Asia-Pacific Network for Global Change Research

Collaborative Studies in Tropical Asian Dendrochronology: Addressing Challenges in Climatology and Forest Ecology

Final report for APN project: ARCP2008-03CMY-Baguinon

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UPLB

SESAM

COLLABORATIVE STUDIES IN TROPICAL ASIAN DENDROCHRONOLOGY: ADDRESSING CHALLENGES IN CLIMATOLOGY AND FOREST ECOLOGY

CFNR

FBS

LOGOS OF COLLABORATING INSTITUTIONS

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Project Reference Number: ARCP2008-03CMY-Baguinon

Final Report submitted to APN

Overview of project work and outcomes

Non-technical summary

Dendrochronology was temperate-oriented (Worbes, M. 2004). Asian tropical trees with distinct growth rings should exist as in tropical America (Worbes, M. 1999). If true, then Asian dendrochronology would go beyond pine-teak locations. This inspired the setting of a tree ring laboratory in the Philippines complementing existing ones. Like in tropical America, climatology will be addressed (Villalba, R. et al., 1998) and as in Africa (Worbes, M. et al., 2003) forest ecology too.

Reconnaissance, the finding of tree species with distinct rings, paid off. Of the 400 tree species investigated, 100 have distinct growth rings. More than a thousand corewood samples are filed in xylarias. If these tree species crossmatch and crossdate, the aforementioned vision will be realized. Aiming to show crossmatch and crossdate was barely met because of the huge number of samples against limited manpower resources.

Notwithstanding the aforementioned limitations, tree ring patterns of 5 species from India and the Philippines show evidence of crossmatching (e.g. ring pulses between trees tend to agree). When overlaid with the Southern Oscillation Index, very narrow rings correspond with El Niño events while broad rings reflect La Niña events. A sequel dendrochronology study should answer more questions addressing tropical Asian climatology/forest ecology.

Objectives

The main objectives of the project were:

1. To establish tree ring laboratories in the region.
2. To conduct reconnaissance of indigenous tropical Asian tree species with clear distinct growth rings.
3. To undergo preliminary work to find if tree species with distinct growth rings have relevance to reconstructing past events.
4. To establish and maintain xylaria.

Amount received and number years supported

The Grant awarded to this project was:

US$ 56,000 for Year1 and 2, 2007-2009:

Activity undertaken

Lamont Doherty Earth Observatory (LDEO) of Columbia University, New York trained the principal investigator on dendrochronology for one month (August 2007) and then a new tree ring laboratory was established in the Philippines at the University of the Philippines Los Baños (UPLB), courtesy of LDEO scientist Dr. William E. Wright. The second tree ring laboratory at Peradeniya University (PU), Kandy, Sri Lanka was not pushed through due to the rebellion in that country.

Collaborators have conducted corewood sampling using increment borers in natural forests where the climate has strong seasonal contrast between wet months and dry months. Photodocumentation on trees were conducted after coresampling. Metadata associated with the trees were securely kept digitally in each collaborators' personal computers.

Corewood samples were brought to the laboratory for mounting, surfacing with sanders and scanned to see if wood cross-sections reveal clear distinct growth rings.

Collaborators met in two meetings at the Kasetsart University Faculty of Forestry (KUFF), Bangkok, Thailand on September 8-9, 2007 and another at UPLB, Philippines on December 5-8, 2008. The former was dealt with the discussion on standardization of reconnaissance procedures among collaborating countries. The latter was focused on discussions regarding the form and content of publishable results by collaborators and appropriate formats required by publishers, in addition to procedural discussions regarding crossmatching of trees with distinct rings.

Findings from 2007-2008 were presented in an international scientific conference sponsored by Past Global Changes (PAGES) at Dalat City, Vietnam on February 16-18, 2009. Through the initiative of Dr. Brendan M. Buckley, a collaborative tree ring reconnaissance research was done with Vietnamese hosts at the Bidoup Nui Ba National Park, Vietnam. Results of Vietnamese reconnaissance append erstwhile APN accomplishments.

At present (and to the end of the project) collaborators are busy writing to publish project results. Several technical research proposals other than one submitted to APN have also been submitted to national and international research funding institutions.

Results

Reconnaissance results among the collaborating countries are as follows:

Team Philippines investigated 452 trees spread in 226 indigenous tree species from 54 families of seed plants and, out of this, 898 corewood samples representing indigenous tree species are filed in the new UPLB xylaria. There were **40 species** with distinct growth rings out of 226 tree species while those with indistinct and absent rings numbered, 134 and 52, respectively. There were also 13 exotic tree species (introduced or non-native), 6 of them had clear distinct rings. Initial results from pine and teak ring patterns show evidence of synchrony with El Niño and La Niña events.
Team Malaysia investigated 64 trees from 13 indigenous tree species. A total of 126 corewood samples have been filed in xylaria. All 4 coniferous tree species studied have distinct rings. Of the 9 lowland tree species investigated 2 had distinct rings. Hence, out of 13 tree species 6 registered with distinct growth rings.
Team Thailand found **28 species** with distinct growth rings out of 91 tree species, while 21 and 42 represent tree species with indistinct and absent rings, respectively.
Team Sri Lanka investigated 142 trees spread in 65 tree species from 29 families. A total of 263 corewood samples were filed in xylaria. Team Sri Lanka found **16 species** with distinct rings out of 65 tree species, 34 with indistinct rings and 15 absent rings.
Team India found **12 species** with distinct rings out of 29 total tree species investigated. This team had 257 corewood samples and 28 discs. Being advanced in the science of crossdating, the team emphasized on replicated sampling and drawing chronologies from *Anogeissus latifolia*, *Albizia lebbeck*, and *Dalbergia latifolia*.

It is interesting that the chronologies from Team India and those from ring patterns of Philippine Benguet pine *Pinus kesiya* and of teak *Tectona grandis* in Carranglan, Nueva Ecija agree with the Southern Oscillation Index. This means that the El Niño Southern Oscillation teleconnection can be reflected by crossmatching tree species in spite of the fact that these tree species are widely separated geographically.

Relevance to APN's Science Agenda and objectives

Implication here is that the increase of tree species for dendrochronology will cover greater geographic space. Together with other meteorological data, the spatially expanded tree ring data would increase information detail. This may matter much in the development of a high resolution climate model for the region.

Part of APN's science agenda is the support of researches that improves modeling of tropical Asian climate. Dendrochronological information, together with other proxies like the use of stable isotopes in ice cores and ocean bed cores, can contribute towards this endeavor especially when calibrated with available instrumental data.

The issue on climate change knows no political boundary (Richardson, K. et al., 2009) and the present collaborative effort among participating multinational institutions from the U.S.A., Philippines, Malaysia, Thailand, India and Sri Lanka is in line with APN objectives.

Collaborating with one another, these tree ring laboratories have been engaged to finding new indigenous tree species with distinct growth rings. Ultimately this initial step will lead to the understanding of the variability and dynamics of climate across the Asian tropics. Consequently this will also create an enabling environment that will help monitor tropical forest responses to changes in climate and human-induced disturbances in the entire Asia-Pacific region (UN Secretary General, 2009). Incidentally, the training of young scientists to continue dendrochronology in the region has started under the current APN project. This endeavor is perfectly in line to APN's capability building mission to its constituents.

Self evaluation

More than 100 tree species in the Indomalayan region were found to have distinct growth rings after investigating about 400 tree species. About half of these tree species with distinct growth rings is widely distributed naturally in the region. Given the abnormally rainy climate in year 2008 and uncertain political events in some member countries, researchers identified 106 tree species with distinct rings across the south and southeast Asia (SSEA) region.

Our goal to bring as many tree species with distinct rings to crossmatch and crossdate was rather ambitious one since we accomplished very limited result towards this end. Efforts on crossmatching and crossdating of these species are here only represented by three graphs matching Philippines' (Northern Luzon) *Pinus kesiya* and *Tectona grandis* tree ring patterns with those of *Anogeissus latifolia*, *Dalbergia latifolia* and *Albizia lebbeck* of Western Ghats, India.

To highlight ring pulses with past climate signals, the aforementioned graphs were layered synchronously with the Southern Oscillation Index to behold a match of narrow rings for El Niño events and wide rings for La Niña events. It is worth mentioning here that the Indian graphs were preceded by replication and subsequent statistical analyses.

Because of the large number of species and corewood samples as against available financial and time resources, considerable number of tree species awaits to be crossmatched and crossdated. However, their corewood samples are systematically and securely filed in xylaria for easy retrieval during future crossmatching and crossdating work when new project funds are again available.

Potential for further work

The identification of 106 tree species with distinct rings is a big milestone to the next important research activity, i.e. determine whether or not these tree species crossmatch and crossdate. If they prove to crossmatch and crossdate, then the next work would be to use them as proxy to the reconstruction of climate change in as many points possible in the region. Such increase in dendrochronological data points for climate in the whole tropical Asia Pacific region together with past and current meteorological information would increase the resolution of climate modeling and may open the doorway for greater understanding on the origin, frequency, intensity and magnitude of occurrence of extreme climates and weather. This brings forth the use of science for informed-decision making (e.g. crafting adaptation and mitigation measures to meet human-induced climate change) and put into better context such challenges as disaster readiness against climate and weather extremes.

Publications

The implementors of the present project are still working double time writing country-based results at the same time also writing to publish a regional paper in accordance with the December 2008 meeting at UPLB.

Two full papers based on Project results were presented this year 2009, namely,

- BAGUINON, N.T., H. BORGAONKAR, K. DUANGSATHAPORN, N. GUNATILLEKE, K. TENAKOON, B.M. BUCKLEY and W.E. WRIGHT. 2009. **Collaborative studies in tropical Asian dendrochronology: addressing challenges in climatology and forest ecology**, presented during the International Workshop on Climate Variability in the Greater Mekong River Basin: Paleoproxies, instrumental data and model projections, on February 16-18, 2009 held at the Agriculture Hotel, Dalat City, Vietnam sponsored by Past Global Changes (PAGES).
- BAGUINON, N.T. 2009. **Studying climate change through dendrochronology in the Philippines**, presented November 19-20, 2009 in the 5th Annual Convention with theme "Understanding the Climate Change Issues: A Key to Better Planning and Investment," held at the University Hotel, University of the Philippines, Diliman, Quezon City sponsored by the Philippine Meteorological Society, Inc. and the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), Department of Science and Technology (DOST).

References

Richardson, K., W. Steffen, H.J. Schellnhuber, J. Alcamo, T. Barker, D.M. Kammen, R. Leemans, D. Liverman, M. Monasinghe, B. Osman-Elasha, N. Stern and O. Waever. 2009. Synthesis Report, in the international conference **"Climate Change – Global Risks, Challenges and Decisions"** held in Copenhagen, Denmark on March 10-12, 2009.

UN Secretary General. 2009. **Forests and climate change**, in United Nations Forum on Forests, 8th Session, New York, 20 April-1 May 2009.

Worbes, M. 1999. **Annual growth rings, rainfall dependent growth patterns of tropical trees from the Caparo Forest Reserve in Venezuela**. Journal of Ecology 87(3): 391-403.

Villalba, R., H.R. Grau, J.A. Boninsegna, G.C. Jacoby and A. Ripalfa. 1998. **Tree-ring evidence for long-term precipitation changes in subtropical South America**. International Journal of Climatology 18(3): 1463-1478.

Worbes, M. 2004. **One hundred years of tree ring research in the tropics – a brief history and an outlook to future challenges.** Dendrochronologia 20(1-2): 217-231.

Worbes, M., R. Staschel, A. Roloff and W.J. Junk. 2003. **Tree ring analysis reveals age structure dynamics and wood production of a natural forest stand in Cameroon.** Forest Ecology and Management 173(1-3): 105-123.

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Technical Report

Preface

Dendrochronology is new in Asia. New Zealand was ahead in the practice of dendrochronology (Bell, V.E. and R.E. Bell, 1958) and followed by Australia (Ogden, J. 1978). In tropical Asia, India spearheaded dendrochronology (Pant, G.B., 1979). There was initially more preference for conifers until teak *Tectona grandis* became a reliable tree species for dendrochronology (D'Arrigo, R. and G. Jacoby. 1994).

Dendrochronology in Indoaustralasia used primarily conifers and teak. Later, it was conceived by Cook et al (2004) in a training they sponsored in Bangkok, Thailand on May 24-26, 2006 that reconnaissance for other Asian tree species should extend South-SoutheastAsian dendrochronology.

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1.0 Introduction

Background information

Although *dendrochronology*, the science of associating growth rings of trees to sequence of events in time and given space, is new in tropical Asia, its practitioners or the *dendrochronologists*, have made great strides in applying dendrochronology in tropical and subtropical America (Drew, A.P., 1998; Schongart, J., 2004; Filho, M.T. et al., 2004), Africa (Gourlay, I.D., 1995; Drew, A.P., 1998; Eshete, G. and G. Stahl, 1999; Fichtler, E. et al., 2004; Schongart, et. al., 2006), New Zealand (Buckley, B.M. et al., 2000; Fowler, A. et. al., 2000), Australia (Allen, K.J. et al., 2001; Heinrich, I. and J.C.G. Banks, 2005) and tropical Asia (Pant, G.B., 1983; Pant, G.B. and H.P. Borgaonkar, 1984b; Pant, G.B. et al., 1988b; Ramesh, R. et al., 1986; Hughes, M.K. and A.C. Davies, 1987; Bhattacharya, A. et al., 1988; 1992a; 1992b; Borgaonkar, H.P., 1994; 2001; Buckley, B.M. et al., 2001; 2005; Chaudhary, V. and A. Bhattacharya, 2002; Duangsathaporn, K., 2006; Wright, W. E., 2006; Borgaonkar, H.P., 2007; Somaru Ram, et al., 2008; Borgaonkar, H.P., et al., 2009a, 2009b; Somaru Ram, 2009). Series of growth rings in wood cross-section have been independently measured by dendrochronologists. More often than not, they have similar conclusions. The variability of growth ring series correlates with climate, especially precipitation.

A growth ring is composed of an *early wood* (in temperate regions the lighter colored spring wood) formed during rainy season and *late wood* (in temperate regions the dark colored summer wood) formed during dry season. If correlation is highly significant between tree ring series and climate factors, then the former can be proxy for the reconstruction of past climate.

In temperate zone or even in summits of tropical mountains, temperature affects tree growth ring variability aside from precipitation. In this case, Y (growth ring) is a function of X_1 (precipitation) and X_2 (temperature). In both tropical and temperate regions, other environmental variables impinging upon growth rings may also be very possible, namely, prolonged floods, defoliation by insect, typhoon wind throws, fire injury, volcanic eruption, and other natural or anthropogenic factors. It is easy to conceive that growth ring variation is multivariate, or $Y = f(x_1, x_2, \ldots X_k)$.

Scientific significance

Although tree ring variation is multivariate, the dendrochronologist can rig his sampling design to isolate any factor or combination of factors that the dendrochronologist likes to focus. Thus, in the literature, there are varied applications of dendrochronology addressing past events other than precipitation and drought, like insect defoliation which reduces photosynthesis. Deciduous trees shed leaves when dry season sets in. The frequency and magnitude of extensive fires, pest outbreaks and incidences of mega-typhoons also cause narrow rings. Narrow rings can also be recorded by prolonged submergence in water, thus dendrochronology can record floods in floodplains. Forest ecologists apply dendrochronology to associate tree rings with suppression or release of a single tree or community of trees from light, water and nutrients. Forest dynamics as reflected in cyclic gap, building-up and mature phases can be captured through analysis of tree ring variabilities across gradients of vegetation.

While the benefits of dendrochronology to science and its practical applications are not to be underestimated, many parts of the world are zero dendrochronologicaly. This is true even if such areas are forested or wooded. One big reason why this is so is that there is little or even zero information on indigenous trees with distinct growth rings. Unless an area undergoes reconnaissance, like listing all tree species with distinct growth rings, that area will never be studied dendrochronologically.

In tropical Asia, bulk of published dendrochronology studies are mainly in India, Indochina and Indonesia (Java, Sulawesi) but such locations are limited only to where conifers and teak are naturally growing. Much of the Indomalayan region are unstudied if at all unless reconnaissance is done.

Objectives

Due to the aforementioned reasons, the present project has been designed mainly to conduct reconnaissance, i.e. marking indigenous tree species that have distinct growth rings. Here, profound knowledge on the tree flora of an area and their taxonomy helps but even more important is the knowledge where to find indigenous tree species so that sampling as many tree species is optimized even under extreme social and weather extremes. Furthermore, the establishment of tree ring laboratories and xylarias are simultaneous requirements for reconnaissance work.

In the present APN Project, a list of indigenous tree species with distinct rings is one of its major outputs. If in the future, these crossmatch or better crossdate, they will be considered assets for local dendrochronology. The present project has attempted to go into crossmatching and crossdating only to five tree species. Their relationship with climate at the local and regional scales are hereby illustrated and discussed.

2.0 Methodology

The *increment borer* is the tool to extract corewood from trees. It consists of a steel barrel with auger tip to burrow into a tree trunk by turning its handle clockwise. Retrieval of corewood is done by inserting an extractor spoon and by turning the handle counterclockwise to severe the corewood from its mother stem, the extractor is pulled outward to remove the corewood. As a rule *two radii* are taken from each tree, for example labels *1A* and *1B*. The corewood is inserted inside a *plastic hollow straw* and with permanent marker the straw with corewood is appropriately labeled indicating the sequence number of the corewood, the radii, the name of tree, place of collection, date of collection and collector's initial, e.g. 1A *Melia azedarach* Aborlan, Palawan 7-29-09 ntb. Corresponding documentation by capturing the following information: elevation and coordinates of the tree using *Geological Positioning System* (GPS) and other *metadata* like slope, slope aspect and slope grade are noted and recorded in notebook. *Photodocumentation* of the tree habit, outer bark, inner bark and at least branch and leaves would be useful for future publication purposes.

Corewood samples are securely kept in *plastic tube with screw cap* tightly closed. At the end of the day used increment borers are cleaned with *WD-40*. This protects increment borer from rusts and obstructions, therefore ready for the next sampling.

In case the tree is unknown, effort is made to collect branch and leaves, then label it with its *vernacular name*. These are inserted in between old newspapers securely held by tightly tying *wooden pressers*. The label on the straw, branch with leaves as well as corresponding written information in notebook should agree as one taxon of a kind. In most cases, future comparison with known voucher specimens in *herbaria* should give the identity of the unknown taxon, otherwise they remain unidentified. With identified specimens, vernacular names may be appended by their *scientific names*.

The procedure for mounting corewood is as follows. It uses a long slender wooden block that has on one side a longitudinal groove whose length and diameter snugly fits those of the corewood sample. The corewood still wet has to be placed in said groove and then with *masking tape* or a *tying thread* held in place for air drying. Air drying may cause the corewood to warp and twist, but this is prevented by evenly applying weight to the corewood, like piles of books. When air dried, the corewood samples are ready for final mounting. This includes proper orientation of the corewood by tilting it until the wood *cross-section* is dorsally exposed while the *radial section* at the sides. This is confirmed by inspection where sides of corewood reflect light, while ends of corewood show wood rays in upright position perpendicular to the groove. Next, corewood is firmly anchored with glue. The corewood is then surfaced using *mechanical sanders* at varying grades from coarse sandpaper to fine sandpaper. A good surfaced corewood reveals growth ring boundaries with the help of *high resolution scanner* and 10x or 20x microscope. Scanned corewood samples are correspondingly labeled with their respective *species* and *family* names.

Each corewood is determined whether it has *absent*, *indistinct* or *distinct* growth rings. Dendrochronologists apply knowledge of *wood anatomy* to know whether or not a cross-section has growth rings. Coniferous wood with few exceptions are usually with distinct rings. One growth ring consists of a pair of lighter and darker band of wood tissues, *spring wood* and *summer wood*, respectively. Coniferous wood lacks pores or vessels while broad-leaved trees (dicot-angiosperms) show large pores or vessels.

Determining distinct growth rings among dicot angiosperms could be tricky. In the tropics, the terms *early* and *late* wood are used instead of spring and summer wood. In one annual ring, woody tissues deposited during *early* wet season precede the darker more dense wood deposited *late* during the end of the dry season.

As a rule, ring-porous tree species have distinct growth rings as in *Tectona grandis*, *Toona ciliata* and *Melia azedarach*. A wood is *ring porous* when large pores or vessels of early wood form concentric bands relative to less dense small pores of late wood. Conversely, wood with homogenous pores uniformly dispersed is *diffuse porous*.

Diffuse porous woods are not always without growth rings (or *absent rings*). The ring boundary may be clearly defined by other criteria. One criterion is when early and late woods are determined by *less dense and very dense concentric bands of woody tissue*, for example in *Mangifera* spp. Such growth rings can be observed by the naked eye.

Aside from *vessels*, there also exist small thin-walled cells called *parenchyma cells*. They are *apotracheal* when not associated with vessels. The term paratracheal is used when they touch vessels. Paratracheal parenchyma enveloping a vessel is described as *vascicentric*. *Aliform* applies to vascicentric parenchyma cells that have extended side, hence giving a wing-like or eye-like configuration. *Confluent* when the aliform parenchyma is further joined together. Finally, the term *metatrachea*l is applied when paratracheal parenchyma are continuous and concentric around the wood cross-section. Metatracheal parenchyma indicates growth ring boundary when in early wood they are broad and closely set but in late wood they are narrow and are apart from each other, showing clear distinct growth rings, e.g. *Bauhinia malabarica*.

Another kind of parenchyma is the so-called *terminal parenchyma* (also known as *marginal parenchyma*) because these cells when concentric and uninterrupted form clear boundary between previous year's growth from succeeding early growth. Examples are found in many tree species, such as in the family Myristicaceae. Usually the terminal parenchyma is seen with the aid of a lens. However, the terminal parenchyma is obvious it occurs as uninterrupted concentric boundaries. Difficult to assess are those terminal parenchymas that are discontinuous or interrupted.

Sometimes, combinations of the different criteria delimit growth rings. For example, in one tree species two or more criteria are found together, hence making the boundary between previous with current growth more distinct. The list of species with distinct rings per country can be seen from *Appendices 1, 2, 3, 4, 5, 6* and *7*.

When positive with distinct growth rings, trees may be next tested for crossmatching and then for crossdating. Only India did such analyses and graphed results.

Crossmatching is demonstrated by two trees in a given species when their growth ring series are more or less in agreement. The term crossdating applies when for a given replicatedly sampled tree species (e.g. at least 20 trees) show synchronous growth ring patterns. Using a pencil, marks are placed as reference points for every 10 years (one dot), every 50 years (two dots), and every 100 years (three dots).

There are two ways to prove crossdating exists. One method known as *skeleton plotting* makes use of pencil and strips of millimeter graphing paper. With the pencil, a millimeter segment may be marked with a long bar for extremely narrow ring, short bar for narrow ring, the letter *b* for rings obviously wider than average rings while average rings are left blank. Thus the skeleton plot of one corewood reflects its ring pattern. The two radii from one tree are expected to have the same ring pattern, but this may not be true when there are one or many *locally absent rings* (also called *missing rings*) because one or many rings wedge on one side of the stem and therefore are not seen on the other side. Corewood samples with many locally absent rings are impossible to crossmatch and crossdate. There are also cases when a ring may have false bands so that one ring appears to be two or more rings. This anomally is easy to correct if the false ring is faint but may be a problem when it is a solid line. For a given species, a skeleton plot for 20 trees collected from sensitive sites should show more or less one to one correspondence and therefore concludes crossdating.

Now crossdating is done with the help of sliding measuring device (e.g. Velmex) equipped with microscope with cross-hair reticle and a counter switch that is pressed everytime the crosshair encounters a ring boundary. Thus in between switches representing two boundaries get its corresponding tree ring width so that, for one corewood sample, data are translated digitally to the computer. This dataset is statistically assessed using software programs like COFECHA and ARSTAN. Tree ring series with anomalous rings, such as many locally absent rings and false rings, can be detected because they show very low correlations. If with high correlation, this indicate that the tree ring series crossdate. This precedes translating the dataset into a *chronology*.

There are two kinds of fieldwork in dendrochronology, one is for reconnaissance and the other is for crossdating. The present APN project conducted field work to satisfy its mission to conduct reconnaissance and determine which tree species in the field are with distinct growth rings. In reconnaissance, the rule is to core all known and unknown trees as long as the individual tree is not defective or not very hard to break increment borers. Therefore, knowledge on the biogeography of the area may help in making an *a priori* list of tree species to be sampled.

Since the objective of reconnaissance is to list tree species with distinct growth rings, field work should give priority to areas that exhibit strong seasonality, for example in the tropics, these would be found in areas affected by the rainshadow effect of north-south trending mountain ranges and also that have been mapped as with dry deciduous to semi-deciduous tropical forest. Please see maps where collaborators conducted their field work (Maps 1, 2, 3, 4 and 5).

The other kind of fieldwork addresses crossdating. When tree species with distinct rings are already known in a given area because they have undergone previous reconnaissance, a return trip may be opted to conduct replicated core sampling for selected tree species with distinct rings.

In the field, if dendrochronology is intended to study climate, the dendrochronologist would core old trees that are in sensitive sites, for example those in steep slopes away from ground water table instead of trees growing along streams. Trees growing in the former would register drought events and corresponding growth ring for these events would be narrow. Trees growing in places near stream banks will still have wide rings even under drought events (or in other words, *complacent rings*), hence such trees tend to have more or less uniformly sized ring segments as opposed to the highly variable ring patterns of trees from sensitive sites.

3.0 Results and Discussion

Reconnaissance

Philippines

Team Philippines summarized its results in Appendix Table 1 and listed the following tree species as with distinct growth rings. The habitat preference, geographic distribution and tree habit of the aforementioned taxa are also described.

1.Sangilo *Pistacia chinensis* Bunge ANACARDIACEAE has rings delimited by concentric rows of large vessels. This particular specimen was from a 20 cm dbh tree introduced at the UPLB, Mt. Makiling, Laguna. Geographic distribution: Philippines (Northern Luzon Cordillera highlands); highlands of Taiwan and South China. A tree up to 26 m tall and 100 cm dbh. (Rojo J.P., 1999). (Plate 1, p. 49)

2.Amuyong *Goniothalamus amuyon* (Blco.) Merr. ANNONACEAE has rings delimited by terminal parenchyma. The specimen is from a 30 cm dbh tree growing in UPLB, Mt. Makiling. Lowland forest. Geographic distribution: Luzon (Abra, Ilocos Norte, Ilocos Sur, Pangasinan, Batangas, Rizal, Quezon), Negros, Bohol, Mindanao. Philippine endemic. Small tree (Rojo J.P., 1999).

3.Almaciga *Agathis philippinensis* Warb. ARAUCARIACEAE has rings delimited by terminal parenchyma. Specimens of this taxon were collected from trees introduced in UPLB, Mt. Makiling as well as from one specimen from Balbalasang, Balbalan, Kalinga. Elevation 1200 to 2200 m and as low as 250 m in Luzon. Geographic distribution: Philippines, Sulawesi and Halmahera. Large tree, 60 m tall. (Plate 2, p. 49)
4. Alibangbang *Bauhinia malabarica* Roxb. CAESALPINIACEAE has rings present due to the uneven distribution of the metatracheal parenchyma and vessels. This taxon was collected at 300 m asl in Carranglan, Nueva Ecija, Luzon. Geographic distribution: India through Myanmar, Thailand, Cambodia, Laos and Vietnam, Philippines (Ilocos Norte to Laguna), Java to Timor, Queensland. None in Peninsular Malaysia. Small tree up to 15 m tall (Rojo, J.P. 1999) (Plate 3, p.49)
5.Supa *Sindora supa* Merr. CAESALPINIACEAE has rings delimited by terminal parenchyma. Specimen of this taxon was collected from Mt. Makiling. Found in lowland forests at low and medium elevations, occurs on limestone ridges. Philippine endemic (Luzon). A tree up to 15 m tall, 30 to 40 cm dbh. (Rojo, J.P. 1999).
6.Narra *Pterocarpus indicus* Willd. FABACEAE has distinct rings due to ring-porous character and also boundary by terminal parenchyma. Specimens are collected from Mt. Makiling and from Carranglan, Nueva Ecija. Forests at lowlands to 600m elevation. Geographic distribution: SE Asia, Peninsular Thailan, Cambodia (Phu Quoc), Malesia, Pacific, Ryukyu Is., Caroline Is., Bismarck Archipelago, New Hebrides, (Plate 4, p.49) Large deciduous tree, 30 m tall or more with large, high buttress. (Rojo, J.P. 1999).
7.Bitaog *Calophyllum inophyllum* L. GUTTIFERAE has rings delimited by terminal parenchyma. Specimen was from trees introduced in Mt. Makiling. Common in seashore forests seldom further inland. Geographic distribution: Tropical East Africa to India through Malesia up to Polynesia. Tree 7 to 25(-35) m tall; dbh to 150 cm (Rojo, J.P. 1999).
8.Salinggogon *Cratoxylum formosum* (Jack) Dyer GUTTIFERAE has rings delimited by bands of woody tissue, distinct in some specimens, indistinct in others. Specimens are from trees in Mt. Makiling. Elevation preferred 0 to 600(-1200) m. Geographic distribution: Hainan, S Vietnam, Cambodia, S Thailand, S Andaman Is, Malesia: Sumatra, Malay Peninsula, Banka, Borneo, Sulawesi, Philippines (Cagayan to Sorsogon, Polillo, Palawan, Busuanga, Sibuyan, Panay, Negros, Samar, Leyte, Mindanao). A small tree to 35 m tall (Rojo, J.P. 1999). (Plate 18, p.50)
9.Paguringon *Cratoxylum sumatranum* (Jack) Blume GUTTIFERAE has rings marked by bands of woody tissue, distinct but indistinct in others. All specimens were from Mt. Makiling. Elevation preferred 200-800(-1200) m. Geographic distribution: Sumatra, Java, Lesser Sunda Islands, Borneo, Sulawesi, Philippines (Luzon, Mindoro, Panay, Samar, Leyte, Surigao). A small tree to 35 m tall (Rojo, J.P. 1999). (Plate 17, p.50)
10.Margapali *Dehaasia incrassata* (Jack) Kosterm. LAURACEAE rings distinct under lens, delimited by contrasting densities of early and late woods. Specimen was from a tree in Mt. Makiling. Found at low and medium elevations. Geographic distribution: Peninsular Thailand, Malay Peninsula, Singapore, Sumatra, Borneo, Philippines:Luzon (Cagayan, Isabela, Nueva Vizcaya, Nueva Ecija, Rizal, Quezon, Laguna), Mindoro, Sibuyan, Camarines, Masbate, Ticao, Panay, Negros, Leyte, Zamboanga. A large tree 20 to 40 m tall and 60 cm dbh (Rojo, J.P. 1999). (Plate 19, p.50)
11.Lamog *Planchonia spectabilis* Merr. LECYTHIDACEAE has rings delimited by dense concentric woody tissue. Specimens are all from Mt. Makiling. Found at low to medium elevations, 600 m. Endemic to Luzon and vicinities. A tree up to 30 m or more high, 100 cm dbh (Rojo, J.P. 1999).
12.Ulam *Barringtonia curranii* Merr. LECYTHIDACEAE rings delimited by dense concentric woody tissue. Specimen was collected from Aborlan, Palawan. Found at low to medium elevations. Geographic distribution: Borneo, Philippines (Palawan). A small to medium tree (2-)13 to 25 m tall, 10 to 40 cm dbh (Rojo, J.P. 1999). (Plate 20, p.50)
13.Batitinan *Lagerstroemia pyriformis* Koehne LYTHRACEAE has ring-porous wood. Single specimen from a tree growing in Mt. Makiling. Found at low to medium elevations. Philippine endemic and in many provinces. A medium to large tree (Rojo, J.P. 1999).

14.Banaba *Lagerstroemia speciosa* (L.) Pers. LYTHRACEAE has ring-porous wood. All specimens from trees in Mt. Makiling. Secondary forests at low and medium elevations. Geographic distribution: Myanmar, Thailand, Indochina, Malay Peninsula, Borneo, Philippines (Luzon, Mindoro, Palawan, Leyte, Mindanao). A medium tree (Rojo, J.P. 1999). (Plate 21, p.50)

15.Vidal's lanutan *Hibiscus campylosiphon* Turcz. MALVACEAE has its late wood appearing as dark band due to denser woody tissue associated with smaller vessels, early wood more porous associated with relatively lighter tissue. All specimens were from trees growing in Mt. Makiling. Elevation preferred low elevations. Philippine endemic: Cagayan, Zambales. Small tree to 10 m tall and c. 15 cm dbh; may reach medium size in another variety to 15 m tall, 30 cm dbh (Rojo, J.P. 1999).

16.Igyo *Dysoxylum gaudichaudianum* (A. Juss.) Miq. MELIACEAE growth rings are indicated by early wood which is lighter contrasting the darker denser late wood that is also delimited by terminal parenchyma. Found in primary and secondary forests including swamp forests, bamboo woodlands and forests on limestone, to 1800 m elevation. Geographic distribution: Christmas Island (Indian Ocean), Queensland, Solomon Islands, New Hebrides, Samoa, Malesia: Java, Philippines (Luzon, Masbate, Palawan, Mindanao), Sulawesi, Lesser Sunda Islands, Moluccas, New Guinea, Bismarck Archipelago. A medium to large tree to 36 m tall and c. 80 cm dbh (Rojo, J.P. 1999). (Plate 22, p.51)

17.Bagalunga *Melia azedarach* L. MELIACEAE has ring-porous wood. Two specimens were collected from Mt. Makiling and another two from Aborlan, Palawan. This taxon is found in areas with marked seasonality especially on limestone, bamboo thickets, tamarind woodland, and Eucalyptus savanna to 1200 m elevation (1800 m altitude in Himalayan tract). Geographic distribution: India, Nepal and tropical China, Malesia: Sumatra, Java, Philippines (Luzon, Visayas, and Mindanao), Lesser Sunda Islands, New Guinea, to tropical Australia and Solomon Islands. A medium to large tree to 40 cm tall and to 60(-180)cm dbh (Rojo, J.P. 1999). (Plate 5, p.49)

18.Kalantas *Toona calantas* Merr. & Rolfe MELIACEAE has ring-porous wood. All specimens were collected from Mt. Makiling. Found in forests at low and medium elevations. This taxon is suspected as only a geographical variant of T. ciliate M. Roem. Geographic distribution: Sumatra, Peninsular Malaysia, Borneo, Java, New Gunea, Philippines (from Batan Island to Mindanao). A large tree to 35 m tall and 152 cm dbh (Rojo, J.P. 1999). (Plate 6, p.49)

19.Danupra *Toona sureni* (Blume) Merr. MELIACEAE has ring-porous wood. Specimens were from two trees growing in Mt. Makiling. Found in primary and secondary forests from 0 to 1700 m elevation. Geographic distribution: India, through Nepal, Bhutan, Myanmar, S China, Thailand, Malesia: Sumatra, Peninsular Malaysia, Java, Philippines (Ilocos Norte, Ilocos Sur, Zambales, Mindoro), Lesser Sunda Islands, Moluccas, New Guinea. A medium to large tree (Rojo, J.P. 1999). (Plate 7, p.49)

20.Akleng parang *Albizia procera* (Roxb.) Benth. MIMOSACEAE has rings marked by contrast in density between early and late wood. All specimens are from trees collected from Carranglan, Nueva Ecija. Mostly found in second-growth forests, thickets at low and medium elevations where there is markedly long dry season. Geographic distribution: India, Myanmar, Indochina, Thailand, Hainan, Taiwan, Australia (Queensland), Malesia: Java, Sulawesi, Lesser Sunda Islands, Moluccas, Kai Islands, Tanimbar, New Guinea, Philippines (Cagayan to Batangas, Mindoro, Busuanga). A medium tree (Rojo, J.P. 1999). (Plate 8, p.49)

21.Banuyo *Wallaceodendron celebicum* Koord. MIMOSACEAE has rings delimited by dense late wood. Specimens collected are from trees growing in Mt. Makiling. Found in primary forests, inland and near seashores; 0 to 850 m elevation. Geographic distribution: N Sulawesi, Philippines (Babuyan Is., Cagayan to Samar, Negros, Cebu). A large tree to 45 m tall, 31 m bole and to 160 cm dbh (Rojo, J.P. 1999). (Plate 23)

22.Yabnob *Horsfieldia costulata* (Miq.) Warb. MYRISTICACEAE has rings delimited by terminal parenchyma. Specimen from a tree growing in Mt. Makiling. Found in mixed dipterocarp forests at 250 to 1200 m elevation. Geographic distribution: Sulawesi, Philippines (Luzon, Panay, Leyte, Mindanao, Basilan). A tree 9 to 30 m tall (Rojo, J.P. 1999). (Plate 9, p.49)

23.Duguan *Myristica philippinensis* Lam. MYRISTICACEAE has rings delimited by terminal parenchyma. Found in low to medium altitudes up to 400 m elevation. Philippine endemic: Mindoro, many Luzon provinces, Samar, Leyte, Mindanao, Basilan. A tree 6 to 15 m high (Rojo, J.P. 1999).
24.Tambalau *Knema glomerata* (Blanco) Merr. MYRISTICACEAE has rings delimited by terminal parenchyma. Forests in low and medium elevation. Philippine endemic: Many provinces from Babuyan Island to Mindanao. A medium tree (Rojo, J.P. 1999).
25.Benguet pine *Pinus kesiya* Royle ex Gordon PINACEAE has distinct growth rings. Specimens were collected from Binbin, Carranglan, Nueva Ecija. Found in forests 300 to 2700 m elevation usually on steep slopes in areas with long dry season. Geographic distribution: Across SE Asia to India (Khasia) down to Myanmar, Thailand, Cambodia, Laos, Vietnam and Philippines (Northern Luzon). A large tree 35 to 45 m tall, about 50 to 100 cm dbh; three-needled (Rojo, J.P. 1999).
26.Mindoro pine *Pinus merkusii* Jungh. et de Vriese PINACEAE has distinct growth rings. Specimen was collected from a tree introduced in UPLB, Mt. Makiling. Found on poor acid podzolic soils over sandstone or fresh volcanic ash from low to 2000 m elevation where there is long dry season. Geographic distribution: E Myanmar, Thailand, Sumatra and Philippines (Zambales, Mindoro and Palawan). A large tree 40 to 50(-70)m tall; two-needled (Rojo, J.P. 1999).
27.Malaalmaciga *Nageia wallichiana* (Presl.) O. Kuntze PODOCARPACEAE has distinct growth rings. Specimen was collected from a tree planted in UPLB, Mt. Makiling. This taxon is found scattered and common in primary forests from 50 to 2100 m altitude. Geographic distribution: SE Asia (S extremity of the Deccan Peninsula), Assam, Myanmar, Thailand, Indochina, Malesia: Sumatra, M.Peninsula, W. Java, Lesser Sunda Islands, Philippines (Cagayan, Isabela, Apayao, Benguet, Baguio, Bataan, Quezon, Laguna, Sibuyan, Surigao), Borneo, N and E Sulawesi, Moluccas, New Guinea. A small to large tree 10 to 54 m high, 7 to 60 cm dbh (Rojo, J.P. 1999) (Plate 10, p.49)
28.Malakawayan *Podocarpus rumphii* Blume PODOCARPACEAE has distinct growth rings. Specimen was from a tree planted in UPLB, Mt. Makiling. Found in primary forests 5 to 200(-600-1550) m elevation. Geographic distribution: Hainan, Malesia: Malay Peninsula, S and C Java, Borneo, Philippines (Zambales, Bataan, Pampanga, Agusan del Norte), Sulawesi. A medium to large tree 12 to 45 m high, 35 to 75 cm dbh (Rojo, J.P. 1999). (Plate 11, p.49)
29.Igem *Dacrycarpus imbricatus* (Blume) de Laub. PODOCARPACEAE has distinct rings. Specimen collected from Balbalasang, Balbalan, Kalinga. Geographic distribution: N. Myanmar, southeasternmost China, through SE Asia, Malesia: Sumatra, Malay Peninsula, Borneo, Philippines (Luzon, Mindanao), Sulawesi, New Guinea, New Herbrides to Fiji. A large tree 5 to 40 m tall and 10 to 100 cm dbh (Rojo, J.P. 1999). (Plate 12, p.50)
30.Taw-a2 Unidentified species. RUBIACEAE. Specimen collected from Aborlan, Palawan.
31.Malugai *Pometia pinnata* Forst. & Forst. f. SAPINDACEAE has rings delimited by fine terminal parenchyma. All specimens from trees in Mt. Makiling. Primary and secondary forests on dry land, swamps, temporarily inundated habitats, slopes and ridges; some common on riverbanks, from sea level to 900(-1700) m elevation. Geographic distribution: Throughout Malesia: Philippines (Babuyan Is., Cagayan, Ilocos Norte, Bataan, Laguna, Mindoro, Palawan, Ticao, Masbate, Negros, Cebu, Samar, Leyte, Mindanao). A large tree up to 50 m tall and up to 1.4 m dbh (Rojo, J.P. 1999). (Plate 24, p.51)
32.Tan-ag *Kleinhovia hospita* L. STERCULIACEAE has rings delimited by terminal parenchyma. One specimen collected from UPLB, Mt. Makiling. Found in thickets, secondary forests and deserted clearings at low and medium elevations. Geographic distribution: India to tropical Africa and Malaya. A small tree (Rojo, J.P. 1999).
33. Bayok *Pterospermum diversifolium* Blume STERCULIACEAE has rings indicated by contrast between densities of early and late woods. Common in forests at low and medium elevations. Geographic distribution: Luzon (Cagayan to Camarines), Mindoro, Palawan, Ticao, Masbate, Guimaras, Negros, Mindanao, Basilan. Indo-china, Malay

Peninsula, Sumatra, Borneo, Java, and the Moluccas. A medium tree (Rojo, J.P. 1999). (Plate 13, p.50)

34.Kalumpang *Sterculia foetida* L. STERCULIACEAE has rings delimited by terminal parenchyma. Specimens were from various sources: around Mt. Makiling, Mt. Lobo, Batangas, and Mariveles, Bataan. Found in forests at low and medium elevations. Geographic distribution: Luzon (Cagayan to Camarines), Mindoro, Palawan, Ticao, Masbate, Guimaras, Negros, Mindanao, Basilan. Indo-china, Malay Peninsula, Sumatra, Borneo, Java and the Moluccas. A deciduous tree to 30 m tall, c. 90 cm dbh (Rojo, J.P. 1999). (Plate 25, p.51)

35.Kakaag *Commersonia bartramia* (L.) Merr. STERCULIACEAE has rings delimited by terminal parenchyma. Specimens from Aborlan, Palawan. Common in thickets and second-growth forests at low and medium elevations. Geographic distribution: Indo-china and the Malay Peninsula through the Malay Archipelago to Polynesia. Small tree (Rojo, J.P. 1999). (Plate 14, p.50)

36.Anilaw *Colona serratifolia* Cav. TILIACEAE has rings indicated by contrast between densities of early and late woods. Specimens were collected from Mt. Makiling and Aborlan, Palawan. Common in secondary forests. Geographic distribution: Borneo, Sulawesi. Small tree (Rojo, J.P. 1999).

37.Danglin *Grewia multiflora* Juss. TILIACEAE has rings indicated by dense late woods. Specimen from a tree in Mt. Makiling. Common in thickets and secondary forests. Geographic distribution: Extending from Malaya to New Guinea. Small tree (Rojo, J.P. 1999).

38.Bunglas *Tectona philippinensis* Benth. & Hook. f. VERBENACEAE has ring-porous wood. Specimen from a small tree planted in Mt. Makiling. Secondary forest and thickets at low altitudes. Philippine endemic in Luzong (Batangas) and Mindoro (Iling Island). Medium tree (Rojo, J.P. 1999).

39.Lingo-lingo *Vitex turczaninowii* Merr. VERBENACEAE has ring-porous wood. Specimen collected from Mt. Makiling. Forest at low altitudes. Philippine endemic. Large tree (Rojo, J.P. 1999). (Plate 15, p.50)

40. Unknown tree species from Kalinga, Northern Luzon, Philippines. (Plate 16, p.50)

Sabah, Malaysia

Team Malaysia summarized its reconnaissance work in Appendices 2 and 3 and those with distinct growth rings are listed below, including other information like the species habitat preference, geographic distribution and tree habit.

1. *Dacydium gracilis* de Laub. PODOCARPACEAE has obvious growth ring boundary. Specimen was collected from a tree in Mt. Kinabalu, Sabah, Malaysia. Geographic distribution: Borneo endemic. Large tree. (Plate 31, p.51)

2. *Dacrycarpus imbricatus* (Blume) de Laub. var patulus PODOCARPACEAE has obvious growth ring boundary. Specimens were collected from Mt. Kinabalu, Sabah, Malaysia. (Geographic distribution, see entry from the Philippines). Large tree. (Plate 27, p.51)

3. *Dacrycarpus imbricatus* (Blume) de Laub. var imbricatus PODOCARPACEAE has obvious growth ring boundary. Specimens were collected from Mt. Kinabalu, Sabah, Malaysia. (Geographic distribution, see entry from the Philippines). Large tree. (Plate 28, p.51)

3. *Phyllocladus hypophyllus* Hook. f. PODOCARPACEAE has obvious ring boundary. Specimens were collected from Mt. Kinabalu, Sabah, Malaysia. Found in moist mountain forests from 900m to 3200 to 4000 m elevation. Geographic distribution: Malesia: Philippines (Abra, Bontoc, Ifugao, Lepanto, Benguet, Isabela, Mindoro, Davao, Bukidnon, Lanao), Borneo, Sulawesi, Moluccas, New Guinea. Large tree. (Plate 29, p.51)

4. *Agathis borneensis* Warb. ARAUCARIACEAE has obvious ring boundary. Specimens were collected from Mt. Kinabalu, Sabah, Malaysia. Found in montane forests. Bornean endemic. Large tree. (Plate 30, p.51)

5. *Pterospermum* sp. cf. *elongatum* Korth. STERCULIACEAE has distinct growth rings due to contrasting early and late wood densities. Specimens were collected from Mt. Trus Madi, Sabah, Malaysia. Borneo endemic. Common tree in secondary forests on

clayish soils along the lower course of the main rivers of East Borneo. One of the belukar trees after logging on alluvial soils. Found scattered in primary forests. Medium sized tree (Meijer, W. 1974).
6. *Vitex pinnata* L. VERBENACEAE has ring-porous wood. Specimens were collected from Mt. Trus Madi, Sabah, Malaysia. Geographic distribution: Bangladesh, India, Cambodia, Laos, Myanmar, Thailand, Vietnam, Sulawesi, Java, Borneo, Lesser Sunda Islands, Sumatra, Malay Peninsula, Philippines. (Plate 26, p.51)

Thailand

Team Thailand summarized its results in Appendix Table 4 and listed the following tree species as with distinct growth rings. Corresponding habitat preference, geographic distribution and tree habit of the taxa are also included.
1.*Lannea coromandelica* (Houtt.) Merr. ANACARDIACEAE has rings delimited by terminal parenchyma. Found in mixed deciduous forest, and along the edge of dry evergreen forest, elevation from 20 to 700 (-100-1400 m) (Royal Forest Department, 1984). Geographic distribution: Bhutan, India, Myanmar, Nepal, Sri Lanka, Cambodia, Laos, Thailand, Vietnam, Malaysia.
http://www.efloras.org/florataxon.aspx?flora_id=2&taxon_id=200012695
Deciduous tree to 17 m with open crown and rather slender branches (Gardner et al., 2000) (Plate 32, p.52)
2.*Garuga pinnata* Roxb. BURSERACEAE has rings delimited by concentric bands of dark-brown wood. Found in mixed deciduous forest and dry evergreen forest in northern, eastern, northeastern, southeastern, and center of Thailand, elevation 50-800 m (Royal Forest Department, 1984). Geographic distribution: Bangladesh, Cambodia, India, Laos, Myanmar, Thailand and Vietnam. Deciduous tree 20(30)m, trunk spreading at the base. (Plate 33, p.52)
http://www.efloras.org/florataxon.aspx?flora_id=2&taxon_id=200012493
Deciduous tree to 20(30) m. (Gardner et al., 2000).
3.*Fernandoa adenophylla* (Wall. ex G. Don) Steenis BIGNONIACEAE has rings delimited by terminal parenchyma. Found in moist upper mixed deciduous forest and along the edge of evergreen forests, at higher elevation on about 1600 m. Geographic distribution: Burma, Andaman Island, E Bengal, Assam and Thailand.
http://www.efloras.org/florataxon.aspx?flora_id=5&taxon_id=250071466
Also in China, Laos, Vietnam. Tree up to 20 m high (Smitinand and Larsen, 1987). (Plate 35, p.53)
4.*Markhamia stipulata* (Wall.) Seem.ex K. Schumann BIGNONIACEAE has rings delimited by terminal parenchyma. Found in mixed deciduous forests with bamboos and along the edge of evergreen forests, elevations up to about 1000 m (Smitinand and Larsen, 1987). Geographic distribution: Fujian, Guangdong, Guangxi, Hainan, Yunnan, Cambodia, Laos, Myanmar, Thailand, Vietnam. Deciduous tree 5-15 m high.
http://www.efloras.org/florataxon.aspx?flora_id=2&taxon_id=210001229
Deciduous tree up to 5-15 m. (Smitinand and Larsen, 1987). (Plate 34, p.53)
5.*Oroxylon indicum* Vent. BIGNONIACEAE has rings delimited by terminal parenchyma. Found along the edges of evergreen forests, in secondary growths and thickets (Smitinand and Larsen, 1987). Geographic distribution: Widely distributed throughout India, from Sri Lanka, the Deccan and the Himalayas through Myanmar, S China, Indochina, and Malaysia eastward to the Philippines, Sulawesi and Timor (Smitinand and Larsen, 1987). Small to medium sized tree. (Plate 36, p.54)
6.*Bombax anceps* Pierre BOMBACACEAE has rings delimited by terminal parenchyma. Found on hillsides of mixed deciduous in northern and eastern regions (Royal Forest Department, 1984). Geographic distribution: Thailand, Cambodia, Myanmar, Laos, Malay Peninsula. Deciduous tree to 30 m, with an unmistakable crown. (Plate 37, p.54)
http://www.efloras.org/florataxon.aspx?flora_id=2&taxon_id=242308814
7.*Cassia fistula* CAESALPINIACEAE has rings due to fine line of terminal parenchyma, usually interrupted. Frequent in mixed deciduous forest, scattered in dry deciduous dipterocarp forest (Smitinand and Larsen, 1985). Geographic distribution: Sri Lanka,

India and Malesia (Java?, Celebes). Tree rarely above 10-15 m tall with glabrous branches.
8.*Terminalia triptera* Franchet COMBRETACEAE. Found in mixed deciduous and dry evergreen forest (Royal Forest Department, 1984). Geographic distribution: S China to N Thailand. Tree.
http://www.ars.grin.gov/cgi-bin/npgs/html/taxon.pl?311529
9.*Wendlandia tinctoria* (Roxb.) DC. RUBIACEAE has rings delimited by terminal parenchyma. Found in hill evergreen forest and tropical evergreen rainforest (Weesommai and Kewduangtean, 2004). Geographic distribution: Himalayas (Nepal to Assam), India, Myanmar, Indochina. Evergreen shrub or small tree to 8 m. (Plate 38, p.55)
http://www.efloras.org/florataxon.aspx?flora_id=110&taxon_id=200022253
10.*Dillenia obovata* (Blume) DC. DILLENIACEAE has rings delimited by terminal parenchyma. Found in mixed deciduous forest and dry evergreen dipterocarp forest (The Forest and Forest Product Manangeble Research Office, 2004). Geographic distribution: Burma, Java, Sumatra, Malay Peninsula, Thailand. Evergreen tree to 25m with dense, irregular crown and short stout trunk. (Plate 39, p.55)
http://www.ghif.net/species/15449204
11.*Diospyros mollis* Griffith EBENACEAE has rings delimited by terminal parenchyma. Found in mixed deciduous forest and elevation 5-500m (Royal Forest Department, 1984). Geographic distribution: Myanmar, Thailand. Evergree or deciduous tree up to 30 m tall.
http://www.aluka.org/action/showMetadata?doi=10.5555/AL.AP.FLORA.FTEA003676&pgs=
12.*Diospyros montana* Roxb. EBENACEAE has rings delimited by terminal parenchyma. Found in evergreen forest 50-500 m elevation (The Forest and Forest Product Manangeble Research Office, 2004). Geographic distribution: Taiwan, India, Nepal, Sri Lanka, Cambodia, Laos, Myanmar, Thailand, Vietnam, Sulawesi, Java, Lesser Sunda Islands, Malay Peninsula, Philippines (Luzon). Tree. (Plate 40, p.56)
http://www.ars.grin.gov/cgi-bin/npgs/html/taxon.pl?14304
13.*Albizia odoratissima* MIMOSACEAE has rings due to contrast density between early and late woods. Found in hill evergreen forest, dry deciduous forest (common) in elevation up to 1000 m. Geographic distribution: India (type), Sri Lanka, tropical and subtropical SE Asia (except Malay Peninsula) (Smitinand and Larsen, 1985). Tree about up to 40 m high.
14.*Vitex canescens* Kurz. VERBENACEAE has ring-porous wood. Found in mixed deciduous forest at 200-1000 m asl (Department of National Park, Wildlife and Plant Conservation, 2007). Geographic distribution: S China (Yunnan), Cambodia, India, Laos, Malay Peninsula, Myanmar, Thailand, Vietnam.
http://www.efloras.org/florataxon.aspx?flora_id=2&taxon_id=200019438
15.*Afzelia xylocarpa* (Kurz) Craib. CAESALPINIACEAE has rings delimited by terminal parenchyma. Found in mixed and dry evergreen forest at lower elevation not above 600 m (Smitinand and Larsen, 1985). Geographic distribution: Thailand, Vietnam, Cambodia, Laos, Myanmar. Tree up to 30 m, with a broad crown.
http://www.efloras.org/florataxon.aspx?flora_id=2&taxon_id=200011866
16.*Sindora siamensis* Teijsm. ex Miq. CAESALPINIACEAE has rings delimited by dense late wood. Dominant in dry deciduous dipterocarp forest, also frequent in beach forest (Smitinand and Larsen, 1985). Geographic distribution: Malay Peninsula, Thailand, Indochina, Laos. Small deciduous tree, very rarely above 15 m high.
http://fos.nud.edu./a/biotik/species/s/sinsi/sinsi_en.html
17.*Lagerstroemia macrocarpa* Wall. ex Kurz LYTHRACEAE has ring-porous wood. Found in dry and mixed deciduous forest (Weesommai and Kewduangtean, 2004). Geographic distribution: Myanmar, Laos, Thailand. Small tree to 12 m.
http://www.biotik.org/laos/species/?/lagma/lagma_en.html
18.*Chukrasia tabularis* A. Juss. MELIACEAE has ring-porous wood, terminal parenchyma, dense late wood. Found in mixed deciduous and dry deciduous forest at 50-600 m elevation (Department of National Park, Wildlife and Plant Conservation, 2007). Geographic distribution: S China, India, Nepal, Sri Lanka, Cambodia, Laos,

Thailand, Vietnam, Indonesia (Sumatra), Malaysia (Malay Peninsula). Deciduous tree to 25m.
http://www.ars.grin.gov/cgi-bin/npgs/html/taxon.pl?10517
19.*Catunaregam spathulifolia* Tirveng. RUBIACEAE. Thailand endemic? Found in mixed deciduous forest, dry dipterocarp forest and beach forest, up to 600 m elevation (Department of National Park, Wildlife and Plant Conservation, 2007). Thailand endemic? Shrub or small tree. (Plate 42, p.57)
20.*Dioecrescis erythroclada* (Kurz) Tirveng. RUBIACEAE has rings delimited by terminal parenchyma. Found in mixed deciduous forest, dry dipterocarp forest and along the edge of moist evergreen forest (Weesommai and Kewduangtean, 2007). Endemic Thailand. Fairly large tree to 12 m. (Plate 44, p.58)
http://www.es.mirror.gbif.org/species/browse/provider/1/taxon/16631290
21.*Haldina cordifolia* (Roxb.) Ridsdale RUBIACEAE has rings delimited by terminal parenchyma. Found in deciduous vegetation (e.g. mixed deciduous forest, deciduous dipterocarp-oak forest, deciduous forest with bamboo) also over limestone sometimes associated with seasonal forest, elevation 250-550 m asl. (Plate 41, p.56)
http://homepage.univie.ac.at/Christian.puff/FTH-RUB-HOME.htm
Geographic distribution: S China, Bangladesh, India, Nepal, Sri Lanka, Cambodia, Laos, Vietnam, Myanmar, Thailand.
http://www.ars.grin.gov/cgi-bin/npgs/html/taxon.pl?103231
22.*Hymenodictyon excelsum* (Roxb.) Wall. RUBIACEAE has rings delimited by terminal parenchyma. Found in mixed deciduous forest and along edge of dry evergreen forest, 30-500 m elevation (Royal Forest Department, 1984). Geographic distribution: India to Myanmar, Java, Philippines. A small to medium sized tree up to 25 m tall. (Plate 45, p.58)
http://www.ars.grin.gov/cgi-bin/npgs/html/taxon.pl?19520
23.*Mitragyna rotundifolia* (Roxb.) O. Kuntze (=*Mitragyna brunonis*) RUBIACEAE has ring-porous wood and delimited by terminal parenchyma. Found in mixed deciduous forest, dry dipterocarp forest, and along the edge of moist evergreen forest (Weesommai and Kewduangtean, 2004). Geographic distribution: E India, Bangladesh, Myanmar, Laos. Small to fairly large trees. (Plate 43, p.57)
http://homepage.univie.ac.at/puffc9/FTH-RUB-Mitragyna-Mitragyna_comp_WEB.htm
24.*Murraya paniculata* (Linn.) Jack RUTACEAE has rings delimited by terminal parenchyma. Found in evergreen forest and rarely found on limestone mountains (Royal Forest Department, 1984). Geographic distribution: S and SE Asia, China, Australasia. Shrub or small tree to 10 m high.
http://en.wikipedia.org/wiki/Murraya_paniculata
25.*Schleichera oleosa* (Lour.) Oken SAPINDACEAE has rings delimited by terminal parenchyma. Found in regions with a dry period, like deciduous dipterocarp forest, mixed deciduous forest, savanna, on day to periodically rather swampy soils of various types, sea level to 900(-1200) m (Santisuk and Larsen, 1999). Geographic distribution: India, Nepal, Sri Lanka, Indochina, Myanmar, Thailand, Indonesia, Malaysia. Tree up to 40 m high.
http://www.ars.grin.gov/cgi-bin/npgs/html/taxon.pl?33252
26.*Sterculia pexa* Pierre STERCULIACEAE has rings delimited by terminal parenchyma. Found in dry evergreen forest, 100-900 m elevation (Department of National Park, Wildlife and Plant Conservation, 2007). Geographic distribution: S China, Laos, Vietnam, Thailand. Deciduous tree up to 20 m.
http://www.efloras.org/florataxon.aspx?flora_id=2&taxon_id=200013864
27.*Colona flagrocarpa* Craib TILIACEAE has rings delimited by terminal parenchyma. Found in mixed deciduous forest 400-1000 m. Geographic distribution: Bengal (type), Laos, Thailand and Vietnam (Smitinand and Larsen, 1993). Tree up to 10 m high. (Plate 46, p.59)

India
Team India summarized their reconnaissance in Appendix 5 so that aside from a list of tree species with distinct growth rings, corresponding information on the habitat, geographic distribution and tree habit are also given below.
1.*Holoptelea integrifolia* Planch. (=*Holoptelea grandis* (Hutch.) Mildlor) ULMACEAE rings indistinct or distinct, present because of contrasting density of the lighter early wood and darker late wood. Vessels diffuse porous. Geographic distribution: Entire India except West zone. Large deciduous tree, up to 18m tall. (Plate 51, p.60)
http://www.flowersofindia.net/catalog/slides/Indian_Elm.html
2.*Anogeissus latifolia* (Roxb. ex DC) Wall. ex Guill. & Perr. COMBRETACEAE rings present but inconspicuous, delimited by concentric terminal parenchyma, vessels diffuse porous. Geographic distribution: India, Nepal, Pakistan and Sri Lanka. Small to medium tree, up to 15m height. (Plate 47, p.59)
http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?3511
http://www.liberherbarium.com/Pn5493.HTM
3.*Dalbergia latifolia* Roxb. FABACEAE with rings delimited by large early wood, as a rule vessels are diffuse porous, very rarely with slight semi-ring porous tendency. Found in dry deciduous forests in India. Geographical distribution: India, Indonesia? Trees up to 20-40m tall and girth 1.5-2m. (Plate 53, p.61)
http://www.agroforestrycentre.org/SEA/Products/AFDbases/AF/asp/SpeciesInfo.asp?SpID=1726#Ecology
http://www.winrock.org/fnm/factnet/factpub/FACTSH/D_latifolia.html
4.*Pterocarpus marsupium* Roxb. FABACEAE has its rings indistinct but tends to semi-ring porosity. Found up to 900 m.
http://ezinearticles.com/?Pterocarpus_Marsupium-Roxb&id=1096020
Geographic distribution: C and S India, Sri Lanka. (Plate 52, p.61)
http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?30289
5.*Lagerstroemia lanceolata* Wall. LYTHRACEAE has rings distinct, ring-porous. Geographic distribution: India, medium to large tree about 25 m tall or higher.
http://us.mirror.gbif.org/species/15596607 (Plate 48, p.60)
6.*Terminalia bellerica* (Gaertn.) Roxb. COMBRETACEAE has distinct growth rings being ring porous. Grows wild in subhimalayan tracts. Geographical distribution: Sri Lanka, India, Pakistan, Myanmar, Indochina, Thailand, Malay Peninsula. Large deciduous tree, 12-50 m tall, ashy bark with bluish tinge.
http://www.eflora.org/florataxon.aspx?flora_id=5&taxon_id=250070668
7.*Terminalia tomentosa* (Roxb.) Wight & Arn. COMBRETACEAE has growth rings indistinct to distinct. Note: This taxon is synonymn to *Terminalia alata* Heyne ex Roth. and to which is also combined with *Terminalia elliptica* Willd. Grows in moists soils and one of the last trees to shed its leaves. Geographical distribution: S and SE Asia in India, Bangladesh, Myanmar, Thailand, Laos, Cambodia, Vietnam. Large deciduous tree 20-30 m tall.
http://www.fao.org/ag/aGA/AGAP/FRG/afris/Data/459.HTM
http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?410549
8.*Toona ciliata* M. Roem. MELIACEAE has a ring-porous wood, hence distinct growth rings. Grows in primary and disturbed, often riparian, rainforests from sea level to 1500 m elevation, occasionally higher. Geographic distribution: Pakistan through India, Bangladesh, S China, Myanmar, Thailand to Malesia: Sumatra, Bangka Island, Malay Peninsula, Borneo, Philippines (Luzon, Mindoro), Sulawesi, Lesser Sunda Islands, Moluccas, New Guinea and in New Britain. A medium to large tree (Rojo, J.P., 1999). (Plate 49, p.60)
9.*Celtis tetrandra* Roxb. ULMACEAE has distinct growth rings. Found from 700-2800m elevation. Geographic distribution: Himalaya (Kumaun to Bhutan), India, Myanmar, Indochina, Thailand, Indonesia (Java, Lesser Sunda Islands, N Sumatra). Large tree with smooth grey bark.
http://www.efloras.org/florataxon.aspx?flora_id=5&taxon_id=242311743
http://www.efloras.org/florataxon.aspx?flora_id=110&taxon_id=242311743
10.*Tectona grandis* L. f. VERBENACEAE has ring-porous wood, therefore distinct growth rings. Found in regions with long dry season. Geographic distribution: India,

Indochina (Myanmar, Thailand, Cambodia, Laos, Vietnam), Java (Central). Large deciduous tree.
http://www.flowersofindia.net/catalog/slides/teak.html
11.*Albizia lebbeck* Benth. MIMOSACEAE rings distinct, marked by contrasting light early wood and dark dense late wood. Grows wild on limestone and sandy coral loam; sea level to 750 m elevation. Geographic distribution: Tropical mainland Asia and E Africa. Introduced elsewhere in the tropics. Medium to large tree to 30 m tall and 90 cm dbh (Rojo, J.P., 1999). (Plate 50, p.60)

Sri Lanka
Team Sri Lanka summarized their reconnaissance work in Appendix 6. Below is a list of the tree species they found to have distinct growth rings including their geographic distribution.
1.*Semecarpus nigro-viridis* Thw. ANACARDIACEAE has distinct growth rings. Geographical distribution: Sri Lanka endemic.
http://data.gbif.org/species/Semecarpus+nigro-viridis
2.*Mallotus philippensis* (Lamk.) Muell.-Arg. EUPHORBIACEAE distinct growth rings. Common in thickets and in secondary forests at low elevations. Geographical distribution: West Himalayas to Malesia, Australia and Melanesia. Philippines (throughout the archipelago). A small tree (Rojo, J.P., 1999).
http://www.efloras.org/florataxon.aspx?flora_id=620&taxon_id=242413649
3.*Piliostigma racemosa* (Lamk.) Benth. CAESALPINIACEAE has distinct growth rings. Geographic distribution: West Pakistan (Punjab); India, Sri Lanka, Myanmar, S China.
http://http://www.eflora.org/florataxon.aspx?flora_id=5&taxon_id=250063481
4.*Cassia fistula* Linn. CAESALPINIACEAE rings marked by light early wood and dark late wood associated with confluent to metatracheal parenchyma. Geographic distribution: India, Sri Lanka, Myanmar, Northern Thailand (Rojo, J.P., 1999).
5.*Cinnamomum dubium* Nees LAURACEAE rings marked by contrasting light early wood and dark late wood. Geographic distribution: Sri Lanka, Indonesia.
http://data.gbif.org/species/15550357
6.*Azadirachta indica* A. Juss. MELIACEAE has ring-porous wood, hence distinct growth rings. Geographic distribution: Bangladesh, India, Myanmar. (Plate 54, p.61).
http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?6161.
7.*Chukrasia tabularis* A. Juss. MELIACEAE has ring-porous wood, terminal parenchyma, dense late wood thus distinct growth rings. (See this taxon also featured from the Indian reconnaissance.) (Plate 55, p.61)
8.*Syzygium aqueum* (Burm.f.) Alst. MYRTACEAE has indistinct or distinct growth rings. Geographic distribution: India to Malaysia.
8.*Syzygium spathulatum* Thw. MYRTACEAE has rings due to contrasting light early wood and dark late wood. Sri Lanka endemic. (Plate 56, p.62)
http://en.wikipedia.org/wiki/Syzygium_spathulatum
9.*Gomphia serrata* (Gaertn.) Kanis OCHNACEAE has distinct growth rings. Geographic distribution: Sri Lanka, India and S China to the Philippines, Sulawesi and Borneo.
http://www.asianplant.net/Ochnaceae/Gomphia-serrata.htm
10.*Psydrax dicoccos* Gaertn. RUBIACEAE has distinct growth rings. Geographic distribution: Hongkong, India, Indonesia, Sri Lanka, Thailand and Vietnam.
http://data.gbif.org/species/14246286
11.*Chloroxylon swietenia* DC. RUTACEAE has ring-porous wood and also with terminal parenchyma ending the late wood. Geographic distribution: Central and South India, Sri Lanka.
http://www2.fpl.fpl.fs.fed.us/techsheets/Chudnoff/SE_Asian_Oceanic/htmlDocs_SE Asian/Chloroxylonswietenia.html
12.*Limonia acidissima* L. RUTACEAE has distinct growth rings. Geographic distribution: S China, India, Pakistan, Sri Lanka, Indochina, Myanmar, Thailand.
http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?22253
13.*Dimocarpus longan* Lour. SAPINDACEAE has distinct growth rings. Geographic distribution: S and Mainland SE Asia. (Plate 57, p.62)

14.*Grewia damine* Gaertn. TILIACEAE has distinct growth rings. Geographic distribution: Africa, Himalaya, India.
http://www.efloras.org/florataxon.aspx?flora_id=110&taxon_id=242422691
15.*Tectona grandis* L. f. VERBENACEAE has ring-porous wood hence with distinct growth rings. Geographic distribution: India, Indochina and Java.
http://www.eol.org/pages/579742

Discussion for Team Philippines-Malaysia
Team Philippines registered 40 indigenous tree species with distinct growth rings out of 226 tree species (17%). Team Malaysia has 2 indigenous tree species with distinct growth rings out of 9 (22%). Team Thailand had 28 tree species with distinct growth rings out of 91 tree species investigated (31%). Team India 13 tree species with distinct growth rings out of 29 tree species investigated (44.83%). Team Sri Lanka investigated 65 tree species out of which registered 16 tree species with distinct growth rings (24.62%). Showing tree species have distinct growth rings is just one step. The second step is to show these crossmatch or better crossdate.

Team Philippines is poised to do crossmatching and crossdating analysis. Priority will be given to tree species with at least two trees sampled from the same site, such as the following, namely, *Agathis philippinensis* (4 trees, 7 cores, Laguna-Kalinga), *Bauhinia malabarica* (4 trees, 8 cores, Nueva Ecija), *Pterocarpus indicus* (5 trees, 10 cores, Laguna-Nueva Ecija), *Calophyllum inophyllum* (3 trees, 6 cores, Laguna), *Cratoxylon formosum* (2 trees, 4 cores, Laguna), *Cratoxylum sumatranum* (3 trees, 5 cores, Laguna-Nueva Ecija), *Planchonia spectabilis* (2 trees, 4 cores, Laguna), *Lagerstroemia speciosa* (2 trees, 4 cores, Laguna), *Hibiscus campylosiphon* (2 trees, 4 cores, Laguna), *Dysoxylum gaudichaudianum* (2 trees, 4 cores, Laguna), *Melia azedarach* (5 trees, 9 cores, Laguna-Palawan), *Toona calantas* (3 trees, 6 cores, Laguna), *Toona sureni* (2 trees, 4 cores, Laguna), *Albizia procera* (4 trees, 9 cores, Nueva Ecija), *Wallaceodendron celebicum* (3 trees, 6 cores, Laguna), *Knema glomerata* (2 trees, 4 cores, Laguna), *Myristica philippensis* (2 trees, 4 cores, Laguna), *Pinus kesiya* (24 trees, 48 cores, Laguna-Nueva Ecija), *Pometia pinnata* (3 trees, 6 cores, Laguna), *Sterculia foetida* (11 trees, 22 cores, Laguna- Batangas-Bataan), *Commersonia bartramia* (2 trees, 4 cores, Palawan) and *Colona serratifolia* (4 trees, 7 cores, Laguna-Palawan). The following taxa had been sampled from only one tree namely, *Pistacia chinensis* (Laguna), *Goniothalamus amuyon* (Laguna), *Sindora supa* (Laguna), *Dehaasia incrassata* (Laguna), *Barringtonia curanii* (Palawan), *Lagerstroemia pyriformis* (Laguna), *Horsfieldia costulata* (Laguna), *Pinus merkusii* (Laguna), *Nageia wallichiana* (Laguna), *Podocarpus rumphii* (Laguna), *Dacrycarpus imbricatus* (Kalinga), Taw-a2 (Palawan), *Kleinhovia hospita* (Laguna), *Pterospermum diversifolium* (Laguna), *Grewia multiflora* (Laguna) and unidentified tree (Kalinga). Exotic tree species collected from Laguna were *Araucaria heterophylla*, *Cedrela odorata* and *Swietenia macrophylla* with one tree and two cores each. Collected in Carranglan, Nueva Ecija with one tree and two cores apiece were *Cassia fistula* and *Acacia catechu*.

Carranglan, Nueva Ecija is among the driest places in Northern Luzon because of the rainshadow effects of two interconnected mountain ranges namely the east-west trending Caraballo Mountain Range united with the north-south trending Sierra Madre Mountain Range. Replicated sampling was conducted here with *Pinus kesiya* (20 trees, 40 cores) and with *Tectona grandis* (20 trees, 40 cores). Note that the pines were from natural forest stand in Binbin, at 1000 m asl while the teak were from a plantation in Punkan, 300 m asl. The first samples of *Pinus kesiya* and *Tectona grandis* had their respective average ring width series plotted in a graph and overlaid with the Southern Oscillation Index graph (Figure 1). Their rings match and apparently synchronize with La Niña and El Niño events.

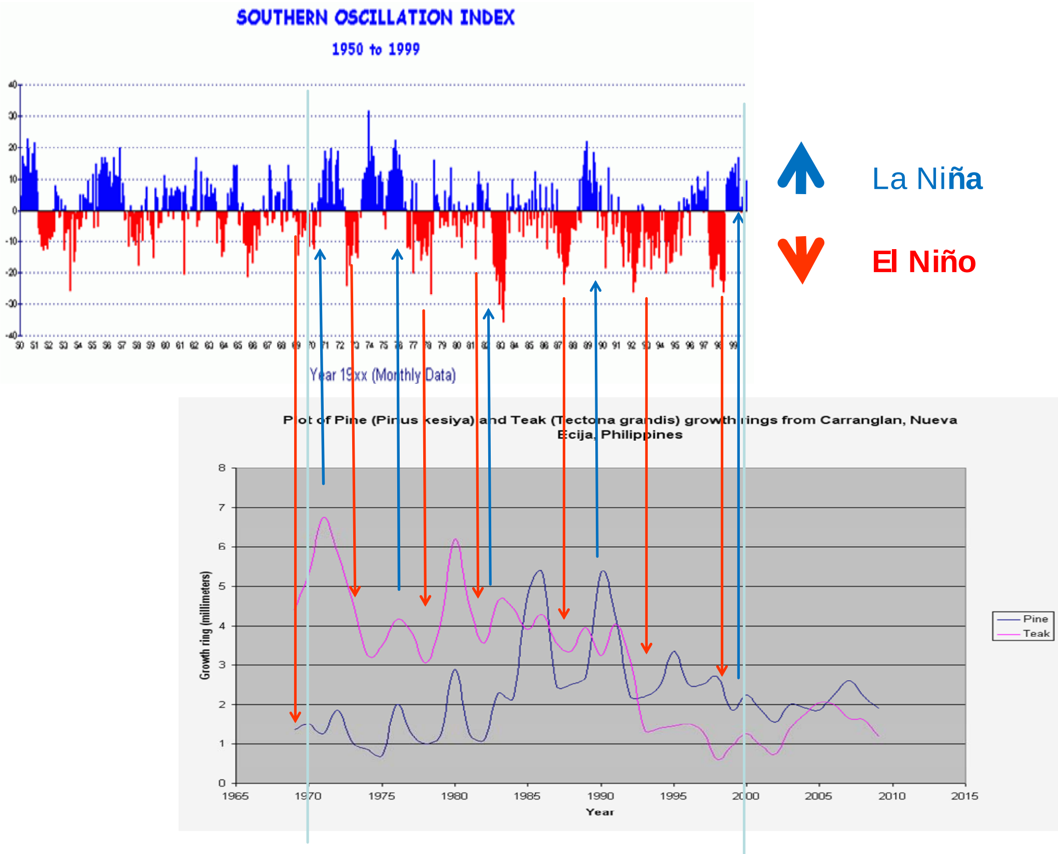


Figure 1. Plot of pine *Pinus kesiya* (blue line) and teak *Tectona grandis* (red line) growth ring series against time (years) of Carranglan, Nueva Ecija, Luzon, Philippines and their correspondence with El Niño and La Niña events (Source: http://www.john-daly.com/elnino.htm)

Lacking a tree ring laboratory, Team Malaysia took replicated samples even if they were not sure the trees they core have absent, indistinct or distinct growth rings. They collected from Mt. Trus Madi, Sabah, Malaysia 31 trees and 60 corewood samples from 9 species. The corewood samples were sent to the Philippines for surfacing and scanning. The result, two out of nine broad-leaved species have distinct growth rings, Bayor *Pterospermum* cf. *elongatum* (5 trees, 10 cores) and Kulimpapa *Vitex pinnata* (4 trees, 8 cores). Team Philippines also assisted Team Malaysia do their replicated dendrochronology field work for indigenous conifers in Mt. Kinabalu at 1,600 m asl with the following, namely, *Agathis borneensis* (19 trees, 38 cores), *Dacrycarpus imbricatus* var. *patulus* (4 trees, 8 cores), *Dacrycarpus imbricatus* (4 trees, 8 cores), *Phyllocladus hypophyllus* (6 trees, 12 cores) and *Dacrydium gracilis* (1 tree, 2 cores).

All the aforementioned corewood samples from the Philippines and Sabah, Malaysia are systematically filed at the Tree Ring Laboratory Xylaria, School of Environmental Science and Management (SESAM), UPLB. Total corewood samples number 1,102. This comes from 554 trees in 252 species. Of this number, 273 corewood samples are from 53 tree species with distinct growth rings ready to be crossmatched and crossdated (Appendix 3).

After the 53 tree species with distinct growth rings will be crossmatched or crossdated, the usefulness of the tree species for future dendrochronology research will be based on the following criteria: (1) wide geographic distribution, and (2) accessability and supply, like their abundance and presence in accessible natural forests (e.g. national parks). Depending upon the application of dendrochronology, other criteria compatible with the purpose of research comes in. For dendroclimatology, the species should have old trees growing in sensitive sites. For dendroecology, all actors in the succession drama like pioneer and climax tree species are valuable as long as their wood exhibit distinct growth rings.

Discussion for Team Thailand

Team Thailand conducted its reconnaissance in one location in Northeast Thailand (Map 3) at Sakaerat Environmental Research Station (SERS), about 80 km^2 of dry evergreen and dry dipterocarp forest. As shown in Appendix 4, it studied 91 species of woody plants and found 28 to have distinct growth rings (30.77%), 21 indistinct rings (23.08%) and 42 absent rings (46.15%). Of the 28 taxa, there were 6 species considered of little value to dendroclimatology because of their habit being shrubs and small trees, namely *Oroxylum indicum*, *Wendlandia tinctoria*, *Catunaregam spathulifolia*, *Dioecrescis erythroclada*, *Murraya paniculata* and *Sterculia pexa.* These may be useful in other applications of dendrochronology like studying forest succession dynamics. If crossmatching and crossdating is proven, the following tree species should be useful in dendroclimatology, namely, *Lannea coromandelica*, *Garuga pinnata*, *Fernandoa adenophylla*, *Markhamia stipulata*, *Bombax anceps*, *Terminalia triptera*, *Dillenia obovata*, *Diospyros mollis*, *Diospyros montana*, *Vitex canescens*, *Afzelia xylocarpa*, *Sindora siamensis*, *Lagerstroemia macrocarpa*, *Albizia odoratissima*, *Cassia fistula*, *Chukrasia tabularis*, *Haldina cordifolia*, *Hymenodictyon excelsum*, *Mitragyna brunonis*, *Schleichera oleosa* and *Colona flagrocarpa*. Their corewood samples are deposited in the Faculty of Forestry Xylaria in Kasetsart University, Bangkok, Thailand.

Discussion for Team India

Team India conducted its field work in Western Ghats region of Karnataka State (Map 4). The team investigated 29 tree species. Out of this number, 10 tree species registered undoubtedly with distinct growth rings, namely, *Anogeissus latifolia* (19 cores, 2 discs), *Michelia champaca* (4 cores, 1 disc), *Albizia lebbeck* (4 cores), *Lagerstroemia lanceolata* (24 cores, 1 disc), *Toona ciliata* (2 cores), *Tectona grandis* (26 cores, 8 discs), *Terminalia bellerica* (10 cores), **Eucalyptus tereticornis* (7 cores, 1 disc), Celtis tetrandra (11 cores), and **Acacia mangium* (1 disc). Those with asterisks are exotic or introduced to India.

Tree species described as indistinct and distinct are interpreted to represent those that have distinct rings in some samples but hazy or indistinct in others. Grouped in this category are *Holoptelea integrifolia* (2 cores), *Adina cordifolia* (=*Haldina cordifolia*) (20 cores), *Mangifera indica* (8 cores), *Dalbergia latifolia* (2 cores), *Hevea brasiliensis (2 cores) and *Pterocarpus marsupium* (20 cores).

The remaining species have no remarks and are interpreted to have absent or indistinct rings, namely, *Gmelina arborea* (27 cores), *Terminalia tomentosa* (10 cores, 1 disc), *Mitragyna parvifolia* (20 cores), *Shorea roxburghii* (8 cores), *Vitex altissima* (3 cores), *Terminalia crenulata* (13 cores, 2 discs), *Bischofia javanica* (2 cores), *Terminalia paniculata* (2 cores, 1 disc), *Calophyllum inophyllum* (2 cores), *Dillenia pentagyna* (3 cores) and **Acacia auriculiformis* (1 disc).

At the end of the project, Team India had collected from 29 tree species a total of 157 corewood samples and 28 discs for their xylaria at the Indian Institute of Tropical Meteorology (ITTM), Pune, India.

Team India also have measured tree ring widths of the following species, *Anogeissus latifolia*, *Albizia lebbeck* and *Dalbergia latifolia*. After analysis, the growth ring series of the three species were plotted in a graph (Figures 2, 3 and 4).

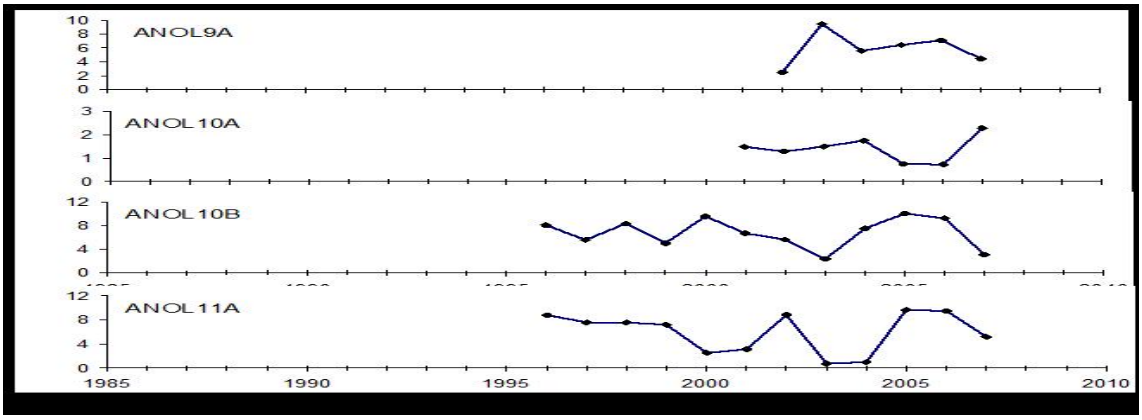


Figure 2. Plot of *Anogeissus latifolia* growth ring series against time (years).

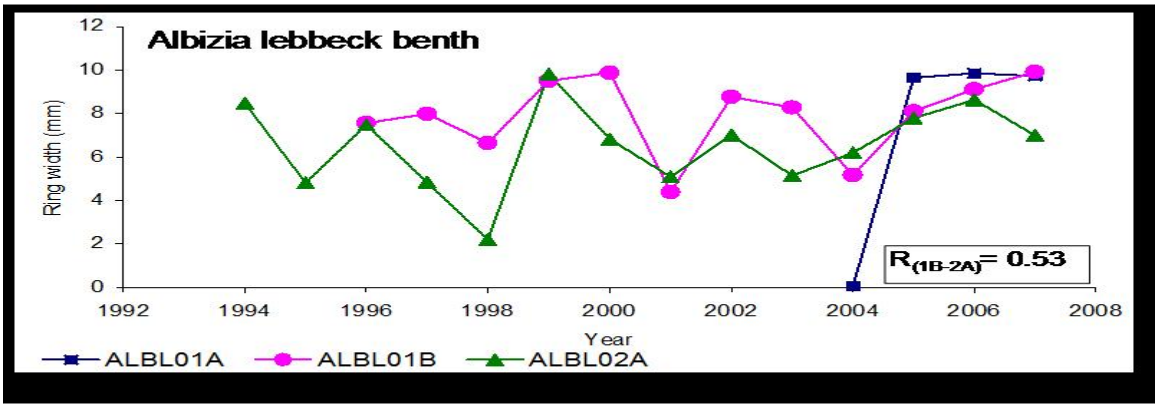


Figure 3. Plot of *Albizia lebbeck* growth ring series against time (years).

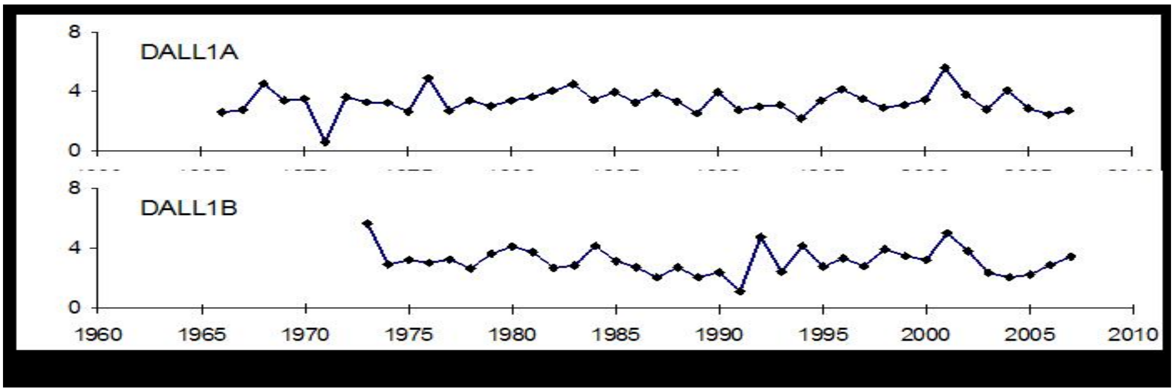


Figure 4. Plot of *Dalbergia latifolia* growth ring series against time (years).

Discussion for Team Sri Lanka

Team Sri Lanka also operated without the benefit of a tree ring laboratory but it studied a total of 65 tree species. *Mallotus philippinensis*, *Bauhinia racemosa*, *Cinnamomum dubium*, *Azadirachta indica*, *Chukrasia tabularis*, *Syzygium spathulatum*, *Gomphia serrata*, *Psydrax dicoccus*, *Chloroxylon swietenia*, *Limonia acidissima* and *Grewia damine* were the 11 tree species that registered positive for distinct growth rings (16.92% of total trees studied). There are tree species that sometimes reveal distinct rings and in other cores of the same species have indistinct rings. In this group which are only irregularly with distinct rings are *Cassia fistula*, *Syzygium aqueum*, *Dimocarpus longan* and surprisingly *Tectona grandis*. The rest shown in Appendix 7 are tree species with absent or indistinct rings. This team has no tree ring laboratory facility and also lacks people to crossdate. This deficiency on top of the rebellion raging in the countryside is a major stumbling block for dendrochronology in Sri Lanka.

Discussion for the whole SSEADENDRO

Prospects for future collaborative and integrative dendrochronology research among SSEADENDRO members (the current collaborators in the present APN Project) are bright because of the current APN Project output. The project shows that the number of tree species with distinct growth rings that have wide geographic range in the Indomalayan region is considerable, some even extending to S China and southwards to tropical Australia like for example *Albizia procera*, *Bauhinia malabarica*, *Toona ciliata* and *Melia azedarach* and likewise with wide ranging tropical conifers like the podocarp, *Nageia wallichii* (Map 6). There are also numerous trees with distinct growth rings whose geographic ranges overlap such that they form continuous areas when their individual geographic ranges are plotted across the Indomalayan region.

A sequel study to crossdate the corewood samples that are now in the various xylarias of the SSEADENDRO may reveal results that would be interesting to dendroclimatology. Take for instance overlaying Team India's plotted growth ring series of *Albizia lebbeck* and *Dalbergia latifolia* with Team Philippine's graphs for pine *Pinus kesiya* and *Tectona grandis* and the Southern Oscillation Index may reveal interesting trends worth studying in more detail (Figure 5a and 5b).

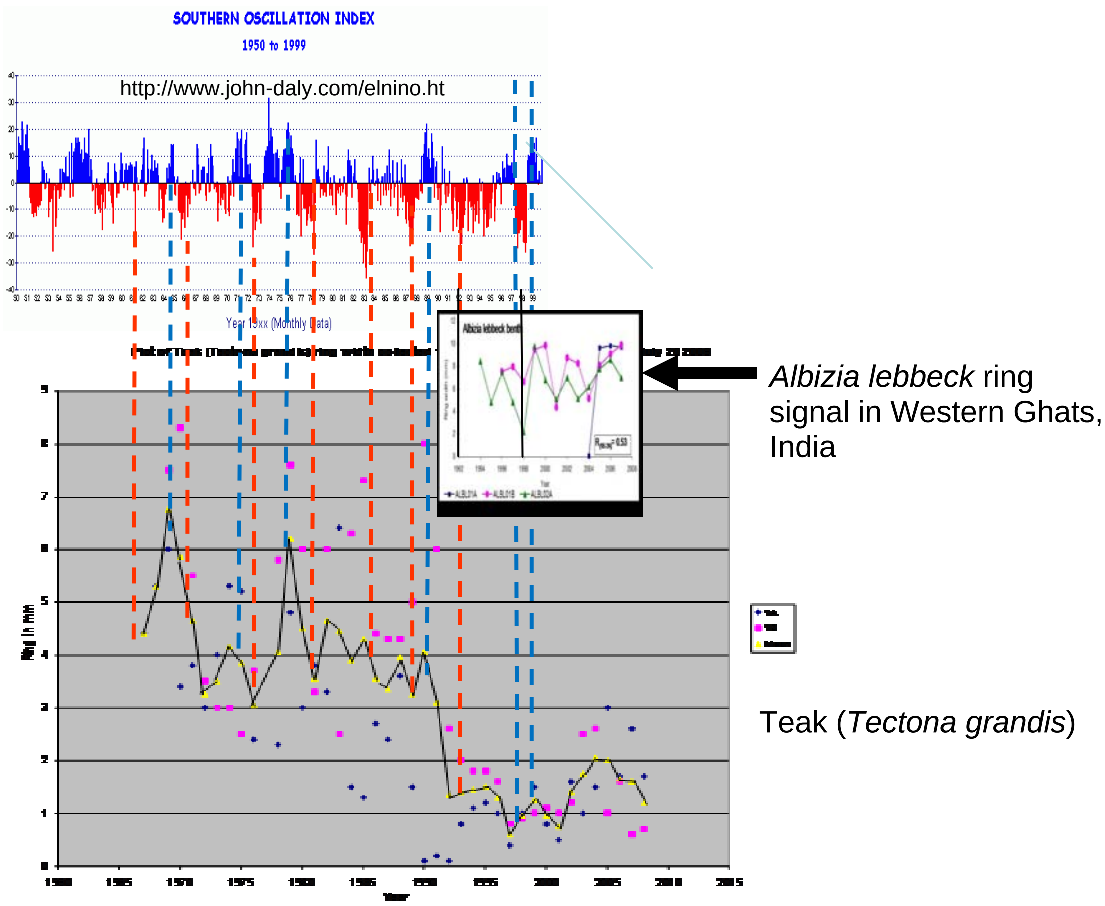


Figure 5a. Overlay of Philippine teak (Tectona grandis) and Indian (Albizia lebbeck) tree rings Southern Oscillation Index (SOI).

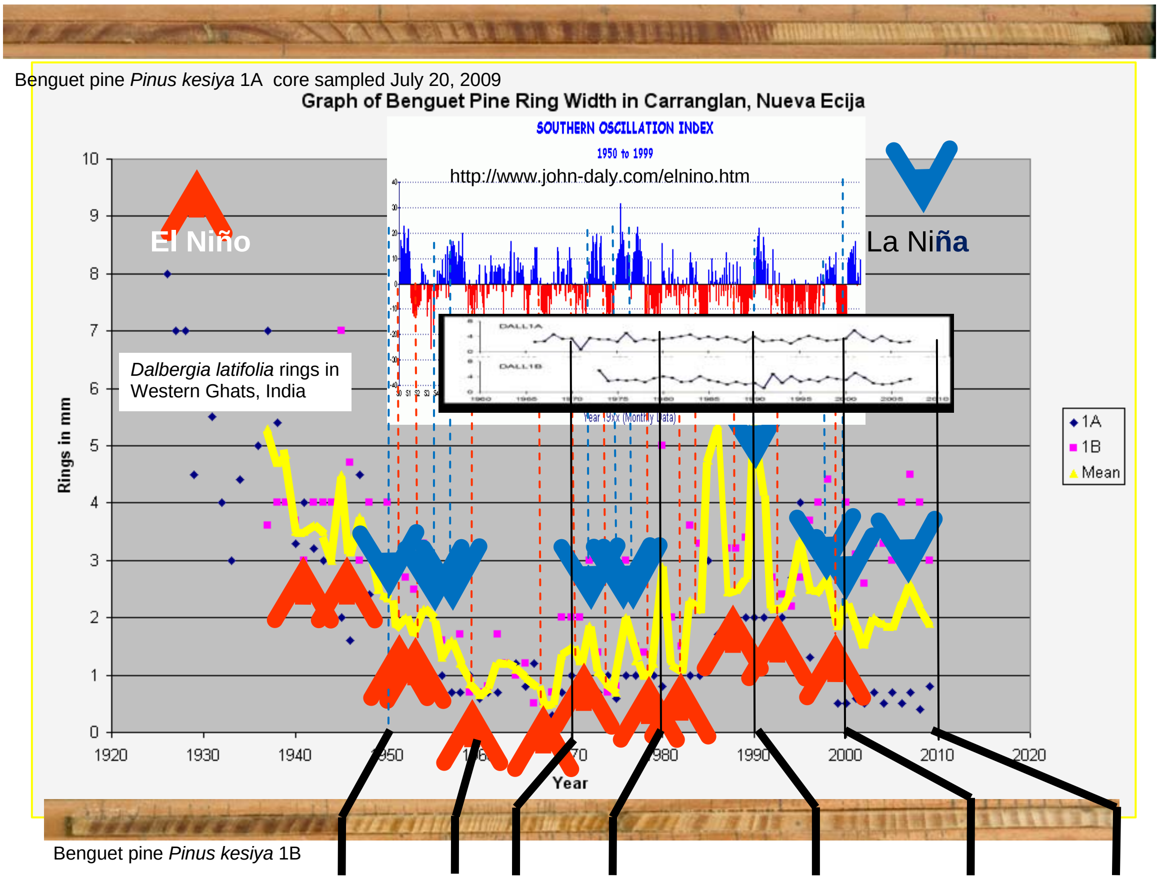


Figure 5b. Overlay of Philippine (*Pinus* kesiya) and Indian (*Dalbergia* latifolia) tree rings with Southern Oscillation Index (SOI).

Figure 1 reveals Northern Luzon pine and teak ring series synchronously follow the El Niño and La Niña pulses. The Indian ring series of *Albizia lebbeck* and *Dalbergia latifolia* were superimposed. Certain agreement between the Indian and the Philippine tree ring widths is apparent (Figure 5a and 5b) although this should be substantiated by more tree ring data-points spread across the Indomalayan region. Crossdating corewood samples in the existing SSEADENDRO xylarias is just one stepping stone. From this leads more studies that would shed light to the Tropical Asia Monsoon. This serves as springboard to a better designed collaborative dendroclimatological research using the expanded array of tree species that allow greater data points. Greater data points, in turn, enable greater resolution of information leading to superior modeling of climate in the region.

4.0 Conclusions

Since the whole Indomalayan region is not known dendrochronologically except in the Himalayas and pine forest stands of India and Southeast Asia, dendrochronologists in SSEADENDRO resolved to conduct reconnaissance of Indomalayan tree species with distinct growth rings. The present APN Project found many trees with distinct growth rings in the Philippines, Malaysia (Sabah), Thailand, India and Sri Lanka. Establishment of a new tree ring laboratory in the Philippines, courtesy of American collaborators (LDEO of Columbia University, NY, USA), was realized as part of the objectives of the APN Project aside from training opportunities they have offered. Numerous corewood samples are now filed in the xylarias of collaborators for both with rings and without apparent rings. If species with distinct growth rings will be studied and found to crossdate, they will become new assets to the science of dendrochronology. Realization of this objective will make the Indomalayan region dendrochronologically literate, so to speak, and will be able to address the challenges of climatology and forest ecology in this western side of the Asia Pacific region.

5.0 Future Directions

New directions on dendrochronology addressing climatology would unfold as a result of successful reconnaissance. Forests on limestone would be an interesting target for dendroclimatology research and this could be tied with other palaeoclimatological studies particularly those involving core sampling of karst limestone and caves using stable isotopes. Lastly, new directions on the application of dendrochronology in forest ecology will have something to deal with the monitoring of the effect of alien bioinvasive tree species on natural forest ecosystem dynamics and succession. With the identification of 100 tree species with distinct rings by the project (Figure 6a), SSEADENDRO may next work on knowing which of these tree species crossdate. This done, SSEADENDRO shall have opened the whole Indomalayan Region (Figure 6b) to dendrochronology and its practical and scientific applications, like higher resolution climate modeling due to increased data points.

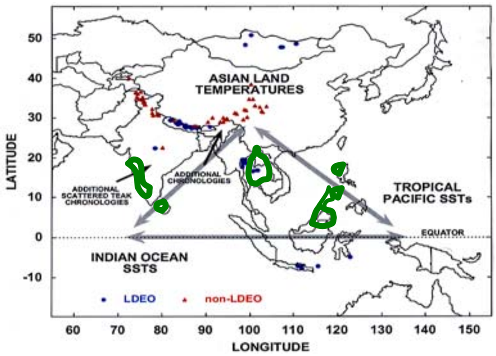


Figure 6a. Project sampling area.

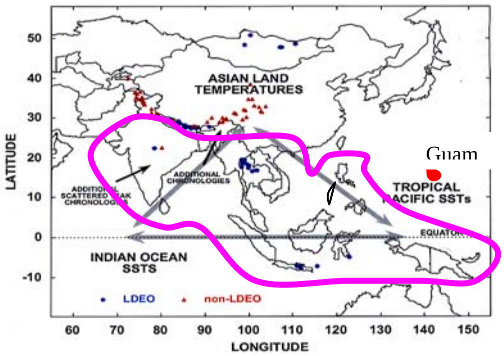


Figure 6b. The Indomalayan Region.

References

On dendrochronology:

ALLEN, K.J., E.R. COOK, R.J. FRANCEY, and K. MICHAEL. 2001. The climatic response of *Phyllocladus aspleniifolius* (Labill.) Hook.f. in Tasmania. JOURNAL OF BIOGEOGRAPHY 28(3): 305-316.

BELL, V. E. and R.E. BELL. 1958. Dendrochronological studies in New Zealand. TREE RING BULLETIN 22:2-6.

BHATTACHARYA, A., LAMARCHE, JR., V.C., TELEWSKI, F.W. 1988. Dendrochronological reconnaissance of the conifers of northwest India. TREE-RING BULLETIN 48: 21-30.

BHATTACHARYYA, A., LAMARCHE, Jr., V.C. and HUGHES, M.K. 1992a. Tree-ring chronologies from Nepal. TREE-RING BULLETIN 52: 59-66.

BHATTACHARYYA, A., YADAV, R.R., BORGAONKAR, H.P. and PANT, G.B. 1992b. Growth ring analysis of Indian tropical trees: Dendroclimatic potential, CURRENT SCIENCE, 62, 736-741.

BILHAM, R., PANT, G.B. and JACOBY, G.C. 1983. Dendroclimatic potential of Juniper trees from the Sir Sar range in the Karakoram, MAN AND ENVIRONMENT, 7, 45-50.

BORGAONKAR, H.P., PANT, G.B. and RUPA KUMAR, K. 1994. Dendroclimatic reconstruction of summer precipitation at Srinagar, Kashmir, India, since the late-eighteenth century. THE HOLOCENE, 4, 299-306.

BORGAONKAR, H.P., PANT, G.B. and RUPA KUMAR, K. 1996. Ringwidth variation in *Cedrus deodara* and its climatic response over the Western Himalaya. INT. J. CLIMATOL.

BORGAONKAR, H.P., N. PUMIJUMNONG, B.M. BUCKLEY, O. TAESUMRITH and S. CHUTIWAT, 2001. A dendroclimatic analysis of a Teak (*Tectona grandis*) ring-width chronology from Mae Na, Thailand. THE PALEOBOTANIST 50 (1):

BRÄUNING, A. 2000. Climate history of the Tibetan plateau during the last 1500 years derived from network of juniper chronologies. Abstracts. International Conference on Dendrochronology for the Third Millenium. April 2-7, 2000, Mendoza, Argentina. p.99.

BORGAONKAR, H.P., A.B. SIKDER, SOMARU RAM, K. RUPA KUMAR and G.B. PANT. 2007. Dendroclimatological investigation of high altitude Himalayan conifers and tropical teak in India. KORIAN JOURNAL OF QUATERNARY RESEARCH 21(1): 15-25.

BORGAONKAR, H.P., A.B. SIKDER, SOMARU RAM, and G.B. PANT. 2009. El Niño and related monsoon drought signals in 523-year-long ring width records of teak (Tectona grandis L. f.) trees from South India. PALAEOGRAPHY, PALAEOCLIMATOLOGY, PALAEOECOLOGY, doi:10.1016/j.palaeo.2009.10.026.

BORGAONKAR, H.P., SOMARU RAM, and A.B. SIKDER. 2009. Assessment of tree-ring analysis of high-elevation Cedrus deodara D. Don from Western Himalayan (India) in relation to climate and glacier fluctuations. DENDROCHRONOLOGIA 27(1): 59-69.

BUCKLEY, B.M., J. OGDEN, J. PALMER, A. FOWLER, and J. SALINGER. 2000. Dendroclimatic interpretation of tree-rings in *Agathis australis*: climate correlation functions and master chronology. Royal Society of New Zealand 30: 275-283.

BUCKLEY, B.M., O. TONGJIT, R. POONSRI and N. PUMIJUMNONG. 2001. A dendrometer band study of teak (*Tectona grandis* L. f.) in north Thailand. Palaeobotanist 50: 83-87.

BUCKLEY, B.M., O. TONGJIT, N. PUMIJUMNONG and R. POONSRI. 2001. Dendrometer band studies on *Tectona grandis* in northern Thailand. THE PALEOBOTANIST 50(1): 83-87

BUCKLEY, B.M., B.I. COOK, A. BHATTACHARYA, D. DUKPA and V. CHAUDRY. 2005. Global surface temperature signals in pine ring-width chronologies from southern monsoon Asia. GEOPHYSICAL RESEARCH LETTERS, Vol. 32, L20704, doi:10.1029/2005 GLO23745, 2005.

CHAUDHARY, VANDANA and A. BHATTACHARYYA. 2002. Suitability of *Pinus kesiya* in Shillong, Meghalaya for tree-ring analyses. CURRENT SCIENCE 83(8): 1010-1015.

COOK, E.R., P.J. KRUSIC, and P.D. JONES. 2003. Dendroclimatic signals in long tree-ring chronologies from the Himalayas of Nepal. INTERNATIONAL JOURNAL OF CLIMATOLOGY 23:707-732.

COOK, E.R., R.D. D'ARRIGO, B.M. BUCKLEY, G.C. JACOBY and W.E. WRIGHT. 2004. Tree-ring reconstructions of Asian Monsoon climate dynamics, an NSF ESH Proposal. 20 pp.

COOK, E.R., R.D. D'ARRIGO, B.M. BUCKLEY, G.C. JACOBY and W.E. WRIGHT. 2004. Tree-Ring Reconstructions of Asian Monsoon Climate Dynamics. NSF ESH Proposal.

D'ARRIGO, R.D. and G.C. JACOBY. 1993. Secular trends in high northern-latitude temperature reconstructions based on tree rings. CLIMATIC CHANGE 25: 163-177.

D'ARRIGO, R. and G. JACOBY. 1994. On the need to rescue teak wood from Southeast Asia for dendroclimatic study. PAGES Newsletter v. 2 (3): November.

DUANGSATHAPORN, K. 2006. Application of tree ring analysis to teak plantation management in Thailand, in the Proceedings of the 7th International Conference on Dendrochronology, June 11-17, 2006, Beijing, China

DREW, A.P. 1998. Growth rings, phenology, hurricane disturbance and climate in *Cyrilla racemiflora* L., a rainforest tree of the Luquillo Mountains, Puerto Rico. BIOTROPICA 30(1): 35-49.

ESHETE, G., and G. STAHL. 1999. Tree rings as indicators of growth periodicity of acacias in the Rift Valley of Ethiopia. FOR. ECOL. MAN., 116, 107-117.

ESPER, J. 2000. Long-term tree-ring variations in *Juniperus* at the upper timber-line in the Karakorum (Pakistan). THE HOLOCENE 19:253-260.

FICHTLER, E., V. TROUET, H. BEECKMAN, P. COPPIN and M. WORBES. 2004. Climatic signals in tree rings of *Burkea africana* and *Pterocarpus angolensis* from semiarid forests in Namibia. TREES 18: 442-451.

FILHO, M.T., C.S. LISI, N. HANSEN and G. CURY. 2004. Anatomical features of increment zones in different tree species in the State of Sao Paulo, Brazil. SCIENTIA FORESTALIS 66: 46-55.

FOWLER, A., J. PALMER, J. SALINGER, and J. OGDEN. 2000. Dendroclimatic interpretation of tree-rings in *Agathis australis* (kauri). 2. Evidence of a significant relationship with ENSO. JOURNAL OF THE ROYAL SOCIETY OF NEW ZEALAND 30(3): 277-292.

GOURLAY, I. D. (1995), Growth ring characteristics of some African acacia species, JOURNAL OF TROPICAL ECOLOGY, 11, 1212-1140.

HEINRICH, I. and J.C.G. BANKS. 2005. Dendroclimatological potential of the Australian red cedar *Toona ciliata* M. Roem. AUSTRALIAN JOURNAL OF BOTANY 53: 21-32.

HUGHES, M.K. and DAVIES, A.C. 1987. Dendroclimatology in Kashmir using tree-ring widths and densities in subalpine conifers. In: METHODS OF DENDROCHRONOLOGY : East-West Approaches (L. Kairiukstis, Z. Bednarz and E. Feliksik, Eds.), International Institute for Applied System Analysis/Polish Academy of Sciences, Warsaw, pp.163-175.

MARIAUX, A. 1995. Growth periodicity in tropical trees: foreword. IAWA JOURNAL, 21: 3-30.

MEIJER, W. 1974. Field Guide to Trees of West Malesia. 328pp.

OGDEN, J. 1988. Investigations on the dendrochronology of the genus *Athrotaxis* D. Don (Taxodiaceae) in Tasmania. TREE RING BULLETIN 38: 1-13.

PANT, G.B. 1979. Role of Tree-ring analysis and related studies in Palaeoclimatology : Preliminary survey and scope for Indian Region. MAUSAM, 30, 439.

PANT, G.B. 1983. Climatological signals from the annual growth rings of selected Tree species of India, MAUSAM, 34, 251.

PANT, G.B. and BORGAONKAR, H.P., 1984b. Growth rate of Chir pines (*Pinus roxburghii*) trees in Kumaon Area in Relation to regional Climatology. HIMAL. RES. DEV. 3(II), 1-5.

PANT, G.B., RUPA KUMAR, K. and BORGAONKAR, H.P. 1988b. Statistical models of climate reconstruction using tree ring data. PROC. IND. NAT. SCI. ACAD. 54, 354-364.

RAMESH, R., BHATTACHARYA, S.K. and GOPALAN, K. 1986. Climatic correlations in the stable isotope records of silver fir (*Abies pindrow*) trees from Kashmir, India. EARTH PLANET SCI. LETT., 79, 66-74.

REYES, L.J. 1938. Philippine Woods. MANILA: BUREAU OF FORESTRY. 536pp.

ROJO, J.P. 1999. Revised Lexicon of Philippine Trees. FOREST PRODUCTS RESEARCH AND DEVELOPMENT INSTITUTE, DEPARTMENT OF SCIENCE AND TECHNOLOGY, 484pp.

SCHONGART, J., W.J. JUNK, M.T.F. PIEDADE, J.M. AYRESS, A. HUTTERMANN and M. WORBES. 2004. Teleconnection between tree growth in the Amazonian floodplains and the El Niño-Southern Oscillation effect. GLOBAL CHANGE BIOLOGY 10: 683-692.

SCHONGART, J., B. ORTHMANN, K.S. HENNENBERG, S. POREMBSKI. 2006. Climate-growth relationships of tropical tree species in West Africa and their potential for climate reconstruction, GLOB. CH. BIOL., 12, 1139-1150.

SOMARU RAM, H.P. BORGAONKAR and A.B. SIKDER. 2008. Tree-ring analysis of teak (Tectona grandis L. f.) in Central India and its probable linkage with moisture fluctuation: A case study. JOURNAL OF EARTH SYSTEM SCIENCES 117(5): 637-645.

SOMARU RAM, H.P. BORGAONKAR, A.B. SIKDER. 2009. Varying strength of the relationship between tree-ring and summer month moisture index (April-September) over central India: A case study. QUARTERNARY INTERNATIONAL JOURNAL. Doi:10.1016/Jquaint.2009.07.029.

WORBES, M. (1995), How to measure growth dynamics in tropical trees - A review, IAWA JOURNAL, 16, 337-351.

WORBES, M. 1999. Annual growth rings, rainfall-dependent growth and long-term growth patterns of tropical trees from the Caparo Forest Reserve in Venezuela. JOURNAL OF ECOLOGY, 87: 391-403.

WORBES, A., R. STASCHEL, A. ROLOFF and W.J. JUNK. 2003, Tree ring analysis reveals age structure, dynamics and wood production of a natural forest stand in Cameroon, FOR. ECOL. MAN., 173, 105-123.

WRIGHT, W.E. 2006. Dendrochronology in the Philippines: *Pinus kesiya* in Northern Luzon, in the Proceedings of the 7th International Conference on Dendrochronology, June 11-17, 2006, Beijing, China

VERHEYDEN, A., J. G. KAIRO, H. BEECKMAN and NICO KOEDAM. 2004. Growth rings, growth ring formation and age determination in the mangrove *Rhizophora mucronata*, ANNALS Of BOTANY, 94, 59-66.

References

On plant taxonomy and wood identification:

ALSTON, A.H.G. 1931. A handbook to the flora of Ceylon, pt 6.

BROWNE, F.G. 1955. Forest trees of Sarawak and Brunei and their products. Printed at the Government Printing Office, Kuching, Sarawak, F.W. Lane, Government Printer.

CHOWDHURY, K.A. 1958. Indian woods. several volumes. India Published by the Manager of Publications, Delhi and Printed by the Northern Circle Survey of India, Dehra Dun.

DEPARTMENT OF NATIONAL PARK, WILDLIFE and PLANT CONSERVATION. 2007. Handbook of Wild Plant Studies. Bangkok. (in Thai)

DESCH, H.E. 1957. Manual of Malayan Timbers, Malayan Forest Records No. 15, vol. I & II.

FLORA MALESIANA, 1954-1993. Publication Department, Rijksherbarium/Hortus Botanicus, Leiden, The Netherlands. Aceraceae, Actinidiaceae, Anacardiaceae, Araliaceae-I, Araucariaceae, Betulaceae, Bignoniaceae, Burceraceae, Celastraceae, Chrysobalanaceae, Combretaceae, Coniferales, Crypteroniaceae, Ctenolophonaceae, Cupressaceae, Datiscaceae, Dilleniaceae, Dipterocarpaceae, Fagaceae, Flacourtiaceae, Gnetaceae, Gonystylaceae, Hypericaceae, Icacinaceae, Juglandaceae, Leguminosae-Mimosoideae, Loganiaceae, Magnoliaceae, Myricaceae, Nyctaginaceae, Ochnaceae, Olacaceae, Pinaceae, Podocarpaceae, Proteaceae, Rhizophoraceae, Rosaceae, Sabiaceae, Salicaceae, Simaroubaceae, Sonneratiaceae, Staphyleaceae, Symplocaceae, Taxaceae, Thymeleaceae, Ulmaceae, volumes 1-11.

FLORA OF THAILAND. 2001. The Forest Herbarium, Royal Forest Department, Bangkok. Actinidiaceae, Apocynaceae, Bignoniaceae, Cannabidaceae, Casuarinaceae, Cephalotaxaceae, Crypteroniaceae, Cupressaceae, Dilleniaceae, Ebenaceae, Elaeocarpaceae, Gnetaceae, Hamamelidaceae, Icacinaceae, Leguminosae-Caesalpinioideae, Loganiaceae, Magnoliaceae, Melastomataceae, Myricaceae, Nyctaginaceae, Nyssaceae, Ochnaceae, Oleaceae, Podocarpaceae, Polygalaceae, Proteaceae, Rhizophoraceae, Rosaceae, Salicaceae, Sapindaceae, Saurauiaceae, Simaroubaceae, Sonneratiaceae, Sterculiaceae, Symplocaceae, Theaceae, Tiliaceae. Volumes 1-7.

KERR, A.F.G. 1911. Siamese mountain flora. GEOGR. J. p. 202-3.

___________. 1932. Report on a tour in the provinces of Surat, Pang-Nga, Krabi, Tiang and Patalung (16 Feb., 3 March 1930). The record (Bangkok), vol. XI, p. 211-24.

KHID SUVARNASUDDHI. 1950. Some commercial timbers of Thailand. Their properties and uses. Bangkok, Royal Forestry Department, 51p., maps, photographs.

LEGRIS, P. 1974. Vegetation and floristic composition of humid tropical continental Asia, in UNESCO, Natural Resources of humid tropical Asia, NATURAL RESOURCES RESEARCH, XII. P. 217-236.

MEIJER, W. 1974. Field Guide to Trees of West Malesia. 328pp.

MINISTRY OF NATURAL RESOURCES and UNIVERSITY OF THE PHILIPPINES. 1986. Guide to Philippine Flora and Fauna, Volume III. Section 1. Dipterocarp and Section 2. Non-dipterocarp Tree Species.

REYES, L.J. 1938. Philippine Woods. Manila: Bureau of Printing. 536 p. 88 plates.

ROJO, J.P. 1999. Revised Lexicon of Philippine Trees. College, Laguna, Philippines: Forest Products Research and Development Institute, Department of Science and Technology. 484p.

ROYAL FOREST DEPARTMENT. 1984. Wood and Some Forest Products of Thailand. Faculty of Forestry, Kasetsart University. Bangkok. (in Thai)

SANTISUK, T. and K. LARSEN. 1999. Flora of Thailand. Vol. 7 Part. 1. Diamond Printing Co. Ltd., Bangkok.

SANTISUK, T. and K. LARSEN. 2001. Flora of Thailand. Printed in Thailand at Prachachon Co. Ltd., by Niran Hetrakul.

______________. 1937. Kandy flora. Ceylon, Government Press.

SANTAPAU, H. 1953. The flora of Khandala on the Western Ghats of India. REC. BOT. SURV. INDIA, Vol. 16 (1) I-XXVII.

SOSEF, M.S.M, L.T. HONG, and S. PRAWIROHATMODJO (Editors). 1998. Timber trees: Lesser-known timbers – Plant Resources of South-East Asia. Backhuys Publishers, Leiden. 859 pp.

THE FOREST AND FOREST PRODUCT MANANGEBLE RESEARCH OFFICE. 2004. Thai Wood Characteristics. Royal Forest Department. Bangkok. (in Thai)

THE FOREST RESEARCH OFFICE. 1999. Thai Trees. The Royal Forest Department. Bangkok. (in Thai)

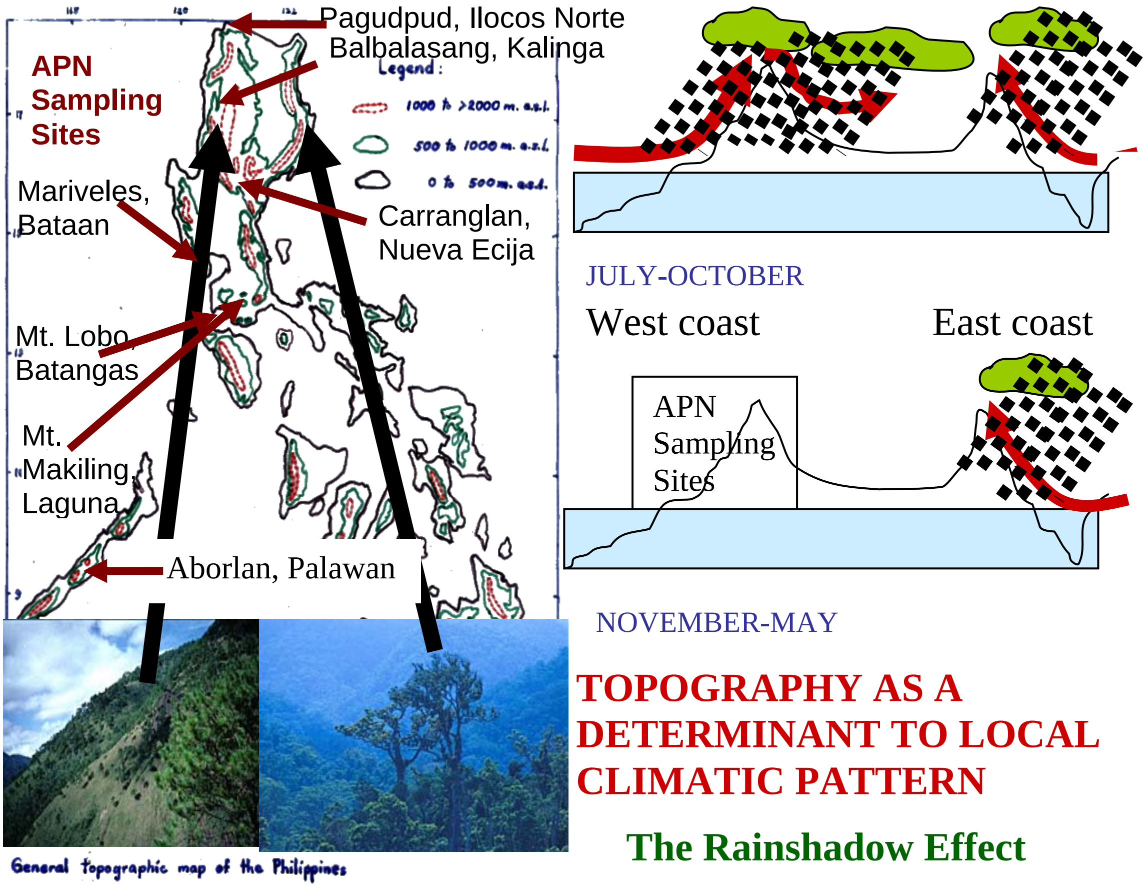
TROTTER, H. 1959. The Common Commercial Timbers of India and their Uses. Printed in India, by the Manager Government of India Press, Nasik and Published by the Manager of Publications, Delhi, 1960.

WEESOMMAI, A. and P. KAEWDUANGTEAN. 2004. Wild Trees of Thailand. I.H.N. Group Publishing, Bangkok. (in Thai)

WYATT-SMITH, J. 1999. Pocket Check List of Timber Trees, Malayan Forest Records, No. 3. Hongkong: Hang Fat Printing Press. 156pp.

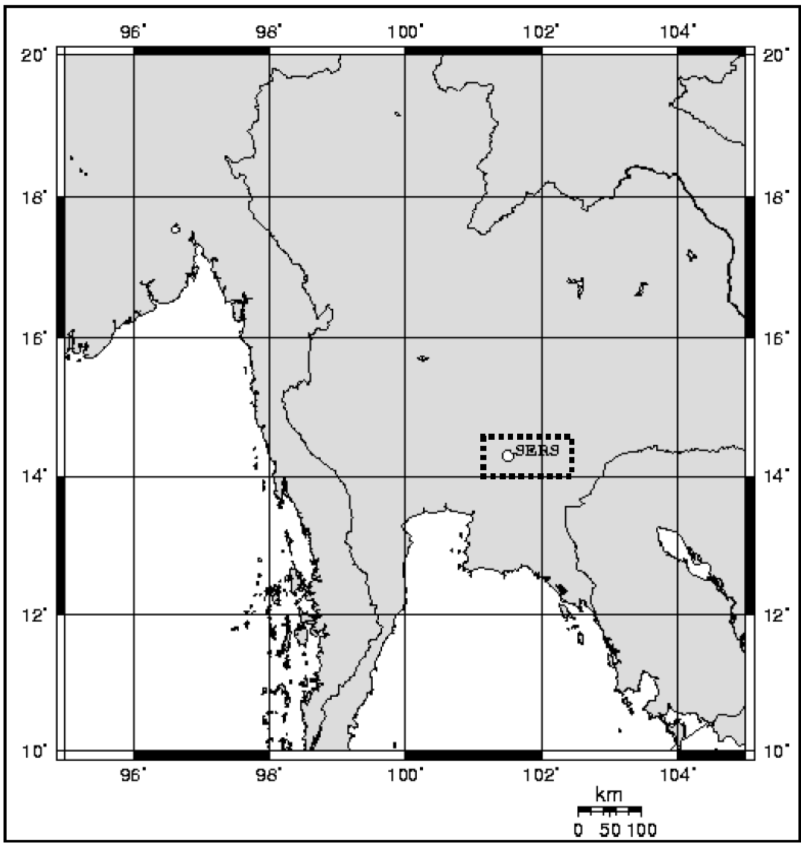
Appendix

Maps



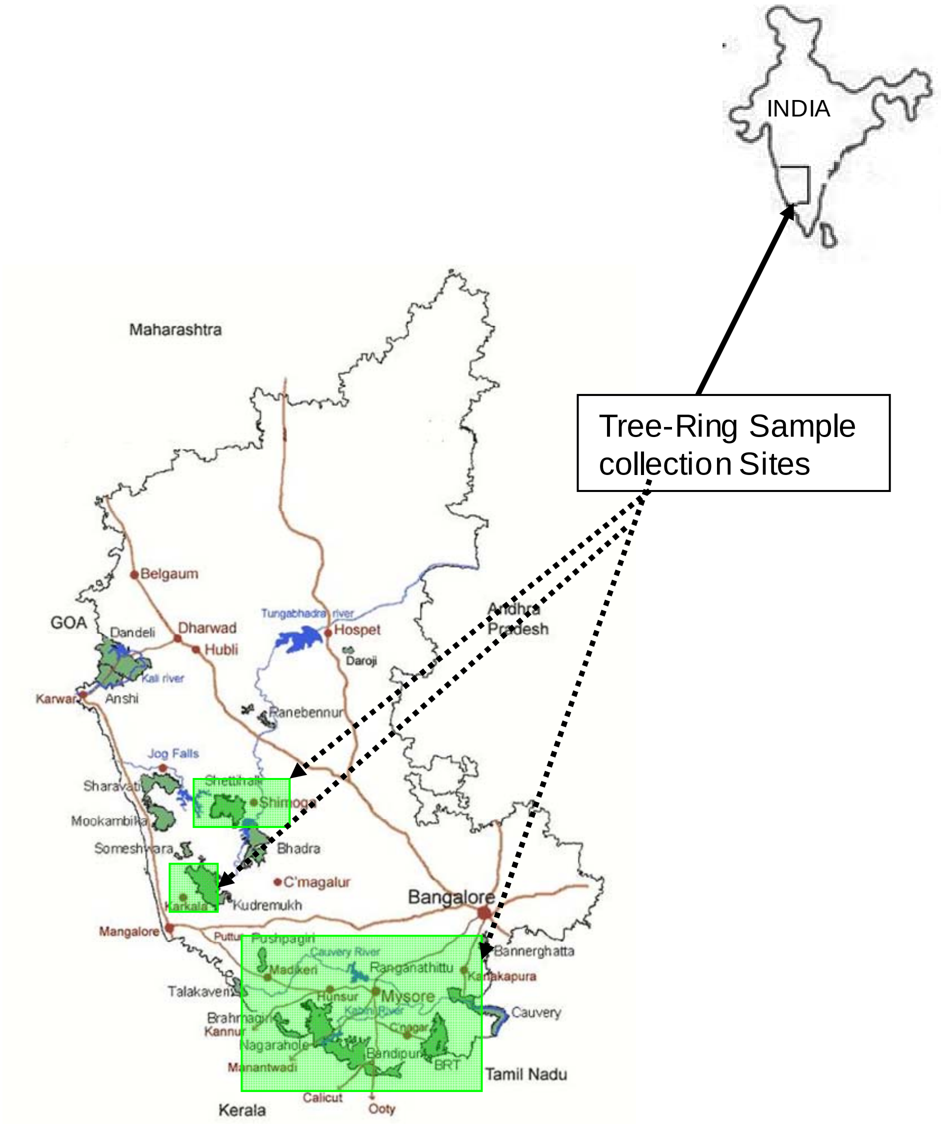
Map 1. Map showing APN Sampling Sites in the Philippines, a) Pagudpud, Ilocos Norte; b) Balbalasang, Kalinga, Cordillera Autonomous Region; c) Carranglan, Nueva Ecija; d) Mariveles, Bataan; e) Mt. Lobo, Batangas; f) Mt. Makiling, Laguna, and g) Aborlan, Palawan.

Map 2. Map showing APN Sampling Sites in Sabah, Malaysia, Mt. Kinabalu and Mt. Trus Madi.



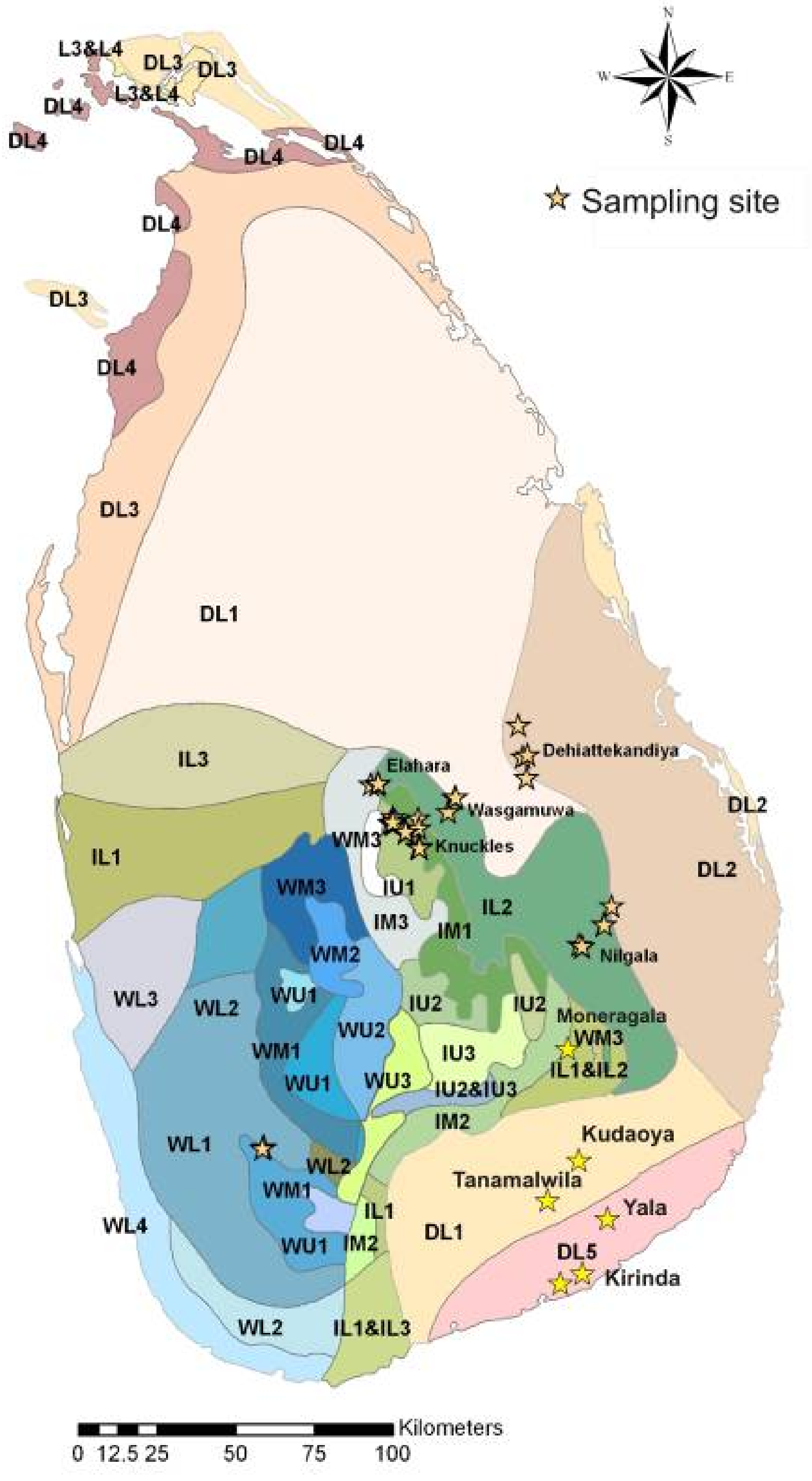
Reconnaissance site of Dr. Khwanchai Duangsathaporn, SERS, Thailand

Map 3. Map showing APN Sampling Site at Sakaerat Environmental Research Station (SERS) in northeast Thailand.



Tree-ring Sampling from India

Map 4. Map showing APN Sampling Sites in Western Ghats in Karnataka State, India.



Map 5. Map showing APN Sampling Sites in Sri Lanka corresponding to four Agroecological Zones (AEZs) sited in the intermediate and three AEZs in the dry zone of Sri Lanka, which have clear annual dry and wet seasons. Ten field visits were done in the eastern escarpment of Knuckles range (IU1, IM1), Elahara (IM3), Kambarawa (IM1), Wasgamuwa (DL1), Dehiattakandiya (DL2), Nilgala (IL2), Moneragala (IL2), Hasalaka (IL2), Bundala (DL5), Yala (DL5) and Thanamalwila (DL1) areas (Map 4) in order to extract core samples, which are located in different agro ecological zones of Sri Lanka.

APPENDIX Table 1. Result of dendrochronology reconnaissance for 225 indigenous Philippine tree species including 11 introduced tree species.

No.	No. trees	No. of cores	Species	FAMILY	Growth Ring		
					Absent	Indist.	Dist.
1	1	2	*Alangium longiflorum*	1ALANGIACEAE		+	
2	1	2	*Alangium javanicum*	ALANGIACEAE		+	
3	4	8	*Buchanania arborescens*	2ANACARDIACEAE		+	
4	2	4	*Buchanania nitida*	ANACARDIACEAE		+	
5	3	6	*Dracontomelon dao*	ANACARDIACEAE		+	
6	2	4	*Dracontomelon edule*	ANACARDIACEAE		+	
7	4	8	*Koordersiodendron pinnatum*	ANACARDIACEAE		+	
8	1	2	*Mangifera altissima*	ANACARDIACEAE		+	
9	1	2	*Mangifera odorata*	ANACARDIACEAE		+	
10	1	2	*Pistacia chinensis*	ANACARDIACEAE			+
11	1	2	*Spondias pinnata*	ANACARDIACEAE		+	
12	2	4	*Cananga odorata*	3ANNONACEAE		+	
13	1	2	*Goniothalamus amuyon*	ANNONACEAE			+
14	1	2	*Miliusa vidaliana*	ANNONACEAE	+		
15	1	2	*Phaeanthus ebracteolatus*	ANNONACEAE	+		
16	1	2	*Platymitra arborea*	ANNONACEAE	+		
17	1	2	*Alstonia angustiloba*	4APOCYNACEAE		+	
18	2	4	*Alstonia macrophylla*	APOCYNACEAE	+		
19	2	4	*Alstonia scholaris*	APOCYNACEAE	+		
20	1	2	*Rauwolfia amsoniaefolia*	APOCYNACEAE	+		
21	6	12	*Wrightia pubescens laniti*	APOCYNACEAE		+	
22	4	8	*Polyscias nodosa*	5ARALIACEAE		+	
23	4	7	*Agathis philippinensis*	6ARAUCARIACEAE			+
24	3	6	*Radermachera pinnata*	7BIGNONIACEAE		+	
25	2	4	*Oroxylon indicum*	BIGNONIACEAE		+	
26	4	8	*Bombax ceiba*	8BOMBACACEAE		+	
27	1	2	*Cordia dichotoma*	9BORAGINACEAE		+	
28	5	10	*Canarium asperum asperum*	10BURSERACEAE		+	
29	4	8	*Canarium hirsutum*	BURSERACEAE	+		
30	1	2	*Canarium luzonicum*	BURSERACEAE		+	
31	2	4	*Canarium ovatum*	BURSERACEAE		+	
32	5	10	*Garuga floribunda floribunda*	BURSERACEAE		+	
33	4	8	*Bauhinia malabarica*	11CAESALPINIACEAE			+
34	1	2	*Cassia javanica javanica*	CAESALPINIACEAE		+	
35	3	6	*Cassia javanica nodosa*	CAESALPINIACEAE		+	
36	2	4	*Cynometra ramiflora*	CAESALPINIACEAE		+	
37	1	2	*Intsia acuminate*	CAESALPINIACEAE		+	
38	1	2	*Intsia bijuga*	CAESALPINIACEAE		+	
39	3	6	*Peltophorum pterocarpum*	CAESALPINIACEAE		+	
40	1	2	*Sindora supa*	CAESALPINIACEAE			+
41	1	2	*Sympetalandra densiflora*	CAESALPINIACEAE		+	
42	1	2	*Solanospermum toxicum*	12CELASTRACEAE		+	
43	1	2	*Atuna racemosa*	13CHRYSOBALANACEAE	+		

44	3	5	*Maranthes corymbosa*	CHRYSOBALANACEAE		+	
45	1	2	*Terminalia calamansanai*	14COMBRETACEAE		+	
46	2	4	*Terminalia catappa*	COMBRETACEAE		+	
47	1	2	*Terminalia citrine*	COMBRETACEAE		+	
48	2	4	*Terminalia foetidissima*	COMBRETACEAE		+	
49	3	6	*Terminalia microcarpa*	COMBRETACEAE		+	
50	1	2	*Terminalia nitens*	COMBRETACEAE		+	
51	1	2	*Octomeles sumatrana*	15DATISCACEAE		+	
52	2	4	*Dillenia philippinensis*	16DILLENIACEAE		+	
53	5	10	*Anisoptera thurifera thurifera*	17DIPTEROCARPACEAE		+	
54	1	2	*Dipterocarpus alatus*	DIPTEROCARPACEAE	+		
55	1	2	*Dipterocarpus gracilis*	DIPTEROCARPACEAE	+		
56	1	2	*Dipterocarpus grandiflorus*	DIPTEROCARPACEAE	+		
57	3	6	*Parashorea malaanonan*	DIPTEROCARPACEAE	+		
58	3	6	*Shorea (Pentacme) contorta*	DIPTEROCARPACEAE	+		
59	2	4	*Shorea almon*	DIPTEROCARPACEAE	+		
60	1	2	*Shorea palosapis*	DIPTEROCARPACEAE	+		
61	1	2	*Shorea negrosensis*	DIPTEROCARPACEAE	+		
62	2	4	*Diospyros discolor*	18EBENACEAE		+	
63	2	4	*Diospyros pilosanthera*	EBENACEAE		+	
64	2	4	*Diospyros pyrrhocarpa*	EBENACEAE		+	
65	3	6	*Antidesma ghaesembilla*	EUPHORBIACEAE		+	
66	2	4	*Bischofia javanica*	EUPHORBIACEAE		+	
67	2	4	*Bridelia penangiana*	EUPHORBIACEAE	+		
68	1	2	*Cleidion spiciflorum*	EUPHORBIACEAE		+	
69	1	2	*Drypetes maquilingensis*	EUPHORBIACEAE		+	
70	3	6	*Endospermum peltatum*	EUPHORBIACEAE		+	
71	4	8	*Macaranga bicolor*	EUPHORBIACEAE	+		
72	1	2	*Macaranga triloba*	EUPHORBIACEAE		+	
73	4	8	*Macaranga tanarius*	EUPHORBIACEAE		+	
74	3	6	*Melanolepis multiglandulosus*	EUPHORBIACEAE		+	
75	2	4	*Neotrewia cumingiana*	EUPHORBIACEAE		+	
76	2	4	*Reutealis trisperma*	EUPHORBIACEAE		+	
77	2	4	*Sapium luzonicum*	EUPHORBIACEAE		+	
78	1	2	*Securinega flexuosa*	EUPHORBIACEAE		+	
79	1	2	*Antidesma sp*	EUPHORBIACEAE	+		
80	1	2	*Mallotus ricinoides*	EUPHORBIACEAE	+		
81	2	4	*Erythrina subumbrans*	20FABACEAE		+	
82	2	4	*Ormosia calavensis*	FABACEAE	+	+	
83	5	10	*Pterocarpus indicus*	FABACEAE			+
84	2	4	*Pangium edule*	FLACOURTIACEAE		+	
85	1	2	*Trichadenia philippinensis*	FLACOURTIACEAE		+	
86	1	2	*Ahernia glandulosa*	FLACOURTIACEAE		+	
87	3	6	*Calophyllum inophyllum*	22GUTTIFERAE			+
88	2	4	*Cratoxylon formosum*	GUTTIFERAE			+
89	3	5	*Cratoxylon sumatranum*	GUTTIFERAE			+
90	1	2	*Garcinia rubra*	GUTTIFERAE	+		
91	1	2	*Garcinia laterifolia*	GUTTIFERAE		+	
92	1	2	*Garcinia sp from Kalinga*	GUTTIFERAE		+	

93	2	4	*Gomphandra luzoniensis*	23ICACINACEAE	+		
94	2	4	*Gonocaryum calleryanum*	ICACINACEAE		+	
95	2	4	*Alseodaphne malabonga*	24LAURACEAE	+		
96	2	4	*Cinnamomum sp fr Palawan*	LAURACEAE		+	
97	1	2	*Dehaasia incrassata*	LAURACEAE			+
98	1	2	*Litsea garciae*	LAURACEAE		+	
99	1	2	*Litsea sebifera*	LAURACEAE		+	
100	1	2	*Litsea perrottetii*	LAURACEAE		+	
101	1	2	*Barringtonia asiatica*	25LECYTHIDACEAE	+		
102	2	4	*Planchonia spectabilis*	LECYTHIDACEAE			+
103	1	2	*Barringtonia curranii*	LECYTHIDACEAE			+
104	1	2	*Fragraea fragrans*	26LOGANIACEAE		+	
105	1	2	*Fragraea sp from Kalinga*	LOGANIACEAE	+		
106	1	2	*Fragraea racemosa*	LOGANIACEAE	+		
107	1	2	*Lagerstroemia pyriformis*	27LYTHRACEAE			+
108	2	4	*Lagerstroemia speciosa*	LYTHRACEAE			+
109	2	4	*Hibiscus campylosiphon*	28MALVACEAE			+
110	1	2	*Astronia sp*	29MELASTOMATACEAE		+	
111	1	2	*Aglaia argentea*	30MELIACEAE		+	
112	3	6	*Aglaia llanosiana*	MELIACEAE		+	
113	1	2	*Aglaia rimosa*	MELIACEAE		+	
114	1	2	*Aphanamixis polystachya*	MELIACEAE		+	
115	1	2	*Chisocheton cumingianus*	MELIACEAE		+	
116	2	4	*Dysoxylum arborescens*	MELIACEAE		+	
117	2	4	*Dysoxylum cumingianum*	MELIACEAE		+	
118	2	4	*Dysoxylum gaudichaudianum*	MELIACEAE			+
119	1	2	*Dysoxylum mollisimum*	MELIACEAE		+	
120	1	2	*Dysoxylum floribundum*	MELIACEAE		+	
121	5	9	*Melia azaderach*	MELIACEAE			+
121	3	5	*Sandoricum koetjape*	MELIACEAE	+		
122	1	2	*Sandoricum vidalianum*	MELIACEAE	+		
123	3	6	*Toona calantas*	MELIACEAE			+
124	2	4	*Toona surenii*	MELIACEAE			+
125	3	6	*Adenanthera intermedia*	31MIMOSACEAE		+	
126	2	4	*Albizia acle*	MIMOSACEAE		+	
127	1	2	*Albizia pedicellata*	MIMOSACEAE	+		
128	4	9	*Albizia procera*	MIMOSACEAE			+
129	2	4	*Albizia retusa*	MIMOSACEAE		+	
130	1	2	*Archidendron clypearia clypearia*	MIMOSACEAE		+	
131	2	4	*Archidendron ellipticum*	MIMOSACEAE		+	
132	2	4	*Archidendron scutiferum*	MIMOSACEAE		+	
133	2	4	*Parkia timoriana*	MIMOSACEAE		+	
134	3	6	*Wallaceodendron celebicum*	MIMOSACEAE			+
135	1	2	*Albizia sp*	MIMOSACEAE	+		
136	1	2	*Artocarpus nitida*	32MORACEAE		+	
137	2	4	*Artocarpus blancoi*	MORACEAE	+		
138	1	2	*Artocarpus odoratissimus*	MORACEAE		+	
139	2	4	*Artocarpus ovatus*	MORACEAE		+	
140	1	2	*Broussonetia luzonica*	MORACEAE		+	

141	1	2	*Ficus ampelas*	MORACEAE		+	
142	1	2	*Ficus botryocarpa*	MORACEAE		+	
143	2	4	*Ficus callosa*	MORACEAE		+	
144	1	2	*Ficus congesta*	MORACEAE		+	
145	2	4	*Ficus gul*	MORACEAE		+	
146	1	2	*Ficus irisana*	MORACEAE		+	
147	3	6	*Ficus minahassae*	MORACEAE		+	
148	2	4	*Ficus nota*	MORACEAE		+	
149	3	6	*Ficus variegata variegata*	MORACEAE		+	
150	1	2	*Ficus variegata fr. Kalinga*	MORACEAE		+	
151	2	4	*Parartocarpus venonosus*	MORACEAE	+		
152	2	4	*Streblus asper*	MORACEAE		+	
153	2	4	*Trophis philippinensis*	MORACEAE	+		
154	1	1	*Horsfieldia costulata*	33MYRISTICACEAE			+
155	2	4	*Knema glomerata*	MYRISTICACEAE			+
156	2	4	*Myristica philippinensis*	MYRISTICACEAE			+
160	2	4	*Syzygium calubcob*	34MYRTACEAE	+		
161	1	2	*Syzygium cumini*	MYRTACEAE	+		
162	2	4	*Syzygium simile*	MYRTACEAE		+	
163	1	2	*Syzygium xanthophyllum*	MYRTACEAE	+		
164	3	5	*Pisonia umbellifera*	35NYCTAGINACEAE	+		
165	2	4	*Strombosia philippinensis*	36OLACACEAE		+	
166	1	2	*Fraxinus griffithii*	37OLEACEAE		+	
167	24	48	*Pinus kesiya*	38PINACEAE			+
168	1	2	*Pinus merkusii*	PINACEAE			+
169	3	6	*Pittosporum pentandrum*	39PITTOSPORACEAE		+	
170	1	2	*Nageia wallichiana*	40PODOCARPACEAE			+
171	1	2	*Podocarpus rumphii*	PODOCARPACEAE			+
172	1	2	*Dacrycarpus imbricatus*	PODOCARPACEAE			+
173	3	6	*Zizyphus talanai*	41RHAMNACEAE		+	
174	1	2	*Alphitonia zizyphoides*	RHAMNACEAE	+		
175	1	2	*Carallia brachiata*	42RHIZOPHORACEAE		+	
176	1	2	*Carallia borneensis*	RHIZOPHORACEAE		+	
177	1	2	*Prunus grisea grisea*	43ROSACEAE		+	
178	2	4	*Anthocephalus chinensis*	44RUBIACEAE	+		
179	1	2	*Canthium monstrosum*	RUBIACEAE	+		
180	1	2	*Hymenodictyon excelsum*	RUBIACEAE		+	
181	2	4	*Nauclea orientalis*	RUBIACEAE		+	
182	2	3	*Neonauclea media*	RUBIACEAE		+	
183	1	2	*Taw-a 1 from Palawan*	RUBIACEAE	+		
184	1	2	*Taw-a 2 from Palawan*	RUBIACEAE			+
185	1	2	*Wendlandia uvariifolia*	RUBIACEAE	+		
186	1	2	*Clausena sp*	45RUTACEAE		+	
187	1	2	*Evodia confusa*	RUTACEAE		+	
188	2	4	*Melicope triphylla*	RUTACEAE		+	
189	1	2	*Guioa koelreuteria*	46SAPINDACEAE		+	
190	1	2	*Harpullia arborea*	SAPINDACEAE		+	
191	1	2	*Nephelium mutabile*	SAPINDACEAE		+	
192	1	2	*Nephelium ramboutan-ake*	SAPINDACEAE		+	

193	3	6	*Pometia pinnata*	SAPINDACEAE			+
194	1	2	*Madhuca betis*	47SAPOTACEAE		+	
195	4	8	*Palaquium luzoniensis*	SAPOTACEAE		+	
196	1	2	*Palaquium philippense*	SAPOTACEAE		+	
197	2	4	*Sideroxylon nitidum*	SAPOTACEAE		+	
198	2	4	*Pouteria macrantha*	SAPOTACEAE		+	
199	1	2	*Unknown Sapotaceae 1*	SAPOTACEAE	+		
200	1	2	*Unknown Sapotaceae 2*	SAPOTACEAE	+		
201	2	4	*Ailanthus integrifolia*	48SIMAROUBACEAE		+	
202	2	4	*Duabanga moluccana*	49SONNERATIACEAE	+		
203	2	4	*Turpinia ovalifolia*	50STAPHYLEACEAE	+		
204	2	4	*Heritiera littoralis*	51STERCULIACEAE		+	
205	4	8	*Heritiera sylvatica*	STERCULIACEAE		+	
206	1	2	*Kleinhovia hospita*	STERCULIACEAE			+
207	8	16	*Pterocymbium tinctorium*	STERCULIACEAE	+		
208	1	2	*Pterospermum diversifolium*	STERCULIACEAE			+
209	2	4	*Pterospermum niveum*	STERCULIACEAE		+	
210	2	4	*Pterospermum obliquum*	STERCULIACEAE	+		
211	11	22	*Sterculia foetida*	STERCULIACEAE		+	+
212	4	8	*Sterculia oblongata*	STERCULIACEAE			
213	1	2	*Balindadagat from Palawan*	STERCULIACEAE		+	
214	2	4	*Commersonia bartramia*	STERCULIACEAE			+
215	4	7	*Colona serratifolia*	52TILIACEAE			+
216	3	6	*Diplodiscus paniculatus*	TILIACEAE		+	
217	1	2	*Grewia minutiflora*	TILIACEAE			+
218	1	4	*Trichospermum? fr Palawan*	TILIACEAE		+	
219	2	4	*Aphananthe philippinensis*	53ULMACEAE		+	
220	3	6	*Celtis philippensis*	ULMACEAE		+	
221	2	4	*Celtis luzonica*	ULMACEAE	+		
222	3	6	*Trema orientalis*	ULMACEAE	+	+	
223	1	2	*Premna odorata*	54VERBENACEAE	+		
224	1	2	*Tectona philippinensis*	VERBENACEAE			+
225	1	2	*Vitex turczaninowii*	VERBENACEAE			+
226	1	2	*Unknown tree from Kalinga*				+
	452	898		54 Families	52	134	40
1	1	2	*Araucaria heterophylla*	ARAUCARIACEAE			+
2	1	2	*Cassia fistula*	CAESALPINIACEAE			+
3	2	4	*Dillenia indica*	DILLENIACEAE		+	
4	5	10	*Aleurites moluccana*	19EUPHORBIACEAE	+		
5	1	2	*Hydnocarpus anthelminthica*	21FLACOURTIACEAE		+	
6	1	2	*Flacourtia jangomas*	FLACOURTIACEAE		+	
7	1	2	*Cedrela odorata*	MELIACEAE			+
8	1	2	*Swietenia macrophylla*	MELIACEAE			+
9	1	2	*Acacia catechu*	MIMOSACEAE			+
10	1	2	*Samanea saman*	MIMOSACEAE		+	
11	3	6	*Sapindus saponaria*	SAPINDACEAE		+	
12	1	2	*Gmelina arborea*	VERBENACEAE		+	
13	20	42	*Tectona grandis*	VERBENACEAE			+
	38	78			1	6	6

238	490	976			53	140	45

APPENDIX Table 2. List of indigenous tree species core sampled from lowland Sabah, Malaysia in Mt. Trus Madi for APN Project.

No.	No. trees	No. of cores	Species	FAMILY	Growth Ring		
					Absent	Indist.	Dist.
1	1	1	Unknown sp	ANNONACEAE	1		
2	2	3	*Diospyros* sp	EBENACEAE		1	
3	1	1	*Lithocarpus* sp	FAGACEAE	1		
4	1	2	*Lithocarpus* sp	FAGACEAE	1		
5	5	10	*Litsea garciae*	LAURACEAE		1	
6	5	10	*Duabanga moluccana*	SONNERATIACEAE	1		
7	5	10	*Pterospermum cf. elongatum*	STERCULIACEAE			1
8	7	15	*Trema orientalis*	ULMACEAE	1		
9	4	8	*Vitex pinnata*	VERBENACEAE			1
10	1	2					
	32	62			5	2	2

APPENDIX Table 3. List of indigenous conifer tree species core sampled from Mt. Kinabalu, Sabah, Malaysia between elevations 1,564 to 1,672 m a.s.l.

No.	No. trees	No. of cores	Species	FAMILY	Growth Ring		
					Absent	Indist.	Dist.
1	19	38	*Agathis borneensis*	ARAUCARIACEAE			1
2	4	8	*Dacrycarpus imbricatus*	PODOCARPACEAE			1
3	4	8	*D. imbricatus* v. *patulus*	PODOCARPACEAE			1
4	6	12	*Phyllocladus hypophyllus*	PODOCARPACEAE			1
	33	66					4

APPENDIX Table 4. Summary of all tree species and core samples in the Philippines and Sabah, Malaysia.

No. Spp	No. trees	No. of cores	Species	FAMILY	Growth Ring		
					Absent	Indist.	Dist.
226	452	898	Indigenous Philippine tree spp		53	134	39
9	31	60	Lowland Sabah tree spp		5	2	2
4	33	66	Mt Kinabalu conifer tree spp				4
13	38	78	Exotic tree spp in Philippines		4	7	8
252	554	1,102			62	143	53

APPENDIX Table 5. Result of dendrochronology reconnaissance for Thailand tree species.

No.	Tree	Shrub to Small tree	Species	FAMILY	Growth Ring		
					Absent	Indistinct	Distinct
1	+		*Buchanania lanzan* Spreng.	ANACARDIACEAE	+		
2	+		*Gluta usitata* (Wall.) Ding Hou	ANACARDIACEAE	+		
3	+		*Lannea coromandelica* (Houtt.) Merr.	ANACARDIACEAE			+
4	+		*Spondias pinnata* (L.f.) Kurz	ANACARDIACEAE	+		
5	+		*Cananga latifolia* (Hook. F. & Thomson)	ANNONACEAE	+		
6	+		*Miliusa velutina* (Dunal) Hook. F. & Thomson	ANNONACEAE		+	
7		+	*Orophea polycarpa* A. DC.	ANNONACEAE	+		
8		+	*Holarrhena pubescens* Wall. Ex G. Don	APOCYNACEAE		+	
9	ST		*Wrightia arborea* (Dennst.) Mabb.	APOCYNACEAE	+		
10	+		*Canarium subulatum* Guill.	BURSERACEAE		+	
11	+		*Garuga pinnata* Roxb.	BURSERACEAE			+
12	+		*Fernandoa adenophylla* (Wall. Ex G. Don)	BIGNONIACEAE			+
13	+		*Markhamia stipulata* Seem.	BIGNONIACEAE			+
14	ST		*Oroxylon indicum* (L.) Kurz	BIGNONIACEAE			+
15	+		*Bombax anceps* Pierre	BOMBACACEAE			+
16	+		*Dialium cochinchinense* Pierre	CAESALPINIACEAE	+		
17	+		*Peltophorum inerme* Llanos	CAESALPINIACEAE		+	
18	+		*Casuarina equisetifolia* J.R. & G. Forst.	CASUARINACEAE	+		
19	+		*Bhesa robusta* (Roxb.) Ding Hou	CELASTRACEAE	+		
20	+		*Parinari anamense* Hance	CHRYSOBALANACEAE		+	
21	+		Terminalia catappa Linn.	COMBRETACEAE		+	
22	+		*Terminalia chebula* Retz.	COMBRETACEAE	+		
23	+		*Terminalia mucronata* Craib & Hutch.	COMBRETACEAE	+		
24	+		*Terminalia triptera* Stapf.	COMBRETACEAE			+
25	+		*Terminalia alata* Heyne ex Roth	COMBRETACEAE	+		
26	ST		*Weinmannia tinctoria* (Roxb.) DC.	CUNONIACEAE			+
27	+		*Dillenia obovata* (Bl.) Hoogl.	DILLENIACEAE			+
28	+		*Dipterocarpus alatus* Roxb.	DIPTEROCARPACEAE	+		
29	+		*Dipterocarpus obtusifolius* Teijsm. ex Miq.	DIPTEROCARPACEAE	+		
30	+		*Dipterocarpus tuberculatus* Roxb.	DIPTEROCARPACEAE		+	
31	+		*Hopea odorata* Roxb.	DIPTEROCARPACEAE		+	
32	+		*Shorea obtusa* Wall. ex Blume	DIPTEROCARPACEAE	+		
33	+		*Shorea roxburghii* G. Don	DIPTEROCARPACEAE	+		
34	+		*Shorea siamensis* Miq.	DIPTEROCARPACEAE	+		
35	+		*Diospyros mollis* Griff.	EBENACEAE			+
36	+		*Diospyros montana* Roxb.	EBENACEAE			+
37	ST		*Diospyros rhodocalyx* Kurz	EBENACEAE	+		
38	+		*Elaeocarpus lanceaefolius* Roxb.	ELAEOCARPACEAE		+	
39	ST		*Aporosa villosa* (Wall. Ex Lindl.) Baill.	EUPHORBIACEAE	+		

40	ST		*Bridelia retusa* (L.) A. Juss.	EUPHORBIACEAE		+	
41		+	*Croton roxburghii* N.P. Balakr.	EUPHORBIACEAE		+	
42	ST		*Mallotus philippense* Mull.-Arg.	EUPHORBIACEAE		+	
43	+		*Phyllanthus emblica* L.	EUPHORBIACEAE	+		
44		+	*Suregada multiflorum* (A. Juss.) Baill.	EUPHORBIACEAE	+		
45	+		*Quercus kerrii* Craib.	FAGACEAE	+		
46		+	*Flacourtia indica* (Burm. F.) Merr.	FLACOURTIACEAE		+	
47	+		*Cratoxylon pruniflorum* (Kurz) Gogel.	GUTTIFERAE	+		
48	+		*Mammea harmandii* Kosterm.	GUTTIFERAE	+		
49	+		*Irvingia malayana* Oliv. Ex. A.W. Benn.	IRVINGIACEAE	+		
50	+		*Vitex peduncularis* Wall. Ex. Schauer	VERBENACEAE		+	
51	+		*Vitex canescense* Kurz	VERBENACEAE			+
52	ST		*Vitex quinata* (Lour.) F.N. Williams	VERBENACEAE	+		
53	+		*Cinnamomum iners* Reinw. Ex Blume	LAURACEAE	+		
54		+	*Barringtonia acutangula* (L.) Gaertn.	LECYTHIDACEAE	+		
55	+		*Afzelia xylocarpa* (Kurz) Craib	CAESALPINIACEAE			+
56	+		*Albizia odoratissima* (L.f.) Benth.	MIMOSACEAE			+
57	ST		*Bauhinia* sp	CAESALPINIACEAE		+	
58	+		*Cassia fistula* L.	CAESALPINIACEAE			+
59	+		*Cassia garrettiana* Craib	CAESALPINIACEAE		+	
60	+		*Dalbergia oliveri* Gamble	FABACEAE	+		
61	+		*Dalbergia cana* Graham ex Kurz	FABACEAE	+		
62	+		*Dalbergia cultrata* Graham ex Benth.	FABACEAE	+		
63	+		*Sindora siamensis* Teijsm. ex Miq.	CAESALPINIACEAE			+
64	+		*Xylia xylocarpa* (Roxb.) Taub.	CAESALPINIACEAE			+
65	+		*Milletia leucantha* Kurz var buteoides (Gagnep.) P.K. Loc.	FABACEAE	+		
66	+		*Lagerstroemia calyculata* Kurz	LYTHRACEAE		+	
67	+		*Lagerstroemia macrocarpa* Wall.	LYTHRACEAE			+
68	+		*Chukrasia tabularis* A. Juss.	MELIACEAE			+
69		+	*Memecylon caeruleum* Jack	MELASTOMATACEAE		+	
70		+	*Memecylon scutellatum* Naudin	MELASTOMATACEAE		+	
71	+		*Artocarpus lakoocha* Roxb.	MORACEAE	+		
72		+	*Streblus ilicifolius* (Vidal) Corner	MORACEAE	+		
73	+		*Syzygium cumini* L. Skeels	MYRTACEAE	+		
74		+	*Ochna integerrima* (Lour.) Merr.	OCHNACEAE		+	
75	+		*Pterocarpus indicus* Willd.	FABACEAE	+		
76	+		*Pterocarpus macrocarpus* Kurz	FABACEAE	+		
77	+		*Carallia brachiata* (Lour.) Merr.	RHIZOPHORACEAE	+		
78	+		*Prunus cerasoides* D. Don	ROSACEAE	+		
79		+	*Catunaregam spathulifolia* Tirveng.	RUBIACEAE			+
80		+	*Dioecrescis erythroclada* (Kurz) Tirveng.	RUBIACEAE			+
81	ST		*Gardenia sootepensis* Hutch.	RUBIACEAE	+		
82	+		*Haldina cordifolia* (Roxb.) Ridsdale	RUBIACEAE			+
83	+		*Hymenodictyon excelsum* Wall.	RUBIACEAE			+
84	+		*Mitragyna brunonis* Craib	RUBIACEAE			+
85	ST		*Morinda coreia* Ham.	RUBIACEAE		+	
86		+	*Murraya paniculata* (L.) Jack	RUTACEAE			+
87	+		*Schleichera oleosa* (Lour.) Oken	SAPINDACEAE			+

88	+		*Ailanthus triphysa* (Denns.) Alston.	SIMAROUBACEAE	+		
89	ST		*Sterculia pexa* Pierre	STERCULIACEAE		+	
90	ST		*Strychnos nux-vomica* L.	STRYCHNACEAE	+		
91	+		*Colona flagrocarpa* (C.B. Clarke) Craib	TILIACEAE			+
					42	21	28

APPENDIX Table 6. Result of dendrochronology reconnaissance for Indian tree species.

Tree-ring samples of different species collected from South India during 27 November-11 December, 2007

No.	No. of cores	Species	FAMILY	CROSS-SECTION Features	Growth Ring		
					Absent	Present	Distinct
1	2	*Holoptelia integrifolia*		Diffuse porous		+	+
2	20	*Adina cordifolia*	RUBIACEAE	Diffuse porous		+	
3	19	*Anogeissus latifolia*	COMBRETACEAE	Diffuse porous			+
4	4	*Michelia champaca*	MAGNOLIACEAE	Diffuse porous			+
5	4	*Albizia lebbeck*	MIMOSACEAE	Sim. Albizia odoratissimus			
6	8	*Mangifera indica*	ANACARDIACEAE	Diffuse porous		+	+
7	2	*Dalbergia latifolia*	FABACEAE	Diffuse porous		+	+
8	20	*Pterocarpus marsupium*	FABACEAE	Diffuse porous		+	+
9	24	*Lagerstroemia lanceolata*	LYTHRACEAE	Ring to semi-ring porous			+
10	2	*Toona ciliata*	MELIACEAE	Semi- to ring porous			+
11	6	*Tectona grandis*	VERBENACEAE	Ring porous			+
12	10	*Terminalia bellerica*	COMBRETACEAE	Ring porous			+
13	7	**Eucalyptus tereticornis*	MYRTACEAE				+
14	11	*Celtis tetrandra*	ULMACEAE				+
15	27	*Gmelina arborea*	VERBENACEAE				
16	10	*Terminalia tomentosa*	COMBRETACEAE				
17	20	*Mitragyna parvifolia*	RUBIACEAE				
18	8	*Shorea roxburghii*	DIPTEROCARPACEAE				
19	3	*Vitex altissima*	VERBENACEAE				
							12

Tree-ring samples of different species collected from South India during 20 December, 2008r-2 January, 2009

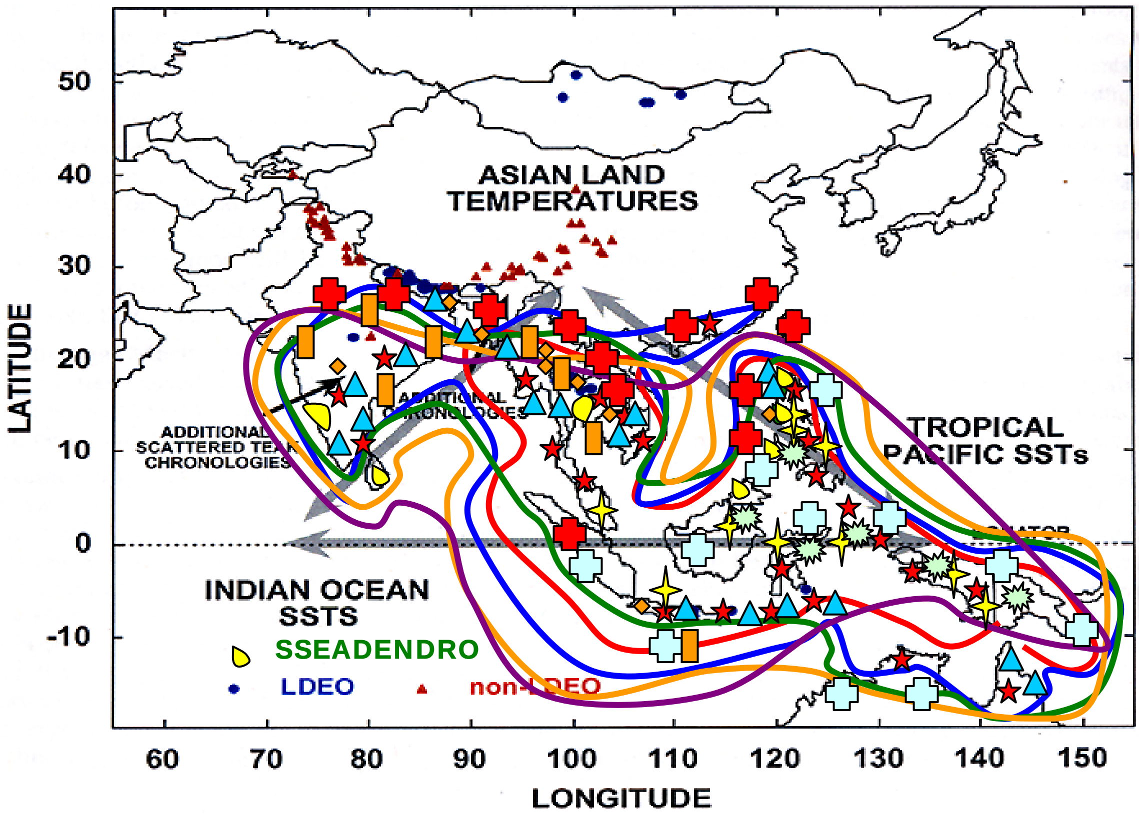
No.	No. of cores	Species	FAMILY	CROSS-SECTION Features	Growth Ring		
					Absent	Indistinct	Distinct
1	Disc-2	*Anogeissus latifolia*	COMBRETACEAE	Diffuse porous		+	
2	13(2 discs)	*Terminalia crenulata*	COMBRETACEAE		+		
3	6	*Bischofia javanica*	EUPHORBIACEAE		+		
4	2	*Bombax ceiba*	BOMBACACEAE		+	+	
5	2	*Hevea brasiliensis*	EUPHORBIACEAE			+	
6	2(1 disc)	*Terminalia paniculata*	COMBRETACEAE		+		
7	2	*Calophyllum inophyllum*	GUTTIFERAE	Diffuse porous		+	
8	3	*Dillenia pentagyna*	DILLENIACEAE		+		
9	20(8	*Tectona grandis*	VERBENACEAE	Ring porous		+	

	discs)						
10	1 disc	*Artocarpus hirsuta*	MORACEAE		+		
11	2 discs	*Pterocarpus marsupium*	FABACEAE	Diffuse porous		+	+
12	4 discs	*Dalbergia latifolia*	FABACEAE	Diffuse porous		+	+
13	1 disc	*Adina cordifolia*	RUBIACEAE	Diffuse porous		+	
14	1 disc	*Lagerstroemia lanceolata*	LYTHRACEAE			+	+
15	2 discs	**Acacia mangium*	MIMOSACEAE			+	+
16	1 disc	*Terminalia tomentosa*	COMBRETACEAE	Diffuse porous			+
17	1 disc	**Acacia auriculaeformis*	MIMOSACEAE			+	
18	1 disc	**Eucalyptus tereticornis*	MYRTACEAE				+
19	1 disc	*Michelia champaca*	MAGNOLIACEAE	Diffuse porous			+

APPENDIX Table 7. Result of dendrochronology reconnaissance for Sri Lanka tree species.

No.	No tree	No core	Species	FAMILY	Growth Ring		
					Absent	Indistinct	Distinct
1	3	5	*Mangifera zeylanica*	ANACARDIACEAE	+	+	
2	2	4	*Semecarpus nigro-viridis*	ANACARDIACEAE	+		+
3	1	2	*Spondias sp*	ANACARDIACEAE	+		
4	1	2	*Polyalthia longifolia*	ANNONACEAE		+	
5	1	1	*Alstonia scholaris*	APOCYNACEAE	+		
6	1	2	*Stereospermum colais*	BIGNONIACEAE		+	
7	1	1	*Bombax ceiba*	BOMBACACEAE	+		
8	2	4	*Cordia dichotoma*	BORAGINACEAE	+		
9	1	1	*Bhesa ceylanica*	CELASTRACEAE		+	
10	1	2	*Terminalia arjuna*	COMBRETACEAE	+		
11	5	6	*Terminalia bellirica*	COMBRETACEAE		+	
12	3	4	*Terminalia chebula*	COMBRETACEAE	+		
13	2	2	*Dipterocarpus zeylanicus*	DIPTEROCARPACEAE	+		
14	1	1	*Bridelia moonii*	EUPHORBIACEAE		+	
15	2	4	*Bridelia retusa*	EUPHORBIACEAE	+		
16	1	1	*Cleistanthus pallidus*	EUPHORBIACEAE		+	
17	1	4	*Drypetes sepiaria*	EUPHORBIACEAE	+	+	
18	4	6	*Hevea brasiliensis*	EUPHORBIACEAE		+	
19	1	1	*Macaranga peltata*	EUPHORBIACEAE	+		
20	1	2	*Mallotus philippensis*	EUPHORBIACEAE			+
21	2	3	*Phyllanthus emblica*	EUPHORBIACEAE		+	
22	3	5	*Albizia odoratissima*	LEGUMINOSAE	+		
23	1	1	*Albizia sp*	LEGUMINOSAE		+	
24	1	1	*Bauhinia racemosa*	LEGUMINOSAE			+
25	4	9	*Cassia fistula*	LEGUMINOSAE		+	+
26	1	4	*Cassia siamea*	LEGUMINOSAE		+	
27	1	1	*Scolopia crassipes*	FLACOURTIACEAE	+		
28	4	7	*Gyrocarpus americanus*	HERNANDIACEAE	+		
29	2	3	*Actinodaphne stenophylla*	LAURACEAE		+	
30	1	2	*Neolitsea fuscata*	LAURACEAE	+	+	
31	1	4	*Cinnamomum dubium*	LAURACEAE			+
32	5	5	*Careya arborea*	LECYTHIDACEAE	+	+	
33	7	14	*Azadirachta indica*	MELIACEAE			+

34	5	13	*Chukrasia tabularis*	MELIACEAE			+
35	1	1	*Ficus racemosa*	MORACEAE		+	
36	3	6	*Eugenia bracteata*	MYRTACEAE		+	
37	1	1	*Eugenia thwaitesii*	MYRTACEAE		+	
38	2	3	*Syzygium aqueum*	MYRTACEAE		+	+
39	1	2	*Syzygium assimile*	MYRTACEAE	+		
40	1	2	*Syzygium gardneri*	MYRTACEAE		+	
41	2	2	*Syzygium rubicundum*	MYRTACEAE	+		
42	2	2	*Syzygium sp*	MYRTACEAE	+		
43	1	1	*Syzygium spathulatum*	MYRTACEAE			+
44	1	4	*Gomphia serrata*	OCHNACEAE			+
45	2	4	*Mitragyna parvifolia*	RUBIACEAE	+		
46	7	17	*Haldina cordifolia*	RUBIACEAE		+	
47	1	1	*Canthium coromandelicum*	RUBIACEAE		+	
48	1	1	*Psydrax dicoccos*	RUBIACEAE			+
49	9	23	*Chloroxylon swietenia*	RUTACEAE			+
50	1	1	*Limonia acidissima*	RUTACEAE			+
51	4	10	*Dimocarpus longan*	SAPINDACEAE	+	+	+
52	4	7	*Filicium decipiens*	SAPINDACEAE		+	
53	2	4	*Lepisanthes triphylla*	SAPINDACEAE		+	
54	2	4	*Manilkara hexandra*	SAPOTACEAE		+	
55	2	4	*Madhuca longifolia*	SAPOTACEAE		+	
56	1	2	*Turpinia malabarica*	STAPHYLEACEAE		+	
57	3	5	*Pterospermum suberifolium*	STERCULIACEAE		+	
58	1	2	*Sterculia urens*	STERCULIACEAE		+	
59	1	1	*Gordonia zeylanica*	THEACEAE	+		
60	1	4	*Grewia rothii*	TILIACEAE		+	
61	1	2	*Grewia damine*	TILIACEAE			+
62	1	1	*Trema orientalis*	ULMACEAE		+	
63	1	1	*Holoptelea integrifolia*	ULMACEAE		+	
64	3	9	*Tectona grandis*	VERBENACEAE		+	+
65	6	9	*Vitex altissima*	VERBENACEAE		+	



LEGEND for GEOGRAPHIC DISTRIBUTION of tree species with distinct growth rings:
Colona serratifolia TILIACEAE
Pterocarpus indicus FABACEAE
Melia azedarach MELIACEAE
Dacrycarpus imbricatus PODOCARPACEAE
Commersonia bartramia STERCULIACEAE
Toona ciliata MELIACEAE
Murraya paniculata RUTACEAE
Mallotus philippensis EUPHORBIACEAE
Nageia wallichiana PODOCARPACEAE
Kleinhovia hospita STERCULIACEAE
Pterospermum diversifolium STERCULIACEAE
Albizia procera MIMOSACEAE - - - - - - -
Bauhinia malabarica CAESALPINIACEAE –
Hymenodictyon excelsum RUBIACEAE - -
Podocarpus rumphii PODOCARPACEAE - -
Phyllocladus hypophyllus PODOCARPACEAE –
Agathis spp ARAUCARIACEAE - - - - - - - -
Pinus spp PINACEAE - - - - - - - - - - - - - - -
Tectona grandis VERBENACEAE - - - - - - - -

LEGEND FOR ACRONYMNS:
LDEO – Lamont Doherty Earth Observatory of Columbia University, New York, U.S.A.
SSEADENDRO – South Southeast Asia Dendrochronology Group (author of this Terminal Report).

Map 6. Selected SSEADENDRO tree species with distinct growth rings with wide geographic distribution in the region (base map from Cook, E. et al., 2004).