at the same time destructive for free grazing livestock. Burning does not control but rather promotes flush regrowth that creates a denser stand of this exotic plant after the rainy season. This will force farmers to simply abandon a field, leaving the drying *C. odorata* stems as the flammable fuel either for intentional burning or for natural fire during the dry season. This means that development of an appropriate windbreak and firebreak within an agroforestry scheme is crucial for management of both fire and *C. odorata*. The current work of the Environmental and Natural Resources Research Centre of Nusa Cendana University is on a community-based project based on this approach. It is managed by PLAN International in Indonesia Programme Unit Kupang and sponsored by AusAID (Mudita 1999). However, the success of such an effort will depend largely on the willingness of the government to adequately resolve the complicated land-use and land tenure issues within the development policy of the province. While working reasonably well when population pressure is relatively low, such traditional land tenure systems have serious drawbacks, particularly to promotion of more advanced types of cultivation systems necessary to cope with problems resulting from *C. odorata* invasion.

Conclusion

Fire is used to some extent in all agricultural systems in ENT, but it plays important roles in shifting cultivation, free-grazing livestock, and hunting and gathering systems. Despite the important roles of fire, however, regulation on fire use for agricultural purposes is non-existent. Implementation of either introduced or locally existing fire management needs to adequately address land-use systems and land tenure practices to achieve some degree of integration necessary for the development of sustainable agriculture.

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Forest Land and Fire Management in East Nusa Tenggara

Slamet Riyadhi Gadas[1]

Abstract

The region of East Nusa Tenggara has a longer dry season compared to other regions in Indonesia. Flora and fauna in the region are mixtures of Asian and Australian types as a result of climatic and geographic conditions. The Province of East Nusa Tenggara has more than 560 islands with a total land area of 4.7 million ha, with about 1.8 million ha being declared as state forest land in 1996. The forest land can be classified into conservation areas (59.8%) and production forests (40.2%). The main problems concerning the management of forest lands in East Nusa Tenggara are claims to forest land by traditional communities, fire, shifting cultivation and grazing practices, uncontrolled tree cutting, and extreme drought. With such a land composition and problems, forestry activities in East Nusa Tenggara are focused on protection and rehabilitation of conservation areas.

EAST NUSA TENGGARA is a province in Indonesia with climatic conditions distinct from other regions of the country. While the other regions in Indonesia mostly have a 6–7 month rainy season, most of the East Nusa Tenggara region is in drought during an 8–9 month dry season, with heavy rainfall during the rest of the year. The combination of climate condition and geographical position of East Nusa Tenggara has led to the development of a unique ecosystem dominated by savanna and monsoon types of forest. The flora and fauna of the region are mixtures of Asian and Australian forms.

The Province of East Nusa Tenggara has a total land area of 4.7 million hectares, consisting of more than 560 islands. The islands can, however, be divided into three major groups—Sumba Islands, the Flores group (Komodo, Rinca, Flores, Solor, Adonara and Lembata) and the Timor group (Sabu, Rote, Semau, Timor, Alor and Pantar).

Based on the Decree of the Governor of the East Nusa Tenggara Province, Number 64 for 1996, the area in the province declared as a public or state forest land is around 1.8 million hectares or 38% of the total land area. However, only about 13% of the forest land is covered by primary forests, while the remaining is secondary forests, shrubs, grasslands and bare lands. Table 1 shows the classification of state forest lands.

[1]Forestry Research Institute, Jl Untung Suropati, Kupang, NTT Indonesia

Table 1. Classification of the state forest lands in East Nusa Tenggara.

Classification	Area (‘000 ha)
1. Protection forests	620
2. Reservation areas	102
3. National parks	194
4. Other recreational parks	165
5. Production forests	727
Total forest lands	1808

Management and Problems of the State Forest

Institutionally, the management of state forest lands in Indonesia is under the control and responsibility of *Departemen Kehutanan dan Perkebunan* (The Ministry of Forestry and Estate Crops or MOFEC). However, the Ministry delegates the management control over the forest land at the provincial level to *Kantor Wilayah Kehutanan dan Perkebunan* (The Provincial Office for Forestry and Estate Crops) in the respective provinces. The Provincial Office is mainly responsible for program development, coordination, monitoring and evaluation of activities, while the implementation of the activities, at provincial or county levels, is carried out by *Dinas Kehutanan* (The Forest Service), *Dinas Perkebunan* (Estate Crops Service), state owned enterprises and private companies. It should be noted that the Provincial

Office is an institution under the central government, while the Forest Service and the Estate Crops Service come under the local government.

Data in Table 1 designate almost 60% of forested land for conservation purposes. However, most of the conservation areas are in a critical state because of poor agricultural practices, such as shifting cultivation in steep sites, slash-and-burn practices, over grazing, and unauthorised hunting. To prevent further degradation, the forestry activities in East Nusa Tenggara are concentrated to protect and rehabilitate conservation areas, particularly through intensive activities on extension services, reforestation, breeding of endangered species, and community development in the buffer zones.

Although the region has about 727 000 ha of production forests, the yield of commercial timber from the forests is only 25–75 m^3/ha. To prevent further degradation of forest resources, the provincial government has banned tree cutting in the state forests. Requirements for building timber have been filled by bringing processed woods from other provinces—mainly from south and southeast Sulawesi, Maluku and Irian Jaya. The annual supply of processed woods to East Nusa Tenggara is estimated around 26 000 m^3. Meanwhile, wood needs for firewood, fencing and other purposes are expected to be filled from private lands.

However, around 80% of the 3.5 million people in the Province of East Nusa Tenggara are among the poorest in the nation. Consequently, most of them are unable to purchase processed wood from other regions. Also, the people rarely grow trees on their own farmlands, except to supply fruit and cattle fodder. Therefore, to meet the demand on timber for buildings, most people cut trees from the state forests without authorisation, causing more degradation to the resource.

Efforts to provide timber for local needs have been conducted by both central and provincial forestry institutions. In 1987 the institutions invited Perum Perhutani, a state owned forestry enterprises based in Java, to develop community forests in East Nusa Tenggara. Up to February 1999, using agroforestry techniques and involving farmers from communities surrounding the developed forest areas, the company has developed 9600 hectares of plantations. Tree species planted are teak (*Tectona grandis*), mahoni (*Swietenia macrophylla*), sandalwood (*Santalum album*), redwood (*Pterocarpus* sp.), and johar (*Cassia siamea*). Beside trees for timber production, the project has also developed multipurpose tree species, such as candlenut (*Aleurites mollucana*), cashew (*Anacardium occidentalis*), jackfruit (*Artocarpus integra*), lamtoro (*Leucaena glauca*) and akasia (*Acacia arabica*). Between the rows of trees planted as main crops, the farmers are allowed to grow food crops—mostly paddy, maize and cassava, or cash crops, such as onion and peanut.

In 1992 *PT. Fendi Hutani Lestari*, a private forest company, obtained government approval to develop timber plantations in East Nusa Tenggara. Up to December 1998 the company had developed about 4400 hectares of plantations with teak, mahoni, sandalwood, candlenut and cashew as main crops.

Unfortunately, the development of timber plantations in East Nusa Tenggara by the two forest companies is unlikely to succeed because of many social, economical and technical problems. Both Perum Perhutani and PT. Fendi Hutani Lestari feel that the community does not support their presence in the region. Many *adat* (traditional) community groups claim areas being developed by the companies. The plantations are also growing very slowly, adding high operational and maintenance costs, particularly for protection of young plantations from fire, grazing, and drought. Facing such disadvantages, the two companies intend to terminate their activities in East Nusa Tenggara before the end of 1999.

Fire Problems

Fire is still one of main causes of the degradation of forests in many parts of East Nusa Tenggara. According to the reports made by the Provincial Office, during the fiscal year of 1996–1997 about 21 000 hectares of forested land caught fire, and in 1997–1998 fire consumed more than 16 000 hectares of forest area.

The most common source of fire comes from the slash-and-burn practices of farmers during the preparation of planting sites, usually carried out from July to September. The technique is chosen because it is simple and inexpensive for removing grasses, bushes and shrubs, and based on farmers' experiences it makes the site more productive. A simple experiment done by Komang Surata, a researcher of Forestry Research Institute—Kupang (FRIK), indicates that corn production from a site prepared using a slash-and-burn technique is almost double that of a site prepared through cuttings. Another fire source is the burning of grassland to stimulate the growth of cattle fodder and to make it easy for hunting.

Many efforts have made to reduce forest fires through various extension activities of both central and local forestry institutions. However, probably due to poverty and low educational conditions, these efforts have been unsuccessful in transforming the habits of East Nusa Tenggara's communities in using fire for land-clearing purposes.

Forestry Research

Nationally, forestry research activities funded by the government are organised and controlled by *Badan Penelitian dan Pengembangan Kehutanan dan Perkebunan* (the Forestry and Estate Crops Research and Development Agency or FERDA), an organisation under the MOFEC. To implement research activities at the regional level, FERDA is furnished with some technical implementation units. One of the unit is *Balai Penelitian Kehutanan Kupang* (Forestry Research Institute—Kupang or FRIK), which is responsible for implementing forest research activities in the provinces of Bali, West Nusa Tenggara, East Nusa Tenggara, East Timor and the county of South East Maluku.

Considering the problems arising in its servicing region, FRIK has established three primary research programs:

- sustainable management of forest resources;
- natural resources conservation;
- forestry for sustainable rural development.

The program on sustainable management of forest resources emphasises rehabilitation techniques for conservation areas and production forests, and development of seed stand models for marketable local tree species improvement in both natural and man-made forests. The natural resources conservation program focuses on the development of various techniques to maintain and rehabilitate the forest ecosystem and its biodiversity, for instance through breeding local flora and fauna, developing management techniques of buffer zones, and developing collections of medicinal plants.

The program on forestry for sustainable rural development concentrates on finding methods to empower and improve the prosperity of rural communities living inside and surrounding the state forest areas, including methods to improve utilisation of non-timber forest products. To support its program activities, FRIK has established three research stations, on the islands of Lombok, Sumba and Timor, and several experimental gardens across the serviced region.

Conclusions

It can be concluded that the primary problems faced by both central and local forestry institutions concerning the management of forest land in East Nusa Tenggara are:

- claims to forest lands by customary or traditional communities;
- forest fires, due to slash-and-burn practices;
- uncontrolled shifting cultivation practices on steep sites;
- grazing practices in forest areas;
- unauthorised tree cutting, in both primary and secondary forests;
- the extreme dry season, leading to low survival rates out of planting activities.

Fire and Weeds: Interactions and Management Implications

Colin Wilson[1] and Wayan Mudita[2]

Abstract

The landscape of eastern Indonesia and northern Australia has undoubtedly been largely shaped by fire. Frequent burning tends to convert forest into savanna and grassland by selecting against fire-sensitive trees and favouring fire-resistant grasses and shrubs. Fire can act as a disturbance, creating opportunities for weeds to invade. A reduction in fire can enable the reversion of grassland to woodland. Northern Australia has seen the relatively recent arrival of fire-resistant, giant, perennial, African grasses (e.g: *Pennisetum polystachion*, *Andropogon gayanus* and *Panicum maximum*), and eastern Indonesia has been invaded by a fire-resistant, scrambling, American shrub (*Chromolaena odorata*). These species interact with fire to create positive feedback loops that maintain and extend their dominance over the native flora. The implications of these introduced species for management are discussed.

FIRE HAS BEEN used by humans for tens of thousands of years in eastern Indonesia and northern Australia for a wide variety of purposes including to clear undergrowth, hunt game, engage in warfare and signal presence. The landscapes we see today in the region have undoubtedly been largely formed and maintained by this all-pervasive use of fire. Regular fire tends to act against trees and in favour of grasses, leading to the conversion of tropical forest into savanna and grassland (Freifelder et al. 1998). The threatened *Imperata cylindrica* (alang-alang or blady grass) grasslands of Australia's Cape York Peninsula (Neldner et al. 1997) and the economically destructive grasslands featuring the same species in tropical Asia (D'Antonio and Vitousek 1992) are probably both the result of this long-term occurrence of anthropogenic fires.

Against this background of fire, we have seen as a result of human activity in recent times a sharply escalating movement of plant species into new regions of the globe, at rates unprecedented in geological history. This movement, both deliberate and accidental, has resulted in many thousands of species becoming permanently established in biogeographic regions that they could not otherwise have reached.

[1]Parks and Wildlife Commission of the Northern Territory, PO Box 496, Palmerston, NT 0831, Australia
[2]Nusa Cendana University, Centre for Research on the Environment and Natural Resources, Jalan Adisucipto, Penfui, Kupang 85001, NTT, Indonesia

The role and behaviour of fire in tropical landscapes is rapidly changing, driven by changing land use practices and by the increasing presence of invasive alien plant species. We will discuss the nature and implications of these changes in this paper.

Fire as a Disturbance

In relatively intact forest and woodland shading plays an important role in limiting the ability of grasses and shrubs to establish beneath the tree canopy (Gentle and Duggin 1997). Low-intensity fires reduce the biomass of the natural shrubby layer, creating opportunities for fire-tolerant alien species to exploit the conditions of increased light availability on the forest floor (Duggin and Gentle 1998) while also increasing the availability of nutrients. High-intensity fires create even more opportunities for invasive plant species such as *Lantana camara* (Duggin and Gentle 1998; Fensham et al. 1994), *I. cylindrica* (Eussen and de Groot 1974) and *Chromolaena odorata* (Gautier 1996) to move into forested areas by opening gaps in the canopy layer.

While it is thought that much tropical grassland is maintained by long-term traditional burning regimes, a subsequent reduction in the frequency or intensity of fire can allow re-invasion by fire-susceptible shrub and tree species. The change in land management practices over much of northern Australia from traditional aboriginal use to cattle grazing has had this effect. Grazing by cattle reduces the available fuel load, pastoral land managers burn less frequently than their aboriginal predecessors to avoid destroying pasture, and they tend to light fires in the early dry season when the moisture content of grasses is still quite high. The resultant fires are smaller and patchier, giving tree seedlings and suckers an opportunity to become established (Neldner et al. 1997). The subsequent shading further reduces the amount of flammable grasses. This reduction in burning of savanna has in part enabled *Cryptostegia grandiflora* (rubber vine), a fire-sensitive species, to become a serious weed in northern Queensland (Grice 1997).

Weeds as a Disturbance

The invasion of fire-resistant woody species into grassland can suppress existing fire regimes (Lonsdale and Miller 1993; Mack and D'Antonio 1998) by reducing the biomass of flammable grasses in the understorey. But a more common and ecologically and economically far more significant phenomenon is the invasion of fire-tolerant alien weeds that leads to an increase in the frequency and/or intensity of fire in an ecosystem. These plants are sometimes dubbed 'fire weeds' for their promotion of positive feedback loops between fire and weed invasion. As the weed becomes more abundant, increasingly intense fires become more common. The fire-sensitive native species begin to decline, enabling a further increase in the alien invader that leads to an even greater probability of intense fire, and so on (D'Antonio and Vitousek 1992; James 1995; Mack and D'Antonio 1998). This process transforms non-flammable, mostly native forest and woodland into highly flammable exotic grassland with very little biological diversity (D'Antonio and Vitousek 1992; Freifelder et al. 1998).

Northern Australia

The savannas that occupy much of northern Australia have been, and continue to be, burnt regularly. The leaves of trees in these *Eucalyptus*-dominated, fire-maintained ecosystems are not highly flammable, native grass fuel does not tend to accumulate and hence the intensity of fire is generally low. Fire rarely carries into the canopy and few mature trees are killed (Lonsdale and Braithwaite 1991).

In relatively recent times, a new phenomenon has been superimposed upon this pre-existing cycle. Giant, perennial, tussock-forming grass species of mainly African origin have been deliberately introduced into northern Australia as fodder for cattle and many have spread beyond intensively grazed pastures (Freifelder et al. 1998; Humphries et al. 1991; Latz 1991; Lonsdale 1994; Low 1997; Macdonald and Frame 1988). Grasses in Africa have co-evolved with hominids and anthropogenic fires for millions of years (D'Antonio and Vitousek 1992). Hence they show adaptations conferring resistance to fire, such as the ability to resprout from underground storage organs and to germinate and grow rapidly following fire (Freifelder et al. 1998).

This invasion of perennial African pasture grasses is beginning to alter the scale of fire in northern Australian savannas. These grasses produce much greater flammable biomass than the native grasses they displace, they cure later in the season when general moisture levels are lower, and they carry flames into the tree canopy (Low 1997). *Cenchrus ciliaris* (buffel grass), for instance, produces 2–3 times as much flammable material as native grasses in central Australia (Latz 1991) and has been observed to lead to progressive destruction of dry rainforest remnants as it carries successive hot fires into the edges (Fensham 1996). *Pennisetum polystachion* (mission grass) produces much greater fuel loads than the native annual grasses it replaces (Macdonald and Frame 1988; Panton 1993) and has been blamed for a significant decline in monsoon rainforest around Darwin (Panton 1993). *Andropogon gayanus* (gamba grass) produces 3–5 times as much flammable biomass as native grasses in the Top End of the Northern Territory (Cook 1991) and it is feared that it could lead to widespread conversion of native savanna woodland into exotic grass monoculture. Other African species implicated in increased intensity of wildfires include *Brachiaria* [=*Urochloa*] *mutica* (para grass) on seasonally inundated wetlands, which is blamed for the disappearance of some floodplain-fringing monsoon rainforest patches in Kakadu National Park (P. Barrow pers. comm.), and *Panicum maximum* (Guinea grass) in dryland savanna in northern Queensland.

Eastern Indonesia

While northern Australia is experiencing an invasion of African grassy 'fire weeds', eastern Indonesia is facing invasion by an American scrambling shrub, with similar consequences for fire regimes. *Chromolaena odorata* (Siam weed) is a fast-growing perennial shrub that forms dense tangled thickets 2–3 m high in open country, but with the ability to climb to about 6 m over other vegetation. It dies back following flowering and the dry stems then burn readily, creating a serious fire hazard. With the first rains following fire, new shoots rapidly appear from the root crown or from undamaged axillary buds, and seeds freely germinate (McFadyen 1989; Tjitrosoedirdjo et al. 1991).

C. odorata was probably introduced into Asia for its ability to suppress grasses such as *I. cylindrica* (D'Antonio and Vitousek 1992; de Rouw 1991) and is now widespread in Indonesia, having progressively invaded from west to east (Sipayung et al. 1991). Eastern Indonesia has large areas of *I. cylindrica* grassland, maintained by fire but considered economically destructive. Following fire, *C. odorata* is able to overgrow the grass layer and eliminate it by shading (Eussen and de Groot 1974). Some farmers consider *C. odorata* desirable as it is easier to control than *I. cylindrica* and is believed to improve soil quality (Tjitrosoedirdjo et al. 1991), but it is not eaten by cattle and has greatly reduced the availability of pasture (Sipayung et al. 1991). It is especially a problem in plantation crops (de Rouw 1991; Tjitrosoedirdjo et al. 1991) by smothering seedling trees and carrying intense fire into the tree canopy.

C. odorata cannot grow in the shade under an intact closed forest canopy, but it forms dense stands in riparian vegetation and along the edges of forest patches. Intense fires are carried from savanna and grassland into the forest canopy, causing forest margins to retreat (Macdonald and Frame 1988). In shifting slash-and-burn agriculture, *C. odorata* invades the newly abandoned fields causing a halt to the normal succession back to secondary forest (de Foresta and Schwartz 1991; de Rouw 1991). The result is domination of the rural landscape by dense thickets of the weed, and a dangerous fire hazard for villages.

Management Implications

The relatively recent arrival and rapid spread of exotic fire weeds in the region has profound implications for traditional and current fire practices. These alien species heighten the likelihood of intense fires, fuelled by a far greater flammable biomass than before, occurring later in the season and carrying flames higher into the tree canopy. In the absence of active management, the prospect is for conversion of biologically diverse and productive forest, woodland and savanna into biologically impoverished grassland (northern Australia) or shrubland (eastern Indonesia).

A biological control program, funded by the Australian Centre for International Agricultural Research (ACIAR) is attempting to reduce the dominance of *C. odorata* over other vegetation in Indonesia (McFadyen 1998) and may ameliorate the weed–fire feedback cycle. It is important to try to prevent the further spread of this weed in eastern Indonesia and into northern Australia.

The problems caused by perennial African grasses are widespread across the world's tropics (D'Antonio and Vitousek 1992). To remain consistent with the new paradigm of 'ecologically sustainable development', we should attempt to prevent their further spread, as extensive use of such species is not ecologically sustainable. Research is desperately needed into ways of managing existing infestations, especially in relation to fire, to minimise damage to infrastructure, agricultural production and the environment.

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Livestock Production and Fire Management in East Nusa Tenggara

Abdullah Bamualim[1]

Abstract

Most of East Nusa Tenggara (NTT) experiences a pronounced dry season lasting 8–9 months each year with an annual rainfall of less than 1500 mm. Traditionally, livestock has been important in the area for social status and to secure the income of farmers. The livestock in West Timor comprises 600 000 head of Bali cattle while Sumba Island has around 40 000 head of Ongole cattle. Farmers also raise buffaloes and horses and keep small animals (pigs, goats and native chickens) as their main source of animal protein and income. Around 70% of lands in Nusa Tenggara are classified as grazing land. It is estimated that more than 90% of breeding animals in NTT are raised extensively on communal grazing land with little input from livestock owners. Fire management on native grasslands is not significantly apparent in the area, except in Sumba Island during the dry season. This paper briefly discusses some aspects of the role of livestock, the production systems and to some extent the fire management.

THE PROVINCE of East Nusa Tenggara (NTT), located in the southeastern part of Indonesia, experiences a long dry season period and receives its annual rainfall (less than 1500 mm) from December to March. The economy of NTT depends on agriculture. It is estimated that some 38% of regional gross domestic product (RGDP) comes from agriculture and about 75–80% of the labour force is employed in agriculture.

Livestock has been raised in the area for centuries, as can be observed from the social and traditional lives of the local villagers. It was estimated in that 46% of the total 550 000 farmers' families raised livestock. Most of the small livestock (pigs, goats and chicken) are for local consumption, while most of the large livestock (cattle, buffaloes and horses) are for inter-island trade. Bali cattle are the predominant breed in West Timor with estimated population is around 600 000 head, whereas Ongole cattle in Sumba Island total just 40 000 head because their reproductive capacity is lower than Bali cattle (Wirdahayati and Bamualim 1990). The cattle industry is one of the main contributors to the economic structure of NTT, especially Bali cattle. Although village goats, pigs and poultry have a valuable role in rural communities, much of the cash flow is generated from cattle sales.

Livestock are raised by the extensive system based on communal grazing areas. Fire management on native grasslands is not significantly apparent in the area, except in Sumba Island during the dry season. This paper will briefly discuss some aspects of the role of livestock, the production systems and to some extent the fire management.

The Role of Livestock

Three factors primarily stimulated the development of the livestock industry in NTT, particularly large ruminants: 1) the availability of adequate land for grazing, 2) the availability of the export market for live cattle and buffalo in Hong Kong in the 1970s, and 3) the existence of substantial amounts of leucaena (*Leucaena leucocephala*) in West Timor.

A hypothetical estimation made by Ayre-Smith (1991) shows that 55% of cattle and buffalo owners own only 1–2 head and 32.5% of owners own 3–10 head of these animals, but he also estimated that almost 50% of cattle and buffaloes were owned by less than 5% of the livestock holders. A survey made in eight villages in two districts of West Timor showed that 59% of farmers in the survey areas own on average 2.4 head of cattle plus a few chickens, pigs and goats per family (Tjaong-Soka et al. 1991), indicating that livestock are an important part of farmer livelihood in NTT.

A study conducted in Kupang district showed that farmer income from the livestock component was significant but varied widely depending on the agro-ecosystems (Momuat and Bamualim 1994)—see

[1]Balai Pengkajian Teknologi Pertanian (BPTP) Naibonat. Jln. Tim Tim km.32, P.O. Box 1022, Kupang 85000, NTT, Indonesia.

Table 1. The data indicated that livestock was more apparent in the drier regions or on marginal soil types than on the better soil types, as demonstrated by farmers living on the Bobonaro clay zone. The difficult environment for growing productive crops might be the main reason why farmers rely more on their incomes from livestock and off-farm jobs than on annual food crops.

It is estimated that the livestock subsector contributes some 12% of the RGDP, derived primarily from the annual export of 70–80 thousand head of cattle from the area, plus 25% of total cattle and buffalo turnoff from NTT for local consumption. Buffalo and horses are used widely for draught and transportation purposes. About 12 000 buffalo and 6000 horses from NTT are sent to Java every year for slaughter.

Small animals such as poultry, goats and pigs also play an important role as sources of income for farmers and for human consumption in the villages. Most village families in NTT will own 2–3 pigs or goats, and a few chickens. Sheep are not favoured in Timor Island, because of their role in spread of malignant catarrhal fever (MCF) to which Bali cattle are highly susceptible.

Table 1. The proportion of farmers' income derived from food crops, livestock and off-farm jobs on different soil types in Timor (values in percentage).

Soil types	Food crops	Livestock	Off-farm
Alluvial	53	26	21
Mediterran*	79	14	7
Bobonaro clay	16	50	34

*Calcareous parent material with dark reddish brown solum

Livestock Production Systems

The extensive system

It was estimated that around 70% of lands in west and east Nusa Tenggara are classified as suitable for grazing animals (Hasibuan and Mangunsong 1993). In general, the farmers communally use the grazing land for large ruminants with an extensive system. However, grazing potential is constrained by lack of water and in some areas also by fires that may cause deterioration of native grazing land. Land degradation around the water points and the expansion of unwanted weeds due to post-burn overgrazing have been apparent in some places in West Timor. Nevertheless, at present the extent to which grazing land has deteriorated due to grazing pressure and fire–grazing interaction is unknown.

With the extensive system, grazing animals experience a significant body weight gain during the wet season and a body weight loss during the dry season. Although average production per year is quite low, it is believed that more than 90% of breeding animals in NTT are raised extensively on communal grazing land. Low production cost is the prime reason that such a system is widely practiced in the area.

An estimation of carrying capacity of different islands in NTT is shown in Table 2. The data indicate that carrying capacity in West Timor may have reached its climax. In this area, therefore, there is an urgent need to improve the management systems of grazing animals in some critical areas, toward an intensive system where sufficient feed reserves are developed to guarantee the quantity, quality and continuity of feed supplies. In Sumba and Flores islands, on the other hand, there is still potential to increase productivity of grazing animals through sustainable utilisation of grazing land and by the provision of adequate water resources.

The intensive system

Feed availability throughout the year is the key variable for livestock productivity and will significantly improve farm income. Tethered animals with cut-and-carry feeding systems are usual in such areas. In general, the productivity of animals raised under an intensive system is much better than those raised under the extensive system.

One of the intensive systems practiced by some farmers in Timor Island is the Amarasi system where farmers intercropped their land with leucaena (*Leucaena leucocephala*) and maize. When leucaena was in full production, the Amarasi system was a classic example of how some dryland farmers were able to fatten 4–5 cattle per family at any one time. Store animals were purchased from other parts of Timor and fattened on a diet consisting mainly of leucaena, producing high liveweight gains. The most serious criticism of the Amarasi system is its total dependence on a single species of tree legume. The

Table 2. Estimated total land area, land used for livestock, number of grazing animals and carrying capacity in NTT.

Locations/ islands	Land area (ha)	Land used for livestock (ha)	Number of animal units (AU)	Carrying capacity (ha/AU)
Sumba	1085440	770 600	145 960	5.3
Flores/Alor	1 909 500	406 170	129 630	3.1
Timor	1 699 060	705 040	537 110	1.3
Total/average	4 694 000	1 475 680	812 700	1.8

infestation of psyllid insects (*Heteropsylla cubana*) on leucaena indicated that monoculture production systems are high risk for small farmers. Therefore a more diverse plant community or the restriction of cattle number, rather than the promotion of leucaena, was the key to the success of the Amarasi system.

The Sikka land-use system is a well known method of controlling soil erosion by planting a dense vegetative barrier, consisting mainly of leucaena, along the contour. The system was developed in the Sikka district in eastern Flores, based on concepts from the Amarasi system where intercropping annual crops with perennial crops is dominant. It is interesting to note that the productivity of Bali cattle raised under coconut plantations in Sikka was the best of any survey sites in NTT (Bamualim et al. 1994).

Fire Management on Grazing Areas

It appears that grazing potential in NTT is constrained by lack of water and in some areas also by fires that may cause deterioration of native grazing land, especially on Timor Island. Fire during the dry season has been apparent in some grazing areas on Sumba and Timor islands. There are two main causes of fire: 1) purpose-burnt by farmers to have new grass grown, and 2) accidental burning by surrounding farmers, passing travellers or by heat from the sun.

There is not much information available on the effect of fire on native grass production and composition in NTT. A study conducted in Sumba Island indicated that fire did not change the native grass production and composition (Subandi et al. 1998). Native grass production data gathered over a 2-year period on burnt and unburnt areas in Sumba are shown in Table 3. Although grass production did not significantly differ between burnt and unburnt treatments, there was a tendency for the unburnt treatment to yield slightly higher than the burnt treatment. However, the trial was conducted without the presence of grazing animals, therefore the biomass production of unburnt grass was higher due to the inclusion of the dead material. The study also indicated that burning did not influence the native grass species in the area; most of the grass species reported by Hoekstra (1948) still exist on the trial site. However, the appearance of some weeds such as *Chromolaena odorata* which colonise quite large areas of grazing land, has limited the grassland resource in the region. Chromolaena is easily controlled by fire and therefore favoured by the shifting cultivation farmers. Nevertheless, the incidence of chromolaena fire in the grazing area is uncommon.

Table 3. Native grass production with burnt* and unburnt treatments in Sumba Island (value in tonnes dry matter/ha).

Parameters	First harvest (March 1998)	Second harvest (March 1999)
Unburnt	3.25	3.66
Burnt	2.71	3.12

* Burnt in October 1997 and October 1998

Conclusions

The role of livestock in the economic structure of NTT province is significant. Because of the dry climate, livestock production has augmented the lower income received by most farmers. Some 90% of large animals are raised in the extensive grazing system in NTT. Nevertheless, an intensive fattening program for Bali cattle has been initiated in the Amarasi area for the export market since the 1970s, due to the presence of leucaena.

Fire, both intentional and unintentional, has been apparent in the area, particularly on Sumba Island. At the present time, the benefit of fire for grazing area in NTT is not fully recognised. Therefore, further studies are needed to find ways to improve grassland quality through the use of fire, grazing management and the introduction of better forage species in the area. Furthermore, a few innovative systems of land use involving tree legumes have been developed in the region. Farmers in Amarasi and Sikka have demonstrated the merits of these systems. It appears that there is a need to intensify the livestock production in the area through the improvement of feed availability and quality, livestock distribution schemes and better management systems.

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Fire, Traditional Knowledge, and Cultural Perspectives in Nusa Tenggara Timur

Hendrik Ataupah[1]

Abstract

This paper is not based on scientific research. The main material for the first part is derived from my early informal education and practical training as a son of a peasant within the Meto ethnolinguistic group in West Timor. This early learning in my nuclear and extended family has been enriched by my personal observations on the kind of informal education and practical training given to young Meto generations. The second or the last part of this paper is based on my observation on cultural issues in many parts of Nusa Tenggara Timur, and my personal view on the observed issues.

THE PROVINCE of Nusa Tenggara Timur is one of the 27 provinces in Indonesia at this time. It is relatively remote and impoverished compared to the other provinces, but this does not necessarily mean that development is lacking or neglected. Many development programs have been successfully carried out since the colonial period, when resident J.A. Hazaart pioneered an integrated physical and socio-cultural development in West Timor in 1810–1832. His pioneering steps in integrated development were unknowingly followed and spread all over the province by governor El Tari in 1965–1978. Despite the efforts of all development programs, poverty still remains the province's most important challenge.

Geographically, Nusa Tenggara Timur is an archipelago of semi-arid islands dominated by savanna. Most of the more than 3.6 million people of the province engage in peasant agriculture. Their way of life is influenced by the complex conditions of the physical and the socio-cultural environment of the island. These conditions need thorough study to gain a clear view of the hampering and constraining factors that must be carefully addressed in designing special programs for development.

The peasants have used fire as the main means and tool of their swidden agricultural activities since time immemorial. Probably they have acquired various traditional wisdom and knowledge about fire from their ancestors, but research into this challenging aspect is lacking. The research is needed because each of the approximately 50 ethnolinguistic groups of Nusa Tenggara Timur may have developed their own distinctive wisdom and knowledge in their own traditional habitats.

Scattered and rare written materials on fire and traditional knowledge about fire are available but insufficient. I have collected some papers on fire from various parts of Nusa Tenggara, but they are too general to incorporate into this paper. This is the reason why I finally decided to rely on my personal early learning experience and my observations to write this paper.

The main material for the first part of this paper is derived from my personal learning experience. I have undergone a traditional informal education and practical training as a peasant's son in my nuclear and extended family within my Meto ethnolinguistic group before joining the elementary school. An endurable discipline to avoid and or to prevent fire has been instilled in my character. I found out later that similar discipline has also permeated the character of other Meto children. The success of the Meto way in educating and training on fire avoidance and prevention is clearly shown through a reality that the catastrophic fires seldom destroy the Meto fire-prone houses and villages. But its weakness is that the children are not educated and trained properly to avoid and or to prevent fires in the grasslands, bushes

[1]Faculty of Social and Political Sciences,Senior Staff of Environmental and Natural Resources Research Centre Nusa Cendana University

and forests that are considered as common accessed properties.

In the second part of this paper I attempt to summarise my personal observations on the use of fire in agricultural activities in various parts of Nusa Tenggara Timur. I have had various chances to visit 16 of the more than 30 inhabited islands during the last 35 years. I have visited more than 1400 villages inhabited by peasants, who use fire in the swidden agricultural activities. Fire is used for hunting purposes at the Bajak peninsular at the northeastern part of the island of Lembata in East Flores. Fire is used at Sumba and the northwestern part of West Timor for intensive animal husbandry purposes, and peasants on the island of Alor have used fire over a period of 8 years to control rats. The fires mentioned above may run out of control and then ruin thousands hectares of accumulated dry materials in grasslands, bushes, village forests, and protected forests in the neighbouring areas.

On the other hand, in the densely populated areas such as in the southeastern part of West Timor, the southern part of the island of Adonara, at districts of Sikka in Flores and West Sumba, outbreaks of catastrophic fires seldom occur. The increase of population as a whole and the increase of the number of peasants will surely have both positive and negative impacts on fire in the future. Thirty years ago the danger and the risks of fire were commonplace in many areas of the district of Ngada in Central Flores. Nowadays, fire stricken areas at Ngada are converted into newly irrigated rice fields and dry farming areas. Many areas in the neighbouring district of Manggarai are converted into a kind of agro-silvipastoral system. Those agro-silvipastoral areas were unintentionally created in the formerly traditional swidden agricultural areas as well as in poorly managed protected forests.

Scientific research on fire in the agro-silvipastoral areas is worth undertaking in the future. This research has to be centered on the concepts of fire, grasslands, bushes, and forests. Local languages and cultures have their own concepts on the above-mentioned land uses. Local systems of land tenure and land rights, which influence those concepts, are worth investigating through such research.

Fire and Traditional Knowledge

The use of fire according to folktales

The forefathers of the Meto ethnolinguistic group in West Timor were gatherers and hunters. According to various folktales they had to live on raw food because they didn't know the existence of fire and its use to process their food.

Once upon a time, the eldest son of the founding forefather of the Pit-Ay clan killed a civet cat on his hunting expedition near the top of Mount Mutis. At the time he was ready to eat the raw meat, a young Tetun princess mysteriously appeared in front of him, and prevented him from doing so. She kindly instructed and assisted him to make fire for the first time, and let him use the fire to burn the raw meat to obtain a more delicious food. She also taught the hunter's companion to set fire to the extended surrounding grasslands to sustain the availability of fire. She instructed them to spread fire toward the coastal areas of Timor, so that other Meto hunting groups could use fire for their hunting activities and food processing.

Several generations later, a group of technologically and socially more advanced newcomers defeated the Meto gatherers and hunters, and taught them to use fire to perform swidden agriculture for securing their food supplies. Since then, fire has been used both for hunting and agriculture, and also for various domestic uses.

The image and the characteristics of fire

The Meto ethnolinguistic group does not have a clear definition of fire. But the people are sure that fire is a natural phenomenon that sometimes starts accidentally by lightning at the beginning of the rainy season. People have also kindled fires since their forefathers learnt fire-starting techniques from foreign newcomers.

Fire is figuratively considered and handled as a living creature that eats, licks, grasps, crawls, leaps and jumps, becomes angry, and so on. Its desired food consists of all kinds of dry flammable materials. It becomes a greedy and unfriendly creature when man carelessly supplies its food. On the other hand, it becomes a reliable servant or an enjoyable pet if its food is delivered restrictively and appropriately.

Fire is the only natural phenomenon that comprises four risky but beneficial characteristics—heat, light, smoke, and smell. They are distinguishable from each other but are always closely related.

Fire's heat is its pioneering and main characteristic, and the only characteristic with the capacity to burn all dry flammable materials. The starting of a new fire is impossible unless the heat is there, and this is immediately followed by the other three characteristics. Each traditional Meto child is trained and tirelessly reminded that there is a built-in danger of fire at every moment after the creation of the heat for a burning process to satisfy any needs. The risks from a wild fire can be detected early from afar by one or more of the five senses of man, but the destructive heat is practically undetectable.

The Avoidance and Prevention of Fire and the Concepts of Burning

Focus of traditional informal education and practical training about fire

Prior to their full awareness of its dangers and risks, small children are forbidden to play with fire. As they grow children gradually learn to avoid and/or to prevent fire. Teaching is undertaken when the children assist their parents and/or elder siblings in using fire in the family furnace or are encouraged to look after fire in the furnace or elsewhere. They are tirelessly warned and reminded to concentrate and thus avoid or prevent catastrophic fires that may be triggered by their slight carelessness, negligence or error, especially when they are very inexperienced.

Actually, the focus of the entire processes of informal education and practical training on fire is to direct children to learn the right way to avoid and or to prevent fire in order to safeguard all kinds of valuable and important belongings of the family and of the community. Safeguarding the fire-prone traditional houses and villages is the noble obligation of each member of a nuclear family as well as extended families.

According to the traditional social land tenure and land-use system of the Meto group, protected government-owned forests as well as community forests are claimed as integrated parts of the traditional areas. Cattle owners use such forests for grazing and many other natural resources are taken from them. But when children receive informal education and practical training those forests are excluded from their tasks of safeguarding. Those forests are considered common property, meaning that they can be accessed and used by everyone without any obligation, including that of extinguishing fire. The apathetic villagers will hastily try to extinguish fire in such a forest only if fires, known by the name of *sbuna* in the Meto language, are blown by fast winds toward the village.

Concepts of burning

There are different contextual meanings for the verb 'burning' in the Meto language. They are *tunnu, nottu*, and *nollak*. The verb *tunnu* is used when fire is used directly and appropriately to change the condition of certain kinds of raw material to produce a directly edible food, or to obtain a desired condition of the raw material for further processing to obtain various kinds of consumable food. The verb *nottu* is used when fire is used to burn out rubbish or to clear dry-slashed material in order to clear lands for swidden agricultural purposes. The verb *nottu* is also used when fire is used to burn a supposedly limited area of grassland or bushes to obtain a desired plot of land or to obtain a predetermined intentional good result. The verb *nollak* is used when fire is burning out rotten firewood, or when fire is intentionally used to burn out undesired standing dry stumps of trees or fallen dry big trunks in a second or third year swidden agricultural field. The intention of *nollak,* mentioned later, is positive. But usually the verb *nollak* is used when the process of burning is unexpected, and/or the result of burning and the impacts of burning are negative. The verb *nollak* is used when burning is done with bad intentions in anyone's mind, or the burning is done by unidentified persons to destroy good grasslands, bushes, or protected forests.

Children and youngsters receive early informal education and practical training to avoid and/or to prevent the outbreaks of catastrophic fire during the *tunnu* or *nottu* activities. Movable dry belongings have to be removed from where the *tunnu* and *nottu* burning activities are under way. *Sakko* or firebreaks are created to prevent the fire jumping toward immovable dry flammable or readily burnt out materials when a *nottu* activity has to be undertaken in a fire-prone neighbourhood. Certain kinds of traditional prescribed burnings have to be carefully and practically applied when a *nottu* activity is unavoidable.

Children and youngsters are also trained to prevent jumping fires when a *nollak* activity is carried out to clear away dry stumps and trunks in second and third year swidden agricultural fields. But they are not exclusively and conditionally trained to prevent or to extinguish fire in the commonly accessed and used grasslands, bushes, and forests. When they are adult they may need spontaneously or willingly to extinguish fire in such common properties, especially when the fire threatens the houses in the village.

Cultural Perspective

When the young Tetun Princess in the above-mentioned folktale instructed the hunter's companion to set fire to the surrounding grassland or when Timor was still sparsely populated, there was no problem of fire. But nowadays everything is changing rapidly. The population of West Timor has exceeded 1.1 million people and the population of Nusa Tenggara Timur exceeds 3.6 million. Many former grasslands, bushlands and forests are being transformed into villages, small towns and transportation facilities, swidden and other agricultural fields. Most of the population in the rural areas consists of poor subsistence peasants, who use fire as the main means and tool in their activities. The relatively few rural and city elite employ these peasants to raise free-ranging cattle and other livestock. The physical and biological components of the environment are degraded by the competing swidden agricultural activities and the traditional extensive livestock raising activities.

The process of urbanisation in Kupang and other rapidly growing small towns in Nusa Tenggara Timur is increasing. But the increasing numbers in the generation of the autochthonous group are reluctant to look to the surrounding straits and seas to earn a better living. Fishing activities are mainly done by newcomers from South and Southeastern Sulawesi to feed the booming population of Kupang as well as the smaller towns and the villages.

Although the area of grasslands, bushlands and forests is decreasing, various scattered areas are still available in East Sumba, and there are many scattered pockets of dry areas all over the province of Nusa Tenggara Timur. Many of these areas of hilly and mountains landscapes were declared protected forest areas by the Dutch colonial government in the 1930s. The Indonesian government expanded the declared protected forests in the 1950s and 1970s. But many groups of people who live in or around the protected forest earn their daily bread from those forests.

Unfortunately, the government accuses them of encroaching on and destroying the protected forests or of stealing the forest's products. Of course the increasing population is one of the main causes of the encroachment of forests and forest products, because some newcomers are settling down in and around the protected areas. Many urban people are also using trucks and other transportation to steal and remove logs and other forest products from the protected forests. But many people who have for generations lived and/or earned their living in and from the currently protected forests are now losing their right because the government declares their forests as government property. The local people want to use the protected forest as the hunting and gathering grounds, or for their swidden and other agricultural activities, or as simply their ordinary living space because they have inherited the forests from their forefathers.

Some parts of the forests, especially areas around the water resources and fertile swidden agricultural fields, have been converted into permanent agro-silvipastoral systems for perennial-commercial crops and livestock. These kinds of agro-silvipastoral enterprises are valuable, inheritable possessions similar to those outside the protected forest. These activities are termed forest encroachment by forestry officials who are not familiar with the traditional land tenure and land use rights. Research is needed in the future to unveil the unknown (by outsiders) traditional land tenure and land-use rights for the sake of the future sustainable agriculture and forestry development endeavours.

Foresters and other government officials frequently accuse these so-called forest encroachments of causing forest fires. But actually there are many causes of forest fires; some of them are still unknown or superficially known. As long as there is sufficient dry material in the grassland and bushes or on the floor of any types of forest, fire is likely at any moment during the long dry sessions. Fire may start from the hands of anyone, a careless passerby, a hunter, a peasant, or accidentally escaping from the lands of a goodhearted fire user.

Fire occurs infrequently in relatively densely populated areas and in relatively well managed farmlands. Thirty years ago fire was the only reliable means of clearing away piles of seasonal grasses on the northern outskirts of Bajawa, the capital of Ngada district in central Flores. Nowadays the fire-prone grasses are replaced with irrigated rice fields and commercial perennial trees, and fire no longer occurs.

Chromolaena odorata, the introduced bushy plant is infesting overgrazed grasslands and pushing back the decreasing forest in Sumba, Flores and Timor. It is becoming a new kind of flammable fuel in the mismanaged protected forests and the long fallowed swidden agricultural fields in some relatively sparsely populated areas of East Sumba. Cattle owners hate and curse this new plant because their starving animals will not eat its abundant leaves. On the other hand, swidden agriculturists in the densely populated villages welcome it because it restores the vegetation cover and the soil fertility of their followed fields within 2–3 years. It is easy to slash then clear away with fire within 1–3 days. So, the competing and conflicting interest between peasants and cattle owners for arable lands and grazing lands is mingled with the feeling of hate and love toward *Chromolaena odorata*.

Concluding Remarks

Fire is being tamed and has become a servant in the furnace within the fire-prone traditional houses. But it has to be carefully managed in the fire-prone semi-arid savannas to become a trustful partner for livelihood. Networking, which means cooperating to achieve a common purpose (in this case sound fire management), is badly needed from various government agencies, universities, non-government organisations, and the community at large.

The Role of Fire in Swidden Cultivation: A Timor Case Study

Tom Therik[1]

Abstract

Swidden agriculture is a subsistence way of life in which fire features significantly. This paper focuses on swidden cultivation in east and west Timor, particularly among the Meto, Tetun and Bunak ethnic communities. The author describes the types of food crop grown, traditions of land allocation and the ways in which each type of land—sacred or 'forbidden' space, dwelling space and cultivation space—are used in a communal sense. Cultivation space is the only land allocated for swidden farming, and the means of using fire on this land and its part in the cropping cycle are described.

GEOLOGISTS COMMONLY agree that the island of Timor had a turbulent past which impacted the island's current topography, soil conditions, vegetation, land use and cultivation system. The island lies between two continents, one extremely wet and one dry, and the average number of dry months is longer than the average number of wet months. These factors directly relate to agricultural practices and the types of drought-resistant food crops cultivated by Timorese farmers.

The following discussion focuses on agricultural practices on the island of Timor, considering the types of vegetation cultivated in the area, the various forms of land utilisation and traditional agricultural activities. In each of these three different perspectives, it will become clear how fire plays such an integral role in the lives of Timorese. To begin with, I will describe the vegetation, particularly the food crops grown in the area by swidden farmers. (The term 'swidden' is used in the Old English sense of 'burned clearing', while the term 'shifting cultivation' refers more broadly to agricultural activities where fields are cultivated for crops then left fallow.)

Food Crops

Dry land agriculture is still the main source of life and income for most Timorese. Their staple crop is maize (*Zea mays*) (Tetun: batar malae = the foreign maize). The name given to this crop indicates that maize is a newly introduced plant. Maize is grown throughout the area from the lowland to the upland. People recognise different varieties of maize by the size of the cobs, the colour of the seed and the length of the growing period, as follows:

Names of maize	**Translation**
batar mutin	white maize
batar mean	red maize
batar ki'ik	small maize
batar bot	big maize

The other major crop in the area is sorghum. In daily speech among the Tetun people in the central regions of the island, the term for sorghum is batar ai naruk (literally, long stalked maize). In Tetun ritual language it is referred to as batar na'an tasi (literally, fish maize) or simply as batar tasi (maize from the sea). A well known myth in south Tetun narrates how the first seed of sorghum was discovered in the head of a knase fish. Locally, the various kinds of sorghum are named according to characteristics of the seed, its color, its taste or its mythical origin, as follows:

Names of sorghum	**Translation**
batar mean lakulot	red charming sorghum
batar bua funan	areca-nut blossom sorghum
batar na'i katuas	respected man's sorghum
batar laka bela	flat flame sorghum
batar	mean red sorghum
batar na'an tasi	fish sorghum

[1]Centre for Regional Studies, Universitas Kristen Artha Wacana

In certain areas on Timor dry upland rice (hare leten) is planted together with maize and other root crops. The Timorese highly value the dry upland rice for two reasons. Firstly, it tastes better than the wet rice. Due to its superior taste, dryland rice is considered appropriate for special occasions such as entertaining guests. Secondly, dryland rice has ritual importance. In agricultural rites, only this kind of rice can be offered to ancestors. If a person from the Tetun area was asked, for example, why dryland rice is used in these offerings, he or she would explain that this was the first rice brought by their ancestors to Timor. Following typical logic in this region, people often explain: 'Wet rice (hare we) cultivation is not the way of our ancestors'.

People's long acquaintance with dryland rice cultivation can be deduced from the mention of rice in their oldest myths and the varieties of dryland rice known in the area, such as:

Name of rice	Translation
hare sukabi	oak (tree) rice
hare kwa metan	black crow rice
hare Bauk morin	fragrant Bauk rice
hare busa ni'an	dog-teeth rice
hare marahuk	furry rice
hare ekekero	taily rice
hare babelik	sticky rice

There are other crops which grow particularly well in the hill regions of Timor, such as varieties of fox-tail millet (tora), which in Tetun are called 'dog-tail' (asu ikun), sesame seed (lena) and cow pea (turis). These crops still have ritual and economic importance for most Timorese. The hill regions are also suitable for certain species of root crops. TheTetun distinguish between root crops cultivated in their garden (fehuk) and those that grow wild in forest (uhi). These two kinds of root crops can often be found at the market during market days. For example see below:

Cultivated root	Literal translation
fehuk ema	people tuber
fehuk samea	snake tuber
fehuk nona metan	black woman tuber
fehuk nona muti	white woman tuber
fehuk fafiur	quail tuber

Uncultivated root	Literal translation
uhi rama	bow (for shooting) root
uhi laku	charming root
maek	(itchy) yam
fia kalo raek	yam (with small leaves)
fehuk lambo	lambo tuber

In addition to these root crops, a number of subsidiary plants classified as beans or legumes (Indonesian: kacang-kacangan) are also known to the area. The Tetun use two words to describe beans. Those that grow wild in jungles are called ahan, while cultivated beans are called fore. Under the category of ahan two types are still important in people's diet, ahan alas (the forest bean) and isikoma. Types of fore grown in the area include peanuts (fore rai), kidney beans (fore tali) and mung beans (fore Wehali).

Land Allocation

The Timorese divide their physical environment into three categories: sacred or 'forbidden' space, dwelling space and cultivation space. Land utilisation is different for each of these spaces. A sacred jungle, for example, is part of forbidden space. People of the same origin group would communally own this jungle. For the Meto ethnic group in the western part of the island, this jungle is a free grazing zone for the community. People may claim individual ownership of wild bee hives for collecting honey, but they may not claim the rights to the trees where the bees build their hives. Formerly, elders in the community would give special permission to hunt deer for consumption. But any activities related to agricultural cultivation are totally banned in 'forbidden spaces'.

Activities relating to agriculture are carried out in the 'cultivation spaces'. People grow food crops only in these specific spaces. This area is also communally owned. The 'land lord' (kua tuaf) of a community is in charge of distributing land to every adult member of each house for a personal garden. In an area where adult members are fewer than the available land, the kua tuaf can allocate a person more than one block of land. The custodianship of a garden may be inherited by people within the same house but they are forbidden from selling the land to outsiders. When planting their food crops, some farmers also grow fruit trees such as coconut and mangoes in these spaces. Fruit from these trees is only for personal consumption of family, and therefore the number of such trees is limited.

The agricultural activities held in cultivation space are important as a source of food in the peasant economy. The failure of food crops cultivated in this area will endanger the life of the people. Therefore, the farmers spent much of their time in the fields from the time of field preparation, through planting, weeding and harvesting.

Dwelling space allows for domestic activities and the location of houses. Fruit trees may be planted in dwelling spaces as a source of cash income, but the risk of fire to houses and fruit trees means the practice of slash and burn is forbidden in this area.

The Role of Fire in Swidden Farming

As mentioned earlier, the most widespread type of agricultural activity on Timor is swidden cultivation. However, the practice of swidden farming is carried out only in the so-called 'cultivation spaces'. The normal sequence of events in the Timorese cultivation cycle is the clearing of fields, followed by burning and then cropping. From the time a field is cleared until post-harvest fire is an essential tool in the swidden farming practices of Timorese farmers. A farmer's future harvest depends greatly on the success of the burn. So for many Timorese, swidden farming activities and the use of fire cannot be separated. Fire guarantees their economic security, or in other words, people's lives depend on the proper use of fire.

Thus in both agricultural rituals for planting seeds and in birth rituals, fire is associated with life. Many factors are involved in the actual firing of fields, including how well the slash dries, the thickness of the heap of slash, the wind direction, and the actual timing of the burn, i.e. whether it is done during the day or night. In opening a new field, farmers usually slash the undergrowth and fell most larger trees. The wood is then chopped in 0.5–2 metre lengths. The Amarasi people (subgroup of the Meto ethnic group) called this activity 'an kes'. In cases where there is not enough wood, additional wood is brought from the forest around the field, and piled in a single layer accross the field (na' nunu). To ignite the wood, dry leaves are used as fuel.

In a land dominated by *Imperata cylindrica* (Indonesian: alang-alang) extra care must be taken by farmers because of the fire danger associated with this grass. Many of the forest fires in Timor are caused by accidental burning of imperata by swidden cultivators or intentional burning by livestockers. Choosing the best time to burn is the most important factor in determining the success of a burn. At the same time, the success of the firing is also determined by the completeness of the slashing and the dryness of the material at the time of the burn. Because of the unpredictable weather conditions found in Timor, farmers have developed considerable local knowledge to decide the 'exact' time of the burn, during a short period prior to the onset of the rainy season.

The Timorese want to burn their fields before the germination of weed seeds, to ensure that their seedlings are not competing with weeds for food.The weather, the exact hour for firing, and the direction of the wind on the day of the burn are crucial, not only for the success of the burn but also for fire prevention. If a field is located close to fruit trees or houses with highly flammable thatch roofs, the burn is postponed until dusk (Meto: tot fai), so that sparks can be easily spotted and extinguished. Otherwise the burn is done during the hottest midday period (Meto: tot mansin maeb) so that the slash is in its driest condition. The wind direction (Meto: ainne poin) and the establishment of fire breaks (Meto: nak sako) are considered in detail prior to the firing. Figure 1 attempts to visualise the burning techniques just mentioned:

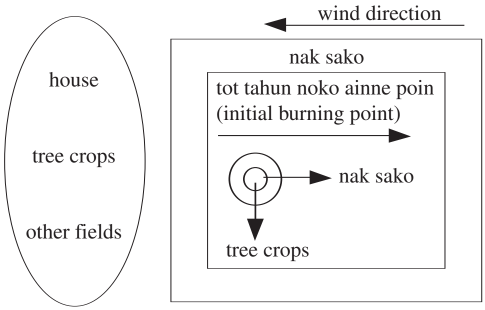

Figure 1. Techniques employed for successful burning of a field.

There are a few techniques used by people to avoid an unfortunate outcome, such as:

- Protective clearing
- Backfiring for burning steeply sloping fields
- Burn the easily ignited spots first, and later the rest of the field.

Fire, a Life-giving Force

I have shown that 'fire' is not only a useful tool for swidden farming. Many rituals concerning the human life cycle also have something to do with fire (and water). The importance of fire as a life-giving force is also narrated in various kinds of myths. Some ethnic communities such as the Sikka who live in the mountain region still mark the end of dry season and the beginning of rainy season by performing an agriculural rite where a block of imperata grass land is burned. A traditional adat official called Paka Watu Api has the ceremonial responsibility of igniting this fire. People still strongly believe that without performing this particular rite, the fertility of the land and the welfare of the people will be jeopardised.

Despite the many benefits of fire in swidden cultivation, the use of fire has been strongly condemned. There are many allegations, particularly from politicians and academics, regarding:

- the ecological impact of such practices;
- the carrying capacity in terms of population–land ratios for a sustainable swidden;
- the nutritive value of slash and burn.

These issues must be addressed seriously because misjudgment and misinformation will certainly affect the life of countless swidden cultivators, particularly the poor Timorese farmers who depend on fire for life.

Fire and Cultural Burning in Nusa Tenggara Timur: Some Implications of Fire Management Practices for Indonesian Government Policy

Andrew McWilliam[1]

Abstract

In eastern Indonesia the sustained use of fire in agriculture has been a central factor in the conversion of extensive forest areas into permanent fire climax savanna grasslands and degraded secondary bushland. From a Government perspective the continuing practice of 'cultural burning' is widely seen as destructive and detrimental to the development of progressive and sustainable agriculture.

In approaching the issue of cultural burning and fire management, however, it is important to recognise the great diversity of ecological conditions and agricultural practices that exist in regions like Nusa Tenggara Timur. The impact of this burning is highly variable across the Province and remains generally poorly understood and under-researched.

Contemporary patterns of burning practices are also highly dynamic over time, reflecting changing responses to economic or environmental factors. For example, the successful cultivation of tree crops, particularly in southern hinterland areas of Flores, has substantially reduced the incidence of cultural burning in these regions. Slash and burn cultivation has given way to higher value permanent tree crop cultivation. Elsewhere, growing rural population densities and the emergence of semi-permanent farming regimes have also significantly reduced the possibility of bushfires. At the same time unregulated savanna grassland fires across the Province, and destructive burning in forest lands and re-afforestation areas continue to pose risks and challenges for longer term management of land resources in NTT. The paper explores some of the patterns of fire and cultural burning in NTT and suggests a range of policy implications and directions for improved management of fire in the landscape.

In 1997 the world was witness to the dramatic impact of uncontrolled forest fires in Kalimantan and Sumatra. The resultant thick pall of smoke and haze that spread across much of western Indonesia, Malaysia and Singapore focused attention on major inadequacies of forestry management in Indonesia. In this case the combination of extended drought conditions and rapacious land clearing, particularly for industrial plantations, produced a major environmental disaster which has had continuing repercussions. Data from satellite imaging have led to estimations of up to 4 million hectares of land were burnt in East Kalimantan alone during 1998 (Siegert and Hoffmann in press). The huge extent of the fires and the management weaknesses they have exposed have prompted significant reforms and policy shifts at the national level.

In eastern Indonesia the sustained use of fire forms a central aspect of indigenous land-use practice. It is a practice that is ingrained within the agricultural cycle of farming communities throughout the region. During the 1980s I spent some years living on Timor island in Nusa Tenggara Timur (NTT), and one of my enduring memories of that time is of the annual burning and smoke fires that ignited across the landscape as the dry season progressed. Driving at night through Timor, the hills and mountains would be regularly aflame with multiple glowing spot fires and ragged lines of burning vegetation along ridges and grassland savannas. Annually from June through November the extended dry season and strong southeast trade winds provide ideal conditions for fire and the so-called cultural burning of the landscape as farmers prepared for the coming wet season.

The pattern and rhythm of seasonal burning has deep historical and cultural roots in Nusa Tenggara Timur. Over 200 years ago (1770) when the English seafarer, Captain James Cook, sailed into Timorese waters during his first voyage around the world, he too felt moved to comment on the presence of fires:

[1]Sacred Sites Authority, North Australian Research Unit
12 Sanders St Jingili NT 0810

'Light land and sea breezes…we saw several smoakes ashore in the p.m. and fires in the night, both upon the lowland and up in the mountains.' And later: 'We continually saw upon it (Timor) smoakes by day and fires by night and in many places, homes and plantations.'

The long-term impact of this sustained use of fire in land-use practice has seen the gradual and continuing conversion of native forests into permanent fire climax savanna grasslands, palm savannas (see Fox 1977) and degraded secondary regrowth bushland. Evidence of this process can be found throughout the islands of NTT but it is particularly marked in regions such as the highland grasslands of eastern Sumba, the heavily populated highlands of West Timor and in central Flores. The principal contributions to this historical transformation of the natural environment have been the widespread practice of shifting agriculture using slash and burn clearing technology and the regular burning of savanna lands for hunting and to regenerate livestock fodder.

Although an evidently successful adaptation to the wet–dry monsoon climate of the region and one that has sustained the populations of the region for centuries, this continuing practice of 'cultural burning' is widely seen as destructive and detrimental to the development of progressive and sustainable agriculture. Government proscriptions on burning and swidden agriculture are frequently justified on this basis.

In approaching the issue of cultural burning and fire management, however, it is important to recognise the great diversity of ecological conditions and agricultural practices that exist in regions like Nusa Tenggara Timur, and by extension eastern Indonesia more generally. The impact of this burning is highly variable across the Province and the underlying local rationale for its persistence and application remain generally poorly understood and under-researched.

NTT is justly renowned for the linguistic and cultural diversity of its human population, but this diversity is also matched by the great variety of ecological and environmental conditions found throughout the region. Factors such as slope, soil types, vegetation, frequency and intensity of burning, population history and rainfall patterns all contribute to a differentially marked impact of fire on the landscape in the region.

In many areas the long-term practice of slash and burn agriculture, while substantially modifying the natural environment, has nevertheless managed to retain a high level of equilibrium and ecological sustainability. Fox (1977) for example has written at length on the comparative ecological advantages of palm economies on otherwise resource poor islands such as Savu and Rote. (See also Lewis 1992 central eastern Flores, and Dove 1984 for comparison with Sumbawa, NTB.) The fact that significant forest areas exist at all in contemporary NTT is in part testimony to the former capacity of swidden cultivators to sustain their forest resources.

At the same time, fire-based farming can and has been highly destructive to natural environments. The combination of steep topographies, fragile and mobile soils with decreased fallow periods can quickly result in deforestation and environmental degradation. During the 20th century the process of deforestation and the penetration of cultivation into increasingly marginal areas has gone hand-in-hand with rising rural population densities. Ormeling (1956) argued that significantly increased cultural burning and clearing took place in the early 20th century when the imposition of the *pax Nederlandica* coincided with population expansion (see also Dove 1984) and an increased demand for land but with farming methods that remained unaltered. Ormeling conjectured that, by the 1950s, several times the estimated 60 000 ha of cultivated bushland ('ladang') in West Timor was destroyed every year by fire.

These preliminary comments on the use and abuse of fire in contemporary land management across NTT highlight two major issues or themes that hold significant implications for Government policy and management responses. The first of these is the relative paucity of detailed and accurate field-based data and analysis on which to base appropriate policy formulation. Despite the evident pressing need for conservation and fire management research in the region, fire policy in NTT (to the extent that it exists as a formal set of strategies) operates to a significant degree in a research data vacuum.

Very little published data on the impact or practice of fire-based farming and cultural burning is available for the region (Kaho 1994 and Subandi et al. 1998 are the most recent examples of preliminary work) and with the current constraints imposed by financial recession, there are limited resources for pursuing fire research programs. The formulation and implementation of effective and sustainable policies towards fire management need to be based on more informed studies of existing practice. Field-based research data, the identification of strategic priorities and an iterative contribution to continuing policy development are vital components in any sustained management approach.

To date, Government approaches to fire and cultural burning have been very much ideologically driven, viewing the practices as more or less universally misguided and inherently destructive. The current Provincial policy proscribes all cultural burning in a wholly futile attempt to curb the practice. This policy position derives in large degree from national perspectives and guidelines, but its origins can also be in identified in historical Dutch Colonial proscriptions against any local use of fire in land management and clearing.

A second major issue confronting the formulation of strategies for fire policy and management is the intricate complexity of the issue in Nusa Tenggara Timur. Fire and the practice of cultural burning represents a multifaceted set of issues that cut across a wide range of agro-ecological (Dove 1984) contexts and institutional responsibilities. The generation of effective management solutions and local policy directions needs to meet this practical complexity with initiatives and coordinated programs that recognise and incorporate local diversity. In other words it is important to pursue an integrated approach to fire management policy and programming—one that incorporates local farming needs and management objectives.

Fire and Cultural Burning in Context

To illustrate this combination of a need for more fire impact research and the evident complexity of fire impacts across NTT, it is instructive to explore aspects of current use in two broad ecological zones where unregulated burning is evidently of concern to Government. These include the water catchment areas in the forested highlands and the predominantly lowland savanna grasslands across the islands. I begin with Metzner's (1982) study of Sikka regency in central Flores, one which provides a rare perspective on local fire history. In the work he notes with alarm the speed at which Sikka's natural vegetation and particularly forests have disappeared.

At the time of Metzner's research in the early 1980s, all the forest reserves created during the Dutch administration of the 1930s were reportedly under threat. Attempts to enlarge and connect the various forest reserves had been largely unsuccessful in the face of population pressures and what he describes as 'fiercely defended claims on land'. Related attempts to regulate the practice of cultural burning had been similarly unsuccessful. Metzner comments that local farming communities consistently ignored regulations aimed at controlling the use and location of fire, and limited Forestry staff resources mean that management and policing were quite ineffective. He illustrates his argument with a list of reported illegal burnings in forestry areas of Kabupaten Sikka. Today, some 20 years after Metzner's research there is little evidence to suggest any reduction in forest clearing or illegal burnings in forestry zones.

The persistence of extensive swidden cultivation in forested highlands and the apparent reluctance of farmers to convert to more intensive, non-fire-based farming is widespread in eastern Indonesia. This is despite long-term Government policies directed against fire and forest clearing often accompanied by extension promoting more intensive agriculture, particularly irrigated rice, in lowland areas.

Suggested factors

In the absence of any definitive study I would suggest a number of likely contributing factors to the persistence of burning and extensive agriculture. The first of these is population increase, especially over the last century, which in NTT has been running at around 2% per annum (e.g. 1.87% between 1971 and 1990 (Nusa Tenggara Timur Dalam Anka 1992)). In the absence of any modification in farming technology, higher rural populations put pressure on available land resources and begin an inexorable expansion into more marginal or critical lands.

The creation of forestry reserves (*kawasan hutan*) under the administrative management of a Government ministry has also contributed to pressure on available arable land resources for cultivation. With some exceptions, such as official reforestation or industrial plantations, local farmers may not legally cultivate forestry land. Where there are officially sanctioned projects, a local work force, in addition to wages, has the chance to grow annual food crops between the tree plantings until temporary permission is withdrawn when the plantation or reforestation is established.

Thus the designation of extensive areas of land within a forestry zone effectively takes substantial areas of agricultural land out of production. At the same time the forestry reservation system has enclosed or appropriated forested land to which a whole range of indigenous rights and claims inhere. These rights are usually not officially recognised and I suspect that many farming communities would justify their incursions and burning of forestry land in terms of asserting traditional rights in land.

A further factor in the continuing attraction of extensive swidden agriculture over higher production-intensive alternatives is the inherent benefit in terms of labour productivity. Dove has argued that extensive swidden agriculture yields a higher return per unit of labour, and that this is significant because it is labour not land that is the critical limiting resource in the dryland farming regions over much of eastern Indonesia (Dove 1984, 1986a). He suggests that farmers typically only intensify their agriculture when population densities rise with subsequent land pressure problems, or when governments compel them to do so. Such processes are evidently at work in NTT where land pressures are increasing—the opportunities of shifting location and opening new areas of forest land are today severely curtailed for swidden farmers.

Evidence of these effects can be interpreted in a number of areas across NTT where fire as an environmental issue is actually decreasing in significance. In the mountainous hinterland along the coast of southern Flores, particularly in Kabupaten Ngada, the successful cultivation of tree crops over the last 20 years or so has substantially reduced the incidence of cultural burning. Slash and burn swidden cultivation has given way to higher value, more or less permanent tree crop cultivation. In the present economic environment the transition has proved highly rewarding to local farming communities who are reaping the rewards for rising commodity prices. The experience points the way for an intensification of tree crop cultivation and the support of export marketing infrastructure in other suitable regions of the Province.

In other areas, including parts of Kabupaten Ende in Flores, areas in West Sumba and West Timor, greatly increased rural population densities in recent decades have led to the emergence of semi-permanent farming regimes with significantly reduced incidence of bushfires or cultural burning. As swidden fallow periods are reduced and cultivation expands, there is a corresponding decrease in the availability of combustible dry matter and bushland. In these circumstances, fire as a farming tool diminishes in importance, but the incidence of fire reduction is more a signal of declining soil fertility in these cropping areas and increasing marginalisation of agriculture

The rangelands and savanna grasslands that cover extensive areas of all the islands in NTT represent another vivid demonstration of the long-term application of fire. Fire-tolerant vegetation species have long become dominant in the savanna lands. Repeated burning has helped prevent or limit reforestation and is widely used to clear dry rank grasses and encourage the regrowth of succulents and green pick for domesticated livestock, especially cattle, goats, sheep and horses. The recent expansion of the highly flammable but fire-tolerant shrub weed *Chromolaena odorata*, and prior to that the choking spread of *Lantana camara L.* (Ormeling 1956; Fox 1977) are also in part a consequence of regular savanna grassland fires.

While fire may well be a key factor in the persistence of anthropogenic grasslands (Dove 1984), unregulated grazing and burning can also contribute to erosion and degradation of the rangelands. Grassfires in the height of the dry season can give rise to wind erosion and later soil erosion (Metzner 1977) when the monsoon rains break and carry away substantial silt loads. In some instances too it is the absence or greatly reduced incidence of fires that signals the impact of overgrazing or loss of topsoil.

In these circumstances research into the use and impact of fire has significant implications for policy directions in such diverse fields as water catchment planning and management, soil conservation, livestock fodder production and carrying capacities, as well as environmental conservation, weed management, agricultural and settlement policies. In other words the use of fire has multiple implications for different land-use contexts and objectives. Part of the development of a research focus on fire practice is a need to understand the complex ecological interrelationships between fire and other land-use processes. Ormeling's warning some decades ago (Ormeling 1956) still has contemporary relevance. 'Reliable information concerning grass burning is, however, scarce and conflicting. Since so much depends on variable factors such as type of grassland, rainfall, the season when burning takes place and intensity of the burning, generalisations are dangerous.'

Ormeling might also have mentioned the variable significance of cultural factors here. An aspect of fire practice in places like NTT is that while at one level there may be a local agro-ecological explanation or rationale for burning and clearing, these practices may also have deeper cultural associations and significance which contribute to a general disposition for seasonal burning. An example of the kind of strong cultural role of fire in the traditional seasonal rhythm of agriculture can be seen in practices reported for Bunaq speaking rural communities in central Timor. Here the passage between the dry season and the rainy season is marked by the conduct of ritual hunts for feral pigs in the wide savanna lowlands. These hunts are sacrificial in character and enact the mythical traditions of the origins of the seeds of agriculture and fertility of the soil. Their conduct is accompanied 'by the burning of the great savannas as well as the lower spurs of the hills' (Friedberg 1980).

It is not clear to what extent ritual hunting for feral pig stills forms an integral precursor to cultivation rituals and the planting cycle among Bunaq communities. However, the point is that the idea of burning and firing the dried grasslands is deeply ingrained as a cultural practice among these communities, as it is in many other regions of the Province. In particular the marked seasonal dichotomy of dry and wet monsoons in NTT has encouraged a symbolic cultural elaboration which associates the sequence of heating and cooling properties with the cyclical reproduction of life and fertility of life forms, including the seeds of agriculture. Schulte Nordholt (1971) has commented in relation to west Timorese populations, that the process of burning off is followed by 'cooling' rituals in which ' the earth has to be made cool (*mainikin*) again and the forces of heat and fire rendered harmless'. These rituals tend to coincide with the early rains of the wet season and usher in a period of 'new life' in agriculture.

The ecology of fire in NTT and its multi-jurisdictional nature also has implications for the coordination of policy between relevant Government agencies and institutions. Because fires do not respect administrative boundaries it is clear that different Government agencies need to develop a cooperative and collaborative approach to fire management. The degree of elaboration of any particular agency fire policy will depend on the extent to which fire and cultural burning represents a constraint or hazard within discrete domains of activity. There is clearly a need for close cooperation in terms of setting policy guidelines and recommendations between the main responsible Government institutions and with non-government organisations active in the field.

Conclusions

This preliminary overview of fire practices and their significance in NTT has indicated a number of policy implications, which I represent below in summary form.

- There are limited current field based data on which to base policy formulation and priorities for Government strategic planning and programming. There is a need to increase research capability and the role of research in policy formulation. There is also a need to bring together and utilise in a concerted way, the variety of existing information and relevant studies that can support policy formulation. This includes both field-based data research and comparative research data from relevant project experience such as the World Wildlife Fund integrated studies in southeast Sumba, Riung in Flores and the Mutis Mountains Forestry Zone in West Timor. Relevant organisations beyond NTT include the Integrated Forest Fires Management Project Centre and the Sustainable Forest Management Project (both based in Samarinda, East Kalimantan), and the Centre for International Forestry Research (CIFOR) in Bogor.
- The practice of fire and cultural burning in Nusa Tenggara Timur cannot be considered in isolation from inter-related processes of land-use management and cultural practice. This understanding has implications both for the design and gathering of research data on fire impact, but also for the subsequent development of improved management strategies. Successful small-scale pilot and demonstration projects provide a phased approach for wider applications. The often unique characteristics of local interventions however, present challenges to scaling-up management solutions for broader application.
- Government has limited skilled resource capacity to directly manage the two critical areas of savanna grasslands and forests. Indeed it can be argued that there is effectively no Government organisation with the responsibility for managing grasslands as grassland. (I am indebted to Jefferson Fox for raising this issue of which much more might be said. To some extent it reflects a longstanding problem in eastern Indonesia where land management policy and programming is developed and promulgated on the basis of agriculture practice from wet tropical environments of western Indonesia.) Central agencies such as the Ministries of Forestry, Animal Husbandry and Agriculture all tend to view grasslands as degraded forms of otherwise more productive land that need to be revegetated or rehabilitated into something else. Improving Government resource management capacity, therefore, also requires significant institutional development and policy shifts (see also Dove 1986b).
- In addition to Government, it is vital to involve local farmers and local non-Government organisations (*Lembaga Swadaya Masyarakat*) in the process of improved land management, knowledge transfer and exchange. This may require a combination of strategic conservation and policing priorities with pragmatic partnerships and equity positions encouraged between rural communities and management institutions.
- Fire management is a public education issue. Dissemination of knowledge and improved practice must be promoted through appropriate public institutions such as radio, village government, church and school programs.

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Forest Fragmentation and Water Catchment Hydrology — Case Study on Sumba

Juspan[1]

Abstract

In East Sumba dryland farming is still mostly dominated by traditional slash-and-burn methods. Forestry potential is relatively low. Natural forest resources have many functions and many benefits, and need to be guarded from all types of intrusions that destroy. One such element is fire. This paper examines the cause and impact of forest fires in East Sumba, detailing their causes and the impact on vegetation, soils and hydrology as well as communities. The paper looks at prevention through better information, silvicultural practices, employment of local knowledge and tradition, community involvement and control through legislation.

EAST SUMBA REGENCY AREA LEVEL II has an area around 7000 km^2 and is located in the southern region of the Republic of Indonesia. It directly faces the Indian Ocean and the Australian continent and is often affected by the presence of dry trade winds. It has a wet season for four months (Dec.–March) and an 8-month dry season (April–Nov.).

The conditions mentioned above are made worse by the mountainous and hilly topography and relatively low land fertility. Based on the facts available, 192 000 ha have slopes of more than 40%, while among these there are 176 000 hectares on very steep hillsides. The level of erosion is quite high and is marked by the visible presence of rocks on the land surface, as well as the existence of gullies.

The population of East Sumba in 1997 was more than 170 000 people, with a distribution of 23 people per km^2. It is estimated that in the year 2000, the population will reach more that 200 000.

The main livelihood of the population in general is farming, with farm operations of dryland farming as well as livestock. Farming for drylands is still mostly dominated by traditional slash-and-burn methods. This method is thought by the community to be the best because it doesn't require costs or much hard labor, and the labor time is relatively short. But if it is looked at from an environmental conservation point of view, this has a great effect on the ecosystem and lowers the land productivity.

[1]Department of Forestry and Land Conservation Regency Area Level II, East Sumba, Indonesia

In accordance with the Method of Forest Use Agreement, the area of forest in East Sumba is 237 600 hectares or 34% of the region's total area. If linked with Ordinance No. 5 1967 concerning basic forestry stipulations, then the area mentioned has fulfilled the requirements, i.e. more than 30%. But if linked with vegetation/plant conditions, it is a greater concern, because dense forest consists of only 31 250 hectares (13%), and swamp or marshland consisting of 6000 hectares (2.5%).

Based on its function, the forest in East Sumba can be classified into six sections, which are:

		Area (ha)
• Protected forest	:	105000
• Stable production forest	:	29700
• Limited production forest	:	20000
• Convertible forest production	:	60
• Forest nature reserves	:	15600
• Forest wildlife reserves	:	8100

In the Regency of East Sumba are seven water catchment areas (DAS), they are, DAS Kambaniru, Kadhang, Watumbaka, Melolo, Kaliongga, Nggongi and Tidas. The condition of these areas is very critical because during the wet and dry seasons there is quite a high fluctuation of the rate of water flow as well as mud content, and a very erratic river flow during the wet season.

Forest potential is relatively low. The kinds of forest products that stand out are, tamarind (*Tamarindus indicus*), *Aleurites mollucana*, *Schleora* *oleosa*, *Melaleuca* cinamomun, cane and various other forest woods. While the fauna potential of endemic birds, among others, are the Sumba button quail (Burung Puyuh Sumba), Sumba green pigeon (Merpati Higau), red-naped fruit dove (Merpati bulu kuduk merah), Sumba cicada bird (Burung penangkap lalat coklat), and *Cacatua sulphurea citrinocristata* (Kakatua Cempaka).

Dividing Factors of the Causes of Forest Fires

General

Forest resources that have such a large function and many benefits must be guarded from all types of intrusions that destroy. One such element is fire. Out of control fires or burning can cause massive disturbances to forests, this is the destruction of forests and the shattered product of many generations.

Fire has many bad impacts. Damage can range from disturbances to the trunk of trees to the destruction of the whole tree. Burning weakens resistance to pests and diseases. Burns on tree trunks create chances for pests and diseases to break through. The destruction of one generation of forests by fire means a loss of time that is needed to reach the standard of coverage mentioned previously.

Soil characteristics are also destroyed because of the loss of humus and organic soil matter, and in time the soil is exposed to the effects of heat and wind. The land becomes infertile and erodes, becomes porous and water levels drop. The loss of manure from the fire causes the fertility of the land to drop, and also destroys the priceless habitat of the wild animals.

Basics about forest fires

Factors supporting the existence of forest fires are heat, fuel and atmosphere. These three elements are usually drawn in a fire triangle. The spreading of fire depends on fuel and climate (wind, moisture and temperature). Strong winds speed up the spreading of fire by increasing the air supply. Temperature is also an important factor, because not only does it affect the fuel and the movement of air or wind, but also has an effect on the fire brigade itself. In hot weather situations the capacity of the fire brigade to work and it's abilities decrease.

Causes of fire

Forest fires in East Sumba are generally created by humans. Besides this, brush fires on fields result from very dry conditions, which occur periodically every year.

Forest fires can be intentionally or unintentionally created. Some reasons for unintentional causes are from smokers, campfires/camping, forest workers, shepherding and hunting. In many cases forest fires start from the intentional use of fire by those who clear land, workers preparing fields, sheep herders who wish to stimulate grass growth, hunters herding prey and others.

Forest and field fires actually represent an occurrence that is linked to the lifestyle of the Sumbanese community which places a high value on livestock and hunting activities and also overcoming food crises in the dry season with crop rotation and weak farming management. The root of the problem is the social prestige connected with owning livestock.

During the famine or food shortage seasons, marginal farmers in general make efforts in hunting wild boar and deer, which are viewed by the community as nutritious foods, also by searching the forests for tubers/roots to satisfy their carbohydrate requirements as substitutes for rice and corn.

To make the catching of wild boar and deer easier, and to restimulate the growth of tubers/roots, the forest and scrub is burnt. Because this burning is not controlled it can spread to areas where it was not intended.

Large proportions of forest fires originate from the method of burning for dry land use at the village level. The clearing of forests by the community is usually done according to customs, to provide land for agricultural products that continue every year (rice, corn, various kinds of tubers and various kinds of beans). The average amount of land cleared by the community is restricted to their own plantations (approx. 0.5 hectares per family), but because this burning is not controlled fire then spreads everywhere. This is what causes forest areas and other pastures to burn as well.

The planting of new forests can also result in the expansion of brush fires. Fire is used for the clearing and preparation of land for planting by the intercropping method. Often fire spreads to surrounding forest areas and causes forest fires.

Impact of Forest Fires

Forest fires are not only considered the main obstacle in the production of forests, but also the main factor that causes a lowering in quality of life. A study concerning plant dynamics has shown that species that are inclined to regrow from seeds or stumps tend to appear again in burnt-out locations. With this, species that easily burn will appear again and create a dangerous type of fuel in that particular area.

Fires that happen every year have resulted in the flourishing of *Chromolaena odorata* (Tai Kabala) in parts of East Sumba. The flourishing of this plant, for the moment, is viewed by farmers as a weed that greatly disrupts agricultural efforts as well as being a hiding place for forest pigs (pests). In accordance with the culture of the area, *Chromolaena* on agricultural land is overcome by burning. This activity is also seen as the only exact way of clearing weeds. Unknowingly, this condition has hastened the spread of *Chromolaena*, which at this moment has penetrated rare forest areas, resulting in suppression of growth of the natural succession of seedlings.

Other dangers from forest fires are the destruction of land fertility and the increase of erosion. Areas where the tops of slopes are burnt tend to decrease the capacity of water catchment areas below. There have been many observations stating that the decrease in quality of land areas arises from repeated burning that results in soil erosion and floods, which subsequently impact on water ways, rivers, lakes and weirs.

The impact of fire which is felt the most is the rising of air temperature (heat) because the production of oxygen through tree leaves becomes restricted.

The burning of forests and fields results in the destruction of microorganisms that fertilise the land. This burning also decreases land productivity, which in turn causes community agricultural yields to decrease. To increase land productivity then requires fertilisation, which of course requires a high cost. The burning of forests and fields also causes the loss of topsoil. The water table level drops, which results in the decrease in the amount and rate of water flow in springs, rivers and lakes.

Fires, which occur at the peak of dry season destroy the fertilisers and topsoil microorganisms that are important in the decaying process.

Efforts in Forest Fire Prevention

Prevention is better than cure. This statement is also relevant to forest fires, where with a good prevention program, fires don't need to occur, and with that the cost of fighting them along with the damage caused can be avoided. This can be achieved through education, siliviculture practices and preventative laws. A number of efforts in forest fire prevention have already been undertaken. Among these are:

Information

Because humans cause most forest fires, whether from carelessness or intentionally, with support and cooperation the community becomes very important for protection programs to work.

This requires repetitive information given to change behaviour as well as the encouragement of community interest towards forests and making them care about forests. Information can be conveyed through:

- the use of community figures who are organised to work for forest fire prevention;
- mass media publications in the area;.
- audiovisual publications;
- circulated letters;
- the installing of notice boards.

Silvicultural practices

Good silvicultural practice involves clearing of land from time to time and the removal of dead trees/dead vegetation. It is important to note the role of certain trees in lowering the risk of fires. It is then possible to choose species for planting that are fire-resistant/enduring of fire (examples are teak, *Gmelina arborea, Schleora oleosa*, tamarind).

Local knowledge

Understanding local culture that has been handed down the generations—for example the presence of sacred forests, which are considered places where gods reside. This is belief of *marapu* communities. The forest represents a place of prayer for marapu communities to praise the gods. This belief that is followed by the marapu communities states that whoever destroys the place/forest mentioned will receive the punishment of the gods.

Cultural oaths

'*Rotu Pandang***'** is one such oath that still exists in the community. It means the community is not allowed to burn forests or fields. Because the whole community of a village pledges *rotu pandang*, then whoever breaks this pledge will receive punishment/misfortunes from the gods.

Formation of groups for safeguarding forests

These groups for safeguarding forests are formed by community groups themselves and are facilitated by a number of community non-profit organisations, the Forestry Department and the Land Conservation Council of Regional Area Level II East Sumba.

The aim of forming these groups is to assist the government in safeguarding forests in its area from various threats like forest fires, theft of forest products, clearing of forests and unauthorised shepherding. For example, in Wanggameti village the KMPH, 'Paberingu Mahanu', has succeeded in preventing forest fires in their village for the past 6 years, so that now secondary forests have grown, especially in the areas around hills surrounding the village.

Attention of community non-profit organisations

A number of local and outside non-profit organisations care greatly about forest conservation on the Island of Sumba. Among them are Tananua Foundation, Mbaha Eti Foundation, Kehati

Foundation, World Neighbors (WN), Bird Life, WWF, Cornell University and others. The presence of these institutions has greatly helped prevention of forest fire activities on the Island of Sumba.

Preventative laws

The regulation of legislation has a very important role in the prevention of fires. Pushing disciplined fire usage is much needed, especially for those who tend to keep violating the laws. The community needs to be given information and educated about these laws. Because of this preventative laws still represent a way to guarantee prevention and they are aimed at those who don't care.

If the laws are upheld and the punishments for those who violate them are announced or published, this could have an impact of lessening the occurrence of fires. Even though the enforcement of laws represents one important part of preventing forest fires, this should be viewed as an educational tool that must be put to use skilfully and wisely.

Fire breaks/green strips

Fire breaks/green strips are only applied to rehabilitated forest plantations. Fire breaks/green strips approximately 10 metres wide are made around the plantation location with the intent of preventing the spreading of fire into rehabilitated locations.

Conclusion

Forest fires represent one factor that causes loss of forest potential. Reality shows that if fire spreads it is hard to control. Forest fires have a great impact on the social economy, ecosystem and hydrology. Because of this, prevention/control of fires must continue to be executed to create forests and ecological reservations. This valuable lesson represents a challenge and a chance to care for the social economy and maintain the water and nutrient cycles in certain areas to ensure the continuing function and benefit of the forests.

Fire in the Trans-Fly Savanna, Irian Jaya/PNG

Neil Stronach[1]

Abstract

The vegetation of the Trans-Fly in southern New Guinea is a complex mosaic of grassland, savanna woodland and monsoon forest, the distributions of which are determined partly edaphically and partly by anthropogenic fire. Human population density has been low historically and remains low in most areas. A strong traditional use of fire includes fires set for hunting, to protect sensitive resources, and to maintain grassland and woodland at the expense of denser woodland and monsoon forest. Failure of the annual rains may lead to drying out of swamps, followed by severe fires in swamp grassland, woodland and forests and the combustion of peaty soils. Social and cultural changes have introduced a suite of non-traditional uses of fire, mostly for reasons of access to remote areas for commercial purposes, and indifference to traditional management goals. In conjunction with heavy grazing by rusa deer, burning has eliminated dense *Phragmites* reedbeds, setting in train a number of major ecological changes which lead to the widespread encroachment of seasonal swamp grassland by melaleuca woodland and forest. Rare severe burning of melaleuca swamp woodland may reverse this trend, but fuel loads in sedge-grassland are insufficient to prevent the growth of even small melaleuca regeneration.

THE TRANS-FLY IS a biogeographic entity that comprises the area of monsoonal climate which lies between the Aramia and lower Digul Rivers in southern New Guinea. Annual rainfall varies between 800 and 2000 mm, most of which falls in the wet season from December to May (Paijmans et al. 1971a; McAlpine et al. 1983). However, there is a gradient in which annual rainfall decreases and the dry season becomes more pronounced southwards. The coastal plain and floodplains of the major rivers are mostly less than 3 m above sea level. Inland the flat to slightly undulating Oriomo Plateau is largely below 30 m above sea level (Paijmans et al. 1971b) .

The vegetation consists of grassland, permanent swamp, savanna woodland and monsoon forest, distributed in a mosaic which depends on rainfall, soil type and duration of seasonal inundation, and the history of fire and other human activities (Paijmans 1971,1976). This complex of vegetation types corresponds to Gillison's (1983) bioclimatic Province No. 4-AIVS. The alternation of dry and wet seasons and the dominance of grass in the herb layer ensures that fire is an annual event (Henty 1982). Many components of the Trans-Fly savanna biota are shared with those of northern Australia, but there is also a strong contribution from New Guinea (Walker 1972; Axelrod and Raven 1982; Gressitt 1982).

The following account is necessarily anecdotal since, apart from the descriptive works referred to above, there has been little empirical research on vegetation ecology and the behaviour and effects of fire in the savannas of southern New Guinea. Unless explicitly stated, the observations were made by the author during 1979–1982 and 1995, and have not previously been published.

[1]Fota Wildlife Park, Carrigtohill, Co. Cork, Ireland

Fuel Types

Grass is the main fuel for fires in the Trans-Fly. Fuel loads vary from sparse low swards in the shade of the denser types of woodland or under heavy grazing to tall dense reedbeds of *Phragmites karka* in seasonal swamps. There are no figures for grass standing crop for southern New Guinea. Extensive areas of woodland and grassland are seasonally inundated by flood water. Extensive open grasslands exist in two main types: those on black soils subject to prolonged inundation; and sedge–grasslands on impermeable soils.

There are no measurements of fire behaviour in Trans-Fly savannas but the following general description is possible. Fallen dry leaves and bark of *Melaleuca* spp. are important in the spread of fire where the grass layer is sparse. During early burning operations in Wasur National Park, Irian Jaya, these fuels supported more intense fires than those in grass swards. A litter of dry leaves allows late dry season fires to enter monsoon forest and thicket. These fires are usually slow-moving and with low flame height. Frequent grass fires in woodlands ensure that dead wood does not accumulate. However, severe fires in melaleuca swamp woodland and forest may kill many trees, providing large quantities of fuel in subsequent years.

Although grass standing crop on higher ground may increase as annual rainfall increases (Fitzpatrick and Nix 1970; Nix 1975), the lower the rainfall in any one year, the greater the area of swamp that dries out sufficiently to burn. Not only does herbage become available as a fuel for fires, but so also do woody vegetation and the organic deposits in peaty soils. The severity of fires increases markedly when the wet season rains fail, as in 1978–79. As grass standing crop increases so also does the likelihood of burning. The rate of fuel accumulation in Trans-Fly grasslands has not been measured but may approximate to Walker's (1981) model in which fuel accumulates up to a maximum after four years, and to the situation described by Williams et al. (1999) for the similar savannas in northern Australia.

Several factors affect fuel loads independently of primary production and the progressive seasonal drying. On the coastal plain there is, locally, intensive grazing by agile wallabies (*Macropus agilis*) and exotic rusa deer (*Cervus timorensis*), reducing fuel loads. Elsewhere, heavy grazing by cattle induces the replacement of grass by a sparser forb community. This effect can be seen in parts of Wasur National Park east of Tomerau. Cattle rearing is promoted in the Trans-Fly of Irian Jaya, but in Papua New Guinea there has been a policy of keeping livestock away from the international boundary for the purposes of disease control.

Grassland and swamps may be heavily dug over by feral pigs (*Sus scrofa* x *Sus celebensi*), particularly in areas remote from human habitation. Pig-rooted ground supports less grass, forming fire breaks and seed beds for the regeneration of *Melaleuca* spp., promoting the spread of woodland and forest at the expense of grassland and open swamps.

Anthropogenic Fire

Traditionally, the indigenous people of the Trans-Fly combine subsistence hunter-gatherer and small-scale cultivator lifestyles. Fire has been used extensively to manage their resources. Early burning is used to protect key fire-sensitive resources such as gardens, and coconut and sago palm groves from damaging late fires. Most fire in the Trans-Fly is anthropogenic. However, the traditional use of fire in the Trans-Fly has not been systematically described.

Fire is used opportunistically in hunting. Stands of taller grasses are burned to concentrate and flush out bandicoots, wallabies and other species. This activity tends to produce a progressively burnt landscape, beginning each dry season with small-scale early burns and ending with small-scale hot burns in relict patches of fuel. Post-burn sprouting of perennial grasses may attract grazers, enhancing opportunities for hunting. No attempt is made to control hunting fires once lit. This suggests a high degree of confidence that fires lit for one purpose will be useful in other ways or will not be damaging.

In discussing the use and effects of fire, indigenous people of the Trans-Fly express satisfaction at the 'cleaning' of the land by fires, a sense of purpose also observed among the aboriginal people of northern Australia (Russell-Smith et al. 1997) and the Wangindo people of southern Tanzania (Stronach unpubl.). This cleaning relates to the removal of litter, the suppression of shrubs and tree regeneration, and the subsequent regrowth of grass species that support grazers such as the agile wallaby. Thus fire is used to maintain grassland, open woodland and a mosaic of these with monsoon forest and thicket, a mixture of habitats which supports a higher diversity and density of prey and food plant species. The removal of the grass sward makes walking easier and hazards such as snakes and feral pigs more visible.

Of particular interest in the area of traditional burning practices is the attitude towards severe fires. Wet season rainfall has decreased and become less regular since the virtual failure of the rains in the 1978–1979 wet season (Kitchener 1997). The severe fires of the 1979 dry season in the Tonda Wildlife Management Area caused considerable alarm among the local people, suggesting that there had been little experience of these conditions in living memory. The sounds of exploding melaleuca trees were misidentified, serious injuries were sustained when people walked into smoldering swamp soils, and people cultivating remote gardens were alarmed at the severe grass fires.

The present situation in the Trans-Fly is one in which traditional fire management is being replaced by less structured practices. Recent administrations have encouraged the concentration of a formerly dispersed population, reducing traditional early burning in remote areas. In Irian Jaya there has been an influx of settlers and urbanisation around Merauke. The younger people are less clear about the aims of traditional burning and, with the intrusion of outside influences and the cash economy, the need to continue them has declined. If the traditional burning practices are to be understood the older people must be interviewed and asked to demonstrate their techniques.

The new burning practices have much to do with ease of access. Hunters who supply the town of Merauke with deer meat use motor bikes for hunting and transporting meat, burning extensively wherever they operate, particularly in the now relict *Phragmites karka* reedbeds. Cattle herders burn wherever the grass sward is not overgrazed and can carry a fire. Increased access to the area by way of the Trans-Irian Highway and other new roads and tracks ensures that the new practices are applied widely. My impression is that the new practices are less discriminate and, while progressive, are unlikely to protect some habitats. The management of Wasur National Park has carried out some early burning in the woodlands and to protect *Asteromyrtus symphyocarpa* regeneration for the commercial extraction of rubbing oils.

Effects of Fire on Vegetation

The most obvious effect of fire in the Trans-Fly has been to prevent the ascendancy of woody vegetation at the expense of grassland. The absence of fire in Trans-Fly woodlands allows the development of fire-sensitive monsoon forest, a change which substantially alters the resource base of people. The development of monsoon forest in woodland can be observed widely in Wasur National Park despite continued access by people, and between Dimisisi and the Fly River where people no longer live. In open woodland maintained by fire, monsoon forest initials are nevertheless conspicuous. For example, forest initials frequently take the form of small thickets of *Dillenia alata*, often growing on eroded termitaria. There are no estimates of the rate of invasion of Trans-Fly savannas by monsoon forest, but interviewing residents may provide useful historical information on this aspect.

Fire enters monsoon forest and thicket during exceptionally dry years, when leaf litter provides a substantial fuel. There was considerable tree death and consequent opening of the canopy following fires in these habitats in Tonda Wildlife Management Area during the dry season of 1979. The subsequent growth of grass (mostly *Imperata cylindrica*) provided the fuel for further fires the following dry season, leaving alive only those species of tree that would be expected to survive in woodland (e.g. *Acacia mangium*, *Alstona scholaris*). Woodland replaced monsoon forest within two years under the influence of fire.

Fire is also implicated in changes in grassland, notably in conjunction with grazing by rusa deer. The people of the coastal plains indicate that in living memory, and coinciding with the establishment of the rusa deer, there have been major changes in the swamps and grasslands. Robust swamp grasses, notably *Phragmites karka*, have declined. Seasonal inundation has been neither so deep nor so long. Large areas of grassland and seasonal swamp have been encroached mostly by *Melaleuca* spp. (Stronach 1995; Kitchener 1997).

Phragmites is eliminated by deer grazing in conjunction with burning, being replaced by a variety of swamp grassland types. Melaleuca does not regenerate in dense phragmites but does on the short grasslands that replace it, particularly following heavy grazing which reduces fire intensity. These extensive vegetation changes appear to be reinforced by rainfall changes, and to have set in train significant changes in hydrology which in turn accelerate the vegetation changes (Stronach 1995; Kitchener 1997). Burning in conjunction with deer grazing eliminates *Imperata cylindrica* which is often replaced by short swards of *Chrysopogon aciculatus* (Henty 1982; Stronach 1995; Kitchener 1997). Traditional burning regimes in phragmites and imperata before the colonisation of deer probably did not have these effects since, in the absence of grazing both phragmites and imperata recover to their former density following burning.

More research is required to provide empirical data on all aspects of vegetation fires. We lack estimates of grass standing crop and its variations in space and time. Similarly, fire behaviour, distribution and timing remain unmeasured. The greatest need is for a survey of past and present fire management objectives as seen by the traditional land managers and by those newcomers who also burn grass. This is a particularly urgent task since the most reliable information on the traditional use of fire rests with the oldest people. Without an analysis of traditional burning practices and their social and resource management contexts, it will be difficult to interpret the changes in vegetation composition and structure and in hydrology that have occurred in the Trans-Fly during the past few decades. The role of fire in vegetation dynamics, particularly its effects on woody vegetation growth and its interaction with grazing in causing vegetation changes, also needs considerable study.

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Fire Management Issues in Northern Australia

Fire Management and Savanna Landscapes in Northern Australia

Jeremy Russell-Smith[1,2], Grant Allan[1,2], Richard Thackway[3], Tony Rosling[3] and Richard Smith[4]

Abstract

The vegetation cover of northern Australia ranges from open forest or woodland savanna (dominated by eucalypts over a range of highly flammable annual and perennial grasses) to hummock and tussock grasslands occupying sandy and fertile fine-textured soils. Like monsoonal eastern Indonesia, the major fire period occurs over the long dry season, typically between April/May–October/November. People light fires for a range of land management purposes; lightning strikes cause relatively few fires at the start of the annual wet season. Based on regional mapping of fires from satellite imagery (mostly NOAA-AVHRR and LANDSAT) from the 1980s, we can identify two broad patterns concerning the application of fire in northern Australia. In northwestern and northern Australia, and possibly also on parts of Cape York in the northeast, intense wild fires typically late in the dry season burn vast tracts annually. Ecological studies indicate that such fire regimes are having catastrophic impacts on native fire-sensitive species, communities, and habitats. Conversely, elsewhere across northern Australia but especially on more productive pastoral lands, the restricted application/absence of burning is in some cases leading to native and exotic woody species thickening/invading, likewise with profound ecologic and economic consequences. Growing recognition of these issues has led to the development of collaborative fire management programs in various parts of northern Australia. Similar cooperative approaches involving practitioners from northern Australia working with relevant parties in eastern Indonesia and Papua New Guinea would bring significant benefit to the study of regional landscape management issues.

VAST TRACTS of the sparsely inhabited savanna landscape of northern Australian are burnt each year by pastoralists, Aboriginal landholders, and conservation (national park) managers, particularly in the Top End of the Northern Territory and the northern Kimberley region (e.g. Press 1988; Head et al.1992; Allan and Willson 1995; McMillan et al. 1997; Russell-Smith et al. 1997). Elsewhere, but particularly on pastoral tenures, fire is little used as part of property management; rather, it is often seen as a threat to infrastructure and pasture. As a result significant concerns have been expressed with respect to the cultural, economic, and ecological sustainability of contemporary fire regimes in that region (e.g. McDonald and Batt 1994; Rose 1995; Grice and Slatter 1997; Jacklyn and Russell-Smith 1998; Saint and Russell-Smith 1998).

In parts of northern Australia dominated by frequent, extensive fires occurring typically in the latter half of the dry season under severe fire-weather conditions, various studies have demonstrated that such contemporary fire regimes incur significant impacts on fire-sensitive native species (e.g. cypress pine (*Callitris intratropica*)—Bowman and Panton 1993) and communities (e.g. small rainforest patches—McKenzie and Belbin 1992; Russell-Smith and Bowman 1992). While no broad consensus is currently available as to the long-term impacts/effects of different fire regimes on eucalypt-dominated forest and woodland savanna (e.g. Bowman et al. 1988; Lonsdale and Braithwaite 1991), it is generally recognised that biodiversity is most likely to be conserved in those landscapes where fire regimes themselves are highly patchy both in space and time (e.g. Woinarski 1990; Braithwaite 1995). Recent, if currently localised, invasion of high biomass, flammable agricultural plants (e.g. the grasses *Andropogon gayanus*, *Urochloa mutica* and *Pennisetum polystachyon*) into natural systems, has

[1] Cooperative Research Centre for Tropical Savannas, Darwin, Northern Territory, Australia
[2] Bushfires Council of the Northern Territory, PO Box 37346, Winnellie NT 0821, Australia
[3] Environment Australia, GPO Box 636, Canberra ACT 2601, Australia
[4] Remote Sensing Services, Department of Land Administration, PO Box 471, Wembley WA 6014, Australia

the capacity to significantly increase fire management problems in the region over the longer term through markedly increased fire intensities (Lonsdale 1994; Panton 1993).

By contrast, relatively little burning is undertaken in many other regions of northern Australia, especially on more arable lands under pastoral management (Craig 1997; Grice and Slatter 1997). In some pastoral areas there is growing appreciation that densities of woody plants, both native (e.g. *Acacia*, *Eucalyptus*) and exotic species (e.g. *Acacia nilotica* (prickly acacia) and *Parkinsonia aculeata*), have increased markedly in recent decades with major consequences both for loss of productive pasture (e.g. Burrows et al. 1990; Hodgkinson 1991; Scanlan et al. 1991), and loss of extensive areas of native habitat and its associated species (e.g. golden-shouldered parrot—Garnett and Crowley 1995). Increase in woody plants, combined with grazing pressure, reduced burning frequency and the use of intense, shrub-killing fires, have all contributed to habitat loss.

To illustrate the contemporary spatial and seasonal patterning of burning across northern Australia, in this paper we provide a landscape-scale assessment of the extent and seasonality of fires during 1997 and 1998. For both years, mapping of fires was undertaken every 9 days through the dry season derived from relatively coarse-resolution (1.1 × 1.1 km pixels at orbital nadir) NOAA–AVHRR imagery (see McMillan et al. 1997 for details). Fires occurring up until the middle of July are described here as Early Dry Season (EDS) fires; from late July onwards they are described as occurring in the Late Dry Season (LDS). Geographic Information System (GIS) analysis of the patterning of EDS and LDS fires is undertaken here with respect to broad-scale coverages describing rainfall distribution in the preceding wet season, vegetation, and land-use.

The definition of the tropical savanna region used here originates from the Tropical Savannas Cooperative Research Centre and is based on the Interim Biogeographic Regionalisation of Australia (IBRA) (Thackway and Cresswell 1995). The map in Figure 1d is derived from this provincial biogeographic regionalisation.

Climate, Vegetation, Land Use, and Biogeographic Regionalisation

Broad-scale northern Australian rainfall distribution, vegetation, land-use and biogeographic features are described in Figure 1 (a-d), respectively. Rainfall, which occurs over the savanna region mostly between October and March under the influence of the Asian monsoon, declines rapidly southwards, from over

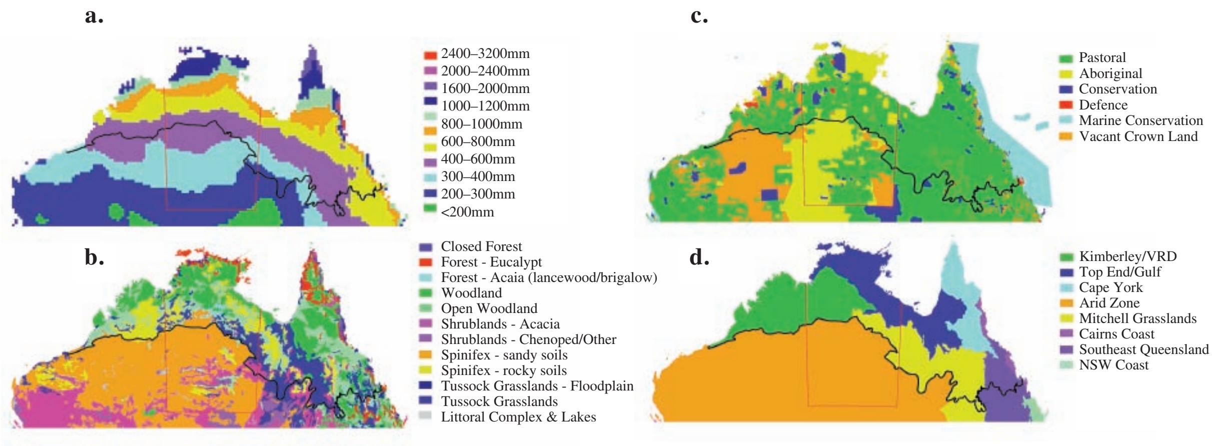


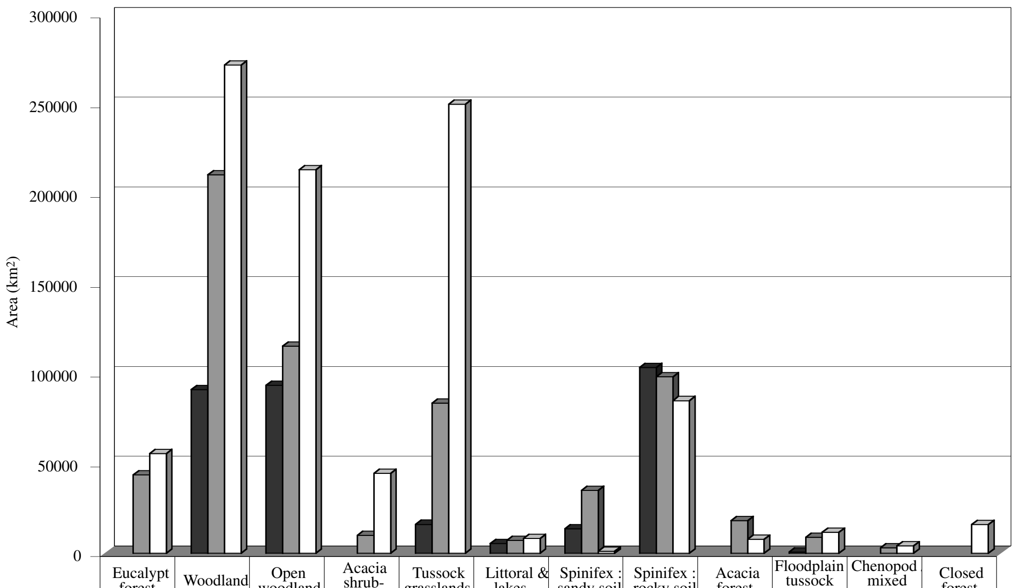
Figure 1. Maps of annual rainfall distribution, vegetation, landuse class, and biogeographic regionalisation, for the Australian tropical savannas region (indicated north of black line on all maps), where: (a) mean rainfall isohyets, 1969–1996 (source: Bureau of Meteorology, quarter degree grid-cell digital database); (b) major vegetation communities, derived from Australian Surveying and Land Information Group (1990); (c) land-use classes derived from Australian Surveying and Land Information Group (1993); and (d) Interim Provincial Regions, from Environment Australia (1996).

2000 mm per annum in a few coastal areas to around 500 mm per annum inland (Figure 1a). Although the amount of rainfall received in any one area is highly variable from year to year, the wet season is a highly reliable event (Taylor and Tulloch 1985). Such climatic conditions are conducive to the production of grassy fuels sufficient for carrying ground fires on an annual basis in higher rainfall areas, to once every few years under lower rainfall conditions (Walker 1981).

In northern parts of the tropical savannas, vegetation cover is mostly eucalypt-dominated woodland developed on a range of typically nutrient-poor soils, becoming increasingly open-canopied and lower in stature with declining rainfall (Figures 1b and 2). In the south, woodland savannas give way to the vast hummock grasslands of the central Australian dune fields. Other regionally significant vegetation types include: (1) pastorally productive tussock (or 'Mitchell') grassland communities predominantly in western Queensland, with restricted areas in the Northern Territory and Western Australia; (2) scattered hummock grassland communities developed on rocky infertile substrates (e.g. sandstone), with significant components of spinifex (*Triodia* spp.) and a range of typically fire-sensitive shrubby species. Rainforest communities are confined mostly to the humid tropics of northeastern Queensland, elsewhere occurring as small patches scattered within the savanna mosaic.

Generalised land use of the savanna lands of northern Australia is given in Figures 1c and 3. As indicated below it is useful to distinguish between 'land-use class' and the more problematic issue of tenure, especially given recent (if overdue) legal recognition of the rights of aboriginal people to share title ('native title') in a range of tenure situations. The great majority of land is used ostensibly for pastoral production, especially the grazing of cattle (*Bos taurus* and *Bos indicus*), and also sheep in parts of western Queensland. Most of this land is leasehold (i.e. leased from respective State and Northern Territory governments), although in the Northern Territory leasehold pastoral properties when purchased by aboriginal people have, from the mid-1970s until recently, been claimable as freehold following successful demonstration of unbroken traditional relationships to the land in question through the highly legalistic 'land claim' process.

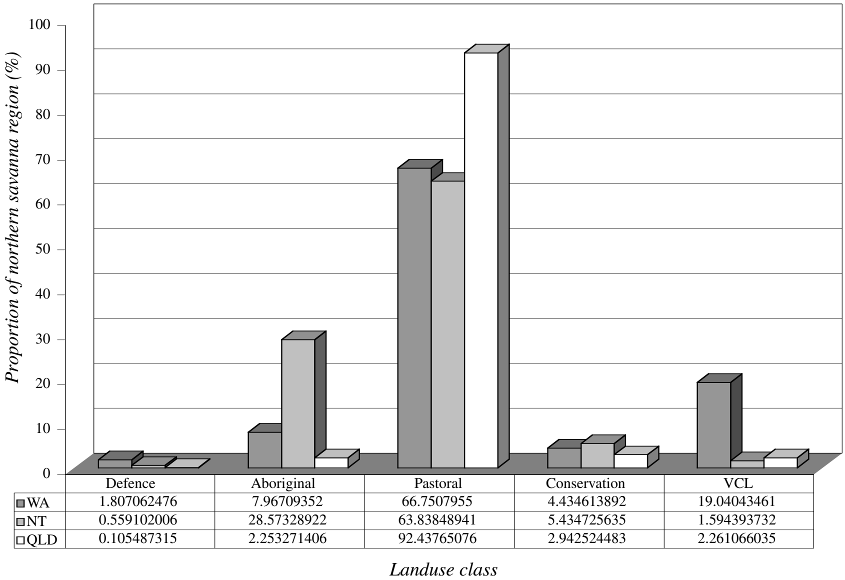
Also, in Western Australia, currently around 25% of pastoral properties in the northern savannas are leased by aboriginal-owned enterprises. Lands allocated to freehold aboriginal tenure in recognition of traditional/cultural usages (i.e. for no specific economic purpose) constitute the next most common



	Eucalypt forest	Woodland	Open woodland	Acacia shrub-lands	Tussock grasslands	Littoral & lakes	Spinifex : sandy soil	Spinifex : rocky soil	Acacia forest	Floodplain tussock grasslands	Chenopod mixed shrublands	Closed forest
Western Australia		91148	93631		16105	5341	13666	103379		656		
Northern Territory	43631	210789	115301	9960	83602	7055	34957	98365	18177	8807	3118	
Queensland	55492	271932	213524	44500	250101	8262	1175	84996	7832	11625	4129	15970

Vegetation community

Figure 2. Extent of major vegetation communities occurring in the tropical savannas region of Western Australia, Northern Territory and Queensland.



	Defence	Aboriginal	Pastoral	Conservation	VCL
WA	1.807062476	7.96709352	66.7507955	4.434613892	19.04043461
NT	0.559102006	28.57328922	63.83848941	5.434725635	1.594393732
QLD	0.105487315	2.253271406	92.43765076	2.942524483	2.261066035

Figure 3. Proportion of five major land-use classes occurring in tropical savannas region of Western Australia, Northern Territory and Queensland; VCL = Vacant Crown Land.

land-use type, especially in the Northern Territory. Finally there are unallocated lands—Government lands (i.e. 'vacant crown land') especially in Western Australia—claimable through the 'native title' process. Also, in the Northern Territory, lands set aside for conservation purposes include significant areas under aboriginal freehold tenure (e.g. Kakadu and Nitmiluk National Parks), managed jointly with Federal and Territory Government agencies, respectively. Despite the small area used for mining purposes, such land use constitutes by far the greatest economic return to the regional economy (Gray 1996).

Patterning of Fires in Northern Australia, 1997–1998

The mapped distribution of fires occurring in northern Australia in the EDS and LDS of 1997 and 1998 is presented in Figures 4 a, b respectively, and the breakdown by State and Territory jurisdictions is given in Figure 5. In sum, the data indicate that pixels depicted 244 000 km^2 and 242 000 km^2 respectively burnt (at least partly) in consecutive years, with the greatest extent, and largest fires, occurring in the LDS in both years. These data have a number of qualifications, including difficulties with mapping fires under cloudy conditions at the start of the wet season (Oct/Nov), and estimating the amount actually burnt in any one 1.1 × 1.1 km^2 pixel. Nevertheless, the data illustrate that relatively little burning occurred in Queensland in both years, especially in the more productive pastoral areas of the tropical savannas. Other data available for the Northern Territory and Western Australia indicate that such observations are broadly typical of other years in the 1990s, for these jurisdictions at least (Allan and Willson 1995; McMillan et al. 1997).

The extent of burning by rainfall class for the preceding wet season shows that both in 1997 and 1998 the majority of burning consistently occurred in the LDS across the region (Figure 6 a, b). Considering only the more extensive vegetation types (see Figure 2) it is apparent that, in both years, most burning occurred in eucalypt-dominated open woodland habitats under relatively high rainfall conditions, and least burning occurred on pastorally productive tussock grasslands (Figure 7). The relative lack of burning undertaken on pastoral lands is evident also when considered by land-use class (Figure 8).

Discussion

Fire is an active partner in northern Australian savannas, as intrinsic as climate, substrates/soils, water relations, vegetation/habitats, people/cultures/politics, land uses. Burning, in some regions of northern Australia, takes place annually/biennially; in other areas, particularly on pastoral lands, it is currently little used. Both situations have implications for

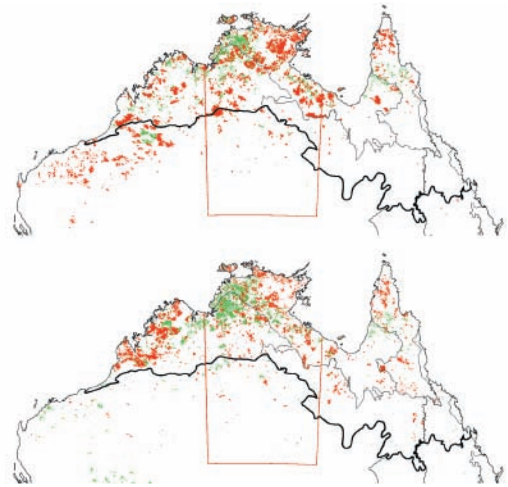
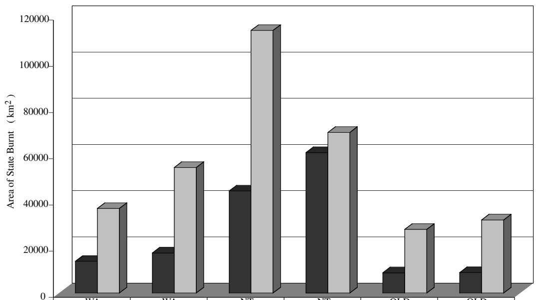


Figure 4. Extent of mapped fires in the tropical savannas region for the Early Dry Season (EDS—green) and Late Dry Season (LDS—red) of (a) 1997, (b) 1998.

ecologic and economic resource sustainability. Fire can be managed, usefully and sustainably, for various purposes.

Effective fire management requires appropriate research, education, sound policy and infrastructure. It requires also cooperation between adjoining landholders/managers; in northern Australia at least, these are relatively few in number. And yet, substantial cultural differences apply concerning the management of land. In this paper we have simplified these to a number of classes: pastoral, aboriginal, unallocated, conservation, defence, mining. Ecotourism is already a major industry across most tenures, as is potentially education. The issue of tenure ('security of tenure') is intrinsic also—hence the current legal debate in Australia concerning indigenous (aboriginal) and non-indigenous people. Also the management of lands at scales ranging from Federal/State/Territory to regions, sectors, properties, habitats, etc.

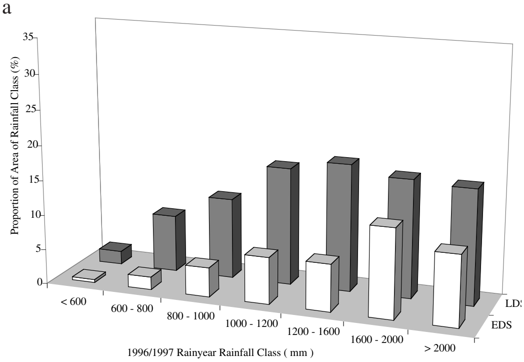
The above issues apply differently, but equally, in eastern Indonesia and PNG. In northern Australia we have commenced a number of regional fire management projects that involve the participation of local communities, across a range of land use activities/tenures. In the Northern Territory, for example, we are undertaking two such projects: one focusing on aboriginal lands with high conservation, tourism, mining, and lesser pastoral, values (see Cooke, these proceedings); the other on lands primarily pastoral, also involving aboriginal,



	WA 1997	WA 1998	NT 1997	NT 1998	QLD 1997	QLD 1998
EDS	13706	17325	44151	60761	8757	8819
LDS	36572	54290	113649	69480	27540	31607

Figure 5. Extent of Early Dry Season (EDS) and Late Dry Season (LDS) burning in 1997 and 1998 for the tropical savannas region, Western Australia, Northern Territory, Queensland.

a



b

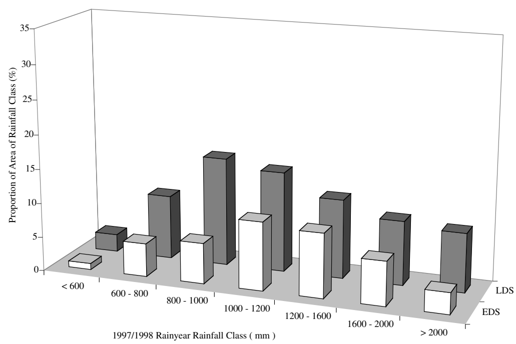
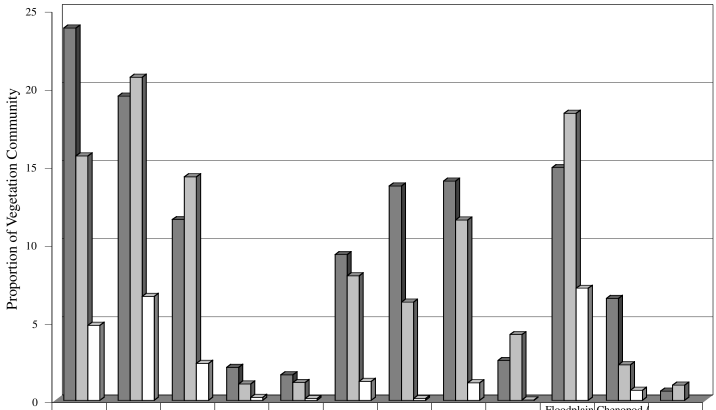


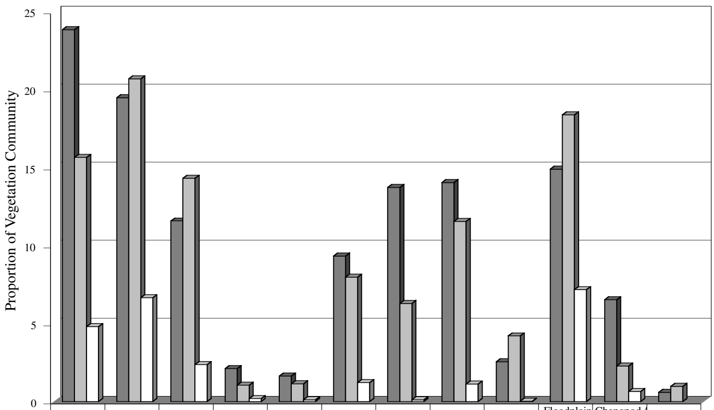
Figure 6. Proportion of tropical savannas region burnt in relation to rainfall for the preceding wet season period, in (a) 1997, (b) 1998.



	Eucalypt Forest	Woodland	Open Woodland	Acacia Shrublands	Tussock Grasslands	Littoral & Lakes	Spinifex : sandy soil	Spinifex : rocky soil	Acacia Forest	Floodplain Tussock Grasslands	Chenopod / Mixed Shrublands	Closed Forest
Burnt 1997	23.830998	19.470471	11.566175	2.1024605	1.6208892	9.3184239	13.725451	14.024552	2.5375831	14.889985	6.5268387	0.5886036
Burnt 1998	15.648235	20.671442	14.308472	1.0429673	1.1414833	7.9678575	6.285393	11.534491	4.2023915	18.370637	2.2768042	0.9643081
Burnt 97+98	4.7910172	6.6410627	2.3652167	0.183621	0.1017701	1.2005034	0.1044219	1.1180861	0.0153793	7.1699545	0.6347454	

Vegetation Community

Figure 7. Proportions of tropical savannas major vegetation communities burnt in 1997 and 1998.



	Eucalypt Forest	Woodland	Open Woodland	Acacia Shrublands	Tussock Grasslands	Littoral & Lakes	Spinifex : sandy soil	Spinifex : rocky soil	Acacia Forest	Floodplain Tussock Grasslands	Chenopod / Mixed Shrublands	Closed Forest
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Vegetation Community

Figure 8. Proportions of tropical savannas major land-use classes burnt in 1997 and 1998.

conservation, defence, tourism, but limited mining values (see Dyer, these proceedings). These projects aim to develop options for better fire management practice in these regions through engagement, community participation and, where appropriate, applied research. Managing fire is of course only one land management issue; nevertheless it concerns/involves everyone.

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Fire Management on Aboriginal Lands in the Top End of the Northern Territory, Australia

Peter Cooke[1]

Abstract

In the Top End of the Northern Territory many aboriginal groups continue to practise traditional management of fire despite a variety of impediments. There is a growing recognition of the positive effects of traditional burning regimes but many non-aboriginal settlers still regard aboriginal landscape burning as anarchic pyromania. This antipathy colours aboriginal perceptions of Government burning regulations and has led some communities to cease traditional burning, believing they may be jailed for lighting fires. The Northern Land Council's Caring for Country Unit helps landowners address fire problems and develop sustainable means of appropriate fire management through participatory planning processes, collaboration between aboriginal ecological experts and non-aboriginal scientists. The Unit also encourages utilisation of economic projects such mining, tourism and buffalo harvesting, to support traditional fire management and resettlement of unpopulated areas and to build capacity within and between aboriginal resource agencies concerned with land management. Future effective management will depend on finding an appropriate mix of aboriginal and non-aboriginal knowledge and technology and the resources to sustain application of that mix.

THE FEDERAL *Aboriginal Land Rights (Northern Territory) Act 1976* established land councils as statutory authorities to assist aboriginal people in the Northern Territory (NT) to claim back crown lands and to manage former aboriginal reserves that became inalienable freehold aboriginal land under that act.

Aboriginal people constituted about 23% of the total Northern Territory population of 195 000 in 1996 (ABS 1999) and own a little more than 40% of the land area of 1.35 million km^2. There are land claims to a further 10% of the NT (Department of Foreign Affairs and Trade 1995). Aboriginal people make up about 2.1% of the Australian population of 18 million (ABS 1999) and own about 13% of the 7.7 million km^2 land mass (Fourmile 1996).

There are approximately 28 000 aboriginal people in the Northern Land Council (NLC) area and about 170 000 km^2 of aboriginal-owned land (ABS 1998). Probably only about half those aboriginal people have title to their traditional lands. For the rest most of their traditional lands have been appropriated by the pastoral industry since the mid-19th century.

Aboriginal people's relationship with land differs from that of the majority of settler Australians. Most importantly land is not a commodity to be sold or traded away but rather it is owned as a sacred trust involving discretely defined groups of landowners, their ancestors and descendants. These ancestors may still be seen in the landscape in particular natural features, often referred to as sacred sites. Aboriginal people who still have that deep spiritual attachment to country are in general not interested in moving somewhere else to follow work or other opportunities—their hearts remain attached to the country wherein lie the bones of their ancestors.

Although most aboriginal groups from the Top End lands suited to pastoralism lost control of their lands in the mid-19th century, some have regained about 40 000 km^2 through purchase of pastoral stations. These are mostly economically marginal properties on which continuing pastoral enterprise rarely generates sufficient income for appropriate management. They provide little of economic benefit to their owners as pastoral enterprises but are significant in regional economies as well as the social and spiritual lives of their aboriginal owners.

The remaining 130 000 km^2 of aboriginal land in the NLC areas is mostly made up of a number of smaller aboriginal lands and the largest, former aboriginal reserve Arnhem Land, which was proclaimed in 1931 after more than a century of failed European attempts at settlement.

[1]Northern Land Council Caring for Country Unit
PO Box 42921, Casuarina NT 0810

Concentration of Populations

As Christian churches established missions from the beginning of the 20th century aboriginal people were drawn away from traditional lands where they lived independent lives and were brought into the Christian fold at least partly through attraction to exotic goods like tobacco and rice. Communal feeding and issuing of rations reinforced the intent of taming the bush Aborigines and leading them away from their own culture towards assimilation into the Euro-Australian culture (Abbott 1950).

Where people weren't drawn into missions they often moved to other sources of trade goods, places like the buffalo camps of what is now Kakadu, and cattle stations near to reserves. The effect over time was progressive depopulation of aboriginal lands and a falling away of aboriginal land management practice, including fire, across the broad landscape as populations became more concentrated.

Western Arnhem Land people, for example, were drawn progressively down from the Arnhem Plateau from the mid to late nineteenth century, joining the buffalo camps and mines from the Alligator Rivers westward (Christian and Aldrick 1977).

In other areas on the larger reserves considerable numbers of groups remained predominantly on traditional lands, living hunter/gatherer lifestyles until the 1950s and early 1960s. By the late 1960s there were few aboriginal bands living on traditional estates on aboriginal land away from missions and settlements, leaving many large areas essentially unmanaged.

Change of Rules, for a While

At that time there was scant recognition that traditional aboriginal land management was ecologically sound practice, and little acknowledgment of the broadly recognised rules and customary practices of management amongst Aborigines. Anthropologist and naturalist Donald Thomson (Thomson 1949) noted such customary rules associated with fire management. He observed that responsibility for directing burning of grass was shared by the old men of an estate-owning clan (members of which were related to that estate and clan through patrifiliation—father–son) and by men of other clans with hereditary rights. The latter individuals are related through matrifiliation (mother–son) to the land-owning clan, but related patrifilially to their own respective clans and estates.

The differentiation of the roles of these groups, referred to in aboriginal English as owners and managers, continues to be a core concept of aboriginal relationships to land and of management of land. The reciprocity of responsibility between these groups extends fire management beyond the boundary of single estates and involves neighbours, who are also kin, collectively in fire management.

But neither aboriginal owners nor managers were involved to any degree when the federal government attempted to impose a western-style forestry land management regime over a large area of central Arnhem Land around Maningrida in the 1960s. The project's government experts planned to increase the percentage of naturally occurring cypress pine (*Callitris intratropica)* by a process of 'enrichment planting' in open forest savannas dominated by stringybark (*Eucalyptus tetrodonta)* and woolybutt (*Eucalyptus miniata*). Total fire exclusion was a major management objective.

Despite the depopulation of the bush generally, individuals still looked for opportunities to hunt on their country, often at weekends and in the right situations using fire as a hunting tool. In October 1968 a number of fires were lit within the forestry 'protected area'. Fuel that had accumulated after several years of fire exclusion contributed to the first recorded 'crowning' in northern forests. About two thirds of the protected area was razed: all regeneration and many of the mature trees of cypress pine were destroyed (Haynes 1978).

At Maningrida, aboriginal resentment of exotic management methods reached a peak in 1972 after forestry managers sent in heavy machinery to extinguish a small fire lit within a sacred ceremonial ground during preparations for a ceremony. At the insistence of landowners the forestry project was closed down and non-local staff withdrawn.

Reflecting on Maningrida's experience with forestry-style management, government forestry official Chris Haynes (Haynes 1978) concluded: 'Everything to do with fire management by an essentially alien body interfered with the customs developed over millennia and the resentment was expressed very actively with the lighting of many fires inside the managed area'.

Back to Country

From about the time of the Forestry Branch's departure, a revival of customary management was under way in many areas as people began to exercise the power of self determination offered by the federal Whitlam Government which came to power in 1972.

Dissatisfied with the life at missions and settlements, and fearful that Government would give their country to mining companies or other developers, many aboriginal people had begun to move back to traditional estates to establish small communities. These small communities, referred to as 'homeland centres' or 'outstations', often have much the same population as the basic traditional land-using unit, sometimes referred to by anthropologists as a band, and numbering around 25–30 people.

This decentralisation, or outstation movement, has grown and consolidated since the early 1970s until there are now hundreds of such small communities in the Northern Territory. In most cases the aboriginal people in these small communities have some access to health and education services and have been provided with water supplies and housing in the locations of their choice. But there are still few formal economic enterprises in these areas. People make and sell arts and crafts, some are considering tourism or other small enterprise, but the mainstay of the outstation economy remains hunting and gathering. These activities are augmented through the Community Development Employment Program (CDEP), a Commonwealth program under which aboriginal people work for unemployment benefits, also referred to as 'the dole'. Others activities such as mining, buffalo harvesting and tourism are proceeding under various arrangements but predicated on the informed consent of landowners under the Aboriginal Land Rights Act.

The return to being on traditional land and using that land has brought back traditional management, including traditional fire management.

Since Chris Haynes first began to describe some of the systematic elements of aboriginal burning and relate it to ecological effect (e.g. Haynes 1985), various researchers have directed their attention to an understanding of the ecological basis for and ecological outcomes from traditional burning.

In recent years satellite imagery allows us to contrast the burning patterns from occupied and traditionally managed country with large areas that remain unpopulated and unmanaged. Although the ideal sized aboriginal fire is too small to show up on AVHRR imagery, the observable patterns reflect a common practice of burning early in the dry season, when fires are unlikely to travel long distances, to achieve a mosaic of burnt and unburnt country. This prevents to a large degree the extensive, uncontrolled wildfires that are commonly observed in unpopulated areas in the late dry season and allows for containment of deliberately lit hot fires for hunting later in the year. Aboriginal people burn to hunt, to promote new grass which attracts game, to make country easier to travel through, to clear country of spiritual pollution after a death, to create firebreaks for later in the dry season and a variety of other reasons which overall 'bring the land alive again' (Yibarbuk 1998).

There is a now an increasing, but not universal, recognition of the ecological soundness of Aboriginal burning practice. A recent collaborative project involving landowners and researchers from the Parks and Wildlife Commission of the Northern Territory (PWCNT) and the Cooperative Research Centre for the Tropical Savannas looked in some detail at the effect of traditional burning on some estates bordering the Arnhem Land escarpment on the Cadell River. In this area one family had refused to move to the settlement of Maningrida and had maintained unbroken occupation and unbroken practice of traditional fire management. The conclusions of the researchers, using a range of accepted indicators, was that these clan estates were being well managed to maintain ecological integrity (Yibarbuk et al. unpubl.).

Urge to Emulate

As non-aboriginal fire managers gain some understanding of the basic principles of aboriginal fire management, there is an increasing tendency for them to seek to emulate what they perceive as the effects of traditional burning. In an attempt to achieve greater economic efficiency and minimise labour requirements they have introduced technological wizardry such as helicopters and aerial burning from fixed wing aircraft.

But there is a danger therein, as the research team from the Cadell River project wisely cautioned in the concluding remarks to their report on the Cadell research:

'Premature or clumsy attempts to 'transplant' the technology without supporting the ongoing participation and recognition of its most skilled practitioners is not only likely to produce inferior results, but also squander an important opportunity to develop genuine partnerships among Australia's indigenous and non-indigenous natural resource managers (Yibarbuk et al. unpubl.).'

In Kakadu National Park, jointly managed by aboriginal landowners and Parks North Australia, we have heard landowners recently voicing dissatisfaction with the hybridised burning regime operating there. Some landowners complain about aerial burning by park staff, saying that it marginalises landowners from continuing fire management as a cultural practice and also suggesting that it lacks the ecological finesse and effectiveness delivered by a person walking through the landscape and lighting fires. Parks staff and landowners are now entering a period of discussion and dialogue to work through the issues and seek practicable solutions.

Some landowners complain about the increasing extent of wet season burning which has been highly effective in removing or radically reducing the amount of speargrass (annual *Sorghum* spp.) available as fuel the next dry season. Kakadu landowners are also debating appropriate floodplain fire management with Kakadu staff now that buffalo, which denuded the flood plains of vegetation for over 100 years, have been almost eliminated and the plains again now carry large fuel loads each dry season.

But while there is debate about the best methods of fire management in Kakadu, fire managers there have one advantage over landowners for much of the rest of the Top End—there are significant human and financial resources to put whatever system is agreed on into effect.

From Farm to Feral Landscapes

Away from such generously funded areas the situation is mixed. From the point of view of the NLC and its Caring for Country Unit, fire management is not considered a critical issue in areas that landowners have been able to resettle and where the principles of traditional fire management continue to be incorporated into daily life. Satellite imagery shows us some continuation of early and mosaic burning patterns across the more closely settled parts of aboriginal land in the Top End. To a pleasing degree fire is being used a management tool for particular ends and all is well down on the firestick farm—or is it? That situation could easily change for the worse if exotic species like gamba grass *(Andropogon gayanus)* in woodlands and para grass *(Urochloa mutica)* on flood plains are allowed to invade and radically escalate fuel loads. The usual rules and parameters for traditional burning won't apply as they did in the past.

The Caring for Country Unit encourages local community-based agencies to establish land management programs under the Community Development Employment Program (CDEP) schemes that operate in most areas. Through these land management programs awareness can be spread about the danger posed by exotic grasses and the agencies mobilised to find and eliminate infestations as they occur.

The Problem without People

In the Northern Land Council's area the most difficult lands for fire management are unpopulated areas and areas where landowners have no access to funds through the CDEP program to support land management programs. Although there are several large areas with very few settlements, western Arnhem Land provides a case study where there has been some detailed investigation of the problem and some possible solutions proposed.

The Western Arnhem Land Plateau is one of several large areas where depopulation is a major obstacle to effective fire management. The escarpment is very important ecologically as well as culturally and in parts includes many important fire sensitive species and communities. There is a record of human habitation for 60 000 years (Russell-Smith et al. 1993; Bridgewater et al. 1998). Landowners from the plateau are now scattered in communities around the plateau and for a number of reasons they have been unable to resettle the plateau country and bring it back under traditional management. Fire maps derived from AVHRR imagery over the past few years illustrate the fire problem; to the north and northeast more traditional patterns of fire are observable in resettled areas and in the south and southeast there is almost no early burning in some years and in others huge, very hot late dry season fires burn for weeks at a time.

The Caring for Country Unit of the NLC, in collaboration with the Jawoyn Association and the Bushfires Council of the NT, is working with landowners to develop a sustainable fire management regime in the area over a 3-year period. The collaborators are trying to develop effective methods of participatory planning—the land is private aboriginal land and for solutions to be sustainable there must be a sense of ownership and commitment to them by aboriginal landowners. The Maningrida forestry experience should have taught us that much!

Focusing Varied Resources

Given the lack of personal financial resources of the landowners there is also a need to develop a strong partnership of collaboration between landowners and a variety of other stakeholders. These include aboriginal organisations, business interests and scientists. A meeting of landowners at Manmoyih outstation in September 1998 looked at ways of getting better fire management by posing a series of questions for group problem solving and brainstorming (Northern Land Council et al. 1998).

At that meeting landowners discussed:

- how can buffalo harvesting help fire management?
- how can mining exploration help fire management?
- how can tourism help fire management?
- how can the undertaking of ceremonial and other cultural practices help fire management?
- how can aboriginal resource agencies help fire management?

Some tentative responses are listed below.

Buffalo There is aboriginal-owned buffalo harvesting in the southeast and likelihood of other areas again being mustered west of there. Early burning can be incorporated into early reconnaissance for buffalo harvesting later in the dry and elders with detailed knowledge of traditional burning can have more input into burning that can be carried during mustering operations.

Mining Mineral exploration can create tracks which enable people to get into previously inaccessible country for early burning. Landowners working with exploration companies on the ground can carry out burning. Mining companies may contribute to costs of getting people into country for early burning because it will protect their camps and equipment from the possibility of being burned out late in the year. But if not properly controlled the tracks can result in unauthorised access, which may bring irresponsible burning and import weeds.

Tourism There is potential to find non-Government funds to pay landowners to walk through the country on traditional walking tracks carrying out early burning. Bushwalkers can pay for the experience of being guided across this environmentally and culturally spectacular landscape by aboriginal guides. The knowledge of these traditional walking tracks is in danger of being lost with the death of the last people who grew up on the plateau and walked extensively over it. Helicopters will be used map the tracks with old people who can't walk long distances and young people will come along to learn the routes and to be introduced the spirits of the country by their elders. Then the younger people can 'test drive' the ecotourism possibilities with some parties of bushwalkers before deciding whether to develop the idea into a full fledged business.

Cultural traditions There are important cultural traditions associated with using fire to hunt kangaroos in particular places on the escarpment. Older landowners will supervise a number of these hunts to pass on knowledge to younger people and as a focus for bringing people back to country. The NLC and Jawoyn Association will try to assist as many families as possible to get back onto the plateau during the mid-year school break in 1999 with the longer term hope that this could lead to more permanent occupation or more regular visits.

Modern as well as older cultural practice is also important in creating awareness of the importance of fire management. A band of musicians from Manmoyih outstation, the Nabarlek band, recorded and released a CD called *Manwurrk* or bushfire with a number of songs about the cultural importance of fire after our first workshops. It has done a lot to get people thinking more about fire in particular and landscape management in general.

Landowners from the corners of the plateau have been enthusiastic about re-establishing cultural and social links with groups of the plateau diaspora. Later this year a meeting of the local resource agencies and landowners from around the plateau will determine what resources the agencies can commit to the collective task of managing fire on the plateau and keeping its management well in the hands of landowners.

Developing Commitment

There seems to be great potential in pursuing fire management strategies that integrate and involve the broad range of land use activities and land users in the business of fire management. There are many users and potential users of aboriginal land–miners, buffalo catchers and tourism operators as well as landowners to name a few. It seems essential to develop the general understanding that participating in landscape management of fire and other key areas such as weed, erosion and feral animal control must be a basic condition of land use.

Effective communication is a key element in working towards this goal. In our Western Arnhem Land Project we ensure that wherever possible linguists or aboriginal interpreters are available to lift the quality of communication.

We should not underestimate the inadequacy of our current communication strategies and the negative effect they can have on management. A Bushfires Council sign that has stood for some years on the road from Bulman to Katherine can serve as an example. It reads: *No lighting of fires during fire danger periods. Penalty $1000 or 6 months imprisonment*. I would not have thought aboriginal people took much notice of it all until a senior landowner from Bulman told me that people took it very seriously and interpreted it to mean that people should stop following traditional burning practice or face jail.

Communication

Communication is without doubt the key.

Better communication amongst aboriginal people is needed to ensure that knowledge of traditional burning practice is passed to new generations.

Better communication is needed to get groups separated by historical circumstance talking together about mutual interest in country and assisting each other to resettle country or develop effective management.

Better communication is needed to involve disparate non-aboriginal land users in recognition that fire management is a responsibility of all land users.

Finally, better communication is needed to focus all these groups on developing locally designed strategies that make best use of western science and of traditional knowledge to increase the capacity of landowners to preserve the quality of their country for future generations.

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The Role of Fire on Pastoral Lands in Northern Australia

Rodd Dyer[1]

Abstract

In northern Australia fire has been regarded as an essential component of pastoral land management, but its use has not always been appropriate or beneficial. This paper examines the interaction between livestock grazing and fire, the effects of grazing intensity on the frequency, extent and intensity of natural fire regimes, and the need for intentional burning. The author describes the role of fire in managing woody plant populations, maintaining pasture conditions, managing grazing distribution, increasing the availability of nutritious herbage to cattle, and reducing the hazard of uncontrolled wildfires. The author also emphasises the need for land managers to understand fire ecology and the interactions between season, burning and grazing on a landscape scale in order to use fire as a sustainable management tool.

CONCERN WITH the role of fire in land management in northern Australia arises from two important issues that threaten the sustainable development of savanna rangelands (Jacklyn and Russell-Smith 1998). The first is an apparent increase in the incidence and extent of uncontrolled, late dry season wildfires across large areas of northern Australia, particularly in high-rainfall, eucalypt woodlands and forests. Such fire regimes have adverse impacts on pastoral management and the stability of rangeland ecosystems. The second and contrasting issue is a reduction in the incidence, extent and intensity of burning, mostly throughout the drier, more productive pastoral lands. Apart from other effects, reduced fire is suggested as being a major cause of significant increases in tree and shrub populations.

Fire may play an important role in managing woody plant populations, maintaining pasture condition, managing grazing distribution, reducing the hazard of uncontrolled wildfires and increasing the availability of nutritious herbage to cattle. Fire also has a role in aiding the establishment and management of improved pastures, contributing to the control of exotic weeds and maintaining biodiversity.

The Pastoral Industry in Northern Australia

Pastoralism is the most extensive land use in northern Australia and is focused on extensive beef production. Significant changes to market conditions have occurred in recent years. During this time fire and other land management issues have become important to the sustained productivity of the industry.

Cattle are raised within vegetation and climatic zones that range from woodlands in the seasonally wet monsoon tropics in northern or coastal areas to semi-arid natural grasslands and arid shrublands in southern inland areas. Northern cattle herds are dominated by *Bos indicus* pure or crossbred cattle that are well suited to tropical conditions and the typical low quality dry season forage of native pastures. Production systems are simple, require few inputs and rely almost entirely on native grass pastures. Grazing management options are limited mainly to adjusting stocking rates and total grazing pressure, burning, strategic spelling and controlling the number and location of watering points and fences.

In recent years rapid growth of the live cattle industry has been a key development. In 1997 live cattle exports from northern Australia totalled 680 000 head, a massive ninefold increase from levels in 1990. This represents a total value of $322 million (MRC 1997). The major destination for live cattle from northern Australia in 1997 was Indonesia, which accounted for around 60% of all exports. As a result of the Asian currency crisis in August 1997 live cattle exports from northern Australia to Southeast Asia plummeted to 346 000 for 1998. This represents only 7 and 25% respectively of the 1997 aggregate exports to Indonesia and the Philippines.

[1]Northern Territory Department of Primary Industry and Fisheries, Katherine Research Station, PO Box 1346, Katherine NT 0851

Fire Regimes on Pastoral Land

The landscape that faced early pastoralists was fashioned by thousands of years of burning. Fire was a natural and frequent part of the landscape (Pyne 1991) and an integral part of aboriginal culture and daily life. They used fire frequently and skilfully for hunting, ceremonies, protecting food reserves and 'cleaning the country' (Haynes 1985; Braithwaite and Roberts 1995). Accounts of early explorers suggest that aboriginal burning occurred mainly between the late wet and the late dry seasons but was most frequent during the early dry season (Braithwaite 1991). Fires during the late dry season would be ignited by frequent lightning during dry storms that preceded the summer wet season (Braithwaite and Estbergs 1985).

There is strong evidence that contemporary fire regimes throughout northern Australia differ significantly from those that prevailed prior to the establishment of the pastoral industry (Braithwaite and Estbergs 1985). Early pastoralists burnt country to promote fresh growth for green herbage that would attract cattle and make mustering easier (Smith 1960). Today however, the frequency, extent and intensity of burning on semi-arid pastoral land generally have decreased. In many areas, managers are hesitant to burn grass that could be used as feed, particularly where rainfall is low and highly variable between seasons. Mineral supplementation with *Bos indicus* cattle breeds enables the utilisation of poor quality carry over pasture. In some areas this has had the effect of increasing grazing pressure, severely reducing fuel and opportunities for burning. A recent workshop noted that many pastoralists are hesitant to burn for a variety of reasons (Grice and Slatter 1997).

In contrast throughout large areas of the wet tropics, frequent uncontrolled wildfires dominate the landscape particularly during the late dry season when fire weather conditions are extreme (Jacklyn and Russell-Smith 1998). These fires are prevalent in less productive pastoral lands, in areas with high seasonal rainfall, tall grass pastures and low total grazing pressure. Wildfires are generally more destructive than less intense, patchy early dry season fires. They are a serious threat to the survival of fire sensitive plant and animal communities as well as pastoral productivity.

Role of Fire in Pastoral Land Management

Fire has a range of potential uses in the management of pastoral land. It is possible that one, several or none of these issues may exist on a given piece of land. Pastoral land managers must therefore identify what goals may require the use of fire, then implement a fire regime to suit these goals. The components of a fire regime that must be considered are fire type, frequency, extent, season and intensity.

The interaction between fire and grazing makes the role of fire on pastoral land unique, though little quantitative information exists on fire-grazing interactions. A trade-off exists between utilising grass as forage for livestock or fuel for fires (Ludwig et al. 1999). In the post-burn phase, grazing management affects the response of both the grass and woody layers to burning. Obviously managing grazing pressure both prior to and following burning is critical. Some of the uses of fire in northern Australia are discussed below.

Management of tree and shrubs

Fire has an important role to play in the management of the tree–grass balance in northern Australian rangelands (Burrows et al. 1990; Scanlan et al. 1991). A reduction in frequency, extent and intensity of burning has contributed to increased densities of native trees and shrubs into once open grasslands and woodlands throughout Australia and the world (Scholes and Archer 1997; Hodgkinson 1990). As trees and shrubs increase in size and density, increased competition with the pasture layer for moisture and nutrients can lead to significant decreases in pasture growth. The impacts of competition are more pronounced in areas with lower and sporadic rainfall and on shallow soils (Scanlan and McKeon 1993). This may have the effect of reducing livestock carrying capacities, burning opportunities and tolerance to drought.

The role of fire is one of managing the tree–grass balance rather than controlling woody plants. An 'appropriate' balance for particular pasture lands is difficult to assess, however evidence from historical photographs in the Victoria River District in the Northern Territory (Daryl Lewis pers. comm.) suggests that significant increases in tree and shrub density have occurred on the more productive pastoral lands. Most native woody species are well adapted to fire and persist by vegetative sprouting or seedling establishment (Gill 1981). Rather than a single fire, effective management requires the implementation of appropriate fire regimes. Frequency of burning is determined by the rates of woody regrowth and fuel accumulation. Fires however can also be used opportunistically to control the seedling establishment that occurs episodically after favourable seasons.

The season and intensity of burning will be determined by management objectives. Where fire is already a frequent disturbance, lower intensity, early dry season fires can suppress a shrubby mid-storey, maintaining open eucalypt woodlands in the wet-tropics. Conversely, a mature population structure of a rosewood (*Terminalia volucris*) on black soil communities in the Victoria River District may require intense, late dry season fires every 4–6 years

(Dyer et al. 1996). Intense, late dry season fires are also effective in maximising canopy scorch and plant mortality in country heavily invaded by *Acacia lysiphlioa* and *Acacia cowleana* around Daly Waters, NT. Seedling establishment is variable after burning.

Reduction of wildfire hazard

Prescribed early dry season fires can play a role in strategically reducing fuel loads and the risk of widespread and destructive late dry season wildfires. Apart from being disruptive to station management and consuming large areas of pasture for grazing, these fires are potentially damaging to fire-sensitive plant communities.

Where uncontrolled fires prevail, prescribed use of early dry season fire along with greater control measures during the late dry are required to create a deliberate shift in the frequency, season, extent and intensity of burning to one that is more ecologically and economically appropriate. Early dry season fires are patchy, less intense and more easily managed (Williams et al. 1995). As well as reducing fuel levels, they create a mosaic of burnt and unburnt areas that impede the progress of wildfires later in the dry season.

Successful manipulation of fire regimes to reduce frequent and extensive late dry season fires has been achieved to some extent in the management of Kakadu National Park in northern Australia. The frequency and extent of late dry season fires in Australia has been reduced by increasing strategic burning during the early dry season (Press 1987, Russell-Smith et al. 1997). This provides a useful model that could be adapted to pastoral lands where regular wildfire is a problem.

Managing grazing distribution

Fire can be used strategically to more evenly spread grazing pressure across pastures. Normally cattle actively select palatable pasture species and preferentially graze certain parts of the landscape (Wilson et al. 1984). Under extensive conditions, cattle return to previously grazed patches, continually ignoring areas of rank mature pasture. Repeated defoliation of these preferred-patch areas can rapidly lead to a reduction in plant yield, death of desirable species, increases in undesirable species and development of bare and scalded areas (Bridge et al. 1983). As selective grazing continues heavily grazed patches expand and coalesce.

Burning rank, ungrazed pasture can break the pattern of selective patch grazing and promote a more uniform grazing distribution (Andrew 1986a). Cattle will preferentially graze regrowth from recently burnt areas (Ash et al. 1982) and display little selection between palatable and normally unpalatable species during the early part of the growing season (Andrew 1986b). To avoid overgrazing the same patches, burning must be rotated to new areas within paddocks, primarily to areas that are less heavily utilised.

Maintaining pasture condition

Fire and grazing can be used strategically to manage pasture condition and species composition. Burning season, frequency and grazing management can be manipulated to determine the impact fire has on the pasture layer. Burning during the dry season, when grasses have seeded and become dormant, generally does not affect the composition of perennial grass pastures that are in good condition (Mott and Andrew 1985a,b).

Wet season burning can result in changes in yield and species composition (Smith 1960). In the wet-tropics of northern Australia strategic wet season burning can be used reduce the proportion of native annual sorghum that dominates the graminoid layer of eucalypt woodlands (Stocker and Mott 1981; Lane and Williams 1997). Each year sorghum pastures produce massive fuel loads (5–8 t/ha) that promote frequent and damaging dry season fires and provide little nutritional value to cattle. Burning these pastures prior to the development of mature seed can result in a significant reduction in sorghum, as the seed bank is transient and most seed germinates or dies during the following wet season (Mott 1978; Andrew and Mott 1983).

When pastures are unburnt and lightly grazed for several seasons dry matter accumulates, tying up nutrients and smothering new growth. This results in pastures becoming moribund and unproductive. Burning can rejuvenate pasture without long-term changes in yield, cover and species composition (Norman 1969). There is evidence however that burning of pastures in poor condition should be avoided. Heavily utilised arid short-grass pastures in the Victoria River District are often dominated by *Brachyachne convergens* (summer couch), an annual 'increaser' species. Burning these pastures, particularly with intense fires, appears to destroy seed exposed on the soil surface, so that the soil remains bare and unprotected after the next wet season. (Dyer and Cobiac unpubl.).

Control of exotic weeds

The establishment and spread of exotic weeds presents a serious threat to the stability and productivity of pastoral lands (Grice and Brown 1996). Fire has a role in the containment and control of established exotic weed infestations as well as the protection of pastoral land against further invasion (Grice 1997a). Weeds such as rubbervine (*Cryptostegia grandiflora),* chinee apple (Z*iziphus mauritiana)*, mesquite (*Prosopis* spp.) and prickly acacia (*Acacia nilotica*) occupy significant areas throughout Queensland, result in serious losses in pastoral production and incur major economic costs. Most of these species are already established or have the potential to invade pastoral lands within the Northern Territory and Western Australia. Fire has potential for cost-effective treatment of large areas. It is likely however that fire will be most effective as a component of an integrated approach to weed management (Grice 1997a), being used in combination with either biological, chemical and mechanical agents.

Research indicates that exotic weed species vary greatly in their sensitivity to fire, and may differ in their vulnerability to fire at different life stages. Fire shows potential for the control of rubbervine and mesquite (*Prosopis pallida*). High mortality rates of both juvenile and adult plants occur following burning. By contrast juvenile and adult stages of chinee apple resist fire and sprout after burning from the base of canopy (Grice 1997b; Campbell pers. comm.).

The susceptibility to burning exhibited by smaller plants of most exotic weed species suggests that the use of fire prior to maturation and seed set will reduce establishment and help contain their spread (Grice 1997a). Even if fire does not cause high mortality of adult plants, it may reduce further spread by destroying seedlings or ungerminated seed. Although burning may not be effective against the adult phase of weeds such as chinee apple, research indicates that fire may help minimise spread by destroying seed (Campbell pers. comm.).

Establishment and management of improved pastures

Mott (1982) has reviewed the impact of fire on improved pastures. Fire can aid the establishment and management of *Stylosanthes* (stylo) pastures (Stocker and Sturtz 1966). Various species and cultivars of stylo have successfully augmented native pastures in the open eucalypt woodlands of northern Australia, leading to improved livestock growth. Establishment without cultivation is possible by sowing seed after effective rains into ash left by burning. Improved germination and seedling survival result from removal of accumulated litter, reduced competition from native pasture and provision of a favourable seedbed.

Prescribed fire can also be used to manage the grass–legume balance in pastures improved with stylos. Dominance of stylo and decline of native grass can occur after several years of grazing. When legumes exceed 40% of pasture yield, fire can be used to thin the stylo population and regain grass dominance. Perennial stylos will re-shoot following burning while annual species will persist via germination of seed stored in the soil.

Conclusion

Fire clearly has an important role in the management of pastoral land in northern Australia. Burning does occur throughout pastoral lands, however there are constraints to the widespread use of fire in normal management. Fire must be a carefully managed to meet specific sustainable objectives. In pastoral lands the interaction between fire and grazing is critical. The challenge for land managers is to manipulate grazing and fire to achieve specific objectives. Work on the impacts and management of fire is under way at specific locations in northern Australia. This work aims to gain a better knowledge of fire ecology and management and to provide solutions that ensure the useful integration of fire into land management.

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Role of Remote Sensing in Bushfire Management

R.C.G. Smith, R.L. Craig, M.T. Steber, A.J. Marsden, N.A. Raisbeck-Brown and J. Adams[1]

Abstract

To assist in the management of bushfires occurring over extensive areas of Australia a FIREWATCH service based on the Advanced Very High Resolution Radiometer (AVHRR) on the United States NOAA polar orbiting satellites has been developed. For this service AVHRR data are acquired automatically during the day from receiving stations in Perth and Melbourne, using the Internet for processing at the Leeuwin Centre in Western Australia. Additional AVHRR data are acquired weekly on tape from Darwin. Following processing, FIREWATCH information products are disseminated to clients in regional areas of Australia using the Internet and fax.

From the the visible, near infrared and thermal infrared spectral bands of AVHRR active fires, fire scars, fuel load build up and fuel flammability are mapped under cloud-free conditions. To assist in tactical management, the locations of hot spots of active fires are posted on the Internet and faxed to regional offices within 2 hours of the AVHRR overpass. To provide a fire history for management of controlled burning and to document the fire regime, the area burn by fire is mapped every 9 days. Fuel load build up and curing of the grasslands are estimated using the Normalised Difference Vegetation Index.

During October 1998, hot spots of fires in southeastern Indonesia were successfully detected from AVHRR data received in Perth. This trial indicated that southeastern Indonesia, with a dry season and cloud-free skies similar to northern Australia, would enable AVHRR optical sensors to be used to map fires, fire regimes, fuel loads and fuel flammability in near real-time. Therefore using AVHRR data from Darwin and Perth, the FIREWATCH project could be extended as part of an Indonesian–Australian collaborative research program into the management of fire in tropical savannas. This extension of FIREWATCH would provide a common data set on fire activity and seasonal vegetation conditions on both sides of the Timor Sea.

In Australia, where grasslands are the predominant source of fuel for fires that burn over large areas, satellites orbiting about 800 km above the earth are used to determine the location of bushfires, map the area burnt and also estimate the fuel load and flammability conditions that predispose towards fires (Smith et al. 1998b). This is achieved at a scale and accuracy not possible from human observations on the ground.

Use of this technology for bushfire management within grasslands in Australia has resulted from the development of an integrated system by Satellite Remote Sensing Services, Department of Land Administration, Western Australia (Smith et al. 1998a). This system ingests and processes NOAA data received in Perth, Darwin and Melbourne and distributes the resulting satellite information to managers in the field and strategic planners in the office. The following products are now routinely produced from the near real-time processing of AVHRR data:

1) Fire hot spots—to locate active fires and fire fronts in remote areas (Perth and Melbourne data only);
2) Fire-affected areas—to map area burnt, establish fire history and evaluate the effectiveness of controlled burning (Perth, Melbourne and Darwin data);
3) Curing Index—to estimate the flammability of grassland fuels at the onset of the dry season for planning controlled burning strategies;
4) Normalised Difference Vegetation Index—to monitor seasonal grass growth to estimate fuel load build up and future fire risk.

[1]Satellite Remote Sensing Services (SRSS), Department of Land Administration (DOLA), Leeuwin Centre, 65 Brockway Road, Floreat, Western Australia 6014
http://www.rss.dola.wa.gov.au

The success of the system depends on being able to access AVHRR data in near real-time from locations around Australia. The Internet is used to bring the Perth and Melbourne data to SRSS at the Leeuwin Centre for processing. AVHRR data from Darwin are acquired on tape. Fire information derived from AVHRR is distributed rapidly using the Internet and where the speed is inadequate fax is used. As a result the impact of distance and remoteness across the Australian continent is contracted and all persons have access to the same information. The same service could be readily extended to southeastern Indonesia using AVHRR data collected in Australia or Indonesia itself, providing a basis for improve interaction between fire managers on either side of the Timor Sea.

Mapping Fire Affected Areas and Fire Hot Spots in Rangelands

Land surface albedo in the visible, near infrared and shortwave infrared wavebands

From one satellite orbit to the next during the daytime, changes in surface reflectance resulting from reduction of vegetation cover by fire can be detected. An increase in reflectance is the common response on bright coloured soils in the spinifex areas of Australian rangelands. However, where significant carbon residue is left, reflectance is decreased and the fire scar appears dark, a response common in the wetter tropical savannas of northern Australia. This signature reversal makes automatic fire scar detection difficult. Decreased reflectance following a bushfire can also occur on dark soils, which have a lower reflectance than the surface vegetation cover. Thus from changes in the reflectance of the surface in the visible, near infrared and short wave infrared regions the **fire-affected area (FAA)** can be mapped from satellite. In agricultural situations the areas burnt are often too small and in forest the tree canopy too dense for the change in surface reflectance to be detected by the satellite sensor. From AVHRR only FAAs greater than 400 ha can be effectively mapped, but **fire hot spots (FHSs)** of areas of about 1 ha can be mapped.

Landsat-TM with 30-m resolution and a 16-day revisit cycle is the main low-earth polar-orbiting satellite measuring in the visible, near infrared and shortwave infrared regions, but unlike AVHRR it is not available in near real-time, at no cost or with mid-thermal spectral coverage. AVHRR with 1-km resolution and a daily revisit cycle measures in the visible, near infrared and thermal infrared spectral regions (Table 1). A single Landsat-TM image covers an area 180 × 180 km and costs $1500, while NOAA-AVHRR data cover a 2500-km swath × 5000 km along track and is free-to-ground.

The more frequent revisit times of AVHRR results in a high probability of detecting FAAs greater than 400 ha. With Landsat-TM, FAAs as small as 0.1 ha can be detected but, if vegetation regrows rapidly and cloud extends the 16-day revisit time to several months, some FAAs may disappear before they can be mapped.

Land surface temperature in the thermal infrared

In the mid thermal infrared (3.55–3.93 μm) waveband peak radiance emitted occurs at temperatures around 800°K. Therefore the heat generated by active fires can be detected from areas less than the 1-km resolution of AVHRR during the day and night. Hence many small fires in agricultural fields and under forest canopies are detected when the FAA is too small be ‘seen’ by AVHRR. However at 3.55-3.93 μm emissivity is below 0.9 and the sensor can be saturated by reflected solar irradiance, which causes ‘false’ hot spots to be detected, particularly in desert regions. Therefore FHS detection from AVHRR is restricted to night time, but geometric accuracy is limited by a lack of visible ground features for precise navigation. Also fires that start and end during the day may not be hot enough to be detected by night-time imagery.

Fires change surface emissivity as well as albedo, therefore the thermal infrared (10.5-12.5 μm) is suitable for measuring land surface temperatures and is also used in combination with other spectral bands for discriminating FAAs and FHSs.

Land surface roughness

Fires, by removing the vegetation cover, change the roughness of the surface and therefore FAAs can in theory be detected using radar in the microwave region (λ=1mm-1m). An advantage of using radar is the possibility in tropical regions of measuring FAAs under cloud. The main commercial satellite available for making such measurements is RADARSAT (λ=5.6 cm) with HH polarisation and a repeat cycle of 24 days. The length of the cycle can be reduced by pointing the sensor. The single wavelength and polarisation of RADARSAT limits the ability to map FAAs, but if the change in surface roughness is substantial then the FAA can be detected. A single image covering 100 x 100 km costs about $6000. The main application of RADARSAT will be where there is persistent cloud such as in tropical rainforests or during the tropical savanna wet season. We have not yet adapted RADARSAT to bush fire monitoring in Australia because of the cost and undeveloped benefits.

Mapping Grassland Fuel Load and Flammability

Fuel load and its *flammability*, two additional variables contributing to the risk of bushfire, can be estimated from the visible and near infrared reflectances. From AVHRR the seasonal flush of green vegetation growth is measured using the Normalised Difference Vegetation Index (NDVI) calculated using the visible and near infrared reflectances as

$$NDVI = (R_{nir}-R_{vis})/(R_{nir}+R_{vis})$$

where R_{vis} is the land surface reflectance in the visible waveband (0.58-0.68 μm) and R_{nir} is the land surface reflectance in the near infrared waveband (0.725–1.1 mm) (Smith 1994).

The NDVI in grasslands has a typical seasonal pattern in response to the growth and senescence of the annual grasses (Figure 1). The increase in NDVI during the wet season is related to the amount of fuel added by new growth and the decrease in NDVI with the onset of the dry season is related to the flammability of this fuel (Paltridge and Barber 1988). Total fuel load can be estimated in the absence of intensive grazing from the biomass accumulated in the current season and the time since the last fire. Similarly the NDVI during senescence estimates the level of curing or flammability of the grassland. The curing index is estimated from an inverse function of the NDVI to give minimum curing (CI=0) at NDVI=1 (Paltridge and Barber 1988).

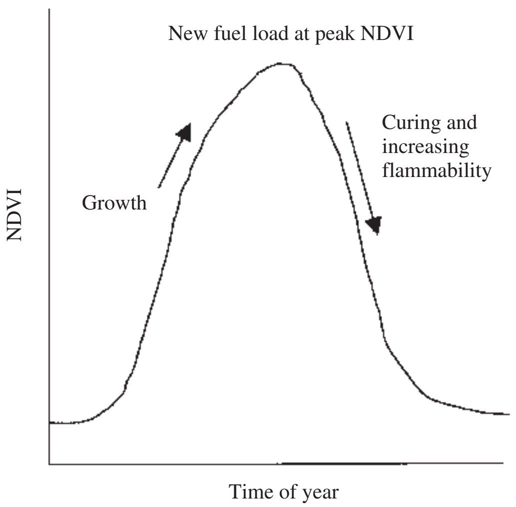


Figure 1. Change in NDVI with seasonal growth of grasslands in relation to fire fuel load and fuel flammability.

Satellite Selection

As indicated previously, choice of the satellite sensor selected for bushfire monitoring depends on the cost of real-time accessibility to the data, vegetation type, risk of cloud, revisit frequency, spectral bands and spatial resolution required. Candidate satellites are generally in low earth, polar and sun synchronous orbit. As satellite parameters are interrelated, the higher the spatial resolution the higher the cost of data and the less frequent the revisit times. Our focus is on use of the NOAA-AVHRR sensor (Table 1) because of its direct broadcast, low cost, frequent revisit and wide spectral coverage, which all compensate for its low spatial resolution.

Table 1. Characteristics of the NOAA-AVHRR satellite sensor.

Band	Wavelength (μm)	Waveband	Applications
1	0.58–0.68	Visible	Surface features, cloud, vegetation, albedo
2	0.73–1.10	Near infrared	Water, vegetation, firescars, albedo
3	3.55–3.93	Thermal	Fires and volcanoes
4	10.5–11.3	Thermal	Sea, land, cloud temperature and evaporation
5	11.5–12.5	Thermal	Sea, land, cloud temperature and evaporation

Swath 2800 km; Scan angle +/- 55.4°; Resolution at nadir 1.1 km; Revisit 12 hours; Repeat cycle 9.2 days.

Other satellite sensors are used when difference requirements exist. Hence Landsat-TM is used to map the extent of wild fires in southern areas for disaster assessment and for the management of fire in the Karijini National Park in the Pilbara, Western Australia.

Western Australia's Fire and Emergency Service concept for the integrated use of AVHRR to provide information on bush fires, fire history, fuel load and flammability for tactical and strategic management is presented in Figure 2. This model requires ultimately the incorporation of the fire information into a Geographic Information System with other geographic data for querying to address the more specific questions of fire managers and researchers. This system is evolving as these questions are being asked of the data.

Application in Operational Bush Fire Management

The application of the four sets of information is presented in Figure 2.

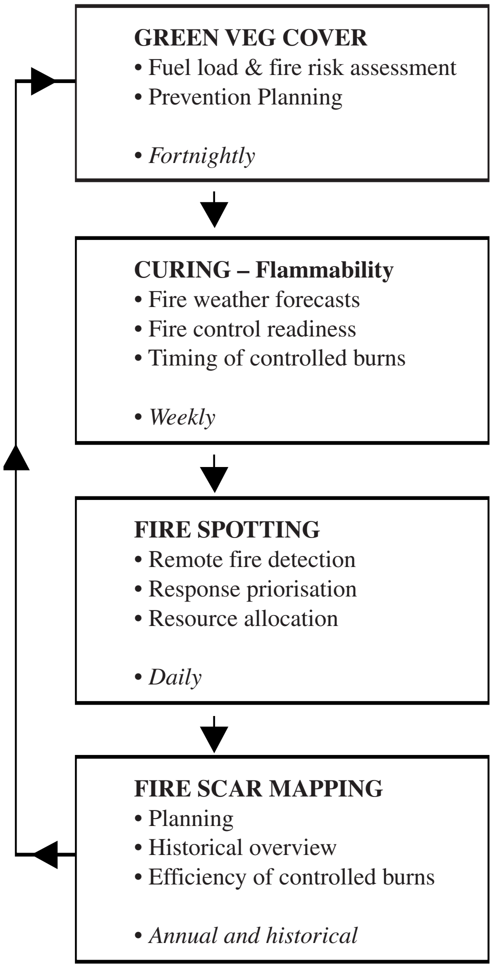


Figure 2. The application and frequency of information derived from the NOAA-AVHRR satellite sensor for tactical and strategic fire management by land managers (adapted from Mal Cronstedt, Fire and Emergency Services, WA).

Fire detection

The use of the four sets of satellite information for bush fire management by the Fire Management Services in northern Australia is illustrated in Figure 2. The most frequently used information is the FHS from the automatic processing of nighttime NOAA-12, -14 and -15 data, posted on the World Wide Web (WWW) at *http://www.rss.dola.wa.gov.au/noaafd/NOAAfd.html* within two hours of the overpass (Figure 3). Location accuracy at night is limited to the orbital model used for satellite navigation. Therefore to provide greater accuracy and interpretation of fire fronts, the early morning overpasses from Monday to Friday are processed manually by panning through the image and looking for groups of dark (hot) pixels in band 3 of AVHRR. This information is then faxed to appropriate regional managers and posted on the WWW. All the computer processing takes place within 3 hours of the overpass to provide land managers with a near real-time update of the location of currently burning fires.

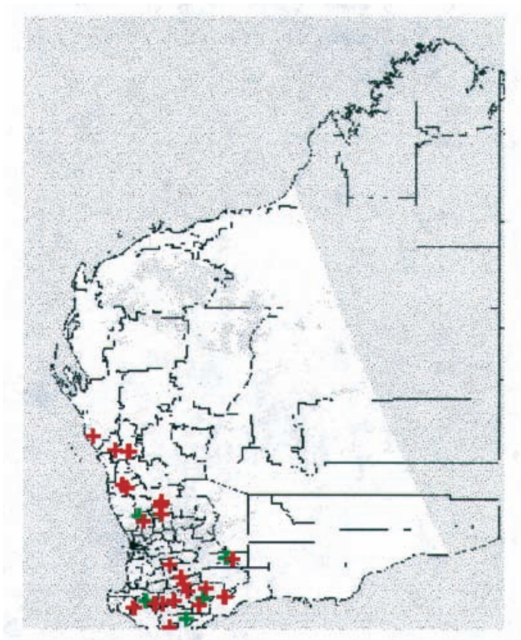


Figure 3. Example of a hot spot image on 3 April 1999 from NOAA-15 at 20.23 hrs. Red denotes hot spots that met all four criteria and green all hot spots that met three of the criteria used in the contextual algorithm employed.

The image (Figure 3) indicates a number of small fires from the burning of agricultural stubble prior to seeding in southwestern Australia**.** An initial study using AVHRR data during October collected in Perth indicated that this technique of fire detection is also applicable in eastern Indonesia (Figure 4).

The hot spots in Figure 4 indicate that hot spots of fires in southeastern Indonesia can be similarly detected. Using the NOAA-AVHRR data from Darwin to complement that from Perth the Australian

Fire Hotspots detected on the Islands of Sumba, Flores and Timor, Indonesia, October 1997

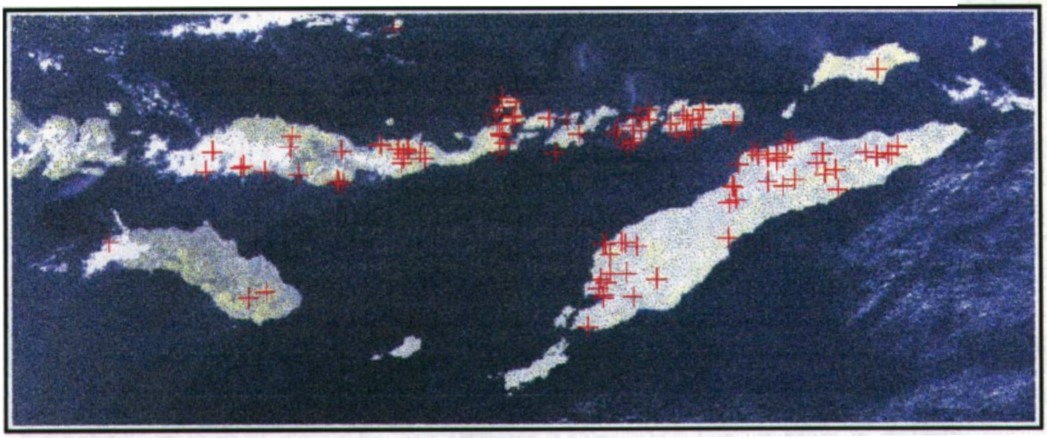


Figure 4. Hot spots detected in Indonesia from 14 fourteen NOAA-AVHRR overpasses collected in Perth during October 1997.

Produced by: Satellite Remote Sensing Services
Department of Land Administration, Leeuwin Centre, Perth, WA
Fires mapped using NOAA-12 satellite imagery during October 1997.
The red crosses indicate the position of fires during this period.

FIREWATCH project could be extended to cover southeastern Indonesia to provide similar products for fire management and fire research.

Fire history

The next most important information is the FAA which, when repeatedly mapped over time, is used to create a fire history (Allen and Russell-Smith 1999—see Figure 5). This information is also used to assess the efficiency of controlled burns in the current season, the area affected by specific fires and fuel load build up, to undertake strategic planning of controlled burns and to access the ecological impact of the frequency and season of the fire. Early-season cool fires in general cause less ecological damage to woody species than later-season hot fires. The FAA has been shown to have adequate accuracy for this purpose (Langaas et al. 1999).

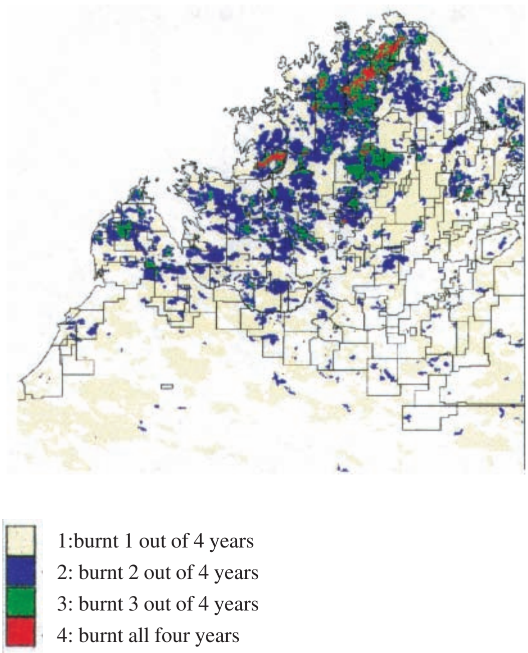
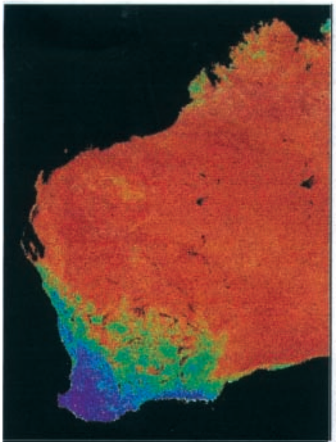


Figure 5. History of areas burnt 1993 to 1996 in the Kimberley region of north western Australia.

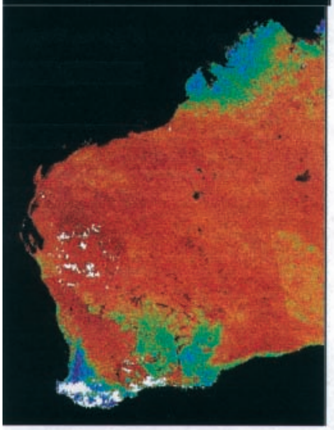
Fuel load build up and curing of grasslands or annual crops

Fuel load build up is estimated from the NDVI images that are produced twice a month from the combination of a sequence of overpasses to get a cloud 'free' view (Figure 6). Level of curing (Figures 7 and 8) is estimated from the NDVI of individual overpasses



Composite NDVI image, October 1997 showing the cured grasslands in north western Australia and the green pastures and crops in south western Australia

Green Vegetation Cover
Blue = high
Green = moderate
Brown = low



Composite NDVI image, April 1998 showing the green grassland growth in northwestern Australia and the cured crops and pastures in south western Australia.

The perennial forests and dense woodlands remain green.

Data in white areas were cloud affected.

Figure 6. Contrast between the NDVI in October 1997 and April 1998 showing the changes in green vegetation cover of grasslands due to changes in seasonal growing conditions.

during the senescence phase of the seasonal NDVI cycle (Figure 1).

The curing index in Figure 7 of the agricultural area of southwestern Australia was produced for the Fire and Emergency Services, WA. It is used in combination with meteorological information to forecast the fire risk and to decide whether a total fire ban should be imposed. This same index is produced for northern Australia for the purpose of planning the timing of controlled burns using aerial incendiary devices to get optimum results across large areas (Figure 8).

Conclusion

The success of FIREWATCH depends on the processing of large amounts of AVHRR data in near real time into relevant information products. Data from nighttime orbits of three satellites—NOAA-12, -14 and –15—received in Perth and Melboure and transferred to the Leeuwin Centre by Internet are currently automatically processed for FHS. This results in up to 20 overpasses being processed every day for FHS information. Automation of this process has enabled provision of this service 24 hours a day 7 days a week to Western Australia, Northern Territory and South Australia.

Provision of this satellite information as a routine service has received favourable response from managers of bush fires in Western Australia and Northern Territory. The Bush Fires Service in WA reports that negative attitudes of land managers to fire management, typified by the feeling that little can be achieved, have been changed positively when reliable near real-time information has been made available. The set of AVHRR information products represented in Figure 2 provides new tools for the management of bush fires in remote areas where information is sparse. Figure 2 depicts the future development of these tools within a GIS that will give land and fire managers better ability to query this information. The AVHRR sensor has limitations but these need to be weighed against the requirement for low-cost near real-time information, which only AVHRR's daily, regional coverage can achieve.

The current FIREWATCH service could be extended to southeastern Indonesia where the climate is similar to northern Australia. AVHRR data collected in Darwin would provide coverage 3000 km to the north and east of Australia. The main requirement would be the establishment of an Internet link between Darwin and Perth of sufficient speed to get the AVHRR data to the Leeuwin Centre for near real-time processing and delivery to fire managers in southeast Indonesia by Internet, fax and ordinary mail. Such a service would provide a useful basis for research into the management of fire in tropical savannas. It would provide a comparable set of data for research and management on both sides of the Timor Sea.

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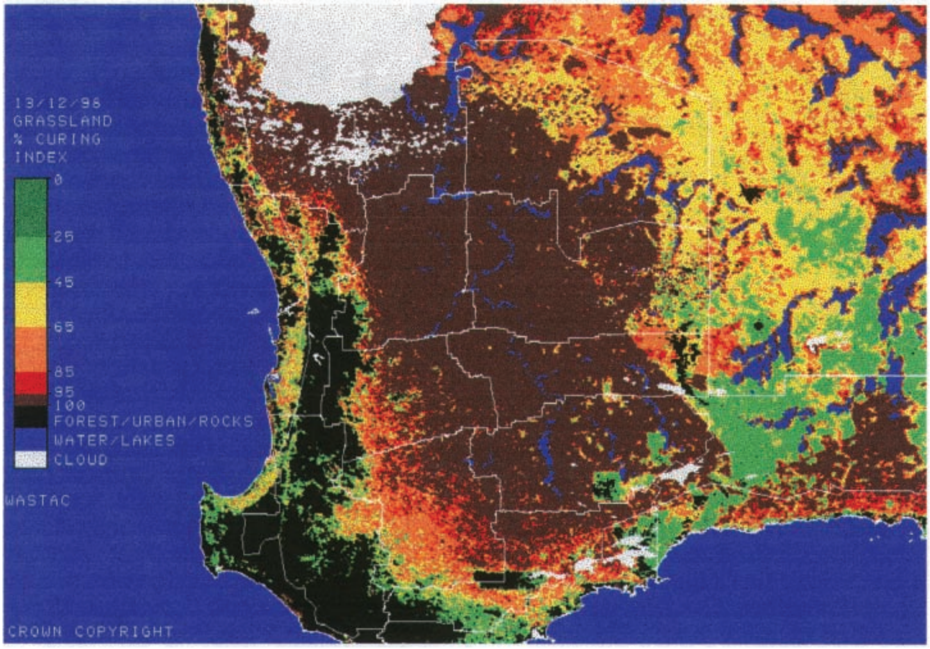

Figure 7. Example of a curing index image from 13 December 1998 from a single afternoon NOAA-14 overpass for use in bush fire risk forecasts.

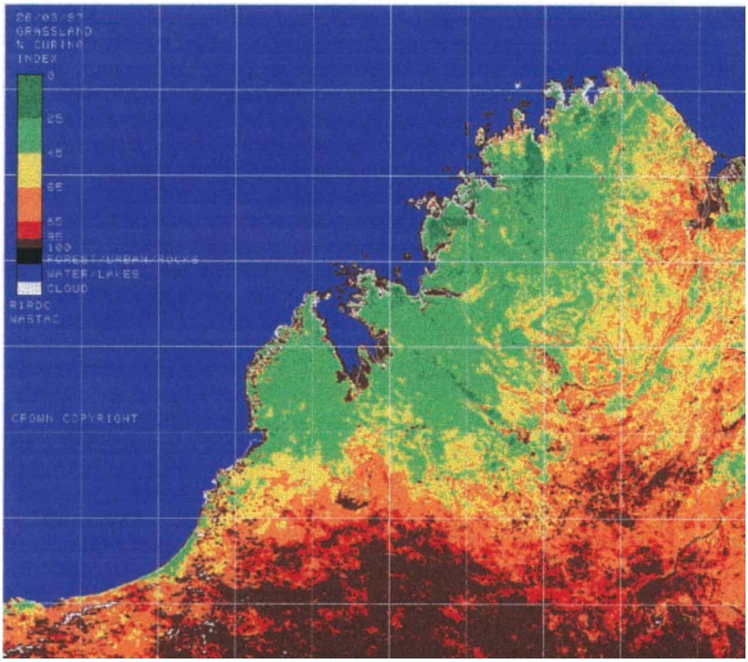

Figure 8. Curing index of 26 March 1997 produced for the Bush Fires Service to estimate fuel dryness to assist in timing controlled burns.

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Communication and Fire Management in Northern Australia

Peter Jacklyn[1]

Abstract

How do we communicate effectively in the area of fire management? There has been little detailed research on this issue. This paper draws on the little information available, primarily from recent workshops on fire management in northern Australia, to draw some rather broad conclusions about where we should be heading. It starts by listing the reasons why communication is important for fire management in northern Australia. Some broad rules about how such resources might best be used in a communication strategy for fire management are then discussed. The paper concludes with a brief overview of the activities of the Tropical Savannas Cooperative Research Centre in fire management communication.

EFFECTIVE COMMUNICATION is an important part of effective fire management in northern Australia. This is a message that consistently emerges from workshops and fora on fire management involving a broad range of fire managers across the region (Jacklyn and Russell-Smith 1998; Russell-Smith and Saint 1998). Numerous techniques and skills of communication are needed for effective fire management—many more than are found in most professional communicators. And reliable expertise is especially vital when one considers the nature of bushfires in northern Australia.

Effective Communication for Effective Fire Management

Some of the characteristics of northern Australian bushfires that are relevant to communication are listed below.

Large size of northern fires

Figure 1 shows satellite imagery of the fire history for northern Australia in 1998. Some of the fires over this time were very large, spreading over land tenure boundaries across different pastoral properties but also across land managed by quite different groups. This can be seen in the land-use map of northern Australia (Figure 2). It shows that pastoralists and aboriginal communities manage the largest areas and that significant chunks of land are managed for conservation and by the defence forces. Added to these groups are tourist operators who influence attitudes, and mine operators who manage fire on mine sites.

Given the size of northern fires, effective fire management requires that all these groups in a given region may need to communicate with each other to devise a coordinated approach. An example of this is seen in the Kakadu region in which a national park is bordered on the west by pastoral properties and defence forces land (Mt Bundy) and on the east by aboriginal land (western Arnhem Land). Wildfires fanned by strong southeasterly late dry season winds can spread from western Arnhem Land into the park or from the park onto Mt Bundy. To prevent such situations park fire managers, aboriginal fire managers and defence force fire managers need to cooperate.

Wide variety of fire management knowledge

Local and traditional knowledge gathered over many years or generations can be needed for good fire management because of the fine-grained and long-term nature of fire's impact on the landscape and because much of the landscape has been shaped by aboriginal use of fire (Russell-Smith 1997; Jones 1995). However, when a combination of these factors impacts on a landscape that is changing through

[1]Tropical Savannas CRC Northern Territory University, Darwin NT 0909

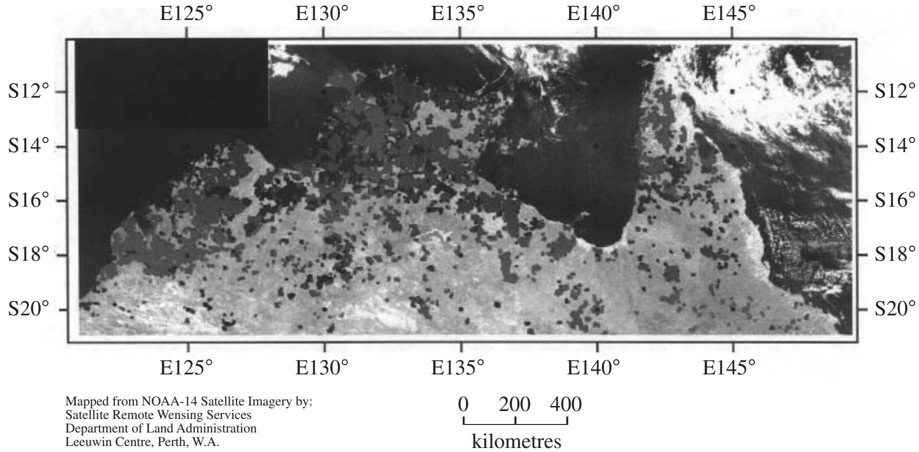

Figure 1. Western Australia, Northern Territory and Queensland fire history — 1998.

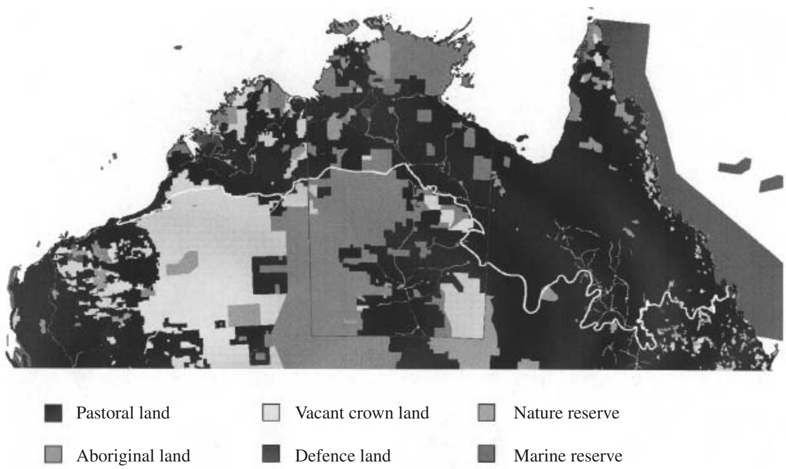

Figure 2. Tenure in north Australia.

human intervention, and this occurs in remote areas with sparser populations, scientific research and technology can also be useful for effective fire management (Andersen et al. 1999). And here the fire researchers need to communicate well with fire managers who have local and traditional knowledge.

This is no simple task. Research scientists have a different cultural outlook from fire managers in national parks, and this has led to communication difficulties over fire management in Kakadu (Andersen and McKaige 1997). The even greater cultural differences that can exist between aboriginal and pastoral fire managers and some fire researchers hinder communication (Andersen and McKaige 1997). Aboriginal and pastoral communities will often regard researchers as 'blow-ins' who have little respect for, and get little respect from the communities they have fleeting contact with. Equally, some fire researchers are frustrated by what they see as an unsystematic approach taken to fire management by the fire managers.

Remoteness of many fire managers

Once people decide that they want to manage fire more effectively they need access to relevant fire management information. At present this is difficult: most scientific papers on fire management are tucked away in university libraries, yet most fire managers are in remote locations across the tropical savannas. Furthermore much of the local and traditional knowledge is not in written form. Intellectual property issues are crucial when considering the wider dissemination of this knowledge.

Emotive nature of fire

Fire management can be an emotive and politically potent issue and public attitudes, regardless of their foundation, can shape political responses to fire management and legislation. In Western Australia, for example, fire management policy is largely determined by attitudes prevailing in the populous southern–western corner, with a consequent emphasis on fuel reduction burns and fire suppression to reduce the danger to life and property from catastrophic fires. This policy can be inappropriate when applied in the Kimberley region. To get more appropriate fire management policies, greater public awareness of fire management is useful (Anderson 1997; Jacklyn and Russell-Smith 1998). For northern Australia the 'public' here are largely the residents of the large urban centres in Western Australia (WA), Queensland (Qld) and the NT, who influence the fire management policymakers in those jurisdictions.

Importance of legislation

Because of the danger to life and property, fire management is bound by laws in each state and in some cases these laws may need to be changed to accommodate more effective fire management in northern Australia. Hence, there is also a need for more targeted awareness communication—the lobbying of politicians and other key decision-makers on fire management (Jacklyn and Russell-Smith 1998).

Improving Communication in Fire Management

Given the importance to fire management of the forms of communication identified above, what follows are some 'rules of thumb' about how such communication may be encouraged.

Use meetings—especially workshops and hands-on demonstrations

Creating better communication between different fire managers and between fire researchers and fire managers requires encouraging conversation between people who often have quite different cultures and perceptions concerning fire. Here a valuable technique is to use meetings or workshops where people talk informally and on a one-to-one basis.

It can also be important that at such meetings the information provided by the different participants is given equal value. For example a workshop that is run after the major decisions have already been made for the purposes of publicising research and/or management may be resented by those not party to the decisions. Consultation needs to take place at all stages of research planning (Andersen and McKaige 1997). Workshops aiming to bridge cultural gaps have a greater chance of success if participants feel they have a reasonable chance of influencing workshop outcomes.

An example here is the North Australian Fire Managers Workshop run by the Tropical Savannas CRC in Darwin in March 1998, where participants included fire researchers and fire managers from across the savannas representing aboriginal communities, the pastoral industry and the defence forces. The workshop was designed to identify fire management issues in the various regions and sectors of the tropical savannas. There were opportunities for break-away discussion groups involving a mix of different fire managers with a common interest in a particular region or sector—which encouraged a useful exchange of diverse views on a particular problem. This workshop received good feedback from almost all participants. It was, however, an expensive undertaking.

An emphasis on 'hands-on' tackling of concrete problems was seen in the successful Kalumburu Fire Workshop, which involved mainly pastoral and aboriginal fire managers getting together with fire researchers near Kalumburu in the northern Kimberley for a demonstration of remote sensing techniques in mapping fires. An area was set alight—a satellite passed overhead and the consequent images of the fire scars were recorded. Getting people to cooperate in practical demonstrations of fire management techniques like this can be a very effective way of communicating the value of the techniques as well as getting different fire managers and researchers to better understand each other's point of view. Again this workshop was very well received by its participants.

Establish good community connections

The skills needed to conduct such workshops are relatively straightforward organisational abilities. However, in order to get useful attendance from often tight-knit aboriginal and pastoral communities, good relationships with those communities are also needed. Establishing mutual respect and trust with a community—not just through workshops but through many different avenues—builds the basis for effective communication with a group. These relationships can't be bought or learned or built quickly.

Another important asset is good connection with key organisations in different sectors and fire manager groups, e.g. with the fire services, pastoral groups, tourist operators, aboriginal organisations etc. Events such as the North Australian Fire Managers Workshop, which saw over 100 people attend, are good at building such links. The Tropical Savannas CRC is also well placed here, having associations with 16 partner agencies, most of them involved in fire management.

Seek professional advice when appropriate

More conventional public relations and media skills are needed to run public awareness campaigns. The production of brochures and the planning of media campaigns targeted at large urban audiences are often best handled by professionals with the design and graphic skills and the media experience. Urban audiences are saturated with slick messages and it takes a well-packaged publication or media campaign to succeed here (Andersen and McKaige 1997; Macnamara 1984). It can also take a deal of luck to get your message across to an urban audience—particularly if the message attempts to convey complex environmental issues. Mazur (1998) describes the convoluted and unpredictable process of influencing public opinion on major environmental issues through mass media coverage.

Considerable resources can be wasted trying to reach a mass audience through the more glamorous media outlets, whereas smaller, regional audiences are easier to reach, particularly if the fire issue is locally relevant. Small local newsletters or newspapers will often publish press releases verbatim if the subject is considered of interest.

Use smart lobbying

Similarly, when it comes to lobbying politicians, experience in the field helps. CSIRO has recently been running national science briefings in Parliament House in Canberra, featuring key scientists giving short, punchy lunchtime presentations to politicians. The organisers found that the presentations must be tailored to politicians—not more than seven minutes long, for example, or the politicians tend to start looking at their watches (Parsons pers. comm). It also helps to be aware of the priorities of key politicians.

Another important audience comprises key decisionmakers who aren't politicians, such as opinion leaders in the fire manager communities. Lobbying here can be very effective but often requires a good relationship with the group concerned.

Establish an accessible database of fire management information

All fire managers do not need direct access to such a database. But if land management agency and fire service officers have access to such information, and if it can be spread by various other media, then it will be indirectly accessible by most fire managers and a broader audience.

This strategy has a low probability of complete failure. Public awareness campaigns can misfire or be misinterpreted, lobbying can run into brick walls and workshops can attract the wrong people, yet an information database will always be useful to somebody. And such databases once created are there for the future when circumstances may be more favourable for successful fire management.

It may also be important to make such a database not just an instrument for disseminating the 'gospel' on fire management—but to make it also a way of gathering fire information from users. This allows it to better incorporate useful local and traditional knowledge (assuming intellectual property considerations are accommodated) and allows it to be more effectively 'owned' by user groups.

Continuously evaluate the effectiveness of your communication

Given the lack of tried and tested methods in this area there is a need to continually test the communication techniques employed. This is particularly the case in fire management in north Australia because the different cultures involved mean that one particular type of communication will rarely work for all groups involved in fire management—and what does and doesn't work may not be intuitively obvious.

Fire Management Communication in the Tropical Savannas CRC

The Tropical Savannas Cooperative Research Centre (TS-CRC) is an unincorporated joint venture between 16 partner agencies covering the major research and land management agencies servicing the tropical savannas, together with the region's universities. It also has close links with stakeholder organisations such as the bushfire services, the Aboriginal Land Councils, pastoral research agencies and tourist bodies in north Australia. Thus it has a ready-made network suitable for fire management communication involving researchers from a range of disciplines and fire managers from a range of stakeholders. For more information on the Tropical Savannas CRC and fire management refer to Hill in these proceedings.

The North Australian Rural Fire Managers Forum

This forum involves the three bushfire services in northern Australia (The Fire and Emergency Services Authority of WA, the Bushfires Council of the NT, the Queensland Fire and Rescue Service) and the TS-CRC. Regular meetings allow whole-of-north Australia communication strategies to be formulated that exploit the links and strengths of the agencies involved. One of the first initiatives of the forum is a fire awareness brochure for north Australia, targeted at visitors.

'Clearing House' of savanna information

This will be a computer-based web-accessible database of land management information that will be launched in July 1999. One of the main areas covered will be fire management. The idea is that users will be able to visit our Clearinghouse website and then click on the region of north Australia where they are seeking fire management information. They will then get a summary of fire information for that region and can choose the particular fire topic that interests them (fire and weed control, fire and biodiversity, fire and grazing etc.). Alternatively they could get an overview of fire management information for the whole of the tropical savannas.

The database is designed both to disseminate information and to incorporate information from users, and it will be made more accessible to fire managers on the ground by exploiting the TS-CRC's links with the extension and outreach services of its partner agencies (see 'Extension and training' below).

'Savanna Links' newsletter

This quarterly newsletter has a circulation of around 3000, encompassing a broad distribution of tropical savanna land managers and land management agencies. It frequently features articles on fire management and associated land management issues. It can also be used to publicise information on fire management available in the Clearinghouse. All issues are available on-line and are integrated into the Clearinghouse.

Regional management studies

These focus on three particular regions in the tropical savannas: the Victoria River District in the NT, the Desert Uplands and the Burdekin catchment, both in Qld. The studies integrate different research disciplines and industry sectors and try to get managers on the ground working with researchers. All the studies involve fire management to some extent, and it is a focus of the VRD study. The Management Studies will provide important communication advantages such as getting fire researchers to work with fire managers; there will be ample opportunity for practical demonstrations and workshops.

Extension and training

The TS-CRC's extension and training projects will have major components incorporating fire management. These projects will exploit the research links of the TS-CRC, the fire management information in the Clearinghouse and the links to fire managers on the ground of the Management Studies. Some publications on fire management aimed at a broad audience have already been released, e.g. Schulz (1998).

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Institutional Linkages and Cooperative Approaches

Eastern Indonesian and Northern Territory Tertiary Institutional Linkages

Chris Healey[1]

Abstract

From its inception the Northern Territory University (NTU) has had a strong orientation towards Southeast Asia in both teaching and research. Indonesian studies have been an important part of this orientation. This paper provides an overview of the development of formal linkages between the tertiary institutions of the Northern Territory and their neighbours in Eastern Indonesia, and offers some comments on the potential for these links to contribute to a better understanding of fire management and sustainable development in our region. It also contains observations about the significance of the current waves of unrest in Indonesia for reaching longer-term research objectives on fire management, sustainable agriculture and forestry development.

THE EMPHASIS of this paper is on the Northern Territory links established with Indonesian universities, especially from the perspective of the Northern Territory University (NTU). My comments are based on firsthand experience in collaborative research with eastern Indonesian universities, as a member of NTU delegations to annual meetings with Indonesian partner institutions, and as a former Dean of the Faculty of Arts at NTU, which has been particularly active in developing institutional links in Southeast Asia.

NTU is the largest research and teaching organisation in the Northern Territory. The University maintains close links with other research organisations operating in the NT in a range of fields, but especially in the environmental sciences. NTU was established in 1989, through a merger of the Darwin Institute of Technology (DIT, formerly Darwin Community College) and the University College of the Northern Territory (UCNT). From its inception, NTU has had a strong orientation towards Southeast Asia in both teaching and research. Indonesian studies have been an important part of this orientation.

Southeast Asian and Indonesian Studies in NT

As a small university contending with an increasingly competitive national environment of tertiary education and research institutions, NTU has sought to focus its activities regionally. NTU has identified the northern Australian and the Southeast Asian regions as of special importance in its teaching, research and community service mission. Within Southeast Asia the BIMP-EAGA region (Brunei, Indonesia, Malaysia, Philippines–East Asia Growth Area) is considered of particular relevance to NTU's research agenda. This is also consistent with the Northern Territory government's promotion of Darwin as Australia's 'gateway to Asia'.

The combination of northern Australia and adjacent, primarily insular, parts of Southeast Asia is a natural and logical orientation. Despite cultural differences, northern Australia and eastern Indonesia in particular share some striking similarities in natural environment as well as experiences of social and economic 'development' in the late 20th Century.

There is considerable potential for research across the environmental and social sciences that systematically explores commonalities and contrasts across insular Southeast Asia and northern Australia. The present project on 'Fire Management in Eastern Indonesia and Northern Australia', involving the Cooperative Research Centre for Sustainable Development of Tropical Savannas, is an important step in this direction. The project is complemented by other research initiatives at NTU. The activities of the Centre for Indigenous Natural and Cultural Resource Management are highly relevant for an understanding of Australian aboriginal relations with the environment. A complementary research project titled 'Arafura

[1]School of Southern Asian and Australian Studies, NTU, Darwin NT, Australia

Linkages' has recently been initiated in anthropology at NTU (Healey 1999). This project embraces the study of change and development over the last 2500 years of the peoples and cultures of the lands in and bordering the Arafura Sea, and includes attention to sociocultural dimensions of resource management, particularly in eastern Indonesia.

A Centre for Southeast Asian Studies (CSEAS) was established at the UCNT to coordinate research interests in the region. The CSEAS is located within the Faculty of Arts, but with a brief that encompasses interests across the full spectrum of disciplines dealing with Southeast Asian issues. (Note that since the presentation of this paper at the Workshop, the former Faculty of Arts has been regrouped into a larger Faculty of Law, Business and Arts, which now hosts the CSEAS.)

The CSEAS actively fosters research and scholarship on Southeast Asian topics, especially in the humanities, social sciences and environmental sciences, and serves as a point of contact for a number of informal and formal institutional linkages. (The foundation Director of the CSEAS was Dr Paul Webb. Dr Ian Walters succeeded him in 1997. In the same year the Centre went through a review of its operations by the NTU Research Committee, which endorsed continuing support for the activities of the Centre for a further 5 years. In line with recommendations of the review panel, the CSEAS is becoming more directly involved in research and delivery of award and non-award teaching programs.)

Table 1 outlines some of the major areas of research and teaching at NTU dealing specifically with Indonesia. The majority of research projects conducted by staff and postgraduate students that are focused locally or regionally, rather than at national level, are conducted in the eastern Indonesian provinces of Maluku, Nusa Tenggara Timur, Timor Timur and Irian Jaya.

Several other Northern Territory institutions have established research interests in Southeast Asia, and especially eastern Indonesia. These include the North Australia Research Unit (NARU) of the Research School of Asian and Pacific Studies at the Australian National University, the Museums and Arts Galleries of the Northern Territory, and a number of Northern Territory government departments, including Asian Relations and Trade, Education, Health and Community Services among others. Government departments and instrumentalities have established contacts with Indonesian counterpart departments. NARU recently entered into an MOU with the Indonesian Academy of Sciences (LIPI: Lembaga Ilmu Pengetahuan Indonesia).

NTU has a considerable concentration of expertise across a range of fields in those areas of eastern Indonesia most relevant to the concerns of this Workshop. To the potential benefits of this expertise

Table 1. Indonesian studies at NTU.
A summary of major areas of activity by broad discipline area within the last 5 years in both teaching and research is outlined below. This list is intended to indicate the range of interests, rather than be exhaustive.

Discipline	Research & teaching interests
Anthropology and archaeology	Early hominids, human ecology, ethnobiology, migration and urbanisation, natural resource management, maritime adaptations, ritual and religion, material culture
Economics	National economy, tourism
Engineering	Power generation and conservation
Environmental sciences	Ecology and natural resource management, botanical studies, ornithological studies, conservation biology
Fine Arts	Traditional and contemporary arts practice
Health sciences	Nursing education
History	History in eastern Indonesia, the role of the church in development in Indonesia, regional histories in Timor, Flores
Indonesian language, literature and cultural studies	Old Javanese, Balinese languages and literature, modern Indonesian literature, European representations of Indonesia, modern Indonesian theatre
Law	Business law in Indonesia, Islamic law
Linguistics	Teaching Indonesian as a foreign language, studies of regional languages in Bali, Timor, Irian Jaya
Marine sciences	Aquaculture, fisheries
Music	Traditional and contemporary music practice
Political science	Indonesian government, media in political system, Australian foreign policy
Multidisiplinary	Several research projects involving input from: Anthropology, Environmental Sciences & Linguistics, Anthropology, History, Indonesian Studies & Political Science

are added the international network of institutional links built up over recent years. This network complements local and national links, of which the partners in the Cooperative Research Centre for the Sustainable Development of Tropical Savannas are a prime example.

International Institutional Links

At present NTU has entered into formal agreements with 24 institutions in nine countries in the Asia-Pacific region. Table 2 summarises these various international agreements, all of which are supported by government-to-government agreements. Thirteen of the agreements specifically include reference to collaboration in research, and 11 of these agreements are with institutions in Southeast Asia. Six of these agreements are with universities in eastern Indonesia (see Figure 1). NTU is thus relatively well prepared through formal institutional links to undertake collaborative research in eastern Indonesia.

The Indonesian universities with which NTU maintains links are the leading state universities in the Provinces of Bali (Universitas Udayana), Nusa Tenggara Barat (U. Mataram), Maluku (U. Pattimura), Nusa Tenggara Timur (U. Nusa Cendana), Irian Jaya (U. Cenderawasih), and the private university servicing East Timor (U. Timor Timur). A brief history of the development of the memorandum of cooperation (MOC) with eastern Indonesian universities, up to 1994, is contained in an NTU newsletter on the MOC (MOC 1994). Details of annual meetings are also published in the same newsletter series.

These six eastern Indonesian universities also maintain a close association with each other, and meet collectively with NTU on an annual basis (Table 3). Meetings are important as an effective means of maintaining cooperative relations, and provide an opportunity to review the progress on current projects and to discuss future directions.

Evaluation and Prospects for the Future

I concentrate here on the MOC between NTU and the six eastern Indonesian universities. While many specific projects are discussed at annual meetings of MOC members, they can be grouped into several general areas for the sake of this outline:

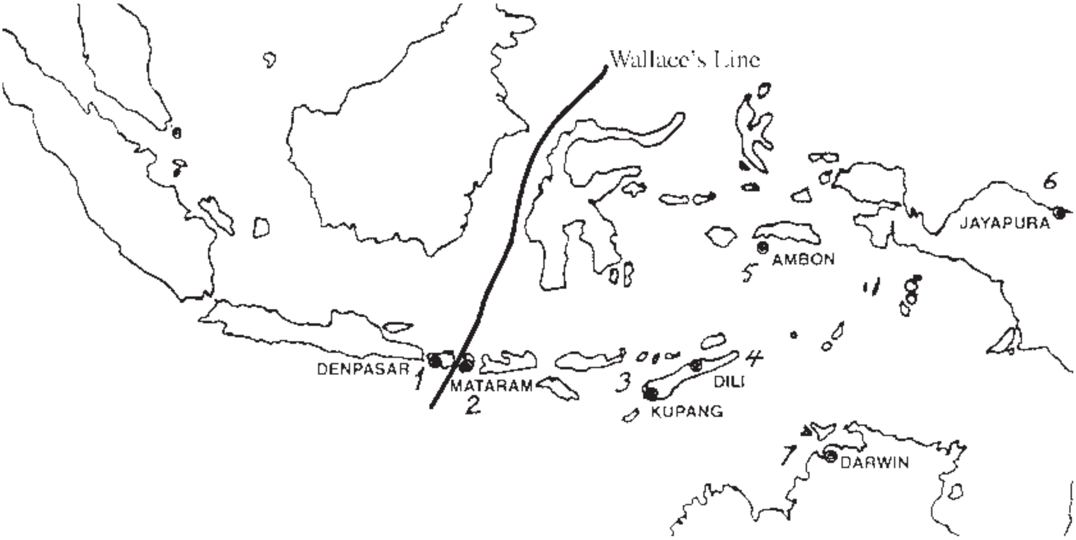
1. Capacity strengthening of university operations: involving library development, university administration, technical training, power and water supply

Table 2. NTU agreements with overseas institutions.

Country	Institution	TYPE*	R/T#
Brunei	Universiti Brunei Darusalam	MOC	RT
	Further Education & Management Consultants	A	T
China	Tsinghua University, Beijing	MOU	RT
	Chinese Management Association Hong Kong	MOA	T
	Shanghai Chinese Relief Foundation	LOI	T
	Hainan University	MOC	RT
India	Myrnd School of Catering, Hotel & Computer Management	MOA	T
Indonesia	Akademi Ilmu Pelayaran Negeri	LOU	T
	Balai Pendidikan & Latihan Pelayaran Dasar	LOU	T
	Universitas Cenderawasih (Jayapura)	MOC	RT
	Universitas Mataram (Lombok)	MOC	RT
	Universitas Nusa Cendana (Kupang)	MOC	RT
	Universitas Pattimura (Ambon)	MOC	RT
	Universitas Timor Timur (Dili)	MOC	RT
	Universitas Udayana (Denpasar)	MOC	RT
Malaysia	Kolej TAFE Malaysia	MOA	T
	Penang National College	LOI	T
	Universiti Malaysia Sarawak	MOC	RT
Papua New Guinea	PNG Institute of Public Administration	MOC	T
Philippines	University of the Philippines	MOU	T
	Mindanao State University	MOC	RT
Thailand	Sripatum University	MOU	T
Vietnam	Nha Trang University of Fisheries	LOI	RT
	Ministry of Fisheries	LOI	RT

* Type of Agreement: A = Agreement; LOI = Letter of Intent; LOU = letter of Understanding; MOA = Memorandum of Agreement; MOC = memorandum of Cooperation; MOU = Memorandum of Understanding.
# R = Agreement includes research; T = Agreement includes teaching.

Figure 1. Eastern Indonesian MOC Partners



(Source: Memorandum of Co-operation News, International Division, NTU, No.1/97)

1. UNUD–Universitas Udayana, Denpasar, Bali
2. UNRAM–Universitas Mataram, Mataram, Nusa Tenggara Barat
3. UNDANA–Universitas Nusa Cendana, Kupang, Nusa Tenggara Timur
4. UNTIM–Universitas Timor Timur, Dili, Timur Timor
5. UNPATTI–Universitas Pattimura, Ambon, Maluku
6. UNCEN–Universitas Cenderawasih, Jayapura, Irian Jaya
7. NTU–Northern Territory University, Darwin, Northern Territory

——— Wallace's Line

Table 3. MOC meetings with Indonesian partners and NTU.

Meeting	Host Institution
1. April 1991	U Pattimura, Ambon, Province of Maluku
2. June 1992	NTU, Darwin
3. May–June 1993	U Pattimura
4. June–July 1994	U Mataram, Mataram, Province of Nusa Tenggara Barat
6. June 1995	NTU
7. May 1996	U Cenderawasih, Jayapura, Province of Irian Jaya
8. June 1997	U Udayana, Denpasar, Province of Bali

NB:
1. At the 4th meeting, the numbering of the next meeting was incorrectly recorded in the Minutes as number 6. There was no 5th meeting.
2. Because of the economic crisis that hit Indonesia in 1997, and serious civil unrest, particularly in Maluku and Timor Timur, meetings scheduled for 1998 and 1999 were postponed.

2. Language training: in-country courses in Indonesian language
3. Social sciences and cultural studies: anthropology, customary and business law, linguistics, tourism studies, demography
4. Environmental and health sciences, agriculture and horticulture, aquaculture, marine sciences, animal husbandry, forestry, nursing training
5. Student and cultural exchange, sporting links

Some proposed cooperative projects in teaching and research require external funding, and lapse for lack of adequate resources. However, a number of projects have been completed successfully or are continuing. NTU continues to provide to MOC partners training and support in library development and general university administration. NTU offers a highly successful intensive in-country Indonesian language program through cooperative teaching arrangements with Nusa Cendana University in Kupang and Mataram University in Lombok. In addition, the Faculty of Arts and its associated Centre for Asia-Pacific Arts runs intensive courses in Bali on contemporary and traditional visual arts and music, in collaboration with other Balinese tertiary institutions and private organisations.

Turning to cooperative research, the most successful projects have been in anthropology and marine sciences. Both areas attracted substantial funding under the Targeted Institutional Links Program through the Australian Vice-Chancellors Committee, as well as funding from other sources. An ongoing anthropology project on change and development in Maluku Province involves anthropologists from NTU and Pattimura University in Ambon. This project received $120 000 in 1991, the first externally funded project to involve any MOC partners. A project on the development of aquaculture industries for trochus shell and other valuable marine resources has involved NTU and a number of MOC partners, but especially the Nusa Cendana and Pattimura Universities. It received $250 000 in 1993.

NTU has provided a limited number of special scholarships to enable staff from Indonesian MOC partners to undertake further studies at NTU. To date, several staff members have obtained laboratory technician qualifications, while others have completed or are currently enrolled in postgraduate research degrees in anthropology and linguistics.

I think it is fair to say that cooperative research activities undertaken under the terms of MOC links with eastern Indonesian universities have so far proved highly successful. This evaluation takes into account the success of research teams to attract external grant support, and the outcomes of research in terms of successful graduations of postgraduates from MOC partner universities, publications, and development of related research projects.

Indonesian MOC partners have demonstrated considerable enthusiasm for collaboration with NTU. A major impediment to achieving greater collaboration is the difficulty of obtaining funds for research projects. There is a tendency for Indonesian MOC partners to expect NTU to take the lead in the development and management of collaborative arrangements, and to secure the necessary funding. This is unfortunate for two reasons. First, it tends to inhibit our MOC partners taking the initiative for projects, including the development of closer cooperative research links between Indonesian institutions. Second, Indonesian institutions potentially have access to national and international sources of funding that are not available to NTU as an institution from the so-called 'developed' world.

Five of the six MOC partners are located in provinces that lie east of the Wallace Line (see location in Figure 1). Among biogeographic features shared with northern Australia are savanna and woodland habitats with marked wet–dry monsoonal climates. These are widespread in southern Irian Jaya and the island of Timor, but are present in all provinces of MOC partners, including in western and southern Bali, and the south and southeast islands of Maluku. In addition, there are broad similarities of traditional patterns of exploitation and management of environments across much of eastern Indonesia, including the place of fire in subsistence strategies.

While broad environmental parameters and patterns of human interaction with the landscape are well known, details of variations at local level remain patchy at best. There is already considerable local expertise in the social and environmental sciences among staff of all MOC partners to fill in these gaps in knowledge relevant to fire management issues.

The research capabilities of MOC partners have been improving in recent years, as more staff in Indonesian universities complete research degrees—many from overseas institutions. This is important, as it means MOC partners will gain enhanced capacity to provide solid training for future generations of researchers. Unfortunately, relatively few universities in Indonesia offer research degrees, and as a consequence a research culture is not as highly developed as it might be. Nonetheless, there is undoubtedly great potential for a more coordinated use of the human and intellectual resources of the MOC partners.

There is also potential for building closer links between NTU, our MOC partners, and other government and various regional, national and international nongovernment organisations (NGOs) working in the areas of environmental resource management, social and economic development in the region. The Nusa Tenggara Community Development Consortium is an example of a well-established regional organisation in southeast Indonesia, but there are numerous other, often small, local NGOs (usually labelled *Yayasan* in Indonesian). MOC partners in the region are particularly well placed to mediate and advise in the development of these links.

The major threats to the research potential of eastern Indonesian universities come from the unstable economic, political and social environment of contemporary Indonesia. The sharp and continuing downturn in the Indonesian economy since 1997 has left universities seriously under-funded, and undermined their ability to provide research infrastructure. The recurrent waves of social and political violence are a major threat to national security. The human and material costs are high, particularly in Ambon and East Timor, where religious, inter-ethnic and political violence continues. Staff of Pattimura University have been killed, and there has been severe disruption to university operations and destruction of university facilities, including the new marine sciences laboratory on the north coast of Ambon near Hila. It is difficult for Indonesian nationals to maintain an active involvement in research in an environment of such turmoil, and virtually impossible in Maluku and East Timor (Brouwer and Soselisa 1999).

Assuming that the central government and provincial authorities are ultimately able to restore law and order in the worst effected areas, the current crisis is unlikely to affect researchers in the long term. However, it would be unwise to assume that MOC partners would simply be able to engage in collaborative research with the capacity they displayed prior to the current crisis without a period of rehabilitation.

Conclusion

The MOC between NTU and eastern Indonesian universities is now well established with a good track-record of successful collaboration in research in both the social and environmental sciences. This should be encouraging for future cooperation building on current networks. Subject to securing external funding, targeted projects should be sustainable and able to achieve goals, to the benefit of all participants.

Economic and political crises are likely to impact on resource use. Increasing poverty will drive many people to look for alternative or supplementary means of livelihood. The ability and will of national and provincial governments to implement and enforce regulations on environmental resource management must also be questioned as economic and political tensions continue. These largely social and cultural factors may have profound environmental consequences, including, for example, shifting patterns of subsistence-oriented agriculture, and changing emphases in the intensity and extent of animal husbandry, plantation agriculture, fisheries and aquaculture, forestry and forest clearance. These factors and their environmental impacts will need to be monitored. Researchers in MOC partner institutions are well placed to undertake such a process, provided that material resources, training and collegial support are made available and consolidate and enhance current research capabilities.

Acknowledgments

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Nusa Tenggara Community Development Consortium

Putra Suardika[1] and Suhardi Suryadi[2]

Abstract

The Nusa Tenggara Community Development Consortium is a network aimed at lifting the wellbeing of farming communities in the Nusa Tenggara region in Eastern Indonesia. It does so through information exchange and hands-on experience in methodology, technology and policy, linking up farming communities with people from government and non-government organisations, and from educational institutions. This paper describes the network's origins and how it has developed through consultation with all parties involved. Its focuses on developing activities that answer real needs of farming communities. Success of the network can be gauged from evidence of increasing participation of communities in program development using the techniques of particpatory rural appraisal (PRA), and greater awareness of conservation issues.

NUSA TENGGARA is a region of Eastern Indonesia which is situated to the east of the Island of Bali and south westerly from the Australian continent (see Figure 1). The region encompasses three provinces, namely West Nusa Tenggara (NTB), East Nusa Tenggara (NTT) and East Timor (Tim-Tim). The population of the three provinces is 7.4 million. The race of Nusa Tenggara represents a transition between the Malaysian and Papuan races, and possesses very complex and various ethnic characteristics. Per capita income is approximately one third of the national per capita income. Almost 60% of the population has only reached primary school level of education.

Most of the Nusa Tenggara community relies on dry farming, which is very dependent on rainfall, as their main source of income. The agricultural system was until recently simple, with rotation and slash and burn methods. However in the last decade, the management of plantations has intensified.

Characteristics of the Nusa Tenggara Community Development Consortium

Based on the natural, economic and social conditions mentioned above, along with experience learnt while assisting the community, in 1992 a few developers took the initiative of developing a cooperative network. The network that was created began with 12 institutions (eight non-profit organisations, one university and three donor institutes), with the aspiration of increasing the effectiveness of agroforestry development as an economic basis for highland and dryland farmers.This network, known as the Nusa Tenggara Community Development Consortium (*Konsorsium Pengembangan Masyarakat Daratan Nusa Tenggara—KPMDNT*), has grown in participation, programs, and activities and also in institutional management.

The Consortium represents an umbrella institution for communication, coordination and cooperation. As a network organisation delivered by developers, the existence of this Consortium is a medium for information and experience exchange in technology, methodology, approach, and policies between different groups. Groups which are involved in the network, amongst others, are non-profit organisations, government institutions, universities, donor institutions, local communities and other groups that have an interest in, and commitment towards, the community problems and conditions in the management of natural resources in NTT, NTB and East Timor (see Figure 2).

The Consortium has formulated a mission that can become an operational reference in network development. It encompasses a program to raise community prosperity and continuity in the management of natural resources through:

[1]World Neighbours Insular Southeast Asia, Bali, Indonesia
[2] Institute for Social and Economic Research Education and Information, Mataram, NTB, Indonesia

Figure 1. Nusa Tenggara, Eastern Indonesia (shaded islands).

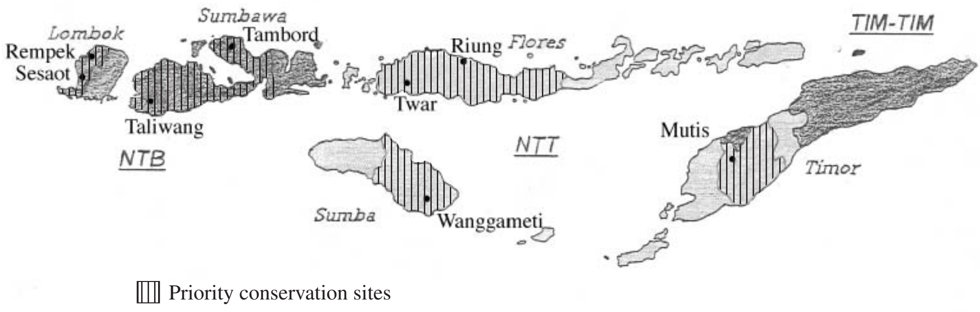

Figure 2. Provincial divisions of Nusa Tgenggara, April 1999, showing the eight conservation locations.

- umbrella institutes for coordination and communication between development elements concerned with the care of natural resources;
- empowerment of the community and its institutions along with human resource development in the management of natural resources;
- the provision of information and knowledge on all aspects such as traditional wisdom, social economy, ecology, technology and methodology;
- integration of gender concepts in developing programs and institutions;
- attempts at perfecting appropriate development knowledge that is acceptable to all parties.

Organisation structure and mechanisms

The sixth annual meeting in Mataram NTB in 1997 became the milestone for beginning to nurture a more formal consortium organisation. Although without a legal framework, the organisational structure will be an indication that the consortium intends to find its place as a development institution in Nusa Tenggara. The structure of the consortium is shown in Figure 3.

The ultimate decisions of the network are made through a consortium general meeting which is held once every two years. The network publishes the JALUR Bulletin every 3 months and shares work group activities (seminars, workshops, exercises etc.).

Programs and activities

In the beginning the network gave attention to the technical issues of dryland agriculture through its agroforestry program. But in its development, the programs and activities carried out by the consortium have grown. After 8 years five main issues have become the focus for the consortium, and these have developed into program areas and work groups. They are:

- Community economy development that is based on dryland farming management—agroforestry, integrated farming, postharvest and marketing. The agro-economy work group oversees the programs and activities.
- Participative approaches and management programs through participatory rural appraisal (PRA) methodology and conflict management. The PRA work group developed the programs and activities.
- The development of programs and institutions with a gender perspective. The gender work group developed these programs and activities.
- Community development in continuing management of forest resource conservation regions. Programs and activities managed by the KSDA working group.
- Development of media information, illumination, awareness and campaigns that support the four programs mentioned above. These programs and activities were managed by the media work group.

Community development programs in forest resource conservation area management focus their attention on the eight conservation locations shown in Figure 2. The program of strengthening community economy and management of dryland agriculture gives attention to communities and land that is in proximity to or within conservation areas. The direction of the programs is shown in Figure 4.

Generally the mentioned programs are carried out through activities, which are, amongst others:

- Research and documentation
- Training
- Cross visits or study exchanges
- Courses or comparative studies
- Meetings
- Workshops
- Seminars
- Media publications

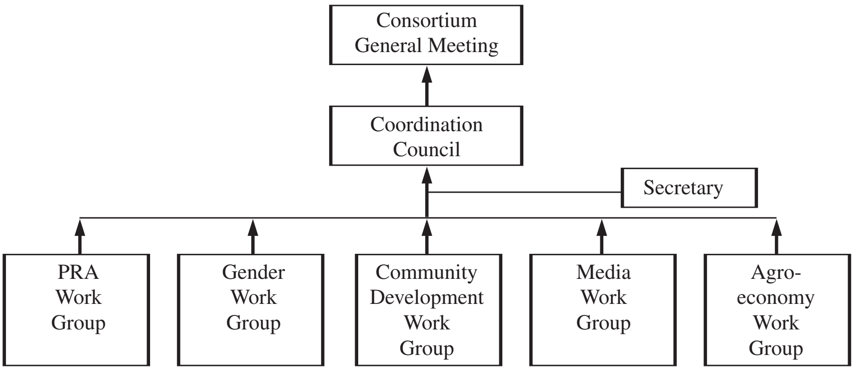

Figure 3. Consortium structure.

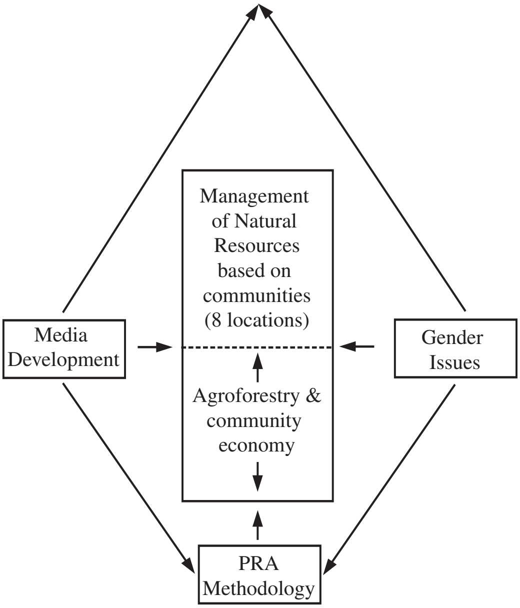

Figure 4. Program unification.

Impacts of the Consortium

Impacts of the programs that are seen now do not just constitute the consortium work results directly, but represent the signs and accumulation of cooperative processes and coordination between stakeholders as well as work from various participating institutions. Impacts of the consortium can been seen at various levels and they are, community, programs and policies.

Community level

- The formation of a number of local institutions in a few conservation areas that have multiple functions, these are to strengthen community unity, increase the economic wellbeing of members and conserve forest resources.
- Communities surrounding the forest preservation areas of Sesoat and Taliwang have the trust of the forestry department to manage the forest preservation areas with community forest methods.
- Insight, knowledge and community abilities in managing plantations that are stable and intensive increase through training study exchange, media information and assistance.
- Community participation and abilities grow in managing programs and fighting for their rights with participative approaches through PRA methodology.
- The formation of communication forums held by communities in conservation areas who have an interest in the management of natural resources, for example the communication forum of Wanggameti community.

Program level

- The formations of nuclear teams that coordinate activities at the local level in developing conservation area management.
- Research approach at regional level can bring all interested parties together to find a way out of natural resource management problems together.
- There are staff resource development programs in PRA methodology, conflict management, program management and networks. There are even enough staff institutions that get access to PRA methodology developments in and outside of Nusa Tenggara.
- There is an awareness and understanding towards the importance of gender issues in developing programs and institutions.
- There is a growth in partnership enthusiasm between government institutions, non-profit organisations, and the community in developing programs.

Policy level

- There has been a change in government approach from the ‘top down’ becoming a mixture between ‘top down’ and ‘bottom up’ and the use of PRA methodology in program development especially by the Forestry Department.
- There is an admission of the success of non-profit organisations in a number of areas especially from the community point of view.
- There is a new approach in conservation area management that previously was only orientated towards preservation but is now directed to increase community prosperity and preserve the area.
- A number of participating consortium institutions have active roles in developing participatory rural appraisal methodology, developing community forests through communication forums and participative meetings in the network at national level.

Analysis of the Consortium’s Development

After being active for 8 years, the consortium represents one of a few communication network organisations between institutions that exist in Indonesia. What is interesting about the consortium is that the work area does not end at the border of one province but works within three provinces. Many network communication institutes and cooperatives like the consortium have developed in Indonesia but there are a limited few that are still active. If there are any, they are only specific institutes and work areas, for example the non-profit organisation forum of Central Java.

To recite the existence of the consortium in carrying out programs and activities, a number of factors that supported its development are:

- Gradual planning and development through the organisations and activities that are in accordance with the demands and problems of community developments.

- Democratic management marked by transparency of activities and acknowledgment of the rights and responsibilities of all sides as well as cooperation in decision-making processes.
- Facilitation in shaping a concrete activity that became required by participant institutions; which in turn became the glue between efforts in coordinating perceptions and common commitments.
- Substantial number of institutions with a commitment and dedication to the role and activities of the consortium.
- Support from a number of donor institutes, both political support and funding for the realisation of its various activities.

Consortium development has been hampered by a number of problems and obstacles, amongst others:

- Many of the consortium's elite members from non-profit organisations are lost to the consortium when they leave their institution to find new experiences in other institutions or regions.
- Participants are spread through three provinces, thus increasing costs in carrying out each program. The consortium needs to cultivate new donors such as commercial businesses and seek more funding commitments from participating institutions.
- The involvement of government institutions in the consortium is still based upon personal approach, not an institutional one. The high frequency of personnel movement in the government means that constant effort is needed to develop new understanding towards new participating institutions and new government officials.

View of the Future

The consortium can be said to constitute the only network institution by a number of groups in promoting the process of participatory highland community development. The consortium represents a strength in building alliances, especially between regional governments that are not totally in agreement with practical political ways of influencing development policies. With the present condition of economic and monetary crisis, this consortium can offer enterprising highland village community development concepts.

Aside from that, Indonesia's changing political system that has become more open and democratic creates the possibility for the community to have control over government development initiatives that deviate from and are not in accordance with community aspirations. The problem is how far is the consortium able to anticipate a number of future Indonesian developments. The consortium will prevail, if it is suitable to the needs of the participants and it can face the next few challenges:

- The main well of funds of the consortium network is still dependent on one donor institution, which means there is a need to find diversified funding for network development at regional and local levels.
- The components and areas of participants in the consortium are not in proportion. This matter is visible in conservation management program, where location priority programs and participants are mostly from NTT, and so are other programs.
- There are demands from a number of network participants concerning how the consortium can have a higher profile role while working with some issues that are strategic and connected with public policy.
- The campaigning of development policies is still not carried out at optimal levels by the consortium whether at regional level or national level. The few consortium successes need to be communicated effectively and thus influence government policy on highland community development.
- There are no processes in place to measure the consortium's level of success in managing natural resources. Each side has its own indicators and the consortium has been challenged to formulate indicators and develop an evaluation and monitoring system that is participatory.
- Natural resource management polices are currently orientated towards community prosperity and environmental preservation. This matter represents a challenge for the consortium to develop concepts and models of natural resource management based on community and continuity.
- With regional autonomy and the need for objective information concerning natural resource management, the consortium is challenged to develop human resources in many aspects, through participative meetings, ecological research, the distribution of legal knowledge and promotion of agricultural technologies.

The consortium has had impacts at all levels—community, program, institute, and policy making. These are cumulative and provide the drive/motivation for all participants to extend and maintain their networks, and continue to work cooperatively at all levels. An evaluation of the consortium and its impacts at all levels is currently under way and it is hoped to have the results of the evaluation ready for publishing towards the end of 1999.

Development of Regional Synergies between Northern Australia and the Trans-Fly Region of Indonesia and Papua New Guinea

Michele Bowe[1]

Abstract

The Trans-Fly savannas of southern New Guinea (including Papua New Guinea and the Indonesian province of Irian Jaya) are broadly similar in the nature of their habitats, wildlife and indigenous landscape management practices, to areas of Cape York and the Northern Territory in Australia. These areas also share similar threats to the integrity of their ecosystems and native wildlife, such as recent changes in fire management, the impacts of feral animals and exotic weeds. World Wide Fund for Nature (WWF), through its offices in Australia, Papua New Guinea and Indonesia, is implementing a program called Tropical Wetlands of Oceania (TWO). The program area covers the savannas and coastal and freshwater wetlands of northern Australia and southern New Guinea. An important component of TWO is the Tri-National Wetlands Program (TNW), which aims to promote synergies between three protected areas in the region. These are Kakadu National Park in Australia's Northern Territory, Wasur National Park in Irian Jaya and Tonda Wildlife Management Area which is contiguous with Wasur and is located in Papua New Guinea's Western Province.

This paper focuses on the Tri-National Wetlands Program, describing how synergies between the protected areas are evolving. Particular emphasis is given to how the program was developed, the interaction of the various levels at which it operates, and especially the numerous lessons that have been learnt over several years of planning and implementation. These lessons have been distilled into a list of general pointers to guide other agencies and organisations intending to set up complex and multisectoral programs relating to the research and management of natural resources.

The Tri-National Wetlands (TNW) Program focuses on three conservation areas. Two of these—Wasur National Park, in the Indonesian Province of Irian Jaya and Tonda Wildlife Management Area in Papua New Guinea's Western Province, are contiguous and protect a large proportion of a biogeographical area in southern New Guinea known as the Trans-Fly. The third reserve involved in the program is Kakadu National Park in Australia's Northern Territory.

The three reserves contain extensive lowland wetlands and lie within the monsoon climate zone of southern New Guinea and northern Australia. Each reserve includes large expanses of seasonally inundated floodplains, an immensely rich system of critical importance for large numbers of migratory and resident waterfowl and waders. All three areas also contain large areas of savanna grasslands and woodlands, small rainforest patches and monsoon gallery forests. In addition are large tracts of undisturbed intertidal mudflats and mangrove in the coastal regions of the reserves. Indigenous people reside within each of the areas and have practised traditional forms of land management for centuries. The most significant management tool employed is that of dry season burning and this has had a profound impact on landscape and vegetation types that we see in the region today.

All three reserves share similar management problems related to exotic weed infestations (*Salvinia* and *Mimosa pigra* in Kakadu, *Eichornia crassipes, Stachytarpeta* spp*., Sida acuta, Chromolaena odorata* and *Mimosa pigra* in Wasur and Tonda). These weeds pose a critical threat to the integrity of the reserve's natural ecosystems. Additional grave threats are the impacts of feral and introduced animals including cattle, horses, dogs, cats and wild pig in all reserves, as well as the presence of vast numbers of introduced rusa deer (*Rusa timorensis*) and numerous introduced fish species in Wasur and Tonda. Other management concerns common to all three reserves include non-indigenous fire regimes and large-scale vegetation changes relating to invasion of woody scrub onto the floodplains grasslands.

Each reserve is currently at a different stage of management planning and implementation.

[1]Tropical Wetlands of Oceania Program World Wide Fund for Nature, Australia Darwin, NT Australia

- Kakadu is a World Heritage Site, and is managed through a joint management agreement between the Aboriginal traditional owners and the Director of National Parks and Wildlife. The Kakadu Board of Management was established in 1989 and has a majority of aboriginal members, representing the traditional owners of land in the park. The Board determines policy for the park and is responsible for preparing park management plans. The park is now operating to its Fourth Plan of Management and, compared with either Wasur or Tonda, has an advanced management structure and infrastructure, plus a federal budget to aid implementation of its management plan.
- Wasur National Park is the management responsibility of the Indonesian Ministry of Forestry's Department of Plantations and Nature Conservation (PKA). From 1991 up to the present the World Wide Fund for Nature Indonesia and PKA (formerly PHPA) have operated a project entitled the Conservation and Development of Wasur National Park. This project aims to develop and implement solutions to the most pressing problems faced by Wasur. A draft management plan has been produced for the park that is currently awaiting ratification. PKA have, in the last 18 months or so, resourced the park to include a manager and some 30 plus rangers, as well as a small amount of office infrastructure. The park however is not well resourced from an operational budget perspective.
- Tonda Wildlife Management Area (WMA) is managed by a committee of traditional landowners, which determines the rules for protection, management and exploitation of the fauna. The initial rules were established in 1975 and have been amended at least four times. In recent years the committee has not been very effective in management of the area. Lack of funds preclude regular committee meetings from taking place and there is a general lack of understanding about the role of the committee and a lack of awareness of some of the more pressing ecological problems. The amount of government support for the WMA is small. A small-scale WWF project is being run in the area, which focuses on awareness raising and capacity building for the committee. A WWF project officer also assists in the facilitation of linkages with the relevant groups in Irian Jaya.

All three sites are important under the Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar). The wetlands of Kakadu were designated a Ramsar site in 1991, Tonda WMA is PNG's only Ramsar site and Wasur has been nominated to become Indonesia's fourth Ramsar site.

The aim of the TNW program is to provide a planning framework which will enable the three governments to cooperate in the field of wetlands management. Specifically at a reserve level the TNW will facilitate a variety of collaborative activities which will further the management and conservation of the three reserves. Activities include:

1 The facilitation of a tri-partite memorandum of understanding (MOU) between the three governments that outlines a formal sister-park relationship between Kakadu, Wasur and Tonda reserves.
2 Using the Ramsar convention as a technical and convening forum, a tripartite coordinating committee will be formed which will determine the scope of work at a field level under the program. Such activities could include:
   - wetlands research programs and cooperative information exchange especially in relation to migratory birds, habitat change, indigenous management of the reserves, control of threatening introduced flora and fauna and the development of a regional database;
   - cross-visits between the reserves to facilitate training for wetland managers and rangers;
   - management planning assistance for the less developed reserves through regular workshops and progress meetings.

At this stage it is suggested that the tripartite coordinating committee via its secretariat would report activities and developments to the Ramsar Bureau.

Ultimately is envisaged that a trans-boundary conservation area arrangement would be established between Wasur and Tonda. This would enable cross-border collaboration for effective, cooperative management planning between the two reserves.

Reasons for Program Development

The program grew from the activities of WWF Indonesia, which initiated its project in Wasur National Park in 1991. Together with the Indonesian Ministry of Forestry's Department of Forest Protection and Nature Conservation (PHPA), a joint project focused on the production and implementation of a National Park Management Plan. The plan was developed following several years of research into management issues. Attempts to manage the most serious threats to the park including introduced and feral animal species, exotic plants and changed fire management regimes, quickly revealed the need to work in conjunction with neighbouring Tonda.

Many of the threats that Wasur and Tonda face, such as fire, feral animals and weeds, do not 'respect' the international border. There is an obvious need to link management actions and strategies across the border, for example weed control work that takes place in Wasur will not be effective unless communities in Tonda have a similar awareness of the problem and have the resources and capacity to act as well. Wild fires are also an issue that threatens both reserves. Customary owners of both Wasur and Tonda practiced fire management, with an awareness of the impacts on landscape, wildlife, important food resource areas and gardens. In more recent years, hot fires burn large tracts of land later in the season, with the result that people's gardens are destroyed, important areas of vine forest are damaged, and fires frequently burn uncontrolled until the next rains, often spreading across the international border.

Finally an obvious example of the need to work together to achieve successful management of Wasur and Tonda is the impact of large numbers of feral animals, especially the rusa deer. Some initial research has shown that the deer are causing large-scale disturbance to natural habitats, especially the grasslands within the reserves. The deer is perceived differently on either side of the border. In Indonesia although it is protected, there has in the past been widespread poaching of the animal to provide meat for the nearby township of Merauke. This has had the unintentional benefit of keeping the population suppressed to some extent. In PNG, the deer are not utilised heavily by the local population, although there is some trophy hunting from a wildlife lodge in Tonda. In both Wasur and Tonda there is not as yet a widespread perception that the deer are a threat. There is no traditional knowledge about the deer since it is an introduced species and in both sites there is a lack of expertise in wildlife and landscape ecology. In Wasur, although WWF had been raising the issues of weed control, feral animals and fire for several years, there had been reluctance (perhaps born out of a lack of real understanding) on the part of the park managers to act on any of these issues.

In 1993 after 3 years work in Wasur, WWF Indonesia brought a group of park managers and traditional owners from Wasur to northern Australia to visit Kakadu National Park. The visit was an unqualified success. Managers and communities could see for the first time a well resourced and managed national park. They could also see for themselves that active fire management was an integral part of the management plan, that other places also controlled feral animal populations and that weed control and prevention was an exceedingly high priority. Interest in tackling similar issues in Wasur was high and the possibility of further technical assistance, especially from another park management authority, meant that the managers in Wasur did not feel isolated and could promote these seemingly alien concepts to head offices in Jakarta with greater confidence.

It was within this framework of similarity of environments—threats, management needs and the need to promote information exchange—that the Tri-National Wetland program began to take shape. It was obvious from the experience of this initial visit that the customary owners and managers of the three reserves could learn much from each other, and at even a very basic level, experience and information sharing could do much to promote effective protection of all three reserves. In 1995 WWF Indonesia sought funding for a program that would further facilitate collaboration between the three reserves in the form of cooperative research programs, cross-visits and training of wetland managers, joint management planning for Wasur and Tonda and regular meetings of staff.

Forming and Maintaining Synergy

At the start of the program there were large differences between the level of management activity in each reserve. In addition the management mechanisms of the three reserves are very different. Both Wasur and Tonda needed funding support as well as technical and institutional support to assist in the management of the reserves. In the case of Wasur this was already provided to some extent by the WWF project on site, and there was already a good working relationship between the government agency, the communities and WWF. This meant that there was a previous relationship on which to build further components of work related to the TNW program. In Tonda, where management of the WMA is decided by a management committee comprising local landowners, the case was very different. Any involvement in the TNW program would need the full informed consent of the WMA committee. In 1996 WWF began a small-scale project in Tonda, which aimed to initiate discussion and agreement in PNG concerning a trans-border conservation project linking Tonda with Wasur. There had always been some local tension across the border area between PNG and Indonesia and so gaining the good will and consent of the local landowners was a critical move.

In the early stages of the development of the program it was evident that because of its international nature, there would be a need for some formal mechanism at a government level under which the collaboration could take place. The linkages between Wasur and Tonda required special attention as there was the added dimension of a shared international border, across which it was hoped that activities could take place. Therefore before looking at mechanisms for collaboration between the three governments, an initial focus was identifying options for Wasur and Tonda. As part of the field project in Tonda, WWF commissioned a report that identified mechanisms for legal and institutional coordination for a proposed cross-border conservation area.

The report concluded that any cross-border collaboration necessitated the inclusion of the project within the framework of an existing bilateral treaty between the PNG and Indonesian governments. The 'Basic Agreement between the Government of Papua New Guinea and the Government of the Republic of Indonesia on Border Arrangements' includes articles relevant to the proposed TNW program, including article 18 on protection of flora and fauna in the vicinity of the border. Pursuing collaboration through a high-level forum such as this would be time consuming and complex. However, the Basic Agreement on Border Arrangements would provide the framework in which to address a broader range of issues relevant to the cross-border conservation area, such as environment, security, border crossings and trade. Both the Indonesian and PNG government agencies have tabled the TNW at border liaison meetings that are held regularly under the Basic Agreement, to seek initial endorsement of the program.

In addition to the endorsement of the program bilaterally between Indonesia and PNG, it was considered necessary by all parties to formulate an agreement between the three countries involved. There are four levels of agreement deemed necessary to achieve good cooperation in the TNW.

- The first, as described above, was the agreement of landowning communities, especially in PNG. The process of consultation with communities in Wasur and Kakadu was less structured than the process in Tonda, involving informal consultation and discussion in Wasur, and discussion at a meeting of the Board of Management in Kakadu prior to a proposed visit of traditional owners to Wasur.
- The second level of agreement was at the 'park management' level, in other words the manager of Kakadu National Park, the head of Wasur National Park and in the case of Tonda, the Wildlife Management Area Committee.
- The third level of agreement was at an agency level in the three countries. This is the Department of Environment and Conservation in PNG, based in Port Moresby; PHPA (now PKA) in Indonesia, based in Jakarta; and the Australian Nature Conservation Agency (ANCA now Environment Australia) based in Darwin and Canberra. In Australia the confusion over which office should handle the cooperative arrangement has caused problems.
- An additional level of agreement that ultimately proved necessary to describe was that of WWF itself since three WWF agencies were operating in the program. WWF Indonesia was based in Jakarta, WWF Australia was based in Sydney, Australia and WWF South Pacific Programme ran its operations from Suva, Fiji and had a national office based in Port Moresby.

Liaison between all these partners has proved to be a sometimes difficult and lengthy process. Misunderstandings about who is doing what have sometimes arisen, but of more concern was the fact that it had been difficult to secure coherent planning and implementation of activities related to the TNW program. In the early stages of the program there was a tendency for a great deal of enthusiasm and energy but little synergy between partners.

It was also evident that a program requiring so much consultation and meeting to maintain clear planning processes would be expensive to maintain. Initially WWF acted as an informal facilitator to convene meetings and promote discussion. As responses from all three governments were positive it was decided that the program should be launched officially. Thinking ultimately about the sustainability of the program, WWF proposed that the TNW program be linked to the Ramsar Convention as a convening forum. All three countries are signatory to this treaty and so would normally meet every 3 years at the Conference of Parties. The Ramsar Convention also promotes international cooperation between member states. Therefore as both a cost-saving measure and also to enable the three countries to report on progress with the TNW program as part of their obligations as signatories to Ramsar, it was decided that the TNW program should be operated within the broader framework of Ramsar. Ramsar would also be able to provide technical assistance in the long term.

The TNW program was officially launched in 1996 at the 6th Conference of Parties (Ramsar) in Brisbane with the financial assistance of WWF and Environment Australia. At this first meeting of participants at an agency level, an in-principle agreement was reached to seek endorsement of the program at a ministerial level in the three countries. It was further agreed that on-ground work including workshops and initial exchange visits should proceed to allow formulation of training requirements and drafting of an implementation plan. This work would form the basis from which formal agreements could be drawn up for Government approvals. Following this meeting, WWF initiated its field project in Tonda and received additional funding for the work from WWF Netherlands and Environment Australia. This funding enabled further training and planning work to establish research priorities in the Trans-Fly. Several publications were ultimately produced—important records of discussions and opportunities that were identified and could subsequently be incorporated into a more formal memorandum.

A second meeting of TNW program participants occurred in 1997, where discussions focused on the development of formal mechanisms for collaboration between the three countries. It was decided that a formal Memorandum of Understanding should be developed. This MOU would formalise the existing informal relationships that had developed between the three countries as a result of field-level activities. Shortly afterwards in 1998. Indonesia developed the first draft of an MOU for discussion and amendment by the other two governments. The MOU was originally sent to Environment Australia for their initial comment and then was to be passed to PNG. Unfortunately changes in staff and department restructuring in Environment Australia have resulted in a bottleneck and very little progress has been made towards getting the MOU finalised. To date the Department of Environment and Conservation in PNG has not seen the draft MOU.

Although progress with the MOU has been slow there has been a great deal of activity happening in the field over the last 18 months. Several cross-visits have taken place, several training courses run, research and management begun in Wasur and a second phase of awareness and capacity-building activity begun in Tonda. Enthusiasm for the program at all levels remains high and there is every indication that although government bureaucracies move slowly, a multilateral MOU will ultimately support the wealth of field activity relating to the program.

Lessons and Conclusions

- Things take time to grow, consolidate and bring results. The Wasur work started in 1991 and WWF is still pursuing a formal government collaboration mechanism, although field-level activities are proceeding strongly. Policy change does not happen quickly and this has to be taken into consideration at the outset of a program because it has financial and other resource implications.
- Focusing at a formal institutional level is insufficient if this is not backed up by field-level activity. Similarly field-level activity will not magnify into something greater if there is no policy backup.
- The best programs grow out of existing work or projects and the agenda have to be developed and supported by local agencies. Outside agenda rarely work if there has been no ‘buy in’ or sense of ownership from local groups, agencies and individuals. There must be community and local agency (both government and non-government) input into the design phase of the program.
- Always build on existing local institutions and take advantage of existing processes rather than create new ones. This ultimately ensures continuity and sustainability since the program will not depend on outside resources to maintain momentum.
- Complement existing and related programs where possible and from the outset find out who is doing what and where and how this can link in.
- Determine common objectives for the program following consultation and set these down clearly so that they are understood and remembered (especially institutionally when key individuals move away—see below).
- Maintain a constant dialogue between stakeholders, even when there has been temporarily no substantial progress, to keep people’s interest alive and maintain clarity of process.
- The support of key individuals is extremely important for rapid short-term progress, *but* long-term progress and success will be achieved if concepts are institutionalised and result in a change in policy or legal frameworks that ultimately change the attitudes of people.
- Formal agreements at a decision-maker or policy level provide confidence to field-level personnel that their actions will be approved.
- It can be extremely difficult to maintain continuity. With the example of the development of the MOU, WWF has had to deal with as many as seven individuals in one government agency alone in the period of 8 months. Drawbacks will inevitably occur as departments restructure or are absorbed and your key people move on.
- NGOs often have greater staffing continuity than government departments and are good brokers or neutral facilitators of complex programs. They often have a better field presence than some government agencies, as has been the case in both PNG and Irian Jaya in past years.
- Often there are relatively few good people to work with and it is tempting to overload the same few key people with all the new programs that start up in an area.
- Practical training works better on site than off as people often have difficulties about extrapolating new situations and information to their own place. In a program like the TNW, practical on the job training is more important than formal educational programs.

Workshop Breakaway Sessions

THE FIRE management workshop incorporated two breakaway sessions, with participants allocated to one of five working groups. Session 1: General discussion of regional fire management issues both in the savanna lands of eastern Indonesia and northern Australia. Session 2: Based on Session 1, these discussions focused on specific identified regional issues: development of broad-scale fire monitoring approaches; cultural issues, tenure, community awareness and education; ecological research issues; agricultural and forestry research issues; and sectoral linkages and collaboration.

The main findings of the two sessions are summarised below.

Session 1: Defining the Issues

The first session aimed to broadly define key fire management issues in eastern Indonesia and northern Australia, and identify research and training needs that could help address gaps and assist with the development of improved fire management practices and policies.

Issues

Documenting the current extent and patterning of burning

There has been significant development in recent years in documenting the extent, seasonality and patterning of burning (e.g. frequency of fire with respect to different regions and land-use sectors) across northern Australia, but information is unavailable for eastern Indonesia. Fire map data have various uses, including locating the daily occurrences of fires, and informing and monitoring the development of appropriate regional fire management practices and policies.

Documenting fire management practices

A considerable (albeit far from complete) body of information is available, documenting past and current fire management practices and approaches of different land-use sectors in northern Australia, yet few data are available for eastern Indonesia. An understanding of traditional fire management practices in local community settings is essential, for example, for informing the development and application in both regions of appropriate fire management systems in contemporary land-use contexts.

Applied research

Some information is publicly available (particularly for northern Australia) concerning the use of fire in pastoral management (e.g. manipulating stock to graze recently burnt areas; conservation of perennial grasses; establishment of improved pasture species; woody plant control), but scant data are available for other primary industry and natural resource management applications (e.g. management of weeds such as *Chromolaena* in agricultural and agroforestry settings; nutrient and soil conservation under increasingly shorter swidden cycles; water catchment management). It was generally felt that, to involve local communities and to encourage eventual implementation of practical solutions, an interactive approach through demonstration or case studies was the best means of addressing such land management research needs.

Tenure

Land tenure issues in both eastern Indonesia and northern Australia are fundamental to the rights (and responsibilities) of individuals and communities on the one hand and government agencies on the other for undertaking fire management. In eastern Indonesian settings both central Government and unofficial, traditional tenure systems may apply independently to the same tracts of land. Tenure issues in northern Australia include the recently recognised legal rights of indigenous (Aboriginal and Torres Strait Islander) custodians to joint 'Native Title' on much Government and pastoral leasehold land, including rights and responsibilities for undertaking traditional fire management. As such, an understanding of tenure frameworks is fundamental to developing appropriate fire management practices and policies in both jurisdictions.

Policy and legislation

Considerable fire management policy and associated legislative development is required both in eastern Indonesia and northern Australia. This applies particularly to recognising the peculiar requirements of living in, and managing, fire-prone savanna environments. In the eastern Indonesian context, the current official total exclusion fire policy is set by the central Government, largely as a response to the international ramifications of biomass burning in the large tropical forest blocs of western Indonesia and northern Irian Jaya. In Queensland and Western Australia, state-wide policies are determined in the southeast and southwest respectively, under vastly different southern Australian, fire-weather conditions and seasonality. Thus, greater understanding of the fire management requirements of savanna systems both in eastern Indonesia and northern Australia will, in time, serve the development of more appropriate regional fire management policies and legislation.

Training, extension and communication

The above issues can only be addressed through targeted training and education programs, from the local community grass-roots level through to the policy makers. Experience in both regions, but in eastern Indonesia especially, has shown that hands-on demonstration activities are practical, effective means for achieving this. As well, there is a need for the development of regional 'information clearing houses', where end-users can readily access information on a range of topics pertaining to land management and related issues, or at least be guided in the right direction.

Collaboration, cooperation and linkages

As with above information issues, workshop participants fully recognised the need for, and advantages of, developing closer institutional ties between eastern Indonesia and northern Australia. Whereas northern Australian agencies and institutions can offer various levels of technical and educational expertise of relevance to fire management in savanna systems, eastern Indonesia provides excellent examples of cooperative, information-sharing networks involving large numbers of NGOs, educational institutions and agencies. Both regions have much to offer each other.

Identified research and training needs

Following is a succinct list of research and training needs identified by the five groups from the first breakaway session:

- Develop the capacity to undertake a comparative assessment of the current extent and patterning of burning in eastern Indonesia and northern Australia, using remote sensing (RS) and Geographic Information System (GIS) approaches;
- Such an assessment would require the concomitant development of appropriate land-use, vegetation and cadastral map coverages, as a basis for developing a fire management database—in eastern Indonesia this might involve considerable work undertaken either as student projects and/or through technical assistance;
- Undertake an assessment of contemporary fire management practices as used in land management, particularly in eastern Indonesia;
- Using above information describe the biophysical, economical, social, cultural, and political effects and implications of current fire regimes;
- Identify key economic and natural resource issues of fire management, and potential locations where such issues could be addressed through demonstration activities and community interaction;
- Implement above demonstration activities and provide practical training to local communities and representatives from provincial community organisations (NGOs) and relevant land management agencies;
- Develop productive land management institutional linkages between eastern Indonesia and northern Australia through: (1) the undertaking of above research and training needs as collaborative programs; and (2) encouraging student exchanges;
- Assist with the establishment of a network of land management information dissemination centres in eastern Indonesia and northern Australia;
- Develop a phased implementation plan to educate land administrators and policy makers of the practical needs for undertaking sound fire management practice in fire-prone savanna environments.

Session 2:
Describing Targeted Research Requirements

Each participant was allocated to one of five groups, keeping in mind respective areas of expertise. Each group was asked to consider and identify specific research, training, information and institutional requirements in a broad eastern Indonesian–northern Australian context.

Discussion group participants

Group 1: Satellite imagery/GIS/remotely sensed monitoring:
Dr Richard Smith, Dr Jennifer Robinson, Mr Paul Ryan, Dr Jeff Fox, Prof Nigel Tapper, Mr Cameron Yates, Mr Grant Allan, Mr Marthen Mallo, Dr Neil Stronach, Dr Richard Noske

Group 2: Cultural factors and land tenure, education/ community awareness:
Dr Peter Jacklyn, Prof Chris Healey, Mr Peter Cooke, Dr Andrew McWilliam, Ir Esthon Foenay, Mr Glen Wightman, Dr Hendrik Ataupah, Ms Kath Thorburn, Dr Sukwong, Ms Carol Palmer, Prof Sulthoni

Group 3: Fire in land management—ecological research requirements:
Dr Jeremy Russell-Smith, Dr Dick Williams, Mr Piers Barrow, Pak Maraden Purba, Dr Phil Cheney, Mr Chris Done, Pak Tri Agung, Mr Bambang Hartono, Mr Robert Muller

Group 4: Fire in land management—agriculture and forestry land:
Mr Rodd Dyer, Mr Colin Wilson, Prof Haryono Semangun, Prof Sulthoni, Mr Michael Riwu Kaho, Dr Tony Grice, Mr Wayan Mudita, Dr Abdullah Bamualim, Dr Subandi, Dr Frank McKinnell, Ir Slamet Gadas

Group 5: Sectoral links and collaborations:
Prof Greg Hill, Mrs Heather Crompton, Dr Siliwoloe Djoeroemana, Prof Saragih, Mr Saharjo, Mr Bambang Hartono, Prof Riyanto, Mr Suhardi Suryadi, Mr Juspan, Dr Mark Johnston, Mr Putra Suardika, Ir Retno Nuningsih, Ms Michele Bowe

Given the outcomes from the first breakaway session, each group was asked to consider the use of case study areas and practical demonstration applications. As well, each group was asked to focus on what sort of research actions would enhance activities (e.g. agricultural, agroforestry, conservation, economic, training) already being undertaken in these case study areas.

Group 1: Satellite imagery/GIS/remotely sensed monitoring

This group discussed the use of remote sensing and GIS in two areas, the Trans-Fly region of Irian Jaya and the island of Sumba. The practical experience of Neil Stronach and Jeff Fox in these two respective regions served to guide this focus. Other members included those with relevant Australian technical experience. The group considered that, in order to understand the distribution of fire in the landscape, it was necessary also to describe and understand the roles and distributions of climate, population, land-use, vegetation/habitat.

Most discussion focused on the role, and appropriate application of, satellite sensors, in relation to specific research questions, for example,

- Where are fires burning on any given day?
- What is the seasonal distribution and extent of burning over an annual cycle in eastern Indonesia?
- What is the seasonal distribution and extent of burning over an annual cycle in northern Australia?
- How can such information be put to use (e.g. for monitoring trends, as bases for economic and environmental assessments, as practical land management tools)?

To be useful the program would require participation with, and assessment of, local communities.

The research issues defined by this group are listed in Table 1. To interpret the table, consider the first question 'When?'. It needs to be understood that the satellite sensors (AVHRR, MODIS) are of relatively coarse resolution (especially AVHRR, with individual pixels of maximum 1.1 × 1.1 km^2) or as-yet-unlaunched (MODIS). Other satellite sensors listed in the table comprise the high resolution (Spot, LANDSAT—maximum 30 x 30 m pixels) and radar (sees through clouds; wide range of pixel sizes). The different sensors have various, useful research applications, as abbreviated in the table. As the table progresses from 'when' through to 'why', satellite sensing assumes diminishing importance and other socio-geographic data are of increasing importance. A first issue, however, is the current location of relevant receiving stations (Indonesia, Philippines, Australia), and what historical satellite data are available.

Group 2: Cultural factors and land tenure, education/community awareness

The conclusions of this group are summarised below.

Key issues

- Establishing cooperative linkages—between land councils, NGOs, regional Indonesian universities, and government agencies;
- Communication of traditional/local fire management knowledge:
  – between older and younger generations (connected with loss of knowledge)
  – between local community and school curricula
  – between local community and general public

Table 1. Research issues potentially addressed by the application of different remote sensors, particularly in relation to the Trans-Fly region of Irian Jaya and the island of Sumba in Nusa Tenggara Timur.

Question	Sensor	Research issue
When	AVHRR	Diurnal, Persistence
	MODIS	Cloud, Orbits, Proportion of fires perceived
Where	AVHRR,	Rate of regrowth
	MODIS, radar,	Curing
How much	AVHRR, MODIS, radar,	Rate of regrowth Size of fires –small scale ⟶ landsat, radar, spot; –cloud ⟶ radar
What	GIS, radar	Vegetation types, land use, soil i.e. existing data
Who	GIS	Existing data—tenure, admin., settlement
Consequences		Change analysis, what changes?
Why	GIS + field interviews	Capture local knowledge + capture imperatives. Ethno-meteorology

- Making fire management knowledge locally relevant;
- Better communication, coordination and courtesy between neighbours;
- Communication of scientific/technical fire management knowledge;
- Improving general access to fire management knowledge:
  – traditional/local
  – scientific/technical through general dissemination and through daily access to tools and images;
- Land tenure issues;
- Raising awareness about fire issues:
  – among general public and among policy makers;
- Development of appropriate training and extension in fire management;
- Lobbying for a review of legislation and policy.

Projects

- Scoping parameters to identify further more specific projects and study area (e.g. Sumba and Flores and Timor);
- Comparison between NT and Indonesia of specific issues relating to fire management, range of stakeholder attitudes/regulations;
- An examination of the practical relevance of customary agricultural and forestry practices for management of fire regimes;
- Improving cattle pastures (Sumba) through appropriate fire regimes;
- Fire histories in study areas (Wasur, Wanggameti) at different scales including local ethno-historical assessment of satellite imagery;
- Can PRA in Indonesia be adapted for Australian needs?
- Networking agency for information sharing, including ongoing process for communication.

Group 3: Fire in land management/ecological research

This group considered areas within eastern Indonesia where fire management in savanna landscapes was a significant resource management issue. Members discussed four locations, describing a range of land uses. The group found that developing such a project, which ultimately might involve demonstration activities being undertaken at a number of discrete locations, would require considerable linkage, coordination, training, education, and extension.

Case Study 1—Sumba: Forest Research Centre near Waingapu

Site

Area of 500 ha, close to town, mostly grassland, flat terrain, limestone/rocky soil, mainly weeds, 8 months dry, ~1000 mm rainfall annually, used by farmers on an annual lease

Priorities

How to improve cattle production

Use of fire to manage grassland areas for weed management, grazing

Research issues

Improving land and pastoral management

Demonstration

Location convenient for government officials/ community/training

Land currently managed by forestry department and university

Case Study 2—Sumba: Wanggameti

Site

Catchment of 70 000 ha, of which 40 000 ha are National Park

Hilly area with rainforest

Problems

Fire in surrounding grassland burns up through hills

Research

Fire management practices for conserving forest areas and for maintaining grassland grazing. Requires good understanding of traditional and contemporary burning practices.

Demonstration

Fire management practices as part of broader study of sustainable land use.

Based on existing studies being undertaken through the Nusa Tenggara Community Development Consortium.

Case Study 3—Trans-Fly region of Irian Jaya

Problems

Feral animals (Rusa deer);
Habitat loss, (e.g. invasion of grasslands by *Melaleuca* and weeds, e.g. *Mimosa*, with effects on native species, e.g. migratory birds);
Outside burns passing through/Trans-Fly regional issues;
Poor official awareness of fire management issues, or how fire might be integrated with other management objectives

Research

Habitat management;
Economic resource management issues (e.g. ecotourism, meat supply);
Asteromyrtus oil production;
Sustainable harvesting of Rusa deer;
Fire ecology and management of floodplain systems;
Understanding traditional and contemporary burning practices;
Education/training;
Putting training into practice.

Case Study 4—West Timor: Mutis Mountains

Problems

Appropriate vs current fire regimes in *Eucalyptus urophylla* forests;
Regeneration requirements of *E. urophylla* stands

Research

Productivity and availability of pastures for grazing outside vs inside the *E. urophylla* forests;
Understanding traditional usage of fires and assessment of changes in fire regimes;
Awareness/education/training of wise, sustainable burning practices;
Fire regimes and regeneration of *Eucalyptus urophylla* (an economically important regional timber).

Group 4: Fire in land management—agriculture and forestry land

This group found that the general aim of fire use in agriculture and forestry should be to improve the productivity of the land. However, a number of problems related to the use of fire were identified, including:

- Conflicting demands between land uses in relation to fire and a lack of knowledge of long-term fire impacts;
- Side effects of changed land-use practices, especially shorter rotations in slash and burning practices leading to declining land condition;
- Effects of fire on tree establishment and growth, and the need for fire protection in forestry;
- Forage quality deficits and the impacts of fire on land condition from a livestock perspective.

Issues related to land use

Livestock grazing

Forage quality/production;
Timing and intensity of fire;
Fire resistant species/fences (protection from uncontrolled fire);
Grazing trials.

Slash and burn crops

Erosion prevention / control;
Soil fertility;
Crop combinations;
Resistant tree species;
Systems of permanent agriculture;
Timing / intensity of fires;
Use of fallows;
Management of *Chromolaena* and other weeds;
Economic means of making fire breaks;
Effects on biodiversity;
Inventory of traditional wisdom.

Plantations

Agroforestry crop combinations, and alternatives;
Fire-resistant species;
Timing of burn-offs, and other control measures;
Design and integration of agroforestry plantations in community agriculture.

Forestry

Early burning to prevent wild fire;
Cash crops within forests;
Biodiversity issues;
Generally, as for plantations above.

Approach: a comprehensive land use management study in West Timor

Both research and training are required in the following areas:

- Land resource mapping—GIS;
- Current use of fire—who, when and why;
- Impacts of current use of fire on current land use components;
- Recommendations and management guidelines.

There is an obvious link between northern Australia and eastern Indonesia in terms of similarity of environmental and fire issues which suggests potential for useful exchange of information.

Group 5: Sectoral linkages and collaboration

This group first listed the relevant organisations which might be involved in the undertaking of a fire and land management project:

Indonesia

- Ministries of Agriculture, Forestry, Education and Environment.;
- Perun Perhutani;
- ICRAF / CIFOR / BIOTROP;
- Provincial Planning Board;
- Information Centre on Semi-Arid Agriculture in Kupang;

- FRIK (Forestry Research Institute, Kupang);
- Nusa Tenggara Community Development Consortium;
- NGOs from World Vision, CARE, WWF, World Food Program.

Australia
- Tropical Savannas Cooperative Research Centre (University, CSIRO, Government);
- Northern Territory Government Department of Asian Relations, Trade and Industry (DARTI);
- Cattle industry;
- Aboriginal Land Councils;
- Key Centre for Sustainable Wildlife Management at NTU, especially in relation to Rusa deer in Irian Jaya;
- NGOs;
- Additional researchers, especially from southern Australia.

Linking mechanisms
- Information Centre Kupang—linked to Ministry for Education and Ministry for Forestry or Agriculture;
- Tropical Savannas CRC—via Northern Territory University.

Project linkages

Need for establishing a working group with representatives from a range of established agencies.

Problems

Poverty/standard of living (note also that one in four people in the NorthernTerritory live in poverty, especially Aborigines). Improved fire management, as part of developing better land management systems, would assist with alleviating chronic environmental, social, and economic problems

Solutions

'Fire Management Package'
- create one or more fire management models
- research and test in various case studies

Thematic emphasis

A two-way means of communication needed, especially in these three areas:

Forests
Livestock
Weeds } northern Australian–eastern Indonesia linkage.

Information collation and review—coordinated through the Information Centre on Semi-arid Agriculture (Kupang), and Tropical Savannas Cooperative Research Centre (Darwin)
- *Fire and ecological consequences*
- – land rehabilitation;
- – different land uses/situations;
- – develop principles/research topics/overview (needed for use by policy makers, government agencies, educational institutions and community groups);
- – future agricultural uses/patterns, i.e.

herbicides use,
transmigration,
horticulture } Effects on fire management.

- *Spatial and temporal distribution of fire*
- – seasonal patterns of burning and distribution
- – development of drought indices e.g. ENSO – El Nino;
- – curing patterns of grasses, and related applications of satellite imagery e.g. NDVI from NOAA – AVHRR, radar;
- – distribution of information to policy makers, land managers;
- – use and application/training.

Final Workshop Discussion

In the final open forum of the workshop participants were invited to summarise the background, aims, and a framework for a future project(s) that might be developed as a result of issues identified during the workshop.

General points of agreement
- – The role of fire is not well understood by all savanna community stakeholders, and there is a requirement for research and training in appropriate fire management practices in eastern Indonesia and northern Australia;
- – A knowledge base concerning fire exists in the region but is not well documented;
- – Appropriate fire management practices can be found for different land-use purposes;
- – Differentiation should be made between controlled/prescribed burning and uncontrolled/ wildfire. This distinction already exists in the Indonesian language—'*api*' refers to burning as a tool and '*kebakaran*' refers to uncontrolled/ unintended fire;
- – That expertise and suitable networks exist to achieve the research and training required for the above undertaking;
- – That 'action research' should be the guiding principle for undertaking demonstration or case study activities. Action research was defined as a process of framing questions, and then undertaking research, in association with clients. The process thus incorporates existing knowledge and all stakeholder interests/views.
- – That the current workshop has established a rationale for developing an ongoing project;
- – That the summary of resolutions should be circulated to a group of key workshop participants for further development.

Purpose/background for developing a collaborative fire management program

There was consensus amongst workshop participants for:

– the development of a project involving fire management to improve living standards and sustainable ecological practice, involving both eastern Indonesia and northern Australia;
– the need for more information to assist with sustainable land management, including different fire regimes tailored for different land-use requirements.

Possible titles of collaborative project

1. Improving regional land use in relation to fire
2. Constructive use of fire in sustainable land management, agriculture and forestry development
3. Role of controlled (i.e. prescribed)/uncontrolled fire …

Possible locations for undertaking future case studies

For eastern Indonesia, the site selection was similar to that already established by the Nusa Tengarra Community Development Consortium, plus the Trans-Fly region of Irian Jaya (Indonesia). Stakeholder interests were also listed for nominated northern Australian sites.

Eastern Indonesia

Timor	Mutis Kupang
Sumba	Wanggameti Waingapu Paberiwai
Flores	Riung
Komodo	Komodo Island (World Heritage area)
Irian Jaya	Wasur

Northern Australia

Victoria River District	pastoral; conservation
Western Arnhem Land	indigenous; conservation
Kimberley	pastoral; indigenous; conservation
Cape York	pastoral; indigenous; conservation
Burdekin (Qld)	pastoral

Ongoing development

A core group was nominated for further development of the project:

Pak Tri Agung	WWF Indonesia / NGO Consortium, Kupang
Dr Hendrik Ataupah	UNDANA University, Kupang
Dr Abdullah Bamualim	Balai Pengkajian Teknologi Pertanian (BPTP) (Research Institute for Farming Technology)
Ms Michele Bowe	WWF Oceania, Darwin
Dr Siliwoloe Djoeroemana	Sekolah Tinggi Ilmu Ekonomi, Kristen Wira Wacana, (Christian School of Economics)
Professor Greg Hill	NTU and Tropical Savannas CRC, Darwin
Dr Jeremy Russell-Smith	BFC and Tropical Savannas CRC, Darwin
Professor Bungaran Saragih	Bogor Agricultural University, Bogor
Mr Putra Suardika	Nusa Tenggara Community Development Consortium

Post-Workshop Discussion with Indonesian and Australian Project Representatives

Group: Pak Tri Agung, Dr Hendrik Ataupah, Dr Abdullah Bamualim, Dr Siliwoloe Djoeroemana, Mr Julian Gorman, Prof Greg Hill, Dr Peter Jacklyn, Pak Michael Riwu Kaho, Dr Bronwyn Myers, Dr Jeremy Russell-Smith, Prof Bungaran Sarigih

The above group met on the day after the workshop to discuss possible arrangements for developing a further collaboration in relation to Nusa Tenggara in the areas of fire research, management, training, and institutional linkages. Indonesian participants indicated that, based on the findings and direction of the workshop undertaken over the preceding three days, they had discussed the development of a broad project outline which they wished to present for consideration.

In short, it was suggested that the part of the ongoing project in Nusa Tenggara should:

- Focus on three demonstration study areas in eastern Indonesia—at Mbay on Flores, at Paberiwai on Sumba, and Fatulew (near Kupang) on Timor;
- At each site, incorporate an active, participatory research approach, involving local community, members of the Nusa Tenggara Community Development Consortium, Government agencies, researchers and academics;
- Be integrated across all three sites under a common set of land management objectives, with the coordinating and information dissemination roles undertaken through the Information Centre for Semi-arid Agriculture, based in Kupang;
- Develop close applied research, management, training and institutional linkages between eastern Indonesian and northern Australian partners.

In order to progress the development of the project, the following actions were agreed upon:

- Indonesian colleagues will prepare detailed background profiles of each of the three study sites. This work would be undertaken under the auspices of the Information Centre for Semi-arid Agriculture.
- This material will be presented and discussed further at a workshop in Kupang in early 2000, with possible visits to each of the three study areas prior to the workshop. A formal presentation will be made subsequently, in Bogor, to the Indonesian Government.
- Australian colleagues will commence preparation of the next-round submission to ACIAR, seeking ongoing funding as a Large Project.
- Uncommitted Darwin workshop funds will be used to facilitate development of project components outlined above.

Participants agreed that the workshop had provided a sound platform for ongoing cooperation and collaboration.

Sesi Lokakarya yang Terpisah

Lokakarya pengelolaan kebakaran dibagi dalam dua sesi terpisah dan peserta diberi kesempatan memilih satu dari lima kelompok kerja. Sesi 1: diskusi umum mengenai persoalan-persoalan pengelolaan kebakaran regional baik di lahan savana di Indonesia bagian timur maupun di Australia bagian utara. Sesi 2: Berdasarkan pada Sesi 1, diskusi sesi ini berfokus pada persoalan regional spesifik yang teridentifikasi: pengembangan pendekatan-pendekatan pengawasan kebakaran secara luas; persoalan budaya, hunian & kepemilikan, kesadaran masyarakat dan pendidikan; persoalan penelitian ekologi, persoalan penelitian pertanian dan kehutanan; dan hubungan-hubungan sektoral dan kerjasama.

Temuan-temuan utama dari dua sesi ini dapat dirangkum sebagai berikut:

Sesi 1: Pendefinisian Persoalan

Sesi pertama bertujuan untuk mendefinisikan secara luas persoalan utama pengelolaan kebakaran di Indonesia bagian timur dan Australia bagian utara, dan mengidentifikasikan kebutuhan-kebutuhan penelitian dan pelatihan yang dapat membantu menjembatani kesenjangan serta membantu mengembangkan praktek dan kebijakan pengelolaan kebakaran yang telah dikembangkan.

Persoalan

Pendokumentasian luasan dan pola pembakaran sekarang ini
Telah banyak kemajuan yang dicapai dalam tahun-tahun terakhir ini dalam pendokumentasian luasan, musim dan pola pembakaran (contoh: frekuensi kebakaran di berbagai daerah dan sektor pemanfaatan lahan) di seluruh Australia bagian utara, tetapi informasi yang serupa belum tersedia untuk Indonesia bagian timur. Data peta kebakaran memiliki berbagai manfaat, termasuk menentukan lokasi terjadinya kebakaran harian, dan menginformasikan serta mengawasi perkembangan praktek dan kebijakan pengelolaan kebakaran regional yang tepat.

Pendokumentasian praktek-praktek pengelolaan kebakaran
Satu lembaga informasi yang besar telah ada (sekalipun belum lengkap) dan telah mendokumentasikan praktek dan pendekatan pengelolaan kebakaran masa lalu dan sekarang atas berbagai sektor pemanfaatan lahan di Australia bagian utara, namun hanya ada sedikit data yang tersedia untuk Indonesia bagian timur. Pemahaman akan praktek-praktek pengelolaan kebakaran tradisional pada latar masyarakat setempat merupakan hal yang penting, sebagai contoh dapat digunakan untuk menginformasikan perkembangan dan penerapan sistem-sistem pengelolaan kebakaran dengan tepat di kedua daerah tersebut dalam konteks pemanfaatan lahan kontemporer.

Penelitian terapan
Beberapa informasi telah tersedia untuk umum (khususnya untuk Australia bagian utara) mengenai penggunaan api dalam pengelolaan pengembalaan (contoh menggiring ternak untuk makan rumput di daerah-daerah yang baru saja terbakar; pelestarian rumput hijau tahunan; penetapan satu jenis padang rumput yang lebih baik; pengendalian tumbuhan yang berkayu), tetapi hanya ada sedikit data yang tersedia untuk penerapan dalam industri primer dan pengelolaan sumber daya alam lainnya (contoh pengelolaan rumput liar seperti *Chromolaena* di lahan pertanian dan agro-kehutanan; pelestarian hara dan tanah dengan tingkat perputaran sistim tebas-bakar yang semakin pendek; pengelolaan daerah serapan air). Untuk melibatkan masyarakat setempat dan memotivasi mereka menerapkan pemecahan-pemecahan praktis, pendekatan interaktif melalui demonstrasi atau studi kasus dianggap sebagai cara terbaik dalam upaya memenuhi kebutuhan-kebutuhan penelitian pengelolaan lahan.

Hunian & kepemilikan
Persoalan hunian & kepemilikan lahan baik di Indonesia bagian timur maupun Australia bagian utara merupakan hal mendasar terhadap hak (dan tanggung jawab) individu dan masyarakat pada satu sisi dan badan-badan pemerintahan pada sisi lain yang berupaya menerapkan pengelolaan kebakaran . Di daerah Indonesia bagian timur baik Pemerintah pusat maupun yang tidak resmi, sistem hunian & kepemilikan tradisional dapat berlaku secara bebas terhadap lahan yang sama. Persoalan hunian & kepemilikan di Australia bagian utara meliputi pengakuan hak-hak hukum akhir-akhir ini terhadap perwalian penduduk asli (Aborigin dan Torres Strait Islander) untuk bergabung dalam '*Native Title*' (Hak Milik Penduduk Asli) pada banyak tanah pemerintah dan pemegang sewa lahan pengembalaan, yang meliputi hak dan tanggung jawab untuk melaksanakan pengelolaan kebakaran tradisional. Oleh karena itu pemahaman kerangka kerja hunian & kepemilikan merupakan hal mendasar untuk mengembangkan praktek dan kebijakan pengelolaan kebakaran yang tepat di kedua wilayah hukum tersebut.

Kebijakan dan perundangan
Pengembangan kebijakan pengelolaan kebakaran yang sungguh-sungguh dan perundangan yang berkaitan diperlukan baik di Indonesia bagian timur dan Australia bagian utara. Pengembangan ini khususnya bertujuan untuk mengenali persyaratan-persyaratan tertentu untuk hidup dan mengatur lingkungan savana yang mudah terbakar. Dalam konteks Indonesia bagian timur, kebijakan resmi tentang kebakaran yang betul-betul terpisah ditetapkan oleh Pemerintah pusat, sebagai tanggapan terhadap ramifikasi internasional atas pembakaran biomassa di blok-blok hutan tropis yang luas di Indonesia barat dan Irian Jaya utara. Di Queensland dan Australia Barat, kebijakan-kebijakan negara yang luas ditentukan berturut-turut di bagian tenggara dan barat daya, dengan kondisi cuaca-api dan musim Australia selatan yang sangat berbeda. Karena itu, pemahaman yang lebih luas terhadap persyaratan pengelolaan kebakaran atas sistem-sistem savana baik di Indonesia bagian timur dan Australia bagian utara akan membantu pengembangan kebijakan-kebijakan dan perundangan yang tepat mengenai pengelolaan kebakaran regional.

Pelatihan, pembinaan dan komunikasi
Persoalan di atas hanya dapat dibahas melalui program pelatihan dan pendidikan yang ditargetkan mulai dari masyarakat yang paling bawah sampai kepada para pembuat kebijakan. Pengalaman di kedua daerah ini, khususnya di Indonesia bagian timur, telah membuktikan bahwa kegiatan-kegiatan demonstrasi yang praktis merupakan cara praktis dan efektif untuk mencapai tujuan ini. Disamping itu, perlu adanya pengembangan 'situs Web' regional dimana para pemakai akhir dapat langsung mengakses informasi mengenai serangkaian topik yang berhubungan dengan pengelolaan lahan dan persoalan terkait atau paling tidak dapat mengarahkan mereka ke arah yang benar.

Kolaborasi, kerjasama dan hubungan
Sebagaimana persoalan-persoalan informasi di atas, para peserta lokakarya telah benar-benar menyadari kebutuhan dan manfaat untuk meningkatkan ikatan-ikatan hubungan kelembagaan antara Indonesia bagian timur dan Australia bagian utara. Sementara badan-badan dan lembaga-lembaga Australia bagian utara dapat menawarkan berbagai tingkatan keahlian teknis dan pendidikan yang relevan dengan pengelolaan kebakaran pada sistem savana, Indonesia bagian timur menyediakan contoh kerjasama dan jaringan penggunaan informasi bersama dan kerjasama yang sangat baik, yang melibatkan sejumlah besar LSM, lembaga dan badan pendidikan. Kedua wilayah ini memiliki banyak hal yang dapat ditawarkan kepada satu sama lainnya.

Kebutuhan penelitian dan pelatihan yang teridentifikasi
Berikut ini adalah daftar ringkas mengenai kebutuhan penelitian dan pelatihan yang diidentifikasikan oleh ke lima kelompok dari sesi terpisah pertama:

- Mengembangkan kapasitas untuk melakukan penilaian komparatif atas luasan dan pola pembakaran sekarang ini di Indonesia bagian timur dan Australia bagian utara, dengan menggunakan pendekatan-pendekatan pendeteksian jarak jauh (RS) dan Sistem Informasi Geografis (GIS);
- Penilaian seperti itu akan memerlukan pengembangan yang mengiringi pemanfaatan lahan, tumbuhan dan cakupan peta batas lahan yang tepat, sebagai dasar untuk mengembangkan *database* pengelolaan kebakaran — dalam kasus Indonesia bagian timur hal ini mungkin melibatkan banyak pekerjaan yang dapat dilaksanakan sebagai proyek siswa dan/atau melalui bantuan teknis;
- Melakukan penilaian terhadap praktek-praktek pengelolaan kebakaran kontemporer sebagaimana yang digunakan dalam pengelolaan lahan, khususnya di Indonesia bagian timur ;
- Menggunakan informasi di atas untuk menggambarkan pengaruh-pengaruh biofisika, ekonomi, sosial, budaya dan politik dan implikasi rezim kebakaran sekarang ini;
- Mengidentifikasikan pengelolaan ekonomi dan sumber daya alam yang utama dari persoalan pengelolaan kebakaran, dan lokasi-lokasi potensial dimana persoalan-persoalan demikian dapat diatasi melalui kegiatan demonstrasi dan interaksi dengan masyarakat;
- Mengimplementasikan kegiatan-kegiatan demonstrasi di atas dan menyediakan pelatihan praktis bagi masyarakat setempat dan perwakilan dari organisasi-organisasi masyarakat di daerah (LSM) dan badan-badan pengelolaan lahan terkait;
- Meningkatkan hubungan kelembagaan pengelolaan lahan produktif antara Indonesia bagian timur dan Australia bagian utara melalui: (1) pelaksanaan penelitian di atas dan pemenuhan kebutuhan pelatihan sebagai program bersama; dan (2) peningkatan pertukaran siswa;
- Membantu pendirian jaringan kerja pusat-pusat penyebaran informasi pengelolaan lahan di Indonesia bagian timur dan Australia bagian utara;
- Mengembangkan rencana penerapan bertahap untuk mendidik para pejabat pertanahan dan pembuat kebijakan mengenai kebutuhan-kebutuhan praktis untuk melaksanakan praktek pengelolaan kebakaran yang baik di lingkungan savana yang mudah terbakar.

Sesi 2: Menjelaskan Persyaratan-persyaratan Penelitian yang Ditargetkan

Setiap peserta dialokasikan pada satu dari lima kelompok dengan mempertimbangkan bidang keahlian mereka masing-masing. Setiap kelompok diminta untuk mempertimbangkan dan mengindentifikasikan persyaratan-persyaratan spesifik untuk penelitian, pelatihan, informasi dan lembaga dalam konteks Indonesia bagian timur – Australia bagian utara yang luas.

Peserta Kelompok Diskusi

Kelompok 1: *Pengawasan Imaginer Satelit /GIS/pendeteksian jarak jauh*
Dr Richard Smith, Dr Jennifer Robinson, Dr Paul Ryan, Dr Jeff Fox,
Prof. Nigel Tapper, Cameron Yates, Grant Allan, Marthen Mallo, Dr. Neil Stronach,
Dr. Richard Noske

Kelompok 2: *Faktor-faktor budaya dan hunian & kepemilikan lahan, pendidikan/ kesadaran masyarakat*
Dr. Peter Jacklyn, Prof. Chris Healey, Mr. Peter Cooke, Dr Andrew McWilliam,
Ir. Esthon Foenay, Mr Glen Wightman, Dr Hendrik Ataupah, Ms Kath Thorburn,
Dr Sukwong, Ms Carol Palmer, Prof. Sulthoni

Kelompok 3: *Kebakaran dalam pengelolaan lahan—persyaratan-persyaratan penelitian ekologi*
Dr Jeremy Russell-Smith, Dr Dick Williams, Mr. Piers Barrow,
Pak Maraden Purba, Dr Phil Cheney, Mr Chris Done, Pak Tri Agung,
Mr Bambang Hartono, Mr Robert Muller

Kelompok 4: *Kebakaran dalam pengelolaan lahan—lahan pertanian dan kehutanan*
Mr. Rodd Dyer, Mr. Colin Wilson, Prof. Haryono Semangun,
Prof. Sulthoni, Mr.Michael Riwu Kaho, Dr Tony Grice,
Mr Wayan Mudita, Dr Abdullah Bamualim, Dr. Subandi, Dr Frank McKinnell,
Ir. Slamet Gadas

Kelompok 5: *Hubungan antar sektoral dan kerjasama:*
Prof. Greg Hill, Mrs Heather Crompton, Dr Siliwoloe Djoeroemana,
Prof. Saragih, Mr. Saharjo, Mr. Bambang Hartono, Prof. Riyanto,
Mr. Suhardi Suryadi, Mr. Juspan, Dr Mark Johnston, Mr. Putra Suardika,
Ir. Retno Nuningsih, Ms Michele Bowe

Melihat hasil-hasil dari sesi terpisah pertama, setiap kelompok diminta untuk mempertimbangkan manfaat bidang-bidang studi kasus dan penerapan-penerapan praktek demonstrasi. Setiap kelompok juga diminta untuk menitik-beratkan perhatian pada jenis tindakan penelitian apa yang dapat meningkatkan kegiatan-kegiatan yang telah dilakukan dalam bidang-bidang studi kasus ini (contoh: pertanian, agro-kehutanan, pelestarian, ekonomi, pelatihan).

Kelompok 1: Pengawasan Imaginer Satelit /GIS/pendeteksian jarak jauh
Kelompok ini membahas manfaat pendeteksian jarak jauh dan GIS di dua daerah, daerah antar lintas udara di Irian Jaya dan pulau Sumba. Pengalaman praktis dari Neil Stronach dan Jeff Fox di dua daerah yang berbeda ini membantu mengarahkan fokus ini. Para anggota lain termasuk mereka yang memiliki pengalaman teknis Australia yang relevan. Kelompok ini mempertimbangkan bahwa untuk memahami penyebaran kebakaran pada satu bentang lahan, kita perlu juga menggambarkan dan memahami peran dan penyebaran iklim, populasi, pemanfaatan lahan, tumbuhan/habitat.

Sebagian besar diskusi bertitik-tolak pada peran dan penerapan sensor-sensor satelit yang pantas sehubungan dengan pertanyaan-pertanyaan penelitian yang spesifik, sebagai contoh;
Dimana terjadi kebakaran pada hari-hari tertentu?,
Seperti apa distribusi musim dan luasan pembakaran pada satu putaran tahunan di Indonesia bagian timur?
Seperti apa distribusi musim dan luasan pembakaran pada satu putaran tahunan di Australia bagian utara?
Bagaimana memanfaatkan informasi tersebut (contoh untuk memonitor kecenderungan, yang merupakan dasar penilaian ekonomi dan lingkungan, sebagai alat-alat praktis pengelolaan lahan)?

Agar bermanfaat program tersebut memerlukan partisipasi dari masyarakat setempat dan penilaian terhadap mereka.

Persoalan-persoalan penelitian yang didefinisikan oleh kelompok ini ada di dalam Tabel 1. Untuk mengartikan tabel tersebut, pertimbangkan pertanyaan pertama ‘Kapan?’. Kita perlu memahami bahwa sensor-sensor satelit (AVHRR, MODIS) merupakan resolusi kasar relatif (khususnya AVHRR, dengan piksel individu maksimal 1.1 x 1.1 km^2) atau seperti yang belum diluncurkan (MODIS). Sensor-sensor satelit lain yang ada dalam tabel terdiri atas yang beresolusi tinggi (Spot, LANDSAT—

piksel maksimal 30 x 30 m) dan radar (melihat melalui awan; ukuran piksel yang berbeda-beda). Masing-masing sensor memiliki berbagai manfaat dalam terapan-terapan penelitian, sebagaimana yang disingkat dalam tabel. Karena tabel mulai dari 'Kapan' sampai 'Mengapa', peran pendeteksian satelit menjadi berkurang, namun peran data sosio-geografi lain meningkat. Akan tetapi, persoalan pertama adalah lokasi stasiun penerima terkait yang ada sekarang ini (Indonesia, Filipina, Australia), dan data historis satelit apa saja yang telah tersedia.

Kelompok 2: Faktor-faktor budaya dan hunian & kepemilikan lahan, pendidikan/kesadaran masyarakat

Rangkuman kesimpulan hasil diskusi kelompok adalah sebagai berikut:

Persoalan utama

- Menetapkan hubungan kerjasama — antara badan-badan pertanahan, LSM, universitas di daerah-daerah di Indonesia dan badan-badan pemerintahan;
- Komunikasi pengetahuan pengelolaan kebakaran setempat/tradisional:
  – antara generasi yang lebih tua dan lebih muda (dihubungkan dengan pengetahuan yang hilang);
  – antara masyarakat setempat dan kurikulum sekolah;
  – antara masyarakat setempat dan masyarakat umum;
- Membuat agar pengetahuan pengelolaan kebakaran relevan bagi masyarakat setempat;
- Komunikasi, koordinasi dan sopan-santun yang lebih baik antar tetangga;
- Komunikasi pengetahuan ilmiah/teknis pengelolaan kebakaran ;
- Meningkatkan akses secara umum terhadap pengetahuan pengelolaan kebakaran :
  – tradisional/setempat;
  – ilmiah/teknis melalui penyebaran umum dan melalui akses sehari-hari terhadap peralatan dan gambar;
- Persoalan hunian & kepemilikan lahan;
- Meningkatkan kesadaran mengenai persoalan kebakaran:
  – antara masyarakat umum dan para pembuat keputusan;
- Pengembangan pelatihan dan perluasan yang tepat dalam bidang pengelolaan kebakaran ;
- Melobi untuk meninjau perundangan dan kebijakan.

Proyek-proyek

- Cakupan parameter untuk mengidentifikasikan secara lebih jauh proyek-proyek dan bidang-bidang studi yang lebih spesifik (contoh: Sumba, Flores dan Timor);
- Perbandingan antara NT dan Indonesia mengenai persoalan tertentu yang berhubungan dengan

Tabel 1. Persoalan penelitian yang mungkin dapat diatasi dengan penggunaan berbagai pendeteksi jarak jauh, khususnya yang berhubungan dengan daerah antar lintas udara di Irian Jaya dan pulau Sumba di Nusa Tenggara Timur.

Pertanyaan	Sensor	Persoalan Penelitian
Kapan	AVHRR MODIS	Harian, Tetap Awan, Orbit, Proporsi kebakaran yang diterima.
Dimana	AVHRR, MODIS, Radar,	Tingkat pertumbuhan ulang Pemulihan
Berapa besar	AVHRR, MODIS, Radar,	Tingkat pertumbuhan ulang Luasan kebakaran – skala kecil → landsat, radar, spot; – awan → radar
Apa	GIS, Radar	Jenis tumbuhan, pemanfaatan lahan, tanah yakni: data yang tersedia
Siapa	GIS	Data yang tersedia—hunian & kepemilikan, administrasi, penyelesaian
Konsekuensi		Merubah analisis, perubahan apa?
Mengapa	GIS + Wawancara lapangan	Mengumpulkan pengetahuan setempat + mengumpulkan hal-hal penting. Etno-meteorologi

pengelolaan kebakaran, perbedaan sikap/peraturan-peraturan dari para pemilik lahan
- Pemeriksaan kebiasan praktek-praktek tradisional dalam bidang pertanian dan kehutanan yang terkait untuk rezim pengelolaan kebakaran;
- Mengembangkan pengembalaan ternak (Sumba) dengan rezim pembakaran yang tepat;
- Sejarah-sejarah kebakaran di daerah-daerah studi (Wasur, Wanggameti) pada skala-skala yang berbeda termasuk penilaian etno-historis setempat dari imajiner satelit;
- Dapatkah Penilaian terhadap Keikut-sertaan Daerah Pedalaman (diketahui dengan istilah *PRA*) di Indonesia diadaptasikan untuk keperluan-keperluan di Australia?
- Jaringan kerja lembaga untuk berbagi informasi termasuk komunikasi yang berkelanjutan.

Kelompok 3: Kebakaran dalam pengelolaan lahan/penelitian ekologi

Kelompok ini mempertimbangkan daerah-daerah yang ada di dalam kawasan Indonesia bagian timur dimana pengelolaan kebakaran di lahan savana merupakan persoalan pengelolaan sumber daya yang penting. Para anggota membahas empat lokasi, yang menggambarkan rentang pemanfaatan lahan. Kelompok ini mendapatkan bahwa pengembangan proyek seperti ini, yang mungkin melibatkan kegiatan-kegiatan demonstrasi diadakan di sejumlah daerah yang terpisah, akan memerlukan hubungan, koordinasi, pelatihan, pendidikan dan pembinaan yang sungguh-sungguh.

Studi Kasus 1—Sumba: Pusat Penelitian Kehutanan di dekat Waingapu

Lokasi

Lahan seluas 500 ha, dekat kota, sebagian besar padang rumput, berlahan datar, berbatu kapur/tanah berbatu, terutama rumput liar, 8 bulan kering, curah hujan tahunan ~1000mm, dimanfaatkan oleh peternak dengan sistem sewa tahunan.

Prioritas

Bagaimana meningkatkan produksi ternak
Menggunakan api untuk mengelola lahan padang rumput dalam upaya pengelolaan rumput liar, pengembalaan

Persoalan penelitian

Meningkatkan pengelolaan lahan dan pengembalaan

Demonstrasi

Lokasi yang cocok untuk aparat pemerintah/masyarakat/pelatihan
Lahan yang sekarang ini dikelola oleh departemen kehutanan dan universitas

Studi Kasus 2—Sumba: Wanggameti

Lokasi

Daerah serapan air seluas 70 000 ha, yang mana 40 000 ha merupakan Taman Nasional
Lahan berbukit dengan hutan hujan.

Masalah-masalah

Kebakaran di padang rumput sekitar merambat sampai ke daerah yang berbukit

Penelitian

Praktek-praktek pengelolaan kebakaran untuk melestarikan lahan-lahan hutan dan untuk mempertahankan pengembalaan di padang rumput memerlukan pemahaman yang baik terhadap praktek pembakaran tradisional dan kontemporer.

Demonstrasi

Praktek-praktek pengelolaan kebakaran merupakan bagian studi yang lebih luas dari pemanfaatan lahan yang berkelanjutan.
Berdasarkan studi yang telah dilakukan oleh Konsorsium Pengembangan Masyarakat Nusa Tenggara

Studi Kasus 3—Daerah antar lintas udara di Irian Jaya

Masalah

Binatang liar (Rusa);
Kehilangan habitat, (contoh penyerbuan padang rumput oleh *Melaleuca* dan rumput liar, contoh *Mimosa*, yang berpengaruh terhadap spesies asli, contoh: migrasi burung);
Persoalan tentang kebakaran di luar yang melewati daerah antar lintas udara;
Kesadaran aparat yang rendah mengenai persoalan pengelolaan kebakaran , atau bagaimana menggabungkan tujuan-tujuan pengelolaan kebakaran dengan tujuan-tujuan pengelolaan lain.

Penelitian

Pengelolaan habitat;
Persoalan pengelolaan sumber daya ekonomi (contoh wisata alam, penyediaan daging);
Produksi minyak *Asteromyrtus*;
Panen Rusa yang berkelanjutan;
Ekologi dan pengelolaan kebakaran terhadap sistem-sistem dataran di sekitar sungai yang terkena banjir pada saat airnya meluap (floodplain);
Memahami praktek-praktek pembakaran tradisional dan kontemporer;
Pendidikan/pelatihan;
Melaksanakan pelatihan

Studi Kasus 4— Timor Barat: Pegunungan Mutis

Masalah
Rezim pembakaran yang tepat vs. rezim pembakaran sekarang ini di hutan-hutan *Eucalyptus urophylla* ;
Persyaratan-persyaratan re-generasi hutan *E. urophylla*

Penelitian
Produktivitas dan ketersediaan padang rumput di luar vs. di dalam hutan-hutan *E. urophylla* ;
Memahami penggunaan api secara tradisional dan penilaian terhadap perubahan rezim api;
Kesadaran/pendidikan/pelatihan untuk praktek-praktek pembakaran yang bijak dan berkelanjutan;
Rezim api dan re-generasi *Eucalyptus urophylla* (kayu regional yang penting secara ekonomis)

Kelompok 4: Kebakaran dalam pengelolaan Lahan —Lahan Pertanian dan Kehutanan
Kelompok ini menemukan bahwa tujuan umum penggunaan api dalam pertanian dan kehutanan seharusnya dapat meningkatkan produktivitas lahan. Akan tetapi, sejumlah masalah yang berhubungan dengan penggunaan api telah dikenali, hal ini mencakup:
Konflik tuntutan antara pemanfaatan lahan sehubungan dengan kebakaran dan kurangnya pengetahuan mengenai dampak-dampak penggunaan api dalam jangka panjang;
Pengaruh-pengaruh sampingan dari praktek-praktek perubahan pemanfaatan lahan, khususnya rotasi praktek tebas-bakar yang lebih pendek yang menyebabkan penurunan kondisi lahan;
Pengaruh-pengaruh kebakaran pada pertumbuhan dan perkembangan pohon, dan perlunya perlindungan terhadap kebakaran di kawasan hutan;
Penurunan kualitas makanan ternak dan pengaruh-pengaruh kebakaran pada kondisi lahan dari perspektif peternakan

Persoalan yang berhubungan dengan pemanfaatan lahan

Pengembalaan ternak
Kualitas/produksi makanan ternak;
Waktu dan intensitas kebakaran;
Spesies /pagar tahan api (perlindungan dari kebakaran yang tidak terkendali);
Percobaan-percobaan pengembalaan

Hasil panen dari praktek tebas-bakar
Pencegahan/pengendalian erosi;
Kesuburan tanah;
Kombinasi hasil panen;
Spesies pohon yang tahan;
Sistem pertanian yang permanen;
Waktu/intensitas kebakaran;
Pemanfaatan lahan-lahan kosong;
Pengelolaan *Chromolaena* dan rumput liar lainnya;
Cara yang ekonomis untuk membuat sekat api;
Pengaruh-pengaruh terhadap aneka hayati;
Inventaris kebijaksanaan tradisional;

Perkebunan
Kombinasi hasil panen agro-kehutanan dan alternatif;
Spesies yang tahan api;
Waktu pembakaran dan tindakan pengendalian lainnya;
Perancangan dan integrasi perkebunan agro-kehutanan dalam masyarakat agraris

Kehutanan
Pembakaran dini untuk mencegah kebakaran yang tidak terkendali;
Hasil bumi tunai di dalam hutan;
Persoalan aneka hayati;
Biasanya, mengenai perkebunan-perkebunan di atas

Pendekatan: studi pengelolaan pemanfaatan lahan yang komprehensif di Timor Barat
Baik penelitian maupun pelatihan diperlukan dalam bidang-bidang berikut ini:
– Pemetaan sumber daya lahan—GIS;
– Penggunaan api sekarang ini—siapa, kapan dan mengapa;
– Pengaruh pemakaian api pada komponen pemanfaatan lahan sekarang ini
– Rekomendasi dan tuntunan pengelolaan

Ada hubungan yang jelas antara Australia bagian utara dan Indonesia bagian timur dalam hal kesamaan persoalan lingkungan dan kebakaran yang menyarankan adanya potensi untuk bertukar informasi yang bermanfaat.

Kelompok 5: Hubungan sektoral dan kerjasama
Kelompok ini mulai dengan membuat daftar organisasi terkait yang mungkin terlibat dalam pelaksanaan proyek pengelolaan kebakaran dan lahan:

Indonesia
- Departemen Pertanian, Kehutanan, Pendidikan dan Lingkungan;
- Perum Perhutani;
- ICRAF / CIFOR / BIOTROP;
- Badan Perencanaan Daerah (Bappeda);
- Pusat Informasi Pertanian Lahan Semi-Kering di Kupang;

- FRIK (Badan Penelitian Kehutanan, Kupang);
- Konsorsium Pengembangan Masyarakat Nusa Tenggara;
- LSM dari World Vision, CARE, WWF, World Food Program;

Australia
- Pusat Penelitian Kerjasama Savana Tropis (Universitas, CSIRO, Pemerintah);
- Departemen Hubungan Asia, Perdagangan dan Industri Pemerintah Negara Bagian Northern Territory (DARTI);
- Industri peternakan;
- Badan Pertahanan Aborigin;
- Pusat Utama untuk pengelolaan Margasatwa yang Berkelanjutan di NTU, khususnya yang berhubungan dengan Rusa di Irian Jaya;
- LSM-LSM;
- Para peneliti tambahan, khususnya dari Australia bagian selatan;

Mekanisme hubungan
- Pusat Informasi Kupang—berhubungan dengan Departemen Pendidikan dan Departemen Kehutanan atau Pertanian;
- Savana Tropis CRC—melalui Northern Territory University;

Hubungan Proyek
Perlu untuk mendirikan satu kelompok kerja dengan perwakilan dari berbagai badan yang telah didirikan:

Masalah-masalah
Kemiskinan/standar hidup (perlu dicatat bahwa satu dari empat orang di NorthernTerritory hidup dalam kemiskinan, khususnya orang Aborigin). Pengelolaan kebakaran yang lebih baik, sebagai upaya dari pengembangan sistem pengelolaan lahan yang lebih baik, akan membantu mengurangi masalah-masalah lingkungan, sosial dan ekonomi yang kronis.

Pemecahan
'Paket Pengelolaan kebakaran '
– menciptakan model-model pengelolaan kebakaran
– meneliti dan menguji model ini dalam berbagai studi kasus

Penekanan tema
Komunikasi dua arah diperlukan, khususnya dalam tiga bidang berikut ini:

Hutan
Ternak
Rumput liar } hubungan Australia bagian utara – Indonesia bagian timur

Pengumpulan dan peninjauan informasi—
dikoordinasikan melalui Pusat Informasi Pertanian Lahan Semi-Kering (Kupang), dan Pusat Penelitian Kerjasama Savana Tropis (Darwin)

- *Konsekuensi kebakaran dan ekologi*

– rehabilitasi lahan;
– pemanfaatan lahan/situasi yang berbeda;
– mengembangkan prinsip/topik penelitian/tinjauan (diperlukan oleh para pembuat keputusan, badan–badan pemerintah, lembaga pendidikan dan kelompok masyarakat);
– pemanfaatan/pola pertanian di masa mendatang, yakni:

herbisida,
transmigrasi,
kebakaran
hortikultura, } Pengaruh-pengaruh terhadap pengelolaan

- *Penyebaran tempat dan waktu kebakaran*

– pola-pola pembakaran musiman dan penyebaran
– pengembangan indeks musim kering, contoh: ENSO - El Nino;
– Pola-pola pemulihan rumput dan penerapan yang berhubungan dengan imaginer satelit, contoh: NDVI dari NOAA – AVHRR, Radar;
– penyebaran informasi kepada para pembuat kebijakan dan manajer-manajer lahan;
– pemanfaatan dan penerapan/pelatihan

Diskusi Akhir Lokakarya

Dalam akhir forum terbuka lokakarya, para peserta diajak bersama-sama meringkas latar belakang, tujuan dan kerangka kerja untuk proyek-proyek di masa mendatang yang mungkin dikembangkan sebagai hasil dari persoalan-persoalan yang teridentifikasi selama lokakarya.

Poin-poin umum yang disepakati:
– Tidak semua masyarakat pemilik lahan savana memahami dengan baik peran api, dan karena itu perlu diadakan penelitian dan pelatihan mengenai praktek-praktek pengelolaan kebakaran yang tepat di Indonesia bagian timur dan Australia utara;
– Peristiwa kebakaran hanya merupakan satu pengetahuan saja di satu daerah, tetapi tidak didokumentasikan dengan baik
– Praktek-praktek pengelolaan kebakaran dapat ditemukan untuk tujuan pemanfaatan lahan yang berbeda-beda;
– Pembedaan harus dibuat antara pembakaran yang terkendali /ditentukan dan kebakaran yang tidak terkendali/menyebar dengan cepat. Perbedaan tersebut telah ada dalam bahasa Indonesia – '*api'*

yang mengacu ke pembakaran sebagai alat dan '*kebakaran'* mengacu kepada api yang tidak terkendali/yang tidak disengaja;

– Bahwa keahlian dan jaringan kerja yang cocok telah tersedia untuk mencapai penelitian dan pelatihan yang diperlukan untuk usaha-usaha di atas;
– Bahwa 'penelitian-tindakan' seharusnya merupakan prinsip bimbingan untuk melaksanakan demonstrasi atau kegiatan-kegiatan studi kasus. Penelitian-tindakan didefinisikan sebagai satu proses pembentuk pertanyaan dan kemudian melaksanakan penelitian, bekerja sama dengan klien. Dengan demikian, proses ini menggabungkan pengetahuan yang sudah ada dengan semua minat/pandangan pemilik lahan;
– Bahwa lokakarya sekarang ini telah menetapkan sebuah rasionalisasi untuk mengembangkan sebuah proyek yang berkelanjutan;
– Bahwa ringkasan resolusi harus diedarkan kepada satu kelompok yang terdiri dari peserta utama lokakarya untuk pengembangan lebih lanjut.

Tujuan/latarbelakang untuk pengembangan kerjasama program pengelolaan kebakaran

Diantara para peserta lokakarya telah ada kesepakatan untuk :

– mengembangkan sebuah proyek yang melibatkan pengelolaan kebakaran untuk meningkatkan standar hidup dan praktek ekologi berkelanjutan yang melibatkan Indonesia bagian timur maupun Australia bagian utara;
– kebutuhan akan informasi yang lebih banyak untuk membantu pengelolaan lahan yang berkelanjutan yang mencakup berbagai rezim kebakaran yang dibuat untuk memenuhi persyaratan pemanfaatan lahan yang berbeda.

Judul-judul proyek kerjasama yang mungkin dipertimbangkan:

Meningkatkan pemanfaatan lahan regional dan hubungannya dengan kebakaran

Penggunaan api yang konstruktif dalam pengelolaan lahan, pengembangan pertanian dan kehutanan yang berkelanjutan.

Peran api yang terkendali (yakni: yang ditentukan)/ tak terkendali …

Lokasi-lokasi yang mungkin untuk melaksanakan studi kasus di masa mendatang

Untuk Indonesia bagian timur, pemilihan lokasinya mirip dengan yang telah dikembangkan oleh Konsorsium Pengembangan Masyarakat Nusa Tenggara, ditambah dengan daerah antar lintas udara di Irian Jaya (Indonesia). Minat-minat pemilik lahan juga dimuat dalam daftar lokasi-lokasi yang ditunjuk di Australia bagian utara.

Indonesia bagian timur

Timor	Mutis
	Kupang
Sumba	Wanggameti
	Waingapu
	Paberiwai
Flores	Riung
Komodo	Pulau Komodo (daerah Warisan Dunia)
Irian Jaya	Wasur

Australia bagian utara

Victoria River District	pengembalaan; pelestarian
Western Arnhem Land	penduduk asli; pelestarian
Kimberley	pengembalaan; penduduk asli; pelestarian
Cape York	pengembalaan; penduduk asli; pelestarian
Burdekin (Qld)	pengembalaan

Pengembangan yang berkelanjutan

Satu kelompok inti telah ditunjuk untuk pengembangan proyek lebih lanjut:

Pak Tri Agung	WWF Indonesia / Konsorsium LSM, Kupang
Dr Hendrik Ataupah	Universitas UNDANA, Kupang
Dr Abdullah Bamualim	Balai Pengkajian Teknologi Pertanian (BPTP)
Ms Michele Bowe	WWF Oceania, Darwin
Dr Siliwoloe Djoeroemana	Sekolah Tinggi Ilmu Ekonomi, Kristen Wira Wacana
Professor Greg Hill	NTU dan Savana Tropis CRC, Darwin
Dr Jeremy Russell-Smith	BFC dan Savana Tropis CRC, Darwin
Professor Bungaran Saragih	Institut Pertanian Bogor, Bogor
Mr. Putra Suardika	Konsorsium Pengembangan Masyarakat Nusa Tenggara

Diskusi Pasca Lokakarya antar Perwakilan Proyek dari Indonesia dan Australia

Kelompok : Pak Tri Agung, Dr Hendrik Ataupah, Dr Abdullah Bamualim, Dr Siliwoloe Djoeroemana, , Mr Julian Gorman, Prof. Greg Hill, Dr Peter Jacklyn, Pak Michael Riwu Kaho, Dr Bronwyn Myers, Dr Jeremy Russell-Smith, Prof. Bungaran Sarigih

Kelompok di atas mengadakan pertemuan sehari setelah lokakarya untuk mendiskusikan kemungkinan pengembangan kerjasama lebih lanjut sehubungan dengan Nusa Tenggara, di bidang penelitian kebakaran, pengelolaan, pelatihan dan hubungan antar-lembaga. Peserta dari Indonesia menyatakan bahwa berdasarkan pada penemuan dan tujuan dari lokakarya yang dilakukan selama 3 hari sebelumnya, mereka telah mendiskusikan pengembangan garis-garis besar proyek secara luas yang ingin mereka ingin sajikan untuk bahan pertimbangan.

Secara ringkas, mereka menyarankan bahwa bagian dari proyek berkelanjutan di Nusa Tenggara harus:
- berfokus pada tiga daerah studi demonstrasi di Indonesia bagian timur: —di Mbay -Flores, di Paberiwai - Sumba, dan di Fatulew (dekat Kupang) - Timor;
- pada setiap lokasi, menggabungkan pendekatan penelitian yang aktif dan bersifat mengikutsertakan yang melibatkan masyarakat setempat, anggota Konsorsium Pengembangan Masyarakat Nusa Tenggara, badan-badan pemerintahan, para peneliti dan para akademisi;
- menyatu dengan 3 lokasi penelitian tersebut dengan seperangkat tujuan pengelolaan lahan yang sama, dimana peran koordinasi dan penyebaran informasi dilaksanakan melalui Pusat Informasi Pertanian Lahan Semi-Kering yang berpusat di Kupang;
- mengembangkan penelitian terapan, pengelolaan, pelatihan dan hubungan antar-lembaga yang dekat antara mitra-mitra kerja di Indonesia bagian timur dan Australia bagian utara.

Dalam rangka meningkatkan pengembangan proyek, tindakan-tindakan berikut telah disetujui:

- Rekan kerja Indonesia akan menyiapkan profil latar belakang yang terperinci dari tiga lokasi studi masing-masing. Pekerjaan ini akan dilakukan di bawah pengawasan Pusat Informasi Pertanian Lahan Semi-Kering.

Bahan ini akan disajikan dan didiskusikan lebih lanjut pada lokakarya di Kupang pada bulan September 1999*, dengan kemungkinan mengadakan kunjungan ke ketiga lokasi studi sebelum lokakarya dimulai.
Penyajian formal mengenai lokakarya ini akan diberikan kepada Pemerintah Indonesia di Bogor.
Rekan kerja Australia akan mulai menyiapkan pengajuan berikutnya kepada ACIAR dan mencari dana yang berkesinambungan sebagai satu Proyek Besar.
Dana lepas dari lokakarya Darwin akan digunakan untuk membiayai pengembangan komponen proyek yang digariskan di atas.
Para peserta setuju bahwa lokakarya ini telah menyediakan dasar yang mantap bagi kerjasama yang berkelanjutan.

* Catatan: Karena adanya ketidakstabilan politik di Kupang, rencana kunjungan pada bulan September telah dialihkan ke Bali pada bulan November 1999, Kunjungan ke lokasi studi di Wasur (Irian Jaya) direncanakan pada bulan
Desember 1999.

Referees

Mr Grant Allan
Dr Hendrik Ataupah
Dr Abdullah Bamualim
Mr Piers Barrow
Ms Michele Bowe
Dr David Bowman
Dr Phil Cheney
Mr John Childs
Dr Garry Cook
Mr Peter Cooke
Dr Siliwoloe Djoeroemana
Mr Rodd Dyer
Dr Jeff Fox
Prof Jim Fox
Ir Slamet Gadas
Prof Johann Goldammer
Dr Tony Grice
Prof Chris Healey
Prof Greg Hill
Dr Peter Jacklyn
Ms Barbie McKaige
Dr Andrew McWilliam
Mr Wayan Mudita
Dr Bronwyn Myers
Ir Retno Nuningsih
Ir Maraden Purba
Mr Noel Preece
Mr Luigi Michael Riwu Kaho
Prof Ir Riyanto
Dr Jeremy Russell-Smith
Dr Bambang Hero Saharjo
Prof Dr Bungaran Saragih
Prof Dr Haryono Semangun
Dr Richard Smith
Dr Neil Stronach
Dr Somsak Sukwong
Prof Dr Ir A. Sulthoni
Prof Nigel Tapper
Dr Tom Therik
Dr Dick Williams

Participants

Indonesia

Pak Tri Agung
World Wide Fund for Nature - Kupang,
Nusa Tenggara Project,
PO Box 1123, Pos Oebobo, Kupang 85000, NTT, Indonesia
Ph: 62 380 821472 Fax: 62 380 821472
triagung@kupang.wasantara.net.id

Ir Bambang Hartono
Head, Balai Taman Nasional Komodo
Pelabuhan Bajo, Flores, NTT, Indonesia
Ph: 62 385 41004 Fax: 62 385 41006

Mr Luigi Michael Riwu Kaho
Fakultas Peternakan, UNDANA Penfui
Jl.. Motoain 21, Naikoten I, Kupang, Indonesia
Ph/ fax: 62 380 824 259
P2SLPT@kupang.wasantara.net.id

Dr Hendrik Ataupah
Lecturer, Faculty of Social and Political Sciences,
Nusa Cendana University (FISIP UNDANA)
Jl. Adisucipto, Penfui, Kupang 85001, NTT, Indonesia
Ph: 62 380 822625/825589 Fax: 62 380825627

Ir Juspan
Dinas PKT, Sumba, Timur, Indonesia
Ph: 62 387 61333

Prof Ir Riyanto
Vice Rector for Academic Affairs, University Mulawarman
Rektorat Kampus Gunung Kelua, Jalan Kuaro Kotak Pos
1068 Samarinda 75119, East Kalimantan, Indonesia
Ph/ fax: 62 541 39890
csf@smd.mega.net.id

Dr Abdullah Bamualim
Balai Pengkajian Teknologi Pertanian (BPTP) (Research
Institute for Farming Technology)
Departemen Pertanian, Badan Penelitanian Dan Engebangan
Pertanian, PO Box 23, Kupang 85000, NTT, Indonesia
Ph: 62 380 833766/826893 Fax: 62 380 833766

Mr Marthen Mallo
World Wide Fund for Nature - Kupang,
Nusa Tenggara Project,
PO Box 1123, Pos Oebobo, Kupang 85000, NTT, Indonesia
Ph: 62 380 821472 Fax: 62 380 821472
triagung@kupang.wasantara.net.id

Dr Bambang Hero Saharjo
Faculty of Forestry,
Bogor Agricultural University
PO Box 168 Bogor 16001, West Java, Indonesia
Ph: 62 251 627750 Fax: 62 251 621244
manhut@bogor.wasantara.net.id

Dr Siliwoloe Djoeroemana
Sekolah Tinggi Ilmu Ekonomi, Kristen Wira Wacana, Christian School of Economics
Jalan Prof Dr W.Z. Yohanes 12 A,
Waingapu 87113, NTT, Indonesia
Ph: 62 387 62337 Fax: 62 387 62279
kriswima@indo.net.id

Mr Wayan Mudita
Centre for Research of the Environment & Natural Resources, Nusa Cendana University (UNDANA)
Jl. Adisucipto, Penfui, Kupang 85001, NTT, Indonesia
Ph/ fax: 62 380 825627
puskom@kupang.wasantara.net.id

Prof Dr Bungaran Saragih
Director of Centre for Development Studies,
Bogor Agricultural University
Jalan Pajajaran (Kampus IPB Gunung Gede)
Bogor 16153, Indonesia
Ph: 62 251 328105 Fax: 62 251 344113
psp-ipb@bogor.wasantara.net.id

Ir Esthon L. Foenay
Provincial Development Planning Board for East Nusa Tenggara (BAPPEDA),
Ketua Bappeda Tk. I NTT,
Jl Polisi Militer No. 2,
Kupang, NTT, Indonesia
Ph: 62 380 831712/833462 Fax: 62 380 821310/833664

Ir Retno Nuningsih
Director of Agricultural Polytechnic
Jl.. Adisucipto, Penfui, Kupang 85001, NTT, Indonesia
Ph: 62 380 831827 Fax: 62 380 826865
jotic@kupang.wasantara.net.id

Prof Dr Haryono Semangun
Faculty of Agriculture, Gadjah Mada University
Sekip, Yogyakarta 55281, Indonesia
Ph: 62 274 563 062 Fax: 62 274 563 062
swcu@server.indo.net.id

Ir Slamet Gadas
Forestry Research Institute, Kupang
Jl. Untung Suropati, No. 7 (Belakong) Kupang, NTT, Indonesia
Ph: 62 380 823 357 Fax: 62 380 833 102
bpkk@kupang.wasantara.net.id

Ir Maraden Purba
Kepala Taman Nasional Wasur
Jl. Raya Mandala, Spadem No.2, Kotak Pos 109, Merauke, Irian Jaya 99611, Indonesia
Ph/fax: 62 971 22495
wwfwasur@jayapura.wasantara.net.id

Mr Putra Suardika
NTCDC, World Neighbors Indonesia,
PO Box 71, Ubud, Bali 80571, Indonesia
Ph: 62 361 975 707 Fax: 62 361 976 487
wnisea@denpasar.wasantara.net.id

Dr Subandi
Agency for Agricultural Research and Development,
Research Institute for Maize and other Cereals
PO Box 1173, Ujung Pandang, Indonesia
Ph: 62 411 371529/371016 Fax: 62 411 371961
balitjas@upandang.wasantara.net.id

Prof Dr Ir A. Sulthoni
Department of Forestry Protection, Fakultas Kehutanan, Univ Gadjah Mada (UGM)
Bulaksumur, Yogyakarta 55281, Indonesia
Ph: 62 274 561947 Fax: 62 274 901420

Mr Suhardi Suryadi
LP3ES NTB
Jl.. Bung Hatta 11/6, Mataram, NTT, Indonesia
Ph: 62 370 27386
lp3es@mataram.wasantara.net.id

Dr Tom Therik
University Kristen Artha Wacana, Kampus Ukaw
Centre for Regional Studies, Jl.. Adisucipto, Desapa,
PO Box 147, Kupang, NTT, Indonesia
Ph/fax: 62 380 832584
ttherik@kupang.wasantara.net.id

Australia

Mr Steve Balch
Member for Jingili
PO Box 42988, Casuarina, NT 0811, Australia
Ph: 61 8 8927 5433 Fax: 61 8 8999 5333

Mrs Heather Crompton
ACIAR
GPO Box 1571, Canberra ACT 2601, Australia
Ph: 61 2 6217 0548 Fax: 61 2 6217 0501
crompton@aciar.gov.au

Prof Greg Hill
Northern Territory University
Darwin NT 0909 Australia
Ph: 61 8 8946 6550 Fax: 61 8 8946 6712
g_hill@banks.ntu.edu.au

Mr Piers Barrow
Project Officer, Natural Resource Management,
Kakadu National Park
PO Box 71, Jabiru NT 0886, Australia
Ph: 61 8 8938 1100 Fax: 61 8 8938 1115
Piers.Barrow@ea.gov.au

Mr Chris Done
Conservation and Land Management
P.O. Box 942 Kununurra W.A. 6743 Australia
Ph: 61 8 9168 4200 Fax: 61 8 9168 2179
chrisd@calm.wa.gov.au

Dr Peter Jacklyn
Northern Territory University
Darwin NT 0909 Australia
Ph: 61 8 8946 6285 Fax: 61 8 8946 7107
peter.jacklyn@ntu.edu.au

Ms Michele Bowe
World Wide Fund for Nature
Tropical Wetlands of Oceania Program,
GPO Box 1268, Darwin NT 0801 Australia
Ph: 61 8 8941 7554 Fax: 61 8 8941 6494
mbowe@wwf.org.au

Mr Rodd Dyer
Department of Primary Industry and Fisheries
PO Box 1346,
Katherine 0851, NT, Australia
Ph: 61 8 8973 9750 Fax: 61 8 8973 9777
rodd.dyer@dpif.nt.gov.au

Mrs Janet Lawrence
ACIAR
GPO Box 1571, Canberra ACT 2601 Australia
Ph: 61 2 6217 0537 Fax: 61 2 6217 0501
lawrence@aciar.gov.au

Dr David Bowman
Centre for Indigenous Natural and Cultural Resource Management,
Northern Territory University, Darwin NT 0909 Australia
Ph: 61 8 8946 7762 Fax: 61 8 8946 7755
d_bowman@banks.ntu.edu.au

Mr Andrew Edwards
Bushfires Council NT
PO Box 37346,
Winnellie NT 0813, Australia
Ph: 61 8 8944 8464 Fax. 61 8 8944 8455
andrew.edwards@pwcnt.nt.gov.au

Dr Frank McKinnell
Conservation and Land Management – Perth
Locked Bag 104, Bentley Delivery Centre,
Perth WA 6948, Australia
Ph: 61 8 9442 0319 Fax: 61 8 9386 6399
frankm@calm.wa.gov.au

Dr Phil Cheney
CSIRO Forestry and Forest Products
PO Box E4008, Kingston ACT 2604 Australia
Ph: 61 2 6281 3879 Fax: 61 2 6281 8348
Phil.Cheney@ffp.csiro.au

Dr Tony Grice
CSIRO Tropical Agriculture
Davies Laboratory, PO Box Aitkenvale,
Townsville, Qld 4815 Australia
Ph: 61 77 538 543 Fax: 61 77 538 600
Tony.grice@tag.csiro.au

Dr Andrew McWilliam
Sacred Sites Authority, NARU
12 Sanders St
Jingili, NT 0810, Australia
Ph: 61 8 89853446

Mr Peter Cooke
Executive Officer, Caring for Country Unit,
Northern Lands Council
PO Box 42921, Casuarina NT 0811 Australia
Ph: 61 8 8920 51 09 Fax: 61 8 8945 2633
peter.cooke@nlc.org.au

Prof Chris Healey
School of Southern Asian and Australian Studies, NTU
Darwin NT 0909 Australia
Ph: 61 8 8946 6725 Fax: 61 8 8946 6955
c_healey@banks.ntu.edu.au

Mr Robert Muller
Project Officer, Kakadu National Park
PO Box 71, Jabiru NT 0886, Australia
Ph: 61 8 8938 1100 Fax: 61 8 8938 1115
Rob.Muller@ea.gov.au

Dr Richard Noske
Senior Lecturer in Ecology, School of Biological and Environmental Sciences
Science Faculty, Northern Territory University,
Darwin NT 0909 Australia
Ph: 61 8 89 466 359 Fax: 61 8 89 466 847
richard.noske@darwin.ntu.edu.au

Prof Nigel Tapper
Monash University, School of Geography and Environmental Science
Clayton Campus, Wellington Road, Clayton,
Victoria 3168, Australia
Ph: 61 3 9905 2931/2929 Fax: 61 3 9905 2948
Nigel.Tapper@arts.monash.edu.au

Mr Frank Zich
NT Herbarium, PWCNT
PO Box 496, Palmerston NT 0831, Australia
Ph: 61 8 8999 4516 Fax: 61 8 8999 4527
f.zich@ais.net.au

Ms Carol Palmer
Worldwide Fund for Nature. Tropical Wetlands of Oceania Program, PO Box 1268, Darwin NT 0801, Australia
Ph: 61 8 8941 7554 Fax: 61 8 8941 6494
c.palmer@wwf.org.au

Ms Kathryn Thorburn
3/5 Bremer Street, Ludmilla, NT 0820, Australia
Ph: 61 8 8948 0541
kethorburn@hotmail.com

Mr Noel Preece
Ecoz Consultancy
GPO Box 381, Darwin NT 0801, Australia
Ph: 61 8 8981 1100 Fax: 61 8 8981 1102
ecoz@ozemail.com.au

Mr Glen Wightman
Parks and Wildlife Commission of the Northern Territory
PO Box 496, Palmerston NT 0831, Australia
Ph: 61 8 8999 4513 Fax: 61 8 8999 4527
glen.wightman@pwcnt.nt.gov.au

Dr Jennifer Robinson
Murdoch University
Env. Science, Murdoch University,
Perth 6150, Australia
Ph: 61 8 9360 6102
robinson@essun1.murdoch.edu.au

Dr Dick Williams
CSIRO Wildlife and Ecology
PMB 44, Winnellie, Darwin
NT Australia
Ph: 61 8 89448426 Fax: 61 8 8944 8444
dick.williams@terc.csiro.au

Dr Jeremy Russell-Smith
Bushfires Council NT
PO Box 37346, Winnellie
NT 0821, Australia
Ph: 61 8 8984 4000 Fax: 61 8 8947 2263
jeremy.russell_smith@nt.gov.au

Mr Colin Wilson
Parks and Wildlife Commission of the Northern Territory
PO Box 496, Palmerston NT 0831, Australia
Ph: 61 8 8999 4698 Fax: 61 8 8999 4793
colin.wilson@PWCNT.nt.gov.au

Dr Richard Smith
Western Australian Department of Lands Administration,
Satellite Remote Sensing Services
PO Box 471, Wembley WA 6014 Australia
Ph: 61 8 9383 9342 Fax: 61 8 9383 7142
richard_smith@notes.dola.wa.gov.au

Mr Cameron Yates
Bushfires Council NT
PO Box 37346, Winnellie NT 0821, Australia
Ph: 61 8 8984 4000 Fax: 61 8 8947 2263

Other countries

Dr Jeff Fox
Director, Program on Environment, East-West Center
1601 East-West Road, Honolulu, Hawaii 96848
Ph: 1 808 944 7248 Fax: 1 808 944 7298
foxj@ewc.hawaii.edu

Dr Mark Johnston
National Agricultural Research Institute
P.O. Box 4415 Lae 411,
Morobe Province, PNG
Ph: 675 472 1751 Fax: 675 472 2242
nari@datec.com.pg

Dr Neil Stronach
Fota Wildlife Park Ltd
Carrigtwohill, Co. Cork, Ireland
Ph:353 21 633007/812678 Fax: 353 21 812744
fota@indigo.ie

Dr Somsak Sukwong
Regional Community Forestry Training Centre
Kasetsart University,
PO Box 111, Bangkok 10903, Thailand
Ph: 662 942 5700 Fax: 662 561 4880
ftcsss@nontri.ku.ac.th