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## **Brief History of Forest Management**

This article is one of 4 papers I wrote in my final year working for the NSW Environmental Protection Authority (EPA). The other 3 papers contain internal Departmental information and will not be published in this newsletter.

I wrote these papers as many of the recent recruits in the EPA had no background or understanding on the history of forestry. In the past I had recruited mainly ex Soil Conservation Officers who had experience in regulating State Protected Lands, foresters and others with significant experience in environmental auditing of the natural world with outcome focus.

### Paper 1; Forest management – History

The first of a series of papers on Forestry management in NSW and future strategies  
Introduction

In this series of papers I hope to bring you greater understanding of forest ecology and management options and tools that can assist you.

To understand Forest Management in NSW you need to understand;

1. The history of forestry and thus history of foresters;
2. The history of NSW forest management and forest conflict; and
3. Growth Habitats of forest trees in NSW; and the options/tools available

I would like to open this discussion by quoting from 6 different sources;

- o French mathematician, Jules Henri Poincaré, “Science is built of facts the way a house is built of bricks: but an accumulation of facts is no more science than a pile of bricks is a house.”;
- o Sir Isaac Newton, “If I see further it is because I am standing on the shoulders of giants”;
- o An old Okinawa saying, “On Ko Chi Shin” – “to search for the old is to understand the new”;
- o Gifford Pinchot, founder of the USA Forestry Services “the role of the forester is to provide the greatest good for the greatest number in the long term”;
- o Jack Westoby, remarked that “forestry is concerned not with trees, but with how trees can serve people”; and
- o Eric Bachelard, doyen of many ANU forestry students, “the most important function of a university is to prepare graduates for a continuing process of self-education and re-education”;

Many people confuse the role of the forester with that of the logger. Most foresters are concerned not only with the harvest of timber, but also with the sustainable management of forests. In 2011, more foresters were employed in the Department of Environment Climate Change and Water than in Forest NSW.

Forestry is the interdisciplinary profession described as “the science, art, and craft” of managing forests for a variety of single or multiple uses. In Australia, The National Forest Policy which incorporates Ecological Sustainable Forest Management (ESFM) principles guides the management of forests.

The main goal of forestry is to create and implement systems that allow forests to continue a sustainable provision of environmental supplies and services. The challenge of forestry is to create systems that are socially accepted while sustaining the resource and any other resources that might be affected.

Silviculture is the tool of the forest manager to produce these outcomes. As I have often said

“tell me the outcome and I will design you a silvicultural system to produce that outcome”.

#### Potted History of Forest Management

Forest management through the ages has been designed to produce a range of products including but not limited to timber, grazing, game/hunting, recreation, firewood/fuel, charcoal, bio diversity, refuge and clean water.

Henry III and his father King John before signing the Carta de Foresta and Magna Carta respectively opened their salutation as “..... by the grace of God, king of England, lord of Ireland, duke of Normandy, Aquitaine, and count of Anjou, to the archbishops, bishops, abbots, priors, earls, barons, justices, foresters, sheriffs, stewards, servants, and to all his bailiffs and faithful subjects, greeting.”

Foresters are mentioned in the court of Nebuchadnezzar (6 th century BC). Their role was primarily to do with the king’s hunting reserves. In some European languages the word for “forester” is the same as for “hunt master”. In most countries a forester is held in high regard and their opinion or decision is sought for matters in the village involving long-term outcomes. Often foresters held titles of prominence in their local communities, and acted as barristers and arbitrators. Most foresters will not see the results of their labour due to the time it takes for trees to grow.

Appendix 1 list important events in Forest Management through time

To be considered a forester in Australia you must meet the requirement of membership to the Institute of Forester of Australia (no you do not have to join). In the United States, postsecondary forestry education leading to a Bachelor’s degree or Master’s degree is accredited by the Society of American Foresters. In Canada the Canadian Institute of Forestry awards silver rings to graduates from accredited university BSc programs, as well as college and technical programs. Appendix 1 list some important foresters and other persons associated with forest management.

The International Union of Forest Research Organizations is the only international organization that coordinates forest science efforts world-wide. Organisations such as the Forest Policy Education Network and the Commonwealth Forestry Association are dedicated to facilitating international forest politics and exchanging information on the subject.

#### Charter of the Forest

The Charter of the Forest (Carta de Foresta) re-established rights of access to the royal forest for free men that had been eroded by the Conqueror and his heirs. Many of its provisions were in force for centuries afterwards.

It was first issued in 1217 as a complementary charter to the Magna Carta from which it had evolved. It was reissued in 1225 with a number of minor changes to wording, and then was joined with Magna Carta in the Confirmation of Charters in 1297.

In contrast to Magna Carta, which dealt with the rights of barons, it provided some real rights, privileges and protections for the common man against the abuses of the encroaching aristocracy.

The royal forests were the most important potential source of fuel for cooking, heating and industries such as charcoal burning. The English community were keen to defend their rights such as pannage (pasture for their pigs), estover (collecting firewood), agistment (grazing), or turbary (cutting of turf for fuel). This charter was almost unique in providing a degree of economic protection for free men, who also used the forest to forage for food and to graze their animals.

The Charter provided a right of common access to (royal) private lands. It also rolled back the area encompassed by the designation “forest” to that of Henry II’s time, essentially

freeing up lands that had become more and more restricted as King Richard and King John designated greater and greater areas of land to become royal forest. Since “forest”, in this

context didn't necessarily mean treed areas, but could include fields, moor or even farms and villages, it became an increasing hardship on the common people to try to farm, forage, and otherwise use the land they lived on. The Charter specifically states that "Henceforth every freeman, in his wood or on his land that he has in the forest, may with impunity make a mill, fish-pond, pond, marl-pit, ditch, or arable in cultivated land outside coverts, provided that no injury is thereby given to any neighbour."

It repealed the death penalty for stealing venison, though transgressors were still subject to fines or imprisonment for the offense; it also abolished mutilation as a lesser punishment. Special Verderers' Courts were set up within the forests to enforce the laws of the Charter. By Tudor times, most of the laws served mainly to protect the timber in royal forests. However, some clauses in the Laws of Forests remained in force until the 1970s, and the special courts still exist today in the New Forest and the Forest of Dean. In this respect, the Charter was the statute that remained longest in force in England (from 1217 to 1971), being finally superseded by the Wild Creatures and Forest Laws Act 1971.

#### Forest management in NSW

Aboriginal survival in many parts of Australia was based on their use and management of the forest and woodlands. The forest provided a range of products from fuel, food, medicines and raw materials to assist them in surviving. I cannot think of one ecosystem in NSW that has not been impacted by Aboriginal use. For some ecosystems the impact was quite dramatic eg dry viney rainforest on the west slopes of the Great Divide (UNE estimates a 99% loss of area) whilst others the impact was minor (sub tropical rainforests).

It is estimated that there was 45 million hectares of forest in NSW in 1788. By 1981 this had been reduced to 16 million hectares. Initially regulations on timber cutting were aimed to ensure sufficient was left for Government purposes. The impact of NSW ecosystems since 1788 has been due clearing, changed fire regimes and the introduction of non native flora and fauna. Some ecosystems have actually increased in area extent eg River Red Gums are now 104% of Janus due to the below Redbank irrigation scheme.

Settlement of coastal NSW followed the cedar cutters and by the late 1800s most of the easily accessible cedar, in the coastal valleys, had been cut. However the effects of earlier settlers were far more devastating on the forest of NSW, in particular rainforest where large tracks were felled and burnt. In the Bellingen Valley alone Swain estimated that 500 million super feet of high valuable timber was lost.

Many areas originally cleared have revegetated as the farming was found to be unviable. Examples of this are the Richmond valley south of Casino, Mount Rae, more swampy sections of the coastal floodplains (most are EECs), various Cypress Pine areas and Jingellic Valley east of Holbrook.

In NSW, State Forests and Timber Reserves were first gazetted, under the Lands Act, in the 19th Century and were administered by the Lands Department. State Forests were originally gazetted to protect the forest from clearing by the expanding settlement. The forests chosen were not necessarily the areas of best timber. In most cases on non basalt soils heavy timbered areas were not cleared. As the population increased and high fertile and easily cleared areas became in short supply even these heavily timbered areas came under clearing pressure.

The first silvicultural treatment of eucalypt forests in NSW was at Termeil and Benandarrah on the South Coast (near Batemans Bay) in 1895 during Ednie Brown's term, and under the supervision of forest ranger J.S. Allan (Grant 1989). Treatment was possibly rudimentary as it involved thinning by unemployed men from Sydney who had little knowledge of forest work.

After the end of the First World War many soldier settlers blocks were established which pitted those wanting to retain State Forests against the need to find employment. The last area of settlement in NSW was the eastern Dorrigo Plateau (Timmsvale, Lowana and Ulong)

in the 1920s. Many of these soldier's settlers blocks have now revegetated. During this period it was the of foresters lobbying the Government that many State Forests were maintained.

Forest policy development of the first half of the 20 th century was dominated by the philosophical divide that resulted in the undeclared and drawn out multi-faceted policy war between the traditional, conservative trained Englishman Charles Edward Lane Poole (Nancy Forestry School) and his protagonist Edward Harold Fulcher Swain, Sydney-born (Sydney University, and the School of Forestry at University of Montana).

Lane Poole maintained his Euro-centric traditionalist approach throughout his career. In contrast, Swain's modern, pro-industry 'forestry is a business' approach was influenced by

his Montana training. Swain pioneered softwood planting and timber technology in Queensland and the gross hoppus system for native forest harvesting, then a first for Australia, against strong political and industry opposition.

However, Lane Poole and Swain had much in common; a passion for forests and forestry, a strong belief in science-based forestry as fundamental to effective forest management, a singular focus on forestry policy and a willingness to take personal risks in vigorous and public dealing with their political masters of the day in defence of forestry, which cost them both dearly.

Their philosophy was largely shared by their contemporary, Norman William Jolly. Jolly was instrumental in introducing silviculture and sustained yield management concepts to the native forests of Queensland and NSW, and in initiating the softwood planting program in NSW.

During this period National Forest Policy was driven with the concept of self sufficient in forest products and Australia was a net importer of forest products mainly softwood timber and paper.

Post Second World War, the NSW Government directed the Forestry Commission to over cut the forest in order to establish a timber industry to supply work and timber for the great demand for housing generated during the depression and war years. This was coupled with an expansion of the plantation estate in the 1960s, again driven by the concept of self sufficiency. After 1 major depression and 2 world wars, self sufficiency was a major theme for many industries in Australia. This Government direction led to the establishment of the Harris Daishowa chip mill at Eden.

The coastal and tablelands forests were divided into 3 working circles with corresponding silvicultural prescriptions. The high yielding coastal and plateau forests were maintained on a sustainable yield basis. Some of the non-rural community believed these forests to be unlogged but anything could be further from the truth. In the early 1980's the Canberra press were concerned with logging near Durras. I was conducting the 8 th known cutting cycle of these compartments. In fact Durras was established as a timber export port and locals had no issue with the logging.

The foothills working circle was cut above sustained yield. The concept was to log these to maximum yield, regenerate them and then to leave until ready for harvesting some 40 years in the future. The Tablelands working circle was logged on sustained yield and its cutting cycle was longer then the Coastal Working Circle.

The Cypress Pine forests were managed on sustainable yield basis. The big issues was to obtain regeneration due to browsing pressure and fire, and once regeneration was established then there was a need to thinning.

River Red Gum forests were managed under different concepts. On many occasions it was predicted that these forests would stop growing and were cut beyond sustained yield. All these predictions have been proven to be wrong. The local foresters became very efficient in utilising limited available water.

After the Second World War the emergence of concepts of multiple use matured in both a policy and operational sense around the time of the Forwood Conference in April 1974, notable for Jack Westoby's address on the subject (Westoby 1974).

This was also the time when Australian forestry was going through the early throws of responding to the challenge of change generated by industry conditions on one hand and a gathering environmental movement on the other. Interesting the debate of the Eden chipwood operations was lead mainly out of Canberra and the Routleys' book "Fight for the Forest". The first edition stated the major problem would be lack of regeneration. The second edition in 1971/72 said the major problem was too much regeneration.

More recently, the challenge is the delivery on ecological sustainability and ecologically sustainable development (ESD); these are much wider and indeed woollier concepts, involving forest productivity at a level quite distinct from the traditional forestry concept of sustained timber yield. Ecologically sustainable forest management (ESFM) currently underwrites forest policy and much of our forestry practice, more so in native forests (C. of A. 1995; Forests NSW 2005); whether it actually delivers tangible benefits to society apart from spawning its own growth industry and affording a warm inner glow remains to be seen. At the policy level, foresters role changed from one of driving conservation (wise use) to having policy imposed by others. Foresters were no longer the change agents as opposed to the period when forest services were being established around the turn of the 20th century and possibly up to about 1970, foresters had far more influence over and indeed direct involvement in development of forest policy than they do today. The various state forestry enabling Acts without exception mandated that a professional forester headed the forestry agency responsible for administering the Act, a very different situation to that we find today. Public forestry also featured far more importantly then in the socio-economic scheme of things, when the rural economy was a much more significant sector than now in its contribution to employment and GDP.

Ian Bevege summarises this change very well when he wrote "... we have seen the marginalisation of foresters and the deprofessionalisation of senior management in forestry agencies in this era of the omnipotent generalist manager. We have seen the ascendancy of

the influence of accountants following the corporatisation of the public plantation sector and the struggle by state treasuries to maximise financial returns from native forest harvesting operations, to which silviculture now plays a somewhat secondary role. ..."

Is it a consequence of the now massive urbanisation of western society with few or no roots in its rural past, lack of traditional knowledge or even sense of its own social history is a challenge for those developing and implementing forest policy?

Future Direction of Forest Policy

"A clear forest policy is one condition of a truly social forestry.....All forestry should be social"

Those were Jack Westoby's last words on the subject written shortly before his death, as the concluding statement in his "Introduction to World Forestry."

Ian Bevege, in his Max Jacob's oration 1, encompasses Jack Westoby's work into the following points;

1. Wood is good. It is one of the world's great renewable resources.
2. Forests are for people.
3. Forests should be conserved and expanded for all their values and multiple uses.
4. A national forest policy embodying these values is the mark of a prudent nation
5. Forests are a major vehicle for socio-economic development.
6. National forest policies are best determined by the democratic political process involving all citizens not just "industry, forest owners, builders and bird watchers"
7. Foresters have an obligation to participate in and inform the political process and to ensure the forests are managed for their socio-economic Values.

UN Intergovernmental Panel on Climate Change (IPCC), 2007 report stated that:  
In the long term, a sustainable forest management strategy aimed at maintaining or increasing forest carbon stocks, while producing an annual sustained yield of timber, fibre or energy from the forest, will generate the largest sustained mitigation benefit.”

#### Discussion

The EPA Forestry Section is in a unique position to contribute to the 7 points raised by Ian Bevege.

The only constant is change be it climate change or forest management change as a result of climate, politically or social needs of the community. The IPCC found in its analysis on climate change that sustainable managed forestry is the best tool we have for adapting to Climate Change. It is interesting this IPCC finding is not quoted by those wanting to shut down forestry. See Appendix 3, extracts of Ian Bevege’s paper on “Adaptation of forests to climate change”.

With change comes uncertainty and perceptions of risk. Individual, community and global response vary on temporal and spatial scales. Strategies for adapting to change can be proactive or reactive. Reactive strategies can be purely “knee jerk” response or structured into an adaptive management regime.

Proactive strategies to perceived change requires a recognition and understanding of the nature, extent, scale, timing and rate of change and social consensus as to the appropriate

1 One of the highest honours for Members of the Institute of Foresters of Australia is to deliver the

Max Jacobs  
oration. Past recipients of this honour include Dr Ian Bevege, Phil Cheney, Graham Wilkinson, Prof Lyndsay

Prior, Prof Gary Bacon, Evan Rolley, Prof Sid Shea, Prof Ian Ferguson, Prof Roger Sand, Dr Hans Drielsma and

Dr Bill Jackson.

course of action. The greater the uncertainty, the greater the risk associated with any response strategies--hence the need for some estimation of the limits of confidence to be placed on the outcomes of predicted change, and the concomitant identification of the inherent risks and opportunities associated with it and with any proposed strategic responses.

#### Summary

It is fundamental that we see the forest, the trees, the wood and other forest services as linked subsystems of a whole, which also embraces the institution and organisation of forestry itself as the moderating influence between &#39;wild untrammelled nature&#39; (is there such

a thing?) and uncontrolled exploitation. Some of the problems that have beset forestry over the last few decades are due to a growing conceptual disconnect by forestry agencies regarding these linked elements, and failure by policy makers and a highly urbanised society to see any connections at all. Reversing this situation is possibly the greatest challenge for change facing forestry and its practitioners: to place the forest and its sustainable multi-functional management for public good squarely back on the societal agenda.

The only constant in the universe is change. In the forest and forestry we see this when we look beyond the short term. Our problem, as part of the those responsible for forest management in NSW, most of the stakeholders/players we will deal with do not see this change, in particular those not involved in forest management ethos. So what we see as obvious they do not. We cannot blame them for that but must help educate and structure our policy setting and how we work with them with this in mind.

I hope this potted history help you understand the history of forest management and assist you in your part of a long tradition of forest management.

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Appendix 1 Important events in Forest Management through time

200 BC-2 nd

Century

Han Dynasty introduce forestry laws and forest management

5 th Century Monks established a plantation of Stone

pine (Italy)

For use as a source of fuel and food, in the then Byzantine Romagna on the Adriatic coast

5 th Century Forest protection Laws introduced into

Germany

6 th Century Roman Empire introduce forestry laws This response was a bit late as significant areas had already been deforested

7 th Century Formal forestry practices developed by the Visigoths (Germany)

In response to the ever increasing shortage of wood, they instituted a code concerned with the preservation of oak and pine forests

9 th & 10 th Century

Forest Law established in France  
1066 William the Conqueror introduces Forest Law to England

12 th Century Forest measurement Plots established in Germany  
Some are still used today

1215 Magna Carta signed by King John  
1217 Charter of the Forest (Carta de Foresta)

Signed by King Henry III

Longest running Forest/Natural Resource Management Law

14 th Century Study of Forestry introduced into a French University

Many words used in forestry worldwide have a French origin

15 th Century Forest measurement Plots established in Sweden

Some are still used today

16 th Century Systematic management of forests for a

sustainable yield begins in German states and Japan.

Typically, a forest was divided into specific sections and mapped; the harvest of timber was planned with an eye to regeneration.

1630s Xu Guangqi wrote the “Nong Zheng Quan Shu” (China) including one chapter on “Silviculture (Chong Chi): forestry preservation”

Although its final draft was unfinished by Xu Guangqi at the time of his death in 1633, the famous Jiangnan scholar Chen Zilong assembled a group of scholars to edit the draft, publishing it in 1639.

1664 John Evelyn publishes his treatise “Sylva, or A Discourse of Forest Trees”. It was written to encourage landowners to plant trees to provide timber for England’s burgeoning navy.

Further editions appeared in his lifetime (1670 and 1679), with the fourth edition (1706)

Louis XIV’s minister Jean-Baptiste Colbert’s oak forest at Tronçais, planted for the future use of the French Navy

The forest matured as expected in the mid-19th century:

1787 Dillenburg in Germany The first dedicated forestry school was established by Georg Hartig

1803 First Australian tree protection order Governor King “forbade the cutting of any tree or shrub within 10 metres of the Hawkesbury River bank

19th Century North American foresters went to Germany and France to study forestry.

1820 NSW timber getters required a licence Granted by magistrates and Crown land Commissioners “to persons of good character”

1877 First issue of Šumarski list (Forestry)

Review) was published

In Croatia by Croatian Forestry  
Society

1881 Henry Kendall appointed NSW first forest

inspector

State Forests was then administered  
by the Lands Department

1886 First issue of Revista Pădurilor (Forestry

Review) was published

In Romania

1 st Sept  
1898

The Biltmore Forest School was  
established near Asheville, North Carolina,  
USA

By Carl A. Schenck

Sept 1898 New York State College of Forestry,  
established at Cornell University  
First forestry school was established in  
Brazil, in Viçosa, Minas Gerais

Later moved to Curitiba, Paraná

1899 Edward Swain appointed first cadet forester

in NSW

NSW Forestry Commissioner 1935-  
48.

Introduced gross hoppus stumpage  
royalty & economic analysis

1916 NSW Forestry Act gazetted

1910 Norm Jolly, starts work in Forestry The first qualified forester to practice  
in Australia, also South Australia's  
first Rhodes Scholar (1904). NSW  
Forestry Commissioner 1918-33

1910/11 First Australian Forestry School established

at Adelaide University

1927 Australian Forestry School established at

Yarralumla

By Lane Poole, Adelaide School  
transferred to Yarralumla

1955 Max Jacob's writes "growth Habits of the

Eucalypts"

1944-1959 Head of the Australian Forestry  
School

Doc Jacobs was a researcher and  
teacher. During WWII he was  
promoted from private to major  
(overnight) once the Army realised  
his abilities

1971 Wild Creatures and Forest Laws Act (UK)

proclaimed

Replaces the Charter of the Forest  
(in place for 784 years)

1975 NSW Soil Conservation Act amended Consent now required to log private  
property on State protected Land

1985 Forestry Practices Act gazetted in

Tasmania

1992 National Forest Policy signed By all mainland states, Tasmania

signed in 1995

1993 The then NSW Liberal Government decide  
to introduce a PNF Code of Practice

Code was to be negotiated with  
Industry- PNF Private Native Forestry

1995 SEPP46 Introduced by new NSW Labor

Government

1997 Native Vegetation Conservation Act

gazetted

1999 First RFA (Eden) in NSW signed Regional Forestry Agreement

2003 Native Vegetation Act gazetted

2007 PNF fully regulated in NSW Code of Practice introduced

Appendix 2 - Notable foresters and forest managers

- Geoffrey Chaucer (1343–1400)
- Jean-Baptiste Colbert (1619–1683) (French plantations)
- John Evelyn (1620–1706) (founder of modern forestry in England)
- Carl von Carlowitz (1645–1714)
- Christian Ditlev Frederik, Count Reventlow (1748–1827)
- Georg Ludwig Hartig (1764–1837)
- Israel af Ström (1778–1856) (founder of Sweden's national Forestry Institute)
  
- Douglas Hamilton (1820–1895)
- Hugh Francis Cleghorn (1820–1895) (Tropical Forestry)
- Dietrich Brandis (1824–1907) (“Father of Tropical Forestry”)
- John Muir (1838-1914) [“Father of the National Parks”]
- Henry Kendall (1839-1882) (first NSW forest inspector)
- Sir William P.D. Schlich (1840–1925) (Oxford Professor of Forestry and author of the five-volume Manual of Forestry (1889-96))
- T. B. Walker (1840–1928) (sawmiller, forest conservationist and at one time 10 th wealthiest person in USA)
- John Ednie Brown (1848–1899)
- Bernhard Fernow (1851–1923) (father of professional forestry in the United States)
- Gifford Pinchot (1865–1946) (founded USA Forest Service)
- Carl A. Schenck (1868–1955)
- Raphael Zon (1874–1956)
- Ralph Hosmer (1874–1963)
- Aimo Cajander (1879–1943)
- Norman Jolly (1882–1954) (first qualified forester to practice in Australia)
- Roy Robinson, 1st Baron Robinson (1883–1952)
- Edward Swain (1883-1970) (first Professor of Forestry in Australia)
- Viktor Schaubergger (1885–1958)
- Lane Poole (1885-1970)
- Aldo Leopold (1887–1948) (author of “Sand Country Almanacs”; Wilderness and ecology concepts)
- F.X. Schumacher (1892–1967)
- Stephen Kessell (1897-1979) (Founding President of the Institute of Foresters of Australia, developed the first Australian Forestry Policy during WWII)
- Max Jacobs (1905-1979) (author of “Growth Habits of the Eucalypts”)
- Jack Westoby (1912-1988) (International Forestry / Social and Economics)
- George Baur (forest typing and eucalypt silviculture)
- Ross Florence (author of “Ecology and Silviculture of Eucalypt Forests”)
- Vaclav (Vince) Hervert (my mentor)
- Brian Furrer (Spotted Gum silviculture)
- David Hamilton (River Red Gum silviculture)
- John Lowry (Cypress Silviculture)
- Alex Floyd (rainforest ecology)
- Alan McArthur (fire behaviour and bush fire physics. First Hume Snowy Forester.
- Phil Cheney (Fire management and behaviour)
- Tom Spies (restoration ecology)
- Hamish Kimmins
- Vijaypal Baghel (Ecoman)

- Dr. Harry V. Wiant
- Andrew Campbell (founder of Landcare)
- Bill Jackson, former Deputy Director General IUCN, and Director General of Parks Victoria and last Hume Snowy Forester.

### Appendix 3; Adaptation of forests to climate change

- extract from Ian Bevege's 2009 Max Jacobs oration, reproduced from the IFA Conference papers, Caloundra Queensland. Footnote comments from Paul Massey-Reed.

Let us set aside for now arguments about anthropogenic determinism and consider some basic facts of the matter:

- In geological terms, Earth is presently in an interglacial period within the current Little Ice Age. As best as can be estimated, mean global temperature today is about 3 0 C lower than the mean global temperature for Earth in the last 600 million years of Phanerozoic history.
- The earth has been warming since around 1850 as it comes out of the Little Ice Age, with periodic fluctuations of shorter-term cooling. Global mean surface temperature is estimated now at 16.5 0 C, having increased about 0.74 0 C over the last century.
- Atmospheric CO<sub>2</sub> has been rising steadily since the early 19th century, having increased from around 270 ppm to about 385 ppm today.

What are the implications for adaptation of forests to rising temperatures and CO<sub>2</sub> levels?

The first point to make is that present conditions via a vis global temperatures and CO<sub>2</sub> are, as far as can be determined, most similar in geological time to those existing 300 million years ago (Mya) in the Permo-Carboniferous period (Scotese 2008), a time of laying down of great coal measures and glaciation of much of Gondwana, which included what is now the Australian continent. These conditions are exceptional in the last 600 million years, that is, the period of life on Earth.

Second, key elements of the flora of direct interest to forestry--the araucarias, pines, eucalypts, acacias, casuarinas and what we loosely call rainforest species--are shown by the fossil and palynological record to have evolved under conditions of temperature and CO<sub>2</sub> far higher than today, and far higher than anything predicted even by the IPCC. The semi-precious stones, jet and amber, are respectively fossilised wood and resin of conifers; jet (from an Araucaria precursor) is dated to the Jurassic 170 Mya (Finlay 2006) while amber (from Agathis and Pinus precursors) formed over a wide period of time 140-30 Mya spanning the lower Cretaceous to the Oligocene (Langenheim 2003). In Australia, the gymnosperms were most abundant in the Palaeocene (65 Mya) and decreased in the Eocene (56 Mya) when rainforests covered much of southern Australia; huon pine (*Lagarostrobos franklinii*) was the most common conifer there at the time. Extant tree genera important today both ecologically and to Australian forestry appear in the Australian geological record as follows (Burbidge 1960; Hill 1994):

- o Cretaceous (159 Mya) Araucaria, Podocarpus, Proteaceae
- o Palaeocene (65 Mya) Nothofagus, Casuarina, Eucalyptus, Tristania, Acmena
- o Eocene (56 Mya) Eucalyptus, Agathis, Lagarostrobos, Wollemia, Cunoniaceae, Lauraceae
- o Oligocene (35 Mya) Elaeocarpaceae, Meliaceae
- o Miocene (23 Mya) Acacia, Rutaceae

To this list we can add *Pinus*, a very significant genus to Australian forestry, which evolved in the Cretaceous.

This flowering of the Cinnamomum Flora from the early Tertiary (Palaeocene-Miocene) took place during a period of warm climate. Over this evolutionary period, average global temperatures ranged from 16 to 21 0 C and atmospheric CO<sub>2</sub> concentrations from 1500 at the beginning of the Cretaceous to a high of 2500 ppm at the end of that period, then falling in steps and stairs to about 180 ppm around the end of the Pleistocene (40-160 kya) (Hill

1994), by which time climates and biotas were similar to today. Hence the tree flora has evolved over 160 million years of widely fluctuating temperature and CO<sub>2</sub> levels and their genes for adaptation to this variability were present well before our current Holocene period. Adaptability is determined by the ability for gene expression in response to climatic stimulus, that is, the genotype x environment interaction. Because of their evolutionary journey, I think that species have far more inbuilt genetic variation than is outwardly expressed, more variation fitting them to cope with and adapt to changing climate than would be apparent from their current biogeographic distribution and growth responses under current climatic conditions. Current distributions are no hard and fast guide to potential distributions, and a restricted distribution no predictor of climatic adaptability. Alfred Russell Wallace, biogeographer extraordinaire, argued strongly that both biological and geological history are necessary to account for observed patterns in the geographical distribution of plants and animals; (Camerini 1994).

Foresters take advantage of this every day with their successful introduction of species to new environments, where species display amazing broad-scale adaptability and acclimatisation that are not apparent from observation in their restricted natural environment. Radiata pine is a case in point; eucalypts at the generic level another.

When we come to consider the effects of rising CO<sub>2</sub>, the story also revolves around genetic fitness. Consequently, given that species have evolved under much higher levels of CO<sub>2</sub> than current ambient, their genetic fitness to variations in CO<sub>2</sub> level is undoubtedly very high. Recall that today's forests are actually growing in a CO<sub>2</sub> deficit situation compared to that to which they were exposed during their long evolution over 160 million years during which CO<sub>2</sub> levels have been as high as 2500 ppm, and ambient CO<sub>2</sub> levels are currently estimated to be at their lowest for 300 million years. We might therefore expect that as CO<sub>2</sub> levels rise, we would observe a growth response. This is indeed the case, as has been demonstrated by exposing trees to experimentally enriched CO<sub>2</sub> atmospheres up to twice ambient (Conroy et al. 1990). Furthermore, trees exhibit acclimation to rising CO<sub>2</sub> levels through time and this is possibly due to genetic buffering resulting from their long evolutionary history 2.

These acclimation responses have implications for how plantation strategies are developed to address current rising CO<sub>2</sub> levels. We should recognise that this is a change that brings challenging opportunities to forestry rather than threats, opportunities to modify species selection for sites, opportunities to take advantage of improved growth rates where water is not limiting--including concentrating plantations to the higher-rainfall tropical north--and opportunities to maximise adaptability through development of trees genetically modified by gene transfer. 3

2 Research by University of Western Sydney has found that all 5 species of eucalypt tested did not exhibit faster great rate but improved water efficiency. They postulate this is due to the eucalypt stomata response to higher CO<sub>2</sub> levels.

3 the long established plots in Germany and Sweden and pollen research, the current northern extent of European

Beech is still some significant distance south then the northern extent that occurred in the medieval warming period.

Fire has been the main tool of nature in resetting forest affected by global climate change. Modern society

cannot allow fire to performer that role across the broad landscape. Professor John Innes (Head of British

Columbia University, Forestry and Environment Department and one of the world's foremost forest

entomologists) set a challenge for natural resource managers that “the management of forests needs to be proactive to allow species to survive sudden climate change thus allowing adaptation to occur.”