International Union of Forest Research Organizations
Union Internationale des Instituts de Recherches Forestières
Internationaler Verband Forstlicher Forschungsanstalten
Unión Internacional de Organizaciones de Investigación Forestal

IUFRO World Series Vol. 24

Asia and the Pacific Forest Health Workshop

Forest Health in a Changing World

Editor
Sim HeokChoh

Extended abstracts
From the workshop held in Kuala Lumpur, Malaysia, 1–3 December 2008

Jointly organized by
International Union of Forest Research Organizations (IUFRO)
Asia Pacific Forest Invasive Species Network (APFISN)
Food and Agriculture Organization of the United Nations (FAO)
Forest Research Institute Malaysia (FRIM)
Korea Forest Research Institute (KFRI)
Asia Pacific Association of Forestry Research Institutions (APAFRI)

ISSN 1016-3263
ISBN 978-3-901347-84-9
IUFRO, Vienna 2009

Recommended catalogue entry:
Asia and the Pacific Forest Health Workshop: *Forest Health in a Changing World.* Extended abstracts from the workshop held in Kuala Lumpur Malaysia, 1–3 December 2008. Jointly organized by the International Union of Forest Research Organizations (IUFRO), Asia Pacific Forest Invasive Species Network (APFISN), Food and Agriculture Organization of United Nations (FAO), Forest Research Institute Malaysia (FRIM), Korea Forest Research Institute (KFRI) and the Asia Pacific Association of Forestry Research Institutions (APAFRI). Sim HeokChoh (Editor). Vienna. IUFRO. 2009–133 p.– (IUFRO World Series Vol. 24).

ISSN 1016-3263
ISBN 978-3-901347-84-9

Cover photos (from left to right):
1. *Corythucha ciliate* adults, sucking on *Platanus occidentalis* leaf – Choi KwangSik, Korea Forest Research Institute
2. A burned Taiwan red pine (*Pinus taiwanensis*) forest in 2002 showing seriously damaged trees – Lin ChauChin; Taiwan Forest Research Institute
3. *Lycorma delicatula* 4th instar larvae, sucking on *Ailanthus altissima* – Choi KwangSik, Korea Forest Research Institute

Published by:
IUFRO Headquarters, Vienna, Austria, 2009

Available from:
IUFRO Headquarters
Secretariat
c/o Mariabrunn (BFW)
Hauptstrasse 7
1140 Vienna
Austria

Tel.: +43-1-8770151-0
Fax: +43-1-8770151-50

E-mail: office@iufro.org
Web site: www.iufro.org

Price:
EUR 20.-
plus mailing costs

Printed by: Ferdinand Berger & Söhne GmbH, Wiener Straße 80, 3580 Horn, Austria

CONTENTS

Introduction and Workshop Report

Introduction

Increased trade and international travel have resulted in significantly increased risks to forest health by the introduction of alien species including pests and diseases, intentionally and non- intentionally. Similarly, growing trends in urban greening and landscape beautification often include imports of exotic plants. This has contributed to rapid increase in the international movement of plant materials including young seedlings. Many previously unreported or unknown pests and diseases, brought in by these movements of planting materials, have surfaced in these countries; further aggravating the threat that has already multiplied by increased trade including, especially, of wood and non-wood forest products. The Asian long-horned beetle, which attacks hardwood trees, for example, is indigenous to China and Korea; but was introduced on wooden packaging material to the United States most probably in the 1980s. This pest is a serious threat to the multi-million dollar hardwood industry in North America. Similarly, Eucalyptus rust, mahogany shoot borer and leaf blight in many of the Asian countries were probably introduced to Asia via exotic planting materials for forest plantations. Other species that have been introduced deliberately have later emerged as serious invasive pests. For example, fishes and frogs introduced for human consumption have out-populated local species, weeds for erosion control have invaded agricultural lands, and even species brought in for biological control have spread out of control.

Alongside these issues, there has emerged a growing awareness of the importance of healthy forests in providing various environmental services. Policies and strategies to strengthen the capability and sustain the capacity of the forests in providing these services are increasingly being debated as important parts of forest management in many countries, and also at many international and regional fora.

All of these concerns are captured in the scope of *forest health* which encompasses factors such as the forest's age, structure, composition, functions, vigour, and presence of unusual levels of insects or disease, as well as resilience to disturbances. The perception and interpretation of forest health are influenced by individual and cultural viewpoints, land management objectives, spatial and temporal scales, the relative health of the stands that comprise the forest, and the appearance of the forest at a particular point in time.

The workshop

The main objective of the workshop was to provide a forum for linking various international, regional and national agencies and institutions dealing with forest health issues, and to share strategies, experiences and knowledge, related to forest health. The workshop has also provided an opportunity for individuals and their associated agencies, organizations and networks to build collaborative linkages and better align programmes to capture synergies. While special emphasis had been given to plant pests and diseases, other topics such as abiotic and biotic disturbances, as well as environmental services of the forests were also covered. The successful practices to control and eradicate invasive alien species in the forest and agricultural field at local level were also introduced. The workshop has also provided an opportunity for various organizations – including IUFRO and APFISN – to assess capacity-building needs in terms of research and extension related to forest health in the Asia-Pacific region.

The workshop was an initiative of the International Union of Forest Research Organization (IUFRO) and the Asia-Pacific Forest Invasive Species Network (APFISN). It was organized by the Asia-Pacific Association of Forest Research Institutions (APAFRI) in technical collaboration with the Food and Agriculture Organization of the United Nations (FAO), Forest Research Institute Malaysia (FRIM), and the Korea Forest Research Institute (KFRI). A total of 40 papers were presented in this workshop, out of which 6 were by representatives of global and regional agencies such as FAO, CBD, CABI and TNC. The other 36 papers cover topics ranging from bilateral and multilateral collaborations, pests and diseases, abiotic and biotic disturbances, and forest health in general. The full programme of the workshop is as in Annex I.

The two-and-a-half-day workshop attracted 54 participants from 18 countries. These included representatives of a number of international and regional organizations, programmes, networks and projects dealing with forest health with special interests in the issue of invasive alien species as well as the individuals working in policy, research and operations related to forest pests and diseases, environmental services, and forest management from the Asia and the Pacific region. The complete list of the participants is appended as Annex II.

Panel discussion

Technical capacity in dealing with forest health issues is generally weak and disorganized in many of the countries in Asia and the Pacific region. Bureaucratic rivalries and lack of coordination further hamper the efficiency and effectiveness of tackling forest health issues. At the regional level, there is little collaboration on many aspects of forest health, as these topics are traditionally handled by agencies of different disciplines. For example, pests and diseases problems are often viewed as principally the territories of agricultural institutions, and environmental issues are handled by the meteorological or environmental agencies; the capability and capacity to deal with these issues are either poor, or totally lacking, in most forestry agencies. These issues collectively create major challenges in developing a holistic approach towards forest health in most of the countries in the region.

On the other hand, there is not much regional investment in forest health beyond some good information sharing. The useful and specific workshops held in the region in the past to exchange information were not connected to follow-up activities, due to lack of resources, financially and personally. There appears to be various activities and prograrmmes that forest health/invasives have a role in. However they are not given sufficient attention to develop regional level of collaborative mechanism in North-South and South-South cooperation.

To achieve the main objective of the workshop to provide a forum for linking various international, regional and national agencies and institutions dealing with forest health issues, and to share strategies, experiences and knowledge, related to forest health, a Panel Discussion was held during the workshop. This discussion also provided the opportunity for individuals and their associated agencies, organizations and networks to express their needs and capacity to build collaborative linkages and better align programmes to capture synergies.

Representatives of the FAO, IUFRO, APFSIN and CBD were invited again for this Panel discussion. The panel discussion, with the topic “Capturing synergies – what and how?”, aimed to seek their views on the needs to develop technical capacity to tackle relevant forestry related issues by developing strong linkages at global, regional and local participatory levels.

It was pointed out that there exists a lot of confusion or even conflicts with regards to the terminologies used for the organisms to discuss on the matters of forest health. For example, invasive species, alien species, non-native species, exotic species, etc. One country’s definition of invasive species may not be of much relevance or even not agreeable in another country where the invasive species may be important at least from the point of view of biodiversity. The workshop was informed of the APFISN definition of invasive species: “an invasive species is a non-native one which can cause ecological /or environmental damage’. The CBD’s definition on ‘invasive alien species’ was also introduced as follows: "alien species" refers to a species, subspecies or lower taxon, introduced outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce; and "invasive alien species" means an alien species whose introduction and/or spread threaten biological diversity.

The panel suggested adopting the definition of invasive alien species under the CBD as it is the international instrument of the largest number of the Parties and framework collaborating with other relevant international environmental agreements.

There are already a few programmes on capacity building such as Australian-Asian Capacity Building (AACBP) to impart training on taxonomic identification and diagnosis of invasive species. Programmes to create awareness among the public on invasive species should still be given high

priority. Incorporating the topic in the school curriculum and involvement of NGOs in the awareness programmes and the role of print and visual media would be crucial to the success of these efforts.

Information on key pathways on invasive species has already been developed and possibility of exploitation of modern diagnostic tools and software for identification of invasive species need to be looked into. Information generation, stock taking, networking, and dissemination and sharing the information have to be strengthened. It was stressed that for any pest/pathogen related issues, contact has to be made with the national networks or agencies. Several programmes and agencies, such as CABI and IUFRO's Special Programme for Developing Countries (SPDC), have existing activities which could support such efforts.

There is also a need for multinational cooperation for pest and pathogen control, since there are >1000 potential invasive species. There was a suggestion that APFISN could explore the possibility of developing multinational megaproject under Global Environmental Fund (GEF).

In addition, CBD called for submission of case studies, lessons learned and best practices to address the threats from invasive alien species from Asia and the Pacific region and informed that the International Day for Biological Diversity in 2009 will focus on invasive alien species.

ASIA-PACIFIC FOREST INVASIVE SPECIES NETWORK (APFISN) ACTIVITIES AND INITIATIVES DURING 2007–2008

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Forest invasive species (FIS) are plants, animals and microbes non-native to a specific forest ecosystem whose introduction will cause economic and/or ecological harm or harm to human health. The introduction of FIS to any particular area/region could either be intentional or inadvertent. In general, inadvertent introductions are helped by international trade and transport of goods. This type of introduction has increased in the recent times – perhaps as a by-product of globalization. On the other hand, intentional introductions happen through import of food crops, ornamental plants and pests and live stocks. Non-native trees introduced for forestry purposes constitute another example of intentional introductions.

FIS are considered as one of the most serious environmental challenges globally. Threats due to FIS are in terms of ecological destruction, economic loss, loss of biodiversity and detrimental social effects. Recent statistics indicate that they cost 5% of the global economy. Loss to China is estimated to be around USD 15 billion annually. In the US, loss is to the tune of USD 120 billion. Unfortunately, such statistics are unavailable for most other countries, especially in the Asia-Pacific region. However, it can reasonably be assumed that the damage due to FIS in the Asia-Pacific countries will be considerable.

It is against this background, in response to the immense costs and threats posed by the forest invasive species to sustainable forest management, that the Asia-Pacific Forest Invasive Species Network (APFISN) was established. The Network is a cooperative alliance of 33 member countries of the Asia-Pacific Forestry Commission (APFC), a statutory body of the FAO. It focuses on inter-country cooperation that helps to detect and prevent the introduction of FIS and monitor, eradicate/control invasive species which have already been introduced. The Network was formal launched during the 20th Session of the APFC held in Fiji in 2004.

The strategic objectives of APFISN are:

1. to raise awareness of forest invasive species through out the region;
2. to exchange information on invasive species among member countries;
3. to facilitate access to expertise, research results and training opportunities;
4. to strengthen capacities of member countries to manage FIS; and
5. to develop action plans for regional collaboration in combating forest invasive species.

The Network has developed several action plans to achieve its objectives. These include: awareness raising, database and information sharing, stocktaking of national activities, capacity building and developing organizational structures to support the Network.

The Network has developed a strong organizational structure to implement its activities. It has constituted an Executive Committee (EC) with six members: four nominated and two ex-officio. The EC provides strategic guidelines to the Network's activities. EC meetings are held periodically – at least once in a year. The Network has also appointed National Coordinators (focal points) in most member countries in consultation with their respective Governments. Of the 33 member countries, 22 have nominated National Coordinators (NC) and the others are in the process of nomination. The NC's are the connecting link between the Network and the member countries. They are responsible for coordinating in-country networking and receiving and imparting training. NC's are also supposed to help the Governments in their respective countries to develop policies to combat invasive species threats. APFISN has also appointed a Network Coordinator who is responsible for the overall management of the activities of the Network which include organizing workshops and training programmes to improve capacity within member countries, raising funds for the activities of Network and engaging countries and focal points in the Network's activities.

To raise awareness on invasive species and to disseminate information, the Network is publishing a bimonthly newsletter, *Invasives*, since July 2006. Also, fact sheets on major invasive species in the region are brought out periodically and disseminated widely. A documentary film on the invasive plant *Mikania micrantha* was produced. To share database and information, proceedings/reports of all the workshops organized by the Network are published or made available on CD. A database of the Network is being developed by the Chinese colleagues. The Network has a website (www.apfisn.net) which provides information on its structure and activities. The website is periodically updated to include new information. As part of information sharing, a system of Email networking was introduced and is being continued. Using this facility, all interested parties are encouraged to clarify doubts, notify new invasions, and seek information and help from the network by contacting the Network Coordinator (sankaran@kfri.org). APFISN has links with other invasive species networks such as Forest Invasive Species Network for Africa and the Pacific Invasive Species Learning Network.

To share information between member countries and to evaluate capacities and identify deficiencies within member countries to deal with invasive species, APFISN requested each member country to prepare a report on national activities on FIS. This report compiles a checklist of all FIS present in each country along with basic information such as geographical area, climate, types of forests and policies and regulations in force to prevent incursion of invasive species. Fifteen countries have so far produced and submitted reports to the Network. APFISN helped countries like Vietnam, Cambodia and Bhutan to produce such reports. The Network is willing to help other countries in the region who are in need of help to carry out this activity. All the country reports are posted on the website of APFISN.

To build capacity of member countries to deal with FIS, the Network organized six workshops so far. These include workshops on the Eucalyptus rust fungus (Bangkok, October 2004), Coconut leaf beetle (Vietnam, February 2005), Early Warning Systems for FIS (Kerala, February 2006), Developing Invasive Species Management Plans (Kuala Lumpur, May 2007), Risk-based Targeted Surveillance for FIS (Hanoi, April 2008) and the current one – Forest Health in a Changing World (Kuala Lumpur, December 2008). Two workshops were co-organized – International Workshop on Biological Control of Invasive Species of Forest (Beijing, September 2007)) and International Workshop and Training Course on Invasive Species (Wuhan, China, October 2008). Future plans of APFISN include staff exchange, sharing of technical expertise and facilitating collaborative research involving member countries on issues of mutual interest and concern. APFISN will also conduct more workshops in 2009.

The current priority areas of work for APFISN are: 1) identify taxonomic expertise in the region and to make the expertise available; 2) produce a target pest list for the region; 3) map current activities on FIS in the region to identify gaps; 4) develop the database and make it user-friendly; 5) identify capacity building requirements in member countries and organize training programmes and workshops including hands-on training on quarantine methods; 6) to concentrate more on raising awareness on threats posed by FIS within member countries by encouraging and helping them to display information at airports/ports, publish and disseminate leaflets on FIS in English and local languages and disseminate information through the media, radio and television; 7) link APFISN with other Networks and professional bodies like IPPC, CBD, APEC, ASEAN, etc. so that the activities can be expanded; 8) encourage member countries to carry out surveillance for FIS and pest risk assessments; and 9) promote in-country networking.

It is felt that more effort is needed to invigorate the network and to attain a better profile. One of the other challenges is ensuring availability of funding to continue the activities. The main supporters of the Network are the USDA Forest Service and the FAO. Occasional support is also received from Chinese Academy of Sciences, APAFRI and ACIAR, Australia. However, it has not been possible so far to identify a sustainable source. The necessity to better engage member countries and National Coordinators is also felt. In-country networking has not been effective as expected. There is a urgent need to improve coordination and communication to cultivate a sense of belonging by the member countries.

If the above issues could be addressed successfully, APFISN will be able to fully achieve its major aims including improving coordination and cooperation among member countries to mitigate the effects of invasive species and to prevent new incursions, improving skills and capacities in each member country to combat FIS threats and rapid sharing of information.

APFISN gratefully acknowledges the support of FAO, USDA Forest Service, APFC, APAFRI, State Forestry Administration of China, Chinese Academy of Sciences, Governments of Fiji, Vietnam and India, ACIAR Australia, Australian Department of Agriculture, Fisheries and Forests, New Zealand Ministry of Agriculture and Forestry and Kerala Forest Research Institute (India).

Stocktaking of forest invasive species in the Asia-Pacific region

Stocktaking of forest invasive species in the member countries is one of the major objectives of APFISN. The main advantages of this exercise are: 1) it identifies current knowledge (and gaps) on FIS in each country; 2) it also identifies needs and opportunities which will guide in developing future programmes and initiatives against FIS; and 3) it helps to initiate rapid actions against a potential threat. A stocktaking report of a country is expected to contain information on the country background, background of forest invasive species, institutional framework and management, strategies, mechanisms and measure to control FIS, and facilities and service available for national and regional co-operation. Of these, information on FIS should essentially contain a checklist of existing FIS in the country, the impact of these (biological, economic or other), costs, potential future threats and concerns, national priorities in combating/controlling FIS, and level of public awareness.

The Network provided detailed guidelines as to how a report is to be compiled. Based on the request by the Network, 12 countries have prepared and provided the report. All these reports are posted on the APFISN website (www.apfisn.net) for easy access. One simple and straight forward way of using the information contained in these lists is by comparison with the list of FIS of the users own country. For example, the coconut leaf beetle, *Brontispa longissima* has been reported from Vietnam, Indonesia, Cambodia, Myanmar and Malaysia. However, it has not been recorded so far from India and Sri Lanka – the main coconut growers. Here is a rare opportunity to issue a warning and arrange rapid action to avoid incursion of the beetle to these countries.

Poor resources and lack of expertise have prevented some of the countries in the Asia-Pacific region in preparing a stocktaking report. APFISN had mobilized resources to help such countries to produce the reports. The APFISN Coordinator visited Vietnam, Cambodia and Bhutan during November-December 2007 to help these countries to produce the stocktaking report. An integral part of these visits was organizing workshops on FIS in each country to raise awareness of the threats posed by invasive species and the necessity to frame policies and initiate actions. The workshop in Vietnam was organized in the Forest Science Institute of Vietnam. Over 20 participants from various government departments, including the Vietnam Forest Department, participated in the workshop.

The checklist of FIS in Vietnam was prepared with the assistance of Dr. Pham Quang Thu (National Coordinator of APFISN in Vietnam) and his colleagues. The checklist contains 44 plants, 115 insects and 34 pathogens. The main invasive plants were *Parthenium hysterophorus, Lantana camara, Chromolaena odorata, Mikania micrantha, Mimosa diplotricha, Imperata cylindrica, Ageratum conyzoides, Arundo donax, Mimosa pigra, Leucaena leucocephala* and *Acacia mearnsii.* The important invasive pests are *Leptocybe invasa, Achatina fulica, Dendrolimus punctatus* and *Quadrastichus erythrinae.* The invasive pathogens included *Lophiodermium pinastri* and *Cryphonectria cubensis* .

In Cambodia, the APFISN Coordinator visited the Forest and Wildlife Research Institute. Twenty six participants form all over Cambodia participated in the invasive species workshop organized by the Network. Samreth Vanna (National Coordinator of APFISN in Cambodia) and his colleagues helped the APFISN Coordinator in preparing the stocktaking report. The checklist included 30 plants, 6 insects and 3 fungi. The important invasive plants in Vietnam were all detected in Cambodia as well. The invasive insects included *Agrilus planipennis* (Emerald ash borer) and *Lymantria dispar* (Gypsy moth). The current list can only be considered as a preliminary one since Cambodia has no expertise in identifying their insects and microbial flora.

The checklist of FIS in Bhutan was prepared with the help of D.B. Dhital (National Coordinator of APFISN in Bhutan), Forest Administration Office, Thimpu, and his colleagues. Fifteen participants from the Forest Department of Bhutan took part in the workshop organized by the Network. The checklist of FIS in Bhutan included 42 plants, 28 insects/birds and 6 plant pathogens. Again, the major invasive plants were common in all the three countries. *Argemone mexicana, Psidium gujava* and *Solanum mauritianum* are some of the other important species recorded from Bhutan. The

insects included *Lymantria dispar, Xylosandrus crassiculus, Heteropsylla cubana, Hyblaea puera* and *Ips longifolia.* The important invasive pathogens are *Dothistroma pini, Cronartium ribicola* and *Lophodermium pinastris.*

A critical analysis of the checklists of the three countries reveals that there are over 15 invasive plants common to all three countries. However, invasive insects and pathogens common to the three countries were only a few. This could probably due to lack of information on the insect and microbial flora rather than lack of commonality. Nevertheless, the checklists compiled with the help of APFISN are important basic documents which are ready for all the three countries. These could form the foundation for further updating when new invasive species are detected.

FAO'S RESPONSE TO GLOBAL FOREST HEALTH ISSUES

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Healthy forests are essential for sustainable forest management, yet forests like other ecosystems are subject to a number of threats that can cause tree mortality or reduce their ability to provide a full range of goods and services. The causes of the negative impacts on forest health and vitality vary from place to place and the magnitude and duration of the impacts are not easy to assess.

Protecting the health of the world's forests requires international cooperation and the gathering and dissemination of accurate and timely information. However continuous monitoring of forest ecosystems is a high maintenance, expensive process which can rarely be carried out by developing countries and countries in transition. To assist, FAO gathers data and information on a variety of topics related to forest health such as forest insect pests and diseases, invasive tree species, forest pest outbreaks and pest control measures.

A review of forest pests (insects, diseases and other pests) in both naturally regenerating and planted forests was carried out from 2005-2007 in 25 countries representing Africa, Asia and the Pacific, Europe, Latin America and the Caribbean and the Near East, published as FAO Forestry Paper 156, Global Review of Forest Pests and Diseases. Based on the available information, 28 profiles of forest pest species considered to be of importance in more than one country, such as *Dendrolimus sibiricus*, *Hypsipyla robusta* and *Lymantria dispar*, have been prepared. Information on the biology, distribution, symptoms and damage, dispersal and spread, and measures for control are presented for each species. This activity is an on-going process, country overview papers and pest profiles will continue to be prepared.

With the cooperation of experts from member countries, FAO has compiled data for a global information system on the impact of insect pests and disease outbreaks on forests. A database on the incidence and extent of insect pests and diseases impacting forests has been created and to date, qualitative information on forest health issues has been collected for 64 countries, mostly developing countries and countries in transition. The information was collected through a search of FAO field project documents, technical responses to questionnaires sent to member countries, and country pest overviews papers.

In order to determine the global status of research and applications regarding breeding trees for pest resistance in the forest sector, the FAO Forestry Department, in collaboration with the Research Branch, British Columbia Ministry of Forests, Canada and the Molecular Tree Breeding Services, US, conducted an informal yet comprehensive review of the topic. A total of 260 activities on breeding for insect and disease resistance in forest trees were recorded in this review. Pines (*Pinus* spp.) and poplars (*Populus* spp.) were the two most commonly investigated genera followed by eucalypts (*Eucalyptus* spp.), spruce (*Picea* spp.), birch (*Betula* spp.), larch (*Larix* spp.), Douglas fir (*Pseudotsuga* spp.), chestnut (*Castanea* spp.), willows (*Salix* spp.) and elms (*Ulmus* spp.). It was noted that the majority of research activities are published in developed countries, such as the United States, Canada, Japan, New Zealand, France and Australia, although some emerging developing countries, such as China, India and Brazil are active or at least publish and disseminate their results.

Starting with documenting the benefits and drawbacks of *Prosopis* spp. which have been introduced in many countries, especially in dry and semi-arid zones, FAO carried out a number of fact-finding studies to assess the extent and intensity of invasiveness by forest trees; this was later supplemented by a review of the impacts of invasive species on forests and the forest sector. An invasive tree species database has been developed which provides summarized information about forest tree species that have been reported naturalized or invasive in at least one country or territory such as *Dalbergia sissoo*, *Leucaena leucocephala*, and *Melaleuca quinquenervia*. Data was collated by CAB International in 2003 and updated by US Forest Service, Pacific Northwest Research Station in 2008

as a collaborative venture with FAO. Data is the combined results of literature reviews, electronic searches of Web resources, and correspondence with forestry professionals and invasive species specialists.

Box 1. FAO information resources related to forest health

- Forest health: www.fao.org/forestry/pests
- Invasive species: www.fao.org/forestry/aliens/en/
- Global information system: www.fao.org/forestry/25350/en/
- Country pest overview papers: www.fao.org/forestry/38536/en/
- Forest pest profiles: www.fao.org/forestry/43795/en/
- Breeding for resistance: www.fao.org/forestry/26445/en
- Invasive tree species database: www.fao.org/forestry/24107/en
- Invasive species networks:
  - Forest Invasive Species Network for Africa (FISNA): www.fao.org/forestry/25470/en/
  - Asia-Pacific Forest Invasive Species Network (APFISN): www.fao.org/forestry/35067/en/
  - Near East Network on Forest Health and Invasive Species (NENFHIS): www.fao.org/forestry/51295/en/
  - Red de Países del Cono Sur sobre Especies Exoticas Invasoras a Ambientes Forestales (Network for the South Cone countries of South America): www.fao.org/forestry/52502/en/
- Climate change and forest health: www.fao.org/forestry/24833/en/
- *Adaptation of Forests and Forest Management to Changing Climate with Special Emphasis on Forest Health: A Review of Science, Policies and Practice* Conference: www.forestadaptation2008.net/home/en/

At the request of member countries FAO provides support through the Technical Cooperation Programme (TCP) and through Unilateral Trust Funds (UTF). Assistance ranges from immediate response to pest outbreaks (both endemic and introduced pests) to establishing long-term prevention and forest protection strategies. Since 1997 FAO has provided technical support and training through field projects to 23 countries. In the Asia-Pacific Region, FAO has provided emergency assistance to control the spread of the Siberian caterpillar, *Dendrolimus sibiricus*, and the Asian gypsy moth, *Lymantria dispar* in Mongolia, and to reduce the spread and impact of the pine moth, *Dendrolimus spectabilis* and *D. sibiricus* in the Democratic People's Republic of Korea. In the Three North Region of People's Republic of China, assistance was provided to develop sound management of shelterbelts and to help control outbreaks of the Asian longhorned beetle, *Anoplophora glabripennis*. Technical support was also provided in development of integrated pest management strategies for production and storage of chestnuts in Xinxian County, Henan Province, People's Republic of China.

In response to the increasing need to share information and in line with the recommendations of the Regional Forestry Commissions, FAO has helped establish regional networks dedicated to the issue of invasive species and the forest sector including the Forest Invasive Species Network for Africa (FISNA), the Asia-Pacific Forest Invasive Species Network (APFISN), the Near East Network on Forest Health and Invasive Species (NENFHIS), and most recently a network for the South Cone countries of South America, Red de Países del Cono Sur sobre Especies Exoticas Invasoras a Ambientes Forestales.

With increasing global trade, new challenges emerge due to the increased risk and frequency of trade-driven international pest movement. In the last decade several pests have been introduced into other countries and continents through international trade, and these have contributed to the international recognition of the importance of International Standards for Phytosanitary Measures (ISPMs), in particular guidelines for regulating wood packaging materials in international trade (ISPM No. 15); adopted in 2002 by the FAO-based Interim Commission on Phytosanitary Measures.

A multi-stakeholder process has been initiated to interpret these complex ISPMs into more understandable and relevant examples in order for the forestry sector to better implement the standards. ISPMs provide guidance that is broadly applicable for forest health, monitoring, the safe transfer of germplasm and trade in trees and forest products.

Climate change is another new challenge impacting the health of the world's forests. FAO has investigated these impacts and a new publication reviewing the impacts of climate change on forests,

forest pests and diseases, and the forest sector is available “Climate change impacts on forest health coupled with a new Web site on climate change and forest health. FAO, IUFRO and SLU hosted the international conference *Adaptation of Forests and Forest Management to Changing Climate with Special Emphasis on Forest Health: A Review of Science, Policies and Practice* in Umea, Sweden, from 25–28 August 2008.

These activities provide forest health specialists, forest managers and policy-makers worldwide with the information and tools needed to protect the health of the world’s forests.

OVERVIEW OF CABI ACTIVITIES AND PROGRAMMES RELATED TO INVASIVE SPECIES AND PLANT HEALTH

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CAB International (CABI) is a not-for-profit organization providing scientific expertise, knowledge and information, with over 350 staff based in 16 countries. Established in 1910 and currently owned by more than 40 member countries, CABI works to improve the livelihoods of some of the world's poorest people by making best use of its innovative research and information skills. These are applied through a network of in-country centres and partners built up over the last 100 years. To ensure that CABI's work has maximum impact, CABI has focussed on three globally important areas: Commodities, Knowledge for Development and Invasive Species. In 2007, CABI worked in 67 countries, on local, national, regional and global projects with a total of 222 projects, of which the highest number was on invasive species (88 projects).

There are three CABI Centres currently active in research and development related to forest invasive species and forest health, i.e. CABI Africa, CABI UK and CABI Switzerland. In addition, CABI has also embarked, in partnership with other international organizations, on developing an encyclopaedic database on invasives, namely, the Invasive Species Compendium (ISC) using compendium technology with which CABI has now more than 15 years experience.

CABI Africa: CABI Africa in partnership with UNEP, IUCN and four African countries (Ethiopia, Ghana, Uganda and Zambia) has started to address invasive species in these countries. Eight invasive plant species have been identified as being major offenders and these form the main focus of the project. These include water hyacinth (*Eichhornia crassipess*), parthenium (*Partenium hysterophorus*) and *Senna spectabilis*, which threaten sustainable forest harvesting of indigenous species and the habitats of chimpanzees. CABI Africa in Nairobi is currently also hosting the Global Invasive Species Program (GISP) Secretariat and the current Director, Dr. Sarah Simons, is CABI staff seconded to GISP.

CABI UK: The most extensive work currently done by CABI UK is on biological control of *Mikania micrantha*, an invasive plant which invades natural and agricultural ecosystems causing serious problems over vast areas of the moist tropical zones of Asia. The initial project was carried in India (where it causes problems in natural forests, tea and teak plantations) using a plant pathogen, *Puccinia spegazzinii* which is a very host specific biological control agent. Following the successful establishment of the pathogen in India, several projects in China (Guangdong and Taiwan), Fiji and PNG have now being initiated. Currently CABI UK is also screening two different rusts, i.e. *Prospodium tuberculatum* and *Puccinia lantanae* as possible biological control agents for the invasive plant, *Lantana camarae* in India and Australia. A highly invasive annual weed in UK, Himalayan balsam (*Impatients glandulifera*) has also been a target of biocontrol research by CABI UK. Two projects are currently being implemented: a) the biological control of Himalayan balsam in the UK, and b) the potential damage to exposed riverine sediment habitats due to invasion by Himalayan balsam.

A CABI UK staff member, Dr. Eric Boa has prepared and published a book entitled "*An illustrated guide to the state of health of trees: Recognition and interpretation of symptoms and damage book*" (FAO, 2003). The aim of this guide-book is to help readers recognize symptoms of ill health in trees and understand their general significance. The guide provides 140 photographs of symptoms from more than 50 tree species to be used as a basis for demonstrating the effects of pest (biotic) and non-living (abiotic) influences on trees. It aims to assist anyone interested in tree health or responsible for managing trees.

CABI Switzerland**:** The emphasis of research at this Centre is the impact and management of invasive insects in Europe. The largest project is ALARM (Assessing Large-scale Environmental Risks with Tested Methods), an Integrated Project of the EU 6th Framework Program involving 65 research teams. Two main focus of the research related to this project are the ecological impact

assessment of horse-chestnut leaf miner (*Cameraria ohridella*) and the harlequin ladybird (*Harmonia axyridis*). The horse-chestnut leaf miner is a gracillariid moth that was observed in Macedonia in 1984. It has now invaded most of Europe, where it causes severe aesthetic damage to horse-chestnut, *Aescilus hippocastanum,* an important ornamental and amenity tree throughout most of the continent. The present and potential ecological impact of the moth on the native flora and fauna in Europe has been studied by the Centre. Two of the most important findings from this study are:

- The invasion of horse-chestnut leaf miner has resulted in a significant decrease in the population (and species richness) of native leaf miners.
- There is a possibility that in future horse-chestnut leaf miners will shift its host to a native maple tree, *Acer pseudoplatanus,* as occasional damage was currently observed.

The Centre is also working with Russia to design a bioclimatic model for the Siberian moth (*Dendrolimus superans sibiricus*), the most serious pest of Siberian forests; and biological control of silver fir wooly aphid, *Dreyfusia nordmannianae*, a serious pest of *Abies nordmannianae* (Christmas tree) in Denmark. In addition, two discussion papers prepared by CABI staff have been published by FAO Rome in 2003 under Forest Health and Biosecurity Working Papers:

- Biosecurity and Forests: An Introduction with particular emphasis on forest pests (by Matthew J.W. Cock)
- The status of invasiveness of forest tree species outside their natural habitats: a global review and discussion paper (by K.A. Haysom & S.T. Murphy).

Invasive Species Compendium: In 2001 the development consortia for the CABI Compendium Programme identified a need for a compendium on invasive species to address the threat posed by invasive species to the global economy and environment. This coincided with a similar recognition by the US National Invasive Species Management Plan. The ISC is a global compilation of knowledge for the management of invasive species (more than 1000 invasive species datasheets) and it will include: Detailed datasheets prepared by expert authors; with referenced information on importance, taxonomy, distribution, impacts, biology and ecology, management options and pathways for introduction; pictures and distribution maps; search and browse functionality; a library of full text; and linkage to the CAB ABSTRACTS database. For the first phase, the rough breakdown of invasive species coverage is planned as follows:

- 50% terrestrial plants
- 25% terrestrial plant and environmental pests
- 15% aquatic invasive species (vertebrates, invertebrates, plants)
- 5% animal diseases, pathogens and pests
- 5% terrestrial vertebrates (mammals, birds, reptiles)

Associated species (natural enemies, hosts, threatened species, etc.), habitats and other information related to the invasive species and their management will also be included. An alpha version of the ISC has been launched very recently, i.e. in October 2008 and complete development would be completed in 2009 (www.cabi.org/isc).

Global Plant Clinic: Is a UK-based alliance between CABI, Rothamsted Research and the Central Science Laboratory (CSL) that diagnoses and advises on plant diseases globally. The GPC is managed by CABI, and has received funds from DFID with complimentary funding from DANIDA, IFAD, SDC and ACIAR. The establishment of GPC in 2000 is drawing on human health services as a model, with the objective of providing plant health services through networks of 'doctors', clinics and expert advice, available when and where they are needed. Mobile plant clinics can promote the solid advances of IPM and farmer field schools and provide reliable plant healthcare for more people at low costs. The first experiment with community-based plant clinics started in Bolivia in 2003 in collaboration with CIAT and PROINPA. The idea was to make information and advice on plant health more widely available to the communities through a regular public service.

Box 1. The operation of a plant health clinic

- The clinics are simple facilities based at a public, easily accessible place (permanent or mobile).
- They usually operate once a week.
- They have simple equipment to examine the samples (knife, magnifier, scissors) and photos and other materials for consultation and display.
- Farmers bring samples of sick plants to weekly clinics, and tell the 'plant doctors' about the problem, and the crop.
- The 'plant doctors' diagnose the problems based on symptoms and offer the best advice sung local and scientific knowledge.
- If the 'plant doctors' cannot diagnose the problem or need more information, they can contact diagnostic laboratories or consult experts.

Today there are more than 80 regular clinics in nine countries supported by the Global Plant Clinic. Regular schemes exist in Bangladesh, Uganda, Cameroon, Congo, Sierra Leone, India, Bolivia, Nicaragua (DANIDA and IFAD) and Vietnam (ACIAR). Rwanda plans to start regular clinics soon and has already run several pilots, as has Kenya (for more information please visit: www.globalplantclinic.org).

INVASIVE ALIEN SPECIES – A THREAT TO FOREST BIODIVERSITY

Actions under the framework of the Convention on Biological Diversity (CBD)

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Introduction

Numerous international instruments, binding and non-binding, have been developed to deal with invasive alien species. The Convention on Biological Diversity (CBD) recognizes that invasive alien species are one of the primary threats to biodiversity, with impacts on native species, habitats and ecosystems (Article 8(h)). CBD calls on its 191 Parties[1] to prevent the introduction of, control or eradicate those alien species. The Guiding Principles of the Convention (CBD decision VI/23[2]) provides guidance for developing effective strategies to minimize the spread and impact of invasive alien species. Under the CBD, governments agree to: prepare national biodiversity strategies and action plans; identify genomes; species and ecosystems crucial for conservation and sustainable use; monitor biodiversity and factors that are affecting biological systems, establish effectively managed systems of protected areas; rehabilitate degraded ecosystems; exchange information; improve communication, education and public awareness; and implement various other activities to meet the objectives of the CBD – conservation, sustainable use and equitable sharing of benefits arising from the use of genetic resources, of biodiversity.

Despite the world's efforts to prevent, control and eradicate invasive alien species, increased human activities in trade, transport, travel and tourism have acted as strong vectors, spreading invasive alien species. Pressures such as habitat change, climate change and other emerging issues have accelerated the spread and establishment of invasive alien species. At the ninth meeting of the Conference of the Parties (COP) in May 2008, the need for capacity building to manage pathways and for assessments on invasive alien species were reaffirmed.

Some Cases in Asia

A healthy forest accommodates various components of biodiversity. The impacts of invasive alien species are complex. The cases listed below demonstrate only a fraction of the full issue.

Mile-a-minute weed, *Mikania micrantha,* has been recorded as invasive in Bangladesh, India, Sri Lanka, Nepal, China, Malaysia, Thailand, the Philippines, Indonesia, Papua New Guinea, Borneo, and many of the surrounding Pacific Islands. The weed climbs up other plants to reach the sunlit tree canopy, smothering the host plants in the process and depriving them of light needed for photosynthesis, as well as competing with them for nutrients and water. The weed also has allelopathic properties, releasing substances that inhibit the growth of other plants (GISP 2004)

Alligator weed, *Alternanthera philoxeroides,* is a fast-growing perennial herb that is capable of growing on land and in water. It has become invasive in a number of Asian countries including China, Burma, India, Thailand, Indonesia and Malaysia. They outcompete and displace indigenous plants, reduce water quality, prevent light penetration into water and inhibit gaseous exchange at the air-water interface. It colonizes new areas when the mats break apart and float downstream, and can spread onto land when its horizontal stems grow up banks and into moist soil (GISP 2004).

The nutria *Myocastor coypus*, also called the coypu, is indigenous to South America, but was introduced to North America, East Africa, Europe and Asia. They are herbivores with a huge appetite for plants, eating approximately 25% of their body weight per day. At high densities their feeding can significantly impact natural plant communities. They have even converted dense stands of reed into

[1] 191 Parties as of December 2008: 190 countries, as well as the European Community.

[2] One representative entered a formal objection during the process leading to the adoption of this decision and underlined that he did not believe that the Conference of the Parties could legitimately adopt a motion or a text with a formal objection in place. A few representatives expressed reservations regarding the procedure leading to the adoption of this decision (see UNEP/CBD/COP/6/20, paras. 294-324).

open water, destroying the habitat of wetland birds. They also increase erosion by digging up roots and underground tubers which help to bind the soil together (GISP 2004). The nutria may also carry parasites such as *Storongyloides myopotami*, *Calodium hepaticum* and *Fasciol*a spp. which cause zoonotic diseases (Matsudate *et al.* 2003).

The red-eared slider, *Trachemys scripta elegans,* is a popular pet that is relatively easy to care for, as it eats a wide variety of foodstuffs. These turtles are also often released during Buddhist merit-making ceremonies. They had adapted to wide variety of habitats, easily establishing themselves, and have disturbed fresh water ecosystems. The red-eared slider can be contaminated with *Salmonella* bacteria and be a carrier of a disease, salmonellosis, that affects humans (GISP 2004).

Recent outbreaks of the highly transmissible fungus, *Batrachochytrium dendrobatidis*, has resulted in the disease chytridiomycosis, causing global declines or extinctions of up to about 200 species of frogs. The impact of chytridiomycosis on frogs is the most spectacular loss of vertebrate biodiversity due to disease in recorded history (Skeratt *et al*. 2007).

Impacts of Invasive Alien Species

Invasive alien species have many negative impacts on human economic interests. Researchers have estimated the following annual environmental costs of introduced pests: Australia – US $6.8 billion; Brazil – US$ 6.7 billion; India – US$ 25.0 billion; South Africa – US$ 3.0 billion; United Kingdom – US$ 6.6 billion; and the United States – US$ 58.0 billion (Pimentel *et al.* 2001). In addition to the direct costs of management of invasives, the economic costs also include indirect environmental consequences and other non-market values. Invasive alien species may cause changes in ecological services by disturbing the operation of the hydrological cycle, including flood control and water supply, waste assimilation, recycling of nutrients, conservation and regeneration of soils, pollination of crops and seed dispersal. Changes to these ecosystems services affect both their current use value and their future potential value. Invasive alien species can transform the structure and species composition of ecosystems by repressing or excluding native species, either directly by out-competing them for resources or indirectly by changing the way nutrients are cycled through the system (GISP 2008). The cost of changes to ecosystem services is not yet clearly estimated. One study estimated the total cost US$157 billion in annual impacts in the USA, and worldwide impacts up to US$1.4 trillion annually – almost 5% of global GDP (Pimentel *et al.* 2005).

Fighting Invasive Alien Species

The invasive alien species programme of the CBD is a comprehensive framework addressing the threat of invasive alien species on the components of biodiversity, including plants, animals and microorganisms. In collaboration with the secretariats of the other UN organizations, including International Plant Protection Convention, World Organization for Animal Health, Convention on International Trade in Endangered Species, World Trade Organization, International Civil Aviation Organization and International Maritime Organization, the CBD is addressing the issue of invasive alien species and facilitating support to Parties[3].

The capacity and expertise needed to deal with invasive alien species are not yet sufficiently developed in many countries. Capacity building and further research on the biology and control of invasive alien species, and biosecurity issues therefore need to be given a greater priority. Tools, mechanisms, best management practices, control techniques and resources need to be provided and exchanged. Awareness raising and education regarding invasive alien species should be given high priority in action plans, and development of economic tools and incentives for prevention are urgently needed. These actions should include the involvement of financial institutions and other organisations responsible for environment and development co-operation, at national and international levels.

In 2009, the International Day for Biological Diversity will be celebrated under the theme of invasive alien species. Collaboration with Asian experts at this event may strongly increase public awareness on invasive alien species and further facilitate the prevention, control and management of invasive alien species, the world's major threat to biodiversity. The active participation of countries and

[3] UNEP/CBD/COP/9/22 see http://www.cbd.int/decisions/?m=COP-09&id=11647&lg=0

relevant organizations in Asia and the Pacific will be essential to the success of the International Day, as a contribution to the efforts to avoid and control the spread of invasive alien species.

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AN OVERVIEW OF FOREST HEALTH ACTIVITIES IN IUFRO

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Introduction

The International Union of Forest Research Organizations, more commonly known as IUFRO, is a non-profit, non-governmental international network of forest scientists, which promotes global cooperation in forest-related research and enhances the understanding of the ecological, economic and social aspects of forests and trees. Scientists cooperate in IUFRO on a voluntary basis and IUFRO is "the" global network for forest science cooperation. It unites more than 15,000 scientists in almost 700 Member Organizations in over 110 countries, and is a member of ICSU, the International Council of Scientific Unions. More information about IUFRO can be found on its website at http://www.iufro.org/auth/discover/organization/

In this presentation an overview of the forest health research and related activities being undertaken by IUFRO is discussed. This discussion focuses on the activities of the Research Groups (RG) and Working Parties (WP) in IUFRO Division 7, Forest Health, in particular those related to alien invasive species and effects of climate change, since these are the topics that his present workshop are concerned with. Division 7 is only one of the eight divisions in IUFRO, each focussing on specific areas of forest research. The eight divisions are Division 1 – Silviculture, Division 2 – Physiology and Genetics, Division 3 – Forest Operations Engineering and Management, Division 4 – Forest Assessment, Modelling and Management, Division 5 – Forest Products, Division 6 – Social, Economic, Information and Policy Sciences, Division 7 – Forest Health, and Division 8 – Forest Environment. In addition to the Divisions, IUFRO has established several Task Forces aimed at strengthening IUFRO activities in specific areas and which contribute to international processes and activities.

Research in Division 7 is mainly focussed on two main areas, i.e. threats of alien invasive pests and pathogens to natural forests, and threats of climate change and air pollution. There are three research groups in Division 7 addressing the broad areas of air pollution and climate change, forest pathogens and forest pests, respectively. These are RG 7.01.00 – Impacts of climate change on forest ecosystems, RG 7.02.00 – Forest Pathology, and RG 7.03.00 – Forest Entomology. Each RG consists of several working parties covering a range of topics, and details including the names and contacts of the office holders can be found in the IUFRO website at www.iufro.org.

Here I shall highlight some of the outcomes and findings of recent IUFRO workshops and conferences related to the topics of alien invasive species and effects of climate change on forest health with the hope that they could serve as guidelines for the formulation of future research on forest health and related activities in the Asia-Pacific region.

Alien invasive species and effects of climate change on forest health – outcomes of recent IUFRO meetings

Alien invasive species and international trade is the focus of research and the title for WP 7.03.12. The objectives of the research undertaken by the WP are i) to examine global forestry issues related to the unwanted international movement of alien invasive species (AIS), including fungi, insects, nematodes, and plants, and ii) to encourage cross-disciplinary exchange in relation to all types of AIS. The working party's broad focus is on the pathways for movement of alien invasive species, especially those associated with packaging wood. In particular, members of the WP would like to share information and research results, develop data sharing agreements and contribute to global pest information systems, and coordinate joint research and monitoring efforts. Researchers from the Asia-Pacific region are encouraged to participate in the activities of the WP as there is much experience

that can be shared. Research by scientists in the WP also aims to encourage improvement and extension of Pest Risk Analysis (PRA) techniques and provide research support toward the development of mitigation strategies. The WP acts as an interface with other IUFRO Working Parties with particular interests in invasive species, e.g. population dynamics, bark beetles, etc.

In July 2006, WP7.03.12 held its inaugural meeting at Jedlnia, Poland; and the proceedings of that meeting can be downloaded from the IUFRO website at www.iufro.org (WP7.03.12, publications). Although the meeting mainly focused on alien invasive species in Europe, it also discussed the ecological impact of alien invasive species in the world, detection and policy, and prevention measures and treatments. The meeting also identified two topics of universal interest, i.e. wood packaging material and implementation of ISPM15, and plants for planting as pathways for movement of pests and pathogens. It is highly likely that these pathways are also the most important pathways for movement of pests and pathogens in the Asia-Pacific region and no doubt some of the papers presented at this workshop will attest to that.

IUFRO meetings related to alien invasive species of forests and effects of climate change on forest health were also held in 2007 and 2008. In September 2007, the International Workshop on Biological Control of Invasive Species of Forests in the United States and Peoples' Republic of China (IWBCISF) was held in China. This workshop aimed at creating a forum for the exchange of information and to foster discussions on issues affecting the use of natural enemies for control of invasive alien species of forests in the two countries. The findings from that meeting would no doubt also be relevant to some other countries in the Asia-Pacific region.

In August 2008, an interdivisional meeting was held in Sweden with the theme, "Adaptation of Forests and Forest Management to Climate Change with Emphasis on Forest Health – Review of Science, Policies, and Practices". The meeting identified some of the future impacts of climate change on forest health and I would like to highlight those of relevance to this present meeting. By 2050, it is estimated that 50% of forests worldwide may be affected by potentially phytotoxic ozone (O_3) concentrations and large increases in tropospheric O_3 have been projected, particularly in Asia. The meeting also noted that elevated carbon dioxide (CO_2) production due to enhanced soil decomposition could lead to mass insect outbreaks turning forests from C sinks to C sources. Considerable research is being undertaken on soil decomposition in temperate forests but there is hardly any such research in tropical forests and this is a challenge to scientists in this part of the world. The meeting also noted that secondary pests may become more important. Many countries in the Asia-Pacific region have yet to identify their main forest pests or to produce a host-pest list. Therefore, it would be difficult to identify the secondary pests and to know when such an outbreak has occurred. Foresters need to be cautious about using climate change as an overall explanation for insect and disease outbreaks. There is a need to fill knowledge gaps related to natural enemies of forest pests under climate change scenarios and this gap is indeed very large for the Asia-Pacific region.

On the other hand, the meeting in Sweden also identified positive effects of climate change, such as, expansion of tree species distribution and increased growth. Such effects may be detected through regular monitoring which unfortunately is not always carried out in many Asia-Pacific countries. In addition, the meeting highlighted that the introduction of non-native species should be based on scientific knowledge, conducting pest risk assessments wherever possible. It was noted that biodiversified ecosystems are more resilient in a world of climate change. This last point is particularly pertinent to many Asia-Pacific countries as many seek to establish or have already established extensive plantations of fast-growing exotic species with little or no knowledge of their pests and diseases or invasiveness.

Policy needs

Some policy needs have been identified by IUFRO for forest health related research, in particular for alien invasive species and for effects of climate change on forest health. For alien invasive species there is a need to expand the linkages between the various invasive species networks and to share databases. For studies on the effects of climate change on forest health, a global effort to conduct forest monitoring and research related to pollutant deposition needs to be designed to look at multiple pressures and interactions. There is also a need for further legally binding protocols on air pollution abatement strategies. Methods to use lichens as air pollution indicators in forests should be developed. Overall more research and development is needed on the amelioration of forest pest

damage, especially by pest parasites and predators. Research needs to cross political boundaries and multinational or international monitoring efforts can be improved or developed. There is also a need to improve remote sensing techniques for early pest and disease detection. This is particularly important for alien invasive species as early detection can prevent the further spread and dissemination of the pest to new areas. Vulnerability assessments for both alien invasive species and effects of climate change should focus on high risk areas to optimize utilization of manpower and other resources. It is also important that research cover a range of stress factors as focusing on single stress factors may lead to improper policy development.

Conclusion

There are many groups and researchers involved in research on alien invasive species and the effects of climate change on forest health. By highlighting IUFRO's activities in these fields, I hope I have provided some ideas and avenues for furthering and strengthening cooperation and collaboration between researchers in the Asia-Pacific region with other international researchers. As I pointed out at the beginning of my presentation, IUFRO is "the" global network for forest science cooperation.

PREVENTING AND CONTAINING THE GLOBAL SPREAD OF INVADERS – AN OVERVIEW OF TNC INVASIVE SPECIES PROGRAMME

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Introduction

The Nature Conservancy (TNC) started in 1951 in the United States of America and since then it has grown to become one of the largest conservation organizations in the world with programmes in over 31 countries, including China. The mission of TNC is to preserve the plants, animals and natural communities that represent the diversity of life on earth by protecting the lands and water they need to survive. TNC has owned and operated several thousand nature preserves and conservation areas across the United States; and has helped other organizations and government agencies identify, set aside and manage many thousands more terrestrial, freshwater and marine conservation areas in the US and many other countries around the world. This experience has taught us that invasive species are one of the most severe threats to native biological diversity. In fact invasive species are the most commonly listed threat on TNC projects worldwide, cited far more frequently in the over 950 completed Conservation Action Plans for these projects than development, pollution, over-fishing or any other threats.

TNC started a small programme to address invasive plants on its projects across the United States in 1991, and has greatly expanded its efforts to address other terrestrial, freshwater and marine invaders across North and South America, the Pacific, Australia, eastern Asia, and most recently Africa, since then. In 2007, TNC launched the Global Invasive Species Team which has two objectives for addressing the threats to biological diversity in terrestrial, freshwater and marine ecosystems posed by invasive plants, animals, and pathogens:

1) Prevent new invasions and the spread of invaders at national and international scales;
2) Ensure TNC programmes and partners have access to strategies, tools, information and training needed to prevent and abate invasive species threats to biological diversity.

Five major strategies have been formulated to achieve these objectives:

1) *International invasive species policy* – Secure adoption and implementation of policies to prevent new invasions through international agreements, multilateral organizations and national policies in key countries.
2) *US invasive species policy* – Promote US federal policies to prevent new invasions via major pathways and to limit spread of invaders in collaboration with partners.
3) *Engaging coalitions and business partners to halt invasions* – Block major pathways and reduce spread of invasive species by building coalitions around shipping, horticulture and forest health to change business practices and government policies.
4) *Operating unit invasive species strategies* – Help TNC state and country programmes create and implement strategic plans to prevent and abate invasive threats.
5) *Tools, training and information* – Identify, develop and provide access to the best invasive species prevention and management tools, information and training for all TNC programmes and key partners.

Global Invasive Species Team includes nine full-time staff trained in science, public policy and business. The Team also includes at least 25 more TNC employees from state and country programmes who have expertise in assessing, preventing and controlling invasive species and who dedicate a percentage of their time to the Team. A few examples of their efforts on combating invasive species across TNC are further elaborated here.

Continental Dialogue on Non-native Forest Insects and Diseases

The impacts of non-native insects and diseases on America's forests have been profound, and the rates of introduction and establishment of new invaders have increased dramatically in recent years. The increase in introductions stems from a failure to adapt government controlling efforts to changes in trade, particularly increased volume of trade, increased speed with which goods move from one continent to another, and increasing diversity of goods traded and ports of origin. As this is a societal problem and not a biological problem, it can be solved.

The Continental Dialogue on Non-Native Forest Insects and Diseases initiates and catalyzes collaborative actions among diverse interests to abate the threat to North American forests from non-native insects and diseases. By 2015, the project hopes to achieve the following goals: to improve the state and federal programmes to eliminate new invasion, to improve the effectiveness of detection and eradication systems to control the survival of newly introduced invaders, to reduce the spread of established populations, and to increase the engagement by all stakeholders though public awareness and incentive programmes.

A website was established to reduce the spread of pests through moving firewood (*www.dontmovefirewood.org*). Moreover, as part of the Dialogue's prevention effort, a working group negotiated a set of consensus recommendations to APHIS on a pending rulemaking. The goal is to minimize the risk of additional introductions via the nursery stock pathway. The principal nursery trade association, American Nursery and Landscape Association, participated in this negotiation and has endorsed the consensus recommendations. This set of consensus recommendations was adopted in October 2007. Since then, the team has been actively encouraging state agriculture departments, state forestry divisions, state nursery associations, state forestry associations, and other stakeholders to endorse these recommendations. To date, TNC have obtained written endorsements from seven agriculture departments, two forestry divisions, and two Society of American Foresters chapters.

TNC China Invasive Species Project – Early Detection to Invaders

TNC China Invasive Species Project aims to reduce the threats that invasive species pose to biodiversity in China's protected areas and local people's livelihoods with the collective efforts of governments, businesses, communities and various organizations. A two-pronged strategic approach was formulated to develop an early warning system for protected areas, and also mitigates the risk of future introduction of invasive species to the areas through policies, institutional capacity building, public awareness and international cooperation. A series of activities at the local, national and international scale have since then been carried out.

The explosive growth of tourism and trade has made northwestern Yunnan Province especially vulnerable to invasive species. Northwest Yunnan is an area of huge cultural and biodiversity significance and also supports rare species including the endangered Yunnan golden monkey. The emergence of aggressive invaders such as Crofton weed (*Eupatorium adenophorum*), threatens to disrupt a carefully balanced eco-system. In order to evaluate the scale of the problem, TNC worked with invasive species experts conducted a field survey that included Geographic Information System (GIS) mapping of invasive species there. The survey showed that population and distribution of invasive species were still at a manageable stage; but appropriate action was urgently required to prevent these invaders taking greater hold. TNC trained officials from the local Forestry and Environmental Protection Bureaus on how to tackle non-native invaders. Officials learned how to identify invasive species, determine the size and risk factor of the populations as well as how best to eradicate them. TNC is also working with partners to increase public awareness of invasive species. Educational calendars and brochures featuring invasive species have been distributed throughout Northwest Yunnan.

TNC and the Chinese Academy of Forestry had co-organized a workshop in Hainan to promote the sharing of newest techniques and experiences on invasive species management countrywide. TNC also supported Chinese Academy of Science, United State Department of Agriculture and Asia Pacific Forest Invasive Species Network, in an international training course on invasive species for researchers and managers from 21 countries. Currently TNC is working with partners developing GIS database of invasive species for 51 national demonstration nature reserves throughout China.

The project team and Global Invasive Species Team attended the Convention on Biological Diversity (CBD) Ninth Conference of the Parties (COP9). By working with the TNC government relations group, TNC programmes in South America and Asia Pacific Islands, and Global Invasive Species Programme, the team encouraged the Chinese Government and 10 other counties to make national commitments on invasive species during COP9. The team is currently developing agreements with the Chinese Ministry of Environmental Protection and State Forestry Administration.

Horticulture Industry and Voluntary Codes of Conduct

The Missouri Botanical Garden and Kew Royal Botanic Gardens, with participation from the horticulture industry and other professionals hosted a workshop in 2001 to develop strategies that will help reduce the new introductions of invasive species. The workshop produced the St. Louis Declaration, which includes findings and principles covering the invasive plant species problem and offer a basis for developing practical and effective ways to address the problem. A set of Voluntary Codes of Conduct appropriate for each of the interest groups was developed, and these are the focus of Preventing Invasion through Horticulture (PIH) project and can serve as guides for responses to curb the spread of invasive plant species, while promoting courses of action that will minimize this spread.

Invasive Species and Resource Management Projects in Hawaii

The objectives in undertaking the short-term demonstration project on invasive animal control in Hawaii are to: collect specific research data about invasive animal movements and behaviours; test intensive ground hunting in remote areas using helicopters to transport staff and equipment up and down steep mountain slopes; and refine strategic plans for non-native animal control in conservation areas. Two leading conservation firms from New Zealand – Prohunt and LandCare Research – assisted TNC staff in carrying out the demonstration project. Prohunt, an animal management company offered integrated tracking, hunting, and monitoring methods and Landcare Research provided guidance in using proven statistical techniques to evaluate animal control programmes. TNC anticipates improving its ability to detect, control, and monitor feral animals on conservation lands across the State. TNC plans to share what had been learned with the hope that this project will stimulate the growth and development of local businesses specializing in animal control and monitoring in Hawaii.

TNC began testing a new remote sensing technology on Kauai that it believes will revolutionize natural resource management in Hawaii. Under a contract with TNC, the remote sensing firm Resource Mapping Hawaii, has developed a collection of imaging technologies that will let conservation officials recognize major weeds on their properties from computer screens. The system can map thousands of acres on a clear day and create images so detailed that individual leaves on trees can be identified. It has a three-dimensional (3D) capability that allows the heights of individual plants to be calculated. Combined with multispectral sensing, that could allow a computer to search the images for specific kinds of plants. All these can be done for just a few dollars per acre over large areas.

Assessment for Non-native Plants in Florida

TNC worked with the Institute of Food and Agricultural Sciences (IFAS - Ag school), University of Florida, to develop the IFAS assessment for non-native plants in Florida's natural areas. That assessment now has three components: a status assessment (what is the species doing right now in FL's natural areas), a predictive assessment (modified from the Australian Weed Risk Assessment (WRA) tool, which has been in regulatory use in Australia and New Zealand for over a decade), and an infra-specific taxon protocol (identifying how to handle cultivars, varieties, etc. in the status assessment). The assessment has since been modified for use in other places, such as Hawaii, and the Great Lakes.

Invasive Species Projects in Brazil and Ecuador

In Brazil, TNC staff worked with forest companies trained company staff on biological invasions, improved management plans for Pinus plantations to avoid invasions; eradicated invasive species

from legally protected natural areas which are part of the companies' lands; and also requesting companies' support for clearing pine invasions in protected areas. These have expanded to training of protected area managers and staff; implementing control programmes in northeastern Brazil; establishing state official lists and state programmes for invasive species in São Paulo, Pernambuco and Rio de Janeiro. Plans are in place to expand these programmes to more states in 2009.

TNC worked with Ecuador's Center for Integrated Surveys for Natural Resources by Remote Sensors and other partners on a project to map the islands. A combination of high resolution satellite images, multi-spectral aerial images and measurements taken in the field, was used to map the presence of quinine, guava, blackberry and rose apple. These four plants are some of the worst invaders on the islands, threatening local species. The information is being used by TNC and their partners like Galapagos National Park to develop strategies to control, eradicate and manage these invaders.

Sharing Knowledge to fight Invasive Species in Pacific Islands

The Pacific islands of Micronesia, Polynesia, Melanesia and Hawaii, have all experienced the devastating impact of invasive species, disrupting delicate ecosystems and causing economical damages to the communities which depend on the natural resources for their livelihoods. TNC is supporting the Pacific Invasives Learning Network (PILN), the Pacific Invasives Initiative (PII) and the Working Group on Invasive Species under the Pacific Conservation Roundtable on capacity building, demonstration projects and the implementation of the regional Guidelines for Invasive Species Management in the Pacific. TNC also assisted Micronesia Regional Invasive Species Council (RISC) in the development and implementation of regional priorities and national strategies and action plans. Recently, TNC is working with the Pacific Invasives Initiative and New Zealand's Te Ngahere, a consulting firm, to design and test training courses for developing and implementing invasive plant management projects.

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Global Invasive Species Team is proud to work with close partners from other NGOs, universities and other academic institutions, government agencies, and corporations. Addressing the threats of invasive species to biodiversity and human livelihoods is a huge but vital task, and we are grateful for the efforts of all of these partners.

Acknowledgement

I would like to thank Stas Burgiel for facilitating the information collection from different projects, and Frank Lowenstein, Silvia Zille, Sean Austin, Faith Campbell, Mark Fox and Doria Gordon for their very prompt and timely contributions. Also, I would like to thank APAFRI and APFISN for the invitation and wonderful organization of the Asia and the Pacific Forest Health Workshop – Forest Health in a Changing World. Finally, I would like to thank John Randal, Jason Spensley and David J. Ganz for their facilitation on the TNC participation to this workshop.

INTERNATIONAL COLLABORATION OF FOREST HEALTH MANAGEMENT IN CHINA

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Introduction

Traditional forest health mainly deals with forest fire risk management, pest control and monitoring (Alan 1994, Regens & Hodges 1996, Eric 2001). However, new factors have been put in forest health management package in China due to diversified function requirements and various other factors that could weaken the forestry ecosystem. Having similar forestry ecosystem and shared forest health concerns, the Chinese Forestry Authority cooperated with several foreign counterparts such as the USDA Forest Service, GTZ from Germany, and KOICA from South Korea, to tackle forest health challenges. New concepts, monitoring measurements and management technologies, have been introduced, integrated, tested and localized in China (Xiao *et al*. 2001, Zhao *et al*. 2002, Xiao 2004, Zhou 2008, Cao 2008). Function-oriented integrated forest health management theories and technologies, which deal with forest health issues systematically, have been developed.

Figure 1. Location of China Forest Health Project Sites

Nine forest health pilot projects, representing most of China's forestry types and related forest health issues, have been initiated since the start of Forest Health Programme in China, in 2002 (Figure 1). Dozens of Governmental agencies, universities and forest management units, both local and abroad, got involved. A wide range of forest health issues have been jointly investigated and researched, including forest pest control (such as white worm (*Hyphantria cunea*) control in China and Asian long- horned beetle *(Anoplophora glsbripennis)* control in the USA; joint control of *Phloeosinus auei Perris* by China and Canada); biodiversity conservation (such as giant panda habitat conservation and reproduction in China and USA respectively, Forest Tenure Reform, log-ban policy modification, high conservation forest management, carbon sequestration, community forest management and adaptability and dynamic of introduced plants to the existing forestry eco system.

Various communication and cooperation have been conducted between Chinese scientists and their foreign counterparts, by way of workshops, field visits and investigations. Hundreds of officials, experts and technicians from the mentioned countries have taken part in these activities. Informative and helpful strategies, experiences and knowledge, related to forest health, have been discussed, studied and shared, which considerably facilitate forest health management in these countries.

Due to the joint efforts, concept of forest health have been broadened and publicized, experience been shared and awareness risen. Local participation has been encouraged/motivated due to their interest being considered, the eco-service functions of healthy forest recognized and improved. More and more sound and practical forest policies/regulations are being implemented to facilitate sustainable forest management in China.

The above mentioned collaborations have made a solid foundation to improve healthy status of forest in these countries. Forest health concerns, however, vary form country to country and therefore, perception and interpretation of forest health are also influenced by various social, economy, cultural conditions and land use objectives. As a result, further and broaden collaboration supported by government and stakeholders and multidisciplinary agencies, is necessary to keep the forest healthy. A regional, or even global, network dealing with forest health issues might be a feasible measurement in the future.

Table 1. Location of China Forest Health Projects

Location	**Acreage (hm^2)**	**Main Task and Activities**	**Participants**
Tahe Forest Bureau of Heilongjiang	28052	Boreal Forest management	Northeast Forestry University
Badaling of Beijing	546.1	Water protection forest management; Fire Risk management; Forest Recreation;	Beijing forestry university The Australian National University Chinese Academy of Forestry
Xinle of Hebei	3491.5	Shelter Belt forest management	Hebei Agriculture University USDA Forest Service
Taishan of Shandong	5387	High Conservation Value forest management	Shandong Agriculture University Shandong Academy of Forestry
Foping of Shannxi	7312	Biodiversity Conservation	Memphis Zoo WWF China The Memphis University
Xinfeng of Jiangxi	7613	Agroforestry	USDA Forest Service The Southern University Jiangxi Agriculture University Chinese Academy of Science
Jintang of Sichuan	1546.2	Erosion Control	
Majiang of Guizhou	2465.8	Community Forestry	Guizhou Academy of Forestry KOICA USDA Forestry Service
Lijiang of Yunnan	2066	High Conservation Forest management	WWF China USDA Forest Service

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Acknowledgements

Special thanks to APAFRI, IUFRO, APFISN and Forestry Research Institute of Malaysia, for successfully organized the forest health workshop.

PLANT HEALTH SERVICES OF THE SECRETARIAT OF THE PACIFIC COMMUNITY – AN OVERVIEW

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Introduction and Background

The Secretariat of the Pacific Community (SPC) is a regional organization of 22 Pacific Island Countries and Territories (PICTs), which spread over a vast area of 30 million km^2 of which 98% is ocean. The geography, populations, cultures, economy and politics of the 22 island countries and territories are extremely diverse. Papua New Guinea is the largest country and together with the Fiji Islands, New Caledonia, Solomons and Vanuatu, make up over 90% of the total land area and more than 70% of the population. Farming is the predominant occupation of the rural populations, who depend on agriculture and forestry for livelihoods. By contrast, in the smaller PICTs, such the American Samoa, Commonwealth of the Northern Mariana Islands, Federated States of Micronesia, Kiribati, Marshall Islands, Niue, Palau, Pitcairn Island, Tokelau, Tuvalu, and Wallis and Futuna, agriculture is mainly on subsistence level.

In the PICTs, forest and agriculture sectors face many challenges including natural catastrophes. Agricultural production systems are narrow based. Natural and human resources, marketing opportunities and physical isolation including social challenges are limitations which impact greatly on the overall economy and life of people and impacting the land resources sector.

PICTs, although are still free from many harmful pests, they do have few very destructive ones, and the risk of new introductions are ever increasing with increased internal and international traffic flow. This has led to introduction of few serious pests in the region such as the taro blight (*Phytophthora colacasiae*) in Samoa in 1994 (Fullerton & Tyson 2003), taro beetle (*Papuana uninodis*) in Fiji 1984 (Autar & Singh 1988), glassy-winged sharpshooter (*Homalodisca vitripennis*) in French Polynesia in 2001 (Grandgirard *et al*. 2007) and recent introduction of the Asian Cycad scale (*Aulacapis yasumatsui*) in Guam which now is spreading in the Northern Pacific Islands. New incursions bring new challenges.

The increasing populations and urbanization are pushing agriculture into virgin forests and clearing of natural forest has become common practice in some of the PICTs to create cropping land (Lal *et al.* 2008). Industrial developments have lessened labour for farming activities. Therefore, farmers are resorting to use modern technology such as machinery and farm chemicals, which degrades soil not to mention the injurious impact on human health.

The Land Resources Division (LRD) at SPC is tasked to improve food security, increase trade and economy and assist the Pacific Community to become more prosperous and healthy and manage its agricultural and forest resources in a sustainable way. LRD is structured into ten thematic-areas viz: forest and trees; forestry and agriculture diversification; genetic resources; plant health; biosecurity and trade facilitation; animal health and production; crop production; information, communication and extension; agriculture and forestry land use policy; and administration. For pest management major emphasis is on the biological control of pests and on use of soft pesticides which are harmonious with nature such as uses of local and plant derived materials.

Plant Health Service Programmes

The Plant Health (PH) thematic group aims to contribute to LRD's objective of obtaining sustainable management of integrated forest and agricultural systems, through participatory development of sustainable pest management systems. Pest management is a critical element in sustainable forestry and agriculture development. The fragile nature of PICTs and the desire of many to go organic indicate a critical need for environmentally friendly options including IPM, biological control and

cultural control methods. Where there are no other options, the PH team works with stakeholders to choose pesticides that are least harmful to the environment and humans or to minimize use of other pesticides. Some of the recent examples of pest management strategies in the PICTs are:

- Management of taro beetle (*Papuana* spp.) in Fiji, Kiribati, New Caledonia, Papua New Guinea, Solomon Islands and Vanuatu. Taro is a staple, cash and traditionally important crop, in the PICTs and taro beetles are major constraints of taro production. Low doses of two insecticides (Imidacloprid and Bifenthrin) with *Metarhizium anisopliae* in a sustainable pest management system have been developed and promoted in the taro beetle infested PICTs (Lal 2008).
- Glassy Winged Sharpshooter (GWSS) which infests over 300 species of plants was first detected in French Polynesia in 2001 and spread to Cook Islands in 2007. It has been successfully maintained at low populations by introduction of egg parasitoid *Gonatocerus ashmeadi* from California (Grandgirard 2007).
- Integrated pest management of brassica crop pests with emphasis on development of "farmer field schools" is underway.
- Kava (*Piper methysticum* Forst.f.) is also an important cash and traditional crop grown in agro-forestry systems in most of the PICTs. An IPM package on disease management, emphasizing cultural control methods for kava dieback that farmers will use has been developed and promoted.
- Biological control of water hyacinth (*Eichhornia crassipes* [Martius]) in Vanuatu by introducing a weevil (*Neochetina eichhorniae*).
- Mile-a-minute *(Mikania micrantha* H. B. & K.) is a common weed in the agro-forestry systems in the PICTs. A biological control programme is underway to reduce the impact of the weed on land degradation.
- Control of yam anthracnose (*Glomerella cingulata/Colletotrichum gloeosporioides*) through breeding programme of resistant cultivars and other biotechnology processes in combination with selected fungicides.
- Promotion and use of Plant Derived Pesticides and aromatic plants in gardens and smallholder farms (National Agricultural Research Institute 2001).
- Plant health team is initiating trials in Solomon Is to develop a management strategy for Taro "mitimiti" disease caused by nematode in Solomon Is.
- Development of strategies for breadfruit diseases management in Kiribati has been trialed since 2004 where breadfruit is the major stable food.

PH develops and strengthens national and regional capacity to manage plant invasive pest species through provision of technical support for the development of national contingency plans. In the event of an incursion of a pest into a country, the PH group provides technical expertise and assists in assessing the potential for eradication or, in the event that the pest is established, develops options for management. Some of the recent incursions in which the PH team provided this support were in the eradication of papaya ringspot virus in the Cook Islands and a delimiting survey and subsequent public awareness for citrus Huanglongbing (greening) disease into Papua New Guinea. More recently, SPC is involved in the disease diagnostics work into an unknown death of coconut palms and betel nut palms in PNG by developing collaborative investigation work with University of Technology, and National Agriculture Research Institute and National Agriculture and Quarantine Authority in PNG. Various weed eradications including African Tulip (*Spathodea campanulata* Beauv.) in Palau, Yap and Chuuk are ongoing. Training and development of training materials are also undertaken by the PH team to strengthen plant protection capacities in the PICTs.

Technical advice and support are given for development of national capacity to comply with international and regional standards related to trade. The PH team provides information and advice to countries in the practical fulfillment of international obligations. A few examples of this support include providing information on choices for organic pest management that will not breach organic standards, mentoring in how to conduct delimiting surveys, and plant virus indexing for safe movement of plant genetic resources. Under this programme a generic standard with auspice of International Federation of Organic Farmers Movement (IFOAM) has been developed.

Developments of sustainable and efficient post-harvest technologies are important functions of PH team to facilitate trade. High temperature forced air (HTFA) as an alternative to ethylene dibromide for treatment of fruits and vegetables against fruitflies.

Improved information on plant health status in PICTs is also an important function. A major part of the work of the PH team is supporting countries in plant pest and disease diagnostic and national plant pest and disease surveys and diagnostics. A regional collection of insects are maintained at SPC and disease records are updated for references. Pest and disease alerts are produced regularly to inform PICTs countries of threats from exotic pest and disease incursions into the region.

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VILLAGE COMMON FORESTS OF CHITTAGONG HILL TRACTS IN BANGLADESH: A HARBOUR OF FOREST HEALTH AND VITALITY IN THE DEGRADED LANDSCAPE

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Introduction

The Chittagong Hill Tracts (CHTs) in southeastern Bangladesh consists of the most significant upland watersheds of the country that once contained highly productive natural forest ecosystems. The forests support traditional subsistence farming called *jhum* to as many as 13 indigenous communities living there (Gain 2002). Decades of government mismanagement favored clear-felling of natural forests to make way for establishing monoculture plantations involving valuable timber species such as teak (*Tectona grandis*) which not only destroyed the healthy natural forest ecosystem but also led to shrinking land base for traditional farming thereby affecting indigenous people's livelihood and culture (Misbahuzzaman 2006). Crop productivity that largely depends on good soil conditions has declined due to unfavorable site factors caused by deterioration in natural forest ecosystem. Continual in-migration of plain land settlers has accelerated forest destruction followed by landscape fragmentation and agricultural intensification. While massive land degradation, soil erosion and water quality deterioration are common in most parts of the CHT, a few community managed forest landscapes called *mouza-ban* or Village Common Forests (VCFs) that struggle for their existence in some places today appears to be exceptional demonstrating the best local resources management practices for maintaining forest ecosystem health (Khisa *et al*. 2006). The aim of the study was to examine the ecosystem health of a few selected VCF landscapes by means of biophysical indicators and to explore the community institutions that govern VCF management.

Methodology

Four VCFs, two in each of Rangamati and Banderban districts of CHTs, were visited for a biophysical survey which were followed by a structured questionnaire survey of 20 village leaders and elders who provided ethno-ecological information regarding VCFs.

Results and Discussions

Biophysical Environment of Village Common Forests

VCFs are smaller forest enclosures of around 100 acres each in size. They appeared to occur in labyrinthine networks of smaller watersheds thereby playing crucial role in watershed management as they contain headwaters of streams, natural springs and other aquifers. VCFs appeared to be large repositories of biodiversity including many native tree species, shrubs and varieties of wild animals. Presence of good understorey vegetation consisting of many herbs of medicinal and culinary use and other plants was the primary indicator of good site conditions that prevailed in the VCF areas. VCF forest floors are characterized by rich layers of organic debris and decomposing materials while most of the non-VCF forest floors are exposed to soil erosion and land degradation. While in most parts of the CHT landscape, water sources have become polluted by intensive agricultural practices and sedimentation from erosion, VCFs yet remain the only sources of cleanest water that fulfills domestic water need of the many.

VCFs as Community Sacred Groves

VCFs in the hill peaks contained many old growth trees of native hardwood species such as *Bursera serrata* Wall. ex Colebr., *Adina cordifolia* Roxb., *Vitex peduncularis* Wall., *Firmiana colorata* Roxb., *Vitex glabra* Wall., *Gargua pinnata* Roxb., *Oroxylum indicum* (L.) Vent., *Dillenia scabrella* Roxb., *Anogeissus acuminata* (Roxb.) Wall. *ex* Bedd., *Baccaurea ramiflora* Lour., *Duabanga sonneratioides* Buch.-Ham., *Syzygium formosum* Wall. Masamune, *Bouea burmanica* Griff., *Terminalia bellirica* (Gaertn.) Roxb. etc. that have already become rare or scarce elsewhere in the landscape. Aggregates

of these trees are treated as sacred groves and revered as ancestral properties where ritual performances are routinely done. In some corners of hill peaks, memorials for dead ancestors are constructed using natural features. In other parts of the VCF hills, spiritual leaders use cave formations for spiritual counseling of those community members who are in distress. Herbs that are available in the cliffs of caves are an essential component in all spiritual activities that are performed during counseling. According to their traditional myths and beliefs forest health is also important for spiritual health of the community members.

Principles of Resources Harvesting in VCFs

Harvesting of forest products from the VCFs is permitted by the village leaders only, and the VCF communities strictly maintain seasonality in harvesting. Only bamboos that grow in gregarious formations are harvested in abundance across all seasons. In general wood is not harvested from VCFs except when there is need for constructing community facilities such as prayer centers etc. Whole tree harvesting is rarely practiced inside VCFs as trees are seen as an essential part in the forest ecosystem functioning. Gathering of wild herbs are done in a very meticulous way so as not to cause any disturbance to regeneration of plants. Hunting of wild animals is strictly regulated in the VCFs. Adherence to community set rules and regulations in collection of forest produces plays significant role in maintaining good forest health that also ensures sustainable flow of goods and services from forests.

Importance of VCFs for Forest Management in CHTs

To combat deforestation and land degradation in the CHTs, forest department has undertaken massive reforestation schemes. However, the recent government plan for participatory reforestation in the degraded watersheds undermines VCF institutions (Misbahuzzaman 2008). Although conservation practices of the VCF communities have a stronger potential for sustainable natural resources management in the degraded landscape (Misbahuzzaman & Marma 2008), their voices are never heard by the policy makers and the resources managers only because community exercise of customary rights over the resources in the traditional landscape is seen as a big threat to resource conservation in the area. The role of VCFs in maintaining healthy forest ecosystems must be recognized and the VCF institutions should be formalized in context of government land use policy. Rejuvenating the deteriorating VCFs in some critical locations of the CHTs could certainly play a significant role in ensuring ecosystem health of the forested watersheds in the region.

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Acknowledgements

The author expresses his gratitude to the key informants and the voluntary field assistants from the villages in Rangamati and Banderban Districts of Chittagong Hill Tracts for their all out support during the fieldwork.

DWARF MISTLETOE: AN INVASIVE PARASITE ON BLUE PINE TREES IN WESTERN BHUTAN

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Introduction

The Himalayan dwarf mistletoe, *Arceuthobium minutissimum* Hook f., is a very common parasite in the region. This is the single most destructive pathogen found on commercially valuable blue pine stands particularly in dry and degraded localities in Bhutan.

It poses serious problem in the management of blue pine forest in Bhutan. Large tracts of blue pine forest, in western Bhutan, have been found to be attacked by dwarf mistletoe. Even though the problem has not reached an epidemic level but the infestation is increasing every year.

The host tree, blue pine (*Pinus wallichiana),* is an ecologically and economically important tree species in temperate conifer forests at elevations between 2100 and 3100 m in Bhutan. This species is a pioneer species which regenerates very profusely on natural condition and found to cover the vegetation gaps created by forest fire and other epidemics. Thus, blue pine plays an important role in protecting steep and fragile slopes around villages and towns in Western Bhutan. Further, this species have added beauty to the surroundings by keeping green all year round.

Figure 1. Tree infected by dwarf mistletoe

This paper is prepared with the objective to highlight the threats that might cause to the blue pine forest of Bhutan in the coming years. Attempt has been made to present the life cycle of the parasite, infestation mechanism, damages caused to the blue pine forest and measures adopted to control the spread of the pest.

Infection and initial shoot development

Infection of host plants, by mistletoe, is equivalent of seedling establishment among the terrestrial flowering plants. Successful infection, by dwarf mistletoe, requires penetration of the host cortex by a growing embryo and development of an endophytic system. For most combination of the host and dwarf mistletoe, infection can take place through young stem tissues, usually a segment less than 5 years old.

Once infection is established, an incubation period of 2 to 5 years elapses before young shoots appear. A swelling at the point of infection usually precedes shoot production by a year or more. Dwarf mistletoe plants begin to flower 1 to 2 years after the initial shoots appear. The endophytic root system of the mistletoe survives as long as the host tissues and continuously produce new shoots.

Symptoms of *Arceuthobium minutissimum* infection

The infection usually results in spindle-shaped swellings on the branches or on the main bole causing deformity and development of ‘witches’ broom’ (Bakshi 1976). As infection develops, swelling enlarges and eventually becomes fusiform. The tree will also suffer from top dying and eventually

death of the affected branches. Heavily infected stands get stunted leading, eventually, to death of the trees (Bakshi 1976).

Typically, dwarf mistletoe infection leads to the production of the profusely branched, dense masses of distorted host branches which is termed as “witches’ broom”. These are of two basic types, systemic and non-systemic growths.

Dispersal of mistletoe seed

Dwarf mistletoes possess one of the most effective hydrostatically controlled, explosive mechanisms of seed dispersal known in flowering plants. Dwarf mistletoe seeds are explosively discharged during late summer at a very speed (Hinds *et al.* 1963). Maximum dispersal distance is about 16 m, but dispersal distance of 10 m or less is more typical and usual. Most seeds are intercepted within 2 to 4 m by host needles. Seeds have viscous coating (viscin) that readily adheres to any object they strike, especially conifer needles (Roth 1959, Haksworth 1965). Intercepted seeds usually remain on the needles until the first rain wets the hygroscopic viscin. Gravity then pulls the well-lubricated seed to the base of an upright needle. As the viscin dries, the seeds are cemented to the shoot surface. Seeds intercepted by downward pointing needles generally fall to the lower branches or to the ground (Shaw & Loopstra 1991).

Figure 2. Young shoots of dwarf mistletoe on blue pine tree.

Germination

The seeds of most dwarf mistletoe have few characteristic that are typical for seeds of flowering plants. Because there are no true ovules in either the Viscaceae or Loranthaceae, there are no testa and consequently no true seeds. The “seed” is an embryo embedded in a chlorophyllous endosperm surrounded by a layer of viscin. The embryo is green, rod-shaped, and only few millimetres long; and it possesses a meristematic radicular apex without a root cap. Typically seed germinate with the onset of higher temperature in the spring.

Climatic factor

Climatic factors are also responsible for distribution of dwarf mistletoe. Its parasitism is reported particularly from drier sites in the Himalayan region from Pakistan to Western Bhutan. Since the blue pine and spruce forests in central Bhutan are much wetter than Western Bhutan, both species of dwarf mistletoes are not found beyond Dochula Pass under Thimphu District. Infestation of the mistletoe is more abundant on ridge tops, intermediate slopes, and least common on valley bottom indicating that the topographic position is also responsible for the distribution of dwarf mistletoe.

Pathogenic effect on hosts

Dwarf mistletoe infected trees develop thick and bushy witches’ broom. Once the lower half of the tree's crown is parasitized, the growth rate declines rapidly; the height and diameter of trees are also reduced, foliage becomes yellow in colour and thin accompanied by top dieback and eventual death. The secondary infestations within the infested trees continue and spread over the entire plant. Whole tree will look bushy “witches’ broom”. Infected trees are subjected to severe moisture, nutrient stress, as such large scale mortality of infected trees is observed particularly in droughty situation. Under normal condition infected trees die slowly.

Infestation of natural regeneration

In general, dwarf mistletoe infected trees are deformed and are not suitable as construction timber. People do not prefer such trees to be used as construction timber. Such trees, however, can serve as seed source if left in the forest. It could also serve as source of infestation. In general, the mistletoe infected trees are scattered around young natural regeneration as such the natural regeneration in and around the infected trees are also infected by dwarf mistletoe. If the regenerations are infected by dwarf mistletoe in the sapling stage, the saplings grow into witches' broom.

The dwarf mistletoes are light demander and any big openings or large scale removal of infected trees favour development of mistletoe. Further researched management prescriptions to deal with the dwarf mistletoe are lacking, in Bhutan, as a result every year the infection level is increasing. The infection is more severe in the ridges where trees are usually weak due to poor site conditions. However, in Bhutan, it is noticed that the infection is spreading on both sides of the ridges. Further dwarf mistletoe infestation has been noticed in isolated areas beyond its natural dispersal distance. This means birds are also responsible for dwarf mistletoe seed dispersal.

Green cover of blue pine natural regeneration on the ridges around Thimphu, Paro and Haa Districts gives impression that adequate regeneration is coming up. But if the regeneration is carefully examined, almost all the regenerated stands are found infected by dwarf mistletoe. The leftover defective and bulky crowned mistletoe infected trees above the young natural regeneration are serving as source of mistletoe seed dispersal.

Mistletoe infested stands are very susceptible to crown forest fire. Therefore, once fire escapes, the mistletoe infected blue pine regeneration will turn into ash. As such the future of blue pine forests, in and around main settlements of western Bhutan, is very bleak.

Figure 3. Formation of witches' broom

Mortality of infected trees

There is severe mortality of dwarf mistletoe infected blue pine trees particularly on drier sites of Thimphu and Paro Valleys. It has been observed that the infected trees usually die due to moisture deficiency. During drought period the mistletoe infected trees suffer moisture stress than the healthy trees. Mistletoe always maintains high moisture level in it. Sporadic death of mistletoe infected tree is quite common but during 2008 it was very unusual because almost all the infected trees that year were dead.

Control measures

Detailed and systematic studies have not been carried out on the control measures to be adopted against the spread of the parasite to other surrounding stands of blue pine. However the following advices/prescriptions are provided, to the field divisions, for controlling the spread of parasite to the uninfected stands.

1. As precautionary measures the forestry staffs, working in the field, have been advised to carry out regular surveillance of the forest and report the occurrence or infestation by the mistletoe.

2. In heavily infected stands, the field staffs are advised to fell all the trees and regenerate the area. Regeneration could be done either naturally or artificially. Further it also advised to burn the area otherwise the parasite will again find favourable conditions and start regenerating.

3. In stands where the infestation is not widespread and is confined to few branches of the trees it is prescribed for pruning the infected branches that bears the mistletoe shoots.

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FOREST HEALTH PRACTICES IN CHINA

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Review of Forest Health in China

Recognizing the importance of forestry, the Chinese Government has, since the reform and opening up to the outside world, set up six key forestry programmes successively to enhance the silviculture and protection of forest resources. Due to the great efforts by the six programmes, remarkable achievements have been made in forestry development. The forest area, volume and the forest coverage have increased dramatically.

According to the Sixth National Forest Inventory (1999–2003), there are 174 909 200 ha of forest all over the country. The total volume of forest is 1.2456 billion m^3, and the forest coverage is 18.21%.

Forest in China can be divided by the ownership of forest land into 73 343 300 ha of national forests and 99 443 700 ha of collective forests. In terms of harvesting rights (concessionaires, or the ownership of forest trees), these could be divided as 72 849 800 ha of national forests, 64 835 800 ha of collective forests and 35 101 400 ha of private forests.

Forests in China are classified into protection forest, timber forest, economic forest, firewood forest and forest for special uses. Protection forest covers 54 746 300 ha with a volume of 5 500 844,800 m^3. Timber forest covers 78 625 800 ha land with a volume of 5 512 419 400 m^3. The area and the volume of the firewood forest have been reported as 3 034 400 ha and 56 270 000 m^3 respectively. Forest for special uses is 6 380 200 ha with a volume of 1 028 102 600 m^3.

In terms of stand age, the forests could be classified into young forest, middle-aged forest, near-mature forest, mature forest and over-mature forest. The area and volume of these five types of forests are as follows:

- Young forest: 47 237 900 ha with 1 284 966 000 m^3
- Middle-aged forest: 49 643 700 ha with 3 425 721 800 m^3
- Near-mature forest: 19 987 300 ha with 2 245 509 900 m^3
- Mature forest: 17 147 900 ha with 3 016 609 800 m^3
- Over-mature forest: 8 769 900 ha with 2 124 829 300 m^3

Oak, pine, fir, birch and larch are the five most dominant tree species in China. The total area cover by these species is 71 307 800 ha, or 49.94% of all the forest land; and the total volume is 4 494 149 800 m^3, or 37.15 % of all the forest volume.

Main challenges of forest resources management in China

Limited forest resource

In recent years, great changes of forest resources have taken place in China. The area and volume, as well as the coverage of forests, have been increasing continuously. However, as a country with limited forest resource, China is still facing the problem that the function of forest ecosystems is still very fragile.

Uneven distribution of forest resource

Forest resource is relatively rich in the northeast, southeast and southwest China. While the forest coverage in the five northwest provinces, of which the area is 32.19% of the whole country, is only 5.86%.

Low quality of forest resource

The average annual growth rate of the forests in China is 3.55 m^3/ha and the average diameter at breast height is 13.8cm. The forest volume per hectare is 84.73 m^3/ha.

Forest health practices in China

To nurture healthy forests, a series of countermeasures have been adopted by Chinese government.

Awareness of forest health has gradually risen

The Administrator General of State Forestry Administration has clearly defined forest management as a permanent theme of modern forestry. The main objective of forest management is to improve the quality of the forest and to cultivate more and healthier forest. A series of plans have been developed to provide policy, financial and technical support for the practice of forest health.

Effectively improving the quality of afforestation

Emphasizes have been focused on tree species selection: native or indigenous and, rare and threatened species, as well as the broad-leaved trees species are the priority species for afforestation.

Agricultural lands on hill slopes are compensated for converting to forests, assisted by artificial planting and aircraft seeding.

Various guidelines had been developed to standard afforestation practices and also emphasizing forest quality assessment in terms of species diversity, crown density, community structure, vegetation coverage, and litter thickness.

Strengthen the management of forest health

The *National Standards of Ecological Forest Construction* and the *Guidelines of Sustainable Forest Management in China* have been released to regulate forestation design, forest management, biodiversity protection, maintenance of soil fertility, pests control, fire prevention and public participation.

The *Temporary Regulation of Forestation Quality Management* is established to regulate the planning and design of forestation, seedling selection, execution, fostering and protection, inspection, incentives and penalties, information documentations, and so on.

Three programmes have been carried out to explore forest health practice. There is a Sino-US forest health cooperation programme, a pilot programme for fostering of the young-middle aged trees in non-commercial forests, and demonstration programmes of sustainable forest management.

Strengthening research on forest health indicators

An assessment indicators system is finally selected after full consideration on the factors including forest productivity, structure, resistance, soil condition as well as socio-economic development.

Discussion

Public participation is indispensable in healthy forests silviculture, especially after the reform of forestry in China. It would be hard to cultivate healthy forests without the participation of the community.

The local rural people's benefit shall be fully considered in the process of implementing forest health practices. The establishment of an electricity generating plan based on bioenergy in Inner-Mongolia is a good example. It not only contributing to ecological protection but also increases the incomes for the local people.

As healthy forests require relatively long period to establish, continuous efforts are necessary. Moreover, the success of such practices also requires implementation of complementary social economic programmes.

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FIJI'S FOREST HEALTH, INVASIVES AND QUARANTINE – CURRENT STRATEGIES AND FUTURE DIRECTIONS

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Introduction

Forest Health in a changing world is a daunting but challenging concept in this era, particularly with continuing globalization, increasing trade, travel and transportation of goods across borders and climate change. The challenge for us is to respond likewise, nationally, regionally and internationally by putting in place policies, strategies, legal frameworks and workable management plans for the protection of our forests and livelihoods of our people.

Forest health in Fiji is part of our strategic development plan, focusing mainly on pests and diseases of economic relevance to our timber industry. More recently with the assistance of the Australian Centre of International Agricultural Research (ACIAR), we have developed programmes for the detection, identification and surveillance of pests and diseases as well as hazard site surveillance and early warning systems of forest invasive species. Awareness of invasive species has entailed a closer link between Forestry Department and our otherwise agricultural orientated Quarantine Department.

Despite all these progresses and achievements, we face a challenging future in maintaining our forest health and preventing the incursions of invasive species. Although the initial responses to international agreements and obligations encouraged the capacity to develop programmes, activities, frameworks and policies on forest health, protection and invasive species, the challenge lies in the actual implementation of these. Furthermore, for a successful response to this more recent and much publicized "change" concept, we need to build our capacity in not only recognizing our problems and identifying solutions but also to address them through management plans and more importantly, implementing and monitoring the plans with all involved government agencies like Agriculture, Quarantine and Environment, other stakeholders and the regional Secretariat of the Pacific Community as well as international agency support.

Background

Forest health in Fiji has been ongoing since the early 1970's and has only recently received recognition and priority in light of international agreements that Fiji is a signatory to. Although the response has been slow due to amendments of our policies, decrees, acts and legal frameworks developed from the 1950's, it however shows promising potential, being adopted in our policies, strategies and corporate plans. Likewise, invasive species which is a fairly recent concept has been given some recognition in the outlining of our forest policy, forest certification standards, sustainable development bill, biodiversity strategy and action plan, the biosecurity bill, Plant Quarantine Act, Environment Act and the Customs Act.

Much of Fiji's biodiversity is unique and this places a heavy responsibility on Fiji since much of the country's economy is based on the use of natural resources and the benefits and services provided by natural, healthy ecosystems. Fiji being a group of islands has developed fauna and flora in isolation without any high level of predation and these can be easily lost through introductions of exotic invasives. In order to compete for the attention of government decision makers, policies regarding forest health, protection and invasives first need to be demonstrated in economic terms and their value in social and economic development.

Forestry is the second most important industry for the Fiji economy with the sector generating over US$30 million and direct employment of over 3000 people. The most important commercial plantations are exotics mahogany and pine and more recently, the establishment of Teak and Silver Quandong. The mahogany plantations, which are valued at $23 million, are inter-planted within native

forests and suffering from ambrosia beetle and termite infestations while potentially at risk from *Hypsipylla*. The pine plantations are at constant threat from *Sirex* with increasing trade. Work involved in plantation health and invasive species surveillance is accountable for by the Forestry Department which is striving to meet the demands posed by the changing world.

Current Strategies

Forest Health

A very important component in Forestry Research is "Forest Health and Protection". The forests in Fiji are relatively free from serious insect, disease and invasive problems, nevertheless, through changing patterns of travel, transport techniques and importation of merchandise through containerized cargo, there is a great element of risk and hazard of introducing exotic pests and diseases. In view of this it is highly necessary to identify potential threats, their mode of spread, environmental influences and valuable ecosystems and species. Also important is to detect actual threats through surveillance and reporting, systematic detection surveys, verifications and notifications, not only nationally but regionally and internationally. More importantly, the recent introduction of Hypsipylla species into Vanuatu, which is close to Fiji and trade exchanges frequent, is reason enough to require early detection and plantation health surveys.

Currently the activities undertaken in Forest Health in Fiji are surveillance, collection and rearing of timber infesting insects belonging in particular to Coleopterous families of bark beetles, weevils, ambrosia beetles, powder post beetles and Isoptera (termites) and Hymenoptera (especially wood wasps). Also undertaken are surveys, collections and cultures of potentially forest damaging pathogens, especially Phellinus and Armilleria species in plantations, natural forests, botanical gardens and vicinities around major ports of entry. These are conducted along guidelines set within the ACIAR projects on forest health surveillance and early detection at hazard sites with modifications made along the way to suit our situation in Fiji. During the project phase, 3 new exotics have been discovered, *Xylosandrus crassiosculus*, *Sinoxylon* species and *Quadrastichus erythrinae.*

The early warning system enables early detection but to implement control strategies as the next step needs expertise far beyond us since issues such as who does impact studies and how to do it as well as control options are all daunting tasks which none of the Departments have the capacity to undertake.

The forest health section liaises with timber inspectors of Timber Utilization Division and Agriculture Quarantine officers with regards to imports of timber, timber products, packaging cases and pallets. Collections from periodical light trapping in logged/unlogged forests, plantations, ports of entry and nurseries are identified through our ACIAR project scientists in Australia (since Fiji lacks forest insect specialists) and stored as voucher specimen for our insect database. This would assist us in the detection of potential invasives. Some potential timber pests not currently in Fiji have been collected and preserved by ACIAR project scientists from Australia and brought into Fiji for the awareness of quarantine officers at borders and post borders. At management level, the forest health section of the department of forestry is represented within the temporary quarantine board in assisting with the development of Biosafety and Biosecurity Acts as well as the regular consultations for import and export permits for the forest sector.

Priority Pests and Diseases

Cedar tip moth	-	Mahogany (Meliaceae)
Phellinus noxius	-	mahogany/sandalwood
Bark beetles e.g. *Ips* species	-	*Pinus caribaea*
Sirex noctilio	-	*P. caribaea*
Ambrosia beetle	-	mahogany
Armillaria sp	-	mahogany/pine/native species
Termites	-	multiple hosts
Asian Gypsy moth	-	multiple hosts
Chlorophorus annularis	-	bamboo species

Forest Imports and Exports

Imports and exports of forest products are regulated by the Forestry Utilization Division through collaboration with the Agricultural Quarantine Department. Forestry timber inspectors are given temporary status as quarantine inspectors, renewable every year. These inspectors carry out inspections of timber exports and issue phytosanitary certificates for all products that do not go through heat and chemical treatments. The quarantine department informs the forestry inspectors if pest/disease symptoms are found in import consignments and these are inspected by forestry inspectors and treatments or other actions determined. All forestry import and export procedures are in line with the Quarantine Plant Protection Act and following the standards set by the ISPM 15.

This system of forestry, quarantine, client collaboration is workable but only for short term given the current budget situation in the Government. Long term strategies need to be worked out where the quarantine officers themselves have the capacity to inspect forest products and identify pest/disease/pathogen/invasive incursions coming in through ports of entry. The Quarantine department currently has capacity only to undertake agricultural biosecurity work whilst the Forestry Department has to frequently liaise with the Quarantine Department on all issues of forest product biosecurity.

Quarantine Overview

The Fiji Agricultural Quarantine Departments role has become important on a national, regional and international scale since Fiji became a member of the World Trade Organization and established bilateral quarantine agreements with other trading countries. The role of the Fiji Agricultural Quarantine is to provide protection against the entry of unwanted pests, diseases and weeds while permitting the flow of international trade and conserve biodiversity by preventing destructive invasive species from entering the country which will pose a threat to our endemic species of plants and animals.

The quarantine department works within the guiding principles of certain laws, legislations, regulations and acts such as the:

- Plant Quarantine Act 1982
- Animal Importation Act 1970
- Fruit Export & Marketing Act 1907
- Plant Quarantine Act Cap 156 & Regulations
  - Part I Preliminary
  - Part II Powers of inspectors
  - Part III Domestic Quarantine Control
  - Part IV General

The areas of work covered by quarantine are border operations, post border operations and monitoring and surveillance. The plant import and export criteria are based from the Plant Quarantine Act and regulations undertaken through import permits and risk analysis of both importations and environment. The process of an import risk analysis involves import risk initiation, pest risk assessment and pest risk management. Some considerations required are an assurance that in the exporting country the commodities are not attacked by injurious insects, that their importation from the specific areas, under prescribed safeguards, can be authorized without risk, that prescribed treatments have been or will be given and that other quarantines do not prohibit the entry.

The Fiji Agricultural Quarantine still needs to reassess their policies and strategies and need to place more stringent controls and measures to counter risks associated with forestry products. They need to form a proper permanent plant protection committee to deal with import issues and have on board a scientific team made up of entomologists, pathologists, nematologist and other experts to identify potential risk introductions as well as biocontrol specialists to advise and assist in implementation of required protocols and field staff who continue to monitor post introductions.

Between forestry and quarantine, the early detection capacity is already in place but we still need the capacity for rapid response and also guidelines on who are responsible for conducting this.

Frameworks in Place

With the increasing emphasis given globally to invasive species, climate change and sustainable forest management, Fiji's response has been immediate by way of reassessing and amending their forest policy to recognize and address these issues.

The 2007 Forest Policy states that "the government will take all efforts to protect natural and plantation forests and their biodiversity from forest fires, natural disasters and invasive species". Another example is one of the guiding principles of the Fiji Biodiversity, Strategy and Action Plan which states "the control of invasive organisms is critical to the success of biodiversity conservation" in their fifth focus which is the Management of Invasive species. The actions are to reduce risks of introduction, control invasives, develop quarantine and government awareness and participation on this issue. Also under our Forest Certification Standards developed in 2008, criteria and indicators within the sixth principal "Environmental Impact" states that "the introduction of exotic species shall not breach the Quarantine Act….risk assessment and import documents to be used as verifications". It also prohibits use of exotic species in natural forests with exceptions on degraded sites and these too to be carefully controlled and monitored.

All these documents have been amended to include forest health and invasive species and these amendments will ensure legal background and support to any programmes on Forest health and invasives for the protection of our natural resources and biodiversity now and in future. Moreover, with Fiji being a signatory to 19 International Agreements and Conventions, the ensuing changes internationally will require an answering response in addressing these changes nationally. All these positive changes are to the Departments advantage but in order to be on par with changes internationally, Fiji will need continued support and expertise in various areas of forest health and invasive species since specialists are lacking in these areas but initiatives and the capacity to learn are not.

Fiji has continued to support these conventions and being a party to them shows its willingness to make progressive changes, but one must not overlook the fact that international collaboration, research and support are our main avenues to implement the requirements of the changing concepts in Forest Health and Forestry on the whole.

CHALLENGES

With current strategies in place, we still face challenges as a result of "change" in international focus and to mould our policies and strategies to these changes requires time since Fiji is still a developing country with a lot of resources to protect relative to the land mass but not enough expertise in the relevant areas to successfully implement these changes. Capacity building and training are important in areas of management plan development and implementation, pest risk analysis, impact studies, control strategies and rapid response to forest invasives. There is a need to train and build the capacity of Agricultural Quarantine officers to be Forest Quarantine officers as well. Taxonomic skills are only available through international projects which are mostly short term.

This issue needs to be addressed and options made available such as networking, university curriculum development to include this subject, consultant taxonomists/entomologists/pathologists to be attached over a period of time to determine endemics and exotics and access to international information on new incursions as well as hosts, favourable environments and mode of entry and emergency action plans.

Conclusion

Forest health and invasive issues in a changing world require utmost attention especially for a country whose economy is mostly resource-based, environment vulnerable and global niche markets highly competitive. The aspirations of promoting a "green Fiji" further necessitate a consistent and responsible approach in addressing forest health and invasive issues under stringent biosecurity measures.

With Fiji being a signatory to many international conventions and agreements, it has a tremendous task ahead in fulfilling these obligations and these can only be achieved through national awareness, regional corporation and international support in areas of change in Forest Health and Invasive threats. Globalization and increasing trade threaten our forest biodiversity and the added climate change focus all add to major responsibilities in forest health issues which for a developing country is beyond it's capacity but with international support and collaboration, these challenges can be met and strategies implemented to fulfill these obligations to safeguard our forests and livelihoods now and in the future.

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FOREST HEALTH MANAGEMENT IN INDIA: PRESENT SCENARIO AND FUTURE CHALLENGES

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Introduction

Tropical forests are in a state of transition: from natural to intensively managed stands, from an era of over-abundance to a period of dwindling supplies, with increasing consciousness for the environment, ecosystem and biodiversity. Forestry, in general has progressed from the concept of extraction and regeneration to sustainable production and management of forest resources and ecosystems. Forest health management concept and practices have also undergone changes from conventional short-term control to more effective long-term integrated management strategies. In India, the estimated 67.7 million ha of forest cover (FSI 2005) comprises around 46.1 million ha of production forests. More than 120 forestry species are used for various afforestation programs with an annual planting rate of 1.78 million ha. Teak, eucalypts, acacias, casuarinas, mahogany, shisham, poplars and pines are the most widely planted species. Scientific conservation and management of forests for the past 160 years have contributed towards improving the growth performance of forests; however, threats from natural influences and anthropogenic interventions affected stand health and productivity adversely. The paper presents the current status of 'forest health and vitality' variables, short-term and long-term forest health management strategies adopted, and highlights future challenges.

Forest health and vitality: General scenario

Natural forests are characterized by high species diversity and manifest strong correlation between diversity and stability in relation to diseases and pests outbreak; whereas, monoculture production forests are prone to diseases and pests. Data generated over the past several years support these generalizations. With the increasing human interventions and harsh climatic influences, the production forest ecosystems became vulnerable to outbreaks of diseases and pests, aggressive invasions of alien weeds, incidence of forest fires and grazing.

Diseases

In India, more than 500 phytopathogens *viz*., fungi, bacteria, viruses, phytoplasma have been recorded on forestry species causing various diseases and disorders. Of these, fungi pose greatest threat. In natural forests, heart rot, a progressive decay affecting the central core of the standing trees is the major problem. About 40 heart rot fungi have been reported on different commercially important species (Bakshi 1975, Mohanan 1994). In sandal (*Santalum album*) stands, spike disease caused by Phytoplasma is spreading at an alarming rate causing large-scale mortality of trees. In bamboo brakes, rot of emerging culms by *Fusarium moniliforme* var*. intermedium* affects the culm production as well as stand productivity (Mohanan 1997). In seed stands of forestry species, damage to the seed crops by fungi and insects affects seed production and seed health. In forest plantations, disease outbreaks are frequent. The recent outbreak of pink disease (*Corticium salmonicolor*) in young teak plantations is a major threat to stand establishment (Mohanan 2008). Earlier, during 1970s and 1980s, pink disease, Cryphonectria stem canker and Cylindrocladium blight, had caused major havoc in eucalypts plantations (Sharma *et al*. 1985). However, at present, these diseases occur in low intensity (Mohanan 2005). Large-scale mortality of young *Acacia mangium* trees due to a disease complex affecting the roots and basal stem leading to wilt, stem rot and die-back is a major problem in humid tracts. *Fusarium solani* and *Ganoderma lucidum* are the pathogens associated (Mohanan 2005, Mohanan & Rajeshkumar 2008). In *Casuarina equisetifolia*, blister bark disease by *Trichosporium vesiculosum* poses serious threat to stand establishment and productivity (Bakshi 1975, Mohanan & Sharma 1993). In conventional nurseries, *Rhizoctonia solani, Sclerotium rolfsii, Cylindrocladium* spp. are the most potential pathogens. In root trainer nurseries, bacterial seedling wilt by *Pseudomonas solanacearum* and *P. tectonae* poses major problem (Mohanan 2000).

Insect pests

Even though nearly 1500 insects have been recorded from the forests, only a few are serious pests causing epidemics in natural forests, plantations and nurseries (Thakur 2000). Epidemic outbreak of sal heart wood borer, *Hoplocerambyx spinicornis* during 1998 affected millions of sal trees. *Hypsipyla robusta,* is a serious pest of toon and mahogany, capable of causing >90% mortality in nurseries and young plantations. Teak defoliator (*Hyblaea puera*), leaf skeletonizer (*Eutectona machaeralis*), stem borer (*Sahyadrassus malabaricus*), Ailanthus defoliator (*Eligma narcissus*), Khasi pine defoliator (*Eterusia pulchela*), Poplar defoliator (*Clostera cupreata*), Chir pine defoliator (*Lebeda nobilis*), are the major pests posing threat to stand health (Nair 1988, Thakur 2000). Outbreak of teak defoliator causes up to 40% loss of growth increment. In young eucalypts plantations, recent emergence of gall insect, *Leptocybe invasa*, is a serious unresolved problem. In conventional forest nurseries, white grubs, termites, etc. are the major insect pests affecting seedling health.

Invasive weeds

Alien weed invasion is one of the major threats to the health and vitality of forest ecosystems. Aggressive invasion by the alien weeds modifies the ecosystem structure and functions by dominating and replacing the native vegetation. *Chromolaena odorata, Mikania micrantha, Lantana camara, Ageratina adenophora, Mimosa diplotricha, Parthenium hysterophorus, Argemone mexicana* are the dominant alien invasive weeds. Of these *L. camara, P. hysterophorus, A. mexicana* are widely distributed throughout the country, while others are more or less restricted to the forests in the Western Ghats and North-eastern states. Alien weeds are steadily increasing their range of expansion in different forest ecosystems by competing successfully with the native species (Sankaran & Sreenivasan 2001).

Forest fire, grazing and pollutants

Most of the forest fires are caused by man deliberately or unintentionally. About 3.73 million ha of forests are affected by fire and around 54.7% of forest areas are fire prone. Apart from direct impact on stands, fire induces incidence of diseases and pests. Uncontrolled and excessive grazing lead to degradation of forests. About 77.6% of forest areas are affected by high incidence of grazing. Atmospheric and soil pollutants have been recognized as hazard to forest health and vitality, however, information on their impact is meager.

Forest health management: Present scenario

Forest health management strategies practiced include both short-term tactics and long-term measures. Even though, mechanized spraying and fogging of chemicals were done in production stands to combat the diseases during 1980s, recently, pesticides are in restricted use due to economic and ecological reasons. More emphasis is given to integrate silvicultural measures such as, weeding, enhancement of tree vigour through fertilization and thinning, light surface burning, etc. along with need-based use of chemicals (Mehrotra 1990, Sharma & Mohanan 1996). Tridemorph and Bordeaux paste are used against stem canker and pink disease, while carbendazim and mancozeb are used in nurseries as prophylactic treatment. Biocontrol measures such as, solarization of seed beds, application of antagonistic fungi, *viz*., *Trichoderma viride*, *T. harzianum* are also used in seed bed nurseries for managing soil-borne diseases (Mohanan 2007). As long-term strategy, genetic improvement of forestry species against potential diseases has been carried out 1980 onwards. Disease resistant species and provenances of eucalypts, casuarinas, acacias were clonally multiplied and ramets are used for large-scale replanting in disease prone areas. For combating the teak defoliator outbreak, a baculovirus based pesticide (HpNV) has been developed (Sudheendrakumar *et al*. 2001). Modernization of nursery practices by introducing root trainer system for raising planting stock had a great impact on nursery health management (Mohanan 2000). As soil-less or soil-free growing media are used in root trainers, soil-borne diseases and pests are excluded from nurseries. Also, the new technology offers planting stock improvement by mycorrhization. Current weed management options centre around slashing and restricted use of herbicides, singly or in combinations (Sankaran & Pandalai 2004). More than 60 years of research efforts employing classical biological control (CBC) tools against *C. odorata* and *L. camara* yielded little success. However, recently *Puccinia spegazzinii*, a co-evolved promising rust fungus has been used against *M. micrantha* (Ellison 2001).

Future challenges

Even though, effect of long-term climate change in forests with regard to forest health is not evident, short-term inter-annual changes as well as day-to-day weather change had considerable impact on distribution, density, diversity and shift in dominance of pathogens and pests in the forest ecosystems. Further, chances of introduction of alien organisms are increasing with the recent spurt in international trade. Thus, with increasing disease and pest pressure and aggravating human influences, the forest ecosystems are prone to catastrophic disease and pest hazards. To meet the challenges and maintain the forests healthy and sustainable, systematic forest health monitoring and efficient forest health management are warranted.

Acknowledgements

The author is grateful to Dr. K.V. Sankaran, Director, Kerala Forest Research Institute, for encouragement; and to APAFRI for financial support for attending the workshop.

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INVASIVE HISTORY OF EXOTIC FOREST INSECT PESTS IN KOREA

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Introduction

Insect pests are among the most destructive agents affecting forests and shade trees. Forest land occupies over 60% of the total land area of Korea, and thus maintenance of healthy forest is of vital importance for the social, economic and environmental benefits of all Koreans. Continuously increasing need of wood has been a strong incentive for planting fast-growing native and exotic tree species, and planting programmes in large scale are going on at many places. Consequently, damage by insect pests is also increasing, particularly at those man-made forests. More than 2 200 species were recorded to be harmful to forests in Korea, and less than 100 species are known as problematic pests. Approximately 10 species, in fact, are treated as major forest insect pests in Korea. Most of the major forest insect pests are invaded from abroad. However, the incidental introduction of exotic phytophagous insect pests has become quite common in Korea. Furthermore the rather wide range of Korean climatic parameters allows the establishment of subtropical species in the southern regions and of temperate species in North and Central Korea. Several alien species have succeeded in acclimatizing to Korean conditions. Of these, the most important forest insect pests in Korea are pine wilt disease moved by *Monochamus alternatus*, Pine needle gall midge, Fall webworm, Sycamore lace bug, Black locust gall midge and *Lycorma delicatula*. In recent years, damage to forest vegetation resulting from increased urbanization, industrialization and global warming is becoming increasingly important in Korea. With increasing international trade of agricultural and forest products, the risk of introducing dangerous tree insect pests from abroad is higher than ever. Major forest insect pests of economic importance in Korea are described with emphasis on their damage fluctuation and control.

Pine needle gall midge, *Thecodiplosis japonensis*

The occurrence of pine needle gall midge in Korea was first reported in *Pinus densiflora* and *P. thunbergii* stands of Kyungbok Palace of Seoul and Mokpo, Cheonnam in 1929 (Takagi 1929). Currently, pine needle gall midge is the most important insect pests of *P. densiflora* and *P. thunbergii*. However, there was little concern about this or of other insect pests of pines until 1970. It was spread throughout the South Korea from 1972 to 1998.

There are 476 local survey sites for the occurrence monitoring of pine needle gall midge in *P. densiflora* and *P. thunbergii* stands all over Korea. Basically, pine needle gall midge survey is of two kinds: detection and evaluation, and there are conducted separately or together. Surveys on the changes of pine needle pairs infested by pine needle gall midge and density of its parasitoids had been conducted since 1968. Observations on the progress of the pine needle gall midge infestations in several

areas of the country have shown that the percentage of foliage infestation reaches its peak 6 to 7 years after initial attack, and decreases thereafter. Gall formation of the midge on the red pine is higher in north stands than in the south, and their mortalities infested are more severe in north stands than in the south. The economic injury level was estimated as 50% in percentage of infested needle pairs and an economic threshold was calculated to be 25% in north stand and 38% in south stand (Park & Hyun 1983).

Table 1. Occurrence area (ha) of the pine needle gall midge by year in Korea

Year	2001	2002	2003	2004	2005	2006	2007
Occurrence area (ha)	148 952	118 352	91 166	73 206	148 846	195 759	179 585

Pine wilt disease by pine wood nematode

In October 1988, the pine wood nematode was first found in Korea at Mt. Keumjong of Busan. The invasion of pine wood nematode, *Bursaphelenchus xylophilus* was from Japan where it has devastated forests of *P. densifora, P. thunbergii* and *P. korainsis*. The wilt disease caused by pine wood nematode, and the nematode is carried by the insect vector, *Monochamus alternatus* and *M. saltuarius*. Several *Monochamus* species are known to transmit the pine wood nematode to new host trees. Among them, *M. alternatus* in the southern part (Chung 2002) and *M. saltuarius* in the central part (Choi *et al*. 2007) of Korea are thought to be the most important vectors in areas where pine wilt occurs. Transmission of pine wood nematode to new host trees through maturation feeding and oviposition wounds are well documented for both *M. alternatus* and *M. saltuarius*.

The Korean government established the Special Law for Pine Wood Nematode Control which was enforced from September 2005.

Table 2. Occurrence area (ha) of the pine wilt disease by year in Korea

Year	2000	2001	2002	2003	2004	2005	2006	2007
Occurrence area (ha)	1 677	2 575	3 186	3 369	4 961	7 811	7 871	6 855

Fall Webworm, *Hyphantria cunea*

The fall webworm, *H. cunea*, was first reported to have occurred in Seoul in 1958 (Chung *et al.* 1987). The fall webworm was though to have been introduced into the US. Army base camp located at Etaewon in Seoul by transportation of military equipment, and its range spread throughout the country very fast.

Although the fall webworm gives damage to various broad-leaved tree species, it should not be consider a forest insect pest in the strict sense, because it mostly defoliates only trees along roadsides, in parks and gardens, but not within forest stands in Korea. Korea Forestry Research Institute has been surveying its annual infestation fluctuations on roadside trees, twice or a year at 27 local survey sites all

over county. Results shown that the damages have decreased gradually since 1979, after severe damage through 1969 to 1978.

Sycamore lace bug, *Corythucha ciliata*

The sycamore lace bug, *C. ciliata* was first found to have occurred in Cheongju, Chungbuk Province in 1995. The pest was though to have been introduced from North America, and spread its range throughout the country in a short term (Chung *et al*. 1996). The only host of the sycamore lace bug, *C. ciliata* is the button-wood, *Platanus occidentalis* along roadsides. Three to four generations have been recorded in Korea per year.

Locust gall midge, *Obolodiplosis robiniae*

The locust gall midge, *Obolodiplosis robiniae,* was first found to have occurred all over the country in 2002 (Woo *et al*. 2003). The host plant of the locust gall midge, *Obolodiplosis robiniae* is black locust, *Robinia pseudo-acacia*, and most of occurrence are on over-matured trees.

Lycorma delicatula

Lycorma delicatula was first found to have occurred in Seoul and Kyunggi Province in 2006 (Choi *et al.* 2007). The pest could have been introduced from China. Its favored host is *Lycorma delicatula*, but it also attacks Japanese coral, *Viburnum awabuki* and Chinese elm, *Ulmus parvifolia*.

The initial occurrence areas of exotic pests have very weak natural enemies in limiting the pest populations. So, there is an explosive increase in the abundance of *Lycorma delicatula*, spreading very quickly.

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HEALTH PROBLEMS OF SOME EXOTIC FOREST TREES AND AGRICULTURAL CROPS IN MYANMAR

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Introduction

The Myanmar Forest Department has introduced some species, such as acacia, eucalyptus, cinchona, pine, for dry zone greening, production of medicine and fuel wood, or as industrial wood. The Agriculture Services has also introduced some agricultural crops , like coffee, cotton, oil palm, potato, tomato for food, oil and fiber in Myanmar. All these are exotic species, and there are many diseases and pests of these exotic species that could not be controlled effectively in nurseries and plantations.

Methodology

A study was conducted to extract relevant information from the collection of pathological and entomological research papers from Forest Research Institute (FRI) and Yezin Agriculture University (YAU). The focus of this study was on pathogen and pest outbreaks of most widely planted exotics trees and crops in Myanmar. In addition, several departmental reports were also reviewed.

Host, pathogen, pest, author and published year of the research document were described in the text. Literatures were listed and the lists of references were arranged in alphabetical order of authors' name. For pathogenic problems, four species of forestry host and sixteen species of agricultural host were described. For pest problems, information on three species of forestry host and eight species of agricultural host was compiled.

Results

Forestry Sector - Disease Problems

From 1997 to 2001, eucalyptus plantations were established under the joint project of Nippon Paper Industry (NPI) and Forest Department (FD) for paper pulp production. Hybrid *Eucalyptus urograndis* and *E. urophylla* were infected in 1999 by a root rot fungus, *Cylindrocarpon sp*., *Cylindrocladium sp*., with a threat level of 50% in the plantations (Wai Wai Than 2000).

Myanmar Pharmaceutical Factory (MPF) received cinchona seeds through UNICEF in 1980 to be planed for quinine production. The seedlings in the nursery succumbed to the attack by fungi *Fusarium sp* and *Rhizoctonia sp.* (Wai Wai Than 2001).

Seeds from many acacia species were distributed to Myanmar by Commonwealth Scientific and Industrial Research Organization (CSIRO). These seeds were planted to supplement fuel, provenance trial, as windbreak and shade, and also for papermaking. The following diseases were documented, such as the powdery mildew (*Oidium sp*.), black mildew *Meliola sp*., tar spot, witches' broom, stem canker *Nectria sp*., heart rot (*Fomes sp.* and *Polyporus sp*.), and root rot (*Ganoderma sp*.) (Wai Wai Than 2003).

Seeds of fir dragon, *Abies fabri*, were received from China in 2003 for species trial in forest nurseries of hilly region. In 2004, needle blight (*Phytophthora sp*.), root collar necrosis (*Fusarium sp*. and *Rhizoctonia sp*.) were detected attacking the seedlings with 37.23% threat level (Wai Wai Than 2004).

Pest Problems

Trial plots of introduced Pinus increased dramatically in the 1983-84 by Asia Development Bank (ADB) assistance. Shoot borer (*Petrova salweenensis* Miller) and cone borer (*Dioryctria sylvestrella* Rats) were found in 1986. There is no record of shoot borer attack on Indigenous *Pinus khasya* prior to introduction of exotics *P.caribea, P. elliotii, P. maximinoi, P. occerpa,* and *P. patula*. (Aung Zeya 1984, 1992).

Pennisetun grass was introduced in 1967 and 1976 from Australia by Livestock Department (Animal Health Development and Artificial Insemination Project) for pasture. The species spread quickly as weed in teak plantations (Wai Wai Than 2008).

Introduced species Mezali (*Cassia siamea*) was attacked by the leaf defoliator (*Catopsilia crocale* Cramer) in every cold season (Win Win Myint 2000).

Agriculture Sector - Disease Problems

Exotic commercial hybrids of tomato were mostly grown and some of those were found to be severely attacked by early blight caused by *Alternaria solani* (Khin Hnin Yu 2006).

Phytophthora sp. is one of the most important pathogenic fungi, attack various parts of the rubber causing black stripe of the tapping panel. Defoliation caused by *Phytophthora* leaf fall was estimated about 50% in 1977. Yield loss due to the black stripe in an estate was up to 3000 and 9000 lb in 1914-1915, respectively (Maung Maung Myint 1994).

Potato was introduced in the 19th century from China. New variety was introduced from Bhutan in 1992 as a resistant variety in some areas. Late blight of potato, *Phytophthora infestans*, was widely distributed in planting sites (Maung Maung Myint 2004).

Banded leaf and sheath blight caused by *Rhizoctonia solani* Kuhn was detected in baby corn plantations. All hybrid varieties were infected (Maung Maung Thein 2003).

Although oil palm has been introduced since 1921, new exotic variety was introduced from Costa Rica in 1996. In 2000, one of the major diseases, anthracnose (*Collectotrichum gloeosporioides*) was detected (Mi Khin Htay Than 2003).

Soybean from China was mass cultivated in 1997, on which, rust caused by *Phakospora pachyrhizi* was very common (Myint Yee 1999).

Po Po Than (2003) mentioned about plant parasitic nematodes on some economic crops. There were *Criconemoides* on citrus, maize, and sugarcane; *Helicotylenchus* on citrus, cotton, maize, pineapple and sugarcane; *Hemicycliophora* on citrus; *Hoplolaimus* on cashew, cotton and tomato; *Meloidogyne* on carrot, pineapple and tomato; *Paratylenchus* on cashew; *Pratylenchus* on cotton, maize and tomato; *Trophotylenchulus* on pineapple and tomato; *Tylenchorhynchus* on cashew, maize, pineapple, sugarcane and tomato; *Tylenchus* on pineapple, maize, sugarcane and tomato; *Xiphinema* on citrus and orange.

Clover cyst nematode *Heterodera trifolii* on white clover and red clover was observed in many planting areas (Pyone Pyone Kyi 2003).

Angular leaf spot disease of cotton caused by *Xanthomonas campestris pv. malvacearum* was the only bacterial disease of economic important in Myanmar. New exotic varieties were multiplied for mass production in cotton research farms. They were found to be susceptible to angular leaf spot disease (Thet Yee Khaing 2002).

In Myanmar, muskmelon or netted melon from Thailand has been widely cultivated since 1980s. Downy mildew, *Pseudoperonospora cubensis* was a devastating foliar disease (Tin Aye Aye Naing 1999).

Sugarcane varieties from China were seriously attacked by red rot disease. Imported new resistant varieties also infested by stem rot disease (*Fusarium monilifoorme*) and red rot disease (*Collectotrichum falcatum*) (Yee Yee Thu 1998).

Pest Problems

Coffee white stem borer (*Xylotrechus quadripes* chevlorat (Coleoptera: Cerambycidae)) was the most serious pest with high incidence and causing great loss in yield of coffee (Aung Kyi *et al*. 2004).

Grain borer, *Rhyzopertha dominica* (Coleoptera: Bostrichidae), is a serious pest of wheat in Myanmar (Aye Aye Myint 2003).

Eight species of insects: leaf miner (*Acrocercops syngramma*), tea mosquito bug (*Helopeltis antonii*), ladybird beetle (*Micraspis* sp.), weevil (*Apion sp*.), thrips (*Selenothrips rubrocinctus),* mayfly (*Hexagenia bilineata*), lace wing (*Micromus tasmaniae*) and spider (*Lycosa sp*.) attacking cashew were recorded by In Kyine Khaing (2003).

Maize weevil (*Sitophilus zeamais* M.) was a problem also in Myanmar (Khin Aye Pwint Khaing 2002).

Groundnut is one of the most important vegetable oil crops. Leafhopper (*Empoasca kerri* (Pruthi)) was found throughout tropical countries as well as Myanmar (Khin Mar Myaing 2006).

Ohnmar Myo Aung *et al*. (2004) described twenty six insect pests (19 families in 9 orders) on cotton. The five major pests were aphid (*Aphis gossypii*), jassid (*Empoasca sp*.), thrips (*Thrips tabaci*), American bollworm (*Helicoverpa ermigerc*) and pink bollworm (*Pectimophora gassypiclla*).

Sunflower, planted in Myanmar since 1977, has been found to be attacked by moth (*Homoeosoma nebulella* Hb.) and broomrape (*Orobanche Cumana*) (Pau Siam Kam 2000).

Cabbage diamondback moth, *Ptutella xylostella* (Lepidoptera: Yponomeutidae), was the most destructive Brassicae crop pest in Myanmar (Thil Bahadur 2006).

Discussion

The diseases and pest problems cannot be solved by breeding until high resistant sources are available. Phytosanitary certification programmes should be intensified by the Agriculture and Forest Protection authorities, and by trained personnel with adequate resources for import and export matters. Before new species or varieties are released, the susceptibility to pests and diseases should be extensively studied.

More effort is necessary to obtain more information on introducing of exotic species, to focus on scientific findings of disease and pest outbreak in the plantations, and to analyze the causes of health problems which was along with original introduced plant materials or exotic species were widely planted in an area.

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PROTECTING FOREST HEALTH IN NEW ZEALAND

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Introduction

The New Zealand forest industry has a significant economic stake in preserving and enhancing the efficient movement of goods between countries as a major proportion of its production is exported. The New Zealand forest industry is also supportive of significant biosecurity investment as its forests are relatively free of significant international pests. Any new pathogen that became established could significantly impact the growth of forests and reduce the profitability of forest production.

Because of these, sometimes conflicting, needs New Zealand's biosecurity system has evolved to resemble "defence in depth". This concept, borrowed from the military, emphasises multiple overlapping and mutually supportive defensive systems rather than a focus on a single line of defence such as the border.

Within New Zealand there is a complementary system of surveillance programs to protect the health of New Zealand's plantation forests. The three main programs are High Risk Site Surveillance, Asian gypsy moth surveillance, and a plantation forest health surveillance programme. While any one of these biosecurity activities, by itself, would be effective in reducing biosecurity risk, each additional activity further reduces the risk to the forest estate. The advantages of the multiple activities are that there is less disruption to trade than there would be if all the resources were put into a single line of defence and post-border activities can plug gaps earlier, or later, in the defence. For example, no matter how effective border inspection is it cannot stop wind-vectored pests. Plantation forest surveillance plugs this gap as well as providing additional benefits.

High Risk Site Surveillance

High Risk Site Surveillance is a post border, risk targeted, surveillance programme for pests of arborescent plants. It is pathway focused through identification of sea container facilities, sea and air ports, and more recently, tourist routes. It is funded and managed by the Ministry of Agriculture and Forestry Biosecurity New Zealand (MAFBNZ) and implemented using a three phase approach.

1. Intensive transect inspections which gives the programme repeatability and flexibility.
2. Extensive walkthrough which provides extra flexibility and ability to cover new hotspots.
3. Discretionary time to respond to new information, either from locals or by special instruction.

Transect inspections are intensive, with inspectors given sufficient time to thoroughly inspect vegetation even in the absence of obvious signs of damage. When a pest or damage is located samples are taken. These samples are forwarded to Scion (New Zealand Forest Research Institute) diagnostic laboratories in Rotorua for identification. The results of the identification are notified to MAFBNZ within specified timeframes.

Inspections of transects in high risk sites alone are insufficient by themselves to provide comprehensive pest detection capability, as host vegetation may be scarce or of limited species composition. Many invasive species are capable of dispersing towards suitable host material some distance from their release point. Hence, High Risk Site Surveillance also

identifies and surveys vegetation rich areas associated with each high risk site, such as parks, golf courses, botanical gardens or arboretum
A database has been built and data integrated in a Geographic Information System. The programme has mapped approximately 5000 high risk sites. This mapping confirmed that the concentration of high risk sites generally occurs in industrial areas, which allows them to be efficiently targeted by High Risk Site Surveillance.

Gypsy Moth Surveillance

Gypsy moth surveillance commenced in New Zealand in 1992. Between 2004 and 2005 the programme was reviewed and updated. As the most likely pathways for gypsy moth invading New Zealand is as egg masses on ships, containers or used vehicles there has been a re-alignment of the programme towards transitional facilities and implementation of a coastal buffer for sites where there is a possibility of larvae ballooning from infested ships towards land. In 2005/06 the programme implemented a 'matrix' and grid cell system that provides more robust trap placement guidelines.

A commercially available pheromone (+) disparlure is deployed in traps to detect male moths, with traps inspected fortnightly during the trapping season. The network of traps are arranged on preferred host trees in a 750 m^2 grid pattern designed by MAFBNZ to cover identified high risk sites. Currently over fifteen hundred traps are deployed nationwide from the beginning of November until the end of April. Any suspected gypsy moths are sent to the Scion diagnostic laboratories in Rotorua for identification. If a moth is identified as gypsy moth then MAFBNZ is notified immediately and an investigation and response process swings rapidly in to action.

The gypsy moth surveillance programme is funded through a levy on sea containers and used vehicles. This is because the available evidence suggests that these are the most likely pathways to result in entry and establishment of Asian gypsy moth.

New Zealand Forest Owners Association Forest Health Surveillance

The New Zealand Forest Owners Association (NZFOA) funds and manages a forest surveillance program in New Zealand's exotic plantation forests. The current forest surveillance program consists of three types of survey activities:

1. Aerial Survey – The entire area of the forest estate is surveyed via transects located at 1000 m intervals. These transects are flown at 300 m above ground level at 70-75 knots while observers visually survey on each side of the plane. During these surveys, observers record the location of any mortality, dieback, defoliation, discoloration or other damage.
2. Drive-through Surveys – Forest health providers plan a driving trip that extends through most portions of the forest estate over a distance of at least 15 m/ha of the estate. While driving at a speed of about 15 km/h, observers visually survey the forest on both sides, recording the location of any damage.
3. Temporary Plots – These plots are placed at any locations where damage was identified in either aerial or drive-through surveys. Plots consist of 0.1 ha transects where the provider investigates the damage located during aerial or drive-through surveys. This investigation includes visual searches of trees for symptoms and causal organisms. Any symptoms or damage is recorded and a sample is collected of any organism or potentially infected plant material that is considered unusual or unknown.
4. High-risk Plots – A total of 60 locations have been identified on NZFOA estates. These locations are considered to be at high-risk to incursion because of their proximity to human activities (e.g., recreation, sawmills, etc) that elevate probabilities of accidental movement of pest organisms. These plots are surveyed using the same protocols used for temporary plots.

Results and Discussion

Each surveillance program contributes to the goal of protecting New Zealand's plantation forests and provides additional benefits. For example, High Risk Site Surveillance provides the main line of post-border surveillance and is targeted around mainly urban high risk sites. The NZFOA forest health surveillance programme incorporates a small number of forest-related high risk sites adjacent to, or within, forests to provide some biosecurity protection and also provides a measure of the forest health status of the forests themselves.

High Risk Site Surveillance has proved itself to be a relatively effective method of finding biosecurity risk pests. This is borne out by the fact that between 1 January 2003 to 31 December 2007, significantly more new to New Zealand pests have been detected firstly in high risk site surveillance or special surveys (14) compared with just 2 within forests (Kriticos *et al*. 2008).

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BUILDING A NETWORK-BASED INFORMATION SYSTEM FOR FOREST HEALTH MANAGEMENT: TAIWAN EXPERIENCE

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Introduction

Managing healthy forest ecosystems at national and regional scales is an important component of providing what society wants and needs from the forest ecosystem. From ecological point of view, a healthy forest nourishes its unique species and processes, while maintaining its basic structures, compositions and functions. From sociological point of view, on the contrary, a healthy forest has an ability to accommodate current and future society needs for values, products and services. Regardless of how different concepts people view these complex forests systems, maintaining the balance between forest sustainability and production of goods and services is the challenge for the forest administrative agency (Ferretti 1997). However, fundamental questions do arise, such as: what is a truly healthy forest and compares to what, by what criteria can we specify a healthy forest, and how do we manage a healthy forest? To answer these questions we need to have multidiscipline scientific data. Without these data, it is difficult for decision makers and forest managers to formulate technically sound policies and address forest health management issues. In Taiwan, relevant data related to forest health are often collected by different scientific groups and consists of a variety of formats and in many geographic locations. To obtain integrated and high quality information to help decision making is often hindered by the lack of standard methodologies for data collection, data management practices, and detailed metadata documentation across groups (Canhos *et al.* 2004).

A research project on building a health forest information network was initiated in 2004. The initial goals were:

1) to aggregate the existing dispersed databases including biodiversity, insect and disease, fire, and invasive species,
2) to develop a web-based portal that would streamline the discovery and exploration of forest health information, and
3) to provide data analysis application.

Methodology

We chose Ecological Metadata Language (EML) as the standard to document all datasets be included. EML has been developed as part of an open source, community-based effort since 1990 (Michener 2006). Led by the National Center for Ecological Analysis and Synthesis (NCEAS) and the Long Term Ecological Research Network (LTER) of the United States, the development of EML involved ecologists, information managers and information technologists. A web portal using Java servlet, user authentication, and backend schema-independent metadata repository was designed to be used for a data catalog. A scientific work flow system was recommended for integrating and analyzing data to generate information of forest health management needs.

Results and Discussion

Figure1 displays the conceptual framework of our information management system and portal. It can be divided into three tiers. The first tier deals with datasets and related information. Data collected by scientists related to biodiversity, insect and disease, fire, and invasive species are transformed and reorganized using species name and/or spatial attributes by this tier. The second tier relates to data archiving. Once datasets have been transformed, the raw data are stored in Storage Resource Broker (SRB) and metadata are stored in a schema-independent database. The third tier consists of the full web-based interfaces that allow easy access to the

second tier. This tier also manages definitions of multiple user categories with different user rights.

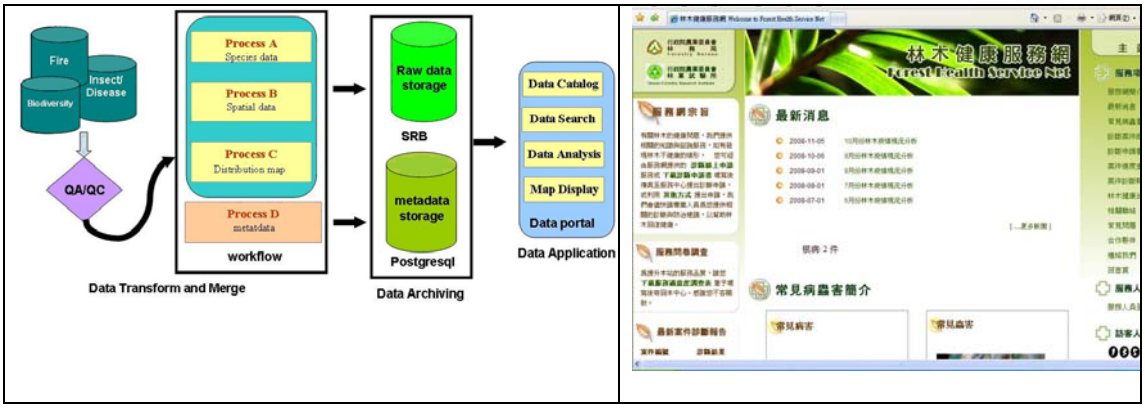

Figure 1. The conceptual model of forest health information system (left) and the web constructed based on the conceptual model (right).

A portal called Metacat has been set up for users to access data related to forest health in Taiwan Forestry Research Institute (TFRI). It contains the modules of the EML document database. The EML document database module is a Java servlet that acts as the interface to any SQL-compliant relational database. It handles storage, replication, query, validation, transformation, and authentication of EML documents and user management for researchers from forest health research community. Furthermore, by pointing directly to the referent locations in the database, the raw data can be stored with the EML documents. A data analysis function module consists of “stylesheets” that translate EML documents into statistical programs and GIS maps (Figure 2). Researchers can use this function for data manipulation, calculation, and graphical display online.

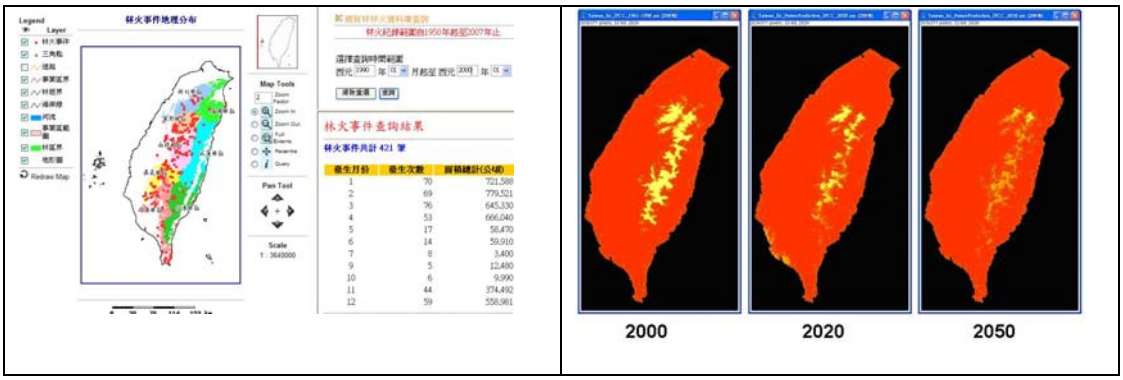

Figure 2. Using query and analysis function of the system, fire occurrence from 1990 to 2000 were retrieved and displayed in forest district maps (left). Using the same function, data were retrieved from biodiversity database to predict the distribution change of an alpine species, Taiwan fir, under global warming effect from 2000 to 2050 (right).

This project has brought together experts in ecology, information management, and computer science to address the challenge of integration on forest health issues. The result has showed the success to facilitate transformation, integration, and exploration of topic-specific forest health data such as the biodiversity change in high frequency fire locations. In the future, more tools will be developed to enable warehousing of more forest health data. Furthermore, Experiences learned from this project might also be applicable to other Asian countries that intend to build a similar system (Lin *et al*., 2006). We concluded that the system might be used to provide:

1) low cost data integration for forest health management,
2) support for the analysis and determination of forest health management needs, and (3) managing heterogeneous databases.

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Acknowledgements

This work was supported by Taiwan Forestry Research Institute and Taiwan Forestry Bureau. The authors would like to thank Dr. Henbiau King (TFRI former director) and Dr. William Chang (US National Science Foundation) for helping make this effort possible and smoothly proceed during 2004 to 2007.

AN OVERVIEW OF CURRENT STATUS OF FOREST INVASIVE SPECIES IN TIMOR-LESTE

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Introduction

Timor-Leste was formally well endowed with forests. At present, the total forest area of Timor Leste is estimated to be about 48% of the total land area (Godinho 2002 cited in Abel & Sequeira 2008). Generally Timor-Leste can be divided into the following six broad ecological zones: mountainous, highland plains, moist lowland areas (southern coast), arid lowland areas (northern coast), marine and coastal areas, in addition to urban areas.

Land tenure in Timor-Leste remains an unresolved and a critically important issue. This has serious implications for the sustainable management of forests and forest resources (Anon 2003). The State Secretary of Agriculture and Arboriculture, The National Directorate of Forestry, within the Ministry of Agriculture and Fisheries (MAFF) carries primary responsibility for management of forest resources and consists of three main Divisions: Reforestation and Conservation, Protection and Management of Forest Resources and Production and Utilization of Forest Products. The Government of Timor-Leste is currently undergoing a restructure which will impact on the structure of DFWR.

Timor-Leste officially became member of Asia and the Pacific Forestry Commission in the twentieth session of Asia and the Pacific Forestry Commission (APFC) that was held in Nadi, Fiji, from 19 to 23 April 2004. Since then Timor-Leste has actively involved in Asia and the Pacific activities in order to discuss forestry issues across the regions. Timor-Leste has involved in the preparation of the Forest Resources Assessment (FRA) 2005, took part in Conference on Forest (COFO) in Rome, Reinventing Forestry Agency and Establishing a Regional Forest Policy Network, in Manila – the Philippines from 28 February to 3 March 2006. In line with this Timor-Leste has received technical assistance from Food and Agricultural Organization (FAO) of the United Nations to develop its forestry policy and strategy. This report attempts to outline an overview of current status of forest invasive species in Timor Leste.

Methodology

An extensive literature search was conducted to obtain information regarding this assignment. The literature mostly reports and publication related to forest and land tenure issues in Timor Leste.

The case study sites were selected based on related activities in forest areas. The case study is covered the area of 6 hectares mainly used for sandalwood as seed bank.

This report's approach explored and made use of a number of key informants such as lead farmers, District Forestry Officer and Forest Guards. The team also visited area heavily affected by virus (*unidentified fungus*).

Results and Discussion

Forests provide not only timber for housing and firewood for cooking but they are also place for potential market products such as candlenut (*Aleurities molucana*) and tamarind (*Tamarindus*

indica) as well as staple food crops such as sago, yams, wild beans, etc. In addition, sandalwood (*Santalum album*) has been centuries providing a significant share in export revenue (Viegas and Xavier 2008). However, there are some serious threats to its economic value. The first threat is over exploitation during Indonesian role and after the independence. Secondly, it has been affected by unidentified fungus. In approximately 10% of the area, the sandalwood and *Eucalyptus deglupta* have been heavily affected by unidentified fungus. This may have serious impact on the existing trees due to lack human resource dealing with this issue.

In terms of legal basis, Timor Leste has established a number of regulations and decree laws. One of the strategies stated in the National Forest Policy and Strategy is that Timor Leste will complete its National Strategy to prevent pest and weeds by the end of 2009. However, lack of human resources and equipment seem to be the major obstacle faced by the Directorate of Protection and Management of Forest Resources. Therefore, expert is needed to help Timor Leste to deal with this issue. Secondly, the Forestry Policy and Strategy has been approved by Council of Minister on 1 August 2007. Finally, the Quarantine Decree Law for import and export of materials, and prevention of health in international travel, has been generated under legislation 2003/21 (31December 2003). This is under the Division of Quarantine, MAFF, and only focuses on pests and diseases. Weeds are excluded. Timor Leste seeks cooperation in the area of information sharing and technical assistance in order to complete its national action plan to combat forest invasive species.

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Acknowledgements

I would like to take this occasion to thank APAFRI, the Asia Pacific Forest Invasive Species Network and the Food and Agricultural Organization of the United Nations (UN FAO) Timor Leste for supporting me to take part in this important workshop. Special thank to colleagues in the Directorate of Forest Protection and Resources Management of the National Directorate of Forestry for their motivation and encouragement in writing and the completion of this report.

NEW RECORD OF LONGHORNED BEETLES DAMAGING FOREST PLANTATIONS IN VIETNAM

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Introduction

In 2005, Vietnam had a forest area of 12.6 million ha or 37.0% of total land area, comprising 10.3 million ha of natural forests (81.4%) and 2.3 million ha of plantations (18.5%). Forests are classified into three forest types: special-use, protection and production forests. According to the draft National Forest Strategy 2020 (MARD 2006), the total area of land with forest cover is to be increased to 16.2 million ha, consisting of 5.7 million ha of protection forest, 2.3 million ha of special-use forest and 8.2 million ha of production forest. The growth of plantations has contributed significantly to Vietnam's economy. Dominant plantation tree species are acacia, eucalyptus, pine, bamboo and some indigenous species. Replacement of natural forests over vast areas, with short rotation plantations, raises a big problem of insect pests and diseases. Devastating outbreaks of pine needle eating caterpillars, pine needle sawflies, and eucalypt leaf diseases have recently been reported.

Some long horned beetles associated with plantations have previously been reported for Vietnam: *Ploceaderus obesus* Gahan caused serious stem damage of cashew trees in southeastern Vietnam (Le Nam Hung 1985); and *Monochamus alternatus* Hope was a vector of the nematode *Bursaphelenchus* sp. causing pine wilt nematode disease of *Pinus kesyia* (Pham Quang Thu 2003). In recently years, insect surveys have been conducted, concentrating on long horned beetle damage in forest plantations. These surveys identified first records of seven long horned beetle species affecting forest plantations in Vietnam.

Methodology

Insect pest surveys and sample collections and identification have been implemented since 2004. Research on biological characteristics and insect life cycles were conducted in the Forest Protection Research Division Laboratory, in Hanoi, Vietnam. Information was gathered from published literature for the long horned beetles identified (Gressitt *et al.* 1970).

Results and Discussion

***Long horned beetles associated with* Eucalyptus**

Sarothrocera lowi White (Cerambycidae, Coleoptera) is brown in colour, slightly tinged with ochraceous and is 35 to 50 mm in length. The length of antennae ranges from 1.5 to 2.0 times the length of the body for the male and from 1.2 to 1.3 times the length of the body for the female. The basal joint of the antenna is thick and furnished at the end on the inside with a tuft of hairs; the second joint is very small with one tuft of hair; the third to seventh joints behind are fringed with longish hairs, the hairs on the third and the fourth are very thick. Legs with the femora are compressed; the tibiae are very compressed, slender at the base, getting thicker towards the middle, and then wide at the end, with the sides nearly parallel. Tarsi are very wide with tarsal formula 4:4:4. Hatched larvae eat bark and the second instar larvae bore into the stem and stop eating to pupate from 20 to 30 April. Adults emerge from the end of May to early June. Female adults make ovi-position slots 10 to 12 mm long and 4 to 6 mm deep, each with one egg. *Sarothrocera lowi* is described for the first time in Vietnam. The beetle started damaging stems of 8 years old *Eucalyptus urophylla* plantations in Pleiku, Gia Lai, reducing wood quality and productivity for saw logs.

Aristobia testudo Voet (Cerambycidae, Coleoptera) is large, ranging from 25 to 35 cm long. Adult emerge from June to July. The female beetle chews depressions (ovi-position sites) in the bark of trees to lay eggs. This species damages *Eucalyptus camaldulensis* stems and branches constraining tree growth. This long horned beetle is an important pest for young *Eucalyptus camaldulensis* plantations in the Mekong delta. The beetle has one generation per year, with adults emerging from June to August. The females girdle branches by chewing off 10 mm strips of bark, and the eggs are laid on the wound and covered with exudates. The larvae hatch from late August and live under the bark until January when they bore into the wood and create tunnels up 60 cm long.

Anoplophora davidis Fairmaire (Cerambycidae, Coleoptera) is large, ranging from 28 to 30 cm long; with very long black and white antennae. The body is glossy black with irregular white spots. Adults emerge from late spring to fall depending on the climate. The predominant reproductive cycle is one year, passing the winter most commonly in the larval stage. The female beetle chews depressions (ovi-position sites) in the bark of trees to lay eggs. A single female beetle can lay from 35 to 90 eggs. Hatching takes 10 to 15 days. The larvae feed on living tree tissue during the fall and winter and, after pupating, emerge through exit holes during the spring. The long horned beetle causes big problems on *Salix tetrasperma* planted as ornamental trees in urban areas, on *Melia azedarach* plantations or scattered plantings, and on *Eucalyptus camaldulensis* scattered plantings. Trees associated with this beetle could die out in affected areas due to the very high density of larva causing serious damage.

Long horned beetles associated with Rhizophora apiculata

Trirachys bilobularis Gressitt and Rondon (Cerambycidae, Coleoptera) is black in colour, in part tinged with pitchy brown on antenna and elytrum, more reddish brown on legs. The body is largely clothed with thin silvery to golden buff pubescence, on elytrum lying in different directions giving a changing pattern. Antennae of male are slightly more than twice as long as the body. Hatched larvae eat bark and second instar larvae bore straight into the stem and stop eating to pupate at the end of February. Adults emerge from the end of March to middle of April. Female adults make ovi-position sites 10 to 12 mm long and 4 to 6 mm deep, each with one egg. *Trirachys bilobulatus* damages *Rhizophora apiculata* in over 20 year-old plantations. This species is described for the first time in Vietnam damaging *Rhizophora apiculata.*

Long horned beetles associated with dipterocarps

Celosterna pollinosa sulphurea Heller (Cerambycidae, Coleoptera) is large, ranging from 30 to 50 mm in body length and is sulphurous in color. Adults emerge from May to July depending on the climate. Predominant reproductive cycle is one year. The female chews ovi-position sites in the bark of branches to lay eggs. Hatching is within 25 to 30 days. The larvae feed on living tree tissue making galleries with direction from branches to the base of the tree. *Celosterna pollinosa sulphurea* damages stems of some dipterocarp species including *Anisoptera costata* and *Dipterocarpus alatus* in southeastern Vietnam with very high incidence and severity in both pure and mixed stand. The incidence and severity were highest in the pure stands. Saw log productivity from infected plantations could be reduced.

Long horned beetles associated with **Canacardium occidental**

Rhytidodera simulans White (Cerambycidae, Coleoptera) is large, ranging from 30 to 40 mm in body length and is brown in colour. The elytral apex is truncated with outer angle dentate and inner angle spined. The beetle damages branches of the cashew tree (*Canacardium occidental*) in southeast Vietnam where it is considered to be a serious pest, reducing fruit productivity. This species is described for the first time in Vietnam.

Dorysthenes granulosus Thomson (Cerambycidae, Coleoptera) is black in colour and has a body length of 40 to 50 mm. The beetle damages stems of the cashew tree (*Canacardium occidental*) in southeast Vietnam where it is considered a serious pest, reducing fruit productivity. *Dorysthenes granulosus* is decribed for the first time in Vietnam damaging cashew trees.

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REMOVING NOXIOUS *Eupatorium adenophorum* FOR BEEHIVE BRIQUETTE PRODUCTION IMPROVES FOREST HEALTH IN COMMUNITY FOREST IN NEPAL

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Introduction

Eupatorium adenophorum is popularly known as Banmara (forest killer) or Kalijhar in Nepal. Native to Mexico, it has recently gained worldwide reputation as an ever increasing noxious weed mostly colonizing cultivated lands, cardamom-based agroforestry systems, slash and burn agriculture and natural forest especially within the altitudinal range between 1000-8000 ft. Ever since its arrival, the species has acclimatized, spread and colonized the region as a noxious weed. The ability of the weed to grow luxuriantly in the diverse habitats, most of which being harsh and nutrient-deficient, is worth mentioning. It is therefore speculated that the vigorous growth may be due to the association of species with native symbiotic mycorrhizal fungi thus supplying immobile nutrients *viz*, P, K, Ca, N, Zn and water to the host (Read *et al*. 1976, Cooper & Tinker 1978, Rhodes & Gerdemann 1978, Allen 1982, Kothari *et al*. 1991).

The ameliorated growth of the weed species in P-deficient sites overgrowing other competing native weeds such as *Artemisia* and *Lantana* sp. is attributed in part to high mycorrhizal nature of the species. The exotic weed have an edge over other weeds as it is a vigorous perennial shrub growing in dense clumps and flourishing up to 10 feet tall thus depriving others of available light and space. Gradual depletion of available soil P caused by ever increasing anthropogenic activities in the fragile ecosystems in Nepal may directly or indirectly favour the further spread of this weed.

Eupatorium adenophorum belongs to Compositae family. Introduced to Himalayas about 100 years ago, it is very common and often gregarious over large area of eastern and central Nepal up to elevation of 1800 m. Flower-heads white, up to 8 mm long, usually in dense doomed or flat-topped cluster. The leaves are with coarse acute teeth. It is a shrubby perennial to 1 m or more (Polunin & Stainton 1997)

Community Forest Management in Nepal

The community forestry concept in Nepal is a courageous, innovative and future-oriented approach towards participatory forest management by local people. Community Forestry Programme is widely recognized as one of the most progressive policy examples of devolving control over forest resources to community-based user groups, which has established a viable procedure for handing over the forests to groups of actual users with a legal status as autonomous and corporate institutions with perpetual succession. Gilmour and Fisher (1991) define community forestry in terms of control and management of forest resources by the rural people who use them especially for domestic purposes and as an integral part of their farming systems. Since community forestry constitutes both social and biophysical elements, both are equally important. The *resource* can be managed effectively with a clear understanding of forest management principles and knowledge of natural system. Likewise, the *social* part can be dealt with a clear understanding of a society and their relationships with the resource and institutions associated with it.

The way community forestry approach used to be defined and interpreted in Nepal up until late 70s, suggests that community forestry implies 'community-resource' relations, commonly known as 'indigenous system of forest management' (Fisher 1989), which was widespread in Nepal's hills. During the 1980s and beginning of the 1990s, nevertheless community forestry was further conceptualized and internalized, new policy framework was crafted (HMGN 1988), legal instruments have been in place (HMGN 1995), various processes, methods and tools have been developed, modified, re-modified and experience gained. During this period, community forestry was understood and recognized as government's priority programme, for which the role of forest bureaucracy in the hills changed from policing to facilitating leading to the evolution of community-resource relations towards a triangular interface among community, resource and government bureaucracy.

The present form of Nepal's community forestry is guided by the Forest Act 1993, Forest Regulations 1995, and the Operational Guidelines 1995. These legal instruments have legitimized the concept of Community Forest User Group (CFUG) as an independent, autonomous and self-governing institution responsible to protect, manage and use any patch of national forest with a defined forest boundary. CFUGs are to be formed democratically and registered at the District Forest Office (DFO), with CFUG Constitution, which defines the rights of the users to a particular forest. The forest is handed over to the community once the respective members through a number of consultative meetings and processes prepares the forest operation plan and submits it to the District Forest Officer (DFO) for approval. The successful implementation of the plan depends heavily on the awareness level of the community members and their participation in the process of the preparation of group constitution and the operational plan together with support from various agencies such as DFO, user group federation, NGOs, civil society organizations, local government and concerned stakeholders. By December 2007, the Government of Nepal has handed over 1,225,993 ha of forest land to 14,389 CFUGs with 1.65 million households, or 35% of total population of Nepal (Department of Forest 2007).

Eupatorium in Community Forestry

Eupatorium is of no use to farmers, unpalatable to livestock and nuisance to community forest in Nepal. Managing the weed in Community Forestry has been tough and labour intensive. But one of the CFUGs, the Bishankhu Narayan Community Forest Users Group, in the outskirt of the Kathmandu valley, is harvesting this weed to produce bee-hive briquette.

Bishankhu Narayan Community Forest is a small patch of forest of 13.5 ha. The forest lies at the altitudinal range from 1100–1600 m having slope of 5–40^{o}. In 2003, it was handed over to a community with 44 household with 110 women and 122 men. The main species found in the forest are *Pinus roxburghii* and *Schima wallichii* (CF operation plan of Bishankhu Narayan 2004).

According to forest operation plan of Bishakhu Narayan Community Forest, a total of 2 184 kg year of fuelwood can be harvested from the forest in a year. But the demand is as high as 57 000 kg per year. Being close to the Kathmandu valley and as the supply cannot be met from the forest; most of the users use kerosene or LP gas for cooking.

Beehive Briquette Making

When beehive briquette making was introduced by a local NGO, the Integrated Development Society Nepal, with the support from a GEF Small Grants Programme of United Nations Development Programme, in the Bishankhu Narayan village in late 2005, the members were not interested in involving in such a cumbersome activity, as kerosene and LP gas were easily available in the market. Later during the period with high political insurgency, the Maoist, then insurgent, imposed a ban on petroleum products in the Kathmandu valley. Being outskirt of the valley, the village was also affected. In order to deal with the energy crisis, the users were, in a way, compelled to briquette making using *Eupatorium*.

The beehive briquette making technology is similar to the conventional charcoal making process. The *Eupatorium* is cut or uprooted and dried under the sun. The dried plant is charred in a charring drum or charring pit. The char is then grinded and mixed with clay and water. This mixture is then moulded and compressed in briquette mould having 16–20 holes and later dried under the sun.

In Bishankhu Narayan Community Forest, while initiating the briquette making process, a group of women members were mobilized and divided into three groups. First group collects the *Eupatorium* and dries them under the sun. Second group chars the *Eupatorium*, and the third group grinds it, mixes with clay and water and moulds the beehive briquettes. Since its inception in 2005, approximately 12 tonnes of *Eupatorium* has been extracted from the community forest.

Status of Forest

In late 2006, 3 plots of 9 m^2 each were sampled from where *Eupatorium* was harvested. Table 1 shows the status of forest seedling regeneration.

Table 1. Seedlings germinated after the removal of *Eupatorium*

Sampling Plot	**Area** (m^2)	**Number of seedlings**			
		Pinus	***Alnus***	***Schima***	**Total**
1	9	22	-	38	60
2	9	-	35	34	69
3	9	15	6	-	21
Total	**27**	**37**	**41**	**72**	**150**
Ave	**9**				**50**

Table 1 clearly indicated that an average of 50 seedlings have been germinated from the sample plots of 9 m^2 each, where *Eupatorium* has been removed. The natural regeneration of seedlings in the area, where once the *Eupatorium* was colonized, is a good indicator of forest regeneration and a sign of good forest health. On the other hand, plantation of new seedlings in the forest was not found successful. It was observed that a total of 80 seedlings of *Phyllanthus, Juglans* and *Choerospondias* Sps were planted after removing the *Eupatorium*, but only 12 plants survived.

Dissemination and replication

The briquette making initiated by the women group in Bishankhu Narayan was highlighted in various papers and electronic media. The entire briquette making process was telecasted by Nepal Television whereas the highlights of briquette making endeavor was aired by CNN. Several community forestry users groups from different parts of Nepal have visited the place to acquire first hand information on briquette making in community forestry. A number of the women members have emerged as resource persons and are providing training to various forestry users groups especially in western part of Nepal.

Lessons learned

1. Uprooting of *Eupatorium* has encouraged other seedlings to grow. On the other hand cutting the weed leaving the root stock ensures its continued supply as raw material for briquette production.
2. Fuelwood demand of the forest users is the key factor while initiating briquette making activities. If the community forestry could not fulfill the fuelwood demand of the community, then it is easier to initiate the briquette producing activities.

3. Igniting briquette and extinguishing burning briquette are difficult and thus where fuelwood supply is plenty in community forestry, users tend to use fuelwood rather than briquette.

Conclusion

The unwanted and noxious *Eupatorium* in the forest has turned to be a valuable resource when used in producing briquette. It has not only provided a steady income for community forestry users groups but also supplemented fuelwood demand. Removing colonized *Eupatorium* from the forest has facilitated other local species to regenerate indicating the resurgence of healthy forest.

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ENVIRONMENTAL CONDITIONS AND GALL RUST DISEASE DEVELOPMENT ON *Falcataria moluccana* IN SOUTH EAST ASIA

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Introduction

Gall rust disease of *Falcataria moluccana* (batai, sengon) caused by *Uromycladium tepperianum* (Sacc.) (Rahayu *et al*. 2005) is definitely serious and devastating, damaging and killing seedlings in nurseries and trees in the plantation. The disease has been detected in the South East Asian region, in the Philippines (Braza 1997), Sabah in Malaysia (Lee 2004, Rahayu 2007a) and some islands in Indonesia (Rahayu 2007a). The disease causes the development of chocolate brown, cauliflower-like or whip-like galls on the stem, branch, petiole, shoot and pod. Severely infected *F. moluccana* trees will die prematurely (Old & Cristovao 2003). As the epidemic gall rust disease is polycyclic, the causes of the disease outbreak can therefore only be determined if the conditions at which it occurs are well understood. Different environmental conditions, including climate, topography and forest stand characteristics have to be determined in order to understand the disease occurrence. Abiotic factors such as temperature and moisture, and their interaction, are often the most important factors affecting the length of a disease cycle (Bowen 2003). Hence, altitude, temperature and rainfall also play significant roles in the development of disease epidemics. Most severe gall rust disease occurred at elevations above 900 m above sea level at Sabah Forest Industries (SFI), Sabah (Anonymous 1993), while in East Timor the disease was most severe at elevations of between 700 and 900 m above sea level in the mountains southwest of Dili (Old & Cristovao 2003). In the Philippines, areas of high elevation where the environmental conditions appear conducive for rust development are not considered for planting of *F. moluccana* (Braza 1997). Planting new areas of batai in community forest in Lumajang, East Java, Indonesia, is currently prohibited for at least 2 years, from 2007 to 2009, in order to reduce the source of the gall rust fungus inoculums (Rahayu 2007b). Spores of *U. tepperianum* are confirmed to be spread by wind and are disseminated when separated from the fruit bodies (Old & Cristovao 2003). Thus, the objectives of this study were to evaluate gall rust disease incidence and to ascertain the environmental factors influencing gall rust disease development in Sabah, Malaysia, and in some areas of Java, Indonesia.

Methodology

Gall rust disease was monitored in (1) planted forest in Tawau, Sabah, Malaysia from March 2003 to March 2007, and (2) agroforestry systems (Kediri, Lumajang, Bondowoso and Probolinggo) in East Java, and community forests (Temanggung and Wonosobo) in Central Java from March 2006 to March 2008. Each location was divided into three ranges of altitude: 0–200, 200 – 400, more than 400 m above sea level. Three blocks were randomly set up at each altitude, one near the road, one mid-way in the site and one deep inside the site. Each block was divided into three replicates with three plots per replicate. Each plot was represented by 20 young or mature trees as a unit sample. Gall rust disease status at each location was rated based on the value of gall rust disease incidence (DI), and DI was calculated using the formula:

$$(DI) = (n / N) \times 100\%$$

where n = number of infected trees, and N = total number of trees of each plot.

Based on DI, gall rust disease status was categorized into:

< 10% = rare
10%–25% = occasional
>25%–50% = common
>50%–75% = very common, and
> 75% = widespread.

In order to indicate the dominant local site and meteorological factors related to gall rust disease incidence, local data (age of the tree, altitude, topography, fog condition, forest opening) and meteorological data (number of sunshine hours, wind speed, relative humidity, rainfall, number of rain days, and temperature for Tawau, and relative humidity and temperature only for East and Central Java) were paired to get regression equation, then used for determination of the dominant factor.

Results and Discussion

In the *F. moluccana* plantations in Tawau, Sabah, gall rust disease was very common in 2003, becoming widespread in 2004. Its incidence then drastically decreased, becoming common again up to 2007. The factors which were closely related to reducing gall rust disease in Tawau were clear cutting, opening of the forests and conversion of the batai plantation into oil palm plantations which resulted in reduced relative humidity in the plantations. In contrast, the status of gall rust disease incidence in East Java was common in 2006, thereafter increasing to become very common (in Bondowoso) and widespread (in Kediri, Lumajang and Probolinggo) in 2008 (Figure 1). High relative humidity, closed forest of the agroforestry ecosystem, and heavy fogs during 2006 to 2007, were closely related to gall rust disease incidence, particularly at an elevation more than 400 m above sea level.

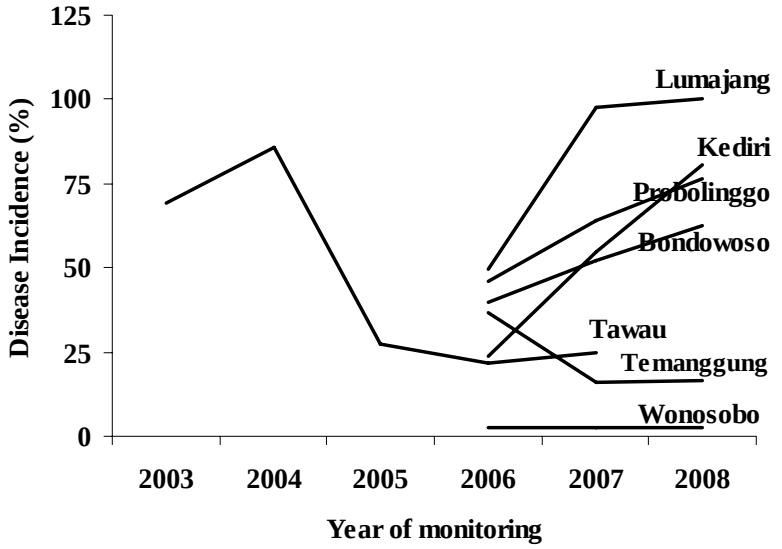

Figure 1. The progress of gall rust disease incidence in Tawau, Sabah, Malaysia, from March 2003 to March 2007; and in East Java (Lumajang, Kediri, Probolinggo, Bondowoso) and Central Java (Temanggung and Wonosobo), from March 2006 to March 2008

Conversely, gall rust disease status in Temanggung, Central Java decreased from common in 2006 to occasional in 2008. Intensive pruning practice thereby opening the forest ecosystem was closely related to reducing gall rust disease incidence. In Wonosobo, the status of gall rust disease was rare and constant from March 2006 to March 2008. However, factors which are closely related with gall rust disease stability have not been investigated yet.

Based on gall rust disease monitoring in Tawau, Malaysia from March 2003 to March 2008, it was found that forest opening, topography and fog were the major factors, while pruning, thinning and clear cutting were intermediate factors, and age of trees and altitude were minor factors. More open forest sites, flat topography, absence of fog, pruning, thinning, clear cutting activities, tree maturity and lower altitude were significant local site conditions that reduced gall rust disease incidence and severity. Relative humidity and wind speed were two meteorological factors significantly related to gall rust disease incidence. High relative humidity and slower wind speed at the site were favourable for gall rust disease development.

Acknowledgements

We thank Yani Japaruddin and M. Hatta (Sabah Softwoods Bhd., Brumas, Tawau, Sabah); R. Himawan Rahardjo (PT Dharma Satya Nusantara, Indonesia); F. Hartono Wijoyo (PT Bioforest, Indonesia), Heru Judianto (PT Kutai Timber, Indonesia), for their cooperation and technical support.

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UNDERSTOREY BIRD SPECIES AS INDICATORS OF FOREST ECOSYSTEM HEALTH

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Introduction

Most of the birds in Malaysia are highly dependent on the tropical forests for their survival. This means that habitat loss and degradation as a result of logging would be a serious threat to bird species (Zakaria & Nordin 1998). The long-term survival of many forest birds and other wildlife will depend largely upon their ability to persist in the ever increasing human-altered habitats (Zakaria & Francis 2001, Styring & Zakaria 2005).

The increasing need for intensive forest land use has motivated efforts to develop methods of sustainable management. To do that, relevant ecosystem qualities should be defined and measured to allow for monitoring and planning (Euler 1999). However, it is impossible to monitor all taxa in species-rich forest ecosystem. One way to monitor and identify the current status or qualities of an ecosystem is to select specific species as indicators of particular ecosystem conditions. These indicator species can be used as alternative or supplement to technological measuring devices.

There are several reasons why birds can act as suitable indicators of ecosystem health. Firstly, birds can be differentiated from other taxonomic groups of organisms with respect to ecological characteristics including habitat preference and dispersal ability. Besides that, they tend to be high in the food chain and thus may be sensitive to many diverse factors affecting the food chain. In addition, birds are one of the best-studied groups of organisms due to the wide public interest in them (Peakall *et al*. 1987). Many studies have been carried out on their ecology, range and behaviour throughout the world, which contributed crucial information in assessment of environmental changes and conservation measures. Their great mobility also allows monitoring over a broad spatial scale (Furness *et al*. 1993).

Therefore, there is a great potential and need to identify species or groups of species that are affected, whether negatively or positively, by logging in turn to provide indication to the forest ecosystem health (Carignan & Villard 2002, Zakaria *et al*. 2005). This would further aid in effective management of forests that are crucial for various human necessities. This paper will examine potential bird species that can be useful as indicators of forest ecosystem health based on preliminary data.

Methodology and Study Sites

Bird survey was carried out using mist-nets at Sungai Lalang Forest Reserve, located in the Selangor State. The study site is classified as a hill dipterocarp forest in which selective timber logging had been practised since the early 1970s. Three compartments: a primary forest (Compartment 24) and two logged forests with 5-year (Compartment 18) and 10-year (Compartment 33) of recovery. All three sites chosen are similar in terms of topography, which is basically undulating and cut by several small streams that form steep gullies. Approximately 90 days of netting were set up in each compartment.

Results and Discussion

The results of mist-netting indicated that a total of 20 families were detected, which were represented by 58 species (280 individuals), 62 species (290 individuals) and 61 species (392 individuals) in the primary, 5-year-old and 10-year-old logged forests, respectively. In general,

the number of understorey species and individuals captured in primary forest were similar to that of the 5-year-old and 10-year-old logged forests. However, the higher in number of birds captured in the 10-year-old logged forest suggested that the establishment of mature secondary growth might provide more food source and thus led to the increase in number of captures.

Table 1 indicated that the total number of species was quite similar in all forest types based on the richness index R1. In terms of species evenness, the distribution of individuals among species was uneven in the 5-year-old (E = 0.54) and 10-year-old logged forest (E = 0.45) compared to primary forest (E = 0.69). Based on Hill's diversity index, the number of abundant (N1) and very abundant species (N2) was higher for the primary forest than that of both logged forests. While the Shannon-Weaver diversity index further indicated that species composition was higher in primary forest (H' = 3.55), followed by that of the 5-year-old logged forest (H' = 3.47) and 10-year-old logged forest (H' = 3.36). This is similar to the results reported by Wong (1985), which indicated that the bird communities overlapped heavily, but the logged forest site had lower species richness and fewer individuals.

The family of Pycnonotidae, Nectariniidae and Timaliidae formed considerable proportion (>50%) of the total species captured in the three sites. Nonetheless, results indicated that the Pycnonotidae and Nectariniidae, which mostly comprised of secondary or colonizing species such as bulbuls and spiderhunters increased in number while the primary forest babbler species of Timaliidae decreased when condition shifted from primary to logged forests. There were several families that were represented by only single species or individual including Meropidae, Pittidae, Ploceidae, Oriolidae and Campephagidae. These groups were either belonged to the migratory species or middle- and upper-storey species, which were not susceptible to capture by mist-net. Another explanation for this might be due to unlikelihood of capturing certain habitat specialists or scarce species that are low in density in the study sites owing to sample size.

As described in Zakaria and Francis (2001), most studies have found some changes in the species composition after logging, with retention of many of the original species and reductions or losses of others. At the same time, secondary or colonizing and edge species often increased. As a result, total diversity or number of species was often similar. In order to understand which species are affected by logging, study with respect to the response of various feeding guilds should also be done.

Following this, all birds captured were further classified according to tropic structures and feeding guilds (Table 2). Results indicated that insectivore guild, which includes sallying insectivore, terrestrial insectivore, foliage-gleaning insectivore and bark-gleaning insectivore, represented the highest number of species captured. This followed by frugivore/insectivore, nectarivore/insectivore/frugivore, carnivore/insectivore and frugivore. More insectivorous species tend to be captured in primary forest compared to logged forest. They represent 46.79% of the total captured in the primary forest against 32.75% and 27.55% in 5-year-old and 10-year-old logged forests respectively. In contrast, more frugivore/ insectivore species were captured in logged forests (31.72% in the 5-year-old and 32.91% in the 10-year-old logged forests) than in primary forest (25.71%).

Further analysis was done in order to identify species that experienced a drastic change in terms of number when forest condition shifted from logged to primary forest (Figure 1). Results indicated that Red-eyed Bulbul (*Pycnonotus brunneus*) and Grey-bellied Bulbul (*Pycnonotus cyaniventris*) had greatly increased in number when primary forests are logged. On the other hand, the number of Moustached Babbler (*Malacopteron magnirostre*) had considerably decreased in logged forest when compared to primary forest. Thus, these species might be suitable indicators of forest conditions due to their sensitivity to habitat disturbance. In relation, the current on-going study on the changing pattern of the two groups, namely Pycnonotidae and Timaliidae have yielded supporting results.

In addition, as highlighted in Table 3, there were few residential species tend to be captured in relatively high number and strictly confined to primary forest, namely the Rufous-tailed Shama (*Trichixos pyrropyga*) and Brown Fulvetta (*Alcippe brunneicauda*). Therefore, these species might also act as indicators of a mature forest. However, further in-depth studies are warranted, for instance with respect to their demography aspects.

From the findings, it seems that most species known from the primary forest are also recorded in the logged forests, although the total number of species in the primary forest remains slightly higher. There is also a substantial shift in the relative abundance of species between logged and primary forests. In general, edge or secondary species, many of which are frugivore/insectivore and nectarivore/insectivore guilds, had increased in number while interior forest species, in particular insectivore decreased in logged forests. The differences in terms of species and guilds may also implies that even after 10-year interval, the logged forest conditions had yet to reach that of primary forests within which most bird community is found. Nonetheless, the slight increase in abundance of some babblers may reflect the reestablishment of a shaded understorey habitat (Zakaria & Francis 2001). Although in cases where selective logging of large timber trees has been practised, severe damages remain to the forest ecosystem. The non-timber species particularly fruit trees were damaged and destroyed. This would reduce the food sources for many frugivorous birds (Zakaria *et al.* 2002). Thus, regeneration may be delayed in the logged forest due to the decrease of frugivores and dispersal of seeds (Zakaria & Francis 2001).

This implies that the sensitivity of birds to the changes in the forest conditions that they depend on may provide direct indication to the health of the forest ecosystem. In other words, the effectiveness at conserving the birds will also indicate the success in safeguarding ecosystem functions and biodiversity as a whole. As such, it means that the maintenance of the key components of biodiversity such as avifauna with respect to their significant ecological roles may be an option that aids in the sustainable management and the long-term productivity of forests.

The study suggested that the condition of a forest may be reflected by the presence or absence of certain forest-dependent bird species. However, it is still in its infancy of using understorey birds as indicators of forest ecosystem health. Further studies would need to be concentrated on factors or habitat requirements that influence the existence of a species in certain forest conditions as well as their changing patterns over time. In extension of the current study, the survey of canopy birds through direct observation may act as a complement to the data available in providing a more complete understanding of the underlying relations. It should be stressed here that the results must be treated with caution. The rare or elusive species that are sensitive to logging might not be captured or represented in this study. Furthermore this study had limited replications and sampling variations, which may not have covered all possible relations existed within the three study sites.

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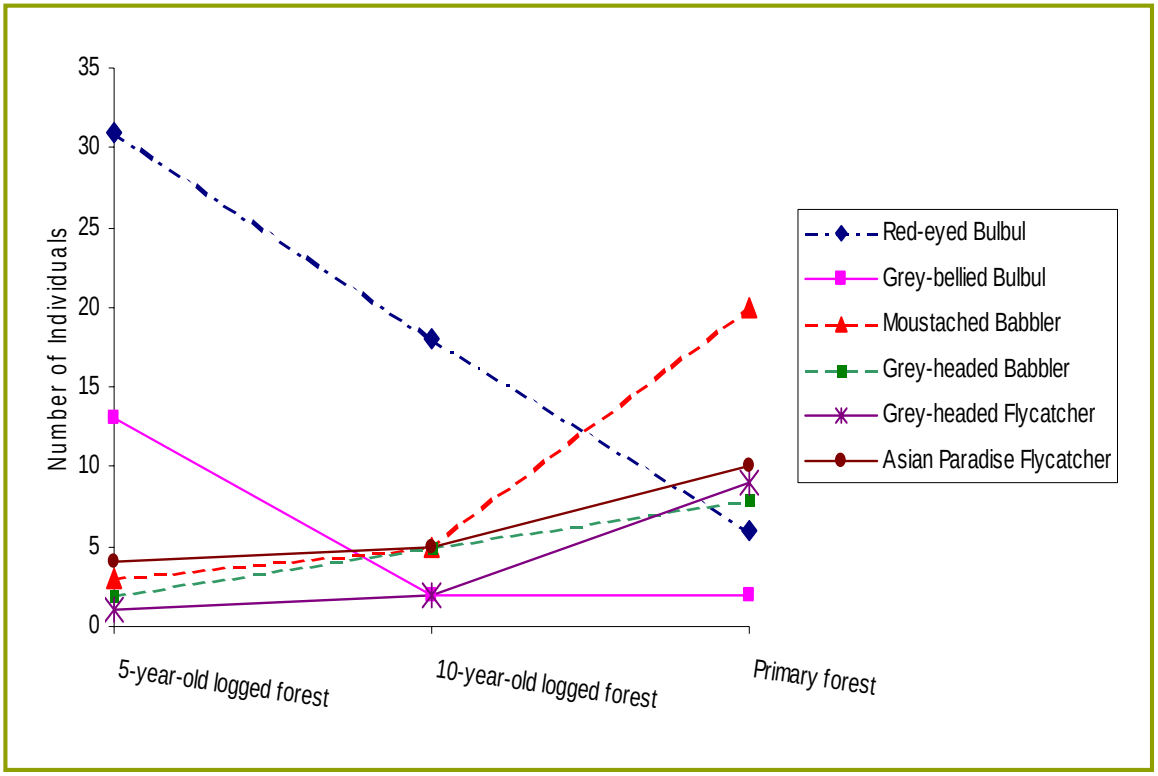

Figure 1. Trend in population size of selected species in different types of forest

Table 1. Diversity indices of bird species in primary, 5-year-old and 10-year-old logged forests

Indices	5-year-old logged forest (Compartment 18)	10-year-old logged forest (Compartment 33)	Primary forest (VJR)
Species richness			
N0	62	61	58
R1	10.75	10.07	10.17
Species diversity			
H'	3.47	3.36	3.55
N1	32.11	28.66	34.66
N2	17.92	13.48	24.12
Species evenness			
E	0.54	0.45	0.69

Notes: N0 = Total number of species; R1 = Margalef richness index; H' = Hill's index; N1 = Measures the number of abundant species present; N2 = Measures the number of very abundant species; E = Evenness index

Table 2. Feeding guilds of birds captured in primary and logged forests

Guild/Species	Number of Birds		
	Compt VJR	Compt 18	Comp 33
CARNIVORE			
(fish, vertebrates)			
Kingfisher	16	7	17
Owl	2	6	6
Shrikes	5	16	2
Sub-Total	23 (8.21%)	29 (10.00%)	25 (6.38%)
CARNIVORE/INSECTIVORE			
(Arboreal Foliage Gleaning			
Carnivore/Insectivore)			
Cuckoo	3	9	1
Sub-Total	3 (1.07%)	9 (3.10%)	1 (0.26%)
INSECTIVORE			
(Terrestrial Insectivore)			
Babbler	4	7	4
Forktail	2	4	8
Thrush	3	0	0
(Arboreal Foliage Gleaning Insectivore)			
Thrush	0	1	0
Robins	3	8	0
Shama	18	9	14
Babbler	55	21	41
Warbler	1	0	0
(Bark Gleaning Insectivore)			
Woodpecker	13	18	21
(Sallying Insectivore)			
Flycatcher	29	18	16
Drongo	6	9	4
Sub-Total	131 (46.79%)	95 (32.75%)	108 (27.55%)

INSECTIVORE/FRUGIVORE (Arboreal Foliage Gleaning Insectivore/Frugivore)			
Trogon	0	1	1
Broadbill	9	1	7
Fulvetta	5	0	0
Cuckoo-Shrike	0	1	0
Bulbul	53	86	113
(Terrestrial Insectivore/Frugivore)			
Pigeon	3	3	6
Pitta	1	0	0
Munia	1	0	2
Sub-Total	72 (25.71%)	92 (31.72%)	129 (32.91%)
FRUGIVORE (Arboreal Foliage Gleaning Frugivore)			
Broadbill	5	4	7
Bluebird	0	2	0
Sub-Total	5 (1.79%)	6 (2.07%)	7 (1.79%)
NECTARIVORE/INSECTIVORE/ FRUGIVORE			
Sunbird	8	3	3
Spiderhunter	38	56	119
Sub-Total	46 (16.43%)	59 (20.35%)	122 (31.11%)
Total	280 (100%)	290 (100%)	392 (100%)

Table 3. Species recorded only in primary forest

Species	Scientific name	Status	Number of birds
Asian Brown Flycatcher	*Muscicapa dauurica*	M & C	10
Rufous-tailed Shama	*Trichixos pyrropyga*	R & U	8
Brown Fulvetta	*Alcippe brunneicauda*	R & C	5
Bronzed Drongo	*Dicrurus aeneus*	R & C	3
Buff-rumped Woodpecker	*Meiglyptes tristis*	R & U	3
Crow-billed Drongo	*Dicrurus annectans*	M & U	3
Hill Blue Flycatcher	*Cyornis banyumas*	R/M & C	2
Hooded Pitta	*Pitta sordida*	R/M & U	1
Hodgson's Hawk Cuckoo	*Hierococcys fugax*	R/M & C	1
Moustached Hawk Cuckoo	*Hierococcys vagans*	R & C	1
Chestnut-winged Cuckoo	*Clamator coromandus*	M & U	1
Oriental Scops Owl	*Otus sunia*	M & U	1
White-necked Babbler	*Stachyris leucotis*	R & U	1
Japanese Paradise Flycatcher	*Terpsiphone atrocaudata*	M & U	1
Brown-chested Flycatcher	*Rhinomyias brunneata*	M & U	1
Inornate Warbler	*Phylloscopus inornatus*	M & A	1
Banded Woodpecker	*Picus miniaceus*	R & C	1
Hooded Pitta	*Pitta sordida*	R/M & U	1

Note: R = resident; M = passage migrant/ winter visitor; C = common; U = uncommon; A = rare

COOPERATIVE SURVEILLANCE AND MANAGEMENT OF INVASIVE ALIEN SPECIES IN THE PHILIPPINES

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Introduction

The surveillance and management of invasive alien species (IAS) are mandated in various agencies of the Philippine Government. The plant, fisheries and animal IAS are taken cared of by the Bureau of Plant Industry, the Bureau of Animal Industry and the Bureau of Fisheries and Aquatic Resources respectively. These agencies are all under the Department of Agriculture. The forest IAS is the domain of the Department of Environment and Natural Resources, but the Plant Quarantine Service of the Bureau of the Plant Industry is in charge of the incoming forest plants and forest products.

Under the present surveillance system, surveillance and management, particularly on pest and disease, are mostly done by the Bureau of Plant Industry thru the farmer's field school, rice, corn, and high value commercial crops pest surveillance. Bt corn post commercialization monitoring (Cayabyab *et al.* 2007) and coconut pest and disease surveillance

Methodology

The information on invasive alien species (IAS) in the Philippines in this paper was gathered from the field experiences of the authors and from published literatures. The proposed cooperative surveillance and management of invasive alien species (IAS) in the Philippines is the outcome of the continuing partnership between the academe, in this case, the University of the Philippines Los Baños, and various agencies of the government such as the Department of Agriculture and the Department of Environment and Natural Resources.

Results and Discussion

Some of the most recent destructive invasions of IAS in the Philippines that emanated from the agricultural ecosystem are the followings.

The invasion of leaf miners in the late 90's in Cordillera, the highland vegetable and strawberry producing region (Colting *et al.* 2003) (Figure 1). The infestation and movement of the rice black bugs from Palawan to Mindanao then to the Visayas and Luzon (Arguelles 2007) (Figure 2).

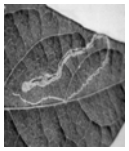

Figure 1. Leaf miner, *Liriomyza* spp., tunnel on legume leaf.

Figure 2. Rice black bug, *Scotinophora* spp.

The Buff mealy bugs (Figure 3) that initially attacked coconuts and palms in Luzon and later the fruit crops and ornamentals (Lit & Lit 2005).

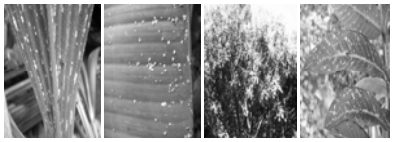

Figure 3. Buff mealy bugs, *Nipaecoccus nipae* (Maskell), on coconut, banana, and mango.

The Eulopid gall wasp of coral trees that started in Luzon (Lit *et al.* 2006) is now spreading to the remaining islands of the country (Figure 4).

Figure 4. Damage pattern on coral trees of *Quadrastichus erythrinae*

The mussel/oyster shell scale of lanzones in Mindanao devastated the crops in 2007 (Figure 5).

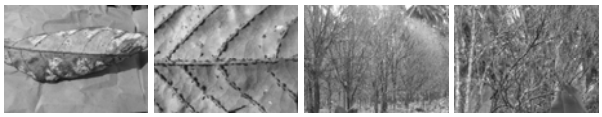

Figure 5. The mussel/oyster shell scale, *Lepidosaphes ulmi* (L.) and damage pattern.

The coconut hispin that was detected earlier in Luzon affects the coconuts, nipa and ornamental palms (Fernandez 2007).

Figure 6. The coconut hispin, *Brontispa longissima* (Gestro)

The current alarming infestations of the new corn plant hopper pest in Mindanao and Luzon (Cayabyab *et al.* 2004, Cayabyab *et al.* 2008) threatens the gain from improved production practices and benefits from biotechnology such as on Bt corn, stacked genes (Bt corn and Round up Ready or Glyphosate resistant corn) RR corn and other hybrids (Figure 7). Most of the time, the presence of the IAS and their effects are detected when they already caused considerable damages.

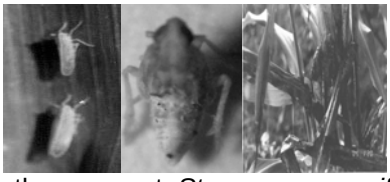

Figure 7. The new corn planthopper pest, *Stenocranus pacificus* Kirkaldy, and damage.

There is a thin line separating the agro ecosystem where most IAS were detected from the forest ecosystem. The impact of IAS from the agro ecosystem into the forest communities is still not known. There are rice fields, cash crops and fruit crops in forest communities that are sources of IAS infestation. The IAS can easily move to other vegetations in the forest thereby affecting the overall forest health. Hence a cooperative surveillance and management programme to combat the menace of IAS is a must.

As mentioned earlier, there is already existing surveillance of pests and diseases where IAS are included under the Department of Agriculture. The BPI together with the UP Los Baños have pioneered the farmer-based pest surveillance via text or short messages sending using mobile phones (Cayabyab *et al*. 2005). This cooperative endeavour can be extended by combining the efforts on the surveillance of plants, animals, and fishes/fisheries products. Stakeholders from the farmers/fisher folks, government agencies, local government units, non-government organizations and the academe will participate. This scheme is feasible due to the Department of Agriculture's rationalization plan. The group will be called the Agricultural IAS Surveillance and Management Team. It will be under the Assistant Secretary for Operations of the Department of Agriculture and with an Advisory Board. This team will address surveillance/monitoring/detection, education, eradication/control, and information management system. The surveillance/monitoring is made up of targeted surveillance, border detection and control, community based surveillance, and diagnostics. The diagnostics will rely on APEC/ASEANET trained systematists and online resources i.e. PESTNET, GISP, etc. Eventually, a harmonized surveillance and management for agriculture and forest IAS will be worked out. Moreover, it is now imperative to conduct targeted surveillance of recent IAS incursions in the agro-ecosystems that eventually move to the forest ecosystem to ensure forest health in the Philippines.

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Acknowledgements

We wish to thank AFPSIN, IUFRO, KFRI, APAFRI, FRIM, and FAO for the invitation and sponsorship to attend this workshop. We also acknowledge with appreciation Ms. Alice G.

Aquino and Mr. Josemari M. Belen for their help in laying out the PowerPoint presentation, and the preparation of the text of this abstract.

FUNGI ASSOCIATED WITH TEAK MORTALITY IN CENTRAL INDIA

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Introduction

Teak (*Tectona grandis* Linn.f.) is grown as one the most valuable timbers in India. The central Indian teak is famous as CP (central provinces) teak in India and neighbouring countries. Teak mortality is not a new problem in central India, it was reported in Maharashtra during 1976 and in Madhya Pradesh in 1972 with no associated pathogen (Bakshi *et al*. 1972). During the last few years this tree again faces a lot of health problems. During this period more than 4000 teak trees were found either completely dead or 50% dead from the top in Bortalab and Khairagarh forest areas of Chhattisgarh, and the same situation was also noticed at Dharani in West Melghat Forest Division, Maharashtra. It was observed that most of the trees with top dying effect and high mortality are of coppice origin. The site is sloppy and roots were exposed due to soil erosion. Many specimens of fungi associated with died and partially died trees of teak were collected from these sites. These fungi colonize different parts of the tree. One fungus was identified as a new species, *Nitschkia tectonae* R.K.Verma, colonizes in between bark and sap wood and produced black rounded spots on the stem below bark and on the bark from inner side. The present paper reports 36 fungi associated with dying of teak with a brief description and their possible role in teak mortality.

Methodology

The specimens were collected from teak forests of Madhya Pradesh, Chhattisgarh and Maharashtra States. The collected and dried specimens were disinfected by spraying of FAA and insecticide (0.1% imiprothrin + 0.15% cyphenothrin) w/w aerosol and stored in airtight polyethylene bags along with naphthalene balls. Details of the symptoms was observed and recorded. Identification of fungi was done with the help of published literature, monographs, books, keys, among others (Bakshi 1972, Dennis 1978, Ellis & Ellis 1985, Müller & von Arx 1973, Verma *et al*. 2008, von Arx 1981). The fungi were classified following the Dictionary of Fungi (Kirk *et al*. 2001).

Results and Discussion

During the last two decades a considerable number of teak trees were found either completely dead or partially dead from the top in Chhattisgarh, Madhya Pradesh and Maharashtra. Trees showed mortality are of coppice origin and planted on sloppy, eroded soil surfaces in general. Main predisposing factors are: fire, grazing and rotation age. Due to these factors, soils become compact leading to suffocation of roots. These weakened plants are thus easily infected by air borne pathogens. The fungi associated with died and partially died teak trees were identified and are listed below:

1. *Acremonium tectonae* R.F. Castañeda, growing as hyper-parasite on rust spores of *Olivea tectonae* on teak leaves and another alternate host of this fungus, *Holarrhena antidysentrica.*
2. *Aplosporella cesati* Sacc., colonizes twigs and branches
3. *Amylosporus campbelli* (Berk.) Ryvarden, causes root rot in plantations
4. *Bagnisiella tectonae* R.C. Rajak, R.C. Gupta, Belap. & A.K. Pandey, colonizes dry bark of branches
5. *Bjerkandera adusta* (Willd.) P. Karst. *=Polyporus adustus* (Willd.) Fr., causing root rot in mature trees
6. *Cephaliophora irregularis* Thaxt., associated with teak seed rot
7. *Cercospora lippiae* Ellis & Everh., causes leaf spotting in nursery and plantations.
8. *Corynespora nana* Meenu & Kamal causes leaf spotting in young plantations.
9. *Daedalea flavida* Lév., colonizes and decomposes dead wood
10. *Diatrype tectonae* M.S. Patil & S.D. Patil, colonizes twigs in plantations
11. *Epicoccum nigrum* Link, colonizes barks of stem, branches and twigs
12. *Flavodon flavus* (Klotzsch) Ryvarden, colonizes dead wood and partially dead stem in standing trees

13. *Ganoderma lucidum* (Curtis) P. Karst., causing root rots in matured trees
14. *Hypoxylon caries* (Schw.) Sacc., *H. rubiginosum* Pers. ex Fr., and *H. rubiginosum* var *tropicum* J.H. Mill., colonize dead stem and twigs
15. *Helicobasidium compactum* Boedijn, its sclerotial stage attacks roots and causes top dying in young plantations and basidial stage colonizes collar region by making a thick mycelial mat (girdle) around the stem
16. *Hexagonia tenius* Speg., associated with branch and stem decay
17. *Hymenochaete fuliginosa* (Pers.) Lév., colonizes dead twigs and branches
18. *Leptosphaeria compressa* (Rehm) L. Holm, causes branch infection
19. *Leptosphaerulina trifolii* (Rostr.) Petr., causes leaf spotting
20. *Monodictys castanea* (Wallr.) S. Hughes, colonizes dead twigs
21. *Moorella* sp., associated with bark of dead trees
22. *Macrophomina phaseolina* (Tassi) Goid., causing root rots in seedlings and young plantations under dry conditions, also causing leaf spots
23. *Nitschikia tectonae* R.K.Verma, is hitherto unpublished new species. The fungus colonizes in between bark and stem.
24. *Olivea tectonae* (T.S. Ramakr. & K. Ramakr.) Thirum., causing leaf rust disease.
25. *Phomopsis tectonae* D.P.Tiwari, R.C. Rajak & Nikhra and *P. variosporum* J.K. Sharma, C.N. Mohanan & Florence, attack leaves, twigs and stem causing top dying in trees including young plantations.
26. *Phoma macrostoma* Mont., causing leaf spots in nurseries and young plantations
27. *Poitrasia circinans* (H. Nagan. & N. Kawak.) P.M. Kirk, colonizes bark of woody roots causing root rot and wilt under water logged situation
28. *Poria rhizomorpha* Bagchee, causing root rot in mature trees
29. *Pyrofomes tricolor* (Murrill) Corner, stem decay in standing trees
30. *Rigidoporus vinctus* (Berk.) Ryvarden, causing root rot in mature trees
31. *Schizophyllum commune* Fr., primary colonizer on dead stem
32. *Trichaptum byssogenum* (Jungh.) Ryvarden, colonizes dead stem and stump
33. *Virgaria nigra* (Link) Nees, colonizes dead bark in standing trees
34. *Uncinula tectonae* E.S. Salmon, causes powdery mildew disease in leaf
35. *Wettsteinina* sp. associated with stem canker in living trees
36. An unidentified synnematous fungus, associated with bark of dead trees

Earlier teak mortality was reported in Maharashtra (Asrali range of south Chanda) and in Madhya Pradesh (Hosangabad), no pathogen was detected and it was co-related with abnormal conditions like drought and fire, during the years preceding the mortality (Bakshi *et al*. 1972). In affected trees, the leader and the side shoots dried from the top downwards and the bark peeled off. The bole was not uniformly dry all around and one face was green and other dry. Roots on the side of the dry face were dry, while they were healthy on the green side of the bole. Eventually the whole tree dried up. The root system dried up last. In most of the cases, where the site is poor in nutrients, root rot pathogens play major role in killing the trees. The dying can also be related to genetic vigour of the trees as in Amravati where trees with top drying have distinct leaf morphology (narrower and darker green as compared to broader and yellowish green in healthy ones). Silvicultural measures including soil bunding, contour trenches followed by application of decayed litter, farm yard manure, sand and low doses of nitrogen, phosphorus and potash, proves effective in minimizing die-back and mortality of teak.

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Acknowledgement

The authors are thankful to Dr. A.K. Mandal, Director of the institute for providing the necessary facilities.

Patterning population dynamics of pine needle gall midge *Thecodiplosis japonensis* (Diptera: Cecidomyiidae) using self-organizing map

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Introduction

To understand the population dynamics of the pine needle gall midge (PNGM), *Thecodiplosis japonensis*, its long-term population density data was analyzed by autocorrelation function (ACF). In this research, population dynamics of PNGM in each survey area were characterized on the basis of ACF and then categorized them using the self organizing map which could then be used to forecast PNGM density in each survey area.

Methodology

Data collection

Long term monitoring data from the database in the *Annual report of monitoring for forest insect pests and diseases in Korea* from 1986 to 2005 was used (KFRI 2005). Korea Forest Research Institute (KFRI) has annually surveyed the occurrence of the PNGM in 93 monitoring areas in Korea since 1980. Among these, data were selected from 67 monitoring areas where surveys were conducted consecutively (Figure 1). In each area, 8 branches each from 5 pine trees in 3 survey sites were sampled in October or November every year, and the percentages of pine needle pairs infested by the PNGM were estimated.

Data analysis

To pattern the population dynamics of the PNGM in each monitoring area, the autocorrelation function (ACF) was estimated. The ACF is a useful method for understanding the long-term time-series data. The estimated ACF provides information on population dynamics on the basis of periodicity and stationary properties. In this study, the population dynamics of the PNGM was characterized based on whether the correlation of the ACF was non-stationary or stationary and non-periodic or periodic. When the correlation of the ACF was stationary, the population dynamics showed a monotonic or oscillatory behavior. Further, when the coefficient of the ACF was non-stationary, it indicated density-independence in the population dynamics. The periodicity of the ACF indicated a regular cycle of population dynamics (Turchin & Taylor 1992). The ACF values in each area were clustered by self-organizing map (SOM).

Results and Discussion

Changes of the PNGM population in 67 monitoring areas were patterned through the learning process of the SOM based on the similarity of their ACF (Figure 1). Overall, clusters reflected geographical differences of the monitoring areas: monitoring areas in cluster 1 were in northwestern and mid eastern areas of Korea, areas in cluster 2 were in southwestern, areas in cluster 3 were mainly in central Korea, areas in cluster 4 were located between clusters 2 and 3, and areas in cluster 5 were scattered along the sea coast of Korea (Figure 1).

The shapes of ACF could be classified according to Turchin and Taylor (1992). The shape of ACF in clusters 1 and 2 were non-stationary without periodicity, or non-stationary or very long cycle. Therefore, the population dynamics in these clusters could be damped oscillation or limit cycle with

very long periodicity. ACF in clusters 3 and 5 were non-stationary without periodicity (Figures 2c and e). Population dynamics of these shapes of ACF showed irregular changes in densities like random walk. Finally, shape of ACF in cluster 4 was stationary suggestive periodicity (Figure 2d). Population dynamics of this shape of ACF showed periodic changes in densities and had periodicity of 8 years.

The different population behavior in each cluster could be explained by several hypotheses: dispersal history of PNGM as invasive species, geographical variation, environmental factors, and interaction with its natural enemies.

On the basis of this research, forecasting in aspect of occurrence timing was possible in areas of cluster 4 and population dynamics in cluster 3 was unstable. This information is useful for decision making in pest management and establishing further monitoring strategies. In addition, further research on potential factors creating differences in population behaviour is useful to understand dispersal process of invasive species.

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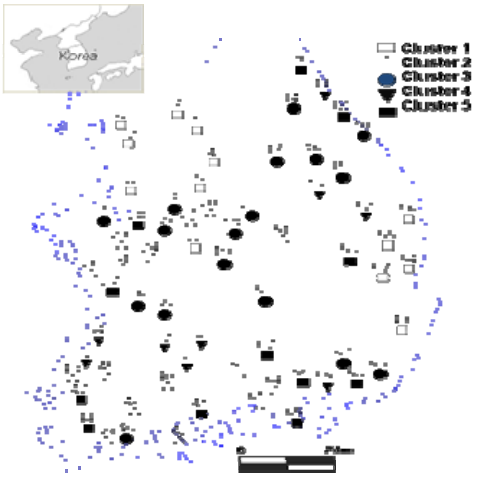

Figure 1. Study areas in Korea. The number in the map indicates the monitoring area for pine needle gall midge. Symbols indicate the different clusters defined by *k*-means cluster analysis on the basis of ACF shape of pine needle gall midge from 1986 to 2005.

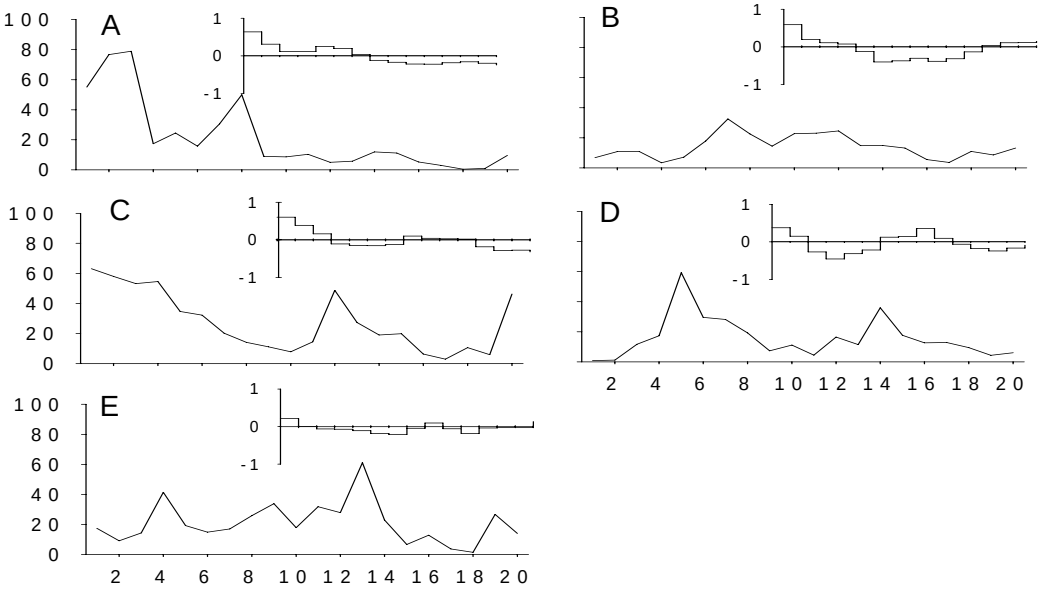

Figure 2. Examples of time series and autocorrelation functions (ACF) for the infestation rates of the pine needle gall midge (PNGM) in selected monitoring areas: (a) Pocheon (7 in Figure 1) in cluster 1, (b) Yesan (29) in cluster 2, (c) Anseong (3) in cluster 3, (c) Sokcho (11) in cluster 4, and (d) Asan (28) in cluster 5.

TROPICAL AMERICAN INVASIVE WEEDS IN SHIWALIK RANGE OF NORTH-WESTERN HIMALAYAS OF INDIA: AN ASSESSMENT OF STATUS AND IMPACT

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Introduction

Invasive Alien Species (IAS) alters the structure and composition of native plant communities, reduce biodiversity and agricultural productivity, and cause huge economic loss (Mack *et al*. 2000; Pimentel *et al*. 2005). In fact, human interference has greatly enhanced biological invasion and globalized the world's biota resulting in biotic homogenization (Drake *et al*. 1989). Invasive species may enter into alien environment either accidentally or are introduced deliberately. However, upon entry into the alien environment, their ecological impact can be far reaching, particularly on the biodiversity. In fact, effect of invasive species on the biodiversity is second only to habitat fragmentation.

Availability of fragmented or disturbed sites provide favourable environment for invasive species. Other attributes of the sites prone to invasion include less species diversity, poor adaptability among native species, absence of natural enemies and predators, and availability of favourable niches for the aliens (Sharma *et al*. 2005). In such sites, the competitive availability of the native species is reduced and hence, the invasive species become predominant. Several hypotheses have been proposed for successful invasion by the exotic species. Heirro and Callaway (2003) proposed the *Natural Enemies hypothesis* (absence of natural enemies like predators, pests, pathogens that cause considerable harm to the species) and *Novel Weapon hypothesis* or *Allelopathy* (through the release of chemicals in the environment that cause detrimental effects on the native flora) for the successful invasion of alien areas by the invasive species and these have been well recognized. Additionally, the invasive species possess a set of biological traits that enable them to rapidly and successfully encroach upon the invaded area. These traits include fast growth rate, greater adaptability, higher reproductive potential, efficient dispersal mechanisms, greater competitive ability, allelopathic property, and phenotypic plasticity (Kohli *et al*. 2004, 2006).

The rate at which invasive species are spreading worldwide demands immediate steps to check their spread and thus reduce species loss. This could, however, be achieved if status and impact of invasive species in the alien environment are known. In other words, there is thus an urgent need to undertake studies on the status of invasive species in the different areas of the world, particularly those which are species rich and vulnerable to invasion. The Himalayas, one of the important mountain ranges, constitute a biodiversity hotspot with rich faunal and floral diversity. However, there is greater human impact on them as a result of which these ecosystems are highly threatened. Kohli *et al*. (2004) pointed out that introduction of invasive plants in these ecosystems have caused a major harm to the biodiversity especially of the endemic species. In this context, a study was planned in the lower regions of Northwestern Indian Himalayas (commonly known as Shiwalik Ranges), which are known for their rich biodiversity, to find out the status and impact of invasive species.

Methodology and Description of the Study Site

The present study was conducted in the Shiwalik Ranges in Himachal Pradesh (northwestern India). The climate of the region ranges from subtropical to temperate. Nearly 66.5% of the state has been recorded as under forest cover (Forest Survey of India 2005).

The study site falls into Una, Kangra, Solan, Hamirpur, and Sirmaur Districts of Himachal Pradesh. A field survey was undertaken during the period 2002-2006 in the study sites to assess the status of invasive exotic species and their impacts on the native communities. The abundance, dominance and important value indices were calculated in the study sites as per Kohli *et al*. (2004).

Results and Discussion

The survey revealed the presence of 52 exotic invasive species in these areas (Dogra 2007) and majority of these were of American origin, followed by Eurasian and European. Among these, five major invasive alien weeds were *Parthenium hysterophorus* L., *Ageratum conyzoides* L., *Eupatorium odoratum* L., *Lantana camara* L. and *Tagetes minuta* L. All these weeds are natives of tropical America and have entered India either accidentally (e.g. *P. hysterophorus*) or introduced purposely (e.g. *L. camara*). During the study, *A. conyzoides* was found to be the most dense and abundant weed followed by *P. hysterophorus*. Among these weeds, though the density of *L. camara* was lesser, yet its dominance (based on basal area) was the maximum (Table 1). The importance value index (IVI) of *A. conyzoides* was found to be the maximum followed closely by *L. camara*. The IVI of *T. minuta* was found to be the least (Table 1). These five weeds that have created havoc in the Northwestern Himalayas are herbaceous except *L. camara,* which is shrubby in nature. *L. camara* belongs to the family Verbenaceae, while the other four weeds belong to the family Asteraceae.

Table 1. Dominance and Importance Value Index (IVI) of the five major invasive weeds found in the Shiwalik Regions of Northwestern Himalayas in India.

Invasive Plant	**Dominance**	**IVI**
Ageratum conyzoides	1.332	19.838
Lantana camara	16.180	17.412
Parthenium hysterophorus	0.547	9.176
Eupatorium odoratum	0.298	0.584
Tagetes minuta	0.248	0.276

Among the major invasive weeds, *A. conyzoides* has created major havoc in the arable land and severely affects the medicinal and aromatic plants in the area. Besides, the weed is also found extensively in the grasslands, forest-grassland ecotones and on available vacant niches. It causes huge loss to crop productivity and fodder availability. The weed is allelopathic in nature and suppresses the growth of other plants (Singh *et al*. 2003, Batish *et al*. 2008). *L. camara*, another tropical American weed with perennial habit, is one of the 100 worst invaders of the world. It has encroached most of the forest lands in the Shiwalik region and has severely disrupted the native plant communities (Kohli *et al*. 2006). *P. hysterophorus* is perhaps the most obnoxious weed found in almost every available habitat in the Shiwaliks. It is a weed of wasteland but is also found in agricultural land, grasslands, forest areas or any vacant land. It is an aggressive colonizer and is known to deplete biodiversity because of its allelopathic effect (Batish *et al*. 2002, Kohli *et al*. 2006). Additionally, the weed is not eaten by the animals as it possesses toxicity.

Tagetes minuta is another weed of family Asteraceae found growing luxuriantly in various disturbed sites such as along roadsides, construction sites and other dry areas in the Shiwalik region. Its fast spread is a cause of concern since it is spreading at the cost of native species. It is an aromatic weed with allelopathic properties.

Eupatorium odoratum is another invasive weed from tropical America that is fast spreading in the Shiwalik regions of Northwestern Himalayas. The study has revealed that this weed is at the early stages of colonization in this region. If suitable management strategies and plans are not devised, then definitely it will assume serious proportions like *L. camara* and other invasive weeds in the region.

From the above discussion, it is very clear that invasive weeds are fast spreading in the Shiwalik region of Northwestern Himalayas and severely disrupted the ecological balance of the area. Thus, immediate steps are required to check their further spread in order to preserve native plant species in this ecologically distinct and biodiversity rich region.

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MANAGING *Lantana camara* AND RESTORING NATIVE BIOLOGICAL DIVERSITY IN THE WESTERN GHATS, INDIA

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Introduction

The Western Ghats is one of the three biodiversity hotspots in India. It harbours more than 25% of the country's plant species as well as an extremely high richness of wildlife. Notwithstanding this apparent richness, numerous factors threaten the conservation of the unique biodiversity of the Western Ghats. One of the threats comes from the alien invasive species that have successfully encroached into the native ecosystems of the Western Ghats, displacing on their way, scores of plants and jeopardizing the native habitats of the wildlife. The most wide spread invasive species is *Lantana camara* (Verbenanceae). With the aim of addressing the issue of managing *Lantana* and restoring native biological diversity along with enhancing livelihood of the communities dependent on these resources, a unique programme was developed and implemented in some parts of the Western Ghats.

Managing *Lantana camara*

Management of *Lantana* has been a challenging issue, both in the agricultural and forested landscapes. In India, quite often there have been *ad-hoc* attempts in clearing *Lantana* along road sides, manually or by machines. However, since most of the roots are deeply lodged in the soil, these efforts have mostly served to provide only temporary relief and therefore have not contributed significantly to lowering the weed biomass.

Several methods, such as chemical, mechanical, fire and biological, have been used to control the *Lantana* invasion, but with limited success (see review in Day *et al*. 2003). Fire is one of the cheapest methods for controlling *Lantana* and is often used in grazing areas. However mature *Lantana* is fire tolerant and re-growth from seeds and basal shoots is common. Extensive efforts have been made to find effective biocontrol agents for *Lantana camara* (Perkins & Swezey 1924, Greathead 1968, Harley 1973, Cilliers 1983, Neser & Cilliers 1989). Unfortunately most of these attempts have been unsuccessful in India and elsewhere in the world (Julien & Griffiths 1998).

Background of the study area

Initial observations in the *Periyar* Tiger Reserve, Kerala, the *Bandipur* Tiger Reserve, and *Malai Mahadeshwara (MM)*Hills Reserve Forest, Karnataka showed that these forest areas are infested with *lantana*. In particular *Periyar* Tiger and *Bandipur* are home to a number of wildlife including tigers, elephants, sambar (*Cervus unicolor)*, spotted deer, gaurs (*Bos gaurus)*, various birds, reptiles and amphibians. The *Periyar* Tiger Reserve in Kerala is estimated to have 35 to 40 tigers and about 900 to 1000 elephants. Both of these reserves are very heavily infested by *lantana*. In all these three forest sites, besides displacing the native vegetation, the invasive plants are a hindrance to uninterrupted grazing by the wildlife. Its impenetrable thicket prevents the free movement of animals and their visibility. Park managers have their logistics of movement constrained. All these sites have a sizable number of people dotting the forest fringes and meeting their livelihoods through a sundry of small and odd jobs.

Methodology

Innovative approach

A novel and innovative approach that encourages the use of *lantana* with an aim to a) manage the weed through its use in alleviating rural livelihoods and b) to restore native biological diversity by

passive and active recruitment of native flora. Series of training programmes were conducted on the use of *Lantana* for the forest dwelling communities in and around the wildlife parks, including Tiger Reserves in the Western Ghats. This was aimed at encouraging the local communities to actively engage in restoring native biological diversity in the area from where *Lantana* is used and removed.

Training and capacity building

Efforts have been made to encourage the use of *lantana* by forest fringe communities in three premier forest areas in Western Ghats. The *Periyar* Tiger Reserve, Kerala, the *Bandipur* Tiger Reserve, and *Malai Mahadeshwara(MM)* Hills Reserve Forest Karnataka. Skilled and interested community members from all these three sites were trained in utilizing *lantana* for making a variety of furniture and toys. Training conducted by experienced trainers and the concept of training of trainers who in turn will train others locally was adopted to teach other community members. At each site, an incubation centre was established.

The *lantana* stems are very durable and are generally resistant to insect pests (Joshi 2002). Stems of *Lantana* ranging from 1cm to about 9cm girth are used for making a variety of articles ranging from waste paper baskets to furniture to toys. The stems most suitable for furniture making are those which are long, with less branching and longer internodes. The stems are cut and debarked by a simple boiling technique which was developed locally. Boiling the stems helps in the smooth removal of the bark, as well as in allowing the stems to be bent with as much ease as is done with rattan and bamboo. The stems are generally harvested throughout the year from the peripheral and buffer regions of the three sites. There are about 50 designs of furniture that have been produced from *lantana*.

Results

At these three sites, around 199 women and 57 men have been trained in *lantana* craft. The number of man-days employment of many of these very impoverished people have increased from about 5 months to about 9 months per year, with nearly a three- to five-fold increase in their annual cash incomes. Efforts were made to use the invasive from the peripheral and buffer regions of the sanctuaries and allowing for both the passive and active restoration of native biological diversity. While it is too early to evaluate the pay-offs of the above approach to the mitigating effects it has on the restoration of native biological diversity, it must be mentioned that, directly, the use of *lantana* has lead to its depredation in the local environments and presumably also in reducing the total seed output for future regeneration.

Discussion

Numerous studies have documented the negative effects of the weed on native biological diversity as well as on local livelihoods of people dependent on forest resources. Efforts to manage the weed, through manual, chemical and physical means have completely failed. Clearly, classical approaches to managing such invasives are not tenable and new approach is required to address them. The Forest Department has since then strongly encouraging forest dependent communities in these three sites to collect *lantana*. Utilization of *lantana* has had significant impacts on the ecosystems, allowing regeneration and recruitment of native plant species and mitigating pollinator loss, as well as improved the livelihoods of the people. The stems, when harvested do coppice but do provide a window of time during which period regeneration of at least some native plants could be facilitated. The extraction of the weed could also help in reducing the spread of forest fires, which otherwise are fanned by *lantana* stems. In other words, the use of the weed by local communities has clear ecological and livelihood implications. A better understanding of these impacts can help to adapt a management package to deal with the invasion so that native ecosystem health is restored and livelihoods enhanced in the process.

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INFESTATION STATUS OF THE INVASIVE ERYTHRINA GALL WASP *Quadrastichus erythrinae* KIM (HYMENOPTERA: EULOPHIDAE) ON THE CORAL TREE *Erythrina variegata* IN SANDAKAN, SABAH, MALAYSIA

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Introduction

Erythrina variegata (Fabaceae) is a popular garden and roadside tree in Sandakan as well as in other parts of Malaysia. This nitrogen-fixing ornamental tree has attractive and unique green leaves with broad yellow stripes along the major veins, hence the name 'variegated coral tree'. It is often grown to break the monotony of the greenness of other plants in the park. Known also as 'dedap', the tree sheds its leaves to produce striking orangey-red flowers which are frequently visited by sunbirds to feed on the sweetish-bitter watery honey. This species is native to the coast of India and Malaysia. It is a medium-sized, deciduous tree, that can grow to a height of 10 m. Besides its ornamental value, the bark and leaves are very commonly used in Asian traditional medicines (Wee 2003).

Since November 2005, the coral trees at the Sandakan Library were infested with leaf and shoot galls (Andi S.K., pers. comm.), as though the trees were having chicken pox. The infestation in other parts of Sandakan was prominent between March and May 2006 which eventually led to almost complete defoliation. However, by June 2006, many of the trees have flushed on new leaves.

Methodology

In July 2006, however, it was noticed that a few of the coral trees within the Sandakan Town Municipality have died due to severe gall infestation. More alarmingly, the remaining coral trees at the Sandakan Library were critically unhealthy while some were dying. Thus, a survey was conducted in mid July to evaluate the extent of damage on other coral trees in Sandakan. Interestingly, all the 194 surveyed coral trees were infested with the leaf and shoot galls, and the tree health was monitored until the end of 2008.

Results and Discussion

Infestation by the pest

Some samples of the infested shoots and leaves from various places within Sandakan were taken for further investigation. After some laboratory work and thorough literature search via the internet, it was confirmed that the infestation was caused by the Erythrina gall wasp *Quadrastichus erythrinae* Kim (Hymenoptera: Eulophidae). Digital images and species diagnosis matched when the specimens collected were examined and compared with the references procured (Yang *et al.* 2004, Heu *et al.* 2006, ISSG 2006). The mode and symptom of attack were also similar. An expert on parasitic Hymenoptera, Dr John LaSalle of CSIRO, Australia, has kindly verified the species via digital images (pers. comm. via email on 25 July, 2006).

The Erythrina gall wasp measures only about 1.5 mm, which is less than one-quarter the size of a mosquito. It was first described in 2004 as a new species by a Korean scientist (Kim *et al.* 2004) who examined specimens from Singapore, Mauritius and Reunion Islands of the Indian Ocean. Around the same time, it was found in Taiwan, and in the following year it was reported from China, Hawaii, Philippines, India and in late December 2005, from Tutuila Island of the American Samoa in the Pacific. In all these locations, it has caused severe damage to Erythrina species. There was no report from Malaysia, thus this is a new record. Adult females lay eggs inside young leaf and stem tissue. As the larvae feed and develop, they cause abnormal growth of the plant tissue, inducing small nodules

on leaf surfaces and uneven swelling and curling of leaf petioles and terminal stems. Defoliation, stunting, and even tree death may follow. The bark of the dying tree would peel off and produce a rotting smell.

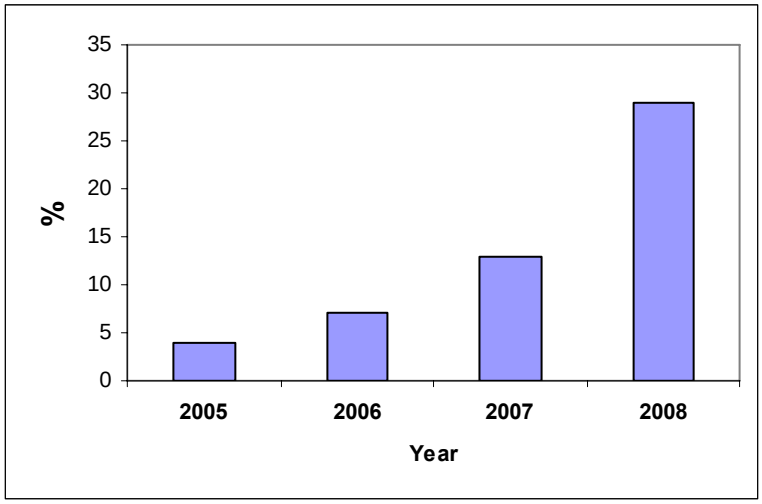

Figure 1. Cumulative mortality of coral trees attacked by the Erythrina gall wasps from 2005 to 2008 in Sandakan, Sabah.

Tree mortality caused by the Erythrina gall wasps is shown in Figure 1. Many of the dead trees were within a radius of 3 km from the town centre. The high incidence of coral tree death within the town area could be due to the high proliferation of the Erythrina gall wasp in an environment relatively non-conducive for many other insects. Thus, not many natural predators could control the wasp. In addition to this, the trees in town are more subjected to heat, pollution and other stresses that weaken the plants. The mortality in 2008 was high because the authorities (parks & schools) decided to fell the unhealthy trees as they were unsightly, and also for safety reasons.

Recommendations for pest management

While integrated pest management (IPM) solutions are preferred, chemical control seems to be the most efficient method against galling insects (Yang *et al.* 2004). A systemic insecticide containing the active ingredient, imidacloprid, may help to reduce damage caused by the wasp (Heu *et al*. 2006), which can be applied through trunk injection. Before application of systemic insecticide, proper pruning and elimination of infested twigs and leaves are helpful for better control.

The most effective long-term solution is still classical biological control using parasitoids from the gall wasp's native region (Yang *et al*. 2004, Heu *et al.* 2006). The Hawaii Department of Agriculture and the University of Hawaii have carried out searches in Tanzania, Africa, where the wasp is believed to have originated. They have found a parasitoid, *Eurytoma erythrinae* (Hymenoptera: Eurytomidae), that could be promising in controlling the pest. This species was only described in 2008 (Gates & Delvare 2008). However, it may take 6-10 years before the agent could be sufficiently tested and approved for release. It must be emphasized that biocontrol remains only a control, not a terminator.

The situation and recommendations for Sandakan

From the survey in Sandakan, chemical control is generally not viable from the economic and environmental standpoint. It is not suitable to be used in public areas, such as school and public library compounds. Some local people also use the leaves for medicinal purposes. For the critically-sick and dying coral trees in town, it is recommended that the trees are removed. The infested areas can be replanted with other robust ornamentals of mixed species but not from the genus *Erythrina*.

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STABILIZATION OF CLIMATE CHANGE IN THE HIMALAYAS

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The mountain communities that inhabit the Himalayan region face an uncertain future in view of the looming threat of climate change. The Himalayas represent a fragile ecology that would be seriously affected by climate change in the decades to come. In addition to adaptation measures, mitigation strategies will also be needed to check warming trends in the Himalayas. As regards the direct implications for the forests in the Himalayan region, mitigation strategies are vital in order to ensure that the forests themselves do not get degraded and destroyed due to climate change. One example is the destruction of thousands of acres of pine forests in Canada due to invasion of the pine beetle. This could hit 25% of the trees in British Columbia and in interior areas, 80% of the trees could be unsalvageable within five to ten years **(**Am Johal 2007**).** The pine beetle was able to spread to these areas due to the increase in temperatures due to climate change. The dead and rotting pine will in turn fuel further global warming.

Specific to the Himalayas, we have evidence of changes in the tree species. In the middle altitudes of the Himalayas, Chir pine (*Pinus roxburghii*) is taking over oak dominated forests. The Himalayan subtropical pine forests are the largest in the Indo-Pacific region. They stretch throughout most of the 3 000 km length of this world's youngest and highest mountain range. Some scientists believe that climate change and human disturbance are causing the lower-elevation oak forests to be gradually degraded and invaded by the drought-resistant Chir pine, the dominant species in these subtropical pine forests **(**Rawat *et al.* 2001**).** Degradation of natural forests due to invasive species and other climate associated factors will in turn further accelerate climate change and rising temperatures, result in further degradation of the forest eco-systems. In this context it is very important to take urgent measures to check the trend of rising temperatures in the Himalayas.

The rivers originating from the Himalayas provide water and food security for over 500 million people in South Asia and South East Asia and for almost 250 million people in China. The rapid glacier retreat and reduced snowfall in the Himalayas will seriously affect the water flow in these rivers. Some of these perennial rivers are likely to become seasonal rivers within the next two decades. They will have water only during the rainy season and will be dry during the summer months. Such an eventuality would be catastrophic not only for the indigenous mountain people but also for the entire region.

The rise in temperatures will adversely affect the biodiversity of the Himalayan region, which is a treasure trove of herbs and plants that are essential for numerous types of preparations in the Allopathic, Ayurvedic, Tibetan and Chinese systems of medicine. The impacts of climate change are going to be more pronounced for the highly sensitive sub-alpine and alpine species like *Saussurea* spp. Analyses of tree-ring samples of *Taxus baccata, Albies pindrow* and *Abies spectabilis* from various forest stands have provided valuable information on the plant growth and climate relationship **(**Pragya Project Report**).** As regards the riverine ecology, the degradation of biodiversity will be felt not only in the Himalayan region, but along the entire course of the rivers and up to the estuaries where they drain out into the oceans. It has been predicted that climate change would impact glacier melt as well as precipitation levels resulting in changes in the river regime, which in turn would impact inhabiting aquatic biodiversity and river dependent livelihoods **(**WWF 2007**).** In the context of invasive species, they could destroy several kinds of medicinal plants in the Himalayas as well as various forms of aquatic life in the Himalayan river systems.

There is sufficient scientific evidence to indicate that the warming trends in the Himalayas are caused not only by the effect of global climate change but also due to the local and regional emissions of certain non-CO_2 gases, black carbon and other aerosols (IGSD/INECE 2008). These local and regional emissions produce phenomenon such as the Asian Brown Haze (G. Carmichael, V.

Ramanathan, 2008). Therefore it will be necessary to cut down drastically on these emissions within the Himalayas and in the contiguous areas adjoining the Himalayan Ranges.

This paper suggests certain practical measures that could substantially cut down on these Regional Emissions in and around the Himalayas. It is important to note that time is a vital factor. International agreements such as the Kyoto Protocol and the Bali Declaration have set 2050 as the deadline for meeting the desired levels of reduction in emissions. However, fragile snow covered mountain eco-regions including the Himalayas may not have that much time.

In view of these facts, the Himalayan Nations namely Bhutan, China, India, Nepal and Pakistan, should come together to formulate and execute a joint strategy for emission reduction of non-CO_2 gases, black carbon and other aerosols in the Himalayan Region by 2020. This could best be achieved by forming an alliance, following the example of the existing Arctic Union **(**Stenlund Peter 2002). The process will need to be facilitated by international organizations such as FAO, UNEP, IUCN, or IUFRO. Funding mechanisms would need to be identified in order to assist the five nations to execute the joint strategy within the given time frame.

The concept of addressing regional and local emissions can also pave the way for a fresh approach to climate change. While carbon dioxide emissions will continue to be addressed at the global level, regional, national and even local governments and other agencies could be encouraged to take steps to reduce non-CO_2 greenhouse gases and aerosol emissions. This will produce immediate benefits in mitigating the local and regional rise in temperatures and will therefore serve to cushion the overall effect of global climate change.

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MAINTENANCE OF TEAK FOREST HEALTH WITH REFERENCE TO VARIOUS BIOTIC AND ABIOTIC COMPONENTS IN CENTRAL INDIA

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Introduction

Teak (*Tectona grandis* Linn.f) yields one of the most beautiful and highly durable tropical timbers of the world. In India, it occurs over nearly 9 million ha of natural forests (moist deciduous and dry deciduous). The major teak forests are in Central India, particularly in Madhya Pradesh including Chhattisgarh and Maharashtra with 23.03% and 17.88% of the total teak forests respectively. The various tactics adopted in teak forest management change the natural ecosystem and thereby, facilitate the incidence of various insects and pathogens. Insect pests and pathogens in forestry species including teak have been well researched by researchers such as Beeson (1941), Khan *et al.,* (1961), Prasad & Jamaluddin (1989) and Tewari (1992). In the present paper an attempt has been made to highlight some biotic and abiotic factors that threaten the teak forest health.

Methodology

Survey was conducted in different compartments in South Forest Division, Chhindwara and Forest Division, Badwaha, Madhya Pradesh, India. Quadrate of size 50 x 50 m was laid out in various affected compartments. Data on the dying off, semi dying off of trees, status of insect pests, diseases and foliar composition of plant samples, from affected and unaffected trees, were recorded. Samples of affected plants and soil were collected and analysed.

Results and Discussion

The detailed information about the status of trees in South Forest Division, Chhindwara and Forest Division, Badwaha; are summarized in Tables 1 and 2. Results revealed that dying trees occurred in all age classes from 21 to 150 cm girth, though the extent of dying was observed to be more in middle age trees, 46 to 60 cm girth, than in very young or very old trees. This indicates that the site is not holding enough water. The top soil is lacking feeder root systems which are very important for enhancing nutrient uptake. The trees are generally not healthy and majority of trees did not produce any fruits and seeds.

The trees started dying from top downwards. Most of the coppice trees exhibited rot symptoms in the heartwood. Such trees are damaged by termites. Trees dying off of in water logged areas are found to be severely infected with the fungus *Diatrype tectonae (*M.S. Patil & S.D.Patil*)*. The root rot fungus *Rigidoporus zonalis* (Murr.) *(Polyporus zonalis* Berk.) is slow growing. Once migrated from infected plants it slowly colonized the root region and exhibited aggressiveness under favourable conditions like extremely water logged situation.

The possible reasons for the dying off of teak in the compartment numbers 1599 and 1601 are the loss of general vigour of the forest due to maintenance as coppice crop for 3–4 rotations and excessive biotic pressure, frost and fire. There is a severe loss of ground cover and compactness of soil. Lack of organic matter, sandy-rocky soil and hard pan with little infiltration are the possible reasons which contribute to dying of trees. Due to water logging and the adverse condition of trees, the uptake of solute reduces result in the top dying which progresses downward and sometimes whole tree become dead.

Insect pests feeding on teak in natural forest areas are summarised in Table 3. The premature leaf fall due to the heavy attack of insect pests i.e. teak defoliator, *Hyblaea puera* (Cram.) and skeletonizer *Eutectona machaeralis* (Walk.) in different compartments not only reduce the timber increment significantly but also affect the phenology of trees. Beeson (1941) very succinctly discussed the role of insect and pathogens in dying off of teak trees.

Table 1. Status of trees in Dry Area at Borgaon Beat, Kanhan Range, South Forest Division, Chhindwara, M.P.

Girth Class	Compartment No. 1599		Compartment No. 1601		Remark
	Semi dying trees	Dying off trees	Semi dying trees	Dying off trees	1. Temp max. 24-48°c, min.10-15°c. 2. RH 60-70% 3. Rainfall 25-63 mm 4. pH 6.6 acidic nature 5. Biotic interference 6. Undulating, sandy loamy soil with hard pan on slopes.
21–30	56	30	16	51	
31–45	1142	430	181	246	
46–60	2652	769	1612	1160	
61–75	1368	307	1640	692	
76–90	430	82	861	269	
91–120	120	33	316	77	
121–150	14	8	35	04	

Table 2. Status of trees in Water Logged Area in Forest Division, Badwaha

Compartment No.	Dying off trees	Girth class (cm)	Remark
111	563	21–70	1. July, 2006 rainfall 288.2 mm. Average rainfall 76.56 mm 2. RH 59.33% 3. Temp max 34.92 C^o &min 20.68 C^o 4. Biotic interference. 5. Feeder root decay, pathogen *Fusarium* & other soil born fungi.
130	492	21–54	
140	29	21–78	
141	53	21–60	

Table 3. Insect pests feeding on teak in natural forest areas

Insect pests	Feed on	Period	Incidence (%)
Defoliator, *Hyblaea puera* Cram.	Leaves	June–August	70–100
Skeletonizer, *Eutectona machaeralis* Walk.	Leaves	July–October	90–100
Termite, *Odontotermes obesus* Ramb.	Stem / Roots	Throughout year	70–80
Bark eating caterpillar *Indarbela quadrinotata* Walk.	Bark	May–June	10–15

Measures of Protection against dying off trees

1. Repeated coppicing should be avoided.
2. Protecting areas from fire and grazing.
3. Soil bunding and contour trenches (as per water harvesting system) using leaf litter, soil, sand, NPK 200 gms, should be applied in the affected areas.
4. Chlorpyriphos 20 EC, 0.05% + Lime + $CuSO_4$ (5:5:50) should be applied against the termite and root rot pathogens.
5. Dead trees from the affected areas should be removed for preventing the spread of pathogens and insects.
6. In water logged areas drainage should be improved to remove the water.
7. Lime, $CuSO_4$ and water (1:1:100) should be drenched after making suitable trenches.
8. The clear felled patches or gaps should be planted with mixed and associated species.
9. During rainy season, fungal fruit bodies should be collected and immediately destroyed.

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Acknowledgements

We are highly indebted to Dr. A. K. Mandal, Director, Tropical Forest Research Institute, Jabalpur, Madhya Pradesh (India) for providing an opportunity to visit the areas. Thanks are also due to Forest Officers and Staff of East Forest Division, Chhindwara and Forest Division, Badwaha, M.P. (India) for providing the necessary field facilities.

THOUGHTS ON FOREST MANAGEMENT UNDER GLOBAL CLIMATE CHANGE

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Climate change is a major global issue that the international community is following very closely, and it concerns the living environment of mankind and the prosperity and development of all countries. Climate change affects almost every aspect of people's life. No country is immune from such an enormous challenge and no country alone can fulfill the daunting task of tackling climate change. International cooperation and collaboration are therefore essential to meet these challenges and contribute to tackling impacts of climate change.

The UNFCCC and Kyoto Protocol have laid the legal basis for international cooperation and also underlined the specific combating mechanisms and measures. Forest has been recognized by international community as a key factor to addressing climate change in international climate negotiation process.

As regard to forest functions, emphasizing forest management under global climate change, with respect to real forest situation in China, it is necessary that the following key points including the relationship between forest and climate change, the status and the potential of forest as carbon sink, and also the ongoing and planned development measures, are discussed.

Relationship between forest and climate change

Forest plays a very important role in the global carbon cycle and the maintenance of the global carbon balance. Forest, in some extent, can become sinks of greenhouse gases (GHG) and that is the reason afforestation and reforestation (A/R) can be qualified as project under CDM in Kyoto Protocol; while in other extent, forest can become a source of GHG emission. It is known that one of the main causes of climate change is deforestation, or unsustainable harvesting. Many severe natural disasters, such as the ice storm in China in January 2008, could be linked to changes in climate and partly show the weakness of forest to address climate change. So in order to fully execute the key role of forest in combating climate change, firstly and mostly is that the forest ecosystem should be healthy. Whereas healthy forest also has strong ability to adapt to climate change.

Status of forest carbon sequestration in China

Since the reform and opening up to the outside world, especial from the 1990s', the Chinese Government recognizing that forestry is a critical factor, had set up six key forestry programmes successively. Remarkable achievements have been made in forestry development since then. The forest area, volume and the forest coverage rate have increased dramatically. It is estimated that from 1980 until 2005, a net total of 4.68 billion tonnes of carbon dioxide is absorbed due to plantation and forest management activities continually carried out by the Chinese Government. During the same period, the emission reduction of CO_2 is about 0.43 billion tonnes with stricter control of deforestation.

Potential of Chinese forests as carbon sinks to mitigate climate change

In general, most of forests in China are still young and of relatively low quality, which means the potential of forest as carbon sink is remarkably high. In order to realize the full potential of these forests as carbon sinks, the State Forest Administration of China, the central government agency in charge of managing forest resources, had formulated five major strategies:

1. Continuously encouraging and facilitating the establishment of plantations to increase forest areas;
2. Continuously improving the quality of forests and increasing the potential of forest s as sinks;
3. Increasing efforts in developing wood-based bio-energy;

4. Strengthening conservation and treatment of water and soil contributing to forest health;
5. Promoting appropriately increased utilization of timber.

Ongoing advancement of forest management under global climate change

At present, China is actively promoting the reform of the forestry system including tenure rights, and the construction of modern forestry. The Chinese Government has attached great importance to efforts to promote forest management as follows:

1. Full implementation of the National Sustainable Forest Management Programme
2. Continue to expand the closing down of mountains to facilitate forest plantations, and to carry out forest rehabilitation scientifically
3. Further improve the prevention and control capacity and capability against plant diseases and insect pests, and also forest fires.

Conclusion

Climate change and forestry development are intertwined. When formulating forestry development strategies and plans, all factors including international forest advancements, the specific domestic socio-economic development requirements, and the needs of ecological services and timber products, should be taken into consideration. Actually, in the process of combating climate change, forest can play an important role through two ways: adaptation and mitigation. The linkage between adaptation and mitigation is healthy forest. So in order to fully execute the key role of forest in combating climate change, it is necessary to accelerate forestry development, in particular, to promote forest management, to increase carbon sink function of forest ecosystem as a whole. At the same time, greater efforts should be taken to further strengthen forest protection, and improve the forest's ability in adapting climate change and contributing to safeguarding the ecological security and ecological balance globally.

ATMOSPHERIC DISTURBANCES DUE TO HEAVY EMISSION FROM THE SPONGE IRON FACTORIES AT RAIGARH, CHHATISGARH, INDIA AND ITS IMPACT ON VEGETATION AND ENVIRONMENT

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Introduction

Sponge iron is the product created when iron ore is reduced to metallic iron usually with coal, at temperature below the melting point of iron in rotary kiln resulting in a spongy mass consisting of a mix of wrought iron and slag. Sponge iron is a recognized alternative to steel scrap as a raw material for the manufacture of various steel products. An immense growth of the sponge iron industry has taken place in India, from a meager capacity of 30 000 tonnes per annum in the year 1980-81, it grew to 7 million tonnes in 2001.

Seventy-two sponge iron factories have been installed at and around Raigarh, Chhatisgarh, India during the last 20 years. A huge amount of SO_2 and NO_x along with CO, CO_2, volatile organic compounds (VOC) and suspended particulate matters (SPM), is emitted into the atmosphere during the extraction of iron from hematite that relies on burning of inferior quality coal (NTPC Publication 2003). SO_2 and NO_x are the primary causes of acid rain. Acid rain causes leaching out of Ca^{++} and Mg^{++} from the root sap into the soil with an exchange of Al^{+++} and Fe^{+++} into the roots, which makes the root sap positively charged causing a fall in its cation exchange capacity. This would in turn cause a sharp decrease in the uptake of nutrient molecules, leading to deficiency and ultimately stunted and deformed growth (Godbold *et al.* 1988, Jackson & Sanderson 1971). The other most dangerous pollutant is SPM (<1mm in diameter), which is supposed to be precipitated by electrostatic precipitators (ESP) of the factories. The SPM gets regularly dispersed by wind from high stag by late night and severely affects the vegetation almost from 500 meter onwards particularly if there is a barrier of hill. The factories are reluctant to use the ESP for its heavy electricity consumption. **R**ecent study was conducted at Raigarh to determine the detrimental effects of severe pollution on the vegetation there.

Methodology

From June 2007 till July 2008 at an interval of 3 months, samples collected for leaf, root and rhizospheric soil of *Cassia siamea*, *Dalbergia sissoo*, *Pongamia pinnata*, *Peltaforum ferruginum*, *Azadirahcta indica*, *Eucalyptus tereticornis*, *Tectona grandis* and *Alstonia scholaris* from least affected (control) as well as from highly affected sites. Some samples were immediately partially fixed to avoid degradation; others were carefully packed and brought for further analysis. Pure SPM was collected to carry out pot culture experiments. The physicochemical and biochemical analyses were done following the methods as described by Jackson (1967) and by Sadasivam and Manickam (1996); pH, electrical conductivity (EC), organic carbon (OC), exchangeable cations viz. Ca^{++}, Mg^{++}, Na^{++} and K^{+} of the rhizospheric soil of the said tree species were assayed. Chlorophyll content, total carbohydrate and total ascorbic acid of the leaves were also assayed.

One-year old seedlings of the said tree species were grown in the nursery as pot culture experiments and were nurtured with treatment of simulated acid rain (SAR). Simulation study was done with the application of a mixture of 1N H_2SO_4 and 1N HNO_3 (70:30) [30 ml/seedling/5 kg soil-mix/day]. In another set, seeds of the above-mentioned tree species were sown in soil mix containing 10% SPM with no treatment of acid rain and were allowed to be incubated under normal practices.

Results and Discussion

The trees at the polluted sites at Raigarh, were found to be poorly grown with reduced collar girth, stem and branches deformed, leaves being chlorotic and/or necrotic with black patches. The levels of pH and OC were lower in all the polluted rhizospheric soils when the EC was found to be higher in comparison to the control samples.

Haynes (1980) described the ion exchange properties of roots and ionic interactions within the root apoplasm and their role in ion accumulation by plants. Godbold *et al*. (1988) demonstrated the aluminium toxicity and consequent forest decline. Gobran and Bosatta (1988) formulated the ecological model showing cation depletion rate as a measure of soil sensitivity to acidic deposition. In the present study, the levels of exchangeable Ca^{++} and Mg^{++} were found to be much higher in the rhizospheric soils of the polluted samples (Figure 1), which strongly support the hypothesis that in acidic environment, Ca^{++} and Mg^{++} leach out from the roots in exchange with Fe^{+++} and Al^{+++} from the soil leading to deformed and retarded growth of the trees. Interestingly, except for few species, the seeds never germinated in soil-mix with SPM in nursery. SPM and slag were dumped on roadside vegetation areas. Unlike other byproduct dykes like that of fly ash or aluminium extraction wastes or different mine overburden areas, where at least some herbs or shrubs were found to be growing naturally, no vegetation came up in the sponge iron waste slag dumps and all the tree species died shortly. This indicates that perhaps the dispersion of the SPM from the sponge iron factories would slowly render the areas unfertile turning them into deserted waste lands.

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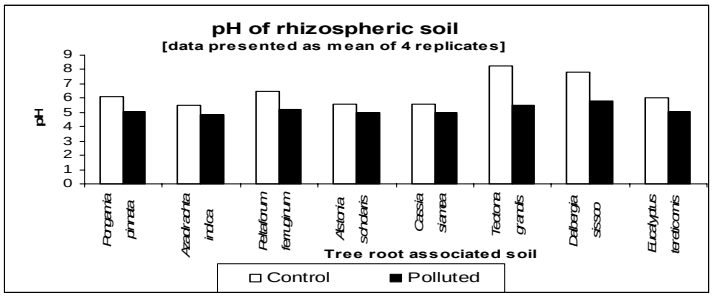

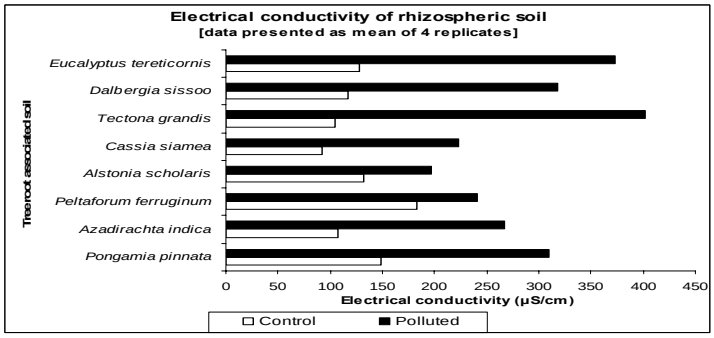

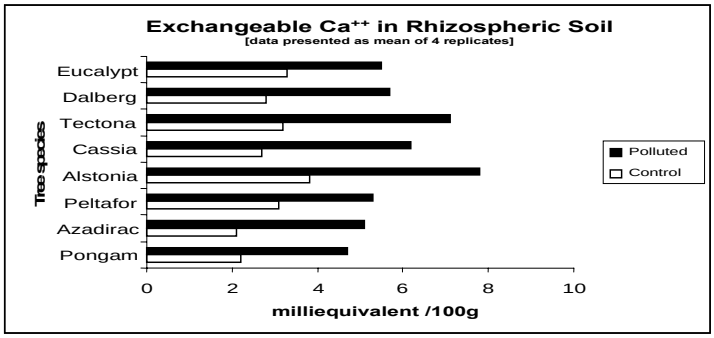

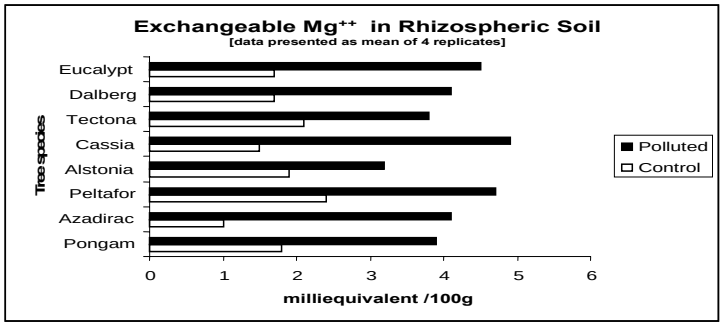

Figure 1. Levels of pH, electrical conductivity and exchangeable Ca^{++} and Mg^{++} in rhizospheric soil.

PEATLAND FIRE IN INDONESIA AS THREAT TO FOREST ECOSYSTEM AND ITS CONTROL EFFORT

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Introduction

Indonesia, with around 21 million ha of peatland, is the country with the world's largest area of tropical peatland. Peatland have an extremely important role to play in the lives of the humans and other creatures. Peatland do not only function as a direct life support system (biodiversity) but also have ecological functions like hydrological control and global climate control. Once they are damaged, peatland areas are difficult to restore.

The total peatland area in the world is about 400 million ha. Ten percent of the world's peatland area, is located in the tropics, of which 60 % is in Southeast Asia with an estimated area of 25 million ha. Indonesia's peatland are found in Sumatra (7.2 million ha), Kalimantan (5.8 million ha), and Papua (8.0 million ha). Peat swamp forest is one of the forest types in Indonesia that grow on peatland, characterized by flat topography, acidic soil, and habitat of important species such as meranti (*Shorea* spp.), jelutung (*Dyera* sp.), rengas (*Gluta renghas*), ramin (*Gonystilus bancanus*), kempas (*Koompasia malaccensis*), geronggang (*Cratoxylon bancanus*), medang (*Dehasia* sp.) and other species.

The main danger that threatening sustainability of peat forest is fire, which might kill all vegetations causing enormous environmental damages, and is difficult to extinguish and produce dense smoke. Fire in peatland is generally started from surface fire and becoming crown fire and ground fire. Ground fire is difficult to detect because it occurs below ground, consuming organic matter and roots of vegetation. Fire occurrence is closely associated with human activities, therefore its control effort should be emphasized on human. This paper describes the characteristics of peatland in Indonesia, the issue of fires in peatland, impact of fire to ecosystem, prevention and control efforts of peatland fire. This knowledge is important for improvement of peatland management towards sustainable forest management.

Methodology

This study has been conducted through literature review and field observations. Some references related to peatland characteristic, its threats, fire issues, impacts of fire, efforts to prevent and control of fires have been collected and reviewed.

Field observations had also been made in Jambi and South Sumatera areas to identify the issues of fire in peatland, and control efforts by the private forest plantation companies.

Results and Discussions

General Conditions and Characteristics of Peatland

Indonesia's peatlands are distributed in swampland, that is land situated at the transition between terrestrial and aquatic ecosystems. This land is almost continuously waterlogged or inundated. In Indonesia, most peatlands are found in lowland swampy plains along the coast. It usually occupies depressions between large rivers near the estuaries, where the rise and fall of the groundwater is influenced by the daily ocean tides. The peat dome and plain usually stretch across a wide basin between large rivers, extending upstream from the coastal plain.

In Indonesia, peat forest occurs on wet climate type of A or B (Schmidt and Fergusson). Generally it is located between swamp forest and rain forest. Peat forest spreads in Sumatera near east coast

and it is a long line from the north to the south along the east coast in the provinces of Riau, Jambi, South Sumatra, and small part in Lampung. In Kalimantan, peat forest is found from northern part of West Kalimantan along the coast to the south, and to the east along the south coast until down stream area of Barito River. There is also peat forest in southern part of Papua.

Peatlands constitute a wetland ecosystem formed from the accumulation of organic matter on the forest floor, originating from the debris of the vegetation above it over a very long period of time (thousands of years). Peatland is *organosol* or *histosol* soil that is always saturated with water or inundated throughout the year, unless it is drained. Like other tropical peat, Indonesia's peat was formed by the accumulation of tropical vegetation residue rich in lignin and cellulose. Due to the slow process of decomposition, heaps of twigs, branches and roots of large plants are often found preserved in the peat, with their structure still relatively clear to see.

Mature peat (sapric type) tends to be finer and more fertile. Conversely, immature peat (fibric type) contains a lot of coarse fiber and is less fertile. Peat possesses rapid horizontal hydraulic conductivity which accelerates the leaching of nutrients into drainage channels. Conversely, its vertical water-conduction capacity (upwards) is extremely slow, with the result that the surface layer of the peat often dries out, even though the layer below is wet. This also impedes the supply of water to the layer where roots are growing. Besides this, peat is also characterized by irreversible desiccation. This means that it will be very difficult for peat that has experienced extreme drought to absorb water again. Following drainage or reclamation, peat will gradually subside. This is caused by the maturing process of the peat and the lack of water. The length and speed of this subsidence depends on the depth of the peat. The thicker the peat, the quicker it will happen and the longer it will continue for. On average, the rate of subsidence is 0.3-0.8 cm/month lasting over a period of 3-7 years following drainage and working of the soil.

Fire Issue

Peatlands tend to be easily combustible due to their high content of organic materials, irreversible desiccation, high porosity, and low vertical hydraulic conductivity. Peatland fires are extremely difficult to put out because they can travel underground. Embers can creep beneath the surface and continue to spread the fire to surrounding areas. Embers in deep peat can usually be extinguished only by heavy rainfall. For this reason, peat fires must be prevented by not burning peatlands, and keeping safe from even tiniest spark of fire from cigarette stubs, especially during the dry season. It is also important to keep peat soil moist by not constructing excessive drainage.

Fire in peatland is usually started from surface fire and travel to under ground burning organic materials and vegetation debris. For ground fire, location of fire is difficult to detect because fire travels underground. Location of fire is usually covered with dense smoke, obstructing view causing pollution and difficult to control.

Fire that burns organic material will form tunnel (especially for young peat) and will form fire crater (especially in mature peat) in the ground. Fire is also fatal to vegetation because it burns root system. Fire movement is relatively slow, and at particular time especially during day time, it can appear in some places, causing new surface fire with relatively faster movement.

All peat fires in Sumatera and on other peat land areas in Indonesia are generally caused by human activities. Fire occurrences are supported by climatic condition such as long drought that causes peatland to dry, because during normal condition peatland is usually wet or inundated by water.

Effect of fire to peatland as hydrologycal regulator

Peat is highly porous and therefore able to soak up huge quantities of water. When saturated, sapiric, haematic and fibric peat respectively can contain water amounting to as much as 450%, 450 – 850%, and more than 850% of the peat's dry weight or up to 90% of its volume. Because of this, peat possesses the capacity to function as a large freshwater reservoir, to the extent that it can prevent flooding in the wet season and release water during the dry season, and prevent intrusion of salt water inland. Fire will reduce peat land capacity as hydrological regulator.

Effect of fire to peatland as habitat for the conservation of biodiversity

Peat is found on only a small part of the earth's surface or about 2.5%. Its limited extent and unique characteristics makes peat a unique habitat for a diversity of flora and fauna. Some of these plants can grow well only on peatland, so if these lands are degraded by fires, the world will lose many species of flora as these cannot grow in other habitats. In Sumatera, more than 300 plant/tree species have been found in peat swamp forest (Giesen W, 1991). Examples of species specific to peatland and have high economic value are jelutung (*Dyera custulata*), ramin (*Gonystylus bancanus*), Meranti (*Shorea spp*), Kempas (*Koompassia malaccensis*), Punak (*Tetramerista glabra*), Perepat (*Combretocarpus royundatus)*, Pulai rawa (*Alstonia pneumatophora)*, Terentang (*Campnosperma spp*), Bungur (*Lagestroemia spesiosa),* and Nyatoh (*Palaquium spp*) (Iwan Tricahyo W, Labueni Siboro, and Suryadiputra, 2004). Sagala (1994) reported species found in peatland of Central Kalimantan with emergent tress include Kempas (*Koompassia* sp), upper layer with meranti (*Shorea* spp), and ramin (*Gonystilus bancanus*). Middle layer dominated by terentang (*Campnosperma* sp), balam (*Dyospiros* sp), nyatoh (*Palaquium* sp), medang (*Litsia* sp), Pelawan (*Tristania* sp) and under layer by jambuan (*Eugenia* spp.). Other tree species found include *Alstonia* sp, Dyera spp, *Durio carinatus*, *Palaquium* spp, *Tristania* spp, *Eugenia* spp, *Cratoxylon* sp, *Diospyros* sp, dan *Myristica* sp. Rare animal species found in this habitat include sinyulong crocodile (*Tomistoma schlegelii)*, sumatran tiger (*Panthera tigris sumatrae)*, sun bear (*Helarctos malayanus*), tapir (*Tapirus indicus*), white winged wood duck (*Cairina scutulata*)*,* and the lesser adjutant (*Leptoptilos javanicus*).

Effect of fire to peatland as global climate safeguard

Climate change is a global phenomenon signaled by changes in temperature and rainfall patterns. The biggest contributor to climate change is the increasing concentrations of 'greenhouse' gases in the atmosphere, such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). These gases absorb long wave radiation, which is hot and will cause the earth's temperature to rise as the quantity of such gases in the atmosphere increases. Peat has a very big Carbon (C) content. According to calculations, the world's peat contains 329-525 Gt or 35% of the world's total C. The peat in Indonesia stores 46 Gt or 8-14% of the carbon present in the world's peat. Thus, peat plays a significant role as a safeguard on global climate. If this peat burns or is degraded, it emits gases (mainly CO_2, N_2O, and CH_4) to the atmosphere ready to cause global climate change.

Peat Fire Prevention and Control Efforts

Almost all peat fires are caused by human activities supported by dry season and availability of fuel. Therefore, fire prevention ad control should be linked with the underlying causes of fires, enhancement of fire fighting capacity, discourage forest conversion and land-use change, encourage community based forest fire management and also a need to engage and integrate multi-stakeholder processes in peatland fire prevention.

On peatlands with concession holders, the companies should have the system of fire control and prevention as obligation according to law. They are not allowed to conduct slash and burn, should make approach to community end equipped the forest areas with early warning system, water management system, tools and equipment as well as standard operating procedures for fire prevention and control. All fires are responsibilities of the company although the fires are caused by human activities.

Concluding Remarks

In relation to peatland fire issue, it is obvious that prevention is better than cure because for peatland ecosystem loss and damages incurred are irreversible. In addition to community involvement, more emphasis needs to be put into the sustainable management of peatlands and the prevention of forest fires, such as through better water management and restoration of degraded peatland areas.

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ECOLOGICAL IMPACT OF INVASIVE WEED *Ageratum conyzoides* ON THE STRUCTURE AND COMPOSITION OF THE NATIVE COMMUNITIES IN NORTHWESTERN HIMALAYAS AND INSIGHT INTO THE MECHANISM OF INVASION

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Introduction

Invasion by the exotic plants in the alien environment significantly disrupts the native plant communities and alters the fundamental structure and functions of ecosystems (Pimentel *et al*. 2001). In fact, the invasion by fast colonizing species puts a severe stress on the native vegetation and is the most serious threat to biodiversity (Mack *et al*. 2000). However, the magnitude of impact varies from place to place depending upon the physico-geographical features, population density, and landscape of the area (Pyšek & Prach 2003). Among the various theories explaining the success of the invasive species in alien environment, the most adopted ones include: lack of natural predators / enemies (Natural Enemies Hypothesis) or release of allelochemicals into the environment, i.e. allelopathy (Novel Weapon Hypothesis) (Bais *et al*. 2003). Additionally, invasive species possess wide ecological amplitude and great ability to change genetically under selection pressure in the alien environment and / or under anthropogenic disturbances (Sakai *et al*. 2001). It is thus pertinent to evaluate the mechanism of invasion in the alien environment, particularly their colonization, establishment, and ecological impact to develop appropriate management strategies.

In India, northwestern Himalayas are a rich repository of plant wealth and home to a variety of medicinal and aromatic plants. Owing to their rich biodiversity, the Himalayas have been recognized as one of the biodiversity hotspots of the world. However, during the last 2-3 decades the native vegetation in this region is severely affected and depleting at an alarming rate. It is largely due to rampant industrialization and urbanization, coupled with climatic changes, mining, and more so, the introduction of fast growing exotic species (Kohli *et al*. 2004). Due to invasion, the native flora and the dependent fauna in this region are under severe threat of depletion (Kohli *et al*. 2004). A recent study has reported that of the 530 species of exotic plants found wild in Himachal Pradesh, ~40% were invasive (Dogra, 2007). Among these, *Ageratum conyzoides* (Billy goat weed; Asteraceae), a native to tropical and Central America, is one of the most abundant species (Kohli *et al*. 2004, Dogra, 2007). It has now invaded various tropical and subtropical parts of Asia including China, Korea, Indonesia, Japan, and India. In India, it has established in the plains of northwestern regions, hilly tracts in the Northwestern Himalayas and invaded the forest understorey where it severely affects the native medicinal and aromatic herbs (Kohli *et al*. 2006). It quickly spreads and forms huge monospecific strands and alters the structure and dynamics of native vegetation. However, no quantitative data is available in this direction. Further, little is known about the exact mechanism of interference / invasion by this weed, though allelopathy has been postulated as one of the mechanism for invasion (Bais *et al*. 2003). It gets further strengthened by the fact that the weed also exhibits allelopathic effects on other plant species and suppress their growth (Batish *et al*. 2008). The present study thus assessed the quantitative (density, biomass etc.) and qualitative (species evenness and diversity) impact of *A. conyzoides* on the native vegetation and explore the possible role of allelopathy (through residues / root exudates) as a mechanism of suppression of plant growth.

Methodology

The present study was done in Shivalik ranges in the hilly state of Himachal Pradesh in northwestern Himalayas, India, with subtropical climate and annual rainfall of 150 to 180 cm. The site was characterized by *Pinus roxburghii* forest, plantations of *Eucalyptus tereticornis*, *Acacia catechu* and *Dalbergia sissoo,* and grasslands under and between them.

Vegetation analysis was done by quadrates method and Margalef's index of richness, Shannon's index of diversity and Simpson's index of dominance were calculated as per Kohli *et al*. (2004).

Evaluation of allelopathy as a mechanism of invasion was undertaken using exudates from roots of *A. conyzoides* and soils amended with residues (5 and 10 g / kg soil) of *A. conyzoides*. *Cassia tora* and *Achyranthes aspera* (two wild growing species in the area of study) were used as bioassay species. The role of allelopathy was further ascertained by using activated charcoal (20 g / kg soil) that has a great affinity for organic phenolic compounds present in soil (Batish *et al*. 2007, 2008). Further, to check whether invasion by *A. conyzoides* results in depletion of soil nutrients, we assessed the invaded soil for nutrient availability. Analysis of the phenolics as putative phytotoxins was done quantitatively (using Folin-ciocalteu reagent) and qualitatively using HPLC (Batish *et al*. 2007, 2008).

Results and Discussion

The density and biomass of the plant species was significantly lowered in the areas infested / invaded by *A. conyzoides* (Table 1). The lognormal distribution of Importance Value Index (IVI) indicated change in the species pattern in the *A. conyzoides* invaded areas compared to non-invaded ones (data not presented). Further, evenness indicating spatial species pattern and Shannon's species diversity index were lesser in the *A. conyzoides* invaded area. In contrast, the index of dominance was higher in *A. conyzoides* infested areas thereby reflecting dominance by a few species and thus homogeneity of the vegetation (Table 1). These results suggest less diverse, poorly distributed and relatively homogeneous vegetation in *A. conyzoides* infested areas.

Table 1. Ecological parameters of vegetation in *A. conyzoides* invaded or non-invaded area.

Parameter	Non-infested area	A. conyzoides infested area
Average number of species/m^2	26.3±3.29	11.8± 1.38*
Plant density (plants/m^2)	212.8±24.18	75.8±7.38*
Biomass (g/m^2)	308.7±21.54	142.7±18.3*
Margalef Index	4.32±0.51	1.98±0.18*
Simpson's Index	0.114±0.08	0.438±0.18*
Shannon's Index or α diversity	2.71±0.32	1.27±0.14*
Index of Evenness	0.84±0.09	0.50±0.04*

* significantly lesser than in non-infested area at P<0.01.

Further, allelopathy was explored as a possible mode of spread of *A. conyzoides*. Root and shoot growth and dry weight accumulation in test plants were severely affected when grown in soil containing root exudates and residues of *A. conyzoides.* Root and shoot growth were reduced in the range of 37 to 61%, whereas biomass was leser by 32 to 49%. However, the addition of activated charcoal partially recuperated (by 24-38%) the negative effects of *A. conyzoides* residues indicating their ameliorating role. Since activated charcoal has great affinity for organic compounds and little for inorganic compounds (Batish *et al*. 2007), it further suggested that the phytotoxins released from *A. conyzoides* are organic biomolecules.

The charcoal addition resulted in only partial removal of *A. conyzoides* negative effects thereby pointing the role of other factors such as nutrient and resource competition / immobilization in inhibitory effects. However, upon analysis the amended soils were not found poor in nutrients; rather, these were enriched with higher levels of organic matter and amounts of available N, P, K, Ca and Mg, and increased electrical conductivity of the soil (data not presented). The soils rich in root exudates and amended with residues of *A. conyzoides* contained significantly higher amounts of phenolics, the known phytotoxins implicated in allelopathy (Mizutani 1999). The *A. conyzoides* amended soil contained nearly 5.5–8.9-times more phenolics compared to control soils. However, the amount of phenolics declined by about 22-38% in the *A. conyzoides* residue amended soils upon addition of charcoal. The direct involvement of phenolics in causing observed growth reductions was further confirmed by their reduced amount vis-à-vis decreased negative effects in amended soils containing amended charcoal. HPLC analyses of the amended and root exudates enriched soils showed the presence of *p*-coumaric, gallic, ferulic, *p*-hydroxybenzoic and anisic acid.

The study concludes that *A. conyzoides* significantly alters the structure and composition of the vegetation in the invaded area and allelopathy plays an important role in negative interference of *A. conyzoides.*

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DEVELOPMENT OF HEALTH ASSESSMENT METHOD IN PROTECTION AND PLANTATION FORESTS

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Introduction

Forest health has attracted international recognition as one of the criteria for achieving sustainable forest management. *Forest Health Monitoring* (FHM) is one of the methods applied to monitor the status, changes and trends of forest health conditions by, among others, using the ecological indicators. A forest is classified as healthy if it is productive, biologically and structurally diverse, large and not fragmented, balance in size-class distribution and resilient to stressors. On the other hand, changes that occur in the forest ecosystem will always create an impact, positive as well as negative ones. This information can be obtained through the implementation of periodic forest ecosystem condition monitoring. Such information will be valuable to the landowners and managers in taking anticipative decisions to improve conditions.

Research activities in FHM have thus far mainly been carried out only on temperate forests. Indonesia is the first country to conduct FHM research in tropical rain forests. The objectives of this study are to develop an integrated assessment method to assess the health conditions of protection and plantation forests based on ecological indicators. The final score of forest health is obtained by combining indicator weights and relative score of each indicator.

Methodology

The sampling plot design used in FHM is called Cluster-Plot Design (Figure 1), adapted from the cluster-plot design described by Alexander & Bernard (1997). The case study established two FHM cluster-plots, in Gunung Gede-Pangrango National Park (GGPNP) and a teak plantation in Central Java. The study shows that four key-indicators could be used to assess the health conditions of protection and plantation forests: forest productivity in term of quality and quantity, forest health and vitality (tree-damage and crown conditions), site quality and biodiversity.

Mensuration provides a record of stand dynamic: growth, mortality and regeneration. Site tree data consists of tree species and local names, tree positions (horizontal distance and azimuth) to the plot center, DBH and DBH-Check. Crown rating quantifies tree vigour by assessing the conditions of each tree crown by evaluating crown diameter (wide and 90°), live crown ratio (LCR), amount of crown dieback, foliage conditions or transparency, and crown density. Tree damage assessment provides a record of visible damages that may affect the ability of a tree to survive. These damages are related to location: root, bole, main crown stem, branches, buds and shoots, and foliage. Damage severity is measured and recorded. Soil quality is a measure of site quality. The organic layers and mineral surface layers are collected, to be analyzed in the laboratory. Cation exchange capacity (CEC) is the important value for assessing soil fertility. All trees growing in the plots were classified into two categories: tree and pole, depending on diameter. All of the trees and poles were identified to the lowest taxonomic level. Based on these data, the species diversity was calculated using Margalef Species Richness Index, Shannon-Wiener Diversity Index and Pielou's Evenness Index J'.

Results and Discussion

Sixty seven trees were found in the GGPNP cluster plot, and 182 trees and 57 trees were found in the young and old tree categories in the teak plantation, respectively. The basal area in GGPNP was higher (0.38 m^2/ha) compare to teak plantation (0.02 m^2/ha and 0.08 m^2/ha).

As crown conditions are influenced by various environmental factors, crown condition reflects the preceding year growth processes. Therefore, crown evaluations that quantitatively assess current tree

conditions is really an integrated measure of site, stand density, and external stresses from the preceding days, months, years or decades (Cline 1995). The average of crown diameter in GGPNP was 1.1 m, and in teak plantation was 0.71–1.04 m. The canopy opening in the GGPNP was 38.64%, while in teak plantation average canopy opening was 55.34%. This means that the crown in GGPNP was still quite dense. Canopy opening is important for seedling and sapling regeneration. Almost all trees in the cluster-plots were damage (85%). Tree damage in teak plantation is mostly open wound and termite mount, while in GGPNP it was liana. Most of the damage occurred was located in the upper root and lower stem. Twenty five species were found in GGPNP and there is no dominance species. High evenness is conventionally equated with high diversity. The high value of species diversity indicated stable ecosystem. Generally, soil health in GGPNP was in good condition and moderate condition in teak plantation. CEC in GGPNP was higher than in teak plantation. As plant grows, available water and nutrients are absorbed from soils so that plant growth development process takes place in a living plant system. Within a given climatic zone, soils significantly determine the nature, productivity and spatial distribution of plant communities.

Among them, protection forest has the highest score for all ecological indicators. Protection forest has basal area of trees (0.38 m^2/year) followed by tree-damage condition (3.29 of 10 maximum), crown condition (3.38 of 10 maximum), site quality (19.63) and biodiversity (0.90), while plantation forest has basal area (0.05 m^2/year) followed by tree-damage condition (2.14 of 10 maximum), crown condition (3.21 of 10 maximum), site quality (17.70) and biodiversity (0.00). Plantation forest and man-made disturbances may decrease the health condition of the forest as found in FHM Cluster-plots in teak plantation, while the stability of forest condition will keep the forest health in stable condition as found in FHM Cluster-plot at Gunung Gede Pangrango National Park. Biodiversity increment indicates the role of biodiversity in forest resiliency to maintain the health of forest. Based on score value from quantification of ecological indicator, among the three sites, GGPNP has the highest score on tree growth, crown condition, CEC, and biodiversity (Table 1).

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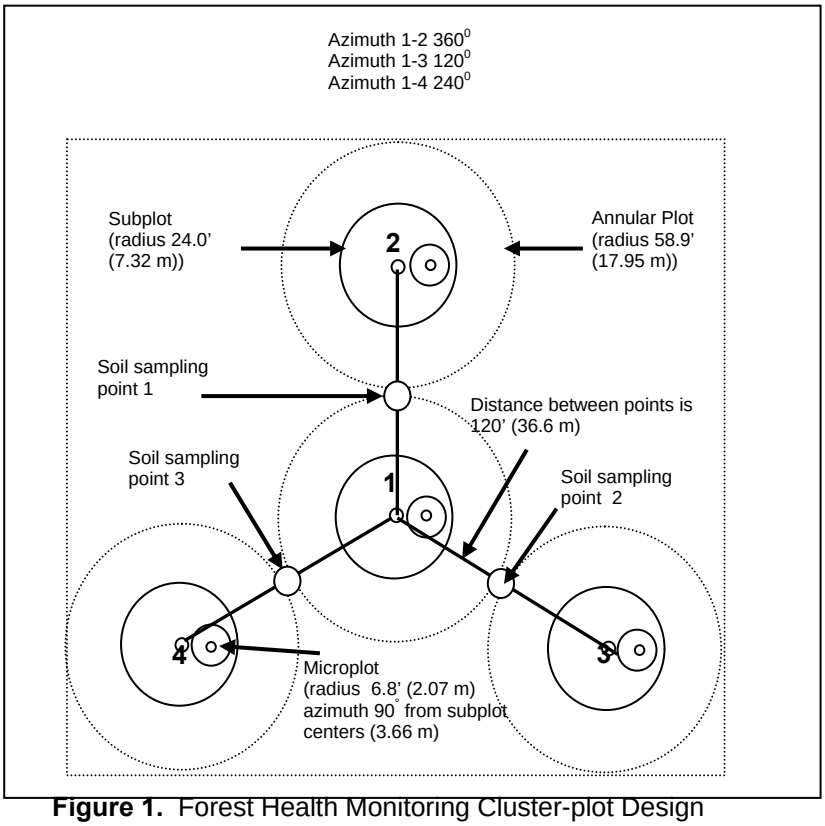

Figure 1. Forest Health Monitoring Cluster-plot Design

Table 1. Score value of forest health ecological indicator

Location/site	Tree growth	Crown condition	Tree damage	CEC	Pielou's J
GGPNP	4	8	8	3	9
Young teak	1	6	9	2	0
Old teak	1	8	8	2	0

Acknowledgements

The authors would like to thank the Ministry of Education, the Ministry of Forestry and Perum Perhutani for their support.

ECONOMIC CONSIDERATIONS TOWARDS FOREST HEALTH: INTERVENTION THROUGH MICROFINANCE AND JOINT FOREST MANAGEMENT

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The diagnosis process for assessing the forest health has to depend on the right recognition of symptoms. In generally only the technical evidences supporting diagnosis would be analyzed or interpreted. However, technical reasons are not the only causes damaging forest health but there could be other reasons too, like excessive harvesting/extraction of non wood forest products (NWFP) beyond advocated for sustainable forest management.

One of the major stakeholders maintaining the forest health is the population dependent on the forest known as forest dwellers, which had remained excluded, if not economically involved with desired returns. For meeting their subsistence, the forest dwellers are forced by circumstances to resort for excessive harvesting/extraction of the NWFPs with no consideration about the consequences on forest health. Forest health is really an issue of contention for all stakeholders including the forest dwellers though they are not aware of it. Hence, it is important to make them aware about the apprehensions of deteriorating forest health and engage their participation in maintaining the forest health. Forest-based economic activities include, in addition to those relating to afforestation for timber trees, promotion of NWFPs and economic gain through value additions.

It has become imperative to provide alternative economic means to the forest dwellers, so that they become inclusively major active actor in protecting the forest health. This step of providing alternative economics means of earning is mainly focused on promoting forest-based small-scale enterprises amongst forest dwellers. Most commonly cited principal constraints in this approach are: requirements of finance and institutional support. The experience from India in this regard can provide some alternatives strategies for protecting the forest health regarding providing institutional and financial inputs.

The Forest Policy of India during 1988 (MoEF 1988), followed by subsequent government resolutions on participatory forest management (MoEF 1990), advocated the people's participation in the management and protection of forests. The policy further mentions that the local people should be motivated to identify opportunities for development and protection of forests from which they can derive the economic benefits. Joint Forest Management (JFM) is a strategy through which the Forest Department and the local people jointly sharing the responsibilities of protecting and managing the forests adjoining to villages and later getting the financial benefits. The local people get a greater access to number of NWFPs, in addition to a share in revenue generated by timber auction. However, this is to be compensated by taking up the responsibility of its protection from fire, grazing and illegal felling.

For managing the good health of forest, multiple products including NWFPs and adding value to them at the local level, are the most important tasks of the JFM programme. Though rights have been given to the forest dwellers to collect the NWFPs, which are not nationalized, it was observed that the continuous shrinking forest areas and deteriorating forest health, leading to declining NWFP production sources. The thirst for maximizing harvesting has prompted the forest dwellers resorted to destructive harvesting practices resulting in threatening the health of natural forests. Hence, one of the basic problems of NWFP collectors is to first address the sustainable livelihood options, which may be possible by dovetailing the concept of microfinance with JFM concept.

The Joint Forest Management Committees (JFMC) are the best suited platforms for forming number of small groups, without affecting the normal JFMC functioning, and can have access to microfinance without physical security traditionally required by banks or other financing mechanisms. Thus the vicious circle of no or low income is being broken. The formation of Community Self Help Groups

(CSHG) amongst the forest dwellers within exiting JFMC and getting the recognition from formal banking sector for extending financial services, based on only social collateral, has been very successful in involving forest dwellers in JFM programmes. The options have been created at local level to increase the share of forest dwellers for produce collected from the forests in the final consumers' payments for such produce. The provision of accessibility to credit for poor forest dwellers has enabled them to adapt value-addition options through adoption of appropriate technologies.

Banks have been given freedom to formulate their own lending norms to give credit to CSHGs, keeping in view the ground realities. They have been asked to devise appropriate loan and saving products and the related terms and conditions including size of the loan, unit cost, maturity period, grace period, margins, etc. Such credit covers not only consumption and production loans for various farm and non-farm activities of the poor but also include their other credit needs such as housing and home improvements.

Amongst the prevailing Bank-CSHG-JFMC linkage models, the model prescribed in Figure 1, is the most successful model in India. In this model, the Forest Department officials or selected NGOs or other Developmental Agencies (DA) act as facilitators. They facilitate the initializing, organizing and nurturing of the CSHGs, and provide training in thrift and credit management. Banks give loans directly to these CSHGs or their clusters/federations.

Joint Forest Management in India with the intervention of the microfinance has been proven to be an acceptable forest management practice which could contribute to eliminating perceived threat to forest health from the forest dwellers. It demonstrates that it is possible to encourage the forest dwellers for setting up small scale NWFP based enterprises with proper institutional support, like formation of CSHGs among JFMC members. Thus, the poor forest dwellers, who were often referred as the largest threat for the forest health due to economic orientation, can be converted from destroyer to protector with appropriate microfinance dovetailing.

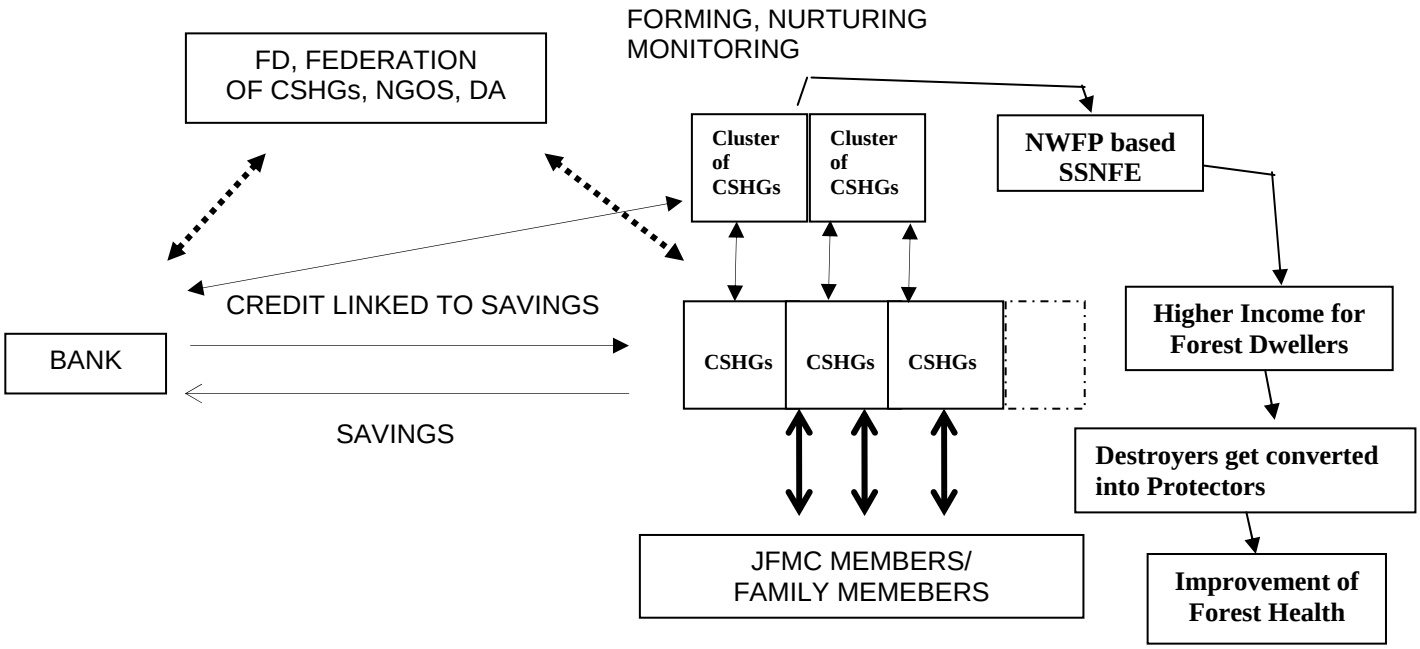

Figure1. CSHG Bank Linkage Model

FOREST HEALTH AND FOREST DISTURBANCE: A CASE FOR SERIOUS CONSIDERATION IN THE MANAGEMENT OF TROPICAL MT. MAKILING

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Introduction

Mt. Makiling is an indigenous forest and a vital natural and water resource in the Philippines continuously providing tangible and intangible environmental benefits to its immediate communities and the greater public in general. It is the living research and training laboratory of the University of the Philippines Los Baños, a biodiversity centre, a geothermal resource, a key ecotourism site of the Philippines, and the water source of industrial, agricultural and residential sector of the CALABARZON region. Mt. Makiling has been battered by typhoons and for the last two years by super-typhoons. These events have adversely affected the ecological state of specific areas in the mountain and the flow of services and products from it. The strong winds and the unusually heavy rains the typhoons brought had caused damage not recorded for the last two decades in the history of Mt. Makiling. Big tracts of land slid from the peaks of the mountain bringing down with it big trees and other living organisms and creating new waterways. Creeks have expanded from about 3m to 30m wide and from 1m to 7m deep. The rampaging water forced boulders and uprooted trees to roll down the mountain slopes which further damaged the area along its path. Mud water from the landslides added to the inundation of the surrounding municipalities/communities.

The changes in the mountain through time after this disturbance were monitored and documented. The data collected from the landslides and landslips in Mt. Makiling provide valuable empirical bases for tropical forest health analysis and management.

Methodology

The ecological state of landslide areas in Mt. Makiling was analyzed from the vegetation that developed in succession within a two year period, from October 2006 to October 2008. The plants were identified and their abundance determined from ocular inspections made. The intensity and scale of the disturbance and the nature of the surrounding landscape were determined and studied as to its effects on the re-vegetation of the area. The “recovery rate” of the area, on the other hand, was evaluated in relation to the forest health of the mountain. Recommendations for management of this tropical mountain were drawn up from the results and observations obtained.

Results and Discussion

The occurrence of several super-typhoons two years ago has ravaged a big portion of Mt. Makiling. These disturbances influenced the internal structure and function of Mt. Makiling particularly its forest reserve area. The landslides that occurred have opened up big areas in the once closed-canopy forest. The destruction of the canopies of trees brought about by the strong wind of super-typhoons has created gaps in Mt. Makiling. This changed the microclimate in the area.

The resilience and health of the forest are evident in the partial, natural rehabilitation of the areas scarred by this earth movement. From an area dominated by boulders and covered with mud and loose gravel and stones two years ago, vegetation has gradually invaded the area (Figure 1), more so in less trodden site. Landslides in closed canopy forest before have recovered faster than those along the creeks. This probably is due to less disruption of the ecological processes, the area being not accessible to people. The landslides around the forest can be viewed now as patches and mosaics of new habitats which according to Meffe *et al.* (1997) is descriptive of a true ecosystem. Plants and other organisms have recovered from the disturbance and manifested adaptation processes suggestive of the health status of the forest as a whole.

Figure 1. Natural rehabilitation of landslide areas in Mt. Makiling

The presence of plants in the vicinity of the landslides contributed significantly to the revegetation of the area. Many of the species that invaded the landslides have been in the area before the disturbance. *Cyathea contaminans, Pityrogramma calomelanos, Selaginella plana, Justicia luzonensis, Saurauia latibractea, Mikania cordata, Ficus nota, Ficus variegata var. sycomoroides,* and *Neonauclea bartlingii* were among the species found in previous rapid biodiversity assessment in the area (Abraham *et al.* 2004). The earlier presence of tree species in landslides in closed canopy forest than landslides near open areas, e.g. along the creeks, came from the surrounding trees which used to dominate the area before the landslides occurred. Unlike in natural ecological succession in open areas where usually "before trees can move in, the area must first be colonized by grasses and shrubs" tree species grew with other shrubs and weed species in landslides in closed canopy portions of Mt. Makiling.

In landslides along the creek, 32 new species were found in October 2008 from those listed in the December 2007 plant survey report. From an area dominated by grasses in early 2007, it now is supporting the growth of many shrub species. The landslides in the interior of the forest are covered with lipang kalabau (*Dendrocnide meyeniana*), wild strawberries (*Rubos rosiafolius*), tuhod-manok (*Justicia luzonensis*), and Dungau (*Astronia williamsii*).

This initial trend seems to lend credence to Connell's (1978) *intermediate disturbance hypothesis* that presupposes that maximum species richness in many systems occurs at an intermediate intensity and frequency of disturbance (Meffe *et al.* 1997). The ecological succession and adaptation processes occurring in the area indicate the health status of the forest as a whole. Within two years of disturbance, Mt. Makiling is recovering well. All these observations point to health status as a fundamental condition, a precondition in fact, to insuring the flexibility, dynamicity and hence sustainability of ecosystems.

Ecosystems dynamics is disturbance driven on many temporal and spatial scales (Meffe *et al.* 1997 p.401). This dynamics is a function of forest health. The capacity to recover from disturbance depends on how robust and healthy the forest is. To insure the fast recovery of Mt. Makiling from the onslaught of the previous super-typhoons, the data and observations generated from this study point to less artificial intervention as more appropriate.

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Acknowledgements

The identification of plants in the landslide areas was done by Dr. Ernesto P. Militante, Professor, and Mr. Dennis Pulan, plant identification specialist of the Department of Forest Biological Sciences, College of Forestry and Natural Resources, University of the Philippines Los Baños. The First Gen Corporation supported the trip and surveys done under the GSW Habitat Care Program.

Appendix I

Acknowledgements

The workshop was an initiative of the International Union of Forest Research Organization (IUFRO) and the Asia-Pacific Forest Invasive Species Network (APFISN). It was organized by the Asia Pacific Association of Forestry Research Institutions (APAFRI) in technical collaboration with the Food and Agriculture Organization of the United Nations (FAO), Forest Research Institute Malaysia (FRIM), and the Korea Forest Research Institute (KFRI).

The KFRI was the sole sponsor of this workshop. Every year KFRI makes significant financial contribution to IUFRO, and a portion of this contribution is allocated to APAFRI for organizing forestry activities in the Asia Pacific region. This is the second workshop that APAFRI had organized utilizing this allocation. In 2007, APAFRI with partners organized an international conference on forest-related traditional knowledge in Kunming, China.

Many individuals had contributed to the success of this workshop. Chris Brown (New Zealand) and Michael Cole (Australia), with their numerous valuable ideas, had assisted in the organizing of this workshop from the very beginning. Lee SuSee (FRIM), Hong LayThong (Bioversity International) and Nik Muhamad Nik Abd Majid (University Putra Malaysia) had assisted in reviewing the abstracts and selection of presenters.

Appendix II

Programme

Day 1 1 December 2008

0800-0900 Registration

0900-1100 *Forest health in a changing world – common but differentiated interests and objectives* Daniel Baskaran
- Asia Pacific Forest Invasive Species Network (APFISN) –*KV Sankaran*
- FAO's Response to Global Forest Health Issues –*Gillian Allard*
- Overview of CABI activities and programmes related to invasive species and plant health –*Soetikno S Sastroutomo*

1100-1130 *Coffee break*

1130-1300 *Forest health in a changing world – common but differentiated interests and objectives* Daniel Baskaran (continued)
- Invasive alien species – a threat to forest biodiversity: actions under the framework of the Convention on Biological Diversity (CBD) –*Junko Shimura*
- An overview of forest health activities in IUFRO –*Lee SuSee*
- Preventing and containing the global spread of invaders – An overview of TNC Invasive Species Programme –*Duan Hui*

1300-1430 *Lunch*

1430-1500 *Regional/sub-regional initiatives and inter-governmental collaborations* Nik Muhamad
- Stock taking in Asia Pacific –*KV Sankaran*
- International collaboration of forest health management in China –*Chen Junqi*
- Plant health services of the Secretariat of the Pacific Community – an overview –*Sada N Lal*

1500-1600 *Capturing synergies – what and how?* Daniel Baskaran

1600-1630 *Coffee break*

1630-1800 *Opening*
- Address by APFISN
- Address by IUFRO
- Address by KFRI
- Address by FAO
- Address by APAFRI
- Official Opening by FRIM

1930-2130 *Official dinner* (Bus leaves hotel at 1900)

Day 2 2 December 2008

0830-1030 *Current forest health practices in Asia and the Pacific* AK Johari
- Village common forests of Chittagong Hill Tracts in Bangladesh: A harbour of forest health and vitality in the degraded landscape –*Khaled Misbahuzzaman*
- Forest health practices in China –*Fan Xibin*
- Fiji's forest health, invasive and quarantine – current strategies and future directions –*Sanjana Lal*
- Forest health management in India: Present scenario and future challenges –*C Mohanan*
- Invasive history of exotic forest insect pests in Korea –*Choi KwangSik*

1030-1100 *Coffee break*

1100-1300 *Current forest health practices in Asia and the Pacific* Gillian Allard
- Health problems of some exotic forest trees and agricultural crops in Myanmar –*Wai Wai Than*
- Protecting forest health in New Zealand –*PM Stevens*
- Building a network-based information system for forest health management: Taiwan experience –*Lin ChauChin*
- An overview of current status of forest invasive species in Timor-Leste –*Pascoal Barros do Carmo*
- New record of longhorned beetles damaging forest plantations in Vietnam –*Pham Quan Thu*

1300-1400 *Lunch*

1400-1600 *Forest health management strategies and activities* Lee SuSee
- Indicator species for assessing the health of tropical forest ecosystem –*Shamsudin Ibrahim*
- Removing noxious *Eupatorium adenophorum* for beehive briquette production improves forest health in community forest in Nepal –*Maneesha Rajbhandari*
- Environmental conditions and gall rust disease development on *Falcataria Moluccana* in the South East Asia –*Sri Rahayu*
- The use of understorey bird species as indicators of tropical forest health –*Mohamed Zakaria Hussin*
- Cooperative surveillance and management of invasive alien species in the Philippines –*Bonifacio F Cayabyab*

1600-1630 Coffee break

1630-1800 *Linkages between forest health and SFM, biological diversity and pest management activities in non-forest sectors* C Mohanan
- Fungi associated with teak mortality in Central India –*RK Verma*
- Patterning population dynamics of pine needle gall midge, *Thecodiplosis japonensis* (*Diptera: Cecidomyiidae*), by using self-organizing map –*Choi WonIl*
- Tropical American invasive weeds in Shiwalik Range of North-Western Himalayas of India: An assessment of status and impact –*Daizy Rani Batish*
- Managing *Lantana camara* and restoring native biological diversity in the Western Ghats, India –*Ramesh Kannan*
- Infestation status of the invasive Erythrina gall wasp *Quadrastichus erythrinae Kim (Hymenoptera: Eulophidae)* on the coral tree *Erythrina variegata* in Sandakan, Sabah, Malaysia –*Arthur YC Chung*

Day 3 3 December 2008

0830-1030 *Linkages between forest health and soil and water, disturbances (biotic and abiotic), and climate change mitigation and adaptation* Choi WonIl
- Stabilization of climate change in the Himalayas –*CP Muthanna*
- Maintenance of teak forest health with reference to various biotic and abiotic components in Central India –*PB Meshram*
- Thoughts on forest management under global climate change –*Zhang Shengdong*
- Atmospheric disturbances due to heavy emission from the sponge iron factories at Raigarh, Chhatisgarh, India and its impact on vegetation and environment –*Rupnarayan Sett*
- Peatland fire in Indonesia as threat to forest ecosystem and its control effort –*Ari Wibowo*

1030-1100 Coffee break

1100-1230 *Legal, institutional and economic frameworks for protection of forest health*
Sim HeokChoh

- Ecological impact of invasive weed *Ageratum conyzoides* on the structure and composition of the native communities in Northwestern Himalayas and insight into the mechanism of invasion –*Harminder Pal Singh*
- Development of health assessment method in protection and plantation forests –*Noor Farikhah Haneda*
- Economic considerations towards forest health: Intervention through microfinance and joint forest management –*BP Pethiya*
- Forest health and forest disturbance: A case for serious consideration in the management of tropical Mt. Makiling –*Portia Gamboa-Lapitan*

1230 *Closing* Sim HeokChoh

Appendix III

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